SVC Summary report:
Alvin video system and post-dive processing

Authors: Jonathan Howland, Scott McCue and Peter Girguis

1. *Alvin* Onboard Video System

The specifications for the HOV *Alvin's* new video data system were presented at several meetings throughout the development and assembly phases of the vehicle. Those details may be found elsewhere on the Science Verification Cruise (SVC) website. In the most basic of terms, it was specified that the *Alvin* record up to two video streams in High Definition (HD), and that the observer be able to select from up to three or more video cameras (sources). Internally, submarine video is routed to two file-based recorders (Atomos Samurai) using a network controlled video switcher. The system currently in use within the vehicle meets these basic requirements, enabling two HD streams to be recorded at any given time. However, the current system also enables the observer to select from up to five sources, namely the Science Camera; two Pan, Tilt and Zoom cameras (PATZ cameras) located slightly above the forward viewports; as well as two HD cameras located on the sponson, or brow of the sub.

During the SVC, the *Alvin* video data system was in continuous transition, so no single comprehensive assessment can be made of its performance. However, here we present a summary of the developments that took place during the SVC.

At the beginning of the dive series, the video output from the router that fed data into the Samurai recording deck was slaved to each observer's monitor, so that whatever the observer was viewing on their monitor was also, in theory, being recorded on the Samurai disks. Thus, when the observer switches their monitor to another camera, the recording deck would capture that datastream. This is an emulation of the way that the video system was set up in the previous submersible.

During the first dive of the SVC, it was found that the file based records on the Samurai disk were broken into dozens of tiny files, and that substantial portions of the video record were missing. At worst, up to about 25% of the video was absent from the hard drives. The multi-file issue was traced to frequent changes in recording lineup. In other words, virtually every time the video source to the Samurai was switched, it detected the change, closed the current file, and opened a new one. Since the handheld router controller required sequentially stepping through the various video sources in order to make a change, this caused the multiplicity of files. This problem was resolved by making the recording destination independent of the observer's monitor video choice. Observers could still switch the recording source at will, but would do so via other means. The video being recorded no longer followed the feed on their personal monitor.

While this solved the issue regarding the number of files and file size, the loss of video data was a far more challenging to resolve. Upon continued examination during subsequent dives, two types of problems occurred: gaps between video files, as well as files with internal gaps. The nature and extent of these video gaps changed throughout the dive series as troubleshooting progressed. After a series of video configuration changes, as

well as benchtop tests and consultation with vendors and consultants ashore, the current explanation for the problem is that the router chosen for the submarine switches video immediately upon command. This sometimes causes a switch of video in the middle of key portions of the video framing. If done properly, the switch should occur during a designated switching period that is part of the standard for HD Video. However, downstream video equipment does not handle an improper switch well. In addition to the previously mentioned Samurai recording deck, there is a time code and audio data embedder that –as the name implies- embeds the time code and audio and data overlays. The embedder sits between the video router and the recording deck. It turns out that one or both of these units, either the embedder or the recording deck, sometimes responded to the resulting malformed video frames by resetting or otherwise interrupting the continuity of video recording.

The solution to this problem that was adopted at sea was to route the video data to the Samurai decks without passing it through the audio/time code embedder. Time code is set in the decks manually, providing correlation of video data with other submarine data. Additionally, at the suggestion of the Samurai manufacturer, a 100 millisecond switch to a dead video channel was programmed into the switcher control software, taking affect before any desired video switch. The theory is that this will allow the Samurai time to properly reset itself and correctly accommodate to the new video source. Two overnight tests following this strategy were performed at the end of the SVC, and resulted in minimal loss of video data despite switching every two minutes for over 12 hours. This was the strategy that was planned for use during the ensuing science cruises.

There are several potential longer term fixes. One would be the purchase of a new switcher that properly honors the HD switching period. A switcher that could fit the size and power constraints imposed by the submarine, and would handle the video properly was not available during the design and construction of the submarine internals. Currently available switchers that can fit into the submarine and not corrupt the data would impose other constraints on the system due to limited channel capabilities. These options are currently being assessed.

Another potential fix is incorporation of frame synchronization capability into the audio/time code embedder. At the instigation of the video consultant hired by WHOI, the vendor of the system already in the system has developed such a capability as an add-on to the current embedder. It is in testing, and offers a potential solution. Incorporation of such a capability would require a currently unknown expenditure, and it remains unclear if and how this will integrate into the submersible.

2. *Alvin* Post-Dive Video Processing

2.1 Overview

The transition to an all digital video recording system requires different post processing pipelines to ensure that the video is of the highest possible quality, that it is readily available to the shipboard party, and that it is properly archived. Accordingly, the priorities of post-processing *Alvin* video is as follows:

1. Transfer and duplication of recordings for delivery and secure archival.
2. Staging of the recordings via on-ship resources to inform subsequent diving.
3. Addition of value through creation of proxy products.

2.2 Transfer, duplication, and staging

The in-sphere recorder hard drives are the sole media of collection. The first order of business is to transfer to enterprise class hardware at the offload and staging station, where hardware redundancy and file duplication are employed to protect the recordings. These video clips, hereafter called Originals, are available to science via the Main Lab workstations immediately upon completion of the transfer. Transfer and duplication typically require about 90 minutes to be completed. Thus, these videos are typically available early in the evening, on the same day as the dive.

2.3 Proxy creation

Original videos are encoded using the ProRes422LT codec, which supports HDTV resolution (1920x1080) and offline editing. This means that file volumes and the on screen image footprints are large, making it difficult to view and archive these clips on portable devices like laptop computers and tablets. To ease this problem, common industry practice is to create representative clips, called "proxies". We produce proxies by transcoding the originals to the h.264 codec. We also reduce image footprint by a factor of 2, yielding imagery of 960x540 resolution. File volumes are typically 5% or less of the Original. During this process, the proxy clips are named with timestamp information that is derived from time code metadata that is imbedded in the Original version of the clip. The h.264 video is encapsulated in a Matroska container file, file extension .mkv.

2.4 Subtitle creation

The time code metadata that is pulled from the Original clip is additionally used to create a subtitle file. The subtitles are created in such a way that once per second the GMT time of the recording is updated. To be used, researchers must perform a merge of the proxy video and the subtitle file using a utility such as 'mkvmerge.' The resulting file, also a Matroska container file, is played back using open source video players like VLC or mplayer. Using controls offered by these programs, the researcher can turn time display on or off.

2.5 Video data delivery

The offload and staging station includes support for creating a deliverable data package. LTO5 tapes, which are cost efficient and have shelf life expectation of decades, are used for the package that is delivered to WHOI. A second LTO5 copy stays aboard the R/V *Atlantis*. Portable, ruggedized hard drives are used to deliver the highest quality videos, as well as the proxies, to the Chief Scientist at the end of the cruise. At handover, the Chief scientist signs a form acknowledging receipt of the package. Within the form the Chief

Scientist assigns data access protections and durations, and also acknowledges the retention of copyright by WHOI.

Upon return to shore, the chief scientist is expected to transfer the data off the portable drives and onto enterprise quality hardware at her/his institution, then return the drives to WHOI for use in subsequent cruises. The LTO5 tapes sent to WHOI are duplicated at WHOI and then archived at separate locations by the NDSF data manager and WHOI's Data Library and Archives. Once duplication is performed ashore, the copy housed on *RV Atlantis* is freed so that the media can be used for new video data.

2.6 Video processing resources available to the science party on board the R/V Atlantis

Previously, members of the science party who wanted copies of the video from the submersible had to "burn" their own copies to DVD on board ship. Thus, science parties often assigned this task to one or two personnel, who ensured that the DVDs were copied in a timely manner and in entirety, prior to the end of the expedition.

As there are no more DVDs, any member of the science party who wishes to have their own copy of the *Alvin* videos may work with the Chief Scientist to get copies once they are ashore. However, it is often more convenient for the science party to make their copies during the course of the expedition. To facilitate these activities, three Apple computer workstations are provided in R/V *Atlantis* main lab for the science party to use in viewing and editing video clips. Two of these workstations offer high end processing hardware and software, including non-linear editing packages such as Apple Final Cut and Adobe Premier. The third workstation is less powerful but offers software for viewing and simple editing tasks. These workstations are networked to the offload and staging station, with read-only access. Researchers have access to video clips once they are staged (offload of Originals) and created (proxies).