

## Panel Discussion at Symposium

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### STATEMENT

*Ivan Johnson*

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This panel discussion will be devoted to statements and questions related to ongoing standards development activities and future standards needs for mapping, remote sensing, and geographic information systems (GIS). Authors earlier presented an interesting and illuminating interdisciplinary group of papers describing some present standardization activities and various techniques and applications of mapping, remote sensing, and GIS as related to the study of soil science, geologic engineering, ground water, and environmental problems. Those presentations show that we have come a long way in some of these techniques from my early days in field work with the U S Geological Survey. In those days we used an early version of GIS where we took a base cultural map and developed a series of transparent overlays containing information such as geology, soil types, ground water, topographic contours, and other such information. These then could be overlain on the base map in various combinations to see the interrelationship of such information. We have been able to advance a long ways from those early days in the use of mapping, remote sensing, and GIS techniques primarily because of the development and subsequent sophistication of the computer.

Our earlier papers started out by talking first of all about "What is GIS?" and then into describing the needs for standards and some activities that are developing standards. From that the papers went into presenting various technologies and into a variety of case histories of applications to different problems. So now this panel is ready to do some discussion about types of standards that are needed and those standards that ASTM standards groups should give priority for development.

First, to acquaint the many people who are not familiar with ASTM, a discussion of this standards organization and its standards development process seems to be in order as a lead in to the following panel discussions.

ASTM is one of the largest voluntary consensus standards development system in the World. Organized in 1898, the organization is known simply as ASTM because it has outgrown its earlier name of "American Society for Testing and Materials" due to its extremely wide variety of standards being developed at present. ASTM is a not-for-profit organization that provides a forum for producers, users, consumers, and those having a general interest to meet on common ground and to discuss and write standards for materials, products, systems, and services. ASTM has a staff of over 200. ASTM has no research or testing facilities, and the staff is for support of the volunteer standards development membership. However, a subsidiary, the Institute for Standards Research, will assist in fund raising and project management for research projects related to the needs of standards development committees.

ASTM annually publishes standard guides, practices, test methods, classifications, specifications, and terminology. The 68 volumes of the "Annual Book of ASTM Standards" contain 8500 ASTM standards. There are over 33 000 volunteer members at present, who are working on 134 committees to develop those standards. Approximately 5000 are international members from 100 countries, and a high percentage of sales of the standards is to foreign countries. The volunteers in an ASTM standards committee meeting are from private companies, academia, consulting firms, manufacturers, and federal, state, and local governments. So ASTM provides the community where all these different interests can get together and develop a consensus standard that is reasonable and that can be used voluntarily by anyone. ASTM itself does not impose standards, they only make them available to individuals, companies, and agencies. Purchasers and sellers incorporate standards into contracts, scientists and engineers use them in their laboratories, architects and designers use them in their plans, government agencies reference them in codes, regulations, and laws, and many others refer to them for guidance.

Standards in ASTM normally are developed by a small Task Group of a half dozen or less members or perhaps by a specialized section, which is a subdivision of a subcommittee—in our case Subcommittee D18.01 on Surface and Subsurface Characterization. Section D18.03 on Remote Sensing and Section D18.05 on Mapping and GIS are the subdivisions involved in development of standards related to topics of this symposium. Once a draft standard has been developed it is submitted to a subcommittee letter ballot, which usually means over one hundred subcommittee members have an opportunity to review and vote on the document. Once the subcommittee approves the document, it is submitted to main committee letter ballot, which in the case of our Committee D18 means over 800 members. Committee D18 on Soil and Rock is the parent committee for the subcommittee in which the remote sensing and mapping and GIS sections are located. Committee D18's scope covers all standards activities that are important to investigation of the soil, rock, and contained fluids that make up the surface and subsurface of the solid earth. Once a draft standard is approved at this main committee level, the document is submitted for balloting by the society membership. During the balloting process, all negative votes, which must include a written explanation of the voter's objections, must be considered fully before the document can be submitted to the next level in the process. Once through the whole process, the document is published as a standard.

So basically then, what are these "standards" that appear to be seriously needed in relation to remote sensing, mapping, and GIS activities? If one uses the basic definition used by ASTM, a "*standard is a rule for an orderly approach to a specific activity, formulated and applied for the benefit, and with the cooperation of, all concerned*." This is what the appropriate sections of ASTM D18.01 are trying to develop as speedily as possible for those operations most important to remote sensing, mapping, and GIS activities. Hopefully, some of the papers presented at this symposium will provide resources for future development of standards. However, in order to make the standards development process work, the community of professionals in remote sensing, mapping, and GIS disciplines must be involved. Presently there are a number of hard-working volunteers working many hours or even days to develop those standards needed for these particular subjects, but additional expert assistance is needed. It is hoped that this symposium will result in interesting a lot of attendees in offering their expertise to our sections and thus help them develop the needed remote sensing, mapping, and GIS volunteer consensus standards.

## STATEMENT

*James Fulton*

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Before discussing the ASTM Section on Mapping and GIS, I would like to emphasize a couple of points that Ivan made. First, he mentioned that standards are written by volunteers and that ASTM staff *per se* do not write standards. You, the people interested and talented in a particular specialty, are the ones who develop standards. ASTM provides the mechanism and the institutional support needed to create a standard from what you put together. Further, ASTM is there to provide support for any group of individuals or organizations that need standards, is willing to put in the time to develop the standards, and that provides a broad balance of user, producer, and general interest representatives for the standards group.

The second point I want to emphasize is that you do not have to be a member to participate in ASTM committee activities. If you would like to participate in this process, do so whether you are a member or not.

It is worth taking a moment to discuss the scope of the ASTM Section on Mapping and GIS. The section is relatively new so this symposium is really being used to give the section directions and priorities for their future standards development. The section (D18.01.05) is in the Subcommittee on Surface and Subsurface Characterization (D18.01) of the Committee on Soil and Rock (D18). This organization could lead one to assume that the section on mapping and GIS is interested only in applications to soil and rock. This is not true—the scope of the section includes all applications of GIS to planet earth.

The section on mapping and GIS meets at least twice each year during the semiannual ASTM Committee Weeks, usually the last week of January and last week of June. The initial meetings of the section have been largely organizational. The first working meeting of the section occurred earlier this week. That meeting focused on identifying the following initial areas of standards development:

1. terminology,
2. locational data representation and accuracy,
3. spatial data documentation,
4. recommended training for GIS,
5. guidelines for estimating costs of GIS projects,
6. large-scale geologic maps, and
7. guidelines for use of elevation data.

During this symposium, we heard many interesting papers where the authors were discussing the application of GIS and spatial data analysis. One of the problems encountered with a new technology such as GIS is that terminology is new and common terms are often used to represent very different concepts. This can be seen in the number of very different kinds of systems that are called GIS. Clearly publishing standard definitions of terms will aid communication in this field.

EPA is working on defining standards for representing locational data for use within EPA. Mason Hewitt will discuss this issue in more detail.

Efforts at USGS and EPA have led to development of standards and tools for documenting spatial data and for managing this documentation with the spatial data. The Spatial Data Transfer Specification requires that data documentation be included when data are transferred, yet GIS does not manage the data documentation. Development of full consensus stan-

dards for spatial data documentation will lead to greater vendor support for the management of spatial data documentation, and will facilitate the sharing and appropriate use of spatial data

GIS is a new and evolving technology. As an increasing number of organizations make use of GIS, the needs for training have become more pronounced, and guidance is needed for the types of training required.

A common problem encountered in GIS projects is that the cost of GIS projects is underestimated. Guidelines are needed to help in evaluating the costs of GIS installations and projects.

The initial purpose for forming the section on mapping and GIS was to develop standards for large-scale geologic maps. While this remains a goal of the section, most of the initial emphasis has been on standards for GIS.

Elevation data have the potential to provide many new applications of GIS. Up to this time, a lack of availability of elevation data, and of software and hardware necessary to support the analysis of elevation data, has limited applications. As elevation data and advanced software and hardware are becoming more widely available, however, the applications of elevation data have increased rapidly. Because of dependencies of analyses on scale and method of development of elevation data, great care is needed in the interpretation of data analyses. Guidelines are needed on the proper uses of elevation data and on the evaluation of errors and scale dependencies.

If you are interested in working on any of the areas listed previously, indicate your interest by sending your name, address, and areas of interest to Bob Morgan at ASTM headquarters.

## STATEMENT

*Richard J Pike*

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I want to make some suggestions regarding the development of Standards for Digital Topographic Data. Mass-produced topographic elevations are among the most important ingredients of hydrologic models and geographic information systems (GIS). The uneven and unpredictable quality of much digital topographic data (DTD), whether created as digital line graphs (DLGs) of scanned contours or as digital elevation models (DEMs) of gridded heights, suggests the need for some DTD standards.

Much of the user community accepts off-the-shelf DTD at face value, with little concern as to their accuracy or precision. Despite the best intentions of DTD providers, however, this information never is error-free. Mistakes are both systematic and random, and individual elevations can be grossly incorrect. Errors arise from sloppy digitizing of contours, suboptimal interpolation (gridding) between digitized contours, intrinsically flawed techniques of compilation, inaccuracies in the source contour maps, and unknown causes. The 1:250 000 scale DMATC-derived DEMs of the United States contain many such errors. Combining even a few truly bad elevations with other types of GIS information can lead to spurious statistical associations that ruin an otherwise good spatial model and yield misleading conclusions.

This situation could deteriorate further. The proliferation of commercial satellites having photogrammetric capability (for example, SPOT) is leading to production of DTD-to-order on a case-by-case basis. In a competitive environment, it is conceivable that even the loose and diverse DTD standards currently imposed by government agencies will be further degraded or ignored. Error-free DTD will never exist, but agreeing upon some reasonable standards will raise the current, unsatisfactory level of DTD quality. Standards for DTD probably should be international and include both government and private corporate entities. DTD standards might address the following points

- 1 Discourage release of DTD failing some minimum, threshold, standard
- 2 Supply technical details on all DTD gathering, compilation, and checking and verification procedures and the relevant hardware/software systems
- 3 Devise tolerance limits for both precision and accuracy of DTD.
- 4 Tie DTD tolerance limits to criteria that vary with topographic character, particularly relief, so that both contour lines and digital heights in flat terrain are more tightly constrained than those in rough terrain. Terrain-inspecific tolerances, such as those of the current U.S. National Map Accuracy Standards, are unsuitable.
5. Apply software tools, such as automated delimitation of watersheds, to the recognition and correction of DTD errors by machine. Tools for detecting and editing DTD visually are available now. Among the most effective are digital images of shaded-relief, slope angle, and slope reversal.
- 6 Pay special attention to DTD in (a) very low-relief terrain (for example, flood plains) where contours usually are too sparse to portray the topography, and (b) heavily timbered areas, where available contour maps commonly represent the top of the forest canopy, not the ground surface

## STATEMENT

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What I want to do is tell about these new ASTM task groups, especially the new ASTM task groups for which I volunteered to take an active part, and what I think we will be doing. I have agreed to chair Task Group Number Two on Locational Data. The EPA has proposed a locational data policy and I went into a little bit of detail on that during my talk yesterday. One of the big debates in that locational policy is the statement of accuracy. At this time the EPA is not specifying any accuracy level at all but rather asking the person entering the data to give a subjective estimate of accuracy without any specified guidance on how to do that. That is creating some controversy in our own agency. EPA has formed a locational task force of which I am a member. We will be having intense debate in the near future about this, with a couple of different groups, one of which is saying "We need accuracy down to a gnat's whisker on everything" because we are a regulatory agency. Another group is saying "No you don't, it doesn't really matter, it costs too much." And then there is the group sort of in between, like myself, who is saying "The program offices need to define what their accuracy requirements are." In any case, this is a required debate that we go through because the locational data accuracy policy has been protested by several of our regions and program offices, so we have to go

through this debate and then come up with recommendations to the agencies. So it seemed logical to me that I also participate in ASTM to recommend an ASTM standard to encompass locational data policy and bring in this debate about accuracy from EPA into ASTM perhaps for debate among a larger audience. So that is why I volunteered to lead this particular task group. I would like to have some additional people to participate in this activity in order to obtain a consensus at all levels, and perhaps even some representation by Canadians, so that we can start a dialogue with Canada.

Another activity that I would like to describe is the cost tracking element of Task Group 5. It is important in my agency and many other organizations to get an idea of costs. Jim Fulton characterized it perfectly—this task group deals with the estimation of costs involving the use of this technology. This is not a cost/benefit analysis, rather Task Group 5 hopes to develop a standard for cost tracking. How would you cost out the benefits or how would you factor the benefits and the costs in a standard? This cost tracking standard might be something that might eventually be added to a project documentation standard so this dialogue about the cost of the technology could be available.

The other activity that I will describe is Task Group 3 on Data Documentation. I think we expanded that task group to the new title of Data Documentation and Sharing so we also could discuss the Spatial Transfer Standard in that task group. Again, in using the EPA perspective, we are in need of a documentation standard because we are looking at some very big programs involving many different federal, as well as state, agencies to which we will be passing around geographic information. There is a need for a common statement for description of those data sets. There are a number of elements that need to go into that standard and that is what I have volunteered to do.

## STATEMENT

*George E. Ulrich*  
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I would like to leave the participants of this symposium with three general statements concerning the application of standards to large-scale mapping, from the geologist's point of view. Many points could be reiterated from the two days of discussion, but there are three that I feel should be emphasized.

The first point concerns the requirement for accuracy and precision of digital maps and geologic maps in particular. While precision refers to the capability of the cartographic system to reproduce spatial data that are geometrically correct, accuracy of geologic information is relative to the physiographic and cultural features of the primary base map to which it is registered. Thus the need for a high quality topographic base map in large-scale mapping, which normally means the 1:24 000 quadrangle series, the largest scale of systematic base map coverage for the nation. For larger scales, at which engineers and geologic specialists may have to work, the lack of a systematic base-map series changes the ball game. Precision becomes of primary concern, and registration to a published base map generally is not required. Thus geologic accuracy is scale dependent, and, except for custom applications such as mine and dam-site maps, geologic mapping attains its highest level of quality for national coverage at the 1:24 000 scale.

The second point I want to emphasize is the preference for latitude and longitude as a standard coordinate system for scales of 1:24 000 and smaller. Although many map makers are using currently other coordinate systems (even the digital line graphs of the USGS are in Universal Transverse Mercator metric units), only latitude and longitude provide totally unique coordinates for every point on the globe, and only latitude and longitude are convertible directly into any desired projection. In addition, the expression of latitude-longitude coordinates as decimal degrees is preferred strongly for standard usage.

Thirdly, I propose that units of measurement, other than geographic coordinates, be standardized in the international or metric system. The continued use of English units is not only cumbersome, it is contrary to the preferred usage of most other countries including the country where it originated.

## QUESTION

*Cornelia Cameron*  
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Would you recommend use of hectares for area?

## RESPONSE

*George E. Ulrich*  
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No, I would recommend square meters and square kilometers

## STATEMENT

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I noted Mr. Ulrich's mention of accuracy in his presentation. Quality assurance (QA) and quality control (QC) have been mentioned frequently in a number of the GIS presentations during the symposium. The terms QA and QC have specific meaning within different industries so it seems the ASTM Section on Mapping and GIS should develop specific definitions in regard to GIS. They also should provide information on how the QA and QC efforts typically are organized on a GIS project.

**STATEMENT**

*Vernon Singhroy*  
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The remote sensing community has done well in providing and documenting interpretations from aerial photographs, satellite imagery, thermal imagery, radar imagery, and information from radiometers. GIS provided the remote sensing community with the opportunity to integrate remote sensing with other data sets and therefore expand the user base. The relationship between GIS and remote sensing is still evolving. One of the purposes of this symposium was to address those issues. The first speaker, Dr. Dangermond, defined GIS and made the point that it's technology driven, it's procedures driven, it's methodology driven, and it's data driven. Remote sensing satisfies all four of these categories. Therefore, remote sensing has a close relationship with GIS technology. In developing remote sensing guidelines at ASTM we are working on application of remote sensing methods to identification of environmental problems, mapping, and site investigations. As was mentioned earlier, we are only as strong as the volunteers on our committee. Mr. Christopher Stohr, Illinois Geological Survey, is working on a draft standard guide on Remote Sensing Methods for Hazardous Waste Landfills. The draft is in peer review. Dr. Dale Elifrits, Professor in Geologic Engineering, University of Missouri at Rolla, has written a new standard guide for acquisition of file aerial photography and imagery for establishing historic site use and surficial conditions. This guide is in the final approval stages. In addition, we believe that there is a need for training in remote sensing procedures and technology, and image analysis in engineering and geological practice. Therefore, we are proposing to develop a training manual, which also would include introduction to ASTM standards developed by our remote sensing section. All of these remote sensing activities dovetail into a variety of GIS techniques.

**STATEMENT**

*Manfred Ehlers*  
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I am quite honored to be the only non-ASTM member on the panel here. First I will inform you a little bit about the National Center for Geographic Information Analysis. Then I will concentrate on the specific initiative that relates to remote sensing and GIS.

The National Center for Geographic Information and Analysis, NCGIA for short, has been funded since early 1989 by a grant from the National Science Foundation. It is a three-school consortium with the University of California at Santa Barbara as the lead school, the State University of New York at Buffalo, and the University of Maine, which I represent here. It is a 5 million dollar project by NSF, enhanced by various donations by vendors and matching funds by the respective universities. At Santa Barbara and Buffalo the National Center is led



by the Geography Departments. At Maine, we have a multidisciplinary effort headed by the Department of Surveying Engineering, but also including Forestry, Economics, Mathematics, and Computer Science. The mission of the NCGIA is basic research on geographic information analysis and GIS. A second goal is the development of education programs in the area of geographic information and GIS. A third part is the transfer of GIS technology to users in the public and the private sectors (outreach program).

Our initial research plan identified twelve initiatives designed to meet the needs of NSF. Each initiative usually starts with a meeting of invited specialists from the outside plus key researchers from the three NCGIA centers. That group then is challenged to put forward a research plan for the specific initiative topics. Consequently, these specialist meetings must invite a critical mass of participants with diverse scientific backgrounds from public and private sectors as well as from the academic community. Potential research projects have to be grouped into basic research and applied research and then prioritized. These projects are not limited to NCGIA personnel but also include participants from the outside. The first initiative (I-1) was on the "Accuracy of Spatial Databases." A book that is one result of this initiative is a compendium of research papers on the "accuracy of spatial databases" and is edited by Mike Goodchild who is initiative leader and co-director of the whole NCGIA. This initiative is now coming to an end. This does not mean that the research stops, but it will be addressed outside the framework of an NCGIA initiative.

The second initiative (I-2) on the "Languages of Spatial Relations," will be also brought to a close this year. This initiative addressed the cognitive-psychological aspects of GIS, especially how humans reason about space—what is close, what is far away, what is north, south, etc., and put that into a GIS perspective. NCGIA will have a NATO Advanced Research Workshop in Spain during 1990. The results will be published by the Springer-Verlag Publishers and will represent the formal end of the second initiative.

Initiative three (I-3) deals with "Multiple Representations." Can one GIS database, the so called OBI (one big one) be used and all levels of resolution and scales be created as "views?" Or does one have to have multiple representations in the database for various applications and various scales, which gives us the headache of maintaining currency and validity of multiple representations in our GIS databases?

Initiative four (I-4) is on the "Use and Value of Geographic Information in Decision Making." That is the most diverse and controversial initiative so far. It involves many people outside geography and GIS and everybody has a different opinion on this matter. In addition, many participants from the outside were just too eager to tell us what we have to do on this initiative. So we are getting some heat on I-4. But it is a tough issue dealing with a dollar value for geographic information. How can we weigh advantages that we cannot measure in dollars against something that economists look at as nickel and dime value? There were controversial but very interesting discussions.

The fifth initiative (I-5) is on the "Architecture of Very Large Spatial Databases," and there was one specialist meeting in Santa Barbara in July 1989. Again, a book with papers from a symposium on this subject has been published by Springer-Verlag. We had many computer scientists in attendance and they had a completely different view of what constitutes a large spatial database in comparison to people who were from government agencies or who are geographers. Actually, in the symposium the word large was mentioned just once in one title. To the computer scientists every database was considered large if it exceeded one page in memory. Especially interested in that topic are government agencies, such as USGS and NASA, who work with large spatial databases. NASA's Earth Observing System (EOS) for example will produce terabytes of remote sensing data which have to be archived, managed, and integrated with GIS.

Initiative six (I-6) on "Spatial Decision Support Systems" has just started. Initiatives are "Visualization of the Quality of Spatial Information" (I-7), "Expert Systems for Cartographic Design" (I-8), "Institutions Sharing Spatial Information" (I-9), "Temporal Relations in GIS" (I-10), "Space-Time Statistical Models in GIS" (I-11), and "Integration of Remote Sensing and GIS Technologies" (I-12). I-12 is a proof that our schedule of research initiatives is not cast in stone. This one has started already, and a report on its status and activities will be presented soon. Also, initiative I-13 on "GIS Interfaces" and I-14 on "Geographical Analysis" were just activated. Before I come back to I-12 I would like to mention our activities in education and outreach, the other two missions of the National Center.

The education outreach goal is to help alleviate the shortage of individuals trained in geographic data management and analysis. There are not enough people trained in GIS so what can we do to overcome that? Our first effort was to design a model curriculum for a one-year course in GIS covering concepts, techniques, and applications. These efforts were headed by Mike Goodchild and Mervin Kemp from the Santa Barbara NCGIA. They produced a model curriculum that is being currently field tested by 75 institutions all over the world. Once we get the feedback from these institutions, we will publish a book which will include, for example, disks for case studies and slide sets.

Within our initiatives we address, of course, the education of undergraduate, graduate students, and post doctoral fellows at the three NCGIA sites. We also have visiting professors and research scientists included in our ongoing activities. The next step will be the development of workshops and summer seminars for users and potential users of GIS. Within the three centers, we can address different geographical regions where we can field test our outreach programs.

The last part of my presentation deals with initiative I-12 on "Integration of Remote Sensing and GIS Technologies." It was targeted for improving methods for data acquisition and processing, developing principles for unifying appropriate data structures for remotely sensed data archives, GIS aid for classifications, and integration of expert systems. Those were the plans when we wrote the proposal but that has changed quite a bit during later discussions.

The initiative officially started in May 1990 with a premeeting in Denver, Colorado, with selected members from academia and government agencies. We did not want to involve vendors at this particular point of time. We had discussions on topics and schedule of I-12. In August 1990, we will have a second premeeting at NASA Stennis Space Center in Mississippi, and we plan a specialist meeting for November 1990 at the USGS EROS Data Center.

For mid-1991 we plan to have a special issue of the *Journal on Photogrammetric Engineering and Remote Sensing* with position papers on the research agenda that we will identify at the next meetings. We also are planning an additional symposium with outside experts, probably in conjunction with the American Society of Photogrammetry and Remote Sensing convention in Baltimore, Maryland, during 1991. In January 1992 we plan a second specialist meeting, and in January 1993 we hope that we have finished a monograph on the integration of remote sensing and GIS, which should be published by a major publisher. Several publishers are very interested. The topics that have been suggested for the specialist meeting include error analysis, data structures and data access, data processing flow, the future computing environment, and institutional issues.

Persons who are interested in getting information or having their name put on the NCGIA mailing list for NCGIA information on the remote sensing and GIS initiative should contact the Associate Director, NCGIA, University of Maine, 107 Boardman Hall, Orono, Maine 04469 (phone 207/581-2207). That will also give you a list of reports and books that have been published by NCGIA.

**STATEMENT**

*Ivan Johnson*  
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I thank all panel members for their statements and now the session is open for comments or questions of the audience.

**QUESTION**

*Connie Blackmon*  
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I am employed by the Atlanta Regional Commission as their Director of Data Services. In addition, I am here today representing the Urban and Regional Information Systems Association. This NCGIA project is indeed a big production. I may have additional comments later, but right now I have a very basic question. "Who is heading up the research initiative on space, time, and statistic models?"

**STATEMENT**

*Manfred Ehlers*  
University of Maine (NCGIA)  
Dept. of Surveying Engineering  
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It was supposed to be Dave Simmonett from the University of California at Santa Barbara. However, Dave Simmonett is ill, and he will probably have to withdraw from future work within the NCGIA. I do not know at this point of time who is going to replace him. It will probably be somebody from Santa Barbara. If you are on the NCGIA mailing list you can get that information through their Newsletter.

**STATEMENT**

*John Clarke*  
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I want to make a comment and see if anybody has any comments about it. I believe we all recognize the danger of misuse of what we are doing here. GIS gives us some beautiful picture output on computer terminals, and quite often you can see how the eyes of people who are making decisions light up when they see these pretty pictures, and they take those pictures as statements of fact. Quite frankly, that scares me. I think that the development of the standards in ASTM will be very helpful to avoid the misuse of these products. One thing I have not heard mentioned during this symposium is the cumulative effect of errors for composite coverages. If you take each layer of a coverage and acknowledge that it has a certain percentage of error, you are adding an accumulative effect on the error. Perhaps this effect should be looked at by the standards committee to see what should be the acceptable limits on cumulative errors.

## RESPONSE

*Mason Hewitt, III*  
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We had a debate in the most recent meeting of my mapping and GIS task group about accuracy. In fact, let me point up that in my research and development agenda at the Las Vegas EPA Laboratory, my number one research item is understanding error propagation, controlling error, and then being able to provide to the consumer of the map products some label on the map that indicates its quality. Those of us who have been involved in this field know that there is a lack of ability to do that right now. Therefore, we are going to have to invent a lot of things, and that is why Las Vegas is participating in the NCGIA (National Center for Geographic Information and Analysis) research initiative, number one of which is spatial accuracy. So we hope to get the theory out of the NCGIA researchers and then translate it into something practical and be able to provide our agency with some guidance about quality assurance and quality control. This ASTM task group decided to defer QA/QC standards in favor of some standards that we could successfully debate and implement in a short time frame. I think we decided that there was enough going on at NCGIA and within the EPA that maybe the task group would wait for the research results before developing it as a standard.

## STATEMENT

*Brian Matuschak*  
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In terms of an ASTM Section activity, it seems that ASTM would be the natural organization to have a committee dedicated to standards for GIS applications in large scale civil engineering type applications and cadastral applications. There is already a task group for geological map standards, but it would seem to be natural to have one for even larger scale type GIS applications.

**STATEMENT**

*James Fulton*  
Applications Assistance Unit  
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Brian Matuschak's statement suggested that he envisions involvement of a lot more local government, which is a type of large scale involvement. I think that makes a lot of sense. There is a lot of activity at the federal sector, but not with all of the same kind of skills in which the local governments are interested. There are a lot of issues that we have identified that transcend skills. There is a real opportunity for some activities in ASTM that compliment what is going on in some of the federal activities. I point up that ASTM is in no way limited in the disciplines of its members, and people who feel they should be involved in this ASTM section on mapping and GIS should in no way be inhibited from volunteering to take an active part in our section's standards development activities.

**STATEMENT**

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With regards to remote sensing, which is part of the GIS issue, we tackled large scale mapping of land fills, dam sites, and others of this type, using fairly simple procedures. There is no task group to answer your question *per se*. However, our ASTM Section on Remote Sensing is looking at those large scale issues dealing with civil engineering/geotechnical investigations.

**STATEMENT**

*C. Berndt Pettersson*  
Brown and Root USA, Inc  
P.O. Box 3  
Houston, TX 77001

The many presentations in this symposium has demonstrated the extremely wide range of topics that can be handled effectively by GIS. The disciplines working with GIS include, for example, cartographers, remote sensing specialists, surveyors, geologists, geohydrologists, geotechnical engineers, civil engineers, and computer specialists. Thus, it will be difficult to define GIS operationally (other than that it deals with obtaining, storing, manipulating, and retrieving of spatial data) so that criteria (or standard guides in ASTM terms) for identifying and training GIS personnel can be established. First, common factors that are mandatory for persons involved in GIS to be knowledgeable will have to be established. Second, with the wide range of topics and disciplines, the ASTM section probably will need to set limits for the planned standardization work.

**STATEMENT***Jay Lund*

University of California  
 Dept. of Civil Engineering  
 Davis, CA 95616

In the area of GIS applications in civil engineering, I am aware of at least two American Society for Civil Engineers (ASCE) task committees, one in the Hydraulics Division and the other in the Water Resources Planning and Management Division, that are looking at applications of GIS in these areas. I do not know about the Hydraulics Division task group, but on the Water Resources Planning and Management Division task group, they have tried to stay away from the area of creating standards as yet because the members of this task group seem to feel that they were just getting a feel for the applications and so would be premature to develop standards for others to adopt.

**STATEMENT***Ivan Johnson*

A. Ivan Johnson, Inc.  
 7474 Upham Court  
 Arvada, CO 80003

There is at least one other ASCE group that has a subcommittee investigating applications of GIS to civil engineering problems. That is the Irrigation and Drainage. However, the feeling in that group was that there was a need for at least some standards and that they should work with existing GIS standards developing groups to see that standards are developed to meet the needs of civil engineering in addition to the needs of other disciplines. They see advantages to working with experienced consensus standards development organizations rather than trying to develop committee handbooks of recommended methods.

**QUESTION***Bruce McDonald*

Canada Soil Information System  
 Land Resource Research Center  
 Research Branch, Agriculture Canada  
 Central Experimental Farm  
 Ottawa, Ontario, Canada K1A 0C6

The previous statements really touch on an issue that occurred to me during the panel discussion. That is the question of liaison. But the question becomes tougher when we begin to talk about liaison between various task groups, liaison with other agencies, liaison with federal and national standards bureaus, and also with other disciplines such as civil engineering and GIS. How will ASTM handle this question of liaison as their section and its task groups start to develop standards in the various selected areas?

**STATEMENT**

*James Fulton*

Applications Assistance Unit  
Water Resources Division  
U S. Geological Survey  
MS 445 National Center  
Reston, VA 22092

That is a really good question. Developing interested section members and liaison with specialty societies is one of the purposes for this symposium. We established liaison with a number of those specialized societies when we invited them to cooperate in this symposium. It will take a lot of communication to keep those contacts continuing and to interest people in those organizations to get involved in this consensus standard process as well. As I said before, there is a lot of infrastructure needed to develop standards. ASTM could provide that assistance by developing standards in cooperation with other organizations. So in many ways this activity is ASTM outreach and assistance in developing standards with the real technical work being done by members of these other organizations. For example, within this ASTM section a lot of work is being done in EPA and then we will introduce the results into the consensus process. Then we need to bring members from those other organizations into that process at an early stage.

**STATEMENT**

*Vernon Singhroy*

Canada Center for Remote Sensing  
1547 Mervale Road  
Ottawa, Ontario, Canada K1A 0Y7

One of our main tasks for the remote sensing section, apart from developing some standards in the geotechnical/civil engineering areas, is to collaborate very closely in all the annual meetings of the Association for Engineering Geology (AEG). This is a two-way street if you like. The AEG infrastructure provided us with a good forum for the review of our standards. We hope our remote sensing cooperative program will have a snowball effect on getting knowledgeable participants in our particular standards development activities.

**STATEMENT**

*Ivan Johnson*

A Ivan Johnson Inc  
7474 Upham Court  
Arvada, CO 80003

As I intimated in my beginning remarks, the whole ASTM consensus process really is a liaison medium. We get a group of knowledgeable people together to discuss a particular problem needing a standard. That is the thing I love about ASTM meetings, a person gets this interplay of different disciplines and experiences, there is debate pro and con, discussions of various

problems from different viewpoints, and then we try to come out with a standard that is useable by them all.

## STATEMENT

*James Fulton*  
Applications Assistance Unit  
Water Resources Division  
U.S. Geological Survey  
MS 445 National Center  
Reston, VA 22092

What Ivan said is true. This meeting really had two purposes. One was to introduce ASTM to those attendees who were not already participants in ASTM. The other purpose was to introduce GIS to present ASTM members and other attendees who were not familiar with this new technique. It is reasonable to assume that the existing ASTM membership may serve only as the user voter and will not provide the technical membership needed for developing the standard or for developing a meaningful consensus. If ASTM is to provide the assistance needed by the GIS community in developing standards, then the GIS community needs to get involved and needs to provide that consensus. What is needed is consensus within the GIS community. This symposium provides an outreach to GIS specialists, and we recognize that we need to continue that outreach in order to get people involved. Without the knowledge of the GIS/mapping specialists it will be very difficult for ASTM to develop standards in this area.

## STATEMENT

*Connie Blackmon*  
President, URISA  
900 2nd Street, NE., Ste 304  
Washington, DC 20002

As I mentioned earlier during this discussion period, I am here as representative of the Urban and Regional Information Systems Association (URISA), and I wish to say a few words about the organization and its interest in standards. URISA is a nonprofit organization whose charter is to provide ongoing education about the effective use of automated information systems at all levels of government. Founded in 1963, URISA now has more than 2900 members representing a wide variety of government agencies, disciplines, and functional areas. URISA members come primarily from the United States and Canada. This membership includes local government professionals, information system developers and manufacturers, consultants, and academicians. For 27 years, the annual URISA conference has provided a forum to explore information system use by federal, state/provincial, and local governments, as well as by the private sector.

URISA is interested keenly in the development of guidelines and standards for GIS. As URISA has evolved in recent years, we have found that our members are maturing as rapidly as the organization. Their interest in standards and information exchange is expanding. Accordingly, URISA would like to be an active partner in ASTM's work on standards for GIS and mapping. In recent years URISA's growth and programs have focused on GIS, both the applications of GIS and education of GIS professionals. We are particularly concerned with



the implementation and application of GIS at the state level and in local governments, which claim most of our members

URISA can bring to ASTM our experience in GIS applications and our membership base in state and local governments. GIS application areas of special interest to URISA members include urban development, growth management, infrastructure management, land records modernization, and natural resource assessment. Many of us are involved in the development of GIS guidelines or information exchange standards at the state level. We recommend that ASTM consider ways to take advantage of the resources offered by the growing numbers of state mapping boards and GIS coordination programs.

The URISA Board of Directors is most interested in working in the areas of data documentation and GIS training. We are concerned also about exploring the role of state and local governments and in issues related to the application of GIS in urban areas.

ASTM offers an excellent forum for URISA and for our individual members. In addition to URISA's experience as an educational association, we offer ASTM a communications channel to our members representing cities, counties, states, and the private sector including GIS vendors and related service firms.

## STATEMENT

*Ivan Johnson*

A Ivan Johnson, Inc  
7474 Upham Court  
Arvada, CO 80003

In organizing this symposium I first invited organizations heavily involved in mapping, remote sensing, and GIS to be cooperators in this ASTM meeting. Those organizations were the U.S. Geological Survey, American Congress on Surveying and Mapping, American Society of Photogrammetry and Remote Sensing, AM/FM International, Association of American Geographers, Urban and Regional Information Systems Association, Canadian Geosciences Advisory Committee, and the International Association of Hydrological Sciences. Then later I followed up by contacting the executive directors of those organizations inviting them to have a representative attend the symposium and participate in the meeting of the ASTM Section on Mapping and GIS. Our thought was that rather than various groups going off in all directions developing standards, that they might be able to work together with the standards development expertise of ASTM, the 92 year old standards-writing organization, and thus develop better standards and in a shorter time frame than if everyone is working separately. So we welcome participation from those organizations, several of which already have had representatives become ASTM members.

## STATEMENT

*Connie Blackmon*

President, URISA  
900 2nd Street, NE, Ste 304  
Washington, DC 20002

It is an excellent forum in which others can become involved. Whereas we have a lot of GIS interest and experience to offer in our membership, ASTM has the standards development expertise.

## STATEMENT

*Ivan Johnson*

A. Ivan Johnson, Inc.  
7474 Upham Court  
Arvada, CO 80003

ASTM has a large building in Philadelphia, offices in Washington, DC, and near London, and a staff of over 200. So it does take quite an operation to operate a standards development and maintenance business. And maintenance is an important word because all standards development processes must have the capability of being revised to keep up with new developments. ASTM has a requirement that all standards be reviewed every five years and balloted as it exists, as revised, or for complete removal. In addition, such action also can be taken any time before the 5-year period.

## STATEMENT

*James Fulton*

Applications Assistance Unit  
Water Resources Division  
U S Geological Survey  
MS 445 National Center  
Reston, VA 22092

I would like to emphasize the list of proposed standards is not a closed list. If anyone has some ideas that our ASTM Section ought to be pursuing, and some people to pursue them, let us get started. While I am speaking I want to point up that this Section on Mapping and GIS holds two working meetings per year, usually the last week of January and the last week of June, and everyone is welcome to attend and to participate.

## STATEMENT

*Vernon Singhroy*

Canada Center for Remote Sensing  
1547 Merivale Road  
Ottawa, Ontario, Canada K1A 0Y7

UNESCO and IUGS (International Union of Geological Sciences) is very much interested in applying GIS to water resources development. UNESCO also has within the International Hydrological Program (IHP) launched through the IAHS (International Association of Hydrological Sciences) a number of groups that are going to study the use of GIS in water resources.

## STATEMENT

*Ivan Johnson*

A. Ivan Johnson, Inc.  
7474 Upham Court  
Arvada, CO 80003

I am involved in the UNESCO program through a GIS Division in one of this symposium's cooperators, the International Association of Hydrological Sciences. I have had contact with UNESCO in Paris for discussions of these activities and standards appear to be one of the issues.

Somebody also mentioned the possible involvement of Canadians in our ASTM developments. Actually a lot of Canadians are involved in various ASTM Committees, including a number of them in our particular subcommittee. Canada is close enough so those members can attend USA meetings fairly easily and occasionally ASTM even schedules meetings in Canadian border cities. And of course the Chairman of our ASTM Section on Remote Sensing, Vernon Singhroy, is a Canadian.

## STATEMENT

*Vernon Singhroy*

Canada Center for Remote Sensing

1547 Merivale Road

Ottawa, Ontario, Canada K1A 0Y7

We have a fairly extensive GIS remote sensing committee in Canada. To give you some ideas about our infrastructure, I work for the Canada Center for Remote Sensing, which is within Energy, Mines, and Resources Canada. Our geomatics industry consists of Canadian companies specializing in mapping, image analysis, GIS, and remote sensing. There is a fairly strong and well established infrastructure in Canada. We conduct, at the federal level and provincial departments, regular annual meetings on GIS and remote sensing. The government mapping departments have this remote sensing and GIS focus. The strategy is to develop a strong natural resource information system that will aid in sustainable development and management. There also are strong links between these government/industry groups and universities. This is reflected at the annual government remote sensing and GIS meetings.

## STATEMENT

*Manfred Ehlers*

University of Maine

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National Center for Geographic Information (NCGIA)

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I just want to comment that I know at least two other groups that are working on data exchange standards. One is on remote sensing, which is within the International Society for Photogrammetry and Remote Sensing. Fred Billingsly from NASA's Jet Propulsion Laboratory is leading this group, which I think is Working Group 2-2 called "Systems for the Dissemination, Archiving, and Storage of Remotely Sensed Data." Then there is a group working on a cartographic standard in the International Cartographic Association, with Hal Mollering of Ohio State University as Chairman. So these represent some resources from the cartographic side. There might be other people who can be contacted who already have lots of experience on the topics of this symposium.

**STATEMENT**

*Ivan Johnson*  
A Ivan Johnson, Inc  
7474 Upham Court  
Arvada, CO 80003

There being no more comments or questions, then I want to thank all attendees, the panel members, and all the people who have been serving as session chairmen I invite all of you to take part in the future meetings of the ASTM Sections on Remote Sensing, and on Mapping and GIS.

# Glossary of Acronyms

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This glossary contains the acronyms used in papers published in this volume as well as some additional useful acronyms. The glossary should assist readers to better understand the new technical language developing among the geographic information systems, remote sensing, and mapping disciplines. For a more extensive glossary related to remote sensing the reader should see ASTM *Special Technical Publication 967* or *ASPRS Manual of Remote Sensing*.

AAG	Association of American Geographers
ACD	Aeronautical Charting Division (NOS)
ACSM	American Congress of Surveying and Mapping
AID	Agency for International Development
AM/FM	Automated Mapping/Facilities Management Society
ANSI	American National Standards Institute
ARC/INFO	GIS Program by ESRI
ARS	Agricultural Research Service (DOA)
ASE	Air Sea Experiment
ASPRS	American Society for Photogrammetry and Remote Sensing
Auto CAD	Automated Computer Aided Drafting
AVHRR	Advanced Very High Resolution Radiometer
BIA	Bureau of Indian Affairs (DOI)
BLM	Bureau of Land Management (DOI)
BNA	Block Numbering Area
BOB	Bureau of the Budget (USA)
BOC	Bureau of Census (DOC)
BOM	Bureau of Mines (DOI)
BPA	Bonneville Power Administration (DOE)
CAD	Computer Aided Drafting
CADD	Computer Aided Drafting and Design
CAP	Central Arizona Project (USBR)
CASS	Computer Aided Support Systems
CD-ROM	Compact Disc—Read Only Memory
CEP	Circular Error Probable
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (EPA)
CIR	Color Infrared
CISTI	Canada Institute for Scientific and Technical Information
CODATA	Committee on Data for Science and Technology (ICSU)
COE	Corps of Engineers, U S. Army (DOD)
COGEOMAP	Cooperative Geologic Mapping (Federal-State)
CPM	Critical Path Method
CPU	Central Processing Unit
CRIC	Computerized River Information System (FWS)

CREEL	Cold Regions Research and Engineering Laboratory (COE)
CTG	Composite Theme Grid
DBMS	Database Management System
DCDS	Digital Cartographic Data Standard
DDF	Data Descriptive File
DEM	Digital Elevation Model (USGS)
DIS	Data and Information Systems (IGBP)
DLG	Digital Line Graph
DMA	Director Memory Access
DMS	Desktop Mapping Software
DMSP	Defence Meteorological Satellite Program
DOA	Department of Agriculture
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
DOJ	Department of Justice
DOL	Department of Labor
DOS	Department of State
DOS	Disk Operating System
DOT	Department of Transportation
DQO	Data Quality Objectives
DRAW	Direct Read After Write Animation System
DTD	Digital Terrain Data
DTM	Digital Terrain Model
DXF	Drawing Exchange Format
EADS	Environmental Assessment Data System
ECDIS	Electronic Chart Display and Information Systems
EDA	Elevation Difference Accuracy
EDD	Exchange of Digital Data
EMSL-LV	Environmental Monitoring Systems Laboratory—Las Vegas (EPA)
EMAP	Environmental Monitoring and Assessment Program
EOCAP	Earth Observation Commercialization Application Program
EOS	Earth Observation System
EOSAT	Earth Observation Satellite
EPA	Environmental Protection Agency (Independent Agency)
ERBES	Earth Radiation Budget Explorer Satellite
ERDAS	Earth Resources Data Analysis Systems
ERS	Economic Research Service (DOC)
ESA/IRS	European Space Agency/Information Retrieval Service
ESIC	Earth Science Information Centers (USGS)
ESRI	Earth Resources Data Analysis Systems
FAA	Federal Aviation Administration
FAO	Food and Agriculture Organization (UN)
FAR	Federal Acquisition Regulations
FCC	Federal Communications Commission
FEDMAP	Federal Geologic Mapping Project
FEMA	Federal Emergency Management Agency
FF	Free Format
FGCC	Federal Geodetic Control Committee (NOS)

FGDC	Federal Geographic Data Committee
FGEF	Federal Geographic Exchange Format
FHA	Federal Highway Administration (DOT)
FICCDC	Federal Interagency Coordinating Committee on Digital Cartography (Chaired by USGS)
FIPS	Federal Information Processing Standard
FIT	Field Investigation Team (EPA)
FS	Forest Service (DOA)
FWS	Fish and Wildlife Service (DOI)
GA	Geographic Analysis
GBF/DIME	Geographic Base Files/Dual Independent Map Encoding (BOC)
GCDB	Geographic Coordinate Database
GEMS	Global Environmental Monitoring System
GEWEX	Global Energy and Water Cycle Experiment
GIRAS	Geographic Information Retrieval and Analysis System
GIS	Geographic Information System
GMSC	Geologic Map Standards Committee (USGS)
GNIS	Geographic Names Information System (USGS)
GPS	Global Positioning System
GRASS	Geographic Resources Analysis Support System (COE)
GRID	Global Resource Information Database
GSA	General Services Administration (Independent Agency)
HDTV	High Definition Television
HP	Hewlett-Packard Corporation
HRIS/MSU	High Resolution Infrared Sounder/Microwave Sounding Unit
HRS	Hazard Ranking System (EPA)
HRV	High Resolution Visible
IACG	Interagency Committee on Geomatics (Canadian Department of Energy, Mines and Resources)
IACWD	Interagency Advisory Committee on Water Data (USGS)
IAEA	International Atomic Energy Agency (UN)
IGA	International Association of Geomagnetism and Aeronomy
IAHS	International Association of Hydrological Sciences
IAMAP	International Association of Meteorology and Atmospheric Physics
IAS	Image Analysis System
IBM	International Business Machine Corporation
IBM PC	International Business Machine Personal Computer
IBWC	International Boundary and Water Commission (Independent; USA and Mexico)
ICSU	International Council of Scientific Unions
IDCCC	Interior Department Cartographic Coordinating Committee (DOI)
IGBP	International Geosphere-Biosphere Programme
IGY	International Geophysical Year
IHO	International Hydrographic Organization
IHP	International Hydrological Program (UNESCO)
IJC	International Joint Commission (Independent Agency, Canada and USA)
IRDS	Information Resource Dictionary System (NIST)
ISO	International Standards Organization
ISRIC	International Soil Reference and Information Centre
ITEM	International Technology Environmental (Database) Management System

LANDSAT	Land Observation Satellite
LIS	Land Information System
LORAN	Ground-Based Navigation System
LTRMP	Long Term Resource Monitoring Program (FWS)
MACDIF	Mapping and Charting Data Interchange Format
MARF	Master Area Reference File (Canada)
MAPS	Map Analysis and Processing System
MFLOPS	Millions of Floating Point Operations Per Second
MGE	GIS Program by Integrgraph
MIADS	Map Information Assembly and Display System
MIMD	Multiple Instruction, Multiple Data System
MIPS	Million Instructions Per Second
MIS	Management Information Systems
MOS	Marine Observation Satellite
MOSS	Map Overlay Statistical System
MOU	Memorandum of Understanding
MSL	Mean Sea Level
MSS	Multispectral Scanner
MSU	Microwave Sounding Unit
MTMC	Military Traffic Management Command (DOD)
MUID	Map Unit Identification Data
MUIR	Map Unit Interpretation Record
MWDI	Master Water Data Index
NAD 27	North American Datum of 1927
NAD 83	North American Datum of 1983
NASA	National Aeronautics and Space Administration (Independent Agency)
NASC	North American Stratigraphic Code
NAWDEX	National Water Data Exchange (USGS)
NBS	National Bureau of Standards (now NIST-DOC)
NCAR	National Center for Atmospheric Research (DOC)
NCDCDS	National Committee for Digital Cartographic Data Standards (ACSM)
NCGIA	National Center for Geographic Information (University Consortium)
NCIC	National Cartographic Information Center (USGS)
NDCDB	National Digital Cartographic Database (USGS)
NDF	Narrative Data File
NDPD	National Data Processing Division (EPA)
NDSDBS	National Digital Spatial Database System (USGS)
NDVI	Normalized Difference Vegetation Index
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NGDC	National Geophysical Data Center (NOAA)
NGRS	National Geodetic Reference System
NGS	National Geodetic Survey
NGVD 29	National Geodetic Vertical Datum of 1929
NIST	National Institute of Standards and Technology (formerly NBS—National Bureau of Standards)
NMAS	National Map Accuracy Standards
NMD	National Mapping Division (USGS)
NOAA	National Oceanographic and Atmospheric Administration (DOC)
NOS	National Ocean Survey (NOAA)
NOWES	Northern Wetlands Study



NPS	National Park Service (DOI)
NTIS	National Technical Information Service (DOC)
NWIS	National Water Information System (USGS)
NWLISN	Northwest Land Information System Network
NWS	National Weather Service (NOAA)
OB1	One Big One
OGWP	Office of Ground Water Protection (EPA)
OIEA	Office of Integrated Environmental Analysis (EPA)
OIRM	Office of Information Resources Management (EPA)
OMB	Office of Management and Budget (Independent Agency)
OMDR	Optical Memory Disk Recorder Animation System
OSWER	Office of Solid Waste and Energy Response (EPA)
OWDC	Office of Water Data Coordination (USGS)
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PC	Personal Computer
PLSS	Public Land Survey System
PVI	Perpendicular Vegetation Index
QAMS	Quality Assurance Management Staff
QA/QC	Quality Assurance/Quality Control
RAM	Random Access Memory
RAMS	Results Analysis and Management System (EPA)
RCRA	Resource Conservation and Recovery Act (EPA)
RDT	Remote Data Transmission
RGIS	Regional Geographic Information System
RDBMS	Relational Database Management System
RMES	Relay Mirror Experimental Satellite
RMSE	Root Mean Square Error
ROM	Read Only Memory
RS	Remote Sensing
RUSLE	Revised Universal Soil Loss Equation
SBUV	Solar Backscatter Ultra Violet Experiment
SCS	Soil Conservation Service (DOA)
SDSS	Spatial Decision Support System
SDTS	Spatial Data Transfer Standard
SIMD	Single Instruction, Multiple Data System
SOP	Standard Operating Procedures
SPC	State Plane Coordinate System
SPOT	Système Pour l'Observation de la Terre (France)
SSSD	State Soil Survey Database
STA	Strategic Transportation Analysis (Integrated Transportation Networks for MTMC; DOD)
STORET	Storage and Retrieval System (Water Quality Data; EPA)
TEGD	Technical Enforcement Guidance Document (EPA)
TIGER	Topologically Integrated Geographic Encoding and Referencing System (BOC)
TIGER/GICS	TIGER/Geographic Identification Code Scheme (BOC)
TIGER/GRF-N	TIGER/Geographic Reference File-Names (BOC)
TIN	Triangular Irregular Network
TM	Thematic Mapper

TMP	Transverse Mercator Projection
TSC	Transportation Systems Center (DOT)
TSS	Total Surveying Systems
TVA	Tennessee Valley Authority (Independent Agency)
UN	United Nations
UNDP	United Nation Developmental Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISIST	United Nations System for Scientific and Technological Information
URISA	Urban and Regional Information Systems Association
USAF	U S. Air Force
USCG	U.S. Coast Guard
USEPA	United States Environment Protection Agency
USGS	U S Geological Survey (DOI)
USNMAS	United States National Map Accuracy Standard
UTM	Universal Transverse Mercator
USAID	Agency for International Development (Independent Agency)
VPF	Vector Product Format
WATSTORE	Water Data Storage and Retrieval System (USGS)
WDSD	Water Data Sources Directory
WMO	World Meteorological Organization
WORM	Write Once, Read Many
WRD	Water Resources Division (USGS)
WWW	World Weather Watch (WMO)