TELEPRESENCE GUIDANCE

FOR

SCIENTISTS AND SHIP OPERATORS

February 16, 2016

UNOLS

UNIVERSITY-NATIONAL OCEANOGRAPHIC LABORATORY SYSTEM

Introduction

Telepresence refers to a suite of communication technologies and methodologies that provide a means for individuals or groups to participate in ocean science research cruises from remote locations. The implementation of telepresence allows for shore-based users to participate at sea without being physically present on ship. This is not a new idea and has been practiced for decades by government agencies and the private sector. However its introduction within the world of oceanography is relatively new, particularly with the advent of National Oceanic and Atmospheric Administration's Ocean Exploration Program (NOAA OER). Ships such as the NOAA Ship *Okeanos Explorer* and the Ocean Exploration Trust's E/V *Nautilus* have implemented telepresence-based operations that can serve as a model for other ships and programs. The technology has also been tested on several University National Oceanographic Laboratory System (UNOLS) vessels.

Telepresence can be supported with technology as simple as a computer based camera and applications, such as Skype, allowing seagoing scientists to connect to a single shore-based classroom or facility. Or, telepresence can be used to reach out to a larger Internet-based audience, requiring more advanced shipboard and shore-based equipment, which allows for high quality communications and for distributing high quality Internet broadcasts. With even further sophisticated technologies and methodologies, telepresence-based science is possible, where a number of audio, video, and data streams are broadcast live from the ship to shore-based scientists making real-time cruise decisions.

Telepresence is also a powerful education tool that can be used to connect scientists, students, teachers, and the public on shore to live images and real-time data, inspiring interest and enthusiasm about ocean science, research, and education. It is also an effective tool that can assist research vessel operators and crew to more efficiently manage cruise logistics, personnel safety and health, equipment maintenance and technical support, and assist in the general well-being of cruise participants.

General Information and Requirements

There are different levels of telepresence technology that can be used, depending on the desired outcome. Each increasing level of telepresence requires increasing amounts of bandwidth, equipment (both shipboard and shore-based), and personnel, which usually increases costs. For each level, it is important that the end-user viewing device and screen size are identified as this will help drive decisions about the hardware and software needed create the best output within the bandwidth budget.

Level 0: Minimal connectivity (no additional bandwidth or shipboard equipment required)
Level 0 telepresence is the most simplistic form and consists of using equipment already owned (such as a computer with an integrated camera), an off the shelf computer program (e.g., Skype, Webex, Google Hangouts) and standard UNOLS bandwidth levels (256Kbps ship-to-shore) to transmit audio and video in real time to one location. This method has been employed from a number of UNOLS vessels where a shipboard scientist(s) uses his/her own computer and a video-chat program to call into a shore-side classroom. This level of telepresence is usually for purposes of outreach, to engage the students in real-time discussions about the shipboard operations and science at hand. Video, because it is often limited to an integrated camera, is usually limited to the scientist(s) making the connection. Although it sounds simple, it is often difficult to make this an effective experience, as shipboard bandwidth levels are barely large enough to support this operation, and both audio and video quality can be, and often are, less than clear.

Requirements:

Bandwidth: 256Kbps ship-to-shore.

Shipboard Equipment: Computer with integrated camera and associated software.

Shipboard Personnel: A host of the session is required.

Shore-based Equipment: None.

Shore-based Personnel: None.

Level 1: Public Viewing (additional bandwidth and shipboard camera system required)

Level 1 telepresence involves the broadcast of video and audio in real-time to a designated shore-based server and website for passive viewing by invited audiences or the general public and media outlets. The video quality is standard definition (SD), which is good enough for viewing on a small computer monitor, but becomes pixilated on a larger screen. Depending on how it's configured, this may require shore-based support personnel and equipment in addition to the dedicated systems and personnel on the ship.

Requirements:

Bandwidth: 1.5-2 Mbps (ship-to-shore), 1 stream of SD video.

Shipboard Equipment: Mobile Telepresence Unit (MTU, see Appendix C for description).

Shipboard Personnel: 0.5-1 shipboard personnel dedicated to organizing the broadcast and operating the camera and MTU.

Shore-based Equipment: Dedicated server and possibly a video streaming service provider such as a Content Delivery Network (CDN).

Shore-based Personnel: Part-time technical personnel to set-up and monitor the equipment feeding the stream to the website.

Example:

Level 1 telepresence was implemented on a cruise in 2012 aboard the R/V *Roger Revelle*, jointly funded by the National Science Foundation (NSF) and the NOAA Office of Ocean Exploration and Research (NOAA OER), to broadcast the activities associated with the exploration of the Northern Lau Basin, Submarine Ring of Fire Expedition, using the Quest 4000 ROV system operated by the MARUM Center for Marine Environmental Sciences (University of Bremen, Germany). The goals of the project were to explore and characterize ecosystems within the basin through examination of their biology, chemistry, and geology. The telepresence component included live broadcasting of the video captured by the ship's Remotely Operated Vehicle (ROV), revealing active hydrothermal venting and other volcanic processes. The video was associated with live audio from the scientists onboard (primarily PI's Joe Resing and Bob Embley of NOAA Pacific Marine Environmental Lab (PMEL)), who were describing their observations from the ROV control room. Audiences were engaged through the NOAA Ocean Explorer website and through special invitations for live audiences at a limited number of selected venues. The live feeds were received at URI-GSO's Inner Space Center (ISC) and rebroadcast to the Internet. An MTU was developed by NOAA-OER to support the project, and a video broadcast engineer was hired to take part onboard the cruise to facilitate the telepresence activities. The satellite bandwidth was procured through HiSeasNet and increased to approximately 1.5 Mbps.

Level 2: Remote Learning, Outreach, and Media Events (additional bandwidth, shipboard camera system, and shore-based equipment and personnel required)

Level 2 telepresence supports events targeting smaller audiences (e.g., classrooms, aquariums, museums, and science centers) to events targeting larger audiences and mass media outlets (e.g., television). Level 2 telepresence is typically implemented entirely by representatives of the science party. The events are supported by a specific shore-based location that manages the audio and video call-in of the at-sea teams. Video quality can still be standard definition that is good enough for viewing on a small computer monitor, but become pixilated on a larger screen.

Requirements:

Bandwidth: 1.5-2 Mbps (ship-to-shore) and 256Kbps (shore-to-ship). 1 stream of SD video; 2-way audio communication.

Shipboard Equipment: Mobile Telepresence Unit (MTU, see Appendix C for description).

Shipboard Personnel: 0.5-1 shipboard personnel dedicated to organizing the broadcast and operating the camera and MTU, and coordinating with shore-based personnel for planned outreach and remote science activities.

Shore-based Equipment: Dedicated servers and video teleconferencing systems, in addition to website broadcast equipment.

Shore-based Personnel: A part time technician and potentially a part-time educational coordinator.

Example:
Level 2 telepresence was used on the R/V *Thomas G. Thompson* in 2014 during a research and exploration cruise, jointly funded by NSF and NOAA OER to the Kermadec Trench region. This expedition used benthic lander systems and the Hybrid ROV (HROV) *Nereus*. Project Co-PI Timothy Shank (Woods Hole Oceanographic Institution- WHOI) coordinated with the ISC and WHOI's National Deep Submergence Facility (WHOI NDSF) to use the *Jason* ROV team's MTU to broadcast live video from the shipboard control room during *Nereus* dives to the bottom of the trench. One of the goals of this Hadal Ecosystems Studies (HADES) program was to characterize one of the deepest marine habitats on earth, the hadal zone with the Kermadec trench, through video observations and biological/geological/chemical sampling. During the cruise, live video was streamed to the ISC where it was received, recorded, and redistributed via the HADES and ISC websites. Dr. Shank provided dive narrations that described the scientific activities through the MTU using the ship's intercom system to reach the ISC. A dedicated videographer and science communicator onboard was trained in the MTU's operation, and together with the onboard marine technicians, worked to support the telepresence operations. One high-profile live event was produced using the telepresence connection and ISC's production studio. A large audience associated with a National Centers for Ocean Sciences Education Excellence (COSEE) Network conference in Washington, DC was convened at the Smithsonian Institution's National Museum of Natural History, inside their new Q?RIUS education facility. This audience included ocean scientists and educators, plus federal agency representatives. Working together, the team members on the ship and at the ISC created a live program centered on the shipboard activities and featured the ROV dive footage to communicate the story of the expedition. The audience was then able to ask questions of Dr. Shank onboard the ship and of scientists in residence in the ISC (in real time) and receive live answers, through the interactive capabilities of the MTU and ISC facility.

Level 3: Telepresence-Enabled Science (additional bandwidth, powerful satellite antenna amplifier, upgraded satellite modem, shipboard camera system, and shore-based equipment and personnel required)

Level 3 telepresence allows for full engagement between a shipboard science team and a shore-based science team. Each team is participating in the shipboard science operations and the decisions around the at-sea operations through high definition (HD) video, two way audio, and data transfers. Level 3 telepresence is typically supported entirely by representatives of the science party and is best conducted at a facility that is equipped to handle high-definition video and real-time two-way audio, such as, URI's ISC.

Requirements:

Bandwidth: 6-20 Mbps (ship-to-shore) and at least 512Kbps (shore-to-ship). Usually more than 1 stream of HD video, 2-way audio communication, large file transfers, ability to support a robust shared network infrastructure.

Shipboard Equipment: An advanced telepresence system (potentially van-based) consisting of either a MTU or more sophisticated video broadcasting equipment installed onboard, that integrates multiple camera systems and audio sources

Shipboard Personnel: At least 1 dedicated telepresence technician onboard to manage the hardware and support most audio/video system; at least 1 dedicated member of the science party to coordinate the telepresence operation.

Shore-based Equipment: Advanced video broadcast, audio, and data server equipment and software, capabilities such as those at Exploration Command Centers or Inner Space Center facilities.

Shore-based Personnel: Full-time technical personnel and potentially a part time science party coordinator and/or educational outreach coordinator.

Example 1:
Level 3 telepresence was implemented on the R/V *Atlantis* in the summer of 2013 during two NSF-funded cruises along the Cascadia Margin and Juan de Fuca Ridge Flank. The ROV *Jason*, part of the WHOI NDSF, was used during both projects. The first cruise was in support of the Cascadia Initiative (PI Douglas Toomey/University of Oregon), led by co-chief scientists Anne Tréhu/Oregon State University and Dean Livelybrooks/University of Oregon, to use the ROV *Jason* to assist in the recovery and deployment of a large number of ocean bottom seismometers from various water depths off the Cascadia coast (Figure 4). The second cruise was to deploy *Jason* to work with instrumentation and collect samples as part of a hydrogeologic experiment using a borehole network on the eastern flank of the Juan de Fuca Ridge, led by PI and chief scientist Andy Fisher/University of California, Santa Cruz. The OET and the ISC equipped and installed a fly-away C-band satellite system and control van onboard the ship for establishing the high-bandwidth ship-to-shore link. A satellite technician was required to help install and configure the system, and participate onboard during the first cruise and to train personnel to support the second cruise. The Verizon company provided the satellite bandwidth and terrestrial infrastructure for linking the ship to the ISC. The *Jason* MTU was used to support the telepresence interactions. The shipboard teams included educational outreach professionals who took part in a new education program called *Exploration Now* – designed to link museum and aquarium audiences with the scientists leading the expeditions. In all, more than 50 educational broadcasts were delivered to live audiences who connected to the ship through the ISC. The audiences were summer visitors to several venues including Mystic Aquarium, the Houston Museum of Natural Science, Texas State Aquarium, and the Aquarium of the Pacific, among others. The outreach professionals, typically participating scientists and teachers-at-sea, onboard the ship served as hosts and communicators who delivered the broadcasts, explaining the onboard research and answering audience questions. The production team at the ISC enhanced the broadcast by mixing in pre-recorded produced packages or dive video highlights from the expedition's live or previous Jason dives. The entire project has been summarized in the following supplement to Oceanography magazine, and in several 2013 AGU abstracts and presentations:

Coleman, D. F., D. Livelybrooks, S. Katz Cooper, G. Mulder, A. T. Fisher, A. M. Tréhu, and D. R. Toomey, Expanding the Telepresence Paradigm: Live Interactive Programming from R/V *Atlantis* and ROV *Jason in* Bell, K.L.C., M.L. Brennan, and N.A. Raineault, eds., 2014. New frontiers in ocean exploration: The E/V *Nautilus* 2013 Gulf of Mexico and Caribbean field season. Oceanography 27(1), supplement, 52 pp, http://dx.doi.org/10.5670/oceanog.2014.supplement.01.

Example 2:
Level 3 telepresence is carried out on a regular basis each year onboard OET's E/V *Nautilus,* through the Nautilus Exploration Program. One recent example, conducted during October 2014, was the NSF-funded Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) project, *TREET: Transforming Remotely-conducted*

Research through Ethnography, Education & Rapidly Evolving Technologies (www.whoi.edu/treet), which conducted its research onboard the E/V *Nautilus* using the ROV *Hercules*, but with all research operations coordinated from shore, via the ISC's Mission Control facility. The TREET project was a particularly valuable example of a Level 3 telepresence cruise because in addition to the ocean research and exploration pursued, the project also explored the complex interface between scientific fieldwork, new educational opportunities for undergraduate students, and the expanding use of telepresence technologies to make remote exploration available to scientists, students, and the general public. Thus, while a team of 6 early career scientists (4 on shore, 2 at sea) and undergraduates from three universities (Harvard, Idaho, and Michigan State; all based ashore) coordinated their research between the ship, the ISC, and a satellite Exploration Command Center at WHOI, a further team of education and ethnography researchers from the Concord Consortium and Harvard's Kennedy School both observed and interacted with the shipboard research team - both to provide real-time feedback on how to make more effective use of the technologies at hand, and to collect their own data for subsequent analyses. This research should lead to recommendations on how to use telepresence more effectively in the future.

Proposal Preparation and Pre-cruise planning

Telepresence technologies have been utilized on UNOLS vessels in the past, but it remains a relatively new tool for the oceanographic community. Most UNOLS ships are not equipped to support telepresence beyond level 0. With proper funding, time, and planning, any of the above-listed levels can be achieved. The number one rule in planning to utilize telepresence technologies and methodologies is to start early, beginning with the project's conception; each step in setting up telepresence - acquiring additional bandwidth, finding and testing the necessary equipment, finding qualified personnel - takes time. Last minute requests are difficult, but not impossible, to fulfill.

Additional equipment needed to conduct telepresence is available within the UNOLS community. The primary bandwidth provider, HiSeasNet, can, with time and funding, support additional bandwidth requirements for telepresence. The R/V *Endeavor*, the R/V *Sikuliaq*, and the *Jason* ROV have versions of MTUs required to support some level 1 and all level 2 telepresence. The ISC has all of the shipboard and shore side equipment and personnel needed to support all levels of telepresence. Through early coordination, these ISC facilities can be made available for users on almost any research vessel.

If funding to support a telepresence operation is requested from NSF, NOAA, or ONR, the justification and a budget must be added to the science proposal. Costs are dependent on the level of telepresence and the number of days it is used at sea. Estimates should include allowances for procuring the extra satellite bandwidth; purchasing or renting telepresence equipment; hiring shipboard technical support personnel; and securing shore-based equipment, services, and partnerships. A cognizant program manager(s) is a good resource for discussing proposals that include telepresence.

Cost Estimates

For general guidance regarding telepresence and to obtain cost estimates for required resources, contacting the ISC (info@innerspacecenter.org) is a good first step. The Center's experience supporting various levels of telepresence on the NOAA Ship *Okeanos Explorer*, E/V *Nautilus*, and UNOLS vessels make them the community expert.

Bandwidth Requirements

The UNOLS primary bandwidth provider, HiSeasNet (http://hiseasnet.ucsd.edu/) can provide estimates on the cost of the required bandwidth. The cost and availability of satellite bandwidth for a planned cruise is primarily a function of geographic location, dates requested, duration, and minimum bandwidth required. All of this information needs to be gathered prior to any discussion with the service providers. The ISC can provide guidance on bandwidth requirements. Satellite time often costs the same for two weeks as it costs for an entire month, and providers will rarely just turn up the bandwidth for short bursts of time. The HiSeasNet group will be able to provide an estimate during the proposal phase, but absolute costs for bandwidth are not known until contracts are in place (i.e. the project is funded and ready to go).

Cruise Planning

Once a cruise is funded and scheduled, it is very important to involve the ship operator in telepresence planning immediately. The operators can help with ideas on how telepresence can be utilized on their ship – what space might be available, existing equipment, deck layout, etc. The operator will work directly with the HiSeasNet group to set-up the extra bandwidth and can help with the technical details of setting up any additional shipboard equipment.

Regardless of the level of telepresence and funding source, it is still crucial to start the planning process early. Community resources and contacts for telepresence implementation can be found in Appendix A.

Implementation at Sea

The Levels of telepresence operations will have widely varying affects on shipboard operations. Level 0 may only affect Internet connectivity for designated periods, while Levels 2 and 3 may have live cameras recording daily operations. No matter what the level, it is important that the entire science party, crew, technicians, and shore-based managers are aware of the telepresence operations and how it will affect them. Communication is key. Although it sounds like there are a lot of challenges implementing telepresence, when telepresence operations are performed correctly, everyone on the cruise will benefit whether it be to satisfy education, outreach, or scientific goals or simply to increase Internet connectivity.

Guidance for the Science Party

Below are some level specific guidelines for the science party.

Level 0

- Check with the ship's operator and Internet service provider when your ship is assigned to make sure all requirements can be met.
- Conduct a technical test with the receiving venue prior to the live event to check quality and latency of the video and audio.
- NOTE: The ship's antenna may be shadowed at certain headings. It is important to check with the ship operator and make sure this heading is avoided during the event.
- During an event, most if not all of the ship's bandwidth will be utilized to support the event's video and audio. Be sure to communicate the time of the event to ensure that others onboard are not competing for bandwidth during that time.
- It is wise to isolate the broadcasting equipment on the network just for the event.

Level 1

- All bullets for Level 0 apply
- If a Mobile Telepresence Unit (MTU) will be utilized, either a shipboard technician or a member of the science party will need to be trained and responsible for its operation.
- Careful coordination with the shore-based team is required.
- For simple live streaming to a public website, it's recommended that best practices be followed for the website development process, development of user interfaces, and general recommended digital media practices associated with social networking and other online tools to enhance the user experience.

Level 2

- All bullets for Level 1 apply.
- A telepresence technician and/or videographer/documentarian is/are highly recommended to support the operation technically and logistically.
- Technical testing directly with the venues prior to the real event is of utmost important.

- To receive HD video broadcasts, the shore-based venues need to have a robust Internet connection and use high quality videoconferencing equipment and/or advanced computer equipment designed to handle the decoding of high-bandwidth video.
- The science party will need to work with the Captain to inform the crew of the locations of the live onboard cameras and the schedule during which they will be operated. Emails summarizing the operations with notices and schedules posted on doors near the live cameras are a good way to keep everyone onboard informed.
- It may be required for some shipboard personnel to sign waivers acknowledging that there are live cameras filming their actions. NOTE: It is important that information regarding the telepresence operations be circulated well in advance of the cruise so that any questions/objections can be dealt with before they become an issue.
- If there are objections to the way telepresence is envisioned or being carried out, the scientists may be required to limit the telepresence operation to a well-defined and controllable space.

Level 3

- All bullets for Level 2 apply.
- Several personnel, both onboard and onshore, should be completely dedicated to the telepresence operation to coordinate watches and regular communications with shore-based team(s).
- Management of the shore-based team's expectations is very important; regular meetings such as daily conference calls are important. It is up to the shipboard team to fully communicate with the shore-based team, who often can be in the dark with all the operational decision-making processes that occur onboard.

Guidance for RV Operators and Technicians

The Levels of telepresence operations will have widely varying affects on shipboard operations. Level 0 may only affect Internet connectivity for designated periods while Levels 2 and 3 may have live cameras recording daily operations. No matter what level, it is important that the entire crew, technicians, and shore-based managers are aware of the telepresence operations and how it will affect them. Communication is key.

Below are some level specific guidelines for technicians and operators.

Level 0

- Work with the scientists in the early planning stages to understand what they are trying to accomplish with telepresence and how they hope to achieve it.
- The Marine Technician (MT) will be required to assist the science party with hook-up to the satellite systems and network configurations to support the system to be used (Skype, Google Hangouts, etc.).
- The MT will need to work with the Captain to inform the crew if the shipboard Internet will be blocked during telepresence events.
- The MT should work with the science party to test the software and connection prior to the real event.

Level 1

- All level 0 bullets apply.
- Pre-cruise planning to work with the primary Internet provider and arrange for extra bandwidth requirements and work with the scientists to understand and plan for any additional shipboard equipment.
- The MT will be required to help with satellite and network configurations to support the event, usually in collaboration with the Internet service provider.
- If an MTU will be utilized, either a shipboard technician or a member of the science party will need to be trained and be responsible for its operation. NOTE: The MTU operator must be decided upon early in the cruise planning stages.

- The MT may be required to help with the configuration of various audio and video devices that scientists need to operate.

Level 2-3

- All level 1 bullets apply.
- The Science party will be primarily responsible for the telepresence operations, but they will need to be in close coordination with the MTs and ship crew.
    - Pre-cruise planning to understand what, where, who, and how they will be conducting operations is pertinent.
    - During cruise the MTs and crew must be in constant communication to ensure there are no surprises that could interrupt operations.
- Additional real-time or near real-time data products will most likely be required for the shore parties. These deliverables should be ironed out during the pre-cruise planning to ensure there are sufficient personnel to meet the demands.

Appendix A – Community Resources and Contacts

UNOLS Office
Alice Doyle
alice@unols.org
970-403-3874

HiSeasNet Contact Information
Kevin Walsh
Scripps Institution of Oceanography
858-822-3356
hiseasnet@ucsd.edu
http://hiseasnet.ucsd.edu

URI Inner Space Center
Dwight Coleman
URI Graduate School of Oceanography
401-874-6637
dcoleman@uri.edu
http://www.innerspacecenter.org

Appendix B – Vessel SatCom Systems and Capabilities

U.S. Academic Research Fleet Ship/Shore Communication Capabilities

Vessel	Class	SatCom System(s)	Level 0	Level 1	Level 2	Level 3
REVELLE@	Global	C-band, FBBx2	X	X*	X*#	X*#!
THOMPSON@	Global	C/Ku-Band, FBB	X	X*	X*#	X*#!
ATLANTIS	Global	C-band, FBBx2	X	X*	X*#	X*#!
SIKULIAQ	Global	C-band, FBB	X	X*	X*	X*!
LANGSETH	Global	C-band, FBBx2	X	X*	X*#	X*#!
ATLANTIC EXPLORER	Ocean/Int	Ku-band, FBB	X	X*^!	X*^!#	X*^!#
ENDEAVOR	Ocean/Int	Ku-band, FBB	X	X*^	X*^	X*^
KILOA MOANA	Ocean/Int	C-band, FBB	X	X*	X*#	X*#!
NEIL ARMSTRONG	Ocean/Int	FBB	X	X*	X*#	X*#
OCEANUS	Ocean/Int	Ku-band, FBBx2	X	X*^!	X*^!#	X*^!#
SALLY RIDE+	Ocean/Int	FBB	X	?	?	?
SHARP	Regional	FBB	X	X*^!	X*^!#	X*^!#
BARNES	Coastal/Local	FBB	X			
BLUE HERON	Coastal/Local	FBB	X			
PELICAN	Coastal/Local	FBB	X			
SAVANNAH	Coastal/Local	FBB	X			
SPROUL	Coastal/Local	FBB	X			
WALTON SMITH	Coastal/Local	Ku-band, FBB	X	X*^!	X*^!#	X*^!#

* Additional bandwidth required

^ Site location limited to Ku footprint

Mobile Telepresence Unit and other shipboard video equipment required

! Antenna upgrades or auxiliary antenna required which are limited to vessel size and requirements.

+ Vessel is still under construction at time of writing. SatCom Systems are not yet finalized.

@ The amplifier on the REVELLE and THOMPSON C-band antennas are scheduled for upgrade in late 2016 (estimate), both will be capable of Level 3 Telepresence without the need for an auxiliary antenna.

Appendix C – Mobile Telepresence Unit (MTU) Description

The MTU is the technical system for delivering telepresence broadcasts and supporting live two-way audio interactions. Each device is configurable to the specifications for the ship's layout, network infrastructure, and bandwidth. The picture below depicts the primary elements to a shipboard MTU.

This particular MTU was designed for the R/V *Endeavor*. It is nearly identical to the MTU designed for the Jason II ROV, which was adapted and used to support a telepresence program onboard the R/V Thompson supporting the HROV *Nereus*. The system shown here, developed by the Inner Space Center is highly portable and relatively low cost. Other MTU systems have been developed to support other platforms, with other requirements, and were generally more expensive to build and more complex to configure and operate.

Fundamentally, the MTU has the ability to ingest and transmit multiple video and audio inputs. Those feeds can be previewed and switched between to generate the input to the video broadcast encoder, which streams the feeds over the satellite Internet connection to a shore-based decoder or computer system. In near real-time, the shore-based systems can turn the stream back into raw video that can then be viewed, recorded, transcoded, redistributed, and/or used as part of a live video production or broadcast. Generally, the MTU setup, configuration, and operation will require some dedicated people and some testing time to work out the customizations particular to different ships, satellite systems, and network infrastructure. The MTU requires power and a shipboard Internet connection.