

Insights on NARSTO
Report Prepared for the NARSTO Review Committee

by

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1. Introduction

NARSTO is a public/private partnership, whose membership spans government, the utilities, industry, and academe throughout Mexico, the United States, and Canada. Its primary mission is to coordinate and enhance policy-relevant scientific research and assessment of tropospheric pollution behavior, with the central programmatic goal of determining workable, efficient, and effective strategies for local and regional air-pollution management.

In addressing this mission, NARSTO is charged with establishing and maintaining effective communication channels between its scientific effort and its client community of planners, decision-makers, stakeholders, and strategic analysts. It is also charged with providing a cross-organization planning process, which determines the most effective strategies for scientific investigation. NARSTO coordinates the allocation of financial resources to implement these strategies, and monitors progress of its effort toward fulfillment of its programmatic objectives.

My goal in writing this paper is to provide the NARSTO Review Committee with a programmatic overview that emphasizes salient aspects of NARSTO's objectives and performance. Although organized according to NARSTO's historical time-line, the paper does not discuss the program's history in depth; rather, it places primary emphasis on NARSTO's operating experience, including its challenges, its successes, its failures, and the question of its utility as a platform for future deployment.

Summarized by the time-line shown in Figure 1 and the field-study summary in Table 1, NARSTO's history can be grouped conveniently into three consecutive stages:

- The Formative Period: program design and initial team-building

- The First Operational Phase: tenure of the first Management Coordinator
- The Second Operational Phase: tenure of the current Management Coordinator

The following sections discuss these stages in sequence, with particular emphasis on my personal tenure period, the First Operational Phase.

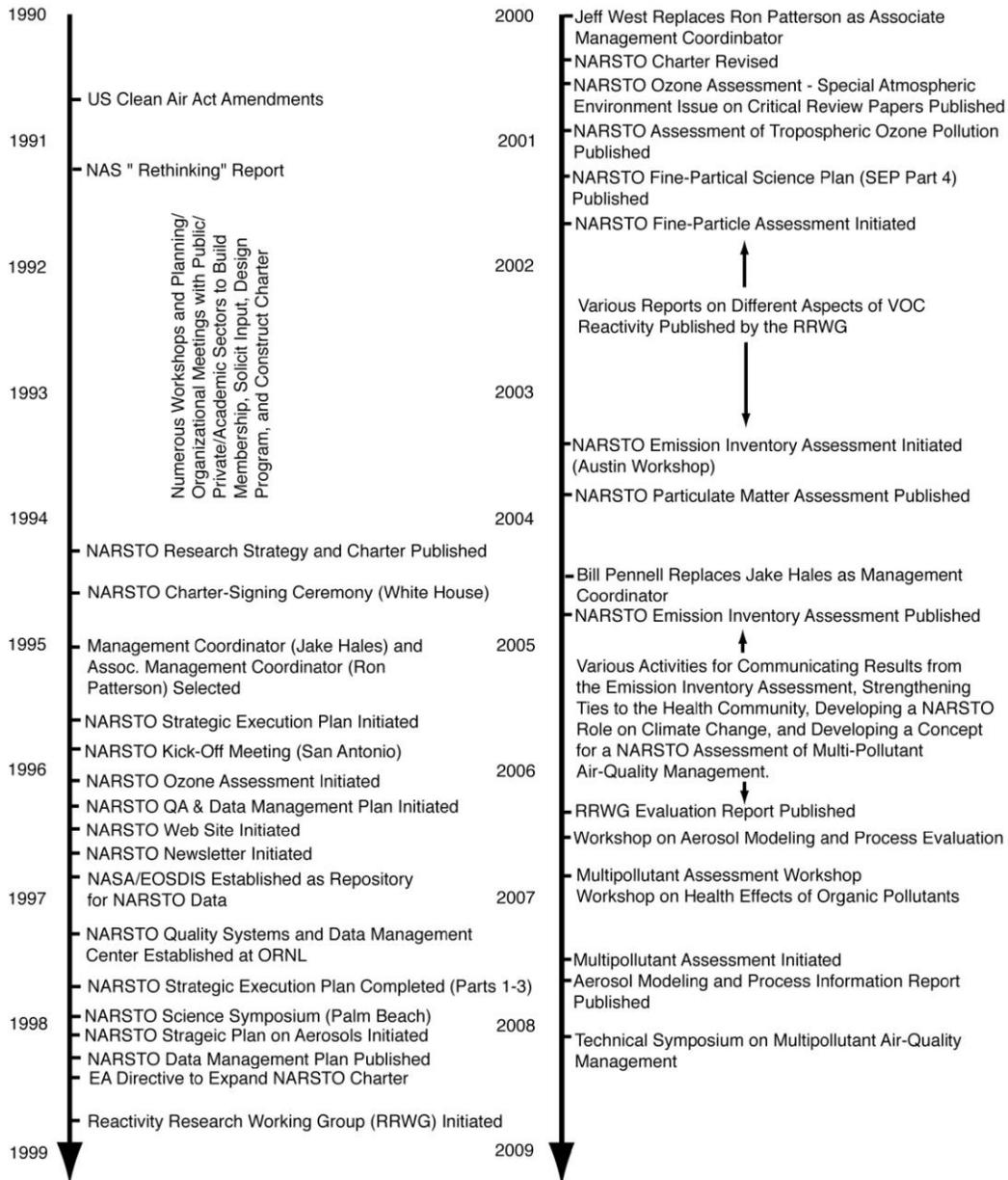


Figure 1: Summary of NARSTO's History and Driving Forces

Table 1: Summary of NARSTO - Related Field Campaigns

Field Campaign	Dates	Location
Southern Oxidants Study	1995	Southeastern US (Several selected locations)
NARSTO Canada-East	1995	Southeastern Canada
NARSTO Northeast	1995	Northeastern US
Southern California Oxidant Study (SCOS97/NARSTO)	1997	Southern California
Texas 2000	2000	Southern Texas
Mexico City Metropolitan Area Study	2002	Mexico City
Central California Ozone Study	2000	San Joaquin Valley
California Regional Particulate Air Quality Study	2000	San Joaquin Valley
SEARCH	1998 - continuing	Southeastern US
Pacific 2001	2001	Southwestern Canada
Pacific Northwest 2001	2001	Northwestern US
Texas 2005	2005	Southern Texas
PROPHET	1995 - continuing	Great Lakes/Central Michigan
Mexico City Fine Particle Study	1997	Mexico City
NARSTO MILAGRO MAX Mex	2006	Central Mexico

2. NARSTO's Formative Period

NARSTO's origins stem directly in response to a 1991 report published by the National Research Council, entitled Rethinking the Ozone Problem in Urban and Regional Air Pollution. In addition to providing a technical description of the chemistry and meteorology associated with tropospheric ozone formation, this report presents a historical overview of North American tropospheric ozone trends and control measures since the 1963 enactment of the original United States Clean Air Act. It notes that despite major regulatory programs over the past 20 years, efforts to attain North American ozone standards have been only marginally successful throughout major portions of the continent.

Reflecting on these features and on the number of ozone studies that have been conducted on a somewhat mutually uncoordinated basis, the National Research Council report concluded that "Progress toward reducing [tropospheric urban and regional] ozone concentrations . . . has been severely hampered by the lack of a coordinated national program directed at elucidating the chemical, physical, and meteorological processes that control ozone formation and concentrations over North America." Accordingly, the report recommends that a major program be established to address the ozone issue, which coordinates and pools associated research activities as well as processing the results for downstream use by the policy community. Moreover, it asserts that the program should be managed independently from regulatory authority, so that program continuity can be preserved, and it should be coordinated over a wide basis to adequately reflect all physical and chemical processes and to maximize effective use of the talent pool. The NARSTO program is a direct response to this NRC recommendation.

Responding to this recommendation, representatives of numerous governmental, industrial, and academic organizations met repeatedly in workshops and a variety of smaller meetings to develop a program design and to embark on the team-building process. This required substantial leadership and effort, and progressed over a two-year period, resulting in the NARSTO Research Strategy and Charter .

Overall NARSTO goals stated in the Research Strategy are to:

- Develop and implement a research strategy reflecting both science and policy concerns.
- Conduct policy-relevant research with frequent and appropriate reporting to policy and air-quality management communities.
- Develop and deliver scientifically credible assessment tools to the assessment community.
- Provide state-of-science assessments of North American ozone problems and their control.
- Provide an information clearinghouse.
- Provide sustained coordination, collaboration, and leveraging of resources.
- Develop an organizational and management structure that facilitates a high level of ownership by individual organizations.

- Provide a unified, cohesive and scientifically sound basis for planning and implementing ozone research.
- Include representation within NARSTO for all stakeholders, including air-quality management, health and ecological-effects, and emission-control communities.

Figure 2 shows the initial organizational structure for attainment these goals. This will be discussed later, in the context of possible program modifications.

NARSTO's initiation process was formalized by an official Charter-signing ceremony at the White House on February 13, 1995, leading to the selection of myself and Ron Patterson as program Management Coordinators, and launching the first operational period of the program.

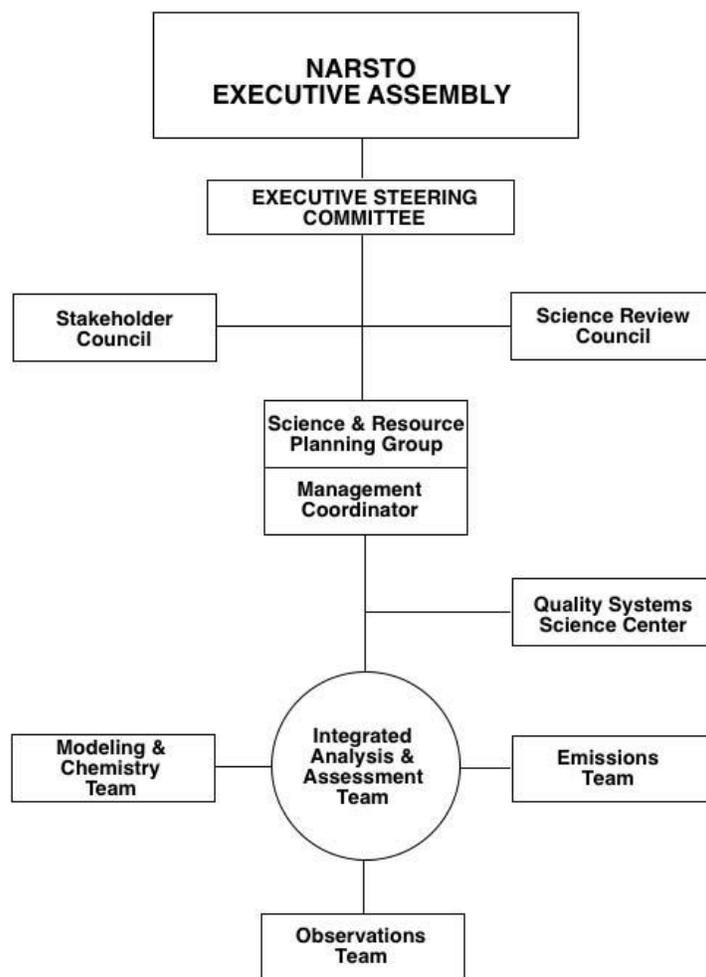


Figure 2: NARSTO's Organization Chart

3. NARSTO's First Operational Period

As can be noted from Figure 1, NARSTO initiated a number of activities immediately on formation of the Management Coordinator's office. These included infrastructure communication and team-building efforts, such as the NARSTO kick-off meeting¹, establishment of the Web site, creation of the newsletter, initiation of monthly ESC conference calls, establishment of the NARSTO Infrastructure Funding Pool, and multiple coordination meetings with key NARSTO teams. Two important functional activities were also launched at this time, the first being the Quality Systems and Data Management function, which was spearheaded by Assistant Management Coordinator Ron Patterson. This involved multiple meetings of the QS&DM team to design the database management system, which was ultimately documented in formal reports and user's manuals. Although early-on NASA agreed to furnish its EOSDIS system as a data repository, funding of the data ingest component initially appeared problematic. This was resolved ultimately by the Department of Energy, when ESC member Michelle Broido designated internal DOE funds to support the data center at Oak Ridge National Laboratory. DOE has continued to fund this facility up through the present time. Currently the data management system serves as the repository and access facility for a variety of data, not only from NARSTO field Campaigns, but from associated efforts such as the EPA Supersites program as well. Late in the first operational period Ron Patterson retired, and was replaced by Jeff West as Associate Management Coordinator. In addition to multiple other duties, Jeff assumed Ron's role for oversight of the Quality Systems and Data Management function.

The second important functional activity, launched through leadership of the NARSTO Analysis and Assessment Team, was the NARSTO Ozone Assessment. This was an important effort, not only because it produced the ozone assessment document and its companion series of technical publications, but also because it set the mold for future NARSTO activities of this type.

Several other NARSTO products emerged during the first operational period, including the Fine-Particle Assessment, several reports addressing VOC reactivity and its potential for regulatory application, and a report on the Phase 1 NARSTO model intercomparison study. The NARSTO Emission-Inventory

¹ Timing for this meeting turned out to be somewhat inauspicious owing to the forced shutdown of the US government during that period, making hotel arrangements and travel difficult. This was partly compensated by emergency travel support provisions to key participants by NARSTO member organizations still having disposable funding sources. Hotel arrangements were extremely problematic. At least one NARSTO member indemnified group meals for the conference on his personal credit card -- an early indicator of NARSTO community spirit!

Assessment also was initiated during this period. Its publication, however, did not occur until early in the second operational phase.

NARSTO participated in a number of additional activities during the first operational period, making special outreach efforts to peripheral programs and stakeholder communities, especially the health community. NARSTO was particularly active in helping to design and launch the EPA Fine-Particle Supersites program and, as noted above, serves as the repository for Supersites data.

As indicated in Table 1, several field campaigns occurred during the first operational period. These were conducted primarily by specific NARSTO member organizations, with the NARSTO organization playing roles in communications, facilitating participation by additional NARSTO groups, and program design. This role has continued into the second operational period.

4. NARSTO's Second Operational Period

NARSTO's second operational period began in 2004, with selection of Bill Pennell to replace Jake Hales as Management Coordinator. The program has proceeded on-course under Bill's leadership, completing the Emission Inventory Assessment and the final report on the Reactivity Research Working Group's activities, and launching the new assessment on multipollutant air-quality management. NARSTO Field campaigns in Mexico have been particularly active during this period. In addition, NARSTO has hosted and participated in a variety of scientific workshops and planning activities.

5. Take-Home Messages

Against the historical backdrop presented above, there are several "take-home" messages that I, as former Management Coordinator, feel are particularly important for the Committee's consideration in their decision process. These address both NARSTO's strengths and its deficiencies, and undoubtedly contain some of my personal biases. They are itemized as follows:

1. This initial message, which has significance only if the Committee determines that NARSTO indeed has value and potential for future utility, is simply this: Construction of the initial NARSTO organization required extensive time, planning, organization, and team-building effort, as well as large amounts of energy on the part of its organizers. This would have to be repeated if a similar organization were to be formed; thus any suggestion that NARSTO should be

discontinued in favor of a newer, similar organization should be considered carefully.

2. While NARSTO has been largely successful as an interactive environment for joint efforts and discussions between its three member countries and between government and industry, it should be recognized that various member sectors participate for a variety of individual reasons. Obviously, for example, the regulators have had rather different agendas than those being regulated, and representatives from the three member countries participate from somewhat different perspectives. My observation is that this interaction has been largely constructive and healthy, in part because NARSTO has presented a nonadversarial forum for meaningful scientific and policy-relevant discussions. NARSTO's three-country, multiple-stakeholder composition presents significant organizational challenges; but it also provides a unique forum, which has been useful and productive in addressing a range of issues.

3. NARSTO has experienced numerous changes in driving forces and organizational demographics over its 15-year history, for several reasons:

- New scientific issues have come into prominence, either because older issues have been resolved (partly through NARSTO's efforts), or because they have been replaced by competing issues. The emphasis shift from ozone to suspended particulate matter (PM) is a prime example. In general NARSTO has demonstrated the flexibility to change its emphasis appropriately as needed, while still maintaining its original intent.
- Personnel have changed. Many of the individuals associated with NARSTO's creation, for example, have either retired or moved on to new positions; thus some of the inherent appreciation for organizational history is fading.
- Political and regulatory driving forces have shifted. Aside from the obvious changes in regulatory driving forces caused by new standards, SIP calls, and so-forth, the US deregulation of the utility industry is particularly noteworthy. Deregulation resulted a more competitive environment among the utilities, leading to less incentive for cooperative ventures. This has resulted in sale of generating facilities by several NARSTO members and thus a lessening of their interest in pollution-related issues. NARSTO's new members include some of the purchasing companies. On balance, however, this has represented a decreasing activity level on behalf of NARSTO's utility members. Just as importantly,

deregulation has resulted in a restructuring of EPRI, one of NARSTO's most important members and stakeholders, leading to decreased participation by that organization as well.

4. NARSTO's successful performance depends strongly on three primary ingredients:

- Strong and consistent leadership by a group of knowledgeable and dedicated individuals. This feature was clearly evident during my tenure as Management Coordinator, and I feel privileged for the opportunity to work with these people.
- An adequate funding base. This is discussed in more detail in item 5, below.
- A commonly perceived issue (or issues) requiring attention. As noted above these issues have evolved and changed as NARSTO has completed initial goals and proceeded to others.

5. NARSTO presents a challenging environment for acquiring funds necessary to meet its scientific goals. Acquiring and allocating funds require substantial amounts of time and effort by NARSTO's leadership. There are two major reasons for this:

- Financial contributions to NARSTO's programs are voluntary, and members benefit from NARSTO products regardless of their contributions. Thus the incentive for contribution is, to some extent, limited.
- NARSTO's membership represents a diverse group of organizations, having different accounting systems, funding processes, fiscal cycles, and constraints. This poses a challenging environment for distributing and pooling funds for joint activities.

With regard to the first of these items, it should be noted that several NARSTO organizations have contributed generously to program operations. It's my observation that members represented by individuals relatively high on their respective organization charts i.e., those sufficiently close to their organizations' funding decision processes, have usually been the most reliable and generous contributors. NARSTO's financial health depends strongly on keeping these high-level representatives actively engaged in the program.

Regarding the second item, NARSTO has (more or less) successfully addressed the variety of financial systems by developing multiple pathways for financial contribution, including the infrastructure funding pool located at the non-profit Oak Ridge Institute for Science and Education (ORISE). With this arrangement it has been possible for contributors to allocate funds to a chosen recipient (typically a research contractor) either directly, through the NARSTO Management Coordinator's office, or through ORISE.

Quite obviously NARSTO is not a typical "top-down" organization. Most often, major scientific efforts are implemented by holding initial meetings with the membership to define needs and to design the associated scientific effort. Subsequently individual members select research components for their particular funding contribution and allocate the funds via their funding channel of choice. This process takes considerable effort by the Management Coordinator as well as the Executive Steering Committee and other NARSTO leadership components.

One should note that while the above coordination process is typical of NARSTO assessments and similar ventures, major NARSTO field campaigns have not been funded in this manner. Often NARSTO plays a significant role in field-study design, and facilitating the pooling of scientific manpower, equipment and analytical resources (see below); but funding typically flows directly to the effort, rather than through NARSTO channels in the NARSTO Management Coordinator's office.

6. NARSTO's organizational structure (Figure 2) has worked moderately well, although some changes may be advisable. NARSTO's organization chart was simplified during the Phase-1 re-chartering process because several of the original components were poorly defined and/or non-functional. In my opinion it would profit by further simplification. In particular, the Science and Resource Planning Group (S&RPG), originally established to plan and allocate financial, personnel, and equipment resources for NARSTO projects, was designed to include a broad spectrum of member representatives. Many members of this group became frustrated, however, because of their feeling that they were not really empowered to make decisions of this type. Consequently most of the S&RPG's intended function migrated upward to the Executive Steering Committee. If any organizational change were made, I would recommend eliminating the S&RPG and forming temporary, ad hoc committees as specific needs arise.

The various core scientific teams (Emissions, Modeling and Chemistry, . . .) were also criticized periodically because of their latency, but in my view this is not really a problem. As presently configured, NARSTO can deal with at most two major initiatives at a time, and it is natural for any team that is not currently addressing a specific initiative to keep itself “on hold” during this period. The Emissions Team, for example, was largely inactive during initial NARSTO years, but rose to the challenge admirably later, when the assessment on emission inventories was initiated.

7. The following discussion of NARSTO’s successes and shortcomings is subdivided into categories of central NARSTO functions, the data-management function, and field studies in the following paragraphs:

7a. Central NARSTO functions: Research Plans, Assessments, Model Analyses, Workshops, and Science Meetings

As noted above, NARSTO has published several reports, including assessments and research plans, and conducted numerous workshops and scientific meetings. The workshops and meetings were well attended, and the resulting reports give some indication pertaining to their quality, usefulness, and influence on downstream programs. The research plans and assessments, however, provide a more quantitative means for evaluation. The research plans were used extensively in guiding the NARSTO effort, and influenced the corresponding plans of a number of member agencies. They also were used for coordinating with other elements of US national air-quality research by the CENR Subcommittee on Air Quality.

The three assessments published to date are (in my opinion) high-quality documents written by competent scientists and processed through multiple stages of review, including the National Research Council. One component of the ozone assessment not submitted for NRC review was the compendium of science papers published in a dedicated Atmospheric Environment edition. These papers were subjected to the standard Atmospheric Environment review process and contain scientific material more detailed than the Ozone Assessment Document, which primarily targeted the policy-community readership. While the Atmospheric Environment volume contains many excellent papers addressing the ozone issue, some variability in quality exists from one paper to the next.

Because no direct means exists for determining serious readership and/or application of these assessments, evaluation of their utility subsequent to publication is difficult. Interestingly, I have received a disproportionate number of

inquiries on these assessments from abroad (Europe, Asia, South America), presumably because it is more difficult to access these documents from these places. The bottom line here, however, is that I believe these NARSTO products to be of almost uniformly high quality, although I have substantially less confidence in assessing their downstream usage.

Other functions coordinated to varying degrees through the Management Coordinator's office include the NARSTO model evaluation and the Reactivity Research Working Group. As its name implies, the model evaluation set the goal of evaluating modern air-pollution regional models by inviting the associated modeling groups to deploy their models on a test case (the NARSTO NE and NARSTO CE database). This effort definitely undershot its expectations, mainly because it contained overly ambitious goals, did not have sufficient buy-in with NARSTO's executive membership, and was launched on a sub-critical funding base. A "lesson learned" from this experience is that, in order to succeed, a project of this type must have a high profile with NARSTO's executive leadership and have its near-unanimous support.

The Reactivity Research Working Group was a quasi-independent NARSTO affiliate, which addressed technical aspects of applying VOC reactivity as a basis for ozone management. This effort led to a number of technical reports and largely succeeded in its goal of evaluating the potential of reactivity-based management schemes. Although the widespread application of such schemes is doubtful at present, the Group's activities resulted in a wealth of needed information and may be considered as a valuable addition and a successful venture.

7b. The NARSTO Quality Systems and Data Center

As noted above, the QS&DM Center (cdiac.esd.ornl.gov/programs/NARSTO/narsto.html) was initiated under the guidance of Associate Management Coordinator Ron Patterson, who coordinated a series of workshops for planning and development purposes. The database management system ultimately chosen was based strongly on existing systems used by Environment Canada and the World Meteorological Organization. NASA's EOSDIS system was selected as the final repository for NARSTO data, and the data ingest and retrieval facility was placed at Oak Ridge National Laboratory.

The ORNL personnel have done a competent job of implementing this system, although significant growing pains occurred during the process. The results of several NARSTO field studies, as well as the EPA Supersites program, currently reside on the database.

The primary “growing-pain” issue was a hesitancy by some scientists to place their data on the database. This occurred for two reasons. First there was a resistance by scientists to learn the ingest process for a data management system other than the ones they currently used - a factor that was often compounded by a natural reticence to spend the considerable time necessary for the uninteresting task of placing data on any database system whatsoever. The second reason was the existence of a bottleneck in the original data-ingest process, which compounded the first.

This bottleneck problem was attacked mid-course by the establishment of a “Blue Ribbon Panel” to determine the best correction approach (See Blue Ribbon Panel report, attached). Application of these corrections greatly improved the ease of data ingest and resolved many of the noted problems.

A cursory view of the QS&DM Web site reveals an impressive array of logged data, and data entry and retrieval facilities. Because of the initial problems, however, considerable amounts of NARSTO field-study data remain to be deposited on the system.

7c. NARSTO Field Studies

As noted above, NARSTO-affiliated field studies study are generally funded directly through channels established by NARSTO member organizations serving as organizers of the individual studies. The Management Coordinator’s office, typically, provides the communications forum for encouraging additional NARSTO members to deploy scientific resources to specific field campaigns and for assisting in planning these field efforts.

Some NARSTO-affiliated field campaigns (see Table 2) benefited more from direct NARSTO linkages than others. SOS was established and conducting field campaigns well before NARSTO’s formation, but held additional field studies during NARSTO’s tenure as well. NARSTO Northeast and NARSTO Canada-East completed their field phases prior to establishment of NARSTO’s Management Coordinator’s office, although the organizations implementing these studies obviously anticipated NARSTO’s formation and conducted their planning accordingly. Some studies (e.g., Southern California Ozone Study , SCOS/NARSTO) did not receive input from a large number of NARSTO organizations, while others (e.g., the Texas studies and the Mexico City studies) deployed diverse arrays of measurement platforms and scientific input from large numbers of NARSTO member organizations. In these cases NARSTO played a key role in encouraging and facilitating this pooling of resources.

6, Final Comments: Suggested Further Criteria for NARSTO Evaluation

In conclusion to this Management Coordinator's overview it is useful to note that although NARSTO research priorities have evolved with time, several premises inherent in the program's design have enduring validity. Notably:

- Multiorganizational pooling of resources and scientific effort, with resulting minimization of wasteful duplication is, and will continue to be, a desirable feature.
- Provision of a communications forum to facilitate discussions between the three NARSTO countries, and between government and industry is a highly desirable function.
- Consolidation of program data in a central, universally accessible database management system is highly desirable, both to NARSTO members and to the external community.

These features should be kept in mind assessing NARSTO's performance and future utility, and in addition to the evaluation of NARSTO's published products I strongly recommend evaluation of the program's past (and potential future) ability to implement these programmatic premises.

Finally, I suggest that perhaps the most critical question for the Review Committee pertains to NARSTO's potential for future performance. Given the fact that organizational demographics and external driving forces have changed, and can be expected to change further, with time (Take-Home message 3), can the program be expected to continue its past performance, and maintain the three ingredients for success itemized in Message 4? If so, what changes to the program and its organizational structure will help facilitate future success and productivity? The Committee's input will be extremely valuable on these points.

Attachment



FINAL REPORT 07/26/01

NARSTO Blue Ribbon Panel – Data Management System Review

Members: Les Hook, Jim Meagher, Peter Mueller, Bill Sukloff, and Jeffrey West

Purpose: In response to a request by members of the NARSTO Executive Steering Committee (ESC), a temporary “Blue Ribbon Panel” was established to review NARSTO data management activities and to report back to the ESC. This panel reviewed the purpose, current status, and future direction of the NARSTO permanent data archive. The key issue questions and answers presented here represent consensus opinion of the panel.

Key Issue Questions, Recommendations, and Conclusions:

1. What is the purpose of the NARSTO data archive?

The NARSTO Charter (Revised 19 January 1999) lists in the overall scope and goals that NARSTO is to provide guidance and assistance on quality assurance/quality control, data management, and data archival. In addition, NARSTO is to establish and maintain a permanent repository for NARSTO data, publications and results utilizing best available storage and distribution technologies. As part of the formal NARSTO structure the Quality Systems Science Center (QSSC) was identified as an independent functional part of the NARSTO organization with its primary purpose being to ensure the credibility, reliability, and accessibility of NARSTO products. Oak Ridge National Laboratory, under sponsorship of DOE, was identified as having the

necessary resources and expertise to carry out this important NARSTO function.

In April 1998 the former NARSTO Committee on Quality Systems and Data Management published the NARSTO Quality Systems Management Plan (QSMP) to be implemented by the QSSC. The QSMP establishes the overarching continental NARSTO quality assurance and data management requirements, standards, specifications, and guidelines. However, it is incumbent on each NARSTO Program/Project manager and principal investigator to establish, within the flexible QSMP framework, the quality and data management requirements and specifications that are commensurate with their specific NARSTO related activity.

2. Is the archive useful?

NARSTO is by definition a “bottom-up” organization in that it does not control funding but rather identifies support needs for NARSTO related activities and coordinates and assists with procuring support from the membership for these activities. As a result most NARSTO activities are performed on a voluntary basis by its membership. However, the most productive NARSTO activities are the result of membership funding of specific NARSTO functions.

With these caveats, the most successful data archiving activities involving the QSSC have been limited to those programs/projects that have planned and funded NARSTO quality and data management functions after 1999. Because many NARSTO sponsoring members had established programs prior to the development of the NARSTO QSMP its implementation was not immediately possible. Currently, there is very limited data in the NARSTO archive in the Data Exchange Standard (DES) format. However, since 1999 several major field programs, sanctioned by NARSTO members, have been funded and are being performed with the intent of utilizing the QSSC/QSMP and the NARSTO permanent data archive (PDA). The Langley DAAC, home of the PDA, has a convenient web data search and order tool for accessing data.

The most significant QSSC activity over the last year has been in supporting the US EPA's Particulate Matter (PM) Supersites (SS) initiative through leading and participating in the data management and quality SS workgroups. Together with the SS site data coordinators, the QSSC has developed a consistent set of metadata for the SS measurements and has performed a major update of the DES (Attachment 1) data file format (and the corresponding Excel input template) to incorporate PM related information. The SS program will be providing data to the QSSC for archiving in the NARSTO DES format.

The QSSC has been doing a good job of leveraging the technical, data management, and system resources that exist across the SS projects, NARSTO, EPA, and Environment Canada to address the issues of managing and archiving the wide array of data types associated with these PM studies. The resulting solutions seem to be fairly robust and should support future projects as well. This coordinated effort is a prime example of why NARSTO was formed and how it can function, and is a good model for future cooperation.

To support the flow of data from projects to the PDA the QSSC has expanded the NARSTO Data and Information Sharing Tool (DIST) to support cataloging and sharing of data sets and documents and to use DIST's output capabilities to facilitate preparing data archive documentation. The QSSC has implemented an FTP Site for staging project data before archiving at the Langley DAAC. The QSSC data processing software has been updated to support reading and verifying the new DES format and generating archive documentation.

3. Who are, or will be the primary users?

The primary purpose of the NARSTO permanent data archive is to aid the future research efforts of the NARSTO community. It is designed so that a user, ten to twenty years in the future, can access and use these stored data on a stand-alone basis. The primary users of the archived data include both data generators and data analysts. The archive is designed to enable analysis of the data generated as a result of the numerous expensive field programs. The archive should provide a repository that is convenient for principal investigators to use as a means of providing future accessibility to their data by air quality analysts. This is especially true of publicly funded research efforts. To satisfy the independent data analysts, both now and in the future, the data must be well documented, and in a known, quality assured, and preferably in a convenient, standardized format. This is the primary focus of the NARSTO QSSC data management activities.

The international air quality research community will benefit from the NARSTO Permanent Data Archive. NARSTO affiliated partners such as EUROTRAC and IGAC could not only contribute to the archive but also be important users. It is also anticipated that Canadian and Mexican researchers will utilize the permanent data archive. The standards and protocols of the NARSTO DES will reduce the effort expended by data users as they integrate multiple data sources into a database. Intercontinental transport of air pollutants has been identified as an international area of concern. NARSTO will make an important contribution by supporting collaboration through improving the compatibility of data sets and meta-data standards, and supporting development of accessible archives and efficient retrieval software.

The Archive is also intended to meet the needs of the public, in particular the informed layperson. To support these users and more technical data analysts, the Archive strives to meet the “20-year test”, namely that someone 20 years from now who is not familiar with the data or how they were obtained should be able to find data of interest, and then fully understand and use the data solely with the aid of the documentation archived with the data.

Once the NARSTO data archive has grown it will become a very valuable tool to encourage, train, and groom young scientists to become future leaders in the atmospheric science and air pollution fields. Through the NARSTO community, a number of graduate fellowships, to be awarded on a competitive basis, for students in chemistry, engineering, physics, and meteorology could be established using NARSTO data as a primary information source. Basically the research opportunities could be advertised, with NARSTO providing access to the data, and the researchers determining what they propose to do. This would foster a lot of creative thinking by an extended community and make significant progress towards NARSTO goals.

Air quality modelers are also primary users of air quality data. To create and maintain air quality models, air quality data are required to develop the various algorithms needed to model the physical and chemical properties of the atmospheric processes leading to human exposure and environmental effects. Such air quality data are also required to evaluate model performance. Both of these activities require that the data be accessible and of known quality and format. Modelers generally agree that having data in a consistent well-documented format and of known quality is essential to their research.

4. How should historical, pre-1999, data be handled?

In April 1998 the former NARSTO Committee on Quality Systems and Data Management published the NARSTO Quality Systems Management Plan. The plan identifies the NARSTO program quality assurance and data management guidelines for ensuring NARSTO product credibility, reliability, accessibility and quality. The NARSTO data management guidelines were not established until 1998 thus most data collected prior to 1999 are not in the NARSTO DES format. There is, however, a desire to make historical data available to the research community. There are several ways NARSTO can make these historical data available.

One option is that these data be archived by NARSTO on a NARSTO FTP site. Data documentation, format documentation, quality assurance, and revision control would remain the responsibility of the data originator unless other arrangements were made. Such a FTP site would not be as permanent as the Permanent Data Archive, and the existence of data in a variety of formats would create some barriers to its use and integration.

Another option, that would require sponsorship, is to establish a temporary (two year) data conversion position through the QSSC. This person could interface with the project data managers and provide much of the effort in reformatting the historical data to match the NARSTO data exchange format.

A third option is for the NARSTO QSSC to accept data in any format and provide any necessary reformatting services as a routine part of the QSSC functions. This option would become very labor intensive and would require longer-term and higher-level sponsorship.

Regardless of which option is implemented the data sets can be made searchable by the NARSTO data information-sharing tool maintained by the QSSC.

5. How should non-NARSTO data be handled?

It is not NARSTO's intent to duplicate established national or international databases that are operated in a controlled manner by other established organizations. NOAA (NWS), NASA (satellite data), EPA (AIRS), USGS (maps), IMPROVE, NatChem, WDCA, and others operate such databases. However, NARSTO could provide links to these databases or store customized versions on a server site in a manner similar to the way historical data might be managed. If NARSTO or non-NARSTO members have well-established databases of known quality and consistent format perhaps an interface, automated or manual, could be developed to convert those data into the NARSTO data exchange format to increase their availability to the international air quality research community.

6. Are NARSTO data management procedures and guidelines too cumbersome?

In response to NARSTO's commitment to PM and oxidant related air quality research the QSSC has been developing a system that follows international units standards for air quality data management including defined conventions for chemical and non-chemical variable naming, site information, data flagging, and key characteristics to capture operational definitions including methods. In collaboration with the data managers from all EPA Supersites and Environment Canada, a revised DES incorporating this nomenclature is currently being tested. The DES follows a tabular format, which is the same structure used by most data originators to work up their data. A template in Excel, with pick lists and extensive comments, has been developed to aid researchers in providing their data and metadata in the DES. Nonetheless, because the DES is new it may be initially cumbersome to some researchers. This emphasizes the importance of early involvement of the NARSTO QSSC in data management planning as is being done with the EPA Supersite program.

QSSC personnel are available to assist data managers and have led weekly data management calls with the Supersite data managers during their research program planning stages. Each research project may develop a unique way to interact with the NARSTO archive. Most projects will maintain their own local database system, which will be able to produce transmittal files in the NARSTO data exchange format once data quality assurance procedures have been completed.

CONCLUSIONS and RECOMMENDATIONS:

The panel members haven't had time to adequately explore and understand the implications of many of the possible solutions to issues surrounding data formats and the multiplicity of extant data management practices and this is reflected in some of the recommendations. The following six conclusions and associated recommendations do reflect the consensus opinions of the panel.

1. The QSSC now has well documented data management guidelines and archiving procedures. It would be beneficial to aid researchers with their initial data archiving activities relative to historic, present, and future air quality data.

◆ Recommendation: NARSTO should seek support for a temporary (two year) full time data coordination position to assist the various field program data managers with their data archiving.

2. For the most successful permanent archiving of air quality data, several principles hold. Metadata (documentation of the what, where, when, how, who, and why) is vital. The number of data formats should be kept as few as possible, stressing user-friendliness and good documentation and explanation. Standardized nomenclature for parameter names, units, flags, sampling sites, methods, dates and times is essential. Quality assurance of archived data sets is important. The DES has been designed to meet these principles. These principles should also be considered in connection with deciding which additional formats if any, besides the DES, may be used for archiving data in the PDA.

Recommendation: The QSSC should establish relationships with experts regarding other data formats (e.g., NASA/Ames and NetCDF) and devise practical solutions for permanent data archiving.

Recommendation: NARSTO should continue to develop and implement the Data Exchange Standard (DES) data and metadata archive format

Recommendation: The archive data format must be as easy as possible to use, but also be flexible to handle the diverse requirements of the NARSTO community.

Recommendation: Standardized nomenclature must be adopted wherever possible.

Recommendation: The data files must be quality assured by a quality assurance center before archiving.

3. The QSSC should increase communication within the NARSTO member community and enhance communication with the international air quality research community.

- Recommendation: The QSSC should be a regular contributor to the NARSTO newsletter as a means of informing the NARSTO members of its activities and services being provided. An annual update to the ESC would also be beneficial.

- Recommendation: The QSSC should enhance communications with the international air quality research community to coordinate greater harmonization of air quality data archiving techniques and procedures. The use of international standards and consistent nomenclature by NARSTO participants should be investigated and NARSTO should continue to expand its guidance and collaboration in this area.

4. Historical NARSTO member data sets data should be made available to the air quality research community at least for the next few years.

- ◆ Recommendation: Although there are many different solutions to the issue of storing historical data we recommend that NARSTO provide an Internet based (FTP) site where field program data can be staged prior to archiving and where historical and non-NARSTO data could be made available to the international air quality research community at least for the next few years. Data residing on this site would remain the responsibility of the data generator including quality documentation and revision control.

5. NARSTO should continue to encourage/require the use of the QSSC and PDA by all NARSTO members at the earliest planning stage of any data-gathering program. NARSTO realizes that there are some existing programs with well-established data management procedures. These programs should be viewed as symbiotic and complimentary to NARSTO.

- ◆ Recommendation: It is recommended that all NARSTO projects designate a data coordinator during the project-planning phase to

interact with the QSSC. The data coordinator should ensure that adequate project resources are appropriated for data processing and archiving activities.

6. There is an opportunity for the development of data management techniques and web tools that can interface among data storage and documentation formats currently in use (e.g. DES, AIRS, IMPROVE, NetCDF, NASA/Ames).

- Recommendation: The QSSC and other data centers should consider the feasibility of developing data management tools that can interface with other archive formats currently in use.
- Recommendation: Consider developing special interfaces, i.e. web based tools, to coordinate the data management functions of different well established programs. We should identify and involve a broad cross-section of funding organizations, data providers, and users in the process.