RUNNING A RESEARCH CRUISE FROM SHORE

Telepresence Technology

Telepresence, in this context, refers to the suite of technologies and operational methodologies required to allow key mission personnel to be located onshore while conducting ship-based oceanographic research and exploration. The technology required to support telepresence largely consists of a high-powered satellite-tracking antenna, advanced networking infrastructure, video/audio broadcast equipment and a suite of software tools for data sharing across the satellite network. This article attempts to explain the nuts and bolts of ship-to-shore telepresence systems.

As a rule, exploring the unknown ocean cannot be accomplished effectively by a small group of scientists and engineers on board ships. They must rely on the telepresence connection to engage with other shore-based participants to make critical decisions during the ROV dives about where to explore, what features to inspect in more detail, what samples to collect and to log observations about the seafloor and water column, including descriptions of the geological, biological and archaeological character of the site. The Ocean Exploration Trust's E/V Nautilus and the National Oceanic and Atmospheric Administration's Ship Okeanos Explorer conduct telepresence-enabled systematic ocean exploration (Figure 1). The Inner Space Center (ISC) at the University of Rhode Island Graduate School of Oceanography is the shore-based hub for telepresence where scientists and students can work and stand watch during the live dives, interacting with the teams on board to make exploration more efficient (Figure 2). The ISC's servers also record and distribute the live video feeds to the Internet so that remote cruise participants located anywhere can also take part in real-time. The ISC has a full video production studio and broadcast facility (Figure 3) that supports live educational programme delivery to schools and informal science educational venues such as museums and aquariums as part of a broad outreach programme.

During recent years, the infrastructure required to support this telepresence paradigm has evolved to become technically robust and the methodologies have become relatively straightforward. Because of this, researchers who conduct seagoing projects on other ships, such as those in the University-National Oceanographic Laboratory System (UNOLS) fleet, can easily incorporate a telepresence component to their research and educational outreach. Most research ships have some sort of satellite tracking antenna and a ship-to-shore network infrastructure that can be enhanced to support a telepresence operation. By simply procuring additional satellite bandwidth, adding some enhanced components to the ship's satellite network and adding a technical system for live audio/video streaming, this telepresence component can be achieved.

A mobile telepresence unit (MTU, Figure 4) can be used to deliver the live feeds and facilitate voice communication. The devices that make up this technology can include encoders, voice-over-IP intercom panels, video conferencing systems, audio mixers, video switches, network switches, and devices for video effects like quad-splitters, frame synchronisers and scan

converters. This gear is more-or-less standard in the broadcast industry and is needed to provide a quality experience for the end users ashore to effectively communicate with the team on board. A simple MTU system can range in cost from about a few thousand to several 10's of thousands of dollars. The shipboard telepresence systems can integrate into the ship's networking infrastructure, integrate with the ship's video surveillance systems, integrate with the ship's voice communication systems and be compatible with the shore-based infrastructure. Occasionally, depending on the network design, a VPN or GRE tunnel may be required to facilitate effective equipment configurations and device communication.

For example, a UNOLS ship owned by the National Science Foundation and operated by the University of Rhode Island Graduate School of Oceanography, the R/V *Endeavor*, was recently equipped with telepresence technology. The technology allowed a shore-based chief scientist, who was not medically cleared, to sail on the cruise to conduct her cruise on schedule. Working with an autonomous underwater vehicle (AUV), a glider, a wire-walking profiling instrument, and a CTD to accomplish the research goals of the cruise, Dr. Melissa Omand led the team on board by communicating constantly through the telepresence system, assisting with data analysis, and providing remote technical support on deck and in the main lab. Several cruise participants used video cameras and microphones to connect live and support Dr. Omand's remote participation (Figure 5). The ISC served as the primary shore-based hub for conducting the cruise operation, and live video streams to the Internet allowed other remote scientists to participate or allowed for Dr. Omand's participation from her home.
Satellite bandwidth can be expensive, depending on the dates and duration of the cruise, the geographic location, and the minimum bandwidth required. Satellite service providers require a 'link budget' to be computed that factors in the technical capabilities of the shipboard tracking antenna (such as the diameter of the reflector and power of the amplifier) and at the terrestrial earth station teleport. Once all these details are known, providers can develop budgetary quotes for the ship-to-shore Internet service. Depending on the technical details, monthly costs can be anywhere from USD5,000 to USD50,000 per month for upload bandwidth in the range of 1.5 – 20Mbps, with smaller return (download) bandwidth. Traditionally, ISC supported telepresence cruises have relied on C-band or Ku-band satellite service. Recent advances in Ka-band capable satellites will potentially allow for much greater bandwidth. The transmission delay for live video and audio to be received onshore is only between 1-2 seconds, typically, depending on the locations, allowing for effective communication. With the capabilities of Internet2 and multicast-enabled terrestrial networks, the live video/audio streams can be globally distributed in near real-time, making it possible to support the communication between the shipboard personnel and anyone in the world.

The total cost for added satellite bandwidth for a one-month cruise, combined with the cost for some extra technical personnel on board and ashore, along with the cost for the extra ship- and shore-based infrastructure still amounts to less than USD100,000 for the duration of a typical cruise, which is equivalent to the cost of about 2 ship days. Telepresence can increase the efficiency of the cruise by allowing more users to participate, increase the broader impacts of the project by having scientists and educators engage with vast audiences, and allow for shore-based teams to communicate, troubleshoot, process data, increase awareness, build a web presence, and educate students in real-time. These efficiencies greatly outweigh the cost.

By combining the advances in satellite telecommunications, Internet2 and multicast-enabled networks and encoded video/audio streaming technology, the telepresence paradigm has been proven effective and is incredibly powerful and robust. Instead of the traditional way oceanographers and technicians have conducted their seagoing business in the past, with science parties of a few dozen people, telepresence can now allow for infinite expansion, broadening the participation globally to all populations. As proven by the Nautilus programme (www.nautiluslive.org) and the *Okeanos Explorer* programme (www.oceanexplorer.noaa.gov), telepresence has allowed for live ROV dives to be viewed by usually hundreds and occasionally thousands of people at a time. New discoveries on the seafloor and scientifically interesting and engaging video content of geologically, biologically and archaeologically significant sites has been key to exciting new generations of ocean explorers. Through these websites and through the video broadcast studios at the ISC, learners of all ages can contribute to the live discussions, ask questions and get live answers about the ongoing research. Telepresence can enable cruise participation by anyone, including those people who are not physically able to go to sea. And telepresence can enable technical troubleshooting of equipment, allow for communication between users on board and vendors ashore, and help facilitate the technical success of seagoing expeditions to remote places that would otherwise be inaccessible.

More Information

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