SALT TECHNICAL OPERATIONS

PROJECT STATUS REPORT

TITLE: STATUS REPORT: TRACKER UPGRADE PROJECT
BM # 38 OCTOBER 2015

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Date: Oct 2015

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Description
CDR	Critical Design Review
CER	Concept Evaluation Review
COTS	Commercial Off The Shelf
CoC	Certificate of Conformance
ECR	Engineering Change Request
FAT	Factory Acceptance Test
FDR	Final Design Review
FEA	Finite Element Analysis
PDM	Product Data Management
PDR	Preliminary Design Review

1 Project Status Summary

The Tracker Upgrade project has successfully completed the Y-Drive Upgrade Stage of the project by passing the FDR and successfully installing/commissioning the upgrade on SALT.

Subsequently, Stage 2 of the project, Rho-Upgrade, has also been successfully completed by passing FAT exceptionally well. FDR was passed and delivered the complete installation kit to SALT early in March 2015. The kit contains all the completed subassemblies as well as all the documents required to do the installation at SALT. This delivery was finally made 2.8 months later than planned mostly due to poor manufacturing supplier performance, resources allocated to other projects like RSS delaying FAT, and the Xmas holidays.

Stage 3 of the project was commenced the end of February 2015 and entails the Hexapod Upgrade. The concept design was culminated in the CER passed the middle of April 2015. The detail design phase was completed by passing the CDR end of July 2015. The industrialization phase is ongoing with the approved manufacturing data pack available middle September 2015 and orders currently being placed on suppliers. So far, we have recovered the original 2.8 month delay to a delay of approximately 1 month.

The Rho and Hexapod Upgrade installation is planned during March and possibly April 2016 to minimize observation down time. This is dependent on the level of interference to be experienced by the laser frequency comb installation planned for January through March of 2016 as well as the servicing of the RSS.
Please see Table 1 for the completion status of the project.

Item	% Complete	Date Complete	Responsible	Comments
Hexapod CDR	**100%**	**July 2015**	**Project Team**	**Completed successfully.**
Hexapod Data Pack and Manufacture	**50%**	**Jan 2016**	**Raoul, Wouter, Keith, Eben, Vic**	**Data Pack complete middle September 2015. Quotes received, orders to be placed.**
Hexapod FAT	**0%**	**Nov 2015**	**Project Team**	**Pulled forward due to resource availability.**
Hexapod FDR	**0%**	**Feb 2016**	**Project Team**	**Planned.**

Rho and Hexapod Upgrade Installation and Commissioning	**10%**	**April 2016**	**Project Team**	**Depends on interference from the laser frequency comb installation planned for January through March of 2016. And servicing of the RSS.**
Project Closure	**0%**	**April 2016**	**Project Team**	**Planned.**

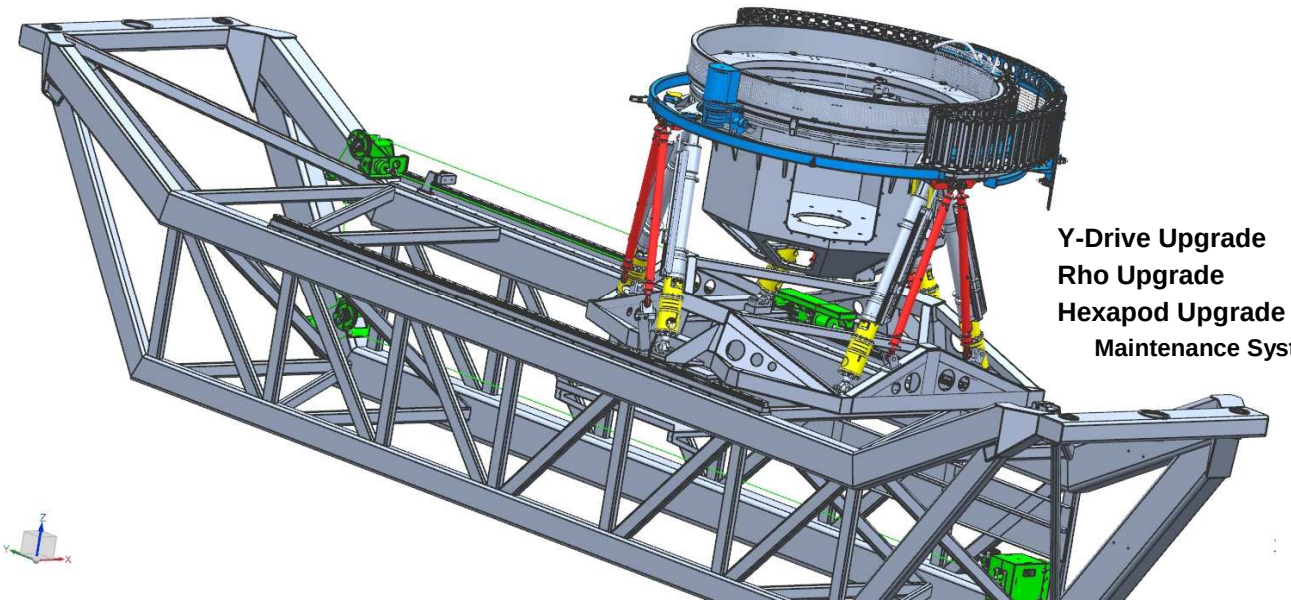
Table 1: Project Completion status.

2 Technical Solution

During the pre-study, and confirmed during the Hexapod Upgrade concept design phase, it was found that the critical components are the Hexapod Ball Joints as well as the Hexapod motors, gearboxes and clutches. The Hexapod Upgrade concept design solution consists of a ball joint load relief system called HAGS (Hexapod Anti-Gravity System) and replacing the Hexapod motors/gearboxes/clutches with Harmonic Drive Systems. The drive motor chosen is a harmonic drive (new technology) which is much lighter, stronger and requires less current, cooling and maintenance as well as replacing the current clutches and gearboxes. Due to maintenance and telescope off-line costs reasons, the decision was also made to replace the X and Y drives with these motors during BM # 37 held in May 2015. All the Harmonic Motors and Servo Amplifiers have been ordered. The Servo Amps have been delivered and the Harmonic Motors are expected to be delivered in October 2015.

Due to complexity of the Hexapod Upgrade design, simulation analysis such as FEM and dynamic modelling exceeded previous stages of the project by a factor of 3. Resulting in an elegant, efficient design solution.

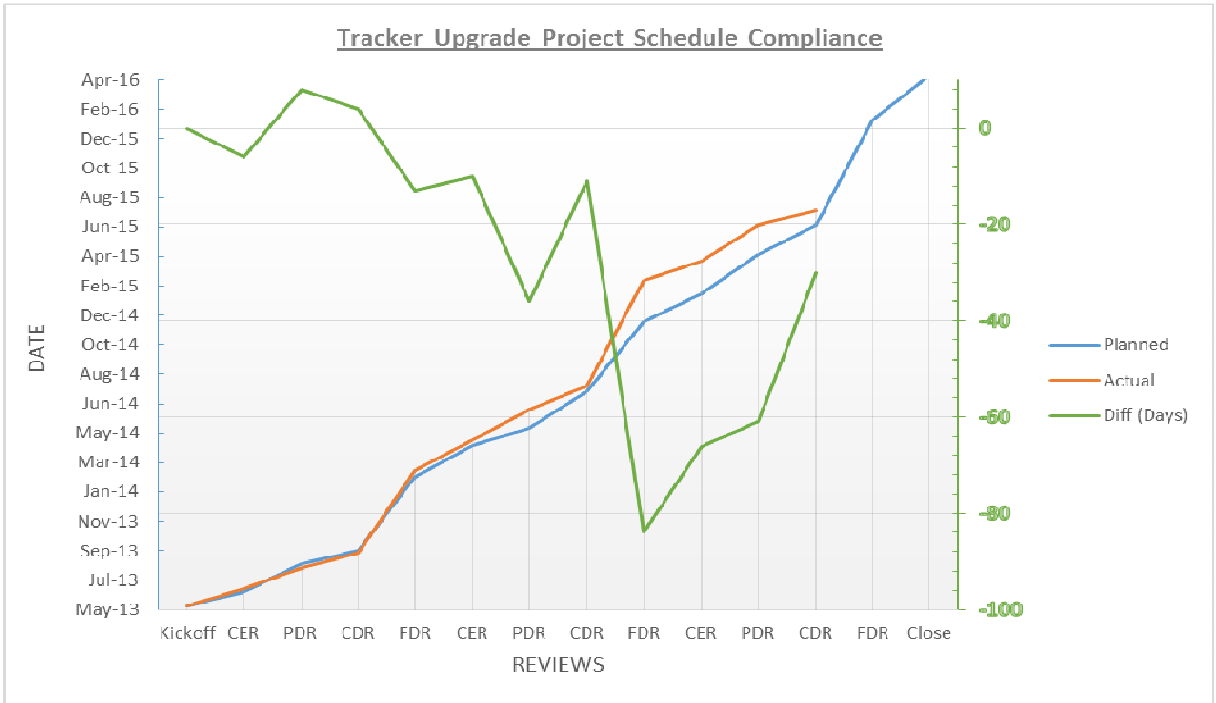
All mechanical components have a minimum safety factor of 1.5 on yielding. The ball joints were tested to 1.2 times the operational load. FAT will be conducted to ensure that all performance specification parameters such as accuracy, track and slew speeds are met or exceeded.

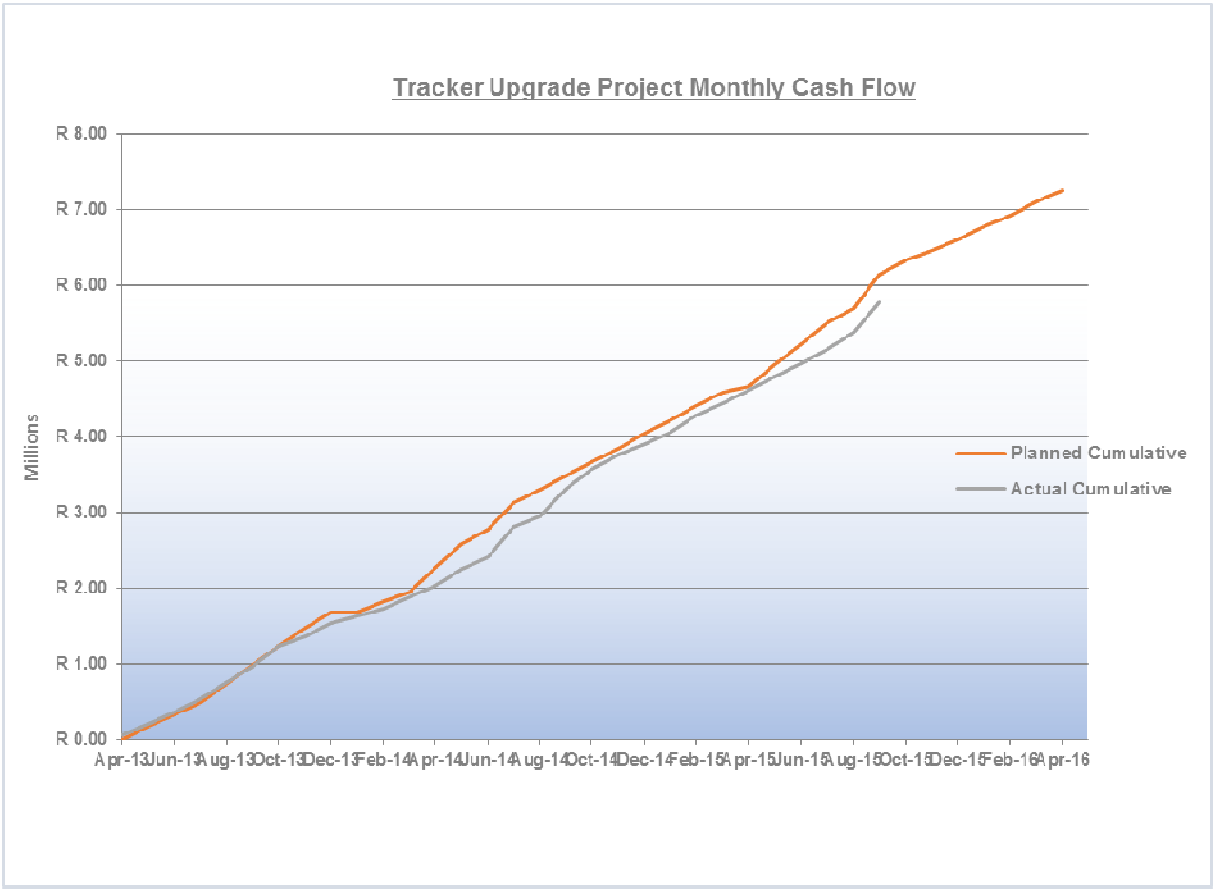


Y-Drive Upgrade – Green.
Rho Upgrade – Blue.
Hexapod Upgrade – Yellow.
Maintenance System – Red.

Components of all 3 Stages of the Tracker Upgrade Project shown on the Tracker

3 Schedule and Cash Flow Compliance





4 Financial Summary Actuals vs. Budget

Project Tracker Upgrade Financial Summary					
PROJECT STAGE	DESCRIPTION	BUDGET	ACTUAL	REMAINDER SHORTFALL	NOTES
Y-Drive Upgrade					
	Manpower	R 1 319 640.00	R 1 294 337.03	R 25 302.98	
	Detail Design	R 0.00	R 0.00	R 0.00	
	Procurement /Manufacturing	R 319 000.00	R 305 144.06	R 13 855.94	
	Factory Acceptance Testing	R 35 000.00	R 33 376.00	R 1 624.00	
	Installation / Implementation	R 50 000.00	R 0.00	R 50 000.00	
	Commisioning	R 0.00	R 0.00	R 0.00	
	Handover	R 0.00	R 0.00	R 0.00	
Hexapod Upgrade					
	Manpower	R 1 942 528.93	R 1 255 656.06	R 686 872.88	
	Detail Design	R 341 000.00	R 38 662.93	R 302 337.07	
	Procurement /Manufacturing	R 245 000.00	R 270 000.00	R -25 000.00	
	Factory Acceptance Testing	R 35 000.00	R 0.00	R 35 000.00	
	Installation / Implementation	R 50 000.00	R 0.00	R 50 000.00	
	Commisioning	R 0.00	R 0.00	R 0.00	
	Handover	R 0.00	R 0.00	R 0.00	
Rho-Drive Upgrade					
	Manpower	R 2 120 926.92	R 2 146 825.96	R -25 899.05	
	Detail Design	R 563 000.00	R 346 490.70	R 216 509.30	
	Procurement /Manufacturing	R 185 000.00	R 148 986.61	R 36 013.39	
	Factory Acceptance Testing	R 35 000.00	R 0.00	R 35 000.00	
	Installation / Implementation	R 0.00	R 0.00	R 0.00	
	Commisioning	R 0.00	R 0.00	R 0.00	
	Handover	R 0.00	R 0.00	R 0.00	
	Subtotal	**R 7 241 095.85**	**R 5 839 479.35**	**R 1 401 616.50**	
	Contingency	**R 454 954.79**			**5% on manpower, 10% DPC's**
	Total	**R 7 696 050.64**			**SALT Tracker Upgrade Fin Review Feb 2013 R7 696 028.**

5 Conclusions

Stage 1 and Stage 2 of the Tracker Upgrade Project have been completed successfully and have passed all FAT, technical and project reviews. Stage 1, Y-Upgrade, was installed and commissioned on SALT early October 2015. Complete Rho-Upgrade 'Installation Kits' are currently in the SALT store ready for installation and commissioning.

Stage 3 of the project was commenced the end of February 2015 and entails the Hexapod Upgrade. The concept design phase was culminated in the CER passed the middle of April 2015, approximately 2 weeks ahead of schedule. The detail design phase PDR was passed on the 25th of June 2015 and was completed by passing the CDR the end of July 2015. The industrialization phase is ongoing with the approved manufacturing data pack available middle September 2015 and orders currently being placed on suppliers. So far, recovering the original 2.8 month delay to a delay of approximately 1 month.

Currently, the project is within budget with a cash flow slightly below planned. Cost to completion is approximately equal to the remaining funds in the project.

6 Lessons Learnt to Date

- Pre-Project definition and documenting of processes & procedures such as for Project Management, Design and Configuration Control are essential for a successful project.
- Training of the project team in these processes, if they are not already working this way, is very important.
- The manual Configuration Control and PDM (Product Data Management) system being used for the project is tedious, time consuming and error prone. It is suggested that a real PDM/PLM system be implemented at SALT/SAAO.
- Design and FEA (Finite Element Analysis) collaboration should be improved. FEA without hand stressing is not worth much.
- Over a project duration of more than a year the current Sutherland team cannot supply more than 1 resource to support any one project.
- Formal Incoming inspections are crucial for quality and to reduce major delays during assembly.
- Industrialisation Phase Process should be followed to link aspects such as incoming inspection, data pack checking/approval, FAT and the procurement process.
- Data Pack Duration KPI's:

  - Stage 1: Data Pack creation, checking, approval, quote and order on 21/10/2013 was 788 man-hours divided by 110/2 drawings = 14.3 hours per drawing.
  - Stage 2: Data Pack creation, checking, approval, quote and order. CDR 5/8/2014 orders 21/10/2014 was 1350 man-hours divided by (102+65)/2 drawings = 16.2 hours per drawing.
  - Stage 3: Data Pack creation, checking, approval, quote and order. CDR 30/7/2015 orders (TBD) was 615+orders man-hours divided by (89)/2 drawings = 13.8+orders hours per drawing.
- Material availability (grade and form) from multiple suppliers are to be checked and confirmed at PDR stage of design.
- Manufacture was estimated at 6 weeks but 12 weeks seems more realistic when including all the other procurement aspects. Ensure orders are in at least 12 weeks before Xmas shutdown.
- Paying a levy for high quality manufacturing and inspection suppliers probably saved a minimum of 3 weeks during incoming inspection and assembly.
- Preparation and simulation of FAT to improve, to reduce wasted time and infant mortality. FAT commissioning/planning phase to be added to FAT schedule.
- By spreading the limited project resources over a number of projects, guarantees them all to fail.
- During Rho-Upgrade FEM was introduced much earlier in the design process (even before PDR) and was used concurrently in the design. This worked well and good correlation was found with the hand calcs. Both were used to check the other. It did however, highlight the need to used interim revision numbers between maturities eg B, B1, B2, B3……,C. Also highlighted is the need to keep the part description short eg. 1516AD2000_B Drive sys, only the number and 1 or 2 well-chosen words. Our servers cannot cope with long part names and because of the computing intensity we cannot run FEM on the server. A PLM system syncing with servers in CT and Sutherland will resolve these issues.
- Our design process requires 3D model checking even before PDR, but due to unplanned OPS events the Sutherland Team was only able to complete this 1-2 weeks before CDR. Although the suggestions were excellent and extremely valuable they should have been given earlier in the design phase such as during or just after PDR. It is suggested that a Sutherland Team Leader be seconded to the project for the Hexapod Upgrade.
- Due to the large percentage of welded assemblies in the Rho Upgrade lower quality manufacturing and inspection suppliers were used costing the project at least 2 months in late/reworked deliveries.

- Develop alternative coating/surface finishing possibilities both from supplier and material point of view will reduce possible delays during manufacturing.
- Tolerance build up on interchangeable parts or for eg. drill jigs must be accommodated in the detail design phase and checked during incoming inspection.