THE CHANGING GEOSPATIAL LANDSCAPE

A Second Look

A Report of the National Geospatial Advisory Committee

December 2015

I. Introduction

The Secretary of the Interior formed the National Geospatial Advisory Committee (NGAC) in 2008 to provide advice and recommendations related to the management of Federal and national geospatial programs. This committee was established under the terms of the Federal Advisory Committee Act of 1972, as amended.[1] The Federal Geographic Data Committee (FGDC), which is the federal entity responsible for managing the National Spatial Data Infrastructure (NSDI), is the designated immediate beneficiary of the NGAC's recommendations. This diverse committee consisted of 28 experts from academia, the private sector and all levels of government: Federal, Tribal, State, regional and municipal.

In 2009, the NGAC produced a report titled *The Changing Geospatial Landscape*. As noted in the preface to that report, during its first year of activity, the NGAC "endeavored to create a common level of understanding as it relates to geospatial technology, policy and programs that exist in the public and private sector."[2] The committee published *The Changing Geospatial Landscape* "to describe the changes and advancements the community has witnessed over the past three-plus decades and to set a context from which in part we will base our future deliberations. While this paper is not meant to be all-inclusive in chronicling the growth of the industry, we do believe it captures the major milestones and identifies several of the major issues that lie ahead."

The subsequent eight years have been a time of rapid technological change in the geospatial industry. Some of the "the major milestones and … major issues" have been achieved and some have been superseded. For example, the rise of cloud computing has changed the way we collect and share information. This can be a beneficial change, as was seen in the global response to the earthquakes in Haiti and Nepal. However, it also has raised significant concerns about privacy, and information integrity and security.

This report is intended to build upon *The Changing Geospatial Landscape*. In this document, the committee contributes its perceptions of incipient technologies that we expect will guide, define or determine the development of this industry in the near and medium term. Of even greater importance, the report highlights those aspects of innovation that bear directly on public policy and on individual privacy and security. The NGAC has also prepared this report to help inform the development of the next iteration of the strategic plan for the National Spatial Data Infrastructure (NSDI) and the development of transition recommendations for the next Presidential administration.

II. "The Future is Coming, Experts Say" – Near and Medium Term Trends

In this remarkably succinct headline from the early 1990s, a west coast newspaper managed in a single phrase to simultaneously confirm and cloud the issue of forecasting. Indeed the future is coming but what will it encompass and how can we ensure beneficial change? During one of its 2015 quarterly meetings, the NGAC conducted a workshop to identify the components of what one member characterized as a *tsunami* of changes. For the purposes of this discussion, we categorize these admittedly multi-faceted changes as primarily related to technology or to human issues (that is, social, economic, and policy-related) and present the NGAC's predictions with brief clarifying notes.

Technology Issues

Remotely Sensed Information – Satellites, Part 1: Imagery

The Federal government launched the ERTS-A (Earth Resources Technology Satellite) in 1972. Renamed Landsat I, this satellite and its successors contributed to a revolution in global mapping. Between 1972 and 2013, the government built and launched seven other Landsat satellites. In 2013 Landsat 8 went into service. It "was turned over to the U.S. Geological Survey in Sioux Falls, South Dakota, in May 2013 to begin service, cost the government about $850 million to build and launch. Five years of operations is expected to push the total to nearly $1 billion."[3] With its instrument packages, Landsat 8 weighs approximately 2623 kg (slightly less than three tons). The revisit interval is every 16 days.

During the 42-year interval between the first and most recent launches, satellite technology has changed significantly. Perhaps the most dramatic change has come from the private sector, which has developed small, lightweight, inexpensive satellite platforms intended to provide current data collected daily. As an example, consider the Dove satellite produced by Planet Labs.[4] The Dove weighs 4 kilograms and measures approximately 10 cm by 10 cm by 30 cm. As of September 2015, 100 Dove satellites are in orbit with a revisit rate of 24 hours for every location on the planet.[5]

What are the implications of such platforms? First, as sensors continue to proliferate, private firms will begin to acquire their data from these less expensive and higher resolution data collectors. This in turn means the federal government will have less control over data acquisition. Second, small satellites solve the prohibitively expensive process of testing and deploying satellites, allowing vast resources to be repurposed. Third, the more frequent rate of data collection, combined with lower cost and higher resolution imagery will enable a much broader range of applications than has been possible in the past. For example, forest fires, storm damage and new building construction could be modeled in human time (that is, one-day intervals).

Remotely Sensed Information – Satellites, Part 2: Location

The Navstar Global Navigation Satellite System (GNSS), also known as the Navstar Global Positioning System (GPS) was proposed by the Pentagon in 1973 and put into services in 1989.[6] GPS quickly solved the problem of precise collection of location information in the field. The reach of this system grew in 2000 when the method of encryption known as selective availability was removed and civilian users had access to high quality data. Since its inception, the Global Navigation Satellite System (GLONASS) launched by Russia, the BeiDou system launched by China, the European Space Agency's Galileo system, and regional systems launched by India and Japan have joined the Navstar constellation in orbits around the earth.

The NGAC believes that the full range of applications for GPS data remains unidentified. The integration of Navstar data with the even more precise Japanese localized data offers the opportunity for highly accurate road vehicle navigation, just as the Navstar GPS had automated many aspects of agriculture. Combining these regional GPS data sets with small satellite imagery offers the prospect creative solutions to problems of many kinds.

Remotely Sensed Data – Unmanned Aerial Systems (UAS) ("aerial drones")

Terrestrial drones are used at building construction sites and in prisons, locations that share a concern with personal safety during data collection. For example, drones are being used to monitor flare stacks for natural gas, avoiding the dangers of placing human observers in the field.[7] Marine drones are being used to map oceans currents and bathymetry. As the Federal Aviation Administration and other agencies move forward with licensing and regulated usage of aerial drones (also known as unmanned aerial systems), their application to mapping and related data collection will grow exponentially. Operating under specific certificates of authorization (COA), private survey firms have already begun using drones to survey and map cross-country power lines and pipelines. Aerial drones offer a safer alternative to helicopter flights over forest fires and flooded rivers, as well as analysis of damaged infrastructure such as storm or accident-damaged bridges.

The use of aerial drones offers significant advantages in data collection. The full range of the applications is unknown, but should be monitored as the NGAC continues its advisory role. More importantly, the use of aerial drones poses several substantial issues related to personal privacy and security, which we consider later in this paper.

Mobile Device Applications

Fourth generation (4G) mobile telephone technology, and its enhancement through Long Term Evolution (LTE), has made mobile computing a reality. We can determine the general location of any commercial mobile communication device by trilateration, using the signals from three (or more) cellular communication towers. The specific location of those devices can be determined using GPS (if this capability is enabled - the default setting in most systems).

This functionality is linked directly to what is often called "The Mobile Revolution." Many apps (software programs written specifically to operate on portable devices) rely on knowing the devices geographic location. Such location intelligence services are driven by commercial marketing considerations. Knowing the precise location of users allows firms to target their promotions and alert users to location-specific opportunities. We have witnessed a collective societal decision to "opt-in" to this environment and have become, in effect, part of a "passive sensor" ecosystem. This also poses several substantial issues related to personal privacy and security, which we consider later in this paper.

Organizations with requirements to gather and utilize program data and document in the field should be able to realize greatly streamline workflow through the use of mobile devices and accompanying software. These platforms will allow enhanced information to be collected in the form of audio, video, and other sensor readings, all linked to the location of observation by means of GPS and interactive maps. Additionally, field workers will be able to navigate better through the use of offline maps and navigation aids in areas as yet unserved by mobile broadband.

Real time traffic reporting is made possible by the use of thousands or millions of passive data collectors. As driving conditions change and traffic slows down, this information is being relayed to mobile mapping and display systems. This is an example of adaptive design in which drivers provide real time inputs. As was the case with aerial drones, this passive sensor technology offers tremendous opportunities but also poses several substantial issues related to personal privacy and security. Moreover, the ubiquity of data access has created certain issues related to trust and data quality that we consider later in this report.

Indoor Positioning

Given that the newest generation of U.S. GPS satellites, GPS III, permits identifying a location anywhere on earth to within one meter and new satellite imagery provides a view of any point on the earth each day with a resolution of less than 2 feet, why is it so difficult to locate people and assets accurately indoors? This is becoming an important question as many of our critical business needs will be satisfied by solutions that require knowing where people, resources and assets are when they are indoors. Indoor positioning technology provides the ability for real-time tracking of location information on people or objects indoor using sensory information from automated devices. NG911 is an excellent example of an application that benefits from knowledge of not only X and Y position, but also Z, or elevation, position.

The expanding use of indoor positioning includes such things as customer tracking and information, indoor navigation, security, safety, augmented reality, location based services and mobile asset tracking. Beyond early adopters with specific high impact needs, the challenges around creating good indoor positioning infrastructure have prevented widespread implementation. There are many reasons that indoor positioning is so challenging, including weak or no indoor GPS signal, limited standards, multiple different business requirements and the technically difficult environment of being indoors.

As with any new capability, standards are being developed (OGC, 2015) and more robust technology is rapidly evolving. Careful planning and investment will allow organizations to develop, over time, a robust indoor positioning infrastructure that meets a large cross-section of the organization's needs. The NGAC should track these efforts and provide appropriate recommendations to the FGDC.

Platform Evolution

Mobile communications devices are advancing in parallel with the evolution in the workplace from mainframe computers to mini-computers to desktop workstations to personal computers and tablets using web services. As processing power has increased, the cost of computing has gone down dramatically. The Osborne OM-1 of 1981 had a smaller display screen than most contemporary smart phones, not to mention substantially less processor power and significantly less storage.

The transition to fast, small-footprint computing tools, cloud storage and mobile computing have enabled development of tools such as the Geospatial Platform, a federal asset that provides a managed portfolio of common geospatial data, services and applications.[8] However, this transition has also engendered a lack of awareness of what geospatial technology is doing in our daily lives. Somewhat "generational" in its impact, the transition has dulled the senses of users with regard to the provenance of the data they are using. This, in turn, has ramifications for the training of the next generation of geospatial professionals and our expectations for their role in the industry.

Storage in the Cloud

"Cloud storage is a model of data storage where the digital data is stored in logical pools, the physical storage spans multiple servers (and often locations), and the physical environment is typically owned and managed by a hosting company."[9] Cloud storage has largely solved the problems of cost and capacity for bulk data storage. Use of applications such as Google Drive, Dropbox and Microsoft's OneDrive are commonplace, as is the use of Rackspace and the Amazon cloud for larger commercial enterprises.

The financial benefits of cloud storage can be substantial, as a former member of the NGAC demonstrated in one substantial region-wide purchasing initiative.[10] Cloud storage certainly is appropriate for federal civilian agency use. Appropriately secured clouds could also benefit agencies that must store and access restricted data.

Crowdsourced Data

Just as Wikipedia has revolutionized collaborative information sharing, on-line systems such as OpenStreetMap and Ushahidi have enabled collaborative mapping in heretofore-unimagined ways. As noted earlier in this report, the NGAC sponsored two workshops on crowdsourcing in 2015. The availability of quantities of detailed information has many benefits but also creates many concerns. For example, must we consider what crowdsourced data should be included within the NSDI? What should be the content requirements for data themes and individual records? Should there be NSDI metadata standards for crowdsourced data and, if so, what should the standards define?

Communications

The nation's infrastructure is at constant risk, from terrorism certainly but also from decay and degeneration. This infrastructure exists at specific locations. Disasters strike at specific locations. Ambulances are dispatched to specific locations. These locations must be communicated to first responders and to engineers working to alleviate the impact of these events. What happens when the communications network goes down?

FirstNet (National Public Safety Broadband Network) hopes to have 8 million credentialed users by 2022 using a single sign-on mechanism to access the network and information. The NGAC asks if this system can be leveraged to access protected layers and services associated with the NSDI. An NGAC member working with the Department of Homeland Security has shared the claim made by agencies associated with the NextGen911 and FirstNet initiatives and their underlying technologies that these will be able to improve emergency response by an average of 2-4 minutes per call.

Leveraging geospatial data is a big part of the strategy to achieve this impact. In August 2015, FCC Chairman Tom Wheeler called for Congress to consider and fund efforts toward NextGen911 including a borderless national public safety map (including roads, addresses, jurisdictions, facilities and similar information).[11] The NGAC recommends continued engagement in this area.

Social, Economic, and Policy Issues

Rural-Urban Dichotomy

There are significant differences in the availability of Internet services throughout the United States. A digital divide exists in which entities in urban areas (for example, Fortune 500 companies and the better-funded agencies) have ample access to geospatial resources and the highest quality data while rural areas do not. This exacerbates competitive advantages and leaves rural communities behind. Strictly relying on market forces and striving for complete efficiency does not always result in the best societal outcome. The NGAC endorses the continued use of the Broadband Map to continue to expand Internet access to the nation's rural areas.

Workforce Development

Today, very few business decisions are made in the public and private sector which don't take into account location or aren't heavily dependent on geospatial data and technology (e.g., GPS). The United States is a world leader in the industry that acquires, manages, analyzes, integrates, maps, distributes, and uses geographic, temporal, and spatially based information - a multi-billion component of the US economy touching every sector from public health to homeland defense.

It follows that economic growth and security depends as much, if not more, on the people who perform the work than on the resulting products and analytic techniques themselves. Unfortunately, this vital component faces a shortage of qualified and skilled workers to meet the demands of this fast growing industry. Beyond workforce development, the industry confronts an identity challenge as the traditional geospatial 'competency model' is rapidly expanding to include more elements than one might think. A good geospatial practitioner can't just be a spatial-data guru. He or she has to be able to speak the language of a particular domain, write some code, apply statistics, all coupled with communication acumen.

This calls for:

- Commercial, academic, nonprofit organizations, and all levels of government use a complementary set of competencies to support systematic geospatial learning and development of training and education programs and curricula;
- Effective and compelling public outreach programs and informational materials about the geospatial profession distributed through geospatial professional organizations and existing DOL-supported education and information channels; and
- A set of skills standards describe the kinds of workers needed to support the geospatial industry; improve employee recruitment and selection; and advance geospatial technology.

These direct and indirect benefits ultimately work to better align educational, employment, and workforce development programs with employers' labor needs, ultimately providing public and private organizations with the knowledge and skills employees need to be successful.

Data Analytics

The development of location based mobile device applications has created a huge appetite for geospatial data. It also has created a demand for higher accuracy, greater relevancy and real-time data (that is, more frequent refresh rates). This represents a huge opportunity for the data analytics industry, but also has implications for the geospatial community.

Many aspects of human behavior can be modeled in aggregate by examining collateral data. For example, FEMA has modeled patterns of movement and evacuation following disasters by sampling sales reports from the Waffle House chain of restaurants. The CDC models epidemics by following hospital bed-use and availability. The NGAC notes that, in a world of ubiquitous passive sensors, similar public health modeling could be performed using CVS and Walgreen sales data. However, this type of application raises several questions.

This type of data gathering and publishing would require meaningful usage statistics for geospatial services. If pursued, these capabilities should be incorporated in application design from the start, not as an afterthought. This, in turn, would improve confidence and relevancy of the data. However, it would raise serious questions regarding individual privacy, a point to which we return below.

Standards

As was appropriate at the inception of the program, the NSDI data standards focus on sources of the data rather than on use of the data. The NGAC recommends a review of the possibility of adapting standards and policies to the rapid pace of technological change and to current and future uses of data. Incentive structures to support adherence to data standards are not expected. Because of this, data standards focus should be on functional, not operative standards and the communication of best practices examples. The NGAC also recommends consideration of a change in focus to reflect the changing user population: everyone in the nation uses these data, not only technically sophisticated employees working in the geospatial industry and government.

Privacy Issues

Personal privacy is a matter of growing concern, especially when user location is linked to mobile devices. Click-through "terms of use" agreements are of little value in this regard, given their small font size, their length and detail, their brief display time, their lack of real-world utility, and the growing opinion that they are increasingly meaningless without legal force. There is real and growing concern with the collection of real-time data and how these data "back into" privacy. Indoor mapping, the "Internet of Things" and small satellites have created more eyes and ears that are seeing and hearing more things. The integration of space and time in data collection has enabled applications that are not only used for static inventories and map-making but also for real-time decision-making and action. The NGAC expresses its concern about the impact of these data collection practices for personal privacy and security. The NGAC also recommend continued dialogue with the CIO Council and other appropriate agencies and entities.

Certainly, in some cases, the GPS capability of mobile devices (discussed previously in this report) offers benefits that may outweigh privacy concerns... Consider the user's ability to turn off the GPS tracking functionality. A common question to law enforcement officials is "don't criminals change the default setting to off so they won't be tracked?" The most frequent answer is "No, the criminals do not usually turn the tracking/GPS off." For example, upon several occasions, mobile phones were used during the commission of a crime in Lexington County, South Carolina. In each time the criminal had not changed the default setting for GPS tracking from "on" to "off." In each case, county officials were able to use local area maps to triangulate locations from the identified towers and demonstrate where and when the criminals were located in relationship to the crime. At South Carolina's most recent statewide Crime Intelligence conference, this counties experience was confirmed to be typical statewide.

Despite the fact that information about precise location can be useful for law enforcement and can be critical for first responders requiring assistance, access to such data does raise privacy considerations. The NGAC recommends on-going consideration of privacy issues as technologies continue to evolve.

Health Issues

One specific area of privacy concern is related to health care. On a positive side, precise geolocation can be used to improve response times for ambulances. There could be similar benefits for disaster response. With proper tools, CVS and Walgreens could track events such as the 2014 Ebola outbreak by recording customer symptoms in real-time and sharing that information with the Centers for Disease Control.

However, there must also be consideration of negative consequences. The Health Insurance Portability and Accountability Act of 1996 (HIPAA) has privacy at its heart. What are the implications for insurance coverage of identifying individual users (by mobile phone number and GPS location) who seek forms of treatment for certain diseases? Could a company decide to terminate medical insurance coverage based on a request for a home pregnancy test kits or AIDS infection test kit?

Public health and safety must be protected, but so must individual privacy. This is a matter of law. There is no one from the health care industry currently appointed to the NGAC. Moreover, the Department of

Health and Human Services does not actively participate in the work of the FGDC. The NGAC recommends that the appropriate federal agencies and organizations work to more effectively address these issues.

Public Safety

NextGen 911 and computer-assisted vehicle dispatch systems are clear examples of the use of geospatial technology for public safety. As the sophistication of relevant technologies including passive sensors has increased, certain additional capabilities have come to light.

Among these newer systems are building mapping systems, often known as Building Information Management (BIM) systems. When combined with building communications systems,[12] these systems afford a measure of security for building occupants and, in time of need, first responders. The NGAC recommends continued monitoring of public safety applications of geospatial information and technology to ensure appropriate advice to the FGDC.

Public-Private Partnerships

Approximately 85% of the nation's critical infrastructure is owned and operated by the private sector. The streets and buildings of private university campuses and larger private firms are maintained by their owners. The street networks used for vehicle navigation are owned by private industry. These data sets and many others should be evaluated for inclusion in the NSDI. We must address the question of when to license commercial geospatial products versus creating public domain products. Public-private partnerships appear to offer value in many areas. The Federal government should aggressively evaluate effective operational public/private partnerships. Given that the majority of the nation's streets fall within cities, which also manage a substantial portion of the nation's critical infrastructure (for example, water and sewage systems), the Federal government should also evaluate an expanded program of local and Tribal government partnerships.

Remotely Sensed Information – Satellites, Part 3: Data Access

A major implication of new satellite platforms and new technology is how they will conform to national remote sensing data law and policy to ensure national interests. To determine this, new systems will require a license.[13] U.S. national interests include keeping appropriate data free of cost to promote scientific, commercial, national security, and foreign policy applications. It took from 1992 to 2004 for U.S. policy and decision makers to learn, accept, and put into practice the fact that satellite remote sensing data paid for, and acquired by, the Federal Government has to be made available on the same basis as GPS and weather data (that is, free of cost) to ensure that these interests are met.[14]

To determine the appropriate policy to be applied to a new system, it will be necessary to determine 1) to what degree it is intended to replace the Landsat system for national purposes; and 2) the degree it is paid for by public and/or private funds.[15] Another crucial consideration is the long-term historical archiving of data. Currently satellite remote sensing data is collected and archived for the very long term in a national archive.[16] New platform operators will have the same archiving provisions in their licenses that the current operators have.[17]

The NGAC recommends that, as required by law, the data policy contained in the National and Commercial Space Programs Act[18]be applied to new satellite platforms.

Data Accessibility

The “flip sides” for public/private data partnerships are initiatives led within the government sector that manage the acquisition and maintenance of geospatial information. This more traditional path remains relevant, especially with regard to geospatial information for which government is, for statutory, economic, or public good reasons, the authoritative source. Public and public/private models should be holistically compared on a case-by-case basis.

Regardless of the model employed to acquire and manage geospatial content, the work must not stop at producing the data resources. The return on investment comes from the beneficial use of geospatial data to guide decision-making and to fuel operational efficiency.

Without significant fanfare, the dominant paradigm for public sector geospatial data has transitioned to an "open data" position. And, this is reflected in open data laws and executive orders at local, state, and national levels, to include action by both Congress and the White House.

This important landscape change toward open, highly accessible data, is relevant to the success strategy for another untrumpeted transition -- across the country, driven by the local requirements, municipal, county, regional, and state government perform much of the framework geospatial data stewarding. With public sector imposed subscription fees and licensing restrictions on data diminishing, the fight against redundant effort is easier, as are "bottom up" approaches to maintaining national spatial data assets.

Along these lines, the NGAC acknowledges the collaborative work, in progress, by the Bureau of the Census and the Department of Transportation in the prototype development of a National Address Database. The NGAC recommends that this model, also exemplified by the EPA Exchange Network, FHWA's Map21 Initiative, the NTIA State Broadband Initiative, and USGS's hydrology map layers, serve to inform the efforts of other Federal agencies.

To maximize ROI from geospatial technology, the data that drives it must be highly discoverable and accessible. Increasingly, current and future users expect to instantaneously find, learn about and utilize data resources, often via a streaming web service, starting from a simple key word web search.

Commercial, open, and custom web "platform" offerings have emerged that greatly aid web-based discovery and exploration of needed geospatial information resources. These platforms often offer metadata documentation, capabilities for two-way file transfer and publishing data web services, access control regimes, and customizable map views that facilitate integrated views across multiple data sources.

Additional and substantial ROI comes from the packaging of geospatial information within web and mobile apps that are each designed to specific business needs. Geospatial data quality, currency, and completeness expectations continue to grow and are of paramount importance, especially when the information is accessed broadly, and by non-technical users. Increasingly, applications do not explicitly describe or qualify the data resources utilized. Some apps that draw directly on geospatial data resources provide the resulting information without the aid of a map view to visually inspect and confirm the validity of results.

Geospatial Identity Crisis

The marriage of GPS with ubiquitous mobile communication devices has created expectations concerning data quality and availability that may, at times, be unrealistic. The typical driver using a dashboard navigation system doesn't ask how the street map was constructed, but it is not unreasonable for someone to pose this question. As driverless cars enter the nation's transportation network, questions related to public safety, property damage and liability will become more significant. Now that geospatial is ubiquitous, how does it govern behaviors?

To some extent, the geospatial industry has suffered from an identity crisis. To address this problem, the industry must articulate the "value-add" of geospatial expertise and investment in training. The NGAC recommends designation of the FGDC as a lead agency to convene a national/international geospatial Congress. The focal points of this Congress would be to examine global, sustainable initiatives to achieve appropriate educational goals and to help secure funding for those efforts.

Conclusion

The goal of this report is to identify key trends that will define the geospatial industry in the future. Near term trends already guide the thinking and analysis of the NGAC. Medium term trends serve to shape the committee's research agenda. The long-term trends depend in large part on our society's decisions regarding the quality of life we desire for our citizens, including the protection of personal privacy and the integrity of information about individuals. It also depends in part on our ability as a nation to make judicious and prudent decisions with regard to: organizing the workforce; refining agency responsibilities, requirements, and process; and, strategically prioritizing and partnering on expenditures and resources.

"Google's mission is to organize the world's information and make it universally accessible and useful."[19] Google's contributions to the common good are generally regarded as positive and access to the information cataloged and presented by Google has changed our world. However, unrestricted access to information about *individuals* is rightly viewed as problematic. Indeed, throughout the European Union, access to personally identifiable information is strictly regulated.[20]

In this regard, geospatial technology is inherently connecting and integrating. Every automobile with a GPS mapping display; every smart phone, smart watch or smart television with a connection to the Internet; and every other component of the "Internet of Things" offer insights regarding personal location, hence personal behavior. A precaution is warranted as geospatial data has the ability to connect to other information that is or may be perceived to be private. The NGAC believes that as geospatial technology continues to evolve, and as we analyze and recommend courses of action for the effective and efficient use of that technology, we must not lose sight of the human beings and society in general affected by those recommendations.

III. For Further Reading

Near and Medium-Term Trends
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IV. Notes

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This report was approved at the December 2015 meeting of the NGAC. The report was prepared by a subcommittee that included the following members: Dr. Robert Austin (Chair), Ms. Julie Sweetkind-Singer, and Mr. David DiSera.

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Major General William N. Reddel III, New Hampshire National Guard
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Ms. Molly Vogt, City of Gresham, OR
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Mr. David Wyatt, Eastern Band of Cherokee Indians