SVC Summary report:
Alvin video and stillframe imaging
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1. Introduction

The new *Alvin* is equipped with 5 new cameras, all of which are capable of recording HD Video. Two of these cameras are attached directly to the submersible on each side, port and starboard, where they can be controlled by the science observers. The fifth camera is actually a 24MPix digital still camera that can also record HDTV video and is designed ultimately, to be mounted on the manipulator arm of *Alvin* but for the SVC cruise was mounted instead in down-looking mode toward the back of *Alvin*'s Science Basket. In this report we discuss the forward looking cameras and the down-looking camera separately.

2. Forward-looking cameras.

Fig.Cam1 shows the arrangement of the 4 forward looking cameras with respect to the submersible as a whole. On each side of the sub there is an integrated Kongsberg Pan And Tilt + Zoom (PATZ) camera mounted in its own housing just above the forward looking observer's view-port while mounted on the brow of *Alvin*, also on each side, there is an InSite Mini-Zeus (MZ) camera on a dedicated Pan & Tilt that also houses a matching Deep Sea Power & Light LED light source pointed in the same direction as the camera. Additional LED lighting units at the start of the SVC cruise included 4 fixed LED lighting units across the brow of the sub facing forward plus, on each side, 2 LED units mounted on the same upper light bar facing out to the side of the sub, above the observers side viewport plus one LED unit down low, in between the observer's side and forward viewports, but angled primarily to illuminate the seafloor visible through the scientists' side view-ports.

2.1 Immediate Concerns during SVC (1): inadequate lighting

An immediate impression gained from the first 2-3 science dives with *Alvin* during the SVC cruise was that the area immediately forward of the scientists' forward viewports was relatively dark with shadows being cast both by equipment in the basket and from the manipulators (although the positions of the manipulators can be changed to minimize those impacts). Even under optimal conditions, however, our experience was that when using either the MZ or PATZ cameras on full zoom in areas immediately in front of the observers view-ports to a range out to the reach of the manipulators, it was impossible to achieve crisp focus or to reduce Iris settings below maximum setting because there was insufficient incident light falling on the seafloor in this prime "work area" region in front of the sub. To remedy this, between *Alvin* dives 4682 and 4683, the science junction box for *Alvin* was drained and 4 additional LED units were added to fixed locations on the submersible. On each side, one further LED was added to the light bar on *Alvin*'s brow pointed down from the forward corners of the submersible, almost directly above the scientists forward viewports, and oriented at an outboard angle of ~45°, to port and starboard, respectively, of the dead-ahead direction. In parallel, on each side, one more

LED was installed close to where the science basket attaches to the submersible, below the science observers' forward viewports. The latter LED units were positioned so that they extend out beyond the edge of the basket itself (to minimize shadows and glare created by contents of the basket) and, again, at an angle of ~45° from the dead-ahead direction to maximize the amount of light falling on the primary work areas immediately in front of each manipulator swing-arm and each science observer's forward view-port.

From comparison of like-for-like imagery recorded during push-core operations undertaken on multiple SVC dives, before and after these upgrades (e.g. Dives 4680 and 4682 vs 4683) illumination in this primary work-area was much improved by these upgrades.

One further improvement to lighting was made during the course of the cruise, also between dives 4682 and 4683. This was to add an additional LED light unit, via a requisite break-away electrical connector, on the starboard manipulator. The logic for this addition is that the port manipulator remains the more dexterous of the two and, therefore, the manipulator of choice for many pilot sampling operations but the starboard manipulator could then be used as a "lighting boom" to bring additional light to play on any given subject to obtain high quality imaging. During dive 4683 in particular, to the Florida Escarpment, both the MZ and PATZ cameras operated by the Port observer were used to obtain rewardingly high quality imagery following this approach to provide the maximum possible levels of light falling on the subject in question.

From dive 4683 onward we considered this problem resolved. The final arrangement of lighting on the submersible, as viewed in darkness in the hangar on *Atlantis* after the upgrades were complete and prior to AL 4683 are shown in Cam.Fig.B. Examples of the video collected during the 4683 dive can be viewed at the *Alvin* SVC web-site (www.alvinverification.whoi.edu).

2.2 Immediate Concerns during SVC (2): camera controllers.

Different users suggested a number of improvements that would be desirable when the opportunity arises. Almost universal was the comment that the sensitivity of the joy-stick was so high that it was impossible to capture video in a smooth form when using the pan and tilt, for example to scan across a field of view at constant zoom at a speed that was not too fast to result in an engaging video-product. The motion of the camera was simply too fast for a small adjustment of the joy-stick so that the only way to collect adequate imagery was to set up a shot of the entire field of view and hold the camera stationary – which would tend to mean settling for a less-then-ideal level of zoom. The zoom-in and zoom-out functions on the same controller were also commented to be more sensitive than ideal although this "over-sensitivity" was not noted as markedly as the pan/tilt function. What WAS also noted was that the ability to focus via a push button (up/down) function was less satisfactory than an improved controller with a dial for focus control would be. No adjustments to the camera controllers were pursued during the course of the SVC but these would be desirable.

2.3 Immediate Concerns during SVC (3): laser pointers.

Only one pair of laser-pointers was installed on *Alvin* during the SVC dives and these were mounted on the port observer's MZ camera and rotated so that they were horizontal when imaged at the seafloor by the start of dive AL 4684. We recommend *(i)* that a second pair of lasers be installed on the starboard observer's MZ camera at the earliest opportunity and *(ii)* that the calibration of these lasers (10cm separation) be verified as part of each pre-dive protocol.

2.4 Immediate Concerns during SVC (4): assessing white balance.

It was recognized during the SVC cruise that the raw imagery from the HDTV cameras being projected onto the observers' monitors in the submersible was of a higher quality than the highest quality imagery that is recorded in the ball and subsequently archived by the NDSF and made available to the science party. Consequently, there might be some disconnect between what is observed in the submersible during video-recording and what is ultimately recorded. A particular case in point relates to white-balance. On multiple occasions, after the issue of lighting was resolved between dives AL4682 and AL4683, the observer in the ball dialed back the aperture setting on the PATZ or MZ camera to what appeared to be a well exposed image only to find, when reviewing video files the next day, that image-sequences were actually over-exposed in the recorded data. We do not recommend that the monitors in the submersible be downgraded nor that the NDSF change the recording format of the Original files delivered to the science party aboard ship (which already take up >1TB per standard dive). Rather, science observers should be cautioned to remain vigilant on this topic when recording video from *Alvin* and, when in doubt err on the side of setting the Iris to record darker than optimal rather than lighter or, ideally, to take the time to record the same scene in multiple Iris settings to ensure that one of the sequences recorded will be optimally exposed.

3. Accessing Imaging Data from *Alvin* Dives

3.1 Missing Data!

The standard data-products provided to the Science Party following each dive are a complete set of the highest quality files recorded from each dive (totaling ~0.5TB per recording deck, per dive [1 deck for each observer's recordings]). An issue during the SVC dive programs was that not all data selected to be recorded by the observers on each dive was actually saved to the hard drives extracted from the submersible at the end of those dives. This issue will be addressed elsewhere in this report (Data section led by Jon Howland) but conflicting and troublesome issues noted in practice during the SVC cruise were:

a) Appearance of red banner-strips across the top and bottom of the video-displays built into the recording decks in the submersible could give false-positive reassurance that all was well: an observer could check that the red banners were present but video-files might still not be recorded.

b) Absence of an advancing time-code (white characters against a black banner across the base of the same screen) might cause a false negative resulting in concern that recording had been interrupted even when it had not.

3.2 File Naming Conventions

A mild inconvenience and/or confusion at the outset of the SVC cruise – and likely to recur in all future cruises – was that the file-names assigned to the video-files delivered to the science party are based on the position of the recording decks within *Alvin* which, in turn, are arranged across the submersible from their viewing position so that each observer can easily confirm that their assigned recording deck is correctly recording the video channel they have selected during a dive. Thus the port observer's video selections are recorded on the starboard deck in *Alvin* and all subsequent files that are delivered to the science party are named "Starboard". Equally, all video recording conducted by the starboard observer are delivered as files with the word "Port" in their name because they were recorded on the Port deck. The naming convention is logical, and the scope exists within the submersible to record any video channels to either deck but even so, alerting this idiosyncracy to each on-coming science party will likely be required to prevent recurring confusion at the outset of each *Alvin* dive-series.

3.3 Stabilizing choice of "proxy" video formats

The highest quality video files provided to the Science Party at sea are only provided to the Chief Scientist at cruise end (1 copy) along with the set of files of equal quality that are returned to the NDSF archive. Because it would not be feasible, ordinarily, to generate multiple additional copies of the same data (a single dive requires order 10h to copy 1TB to en external USB 2.0 drive) part of the standard data products established by the NDSF (borrowing the idea from one established by NOAA's Ocean Exploration Program) is also to generate a lower-resolution data-product by the morning after each dive which approaches Blu-Ray quality (i.e. should be difficult to distinguish in quality from the original files on any conventional computer or TV screen) but takes up an order of magnitude less file space and, hence, would lend itself to being copied multiple times among the science party (~10 min to copy 1TB of dive-video per dive). The format selected to achieve this at the outset of the SVC cruise was the .mkv format which can be reviewed using the free software VLC (supported by the SSSGs aboard the *Atlantis* who will maintain up to date versions of VLC) when reviewing files for the purposes of writing up dive reports etc. and which can also be used to extract still frame images easily for the purpose of illustrating such reports and/or providing images to be taken to the seafloor by subsequent dives when chasing specific targets.

A major limitation of the .mkz files that was identified during the SVC cruise was that the VLC software is optimized for replaying video data and does not have the functionality to clip and/or trim large video files to extract specific "highlight" sequences of video. Further, the .mkz format is not readily importable into other commonly employed software packages, notably QuickTime or the iMovie software installed on all Macintosh computers. Accordingly, an experiment was conducted into generating alternate .mp4 files which would be importable by QuickTime and iMovie and, hence, achieve the additional functionality that the .mkz files lacked. A suggestion that we upgrade the data pipeline to generate .mp4 files in addition to .mkz files was considered but it was soon recognized that this was unsustainable. The SSSGs aboard ship only have sufficient resources (hardware, time) to generate one set of proxy files per dive before the next dive begins, to attempt both would be unsustainable. Recognizing that fact, the decision was made, for one dive (AL 4680) to generate both formats and intercompare the two on a like-for-like basis with the following outcomes: for the quality of .mp4 file that could be generated by the morning after each dive (i.e. to provide the immediacy of access to the data that the .mkz files achieve) the equivalent proxy files were at least two-fold larger in size. While this was not immediately a show-stopper, what like-for-like intercomparison of scenes written to the original .MOV format and the candidate proxy formats (.mkv, .mp4) revealed was that the .mkv files were closer to true color than their .mp4 counterparts and also crisper in their clarity when viewed on a laptop computer screen. While even the .mkv imagery could be seen to be degraded from the Original .MOV format, the step-down was not so marked as to the .mp4 format where any ease of editing files together to make a highlights movie would be obviated by the recognition that the quality of the product generated would not do justice to the quality of the original video recorded from *Alvin*'s HDTV cameras. While .mkv proxy files could be expected to provide science party members with close-to-Original quality imagery in small-enough files that they could readily take copies home for their academic use, the same could not be said of the .mp4 files.

Accordingly, the SVC science party opted to stick with the .mkv format for proxy files going forward, but to research how to make it easier for the science party at sea to (a) review entire video files at sea; (b) identify which time-sequences in the original videos were of the highest quality and, hence, worth extracting material from, using the resources available aboard ship and (c) edit and export files from those original .MOV files for the highest-value video sequences recorded by *Alvin*. This was undertaken by members of the SVC science party once lighting issues had been resolved (dive AL4683 onward) and a series of recommendations for future users were developed.

4. Guidance for general use of *Alvin*'s forward looking HDTV cameras

Two 2-page "cheat-sheets" for videography from *Alvin* were developed by the SVC science party: one to equip any user with the basic rudiments required to acquire acceptable imagery at the seafloor, the other to explain how best to access, review and extract high-quality highlights from those video-files using the resources provided for that purpose aboard ship. The relevant .pdf files are:-

- VideoCheatSheet1_SubSea
- VideoCheatSheet2_PostDive

Both are available from the SVC web-site and from the SSSGs aboard *Atlantis*.

5. Science camera capable of still photography: SubSea with Sony HDR

For the Science Verification Cruise, the *Alvin* Group installed the new SubSea Science Camera which comprises a 24MPix digital still camera that can also record HDTV video mounted in a housing with a sapphire end-window. Although ultimately intended to be mounted on *Alvin*'s manipulator arm, that will now require development of a fiber-optic break-away connector before installation in that location will be approved by NavSea. In the interim, this camera was mounted in a down-looking orientation to the rear of *Alvin*'s Science Basket. The stills are recorded internally on a 96 GB hard drive, which yields thousands of images at the full resolution of 24 MP.

During the SVC, the downlooking camera was mounted on the port side of *Alvin*, aft of the science basket. Lighting was adjusted after the first two dives determined that the images (a) when the down-looking LED unit was turned on, the LED in the science basket (on a common circuit) cast uneven shadows across the camera's field of view but (b) if both LED units were turned off and just the low-mounted and side-looking observer LEDs were used, the resultant images were too dark. After dive 4681 it was requested that this be address and the resultant light configuration, which was not altered throughout the rest of the dive series had two LED units on the starboard side, aft of the basket, on the opposite side from the science camera. This is not ideal and often yielded unevenly lit images that were underexposed and overexposed on left and right halves of the photos, respectively. There are plenty of LEDs available to the *Alvin* group to facilitate optimal lighting although strobes are not available at this time. If downlooking photomosaics are needed, some lee time will be needed to get the lights set up before the dives, and it will be important to maintain that configuration. Optimizing camera controls are discussed below. If general imaging of the seafloor is needed, then balancing LEDs equidistant from the camera would improve the evenness of the light.

After consulting with the pilots, in order to balance out the lighting around the camera and improve lighting all around for downlooking still imagery, we suggest mounting the camera in the middle of the back end (aft) of the basket. Lights may be added to the swing arms, such that adjusting the lighting would simply involve moving the arms during the dive. Alternatively, the LED lights could be mounted forward on the basket, which could not be adjusted on the seafloor because they are fixed, but would allow for consistent image capture for the course of the dive without the need of the swing arms. If there is an issue with the swing arms during the dive, or if there is a need to use the swing arms for other operations (e.g. sampling), then the fixed option may be more appropriate.

Adjusting the camera's settings:

Access to the camera's control system is via the *Alvin* computer, accessed through the pilot's GUI. The camera is currently set up for taking still images at 10 s intervals. In order to stop image capture, first cycle power to the camera, then push reset. Pushing reset before cycling power will not stop interval image capture.

The iris settings can be manually adjusted through the camera's menu setting. First, it is necessary to select "Menu" on the Subsea software (PC). This will bring up the camera's menu option and the video controls need to be switched to the downlooking camera in order to use the camera menu. Note that selecting different iris settings takes time, e.g., several minutes, so it would be efficient to become acquainted with these controls before the dive, if possible. The possibility of a pre-dive briefing that included a hands-on tutorial on camera use and functions, not only for the downlooking, but also video cameras was discussed, and the pilots also had discussed this idea independently. All cameras may be controlled from the ET lab, which would accommodate more people at a time than the sub. These briefings, plus a how-to imagery cheat sheet that could be reviewed before dives will save a great deal of time on the bottom troubleshooting.

There may be times when it is not possible to access the menu to adjust the iris or other camera controls. When this happens, first verify that the correct comm port is selected. If you are still unable to select menu, then, cycle power and let it sit for 10-15 min before using. If neither of these options work, then no other option is available at this time.

6. Long-term use of digital still camera for downlooking imagery

Given that light is a major factor that influences image quality, the ideal route forward would include the addition of strobes to *Alvin*'s swing arms and centering the camera aft of the science basket or on the *Alvin* frame. Strobes are not available at this time, because funding of those upgrades was deferred to Phase 2 of the Replacement HOV project by NSF in consultation with RHOC (Replacement HOV Oversight Committee). One priority for the immediate future will be to pursue development of the necessary connector that will allow mounting of this camera on the *Alvin* manipulator – the purpose for which it was purchased, to be approved. In parallel, it is worth pursuing the investment required for a new digital still camera and associated lighting for downlooking imagery that is appropriate for photomosaicing.