EOS
SPACE SYSTEMS

UCO/Lick APF

IceStorm Enclosure (Series 2)

Lick APF Site Inspection Report

6 June 2007

COMMERCIAL IN CONFIDENCE

SUBJECT TO PRIVILEGE

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1. OVERVIEW

The as-built enclosure was inspected by Jason Chapman on behalf of EOS on 15 May 2007 and 16 May 2007, with attention to the nominated issues and claims as made by UCO-Lick. Some deficiencies in workmanship were identified during the course of the inspection by EOS. In discussing the identified issues, UCO-Lick expressed an interest in helping EOS complete any repairs, with guidance and part costs covered by EOS.

WPY Foreman Matt Beaver has indicated that WPY accepted full responsibility for caulking, along arch beam troughs and infill panels.

EOS Observatory group are preparing a trough and infill panel re-caulk procedure to distribute to UCO-Lick and WPY.

EOS Observatory Group are also investigating some documentation claims. Some previous unconfigured documents will be checked, configured and re-sent to UCO-Lick if required.

2. CLAIMS BY UCO-LICK WITH RESPONSE BY EOS

This section outlines the claims made by UCO-Lick and a response by EOS following briefings by Jason Chapman on his return from Site.

This response is drafted to match item numbers in a paper document "Draft Preliminary Punch List" received by Jason Chapman on 14th May 2007. Additional items that came to light during or just before the site visit have been added.

1. Azimuth Drive Wheel Contact
2. Azimuth Concentricity
3. Snow Melt Cables
4. THUD Box
5. Ring Wall Seal Gaps
6. FRP void

From MATT RADOVAN 14/05/07
APF WARRANTY CLAIMS

Draft Preliminary Punch List

Safety Deficiencies:

1. Level 1 door needs hydraulic closer to keep it under control when windy
2. Guards needed to cover ring beam and bogy wheels
3. Level 3 floor hatch shock mounts are not properly positioned. Hatch is very difficult to open and slams at the end of travel
4. Safety chain behind level 3 floor hatch doesn't have anything solid to connect.
5. Tripping hazard on level 3 at top of stair where the level 3 hatch folds.
6. Temporary dead bolt on exterior needs to be removed

Dome Operational and Assembly Deficiencies:

1. E-stop trips when computers turn off the building lights. Tests have determined that the fly lead on level 3 and the power for the bench light is NOT the problem as suggested by Jack Grey.
2. Lower shutter non-operational due to water damaged circuit board
3. Level 1 ceiling water damaged from leaks at the base of the arch girders.
4. Shutter blade seal tape coming off
5. Shutter seals too short and wrinkled because they are made from straight strips of rubber.
6. Level 1 ceiling to base seals wrinkled due to straight cut material (air and thermal leak between level 1 and the observing space.
7. Missing and loose bolts on shutter seal
8. Shutter cable bulkheads missing fasteners and seals (both bulkheads)
9. Door sheet metal hasn't been changed to match ring wall
10. Exterior door missing weather proofing seals
11. Calculation for as-built shutter panel attachment to show design still meets the survival requirement of the contract. (Because almost every bolt hole didn't line up the attachment points were drilled and tapped into un-reinforced sections of the structure as a field modification by Mark Epsick.)

Dome Water Leaks:
1. Base of arch girders (4 places)
2. Most joints between shutter troughs
3. Joints between rear infill panels (all panels-4 joints)
4. Arch girder bolt heads
5. Vent door lower rail bolt heads
6. Main panel attachment bolts on lower shutter
7. Right corner of lower shutter where it meets the upper shutter
8. Bulkheads for shutter cables

Figure 1 List received from Matt Radovan – 14th May 2007. Page 1

FROM MATT RADOVAN 14/05/07.
APF WARRANTY CLAIMS

Missing deliverables:

1. All proprietary info for any EOS designed and/or programmed item in the dome:
   1a- Source code for all dome software in a self- extracting form.
   1b- Complete build environment (operating system, compilers, linkers, and any other system utilities) and build procedures need to compile and link the source code into an executable form and to build any dynamically loaded or statically-linked libraries.
   1c-Drawings (included but not limited to board-level, sub-system-level, and system-level schematics, board fabrication drawings, parts placement diagrams, etc.) for all EOS-designed circuitry and circuit boards.
   1d- Instructions, logic equations, and programs for all programmable logic devices on EOS designed boards

2. Complete package of HVAC. Mechanical, Structural, and Electrical drawings (paper and electronic form) including a drawing tree and list of ALL dome drawings, included but not limited to mechanical, electrical, plumbing, etc.

3. Configured as-built cooling Design Analysis Report: Lick APF Cooling kit report

4 Warranty and inspection report for service on shutter gearboxes (Shutter gear boxes were leaking oil shortly after installation. Gearboxes were removed and serviced by a factory service center in the San Jose. Water had passed the seal causing rust on the shaft and the subsequent oil leak.)

5 Current vs Position maps for all moving parts (on list of deliverables but can be demonstrated and documented during acceptance testing)

6 Revised dome assembly manual for the Icestorm 2 series dome (specifically assembly sections for the shutter infill troughs and shutter assembly).

7 Procedure for front shutter infill panel removal and track assembly installation to install or remove the mirror.

8 All parts and drawings to install the lightning protection system (Note: EOS claims all hardware is onsite- I need to confirm). Installation instruction for the contractor.

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Figure 2 List received from Matt Radovan – 14th May 2007, Page 2

2.1 Claimed Safety Deficiencies

2.1.1 Level 1 Door Closer

UCO – Lick claimed that the Level 1 door was dangerous in windy conditions and required a hydraulic door closer. Once on site it was apparent the door in question was actually the staff entry door, into the enclosure ring wall.

EOS design does not include a door closer of any type. No such closer is installed at the Mt Stromlo facility, which was visited by UCO Staff and no mention of a requirement was made by UCO during the design reviews. EOS has not encountered any injury or damage causing occurrence operating the entry door at the EOS test facility.

EOS does not consider that this is a design safety deficiency requiring rectification or further action.

2.1.2 Guards Around The Ring Beam

UCO-Lick saw potential crush hazards on the ring beam during operation. A request was made for guards to be supplied and installed.

EOS design does not include custom guards of any type around the ring beam. No guards are installed at the Mt Stromlo test facility, which was visited by UCO-Lick staff.

EOS has not encountered any injury or damage causing occurrence during normal operations. If appropriate operating and personnel procedures are developed by UCO-Lick, no guards are necessary. It is noted that the enclosure is designed for autonomous operation and is not anticipated to be used in such a way that guards are necessary.

Guards are not part of the enclosure kit, although for the abundance of caution, if UCO-Lick deem guards as necessary, then EOS agrees to provide a design of these guards for manufacture and installation by UCO-Lick.

2.1.3 Level 3 Floor hatch Gas Struts.

UCO-Lick indicated that the level 3 floor hatch mounts are not adequate and safe. An attempt was made by EOS to improve the use of the hatch by removing a gas strut from each hatch section during 2006.

It is agreed this is not an adequate fix and potential for serious injury increased, due to insufficient force applied by the single strut preventing the hatch from falling. It has also meant that strut pins may have fatigued as they are "working" twice as hard.

A site inspection prompted Jason Chapman to advise UCO-lick to lock the hatches in a safe position until appropriate remedy is applied. The second gas strut was re-installed to the heaviest hatch piece and the hatch became workable.

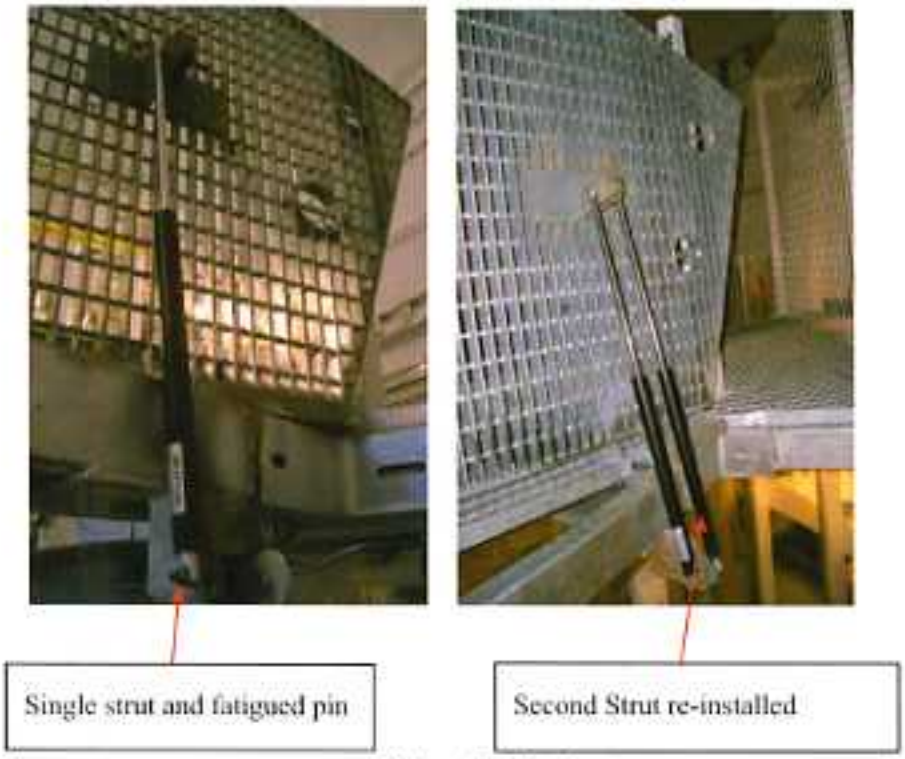

Figure 3 L3 Hatch struts.

The position of the struts is determined by the geometry of the hatch.

2.1.4 Level 3 Safety chain

UCO-Lick expressed an interest in having an ability to cordon off the back of the level 3 stair well with a secure safety chain.

EOS would suggest that UCO-Lick install an attachment point could be screwed to the enclosure frame allowing a secure anchor point for the chain.

2.1.5 Level 3 Trip Hazard

UCO-Lick identified a void in the level 3 floor adjacent to the hatch. The void has the potential to be a trip hazard.

During assembly of the enclosure, EOS provided an infill piece to fill the void, which was caused by hatch modifications. The piece was small and was not located on site when Jason Chapman inspected the enclosure in May 2007.

UCO should find or make and install this part to eliminate the trip hazard.

Figure 4 Void in floor, EOS are asking UCO to fill.

2.1.6 Exterior Deadbolt

UCO-Lick claimed a safety hazard was imposed by the exterior deadbolt system on the staff entry door. The claim was made that someone could be trapped inside the enclosure if the bolt was utilised. UCO-Lick appeared to be under the impression the deadbolt was temporary.

The deadbolt existed as a precautionary lock during extreme survival conditions, to avoid the door latch being the only part preventing the staff door from being sucked open. The deadbolt has always been part of an IceStorm design, it is present at the Mt Stromlo facility and appeared on design review models.

EOS does not consider this as a design flaw or safety risk and proposes no further action is required. However, for the abundance of caution, if UCO-Lick deem this to be an unacceptable risk, then we propose to cut off the deadbolt tang to render the deadbolt inoperable.

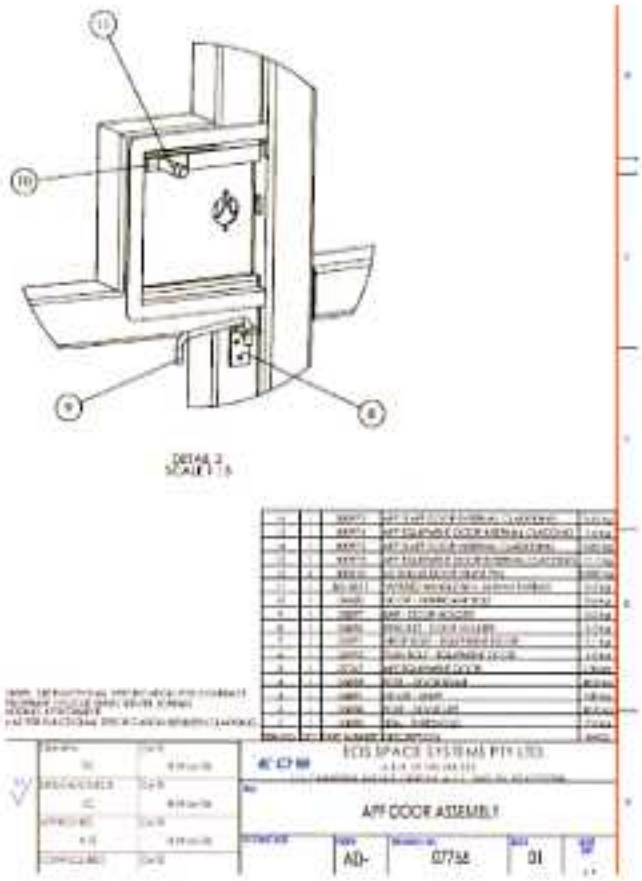

Figure 5 Exert from door drawing – Calls out dead bolt as "Door Hurricane Bolt"

2.2 Claimed Dome Operational and Assembly Deficiencies

2.2.1 E-Stop trips

UCO discovered that switching their enclosure lighting circuit causes the emergency stop circuit to switch to STOP mode.

This matter will be addressed by the EOS Controls Group separately.

2.2.2 Front Shutter Non Operational

UCO tried to operate the front shutter after a period of high rainfall. The shutter would not operate and a preliminary investigation showed potential damage to a printed circuit board directly linked to front shutter operation.

The printed circuit board was replaced on site by Jason Chapman and the replacement proved to have communications with the appropriate parts of the control systems, however the shutter was still not operational.

Further investigation by Jason Chapman and Steve Vogt indicated that the front shutter controller / amplifier was not communicating with the rest of the control systems. After a phone conversation with the EOS electrical group the decision was made to remove the amplifier and return it to Australia for assessment.

The control cabinet has obvious signs of water ingress, which seems the most likely cause of shutter parts malfunction or failure. The water has apparently made its way into the control cabinet from upper levels of the enclosure. During installation, EOS installed expansion foam on the top of the cabinet to control moisture ingress (water and humidity) to the control cabinets. On inspection this was no longer present.

Figure 6 Shutter control panel

2.2.3 Level 1 Ceiling water damage

UCO-Lick claimed that the level1 ceiling was water damaged.

The ceiling has some slight discoloration in places. The ceiling did not show any signs of failure or significant swelling that might have an effect on seals.

EOS supplied original ceiling parts which were water resistant and of good quality. UCO engaged contractors who made a poor attempt to install the ceiling, requiring significant remedial work to rectify. The ceiling was deemed acceptable as fit for purpose by UCO, after installation by WPY. EOS is of the opinion it is still fit for purpose.

Water damage could have been caused by insufficient WPY caulking works. (**Also see Arch Girders leak section**)

2.2.4 Shutter Blade Seal Tape Coming off

UCO noted that a tape installed on the longitudinal seal blade was falling away.

Further investigation by Jason Chapman and Matt Radovan showed the tape on the seal blade was not the correct tape specified by EOS. It was also noted that it was installed in incorrect positions and was probably installed on stainless steel blades that were not cleaned sufficiently prior to installation of the tape.

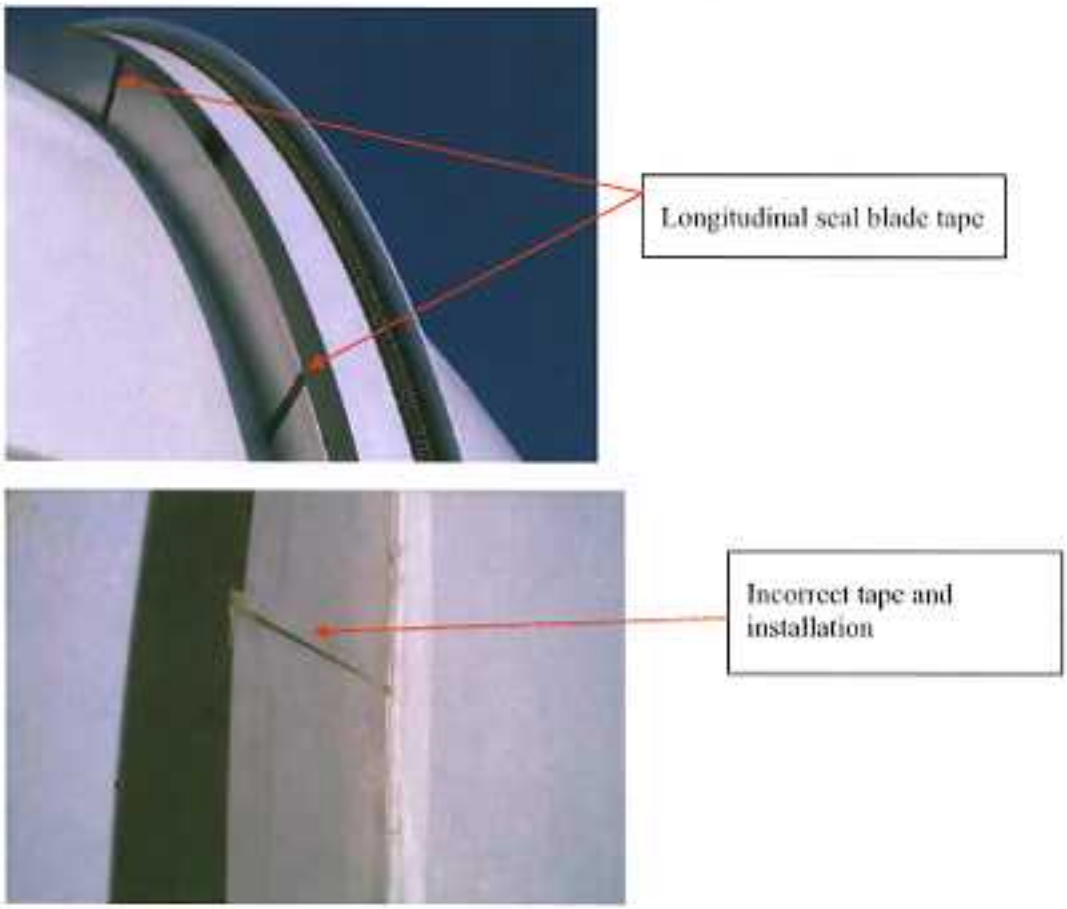

Figure 7 Longitudinal seal blade tape, preventing seal flap snags on blade ends.

Temporary tape had been installed during shutter frame alignment. The final to-be-installed tape was issued and was to be re-installed by WPY after shutter alignment work was complete.

New tape will have to be installed after the trough re-caulking procedure has been completed. When re-installing the seal blades, they will be required to properly install the correct tape. EOS can provide instruction on this.

2.2.5 Shutter Seals Too Short and Wrinkled

UCO-Lick has stated that the shutter longitudinal seals flaps are not sealing appropriately due to wrinkling.

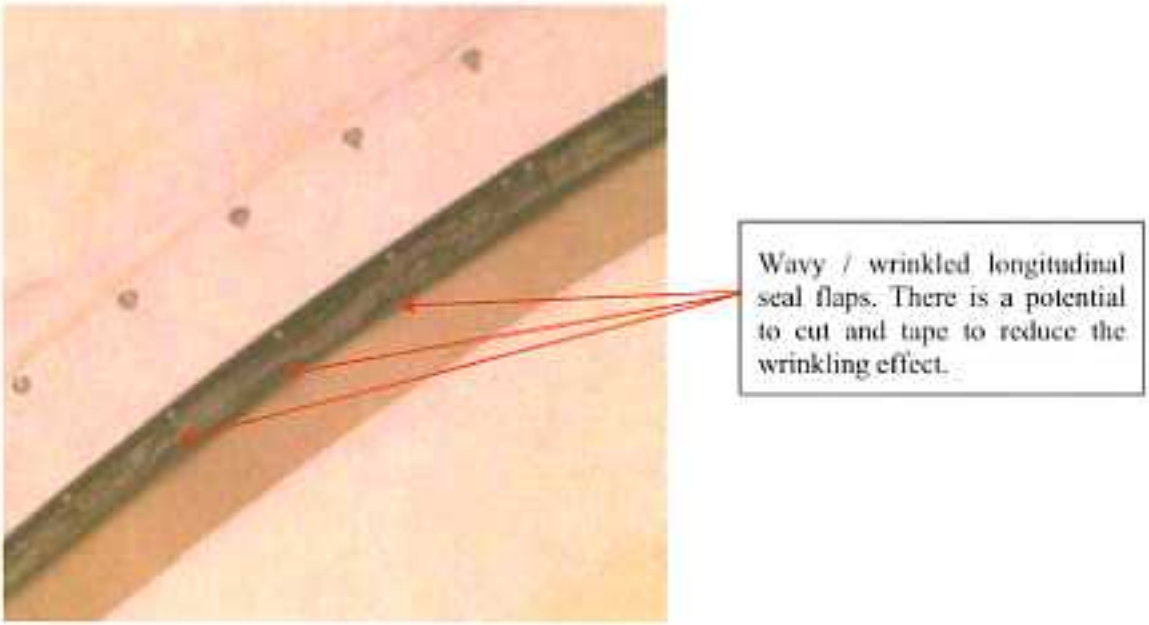

Figure 8 Longitudinal seal flaps.

These longitudinal seal flaps are installed to prevent significant light leaks and to minimise air flow between the exterior atmosphere and the enclosure interior. No light leaks were observable along these seal flaps. It is not easily determined if the seal flaps would improve air leakage significantly if they had 100% contact along their length.

As no moisture is infiltrating at these points EOS has determined the seal positions and function as acceptable, and replacement of the seals is not necessary.

At UCO-Lick's discretion, the seal flaps may be relieved to reduce wrinkling, with cutting then taping (with UHMWPE tape) between joins by UCO or WPY during the re-caulking project.

2.2.6 Pier to L1 Ceiling and L2 Floor seal.

UCO-Lick observed a source of light leak from Level 1 to Level 2 during night hours, when Level 1 lights are switched on and the observing space is in darkness. The leak was traced to the seal that runs around the telescope base.

It appeared that there is a significant gap were the silicone rubber seal flap should run on a stainless steel pier seal seat.

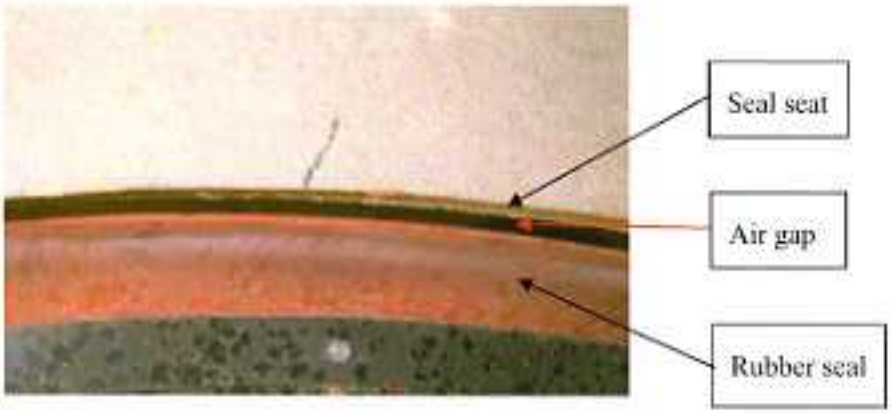

Figure 9 Air gap present in pier seal.

The problem appears to stem from straight strips of rubber being bent on a tight radius to form the seal flap. The radius is seemingly too tight and the rubber folds back on itself without touching the seal seat.

EOS will test some different rubber configurations to find the pattern that works best. Cut rubber could be sent to UCO-lick to install and alleviate the problem.

2.2.7 Missing and Loose bolts on Shutter Seal

UCO-Lick have observed missing fasteners on a shutter seal. EOS representatives have not viewed these missing or loose fasteners.

As all fasteners were supplied by EOS, to be installed by WPY, missing fasteners are an issue for determination between WPY and UCO-Lick. WPY did not at any stage

approach EOS supervisors and indicate that there were any problems installing the supplied fasteners.

It is noted that many fasteners are still stored in the old enclosure adjacent to the APF site.

2.2.8 Insufficiently Installed Cable Bulk Head

UCO-Lick expressed dissatisfaction with the installation method of the shutter cables entry bulkhead, located on the inside of the troughs. There is no evidence of seal gaskets and 2/3rds of the attachment studs are missing nuts.

This was observed as being a valid assessment by Jason Chapman. Light leaks were prevalent around the bulkhead.

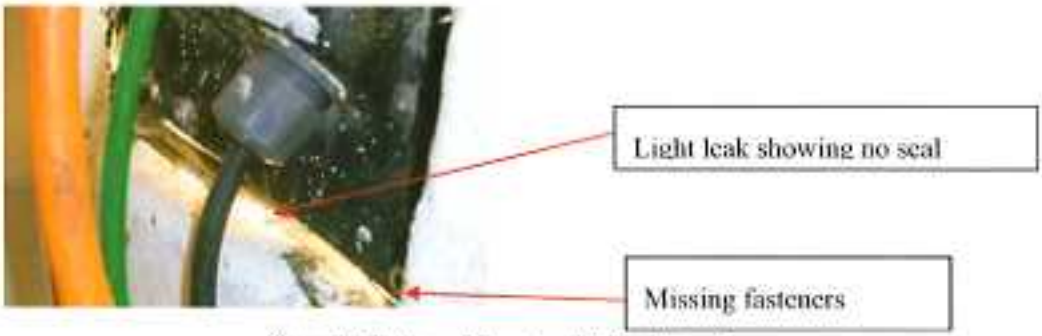

Figure 10Shutter cable entry bulkhead / panel

EOS will fabricate and deliver 2 x closed cell foam gaskets and a bag of fasteners to UCO Lick for installation onto the gland plate.

2.2.9 Different Pattern Cladding on Entry Doors.

UCO-Lick noted that during the assembly there were problems with steel ring wall cladding supply. Locally sourced cladding was required to finish the enclosure.

The EOS supplied cladding profile differed to the locally sourced cladding profile, although the colour is a close match. When the ring wall was clad, the entry doors were left the same as they were fabricated with correctly installed cladding.

EOS does not consider the cladding profile differencesto be a function, design or other issue and in fact enhances safety as it acts as a tactile indicator of reaching the door when lights are extinguished in the enclosure.

The cladding on the door has been sealed with closed cell foam that conforms to the EOS supplied cladding profile. The advantages of keeping the supplied cladding profile outweigh any visual effect from replacing it.

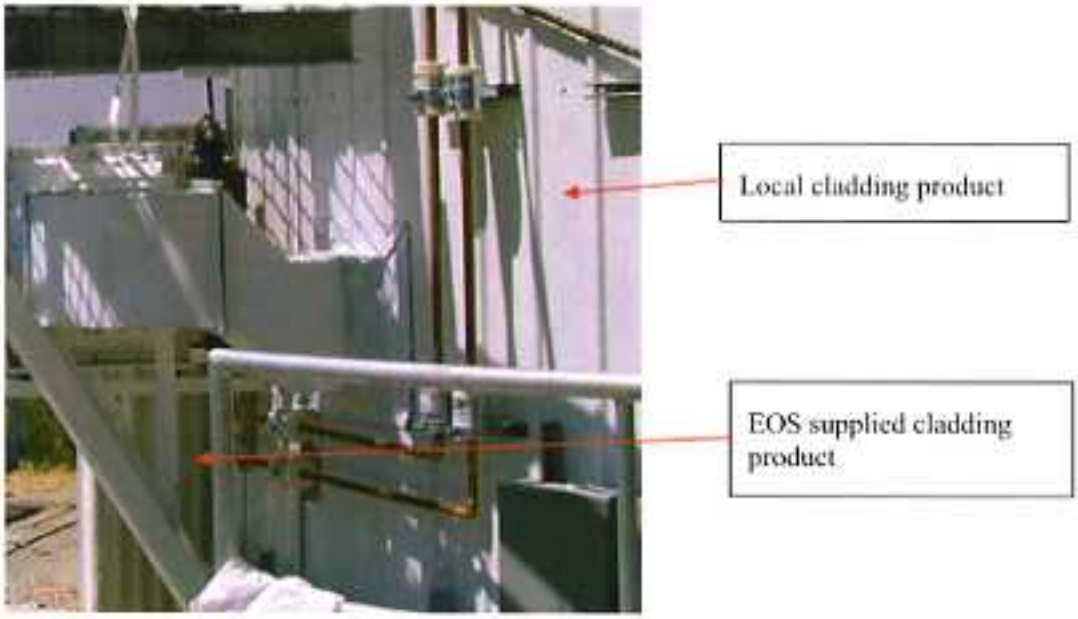

Figure 11 Different cladding on the entrance door and ring wall.

2.2.10 Entrance Door Weather Proofing

UCO-Lick pointed out a claimed deficiency in weather proofing the front entrance door. The claim was that seal material around the door jam is not sticking and the seal was inefficient.

The seal design is based on compression of closed cell foam between the door frame and the door jam or weather strips.

Figure 12 Entrance door weather seal

New closed cell seal tape can be provided and re-installed on clean steel door jams if required by UCO-Lick.

Seal style design will not change if no proof of normal weather conditions (wind blown rain other than extreme unusual force winds) causing leaks around the door can be demonstrated or recorded. If normal, as expected weather, can not infiltrate the entrance door seals the seal is regarded by EOS as fit for purpose.

2.2.11 Shutter Flare Fit

UCO-Lick raised an incorrect fit of shutter flares to Jason Chapman. Several of the (cosmetic) flares, which are attached to aluminium rails by screws, appear to missed the intended threaded hole and backing plate, and were screwed directly to un-reinforced aluminium rails.

UCO-Lick claimed that an EOS representative, Mark Elphick, installed the flares in this manner. Ultimately WPY ought to have installed these parts.

Photos were not taken of the incorrect installation

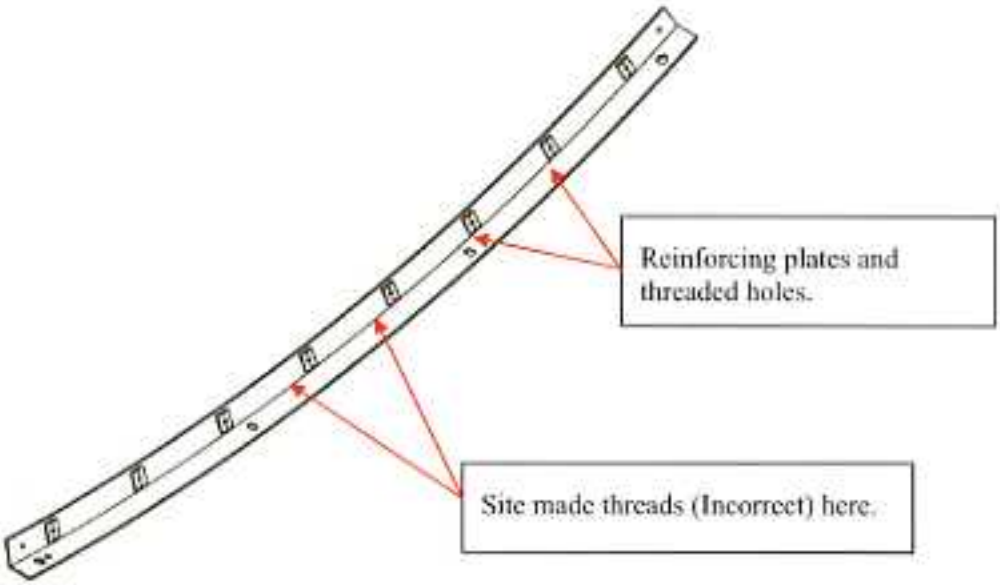

Figure 13 Shutter rail – Shutter flares installed to these

UCO-Lick would like assurances that the incorrect installation still meets survival conditions.

EOS will calculate the effect of the as built installation and email our findings to UCO. If the flares do not meet specification, rectification will require holes in the flares to be re-drilled and fasteners installed to the correct threaded holes. Old holes can be plugged (white plastic plugs) closed. As the flares are cosmetic covers for drive gear, the standard of weather sealing does not matter.

Any rectification must be completed when a boom lift (Elevated work platform) is on site. It would be ideal to do this during the re-caulk exercise. Calculations will be made as soon as possible.

2.3 Dome Water Leaks

The largest item in terms of claimed Dome operational deficiency was the ingress of water.

EOS maintains, on the basis of recollection and site records, that EOS had given sufficient instruction to WPY to perform works appropriately, both in the form of verbal instruction and supply of materials to complete the caulking works.

Matt Beaver, Jim Deming and Matt Radovan were present during a briefing conducted by Jason Chapman stressing the importance of high quality caulking. No objections or questions came out of that meeting and it was expected WPY accepted the briefing as sufficient instruction.

Following inspection of the caulking by Jason Chapman, EOS maintains that, with competent contractor workmanship, all identified leaks could have been avoided through proper caulking of the enclosure.

2.3.1 Leaks Around the Arch Beam Feet

UCO-Lick claimed significant to large amounts of water were infiltrating the enclosure around the base of the Arch Girders (EOS Terminology – Arch Beams).

Upon inspection by Jason Chapman it was apparent that the base of the arch beams were not caulked properly, including sealing of the temporary arch beam fastener heads.

EOS has agreed to design and provide fibreglass or plastic inserts to cover the arch beam feet area. These inserts will be retained in place with Dow Corning 795 sealing compound. They will be designed to minimise effort to seal and will cover the temporary fasteners as well. UCO will need to test fit the inserts when they are available.

The final installation could be done during the re-caulking project.

2.3.2 Most Joins Between Shutter Troughs.

UCO-Lick has indicated water ingress coming from the region of the shutter chain troughs. Claims had been made by UCO-Lick and WPY that the design of the troughs was such that sealing was impossible due to large gaps between troughs.

Upon inspection by Jason Chapman and Matt Radovan (with Steve Vogt in attendance), it was determined that the joins were in fact sealable, or within acceptable tolerance ranges allowing sealing to occur, but the caulking by WPY contractors was poor.

Large pockets and gaps were easily distinguishable in most of the joints reviewed. All of these flaws would cause serious leaks, especially as the troughs act as a gutter during periods of precipitation. High flows of water would be prevalent in these areas.

The joints were also inspected by WPY. Matt Beaver, the WPY foreman during assembly, agreed that the workmanship was extremely poor and that it would in fact be possible to seal the troughs.

EOS will provide a procedure to re-caulk the enclosure infills and troughs, which will attempt to eliminate the need to remove the shutters from the enclosure.

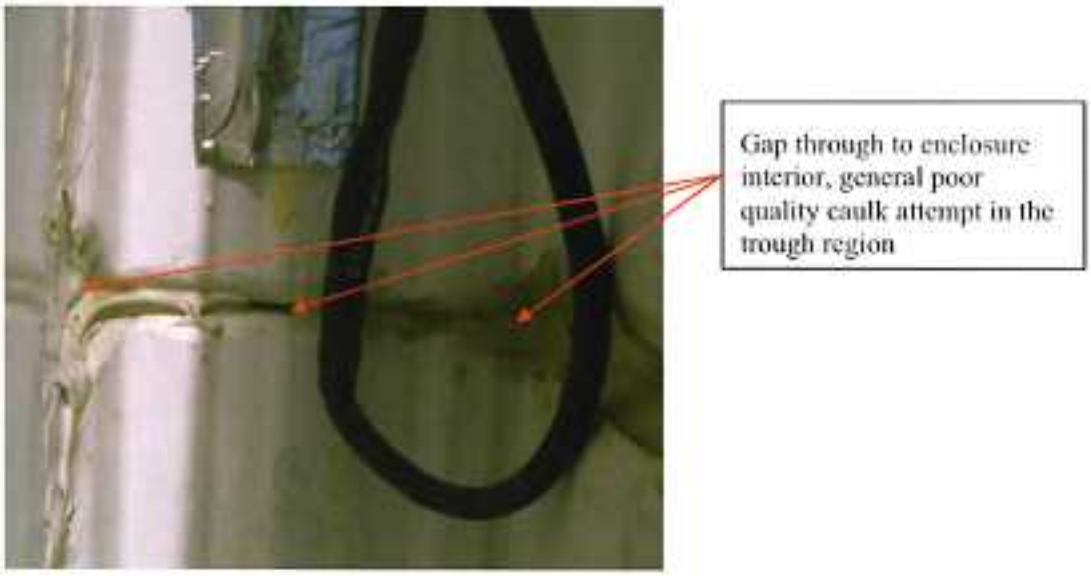

Figure 14 General example of trough sealing quality

2.3.3 Rear Infill Panel Joins

As per the trough leaks, UCO observed water ingress in the rear infill panel joins. WPY originally claimed it was not possible to seal this area.

After inspection, which included exploratory caulk removal, by Jason Chapman, Matt Radovan and Steve Vogt, it was agreed by all in attendance that poor workmanship was the cause of leaks.

Several types of caulk failings were noted those included holes and caulk that did not bond to the fibreglass.

Adjacent to these leaking areas the caulk adhered well and had good penetration into gaps, evidence that the caulking could have been completed appropriately.

The joints were also inspected by WPY. Matt Beaver, the WPY foreman during assembly, agreed that the workmanship was poor and that it would be possible to seal the infills.

2.3.4 Arch Beam Bolt Heads

UCO-Lick found leaks under temporary alignment bolts at the base of the Arch Beams.

The EOS supplied retro-fit for the arch beam base, see "**Leaks Around Arch Beam Feet**" will resolve further leaks in this area.

2.3.5 Vent Door Lower Rail Bolt Heads

UCO-Lick incorrectly identified leaks as originating from the Vent Door Lower Rail Bolt Heads. Some slight discoloration is shown in the inside of the skirt attachment screws, inside the Azimuth support beam.

This discoloration is slight and Jason Chapman could not see any evidence of significant leaks, the discoloration may be caused by condensation after assembly, when the enclosure was still open to the elements. The position of the screws suggests it would be very difficult for water to make its way inside the enclosure from these points.

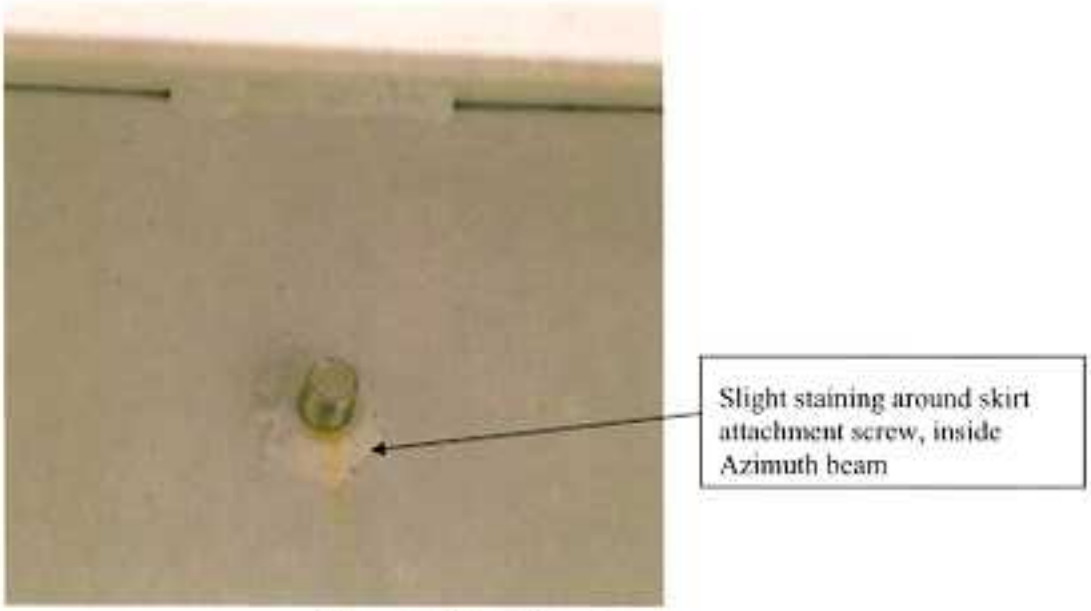

Figure 15 Skirt attachment screw

2.3.6 Main Panel Attachment Bolts on Lower Shutter

UCO-Lick found water dripping from 2 bolts on the upper right hand side of the front shutter, after a period of rain. An *assumption* was made that water had made its way into the enclosure via flare attachment points.

After investigation and suggestions by Jason to pour water on the shutter transverse gutter, the leak point was identified as a hole in the caulking, under the upper right hand side of the top transverse beam. Water channelled between an interior seal, until it reached the through-bolt connections and ran into the enclosure.

EOS suggests that UCO or WPY staff fill the hole with caulk during the shutter trough re-caulk project.

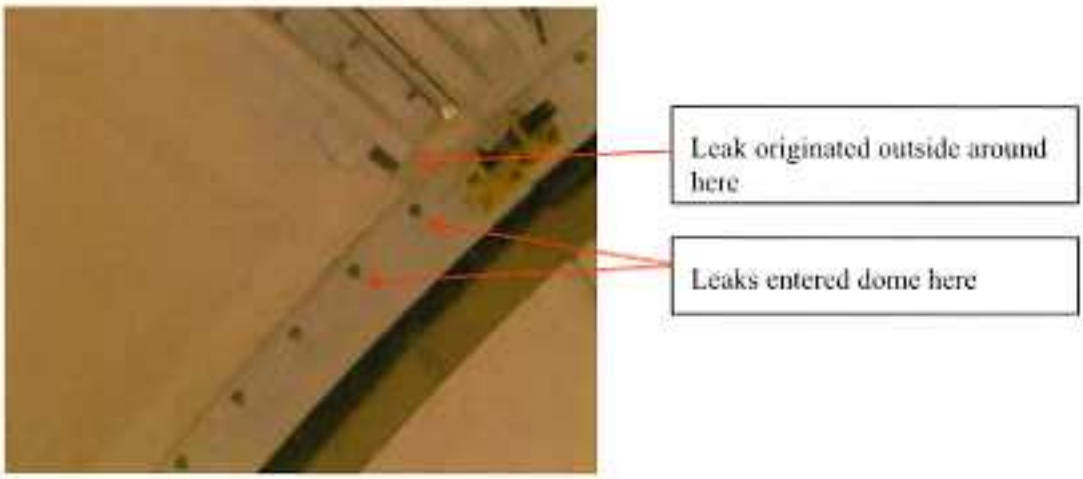

Figure 16 Shutter bolt leak

2.3.7 Right Corner of lower shutter

UCO-Lick identified a light leak, but no mention was made of a water leak at this point.

UCO-Lick staff (Matt Radovan) could not put his finger through the hole from the enclosure exterior, due to the geometry of the shutter fibreglass and frame.

For water to ingress at this point, it would have to travel through a series of fibreglass overhangs, and be blown up-hill.

EOS response is that this claimed leak is not in fact an issue, as no evidence of water, or the ability for water to enter here exists. UCO-Lick can adapt the shutter if they wish to try and reduce the small amount of light leakage.

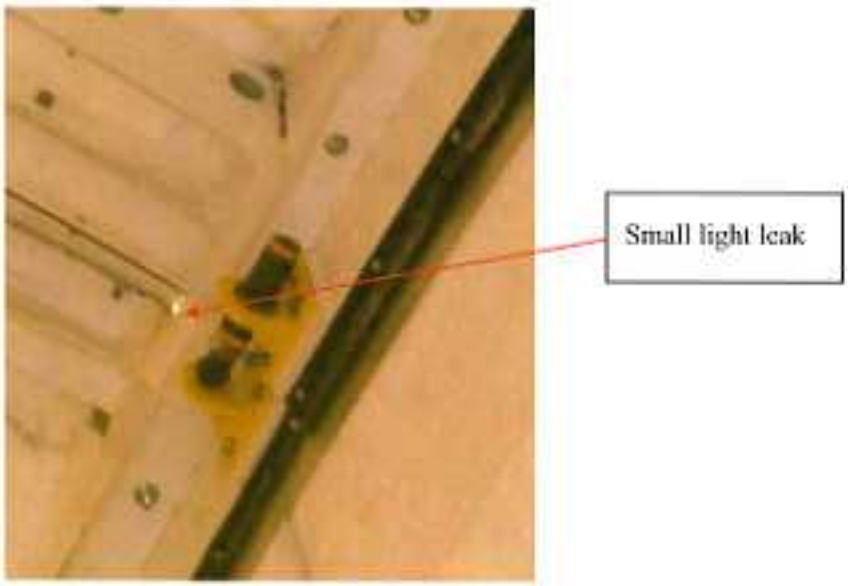

Figure 17 Shutter butt join light leak

2.3.8 Bulkheads for shutter cables

See section "**Insufficiently Installed Cable Bulk Head**"

2.4 Claimed Missing deliverables

UCO-Lick claims missing documentation and electronic file deliverables. This is not relevant to the enclosure inspection.

2.4.1 Mechanical deliverables

Chapman investigated the level of mechanical documentation that had been sent to UCO-Lick.

Some assembly drawings possibly required for maintenance purposes will be re-sent to UCO-Lick. Other documents including the cooling design notes were not configured. A configured copy can be resent.

2.4.2 Electrical and Software deliverables

Lightning protection parts were sent to UCO-Lick and were stored in the Astrograph. If these parts have gone missing, proof of shipping documents can be produced by EOS to evidence delivery. This is a matter for UCO-Lick.

Installation drawings have been delivered to UCO-Lick. They can be resent if required.

2.5 Additional Claims (Made during the site visit)

Some additional claims were made by UCO-Lick, during the site visit by Jason Chapman 14th May 2007.

2.5.1 Azimuth Drive Wheels

It was observed by UCO-Lick that both Azimuth drive wheels were not making 100% contact with the Azimuth ring beam.

This was assessed by Jason Chapman. The enclosure seemed to have settled slightly and the only flow on affect was the drive wheel issue. It was not possible to obtain a photo.

Jason measured all of the rubber springs that support the rotating enclosure and established that they were compressed to an acceptable size in every position, meaning the enclosure was not overweight.

The best solution was to shim under the drive assembly pivot blocks, in affect raising the drive assembly by 3/8" (~10mm), which had the flow on affect of increasing the drive wheel contact to ~100%.

UCO-Lick was instructed verbally and by demonstration how to do this. It was accepted by UCO-Lick that they could perform the work themselves. Skew and alignment procedures were followed according to the maintenance manual. This was also demonstrated to UCO-Lick staff (Matt Radovan, Steve Vogt).

UCO-Lick were also instructed to minimise operation of the azimuth until the rear (Front was completed by Jason) drive assembly was adequately shimmed.

Pinch rollers were also adjusted to enhance azimuth operation.

Figure 18 Azimuth drive assembly shimming

2.5.2 Azimuth Concentricity

Jason Chapman observed the enclosure was not concentric with the ring wall and pier during azimuth testing. (The centre of the rotating enclosure was not within tolerance of the pier and ring wall centres).

Azimuth guide bogies appear to have been adjusted by someone prior to the visit by Jason Chapman, thereby affecting the ability of the rotating enclosure to hold position.

UCO-Lick was instructed on how to reset the Azimuth guide wheels and regain acceptable concentricity tolerances.

2.5.3 Snow Melt Cables

It was observed by Jason Chapman that the snow melt cables were in a dangerous state, missing mechanical protection in the shutter trough. The shutter cable chain could eventually wear through the insulation and the potential for electrical fault is high.

All cable covers were supplied on site. The particular cover missing would have to be trimmed in situation. WPY would have been responsible for this work as part of the enclosure build.