Ship Presence:

A Collaborative Journey

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25 June 2020
Revision - 1.200629
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Introduction

The Academic Research Fleet (ARF) consists of numerous vessels which are important mobile platforms for studying world oceans, they offer a unique opportunity to immerse oneself in the study of Oceanography and all its disciplines. A successful scientific cruise is dependent on a number of people including scientists, crew, technicians, graduate students, and outreach personnel. As the ability to collect more and more data increases, the number of cruise participants that can sail is diminishing. Near real-time data (NRT), real-time Access (RTA), and traditional telepresence offer shore participants the opportunity to remain involved and collaborate with science at sea.

Near real-time data (NRT), is data collected on the ship either by the ship's underway systems or science installed equipment. It is collected and then synced to shore within minutes of collection. Running a basic quality check and/or processing of NRT data can provide state-of-health information to ensure optimal operation and help predict sampling opportunities. Having NRT available on shore for shore participation and involvement can help mitigate issues when sailing with a smaller science party. There are numerous mechanisms for transferring NRT data to shore some of which will be discussed later in this document.

Real-time access (RTA) to data is a bit more difficult to attain and in most cases requires some dedicated bandwidth. Shore participants can access real-time data via screen sharing of the acquisition computer, by accessing the data on the vessel and processing or quality assessing it, or streaming video to shore for metadata/annotation. Real-time collaboration can occur using VOIP phones installed prior to the cruise to discuss sampling and potential data issues. Technical expertise can be accessed via phone, WhatsApp, or other messaging tools. Students can actively participate by processing video from the deep while on shore using a lower resolution video stream.

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 the ship. Typically this is done through the use of cameras, video, and voice.

The ability to share data, collaborate with experts in the field, and interact in real-time can lead to a successful scientific cruise.

Example Use Cases:

The following is a list of use cases for collaborative Ship presence on shore.

Use Case 1: OOI Mooring Cruise with One Scientist Per Cabin

A mooring array may include a network of moorings and autonomous robotic vehicles to monitor waters of the shelf-break front where nutrients and other properties are exchanged between the coast and the deep ocean. These data sets would provide new insights into coastal ocean processes such as shelf/slope nutrient exchange, air-sea property exchange, carbon cycling, and ocean acidification that are important to continental shelf ecosystems around the world.

A reduction in scope to mitigate risks relating to the COVID-19 pandemic may include a modified cruise plan, fewer CTD casts, or less scientific instrumentation installed on the vessel for opportunistic sampling. Reducing the number of participants will have a direct impact on ancillary activities and available expertise sailing on board.

In a recent OOI cruise several scientists in the auxiliary science program were unable to sail, however they were able to install their underway Imaging FlowCytobot (IFCB). The Imaging FlowCytobot (IFCB) is an in-situ automated submersible imaging flow cytometer that generates images of particles in-flow taken from the aquatic environment. A desktop sharing application was used to help configure the system, and a subset of the data collected was synced to shore in NRT.

Use Case 2: LatMIX

Two major field experiments were conducted under LatMix, one 21-day experiment in the Sargasso Sea in June 2011, and one 25-day experiment along the north wall of the Gulf Stream in Feb/Mar 2012. Both efforts were multi-ship, multi-investigator efforts, of which the dye, drifter, and lidar work under this project were one part. Analysis of data from these field efforts was a collaborative effort between the field PIs, shore numerical modelers, and (field and shore) theoreticians. During the two experiments, data collected on the ships was synced to shore servers and ingested into a real-time model. Meanwhile the results from shore were shared with the ships to coordinate further sampling strategies.

Use Case 3: Watch Standing with Multibeam

The ARA San Juan submarine disappeared 430km (270 miles) off the Argentine coast on 15 November 2017 while the Atlantis was transiting to Montevideo, Argentina. The Atlantis was diverted to help search for the sub using their EM122 multibeam. There were only the two technicians on board. While the ship was relocating extra bandwidth was allocated (the other

AOR users on HSN were dockside) and a multibeam expert on shore was asked to assist. The shore expert was able to view the multibeam screen in real-time using Teamviewer to assist in looking for anomalies in the ocean floor. At the same time full resolution multibeam files were rsycned to shore for areas of interest. The data was processed and maps were created that were shared back with the ship.

Use Case 4: Live Tours and Presentations Using Low Bandwidth

On at least 3 occasions over the last few years a science party was conducting real-time presentations and tours of the ship with grade school classrooms as part of an outreach effort. By limiting the connections that could be made over satellite a laptop on board using Zoom in two cases and Skype in another was able to communicate effectively with the classroom using the normal Level 0 bandwidth. The ship computer broadcasted video and the shore side used audio only. In these cases other network traffic had to be paused for those specific periods of time. For coordinated periods of time this can be an effective use of existing bandwidth.

Use Case 5: Facebook Live Classroom Presentations, Earth Day 2019

Four Facebook Live presentations were broadcast to classrooms around the world from a research cruise on Earth Day 2019. A high quality presentation was prepared by an on-board media team and host. The science party engaged students and the public with a lively Q&A session. The project was a successful implementation of Level 3 telepresence on a modest budget with smart use of 5Mbps bandwidth.

Use Case 6: Full Telepresence with high quality ship to shore video and audio

Every summer the Ocean Observatories Initiative, Regional Cabled Array (OOI-RCA) team replaces equipment along over 600 miles of cable off the Oregon/Washington coast. Instruments on the array are powered on/off by personnel on shore, and data from those instruments travels back to shore in near real-time. Close coordination is required between the people controlling and monitoring instruments on shore and the people operating the ROV and ship based equipment at sea. At least one high quality video stream from the ROV is broadcast to shore so the shore based engineering team can see how instruments are being placed on the seafloor. VoIP phones on ships are used to communicate between ship and shore. During active instrument placements personnel in the science party on board are coordinating placement with ROV personnel while simultaneously on the VoIP phone with engineers on shore. The engineers power on the instruments, verify they are working correctly and monitor the data they produce. In many cases the instrument placement is then fine-tuned to get the optimal data.

Telepresence Levels using Near Real-Time (NRT), Real-Time Access (RTA), and Traditional Telepresence

There are a myriad of ways to have ship presence available to science on shore depending on bandwidth availability and desired outcome. Each increasing level requires increasing amounts of bandwidth, equipment (both shipboard and shore-based), and personnel, which usually increases costs. For each level, it is important that science understands their data and communication needs.

Table 1: Telepresence Levels and associated minimum bandwidth requirements.

	Notification Time Required	Satellite Carrier Type	Required Bandwidth	Teleconferencing	File Transfers Ashore	Streaming Data Ashore	Streaming Video (Quality/Frame Rate)	Additional Berthing/Staff Required
Level 0	None	Any	500kbps+	1:1 Audio Only	Periodic <100MB	<100kbps unreliable	Low/Low	None
Level 1	2 Weeks	Any	500kbps+	1:1 Med. Quality Video	Periodic >100MB	<500kbps unreliable	Med/Low	None
Level 2*	3 Months	Any	2Mbps+	1:Many High Quality Video	NRT >100MB	>500kbps reliable	High/Med	None
Level 3*	6 Months	SCPC or TDMA 1:1	5Mbps+	1:Many High Quality Video	NRT >100MB	>500kbps reliable	Broadcast Quality High/High	1+

*bandwidth expansion or 3rd party satellite contract required

Table 2: U.S. Academic Research Fleet Ship/Shore Satellite bandwidth available as of July 25, 2020

Vessel	Class	SatCom System(s)	berths	Marlink FX	Marlink Sealink	HSN
REVELLE	Global	C/Ku-band, Fx	58	1024/512	1024/512	-
THOMPSON	Global	C/Ku-Band, Fx	59	1024/512	-	512/256
ATLANTIS	Global	C/Ku-band, Fx	60	1024/512	1024/512	-
SIKULIAQ	Global	C/Ku-band, Fx	46	1024/512	-	512/256
LANGSETH	Global	C/Ku-band, Fx	55	1024/512	1024/512	-
NEIL ARMSTRONG	Ocean	C/Ku-band, Fx	44	1024/512	1024/512	-
SALLY RIDE	Ocean	C/Ku-band, Fx	45	1024/512	-	512/256
KILO MOANA	Ocean	C/Ku-band, Fx	48	1024/512	1024/512	-
ATLANTIC EXPLORER	Intermediate	Ku-band, Fx	34	512/256	512/256	-
ENDEAVOR	Intermediate	Ku-band, Fx	30	512/256	512/256	-
OCEANUS	Intermediate	Ku-band, Fx	25	512/256	512/256	-
SHARP	Regional	Fx	22	512/256	-	-
RACHEL CARSON	Coastal/Local	Fx	13	512/256	-	-
BLUE HERON	Coastal/Local	Fx	11	512/256	-	-
PELICAN	Coastal/Local	Fx	21	512/256	-	-
SAVANNAH	Coastal/Local	Fx	22	512/256	-	-
SPROUL	Coastal/Local	Fx	17	512/256	-	-

WALTON SMITH	Coastal/Local	Fx	19	512/256	-	-

* The numbers are in kbps (kilobits per second) and are the Committed Information Rate (CIR) and show DownLink (shore to ship)/ Uplink (ship to shore).
* Maximum Information Rate (MIR), specifies the maximum data rate available for burst transmissions, if available. For the 40+ bunk ships the MIR is 4096/1024; for < 40 bunks 2048/1024 (FX) and
* The ships using the HSN service are anticipated to receive more MIR/CIR in mid-July 2020

Table 2 is a snapshot of the current ship satellite systems available bandwidth as of June 28, 2020. The numbers are in kilobit per second (kbps) and are the Committed Information Rate (CIR), more detailed information can be found in Appendix A. This information was pulled from the HiSeasNet website (https://hiseasnet.ucsd.edu).

Level 0: Minimal connectivity (no additional bandwidth or shipboard equipment required)

The most underutilized form of telepresence, Level 0, has the potential to revolutionize the ship to shore interface experience. The most appealing aspect of Level 0 is the ability to use equipment presently in use on any ARF vessel and it does not require additional bandwidth in its implementation. The possibilities are within reach and only needs encouragement to fulfill its true capability.

One of the initial challenges, though not difficult, is transferring data collected on the ship to shore. A common misconception is that transmitting data to shore requires extensive bandwidth; in reality NRT data can be sent to shore as a background process with minimal effect on the ship's available bandwidth. Once accomplished, NRT data can be utilized by shore side science to determine the next course of action.

Subsets of several data acquisition systems are already available on shore including University of Hawaii Data Acquisition System (UHDAS), Shipboard Automated Meteorological and Oceanographic System (SAMOS), and the Research to Repository (R2R) Science Eventlogger.

UHDAS acquires data from RDI ADCPs and ancillary sensors (eg. gps, gyrocompass, and inertial attitude sensors) and uses CODAS processing to incrementally build a dataset of averaged, edited ocean velocities for each ADCP and ping type specified. Processed data and plots are served on the shipboard network, and daily status summaries are emailed to shore. To learn more, see this sample snapshot of the on-board UHDAS website that is installed on a ship. The on-board UHDAS web site can be brought to shore and hosted on a shore server as an instance of Level 0.

The Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative aims to improve the quality of meteorological and near-surface oceanographic observations collected in-situ on research vessels (R/Vs). A daily email of the one minute MET and Saltwater System Underway instrumentation is sent to shore and is available for download from their website.

The R2R Eventlogger is a program that creates a record of the scientific sampling events conducted during a cruise. Each entry in the scientific sampling event log includes date and time (UTC), position (latitude and longitude), fields for station and cast identifier, sampling instrument name (e.g. CTD, MOC10), the action being performed, the name of person responsible for the sampling event, and a comment field to record additional information. During a cruise the R2R Eventlog is *rsync'd* to shore in NRT. Currently the Eventlog can be shared with scientists on shore, but this capability can be expanded.

Presently there are numerous options for transferring NRT data to shore. The most accessible NRT data include one-minute averaged files from MET and Science Saltwater Underway System (Sea Surface Temperature, Salinity, Fluorescence, Turbidity, pH). In most cases, full resolution PCO2, CTD, XBT, and magnetometer data can also travel off the ship. Depending on its magnitude a subset of Gravity, EK80, and multibeam data can also be sent to shore. In the case of multibeam data the Multibeam Advisory Group (MAC) has a tool, File Trimmer, that will disseminate the large multibeam data files for transfer to shore and use with Qimera.

Incorporating the Presence of the Ship to shore takes a bit more creativity, nonetheless it is still achievable. In order to bring the 'feel' of the ship, screen grabs of data acquisition systems can be sent to shore at periodic intervals. On a limited basis real-time screen sharing for watch standing, outreach, and video conferencing can be accomplished.

The Regional Class Research Vessel (RCRV) project has created a system for NRT data, CORIOLIX. Scheduled for delivery with the RCRVs but available now in development, CORIOLIX provides a framework for creating and managing continually updating NRT underway data streams as well as a web user interface for visualization and management. Data is transferred using MQTT publish/subscribe capabilities for network transport. The result is real-time data presence for remote participants ***(See Appendix E for more information).***

Traditionally Level 0 has been employed on a number of 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 is often limited to an integrated camera so its use should be initiated by the science party.

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

Level 1 telepresence can be arranged with prior notification and approval of the vessel operator and technical staff. This option may require some network optimization, but it still includes all options of Level 0.

NRT data sent to shore can be a bit more dense, and each case would need to be examined.

The biggest difference between Level 1 and Level 0 is the ability to broadcast 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 will become pixelated if viewed on a larger screen. Depending on it's configuration, this may require shore-based support personnel and equipment in addition to the dedicated systems and personnel on the ship.

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

At this level a bandwidth expansion is required through the existing NSF Hiseasnet contract. Level 2 telepresence supports events for smaller audiences (e.g., classrooms, aquariums, museums, and science centers) as well as events geared towards larger audiences and mass media outlets (e.g., television).

Level 2 supports previously mentioned levels including data which had been scaled down for transfer. This scaled down data can now be transmitted in full resolution, during non-event time. Care should be taken to check on size and duration of data before starting the transfer.

This level of 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 may still be standard definition, which is good enough for viewing on a small computer monitor, but becomes pixelated on a larger screen.

Level 3: Telepresence-Enabled Science (additional bandwidth, powerful satellite antenna amplifier, upgraded satellite modem, shipboard camera system, and shore-based equipment and personnel required). Multiple simultaneous bandwidth intensive activities. Requires significant planning time and cost.

The next phase of telepresence, Level 3, comes with high quality and reliable real-time ship to shore video and audio. This level would require a bandwidth upgrade using a satellite carrier type of Single Carrier Per Channel (SCPC) or 1:1 TDMA which adds significant cost and configuration overhead.

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. This level 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.

This level typically requires additional onboard staff such as a broadcast engineer whose sole responsibility is to manage what video feeds are streaming from ship to shore, and production crew which would occupy science berthing. If there are video streams from shore to ship there will be at least one person on shore managing those video streams.

When video is not being streamed, data can be sent to shore. The data files may be more dense than the prior levels, but care should be taken that the transfer will finish before the streaming resumes.

PLANNING

Pre-Cruise

Science parties asking for more bandwidth need to submit a detailed cruise plan with waypoints/bounding box/track information. Satellite bandwidth upgrades and pricing are subject to geographical constraints and satellite availability. When 90 days' notice or more is feasible, please communicate early; the outcome will stand a better chance of success.

Telepresence operations must be coordinated with and approved by vessel operations in addition to funding agencies as they require network configuration to operate.

All science computers to be installed on the ship should be made **AT-SEA** ready, by turning off all updates and installing a bandwidth limiter. Guides are available on https://satnag.unols.org. It might be beneficial for participants to include their Institution's IT department for assistance.

To request additional bandwidth for cruises that have already been funded and scheduled, contact Brandi Murphy in the UNOLS Office brandi@unols.org. We will discuss your goals, timeline, vessel and study area.

Funding

Higher level telepresence can require additional equipment, expertise and/or satellite bandwidth and should be included as early in the process as possible to consider any additional funding that might be required by the project. A cognizant program manager(s) is a good resource for discussing proposals that include telepresence.

Data Security

Underway data collected and copied to shore in NRT by default is public domain, if the datasets are to be shared with the Sailing Scientist and Shore participants this should be stated during the pre-cruise planning. Conversely, it is of utmost importance to determine whether any data from the cruise should be placed under embargo for any length of time.

It is imperative that the science party understands any restrictions required on the data being transmitted to shore and need to work with the knowledgeable parties to ensure that the restrictions are adequately followed.

The PI is responsible for checking with the funding agency for known data restrictions including controlled access to data, on shore data security, remote access to vessel networks, and cybersecurity reviews.

Conclusion

Moving forward, it is essential to utilize technology in an effort to assist research being conducted on vessels in the ARF. Collaboration is vital between technicians, institutions, and researchers to include shore-side integration. The first step is to determine what science objectives need to be accomplished and how telepresence can aid in its completion. If the ship has to sail with limited science members, take into account what can be done on shore without having to take up a berth. It is highly recommended to utilize Level 0 telepresence to transmit data to shore in NRT. Further application of telepresence can be established and expanded from there. This document should not in any way limit options and uses of telepresence, but should spark inspiration on how to best employ bandwidth availability.

Appendix A Bandwidth

Sealink (C/Ku Band)
Sealink is Marlink's commercial service for Cband/Kuband service. It is comparable to HiSeasNet, but with some differences:

1. The Sealink service can use spectrum on many satellites. When used, ship's generally have an easier time of starting online when there are notable blockage zones in the ship's installation.
2. Sealink uses Time-division multiple access (TDMA) instead of Single channel per carrier. This can result in a more jittery network performance during high bandwidth performance events.

Marlink Sealink (ships < 40 berths)
CIR UP (ship to shore): 256 kbps
CIR DOWN (shore to ship): 512 kbps
MIR UP (ship to shore): 512 kbps
MIR DOWN (shore to ship): 1024 kbps

Marlink Sealink (ships > 40 berths)
CIR UP (ship to shore): 512 kbps
CIR DOWN (shore to ship): 1024 kbps
MIR UP (ship to shore): 1024 kbps
MIR DOWN (shore to ship): 4096 kbps

Marlink FleetExpress (Ka/FBB)
Inmarsat offers tiers of performance at pre-negotiated rates.

Fleet Express (ships < 40 berths)
CIR UP ship to shore: 256 kbps
CIR DOWN (shore to ship): 512 kbps
MIR UP (ship to shore): 512kbps
MIR DOWN (shore to ship): 4096 kbps

Fleet Express (ships > 40 berths)
CIR UP (ship to shore): 512 kbps
CIR DOWN (shore to ship): 1024 kbps
MIR UP (ship to shore): 4096 kbps

MIR DOWN (shore to ship): 8192 kbps

HSN CBAND AOR (Atlantic) POR (Pacific):

CIR UP (ship to shore) : 256Kbps (dedicated to ship)
CIR DOWN (shore to ship): 409 Kbit/s in 4 ship mode. 546 Kbit/s in 3 ship mode.
MIR UP (ship to shore) : 256Kbps (dedicated to ship)
MIR DOWN (shore to ship): 2 Mbps (20% head room for bursting capacity)

HSN KuBAND

CIR UP: 192 kBps in 4 ship configuration
CIR DOWN:
MIR UP:
MIR DOWN: 786 Kbit/s burst-able

CIR: Committed Information Rate, specifies the minimum data rate guaranteed to the relevant subscriber.

MIR: Maximum Information Rate, specifies the maximum data rate available for burst transmissions, if available.

Appendix B: Ship Underway Data Systems

Shipboard instrumentation including navigation, meteorological, acoustic, hydrographic and geophysical are called out below. This is not an exhaustive list, nor does it include science supplied instrumentation. The numbers in **()** beside the specific instruments are from the United Kingdom's Natural Environmental Research Council (NERC) Vocabulary Server hosted at British Oceanographic Data Center (BODC). The instrumentation is referenced as controlled vocabularies where available. Controlled vocabularies are used to standardize and organize instrumentation to improve information retrieval and understanding of a particular instrument and data collected.

Continuous Environmental and Navigation Instrumentation

There are numerous shipboard acquisition systems that collect data from navigation instruments, meteorological sampling systems, and flow-through seawater systems.

Navigation instruments can include GPS (L05/POS03), DPGS (L05/POS04), Inertial Reference Unit (IRU; L05/POS19), Inertial Motion Units (IMU) , Heading.

Meteorological sampling systems are typically incorporated in Meteorological Packages (L05/102) and can include barometers, wind sensors, air temperatures, rain gauges, radiometers, hygrometer, etc. They can be separate individual sensors or multiplexed systems.

Flow-through Seawater instruments typically include thermosalinograph, PCO2 systems, fluorometers, transmissometers, pH, oxygens sensors.

These data types are usually captured continuously and at full resolution, they can also be included in 1 minute files as typically sent to SAMOS.

Acoustic, Hydrographic and Geophysical Shipboard Instrumentation

ACQ SYS UHDAS (R2RE/1104)
University of Hawaii DAS acquisition software, controls multiple ADCPs.

Bell Aerospace BGM-3 gravity meter (R2RE/9041)
Instrument that makes measurements of the Earth's gravity field

EK80 (L22/TOOL1205)
A high precision scientific echo sounder, designed to simultaneously operate frequencies ranging from 10 to 500 kHz. EK80 is a modular echo sounder system, and can operate with a

combination of split and single beam transducers facilitated by a built-in calibration application. This system was built in succession to the EK60 echo sounder.

Furuno FE 700 echo sounder (L22/TOOL0797)
The Furuno FE-700 is an echo sounder for shallow or deep water applications. This instrument uses ultrasonic pulses to detect the seabed and other underwater objects. The operating frequency is 50 kHz, 200 kHz or 50/200 kHz alternating transmit. Echo sounding data is displayed on a 6.5-inch colour TFT (Thin Film Transistor) LCD display. It has an operating range of 800 m (2500 ft, minimum range is 0.5 m (200 kHz), 2.0 m (50 kHz)). Accuracy is +/-2.5%.

Furuno FCV 582 fish finder (L22/TOOL0796)
The Furuno FCV-582 is dual-frequency (50kHz and 200kHz) color video sounder designed for smaller vessels. Its 8 or 16 color presentation gives information on fish density and the nature of the ocean floors. This device has six pulse lengths from 0.2 to 3.6ms for performance on both shallow and deep ranges. It has a colour CRT display and has an operational range of 500 m (1500 ft).

General Oceanics model 8050 pCO2 measuring system (L22/TOOL0724)
The General Oceanics model 8050 pCO2 Measuring System is an autonomous analytical system for measuring carbon dioxide in surface water. It includes a headspace equilibrator, an infrared CO2 analyser, and computer-controlled and -monitored pumps. It measures: pressure (flow) in range 0 to 10 dbar, with accuracy of 0.2 percent and resolution of 0.03 percent; temperature in range -3 to 50 degC, with accuracy of 0.003 percent and resolution of 0.0005 degC; conductivity in range 0 to 64 mS/cm, with accuracy of 0.003 mS/cm and resolution of 0.001 mS/cm; Oxygen in range 0 to 25ppm (250 percent saturation), with accuracy of 0.1ppm (1 percent saturation) and 0.01ppm (0.1 percent saturation); pH in range 0 to 0.14 pH, with accuracy of 0.01 pH and resolution of 0.001 pH; Redox in range -1000 to 1000 mV, with accuracy of 1 mV and resolution of 0.1 mV.

Kongsberg EM302 (R2RE/1066)
Kongsberg EM 302 multibeam echo sounder is designed to map almost all of the ocean floors excepting the deep trenches with an unsurpassed resolution and accuracy. It replaces the highly regarded EM 300 introduced in 1996, of which more than 20 systems are operational. It has the same transducer dimensions as in the EM 300, but with new electronics and software.

Kongsberg EM710 (L22/TOOL0746)
The Kongsberg EM710 is a high resolution multibeam echosounder. It operates at frequencies from 70 to 100 kHz, with a maximum ping rate of 30 Hz. The EM710 features a depth range of 3m below the transducer to 2000m (1000m for the EM710S model, and 600m for the EM710RD model). The swath width is up to 5.5 times water depth, to a maximum of more than 2000m.

Kongsberg EM122 (L22/TOOL0492)
A multibeam 12 kHz echsounder designed for high resolution seabed mapping. It uses both Continuous Wave (CW) and Frequency Modulated (FM) sweep pulses with pulse compression on reception in order to increase the maximum used swath width. This system has up to 288 beams/432 soundings per swath with pointing angles which are automatically adjusted according to achievable coverage or operator defined limits. The transducers are modular linear arrays in a Mills cross configuration with separate units for transmit and receive. It has a depth range of 20 to 11000 m and a depth resolution of 1 cm.

Kongsberg (Simrad) TOPAS PS018 sub-bottom profiler (L22/TOOL0859)
TOPAS parametric sub bottom profiler is a high spatial resolution system designed for use in depths from 10 metres to full ocean depth operation. The system is based on low frequency signal generation, high bandwidth (~80%), narrow beam profile and absent side lobes. Comprises of a transducer, transceiver unit, operator console and optional multi-channel receiver or beam former.

Kongsberg (Simrad) EA500 echosounder (L22/TOOL0130)
A single-beam, single-frequency (12kHz) deep water echosounder, with a maximum power of 2kW, 160dB dynamic range and Transducer 12-16-60 (16 degree circular, 60 degree passive beams). It was introduced in June 1989 and and replaced by the EA 600 in 2000.

Knudsen 320BR echosounder (L22/TOOL0892)
The Knudsen 320 B/R operates at different frequencies (12kHz and 3.5kHz). The 12kHz allows for water depth record and the 3.5kHz to track pingers attached to various instruments over the side. This is also used for sub-bottom profiling applications.

Knudsen Chirp 3260 **(**L22/TOOL0890)
The Knudsen Chirp 3260 is a deep water system capable of reaching depths up to 10,000m plus. This instrument is available in a 2 or 4 channel configuration with frequencies ranging from 3.5kHz to 210kHz. The Chirp 3260 is designed for full ocean depth requirements where high power output is required

Marine Magnetometer , **Geometrics G882** (L22/TOOL0832)
A magnetometer designed for the detection and mapping of ferrous objects. It uses a self-oscillating, split-beam Cesium Vapor (non-radioactive) sensor. It can be operated from small or large vessels for shallow water and deep tow applications. Operation range: 20,000 to 100,000 nT. Operation depth: up to 2750 m.

Marine Magnetometer, Marine Magnetics SeaSPY (L22/TOOL0474)
A marine magnetometer that measures the ambient magnetic field using a specialised branch of nuclear Magnetic Resonance technology applied to hydrogen nuclei. It uses an Overhauser sensor that allows omnidirectional data collection regardless of the direction of the ambient magnetic field. The sensor is accurate to 0.1 nT with a resolution of 0.01 nT. The magnetometer

and associated electronics are held in a fibreglass towfish and the SeaSPY is available in three depth ratings: 1000 m, 3000 m and 6000 m. Optional extras include a pressure sensor, altimeter, transponder and side scan integration.

Teledyne Reson SeaBat 8101 (L22/TOOL0773)
The Teledyne Reson SeaBat 8101 is a 240kHz multibeam echosounder designed for use in water depths between 120m and 3000m. The transducer array includes 101 beams (spaced at 1.5 degrees). The instrument has swath coverage of 150 degrees (upgradable to 210 degrees) and up to 600m swath width.

SBE 911+ CTD (L22/TOOL0058)
High precision and accuracy CTD comprising an SBE 9plus underwater unit (SBE 3 temperature and SBE 4 conductivity sensors) and an SBE 11plus deck unit. Sensors may be connected to a pump-fed plastic tubing circuit (usually temperature, salinity and oxygen) or stand-alone. All instruments (8 channels available) on the package are logged by the SBE 11. The unit is the production off the shelf version of the SBE 911 (each 911 was custom built to individual specification).

WaMoS II wave and current monitor (R2RE/1143)
The WaMoS II software is loaded onto a standard PC (WaMoS II components), which is connected to a commercially available marine X-Band radar. The system extracts wave information from the radar images (up to 3 miles from the antenna) and by analyzing the spatial and temporal changes of the radar backscatter from the sea surface (sea clutter), determines directional wave and surface current information.

XBT (BCODMO/545)
An XBT is an expendable free-fall temperature probe that provides a profile of measured temperature against depth calculated from a fall-rate model. For example, two popular XBT models are the T-5 and T-7 probes from Sippican. More information is available from Lockheed Martin Sippican at URL: http://www.sippican.com

Appendix C: Assignment of Data Protection

Pre-Cruise Assignment of Data Access Protection

The default access status for the Cruise Data is that they will be immediately accessible by the public after being copied to shore. If something other than this default protection is desired, the Chief Scientist must assign alternate protection as indicated below. For cruises funded by the National Science Foundation, the maximum protection is two years, for non-NFS cruises, other guidelines may apply.

For underway data including GPS, IMU, GYRO, Metsensor, Science Saltwater instruments this data will be immediately accessible by the public.

Cruise Metadata and Chief Scientist contact information:

Vessel:	Cruise ID (Assigned by Operator):
Chief Scientist (CS):	Cruise ID (science):
CS email:	CS Institution:

Assignment of Access Protection by Data Type:

Embargo periods are not available for the following data types: cruise metadata, ship navigation, meteorological, sea surface temperature, salinity, and fluorescence.

To apply an embargo period to specific data types please specify assignments below.

Instrument/Data	**Duration of Embargo/End Data**
ADCP (Acoustic Doppler Current Profiler)	
CTD	
Echosounder	
Gravimeter	
Multibeam	
Expendable Probe- XBT	
EK80	
Magnetometer	
Science data	

Appendix D: Solutions for Science Communications

Access to common communication systems for voice, video, text, desktop sharing, and file sharing for image and documents can be critical for collaborative ship to shore science communication. Many popular candidate solutions for science communication include the following.

Remote Vessel Access and Desktop Sharing

Lite Manager Remote Desktop

http://www.litemanager.com/

Lite Manager is remote access software for remote administration of computers over the Internet for distant learning, providing remote support to users, it can be used to share the screen of an acquisition computer during a cruise.

The program allows complete control of a computer desktop in real-time with full support for Windows. It provides secure remote access to the file system, processes and services of the remote computer. LiteManager has built-in tools for creating network map, collecting technical data, ability to deploy and update using remote installation services, configure private ID router (NOIP) and many other features.

TeamViewer

https://www.teamviewer.com/en-us/

TeamViewer is a comprehensive, remote access, remote control, and remote support solution that works with almost every desktop and mobile platform, including Windows, macOS, Android, and iOS. TeamViewer lets you remote in to computers or mobile devices located anywhere in the world and use them as though you were there.

NoMachine

https://www.nomachine.com/

NoMachine is remote PC access software with high performance and security. There are many connection options with NoMachine, including a cloud server, a terminal server and a virtualization server. While NoMachine specializes in remote Linux connections, it's a versatile option for any platform. It has numerous sharing tools and compatibility features for you to use during any remote session.

ZOOM

https://zoom.us/

Zoom Meetings is a popular cloud-based video conferencing application, used primarily by businesses to host meetings with remote or international colleagues and clients. ZOOM allows users to share desktops.

ZOOM ROOMS
https://support.zoom.us/hc/en-us/articles/204003179-System-Requirements-for-Zoom-Rooms

SSH tunnels
SSH tunneling or SSH port forwarding is a method of creating an encrypted SSH connection between a client and a server machine through which services ports can be relayed. It can be used to access remote computers.

CJDNS Mesh Network
https://github.com/cjdelisle/cjdns/#cjdns
An encrypted IPv6 network using public-key cryptography for address allocation and a distributed hash table for routing.

Ship to Shore File Sharing / Syncing/ Transfers

MQTT
http://mqtt.org/
MQTT is a machine-to-machine (M2M)/"Internet of Things" connectivity protocol. It was designed as an extremely lightweight publish/subscribe messaging transport. It is useful for connections with remote locations where a small code footprint is required and/or network bandwidth is at a premium. For example, it has been used in sensors communicating to a broker via satellite link, over occasional dial-up connections with healthcare providers, and in a range of home automation and small device scenarios. It is also ideal for mobile applications because of its small size, low power usage, minimised data packets, and efficient distribution of information to one or many receivers.

Rsync
rsync is a utility for efficiently transferring and synchronizing files between a computer and an external hard drive and across networked computers by comparing the modification times and sizes of files. It is commonly found on Unix-like operating systems. Rsync is written in C as a single threaded application. Rsync is the facility typically used for synchronizing software repositories on mirror sites used by package management systems

Windows (Git Bash + Rsync works best)
- https://git-scm.com/download/win
- http://www2.futureware.at/~nickoe/msys2-mirror/msys/x86_64/rsync-3.1.2-2-x86_64.pkg.tar.xz

Syncthing
https://syncthing.net/
Syncthing is a continuous file synchronization program. It synchronizes files between two or more computers in real-time, safely protected from prying eyes. Your data is your data alone and you deserve to choose where it is stored, whether it is shared with some third party, and how it's transmitted over the internet.

Ship to Shore Group Chat

Riot.IM
a universal secure chat app entirely under your control.
https://www.slant.co/versus/5637/20863/~discord_vs_riot
https://www.matrix.org/bridges
John Haverlack: https://riot.im/app/#/user/@jehaverlack:matrix.org

SLACK
Allows you to chat, share files, add widgets, and make video/voice calls and conferences. Slack offers many IRC-style features, including persistent chat rooms (channels) organized by topic, private groups, and direct messaging.Content, including files, conversations, and people, is all searchable within Slack.

SKYPE
https://www.skype.com/en/
Skype is a telecommunications application that specializes in providing video chat and voice calls between computers, tablets, mobile devices. Skype also provides instant messaging services. Users may transmit text, video, audio and images. Skype allows video conference calls.

Call Type	Minimum down/up speed	Recommended down/up speed
voice	30 kbps /30 kbps	100 kbps/ 100 kbps
video/screen sharing	128 kbps/ 128 kbps	300 kbps/ 300 kbps

video calling HD	1.2 Mbps/ 1.2 Mbps	1.5 Mbps/ 1.5 Mbps

During some testing it appeared that sharper video than ZOOM over low bandwidth and seems to have the best video performance (jitter) over low bandwidth

Discord
https://discord.com/

WhatsAPP
https://www.whatsapp.com/
An encrypted text and video chat service. WhatsApp voice and video calls use your phone's Internet connection.

Appendix E: CORIOLIX

Cruise **O**bservations **R**eal-time **I**nterface & **O**pen **L**ive **I**nformation e**X**change

Cruise **O**bservations (SCOPE):	Resident "underway" meteorological, flow-through seawater, and navigation sensor suites.
Real-time (ARCHITECTURE):	Implements real-time (continually updating) sensor data streams to move data off the ship. Provides publish/subscribe capability for client systems.
Interface (ACCESSIBILITY):	Provides a mobile ready web user interface on both ship and shoreside. Designed for use by both scientific and marine and technical remote participants.
Open (LICENSING):	CORIOLIX is planned for release under an MIT (or similar) open source instrument.
Live **I**nfo**.** e**X**change (USE CASES):	Monitor – Access underway data from shore. Transform – Process underway data to information. Inform - Feedback results to shipboard team.

User components

- Shipboard and shoreside Web User Interfaces:
    - https://coriolix.ceoas.oregonstate.edu/oceanus/ (*Oceanus* test site)
    - https://datapresence.ceoas.oregonstate.edu/demo/ (Demo site)
- Charting tools for real-time mapping, route planning, & spatial awareness
- Built-in event logging (ship & shoreside event logs are synchronized)
- Dashboard style live and interactive data display pages
- System status, metadata, and documentation pages.
- Notifications -user defined alerts & notifications over SMS, Email or Slack.

Technical components

- SymmetricDS two-way database synchronization for cruise events & metadata
- MQTT publish-subscribe network transport protocol for real-time data.
- API tools for data access on both ship and shore (*urls link to our demo services*):
    - ERDDAP - http://sardinops.coas.oregonstate.edu:8180/erddap/info/index.html
    - CORIOLIX REST - https://datapresence.ceoas.oregonstate.edu/demo/api/

Project support & status

- CORIOLIX is in active development under the NSF RCRV MREFC project.

· CORIOLIX is on track for a V1.0 release in September 2020.

· CORIOLIX is currently deployed “live” on *Oceanus* & *Endeavor (bandwidth utilization = <3% of available uplink).*