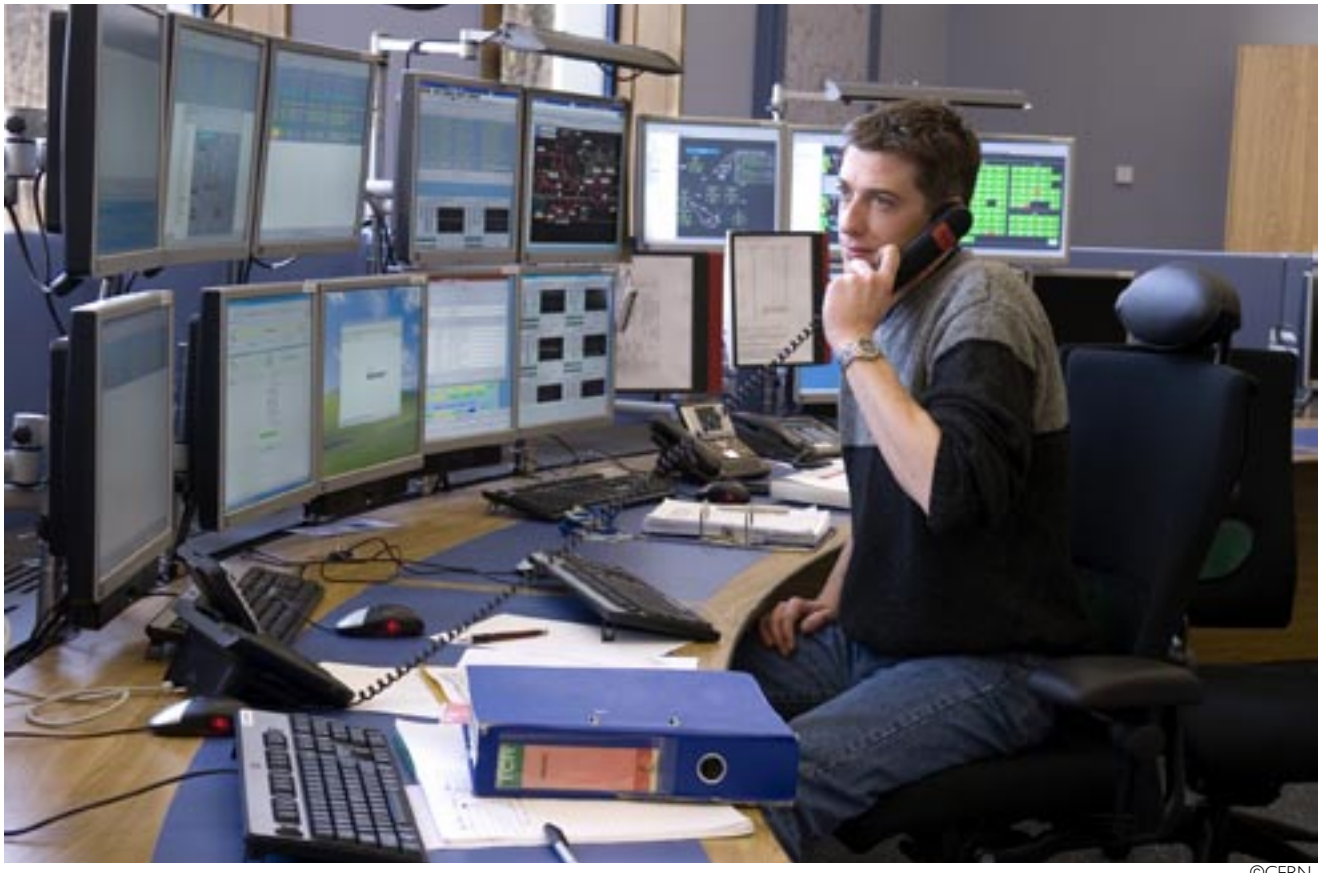
GLORIAD: Cooperation in Research and Education

Greg Cole, Principal Investigator



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The control center at CERN—the European Organization for Nuclear Research, a frequent user of the GLORIAD network—combines all control rooms for the accelerators, the cryogenic system, and the technical infrastructure.

China, Russia, and the United States have joined forces to build and manage a fiber optic network that circles the Northern Hemisphere, creating a high-bandwidth Internet-like system that links scientists, educators, and students worldwide. The Global Ring Network for Advanced Applications (GLORIAD, http://www.gloriad.org*), based at the University of Tennessee and the U.S. Department of Energy Oak Ridge National Laboratory, is funded by government agencies in the three countries and features partnerships with the world's most advanced research and education infrastructures in Canada, the Republic of Korea, the Netherlands, and five Scandinavian countries.*

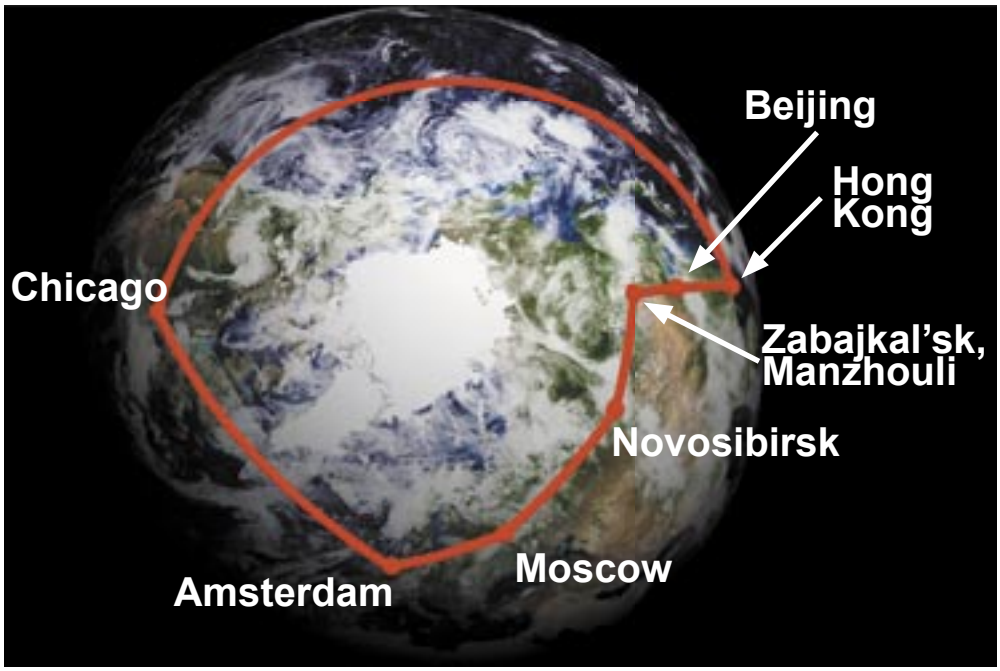
Courtesy of Greg Cole

Greg Cole

Greg Cole is principal investigator of the U.S. National Science Foundation program that established GLORIAD, and the program's predecessor, NaukaNet, with funding of $9.5 million (1998-2009). He co-directed (with Natasha Bulashova, now co-principal investigator of GLORIAD) the Ford Foundation-funded U.S.-Russian Civic Networking Program and directed other U.S.-Russia network infrastructure and community development programs funded by such organizations as NATO, the U.S. State Department, the Eurasia Foundation, Sun Microsystems, and others.

GLORIAD grew out of a successful U.S.-Russian initiative funded by the United States and Russia in 1997 to establish the first high-performance Internet between the U.S. and Russian science communities. The project, MirNET (later re-named NaukaNet), was a collaborative effort among the U.S. National Science Foundation (NSF); the University of Tennessee; the Russian Academy of Sciences; the Russian Ministry of Industry, Science, and Technology; and the Russian Research Center/Kurchatov Institute.

The idea was to connect research and education institutions in the United States via a major network exchange point in Chicago called STAR TAP—now called StarLight—with a similar facility in Moscow that connected nearly all research and education institutions in Russia. By establishing a fiber optic circuit across the Atlantic Ocean, Europe, and North America that connected the endpoints in Chicago and Moscow, we linked for the first time most major research and education institutions in the two countries.



Courtesy of National Science Foundation/T.Schindler

The route of an early version of the GLORIAD network that passes through Chicago, Amsterdam, Moscow, Novosibirsk, Zabajkal'sk, Manzhouli, Beijing, and Hong Kong.

Over the next several years, partnerships between U.S. and Russian scientists increased and network use grew dramatically. In 2003, we received permission from NSF to extend another connection to Russia, this time across the Pacific Ocean and, very importantly, through the People's Republic of China. We found partners connected in Hong Kong with our partners from the Chinese Academy of Sciences, then they connected the circuit from Hong Kong through Beijing and up to the Russian border near Khabarovsk. Our Russian partners extended their network to Khabarovsk, and Russia and China for the first time crossed their shared border with a telecommunications circuit. At that point, the ring around the Northern Hemisphere was complete.

The network was operating in early 2004. Later that year, NSF and our Russian and Chinese sponsors agreed to fund our new five-year program called GLORIAD, which expanded the service capacity of the ring around the Earth and implemented a new architecture for an advanced Internet. The new architecture lets us provide dedicated circuits to individual science collaborators that they can use for hours, days, or months, in addition to the shared services—like e-mail and videoconferencing—that we continue to provide.

In the last several years, science applications have grown to the point where some groups need the equivalent of their own Internet for a short time—either to move a lot of data or to ensure a quality experience, for example, in streaming high-definition video or remotely operating an electron microscope. The shared Internet is good for applications like e-mail that are not time or quality sensitive. But if you're remotely steering an electron microscope, you need an instantaneous response. That's one of the reasons we are building what we call a hybrid architecture with GLORIAD that allows us to provide dedicated circuits to scientists along with a shared Internet for their e-mail and Web applications.

The next step in developing GLORIAD was adding the Republic of Korea/Korea Institute of Science and

Technology Information as our fourth core member. They joined the project in 2005 and engineered and funded, thanks to the Korean Ministry of Science and Technology, a 10-gigabit circuit from Hong Kong, China, to Daejeon, Republic of Korea, to Seattle, Washington. This was the first piece of GLORIAD engineered to provide hybrid services. Our goal is to have the network operating around the Earth at 10 gigabits per second, and we're getting there one step at a time. With 10 gigabits per second, for example, we could support 25,000 videoconferences simultaneously, or roughly 1 million Internet telephone calls. Today, between the United States and China, and between the United States and Russia, we can support about a fourth of that.

The single biggest application running on GLORIAD at the moment is a connection between a high-energy physics institute in Italy and a cosmic ray detector facility, high in the mountains of Tibet, operated by the Chinese Academy of Sciences. An enormous amount of data is collected for analysis by scientists in Italy and China. That stream of traffic runs 24 hours a day. In the last hour, as I write this article, we've seen about 4 gigabytes of data travel between the sites.

Our second biggest application today is a data transfer from a NASA division, Engineering for Complex Systems, to the Chinese Academy of Sciences. We see a lot of space science research, particularly satellite imagery and atmospheric science data. Atmospheric sciences—climate scientists and weather forecasters—are among the heavier network users. These include the National Center for Atmospheric Research in Colorado, the Chinese Academy of Sciences in Beijing, and the Russian Hydrometeorological Center in Moscow.

We recently met with our GLORIAD partners in Moscow, where we learned about interesting telemedical applications. Our Russian partners have developed equipment that uses data from magnetic resonance imaging equipment to produce three-dimensional, life-size polymer models of patient organs, including the brain. It requires an enormous amount of data. These models are then used for analysis and for preparing appropriate surgical plans.

These are just a few examples of applications that you can't run over today's Internet, even with a broadband connection. That Internet just does not support the quality or throughput our science communities need.

One of the issues we deal with is cybersecurity—all the countries involved in GLORIAD try to deal with it collaboratively. We've developed some interesting applications that allow us to monitor use of the network, and we're developing some capabilities now to monitor abuse of the network. One of the problems we have at times is denial of service attacks, in which people orchestrate flooding a site, say in Moscow, with data from many sites around the world simultaneously, essentially shutting down the site. The sites receive so much data that the computing device can no longer keep up. There are many examples of how people misuse communications networks, and one important part of our effort in the United States is to research and implement safeguards against those abuses.

Throughout the project's development, network use has been limited to the research and education communities. Most of our customers are university researchers, but most of our traffic comes from national laboratories and other federally funded research facilities—including NASA, the Department of Energy, the National

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U.S., Russian, and Chinese scientists involved in the Compact Muon Solenoid Collaboration at CERN use the high-capacity GLORIAD network to transmit results of their experiments.

Oceanic and Atmospheric Administration, and the National Institutes of Health.

More than half our traffic today with Russia and China is sourced at federally funded facilities, where the big data archives reside. Most traffic is to and from our international partners—Russia, China, South Korea, and now the Netherlands, Canada, and the Scandinavian countries. Through a network called NORDUnet, our newest partners are Denmark, Sweden, Norway, Finland, and Iceland. NORDUnet is one of the most innovative networking groups in the world. They were involved in developing the early international Internet and have continued to be innovators in developing advanced network services. They will be contributing to GLORIAD a wavelength (a 10-gigabit-per-second circuit) from the Netherlands across Europe and to as close to the Russian border as possible.

In a sense, the network is about two things. It's connecting computers and instrumentation to allow scientists to share ideas and data, but it's also about improving our ability to communicate.

One thing for sure about GLORIAD, no matter how fast we move on increasing capacity and services on the network, the various science groups out there are moving faster. We're seeing many terabytes (1 trillion bytes) of data transferred each month and expect petabytes (1 quadrillion bytes) in the not-so-distant future. So it's a real challenge for us, but it's a good challenge. ■