A NATIONWIDE NETWORK OF NETWORKS

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In January 2013, the AMS-sponsored Ad Hoc Committee on a Network of Networks was recognized as a Committee, under the Board on Enterprise Strategic Topics (BEST), of the AMS Commission on the Weather and Climate Enterprise. New terms of reference (TOR) and new leadership are being defined in order to move the NNoN effort forward.

A Nationwide Network of Networks (NNoN) is envisioned to be a nationally recognized organizing body that seamlessly facilitates weather and climate data exchange from a diverse community of data providers to the national and international data users. This body is planned to formalize existing standards and/or develop new standards (e.g., for metadata and policy), and ensure adherence to those standards by the member network operators. NNoN is also expected to provide guidance, expertise, and potential funding avenues to the member networks so the networks may be economically viable and be able to add more critically needed observational platforms, as required. NNoN is made possible through community participation within the AMS.

Mesoscale representativeness of existing networks is severely limited both in horizontal and vertical directions. Spacing between sensors is not necessarily small enough to capture all the mesoscale processes occurring within a given network. Similarly, profiles of observations, especially within the planetary boundary layer, are rather nonexistent in many operating networks. Adding complexity to this situation, two mesoscale networks with the same horizontal and vertical resolution may not achieve the same level of mesoscale representativeness, because different physical processes prevail within and around different networks.

This proposed NNoN is expected to provide guidance to its member networks to increase their data collection capability without imposing increased pressure on their already tight budgets. By using more cutting-edge tools such as mesoscale models and observation system simulation experiments (OSSEs), more representative and increased data collection capability is achievable from any existing network infrastructure. For example, mesoscale models and OSSEs can help determine optimal sensor placement strategies, data type and collection frequency, etc., for more efficient mesoscale data collection, although the use of such tools does not mean that investments in measurement sensors are no longer required. Effective utilization of such tools will critically depend on an ongoing two-way feedback between model results and measurements. In this way, networks will continually improve and be considered perennial research and development (R&D) testbeds.

The government, academic, and private sectors operate observing networks with their own goals, objectives, sensor arrays, processing techniques, and distribution requirements. For example, government maintains networks to achieve its missions: 1) to save lives and property from damage and destruction, 2) to monitor climate variation and impacts, and 3) to support national weather- and climate-related economic activity. Numerous academic sector entities own and operate networks to conduct research, develop and test new technologies, protect and serve their state's citizens, and serve the broader educational community. The private sector builds networks to commercialize both raw weather and climate data and value-added products. Across all of these networks are inconsistent standards for site and sensor selection, installation, and maintenance; data quality assurance and processing; data and product formats; and data-sharing policies.

Given the status quo, would it make sense or would it even be practical to form a national body to organize all networks to disseminate weather and climate data, and perhaps other value-added products, by a single organizational entity? What would be the best business model for that entity? How would such an entity resolve potential conflicts among the three sectors (if any), such as with respect to data ownership and protection issues?

Undoubtedly, weather and climate information users would benefit immensely from an organization like the NNoN, since the user currently spends more

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time than necessary searching for information, finding network-specific data formats, and converting those data formats as suitable. In addition to the extraneous effort, the consumer is unsure of the data quality because providers do not follow coherent national metadata standards and in many cases do not even document their procedures. Easy, quick acquisition of relevant and high-quality data would be a savings to the consumer. The NNoN can enhance this economic benefit to the consumer by gathering diverse network data into a single portal and standardizing metadata. Through the NNoN, the U.S. weather and climate enterprise could see increased economic value created by the private sector, for the same amount of data collected by the networks individually. With the increased access provided by the NNoN, the private sector would be able to generate more economic value by leveraging its own network assets as well as the continued research and development by the other two sectors.

BACKGROUND. The 2009 National Research Council (NRC) report, *Observing the Weather and Climate From the Ground Up: A Nationwide Network of Networks*,[1] shaped the vision for NNoN as a national asset and provided an impetus for its development. In response, the Office of the Federal Coordinator for Meteorology (OFCM) Committee for Integrated Observing Systems (CIOS) reviewed and established federal positions and activity. Also, Congressional earmarks and the overall direction for the National Oceanic and Atmospheric Administration (NOAA) have shown aggressive response to the report. In light of the report, the weather and climate community is positioning itself to respond to enhanced requirements for boundary layer observations.

The AMS established an ad hoc committee to enlist experts from across the weather and climate enterprise to recommend how the broader community should move forward on NNoN. The ad hoc committee volunteers engaged in this effort for more than two years, offering options and actions for implementing the 15 recommendations in the NRC report. Draft versions of this committee's report were made available to the larger weather and climate enterprise community for comments over many months. The recent and final version of the report (www.ametsoc.org/boardpges/cwce/docs/NoN/2013-06-01-NNoN-Final-Report.pdf) reflects the wider community input.

[1] www.nap.edu/catalog.php?record_id=12540

Additionally, this ad hoc committee made a concerted effort to identify both support and concerns from various stakeholder groups about a coordinated network of this magnitude and national importance. The overarching objective for the ad hoc committee has been to establish an NNoN that must be inclusive and inviting to network operators, data users, and those who add value as data pass from networks to users. The main challenge of formal sponsorship of an NNoN as a distinct organization is of economic return while maintaining an all-inclusive policy. A recommendation of sponsorship through the public sector with an advisory committee made up of delegates from the AMS and the University Corporation for Atmospheric Research (UCAR) is to carry the financial burden through—and offer accountability to—the public generally.

However, the team quickly realized that there are many other significant challenges ahead in developing, and successfully implementing, a widely accepted plan. For example, the team found that it cannot easily secure widespread support for the idea of a "central authority," which the NRC report recommended as an organizing body of the NNoN. Despite its best efforts, the team was unable to recommend agreeable organization and business models for such a central body.

Other major challenges the team identified are: 1) how to make a network-organizing body that is both autonomous and not unduly influenced by any one sector, 2) how to make this body financially sustainable, and 3) how to engage all of the major stakeholders (including weather and climate data consumers), garner their support for the idea, and contribute to its success. With respect to the third aforementioned challenge, many of the sought-after stakeholders—particularly data users—may not be actively engaged in the weather and climate enterprise community activities, and so finding effective ways to reach out to them becomes an even bigger challenge.

SPECIFIC RECOMMENDATIONS. One noteworthy accomplishment of the committee's effort is in making key players of all three sectors aware of the critical importance of an NNoN in order to fill the void in boundary layer observations. The committee strongly agreed with the report that a "central authority" is essential to coordinating and/or managing the NNoN for ensuring metadata standards and for providing a marketplace for data exchange and other core services.

The AMS ad hoc committee, with the support of its many working groups, thoroughly investigated the

THE UNITED STATES OF AMERICA NETWORK INTEGRATOR (TUSANI)

A new NNoN Committee is being put together to continue the previous NNoN efforts to establish a national organization, called "The United States of America Network Integrator" (TUSANI), which would integrate all member networks. Initially, TUSANI will be a team within the NNoN Committee before becoming a self-funded business entity in four years.

To reach this overarching goal, three working groups have been established for 1) implementation, 2) outreach, and 3) advisory. These working groups have been further divided into several teams.

TUSANI will work with the outreach teams to identify networks willing to sign up as member teams within the Implementation Working Group. The outreach teams will also reach out to users/customers who will utilize the data offered by the member networks. This is a benefit TUSANI will offer to its member networks.

TUSANI will also work with the advisory teams to provide guidance to member networks on the various recommendations made in the NRC/NNoN reports. Advisory teams will be called upon to support network member requests for information in relation to the metadata, architecture, measurements, R&D/testbeds, and human dimension related issues. Advisory team members are not expected to be involved in the network member activities as TUSANI.

TUSANI will directly benefit from the recommendations to be made by the Organization/Business Models Team, within the Advisory Working Group, in further shaping its business structure to be eventually spun off as a viable national—most likely nonprofit—business entity. TUSANI will closely work with the network teams in sharing pros and cons learned from other network members (anonymously), and in offering additional benefits to all member network teams.

People interested in participating in the new NNoN Committee as chairs, team leaders, and members (see open positions marked TBD in the table below) should please contact James Stalker at *jrstalker@respr.com*.

Table 1. NNoN Committee.

James Stalker, Chair
George Frederick, Past Chair

Implementation Working Group Greg Pratt, Chair	**Outreach Working Group** John Lasley, Chair	**Advisory Working Group** Don Berchoff, Chair
TUSANI Team Nancy Grady—Team Leader Mike Fowler, Mohan Ramamurthy, Joe Facundo—Members **CASA Team** Brenda Philips, Fred Carr —Co-team Leaders Jerry Brotzge—Member **MADIS Team** Leon Benjamin, Greg Pratt —Co-team Leaders Tom Kent, Gopa Padmanabhan, Leigh Cheatwood—Members * * * Future Network Member Teams	**User Sector Team** Jim Purpura—Team Leader Randy Bass, Bryce Ford—Members **Government Sector Team** Allan Eustis—Team Leader Somnath Roy—Member **Academic Sector Team** TBD—Team Leader Jerry Brotzge—Member **Private Sector Team** Dick Westergard—Team Leader Bryce Ford, Steve Root—Members **Mini Summit #1 (2013) Team** TBD—Team Leader Tom Fahy, Jenny Dissen, Steve Root —Members **Mini Summit #2 (2014) Team** TBD—Team Leader Tom Fahy, Jenny Dissen, Steve Root —Members **Stakeholder Summit (2015)Team** Tom Fahy—Team Leader Jenny Dissen, Steve Root—Members **International Engagement Team** Marjorie McGuirk—Team Leader	**Org/Business Models Team** Carl Bjerkaas—Team Leader Brian Bell, Apoorva Bajaj, Steve Woll —Members **Metadata Team** Kevin Kloesel—Team Leader Brenda Boyce—Member **Architecture Team** Mohan Ramamurthy—Team Leader **Measurements/Infrastructure Team** Joe Facundo—Team Leader **R&D/Testbeds Team** Fred Carr—Team Leader Wes Perkins—Member **Human Dimension Team** Brenda Philips—Team Leader

recommendations made in the NRC report and (in summary) recommended:

- A stakeholders' summit should be convened soon to foment the NNoN initiative and continue the momentum achieved to date. Implementation plans should result from this summit.
- As funding for an NNoN will be a challenge, an implementation strategy should be developed to prioritize systems based on their economic benefits [e.g., it was evident that systems to improve observations of the Earth's boundary layer would benefit multiple users (wind energy, aviation, forecasting onset of convective activity) and should be given a high priority].
- Ongoing R&D and treating all networks (new and old) as perennial testbeds will be essential to success in constantly assessing and improving the member networks of the NNoN and in developing new and innovative methods for observing Earth's boundary layer.
- The NNoN should adopt the Unidata local data manager (LDM) to provide the communications backbone.
- Metadata will be mandatory for applying data from the NNoN and an ISO and SensorML standard are recommended as schema to document data to enhance stakeholder usage of NNoN datasets.
- The human dimension must be considered when developing the NNoN, and is key to engaging stakeholders and network operators as the market is developed. User assessments and education will be key parts of this effort.

Although there was no particular order of importance of the six major recommendations, the first two are the most critical. Without a stakeholders' summit attended by many in support of the NNoN, an effort to form the NNoN may be unsuccessful. Also, without establishing a funding mechanism to support this type of development activity, it would prove impractical to actualize the NNoN.

AN ORGANIZATIONAL MODEL. Another culminating accomplishment of the ad hoc committee is an agreeable organizational model for the near-term future. Several key people who served on the AMS ad hoc committee and others joined a meeting in Washington, D.C., during the AMS Washington Forum 2012. They agreed that at this point in time, a more viable organizational model is to let multiple clusters of networks emerge competitively, primarily driven by market forces, instead of establishing a single (NRC-recommended) overarching NNoN.

This organizational model will allow all three sectors to form their own clusters of networks, however small, and encourage or compete for other networks to join. The weather and climate community has developed a handful of such clusters already. The idea behind this organizational model is that market forces will eventually lead to a merger of these smaller clusters of networks into the desired nationwide network of networks.

This model certainly helps overcome many of the challenges the ad hoc committee struggled with as it tried to support the formation of a central authority to oversee the nationwide network of networks. Two key questions arose during these discussions: 1) What makes an organization a central authority? and 2) If authority were not granted by Congress, how long will it take this nongovernment organization (NGO) to be considered a true central authoritative body by member networks?

While the newly proposed organizational model seems to hold multiple aspects acceptable to all three sectors, other issues may arise in pursuit of this model. For example, any individual network may choose to operate independently, without joining a cluster of networks. If many networks chose this path, the future will be no different than the current existence of individual networks and a few clusters of networks. The ability for networks to achieve economic benefits (e.g., reduced cost of increased data-collection capability) via leveraged research and development efforts of the central body may not occur by adopting this organizational model.

Another issue that may arise is that the government and academic networks do not directly respond to market forces and, hence, feel no incentive to join a cluster of networks. There are exceptions to this distinction between private and government/academic networks: certain academic networks are funded by both public and private sectors. Market forces may only partially impact these mixed-type networks.

To address at least one of the above issues (i.e., networks uninterested in joining a network of networks), it was agreed that an organization such as the AMS could develop and offer "data provider certification" standards, similar to the AMS Certified Consulting Meteorologist designations for individuals. Certain clusters of networks could create a competitive advantage by securing such certification and successfully attract more networks to join them.

The cost and time commitment that network operators must make to obtain such certification will

have to be made attractive. Otherwise, some networks may rightfully decide not to obtain the certification.

DISCUSSION. Even though a plausible organizational model has been described here, the right type of business model for the eventual all-inclusive NNoN is still elusive. There is a need for a new way of forming this public–private partnership, as the more traditional public–private partnership is inadequate. For example, the federal government has been the chief provider of weather and climate information to the private and academic sectors for decades. However, the view of the federal government as the sole provider of weather and climate information has evolved over time as academic and private sector entities have invested in their own networks. The business models of the federal government to provide free weather and climate information and the private sector to provide value-added information for profit, respectively, will have to be transformed in order to coexist. Such a transformation will require new ways of forming public–private partnerships. For example, the federal government may find it economical to buy data from private and academic sectors. Such new ways of the future may lead to new public–private partnerships conducive to forming a centralized NNoN.

Also, the private sector is not traditionally known for its appetite to invest in high-risk research and development programs, although such efforts are critically needed to ensure, for example, the mesoscale representativeness of the member networks. In other words, the new public–private partnerships will leverage the strengths and preferences of all three sectors to produce cost-effective mesoscale data collection capability across the United States.

While federal support for an NNoN may diminish due to budget constraints, and private-sector resistance against universal collaboration may increase, a weakening world economy, draconian budget cuts, etc., may force all parties to come together for a mutually beneficial arrangement as the NNoN.

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FOR FURTHER READING

AMS ad hoc Committee on a Nationwide Network of Networks, 2011: Report of the AMS ad hoc Committee on a Nationwide Network of Networks, 94 pp. [Available online at www.ametsoc.org/boardpges/cwce/docs/NoN/2011-12-NNoN-Draft-Final-Report.pdf.]

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