

EXECUTIVE SUMMARY

Has the Unidata program been a successful investment? How has it been successful and why? Has it been transformational in the way you conduct your teaching and/or research? These are important questions to which the Unidata Program Center (UPC) and the National Science Foundation (NSF) were seeking answers. Based on NSF panel recommendation and in consultation with NSF officials, the Unidata Program Center hired Nelson Consulting, LLC to conduct this independent study.

Unidata is a diverse community of over 160 institutions vested in the common goal of sharing data and tools to access and visualize that data. For over 20 years, Unidata has been providing data, tools, and support to enhance Earth-system education and research. In an era of increasing data complexity, accessibility, and multidisciplinary integration, Unidata provides a rich set of services and tools. In deciding the best methodology for this study, Nelson Consulting, LLC recommended the development of a survey, the use of focus group discussions, individual interviews, and case studies. The web-based survey was used to gather information from community members who were dispersed across 44 states and 37 countries. The information gathered from the survey was used to develop the focus group protocol. Individual interviews were used to engage community members who had been members of the Unidata community for five years or longer. This group of members offered a unique perspective about the transformative nature of Unidata's work. The case studies were also used to demonstrate how the Unidata program had contributed to transformative research to enhance Earth-system education and research.

The Unidata Program Center, as the leader of a broad community:

- Explores new technologies
- Evaluates and implements technological standards and tools
- Advocates for the community
- Provides leadership in solving community problems and develops innovative solutions and new capabilities to address community needs
- Negotiates for new and important data sets for use in research and education on behalf of the community
- Facilitates data discovery and use of digital libraries
- Enables student-centered learning in the Earth system sciences by promoting use of data and tools in education
- Provides software and tools for visualization and analysis of Earth system science data
- Provides support to the growing community
- Values open standards, interoperability, and open-source approaches
- Develops innovative solutions and new capabilities to solve community needs
- Stays abreast of computing trends as they pertain to advancing research and education in the geosciences
- Performs governance activities using a community-based approach

Every stage of this study offered an opportunity for the consultants to experience all the reasons why the Unidata program has been successful and the organizational excellence reflected in the daily operations of the Unidata Program Center. The staff is extremely knowledgeable, dedicated, and interested in promoting and sharing their work. Unlike some other organizations

where staff members hardly communicate with each other, it is obvious that whether a person works in software or in outreach, there is a sense of unity and equality among the personnel. Every person's contribution is viewed as important to the overall productivity of the organization. In addition to the outstanding staff and their sense of duty, the "community process" (which includes community engagement, governance, feedback, partnership, and support) is the most important factor in Unidata's success.

In conversing with the community members, the consultants learned that the Unidata program was irreplaceable. Faculty are exposed to technological developments that affect their discipline and that they find extremely valuable for their professional development and for their students. The program is truly community-based and this is reflected in its daily operations and also at the governing level. The community members expressed how impressed they were by the ability of the staff to respond to their inquiries in a timely manner. The Unidata program has established a reliable socio-technical environment that leverages developments in data delivery to maximize creativity and learning in the geosciences. For example, the smaller undergraduate institutions appreciate the fact that without the Unidata program, it would be impossible for them to experience the current level of collaboration with other larger institutions. The ability for professors and students to access software building blocks so that they do not have to re-invent the wheel is vital for improving productivity at a small institution. The Unidata program has encouraged the community to move toward open standards and this is revolutionary from the user's and data provider's perspective.

The Unidata program has truly transformed teaching in the field of geosciences. In one institution, this transformation led to a tripling of the undergraduate majors in the meteorology program. As explained by faculty members throughout this study, without the data and software provided by Unidata, the meteorology programs would be severely limited in their ability to carry out their mission. Unidata has helped these programs expand the spectrum of meteorological data and created the ability for faculty to easily interrogate data, allowing them to spend more time teaching and on research in atmospheric science. In another instance, the National Climatic Data Center frequently uses Unidata software and formats (netCDF), and their processing and access is moving towards Unidata-developed architecture. Overall, netCDF was frequently praised as a step toward a long term perspective on standard data formats, making this one of the most important case studies in this report.

The consultants were very impressed with the indirect benefits of the Unidata program. Indirect benefits are benefits that are not directly related to Unidata's mission but they occur because the Unidata community has leveraged the direct benefits of the program. For example, the University of Kentucky has been a Unidata member for several years and this has allowed the university to build a comprehensive outreach and educational program including weather-related products for Kentucky residents within the agricultural industry. The agricultural community informed the university that the educational products they provide are a "quantum leap forward" in agriculture. In another instance, a participant from a facility that does not engage in education or research explained that many Unidata products are used in support of the Space Shuttle program. For example, the Local Data Manager is indispensable to forecast operations and plans for larger uses supporting future manned and unmanned space activities that are currently underway.

In conclusion the Unidata program is in alignment with NSF's Goals for Ideas, People, and Tools because it has (a) facilitated a more inclusive workforce and increased the community members' information technology knowledge, (b) transformed the speed at which data can be accessed, displayed, and analyzed to promote academic learning, (c) transformed organizational

culture, and (d) contributed extensively to the transformational research at an institutional level by drastically reducing the amount of time and effort required to conduct research activities. In addition, the ability to visualize multiple types of data using a variety of views provides a unique learning experience for students interested in meteorology while giving students with different learning styles a way of engaging with the subject of meteorology. The Unidata workshops are highly regarded by the community with 97% of workshop participants stating they would recommend them to other people. Finally, the community-based governance works well in meeting community needs both at a personal and institutional level.

The overall perception of the Unidata Program is extremely positive based on the interviews, focus groups, survey outcomes, and case studies. The summary of recommendations outlined below are based on the outcomes of this study, statements made by community members, and statements made by Unidata personnel. The consultants are aware that it may take time to implement these recommendations; however, the effort would be a worthwhile investment. The Unidata Program can be improved by (a) the transfer of highly specialized knowledge to ensure continuity in projects, (b) hiring a QA/testing resource and/or technical writer, (c) implementing a cross-sharing of resources where developers test each other's code, (d) leveraging resources to assist in knowledge transfer of data sets, documentation, and reduction in the duplication of common process steps, (e) reviewing the current code control tools and determining if investing in new code control tools is beneficial, (f) seeking additional funding for on-site training at member universities, and (g) considering a follow up study to explore the indirect benefits of the Unidata program.

The quality of software and support offered by the Unidata Program to its community members is exceptional and community members were in strong agreement that Unidata has stayed true to its core values while accomplishing its goals. The Unidata Program is one of the most important things that UCAR has done over the years. The impact has been experienced by future scientists, educators, and students in the classroom, as well as other professionals. Unidata was repeatedly stated to be a model program by the community members. One respondent explained it as follows: “The Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI) is an organization representing more than a hundred USA universities – it is the Hydrology equivalent of UCAR. In recent years, with NSF support, CUAHSI has been working on providing hydrologists with better access to hydrology data. Most hydrologists would agree that the ultimate goal is to have an equivalent of Unidata for hydrology.”

It is fair to conclude that the Unidata Program has been successful because (a) the community is in relative agreement with the program objectives and outcomes, (b) feedback from the community is encouraged by the governing committees, (c) the workshops and training offered keep community members linked to the program, and (d) when problems arise, they are resolved in a timely manner.