SALT TECHNICAL OPERATIONS

RSS COLLIMATOR REPAIR: STATUS REPORT

TITLE: **RSS COLLIMATOR REPAIR: STATUS REPORT MAY 2015**

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1 Project Status Summary

The Collimator repair project was put on hold in April 2014 when we became aware of transmission losses occurring in RSS which we could not explain. The Service during September and October 2014 subsequently showed that a major contribution to the transmission loss was due to dust and dirt on the lenses. Cleaning the lenses made a significant improvement in the throughput however the UV performance of the collimator could not be fully recovered and it is still 27% below the expectation. Recovery of the UV performance is the primary goal of this project; to achieve full recovery of the UV requires replacement of other optical groups. However, the UV is not the only goal – the throughput in other wavelength intervals is also below expectation – e.g. between 400 and 500 nm, performance is still deficient by about 10 per cent and replacing any of the groups will improve this performance.

Previously, the Board requested a budget proposal to include the replacement of L3+L4. It turns out that it is more advantageous to replace the Field lens. This costing has now been included in the later sections of this report.

Further, during the service we also had the opportunity to inspect the optics and the mechanics and we found that the original and new coupling fluids are indeed immiscible. We also found that the opto-mechanical design had inherent flaws which must be avoided in any new hardware. These flaws include the incompatibility between the coupling fluid and the Sylgard elastomer holding the lenses. This leads to extensive swelling of the elastomer. Finally, we are still not sure which material causes the throughput of the optical coupling fluid to degrade in the UV although this is a minor issue.

In the original project definition (replacement of collimator triplet and doublet) it was planned to copy the Pilot Group optomechanical design in order to reduce the cost and risk. However, given that the design is flawed, some technology will have to be developed and proven in order to complete the project. Given these reasons, the project had to be re-scoped and an updated project budget is presented in this report. This new budget requires additional funding of R1.22M.

We have now received all lens elements, figured and coated, required for the replacement of the Triplet and Doublet. These are now in our optical lab awaiting approval to complete this project.

The collimator repair project has been assigned P1 priority status at the project prioritisation meeting in March 2015. The required manpower will only work on the project if they are not required by P0 projects. The schedule will therefore be volatile.

2 Options Going Forward

How do we recover the UV throughput?

2.1 Expected Performance

In Figure 1 below the transmission curves are plotted demonstrating the performance gains expected by replacing one or more of the optical groups. As can be seen in the plot, doing nothing (i.e. leaving the performance as per the "Present Collimator") results in an average throughput of about 75 per cent at wavelengths longward of 400 nm, and only 53 per cent at 350 nm. Replacing Triplet and Doublet (which we refer to as "Option A" later) results in about 15 per cent further across 400-850 nm and 25 per cent improvement in the UV. The only way to recover the UV performance fully, is to replace the **Field lens** group in addition to the currently planned Doublet and Triplet (called "Option B" later).

As reference we have also included the predicted performance for replacing the complete collimator, both in the current VIS/NIR band pass (320 nm - 1750 nm) as well as a collimator tailored only for the UV + Visible band-pass (320 nm - 850 nm). As can be seen in Figure 1 the performance of a dedicated VIS collimator ("Option C") is significantly better than a VIS/NIR combined instrument. Although replacing the complete collimator may be unaffordable at this time, the figure below does illustrate quite clearly the advantage of dedicated and specialised instruments.

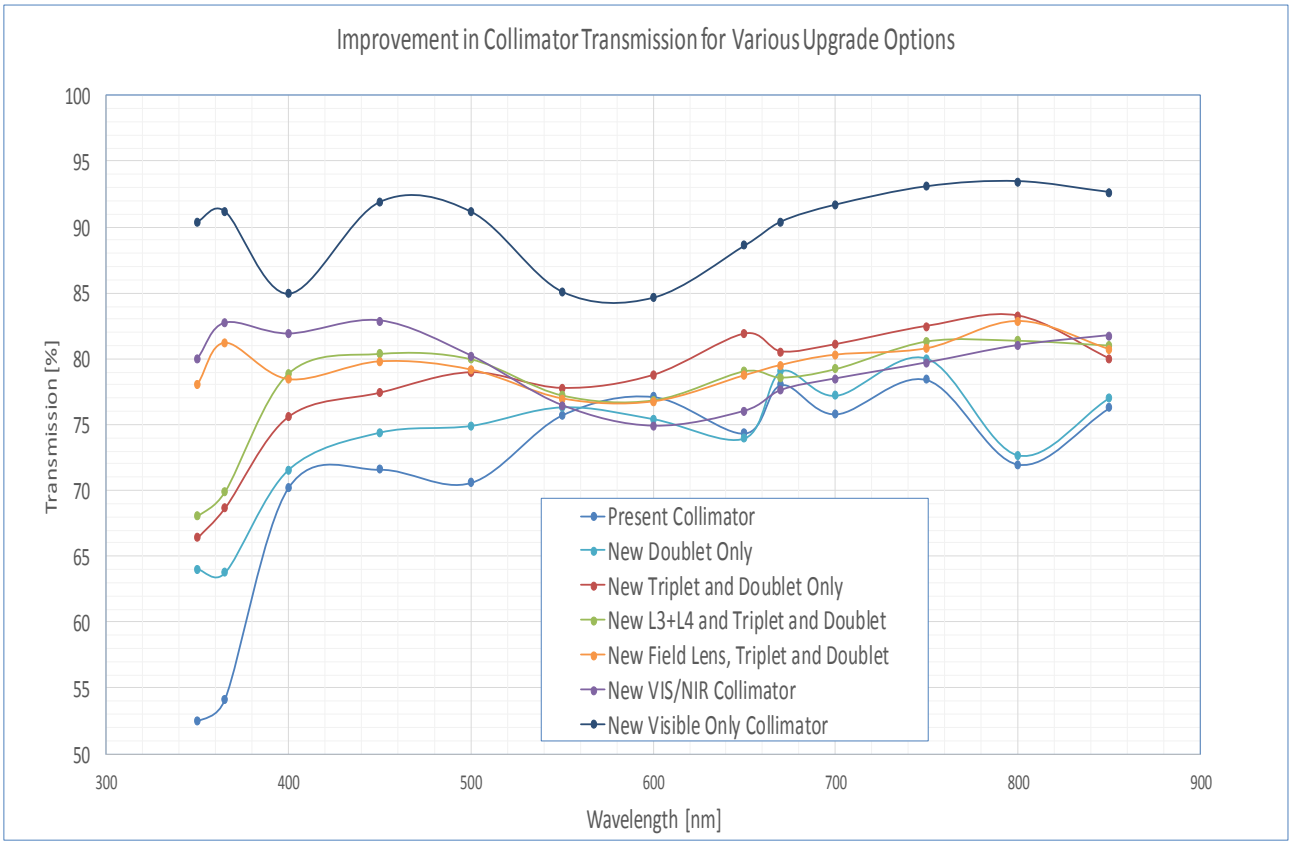


Figure 1: Transmission response for replacing various parts of the collimator. See the legend below.

Table 1: Legend for Figure 1.

Legend in Figure 1	Description
Present Collimator	Performance of the collimator currently on the Telescope after optical service. In other words doing nothing further.
New Doublet Only	The performance of the present collimator but with a new Doublet installed.
New Triplet and Doublet Only	The performance of the present collimator but with a new Triplet and a new Doublet installed.
New L3+L4, Triplet and Doublet.	The performance of the present collimator but with a new L3+L4 lens pair, a new Triplet and a new Doublet installed. (Only the Field Lens is retained)
New Field Lens, Triplet and Doublet.	The performance of the present collimator but with a new Field Lens, new Triplet and a new Doublet installed. (Only the L3+L4 pair is retained)
New VIS/NIR Collimator	Replacing all the lenses in the collimator with lenses optimise for a broad UV/VIS/NIR pass band of 320 to 1700 nm. (Old Lenses could be cleaned used as spares.)
New Visible only Collimator	Replacing all the lenses in the collimator with lenses optimise for the UV+ Visible pass band of 320 to 850 nm. (Old lenses could be recoated and used for spares.)

2.2 Costs Options

The expenditure of the project was reviewed and all direct project costs (DPC's) i.e all the capital expenditure on the project, pertaining to the optical service were identified and allocated to the asset renewal line. All manpower cost associated with the service is still allocated to the project. This leaves the project with unspent funds totalling R 1 094 075 which can be used to partially fund the remaining work.

Costs are presented below for:

Option	Description
Option A	Replacement of the Triplet and Doublet as currently planned
Option B	Replacing the Field Lens in addition to the Triplet and Doublet
Option C	Cost of a new UV+Vis optimised collimator.

Table 2: Cost options.

Option A: Cost Summary - Replace Doublet and Triplet					
Phase	**DPC**		**Manpower**		**Comments**
Stage 1 - Mechanical Concept Design	R	89 700	R	410 208	
Stage 2 - Triplet Design and Production	R	111 000	R	582 376	
Stage 3 - Doublet Design and Productior	R	84 000	R	591 031	
Stage 4 - Facility Development	R	279 062	R	-	
Contingency	R	84 564	R	79 181	Contingency 15% on DPC, 5% on Manpower
Sub Total	R	648 326	R	1 662 796	
Project Total Cost	R			2 311 122	
Less remaining funding	R			1 094 075	Project expenditure on 2014/05 - Outstanding invoices + Service DPC - Service Manpower
Total Additional Funding Required	**R**			**1 217 048**	

Option B: Cost Summary - Replacement of Field Lens, Triplet, Doublet					
Phase	**DPC**		**Manpower**		**Comments**
Phase 1 - Optics Procurement	R	411 794	R	102 063	
Phase 2 - Mech Concept	R	65 700	R	486 042	
Phase 4 - Field Lens	R	84 000	R	591 031	
Phase 5 - Triplet	R	111 000	R	582 376	
Phase 6 - Doublet	R	84 000	R	591 031	
Phase 7 - Facility Development	R	407 262	R	-	
Contingency	R	407 315	R	352 881	Contingency 35% on DPC, 15% on Manpower
Sub Total	R	1 571 071	R	2 705 423	
Project Total Cost	R			4 276 494	
Less remaining funding	R			1 094 075	
Grand Total	**R**			**3 182 419**	Additional funding required

Option C: Cost Summary - New Collimator					
Phase	**DPC**		**Manpower**		**Comments**
Phase 1 - Optics Procurement	R	986 094	R	204 125	
Phase 2 - Mech Concept	R	65 700	R	486 042	
Phase 3 - Field Lens	R	84 000	R	591 031	
Phase 4 - L3+L4	R	60 000	R	384 769	
Phase 5 - Triplet	R	111 000	R	582 376	
Phase 6 - Doublet	R	84 000	R	591 031	
Phase 7 - Facility Development	R	407 262	R	-	
Contingency	R	629 320	R	425 906	Contingency 35% on DPC, 15% on Manpower
Sub Total	R	2 427 376	R	3 265 279	
Project Total Cost	R			5 692 655	
Less remaining funding	R			1 094 075	
Grand Total	**R**			**4 598 580**	Additional funding required

Note that the contingency differs between the options. For Option A contingency is 15% on DPC's and 5% on Manpower. For Options B and C the contingencies are 35% on DPC's and 15% on Manpower. The increase in DPC contingency for B and C was deemed necessary as the major portion of the DPC will be spent importing optics.

To summarise the options, costs and benefits:

Table 3: Cost benefit summary.

Option	Description	Benefit compared to Present Collimator	Cost
Option A	Replacement of the Triplet and doublet as currently planned	• **Partial UV Recovery** • 25% increase between 320 nm - 400 nm • 15% increase between 400 nm – 850 nm	R1.22M
Option B	Replacing the Field Lens in addition to the Triplet and Doublet	• **Full UV Recovery** • 45% increase between 320 nm – 400 nm • 15% increase between 400 nm – 850 nm	R3.2M
Option C	Build a new UV+Vis optimised collimator.	• **UV-Vis Optimised** • 70% increase between 320 nm – 400 nm • 24% increase between 400 nm – 900 nm	R4.6M

At this time Option B and Option C are unaffordable given the other higher priorities of the company. Therefore Option A is the recommended plan going forward. (Note that the lenses for Option A are already delivered).

This budget will be explained in more detail in the appendices.

3 Project Plan, Priority and Schedule

The re-planned project will be comprised of 4 Stages. The first stage will use the design in-hand and the lessons learned from the optical service to develop a proven opto-mechanical design for the Doublet and Triplet as well as improve the chemical compatibility of the materials. Stage 2 and 3 will apply this technology to design and produce the Triplet and Doublet assemblies. Stage 4 runs in parallel to Stage 1-3 and is used to develop the required test equipment and assembly equipment.

The collimator repair project is current assigned P1 priority status. This means that progress will be made on it when the manpower is not required for P0 work. Hence the schedule presented below is likely to slip significantly if, as so often happens, resources are pulled away from a project and re-directed to other work.

The project has been re-planned to utilise existing personnel as far as possible. In most of the Stages only two team members will be utilised. This will prolong the duration of the project but eases the cash flow.

Table 4: Proposed Project Schedule.

	2015				2016		
Project Phase	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**
Stage1	Concept	Concept					
Stage2			Detail Design	Indust	Production	Assy + Test	
Stage3				Detail Design	Indust	Production	Assy + Test
Stage4	Facility	Facility	Facility	Facility	Facility	Facility	

4 Summary

- The RSS Collimator Optical Service yielded substantial gains in throughput, but further improvement is possible: ~10 per cent across the visible and near-infrared parts of the bandpass, and ~27 per cent in the UV.
- A re-scoped project has been presented with 3 budget options. Given the tight financial circumstances, the least expensive (replacing the Doublet and Triplet) is recommended. If additional funds become available for this work, the additional scope of the costlier options can still be implemented at that stage.

We request the decision of the Board on the way forward.

5 Appendix A – Budget Details

The proposed budget summary can be seen in **Error! Reference source not found.**.

Table 5: Proposed Budget summary.

Summary					
Phase	**DPC**		**Manpower**		**Comments**
Stage 1 - Mechanical Concept Design	R	89 700	R	410 208	
Stage 2 - Triplet Design and Production	R	111 000	R	582 376	
Stage 3 - Doublet Design and Production	R	84 000	R	591 031	
Stage 4 - Facility Development	R	279 062	R	-	
Contingency	R	84 564	R	79 181	Contingency 15% on DPC, 5% on Manpower
Sub Total	R	648 326	R	1 662 796	
Project Total Cost	R			2 311 122	
Less remaining funding	R			1 094 075	Project expenditure on 2014/05 less Outstanding invoices plus Service DPC less Service Manpower
Total Additional Funding Required	**R**			**-1 217 048**	

The total cost of the project going forward is R2.3M, including an aggressive contingency line of R164k. **The contingency is calculated as 15% of Direct Project Cost's (DPC's) and 5% of the manpower budget and should be included the total Board contingency line.** The additional scope is included in the budget as concept phase at a cost of R500k. More funding is also required for the Facility Development than the original budget allowed (R279k vs R112k). This increase is due a better understanding of the test and alignment requirements.

These three lines make up the majority (R943k) of expected R1.22M shortfall in the proposed project budget. The remaining R274k is due to manpower expended during the optical service. Approval of additional funding to make up the shortfall is required to complete the project.

Project Phase 1 - Optical Mounting Concept Design					
WBS Description	**Quantity**	**Unit Cost**	**DPC**	**Manpower**	**Comments**
Manpower - Cell Design	1	R 76 667		R 76 667	
Manpower - Cell Drafting	0.5	R 37 500		R 18 750	
Manpower - Cell Assembly	0.5	R 114 167		R 57 083	
Manpower - Alignment Test	0.5	R 114 167		R 57 083	
Material compatibility testing	1.5	R 76 667		R 115 000	
Manpower - Bladder Design	0.5	R 76 667		R 38 333	
Manpower - Bladder Manufacturing	0.5	R 37 500		R 18 750	
Manpower - Testing	0.25	R 114 167		R 28 542	
Test Connectors + PTFE tubing	20	R 175	R 3 500		
Material test consumables	2	R 4 600	R 9 200		
Bladder Materials	4	R 1 500	R 6 000		
Manufacturing	120	R 500	R 60 000		
Servicing manufacturing equipment	1	R 10 000	R 10 000		
Mold Materials	1	R 1 000	R 1 000		
Sub-Total			**R 89 700**	**R 410 208**	
Grand Total			**R**	**499 908**	

Project Phase - Doublet Design					
WBS Description	**Quantity**	**Unit Cost**	**DPC**	**Manpower**	**Comments**
Preliminary Design	1	R 114 167		R 114 167	Design of the mounts,bezels and Assembly, Test and Integration equipment 1 engineer +1 draughtsman
Detail Design	1.5	R 114 167		R 171 250	Includes a redesigned mounting scheme
Industrialisation	2.4	R 39 563		R 95 197	
Assembly	0.5	R 114 167		R 57 083	
FAT	0.5	R 153 333		R 76 667	
Installation and Commissioning	0.5	R 153 333		R 76 667	
Materials	1	R 12 000	R 12 000		
Manufacturing	240	R 300	R 72 000		
Sub-Total			**R 84 000**	**R 591 031**	
Grand Total			**R**	**675 031**	

Project Phase - Main Group Design					
WBS Description	**Quantity**	**Unit Cost**	**DPC**	**Manpower**	**Comments**
Preliminary Design	1	R 114 167		R 114 167	Design of the mounts,bezels and Assembly, Test and Integration equipment
Detail Design	1	R 114 167		R 114 167	
Industrialisation	2.2	R 39 563		R 86 543	Based on 50 parts including handling and test fixtures. Includes drafting, checking, quotation, manufacture and incoming inspection.
Cleaning, Assembly and Bonding	1	R 114 167		R 114 167	
FAT	0.5	R 153 333		R 76 667	
Installation and Commissioning	0.5	R 153 333		R 76 667	
Materials	1	R 15 000	R 15 000		
Manufacturing	320	R 300	R 96 000		
Sub-Total			**R 111 000**	**R 582 376**	
Grand Total			**R**	**693 376**	

Project Phase - Facility Development					
WBS Description	**Quantity**	**Unit Cost**	**DPC**	**Manpower**	**Comments**
Procure Rotation Stage	1	40 800	40 800		Originally estimated as R169000 but saving can be made by buying 2nd hand equipment.
Alignment System mount	1	50 000	50 000		
Air Handling	1	20 000	20 000		Add airdrier and filters
Alignment Frame Mods					
Design	0.75	R 37 500	28 125		Sub contracted
COTS bearings	2	R 175	350		
Adjusters	6	R 1 500	9 000		
Parts	3	R 4 500	13 500		
INF Bottom					
Design	0.5	R 37 500	18 750		Sub contracted
Hardware	15	R 836	12 540		Parametrically scaled
AT Mount bottom					
Design	0.5	R 37 500	18 750		Sub contracted
Hardware	15	R 836	12 540		Parametrically scaled
INF Test Mirror					
Design	0.5	R 37 500	18 750		Sub contracted
Mirror	1	R 6 210	6 210		
Mirror retainers	3	R 400	1 200		
Post	1	R 500	500		
Mount	1	R 6 272	6 272		
Adhesive injector					
Design	0.25	R 37 500	9 375		Sub contracted
Boom	1	R 5 000	5 000		
Injector housing	1	R 5 000	5 000		
Pneumatic Cylinder	1	R 2 400	2 400		
Sub-Total			**279 062**	**-**	
Grand Total				**279 062**	