NRF / SKA SA Dish Concept: Logistics Engineering

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NRF / SKA SA
14 July 2011
Penticton

Logistics engineering

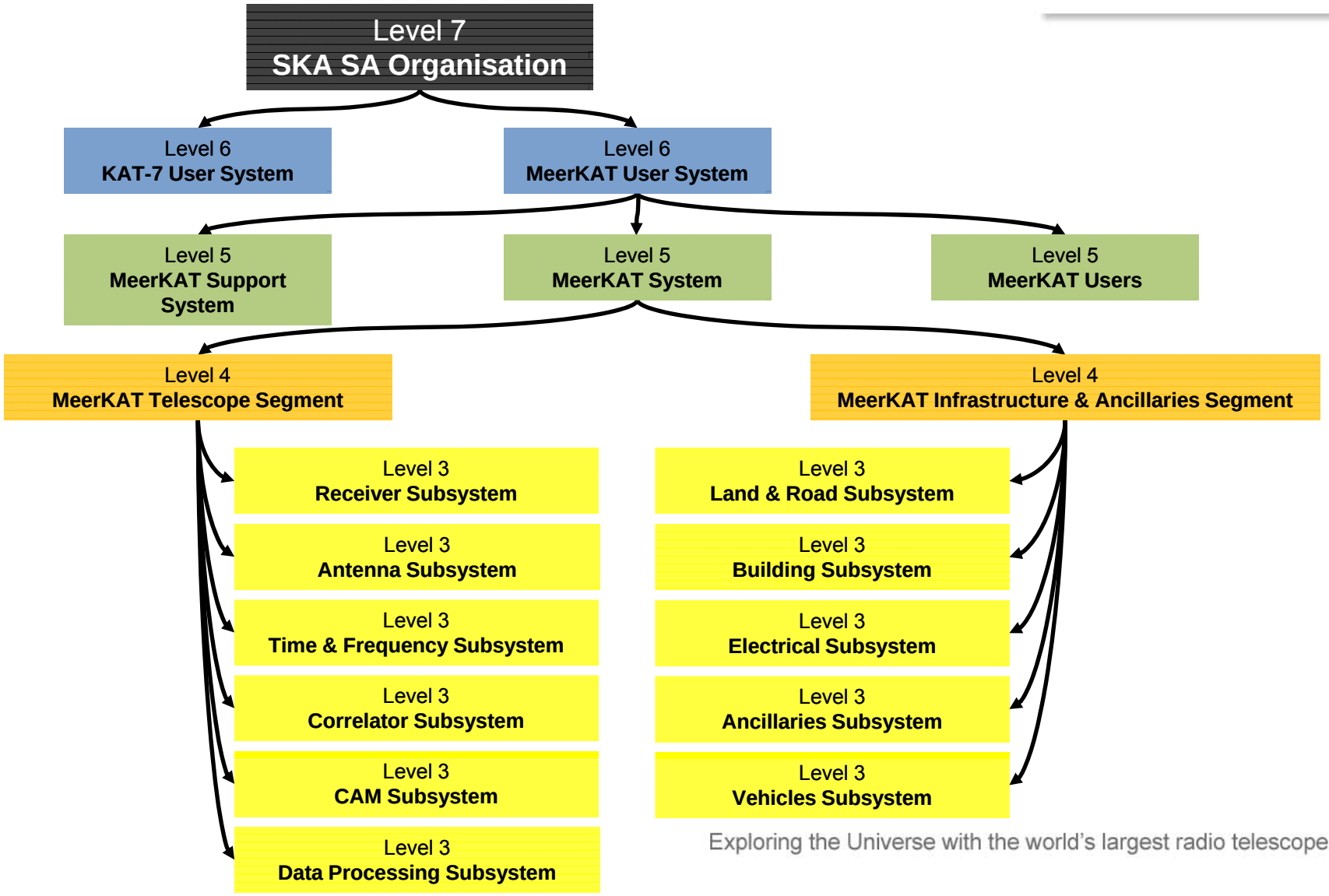
KAT-7 & MeerKAT approach

"Design for Support, Design the Support & Support the Design"

- We do **NOT** look at components or "level 3" subsystems in isolation in our system engineering or logistic engineering approaches
- This has been our approach from the outset in 2005
- South African developed commercially available & proven software tool (since 1990)
  - **Ramlog Information Management Module** for analyses and generation of manuals
  - **Ramlog Simulation Module** for simulations and optimization
  - **Ramlog** for Maintenance Management
- The next few slides will give a quick snapshot of progress and how our "motto" is implemented in our projects (both KAT-7 and MeerKAT systems)

MeerKAT Hierarchy

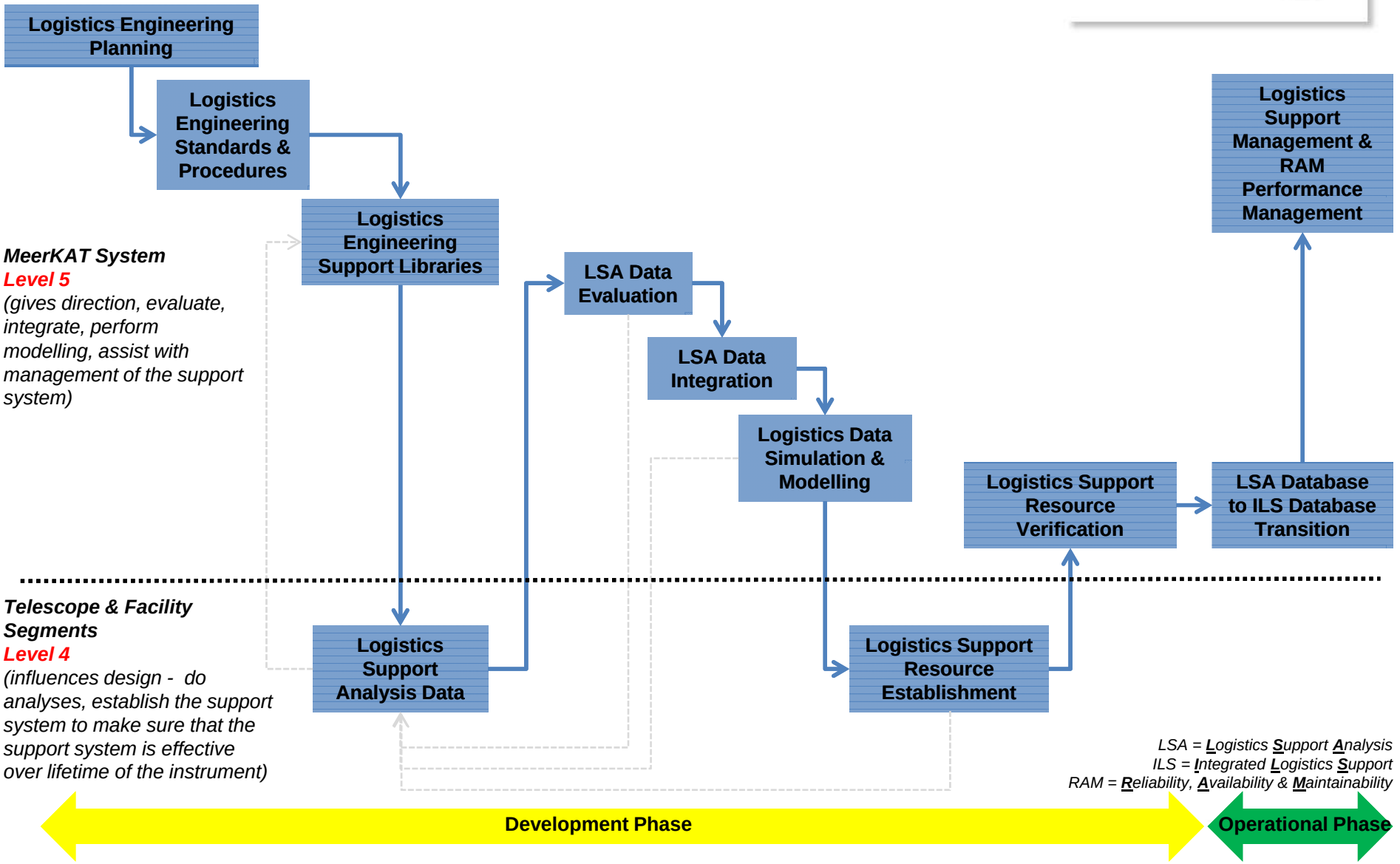
System levels



Logistics engineering

KAT-7 & MeerKAT

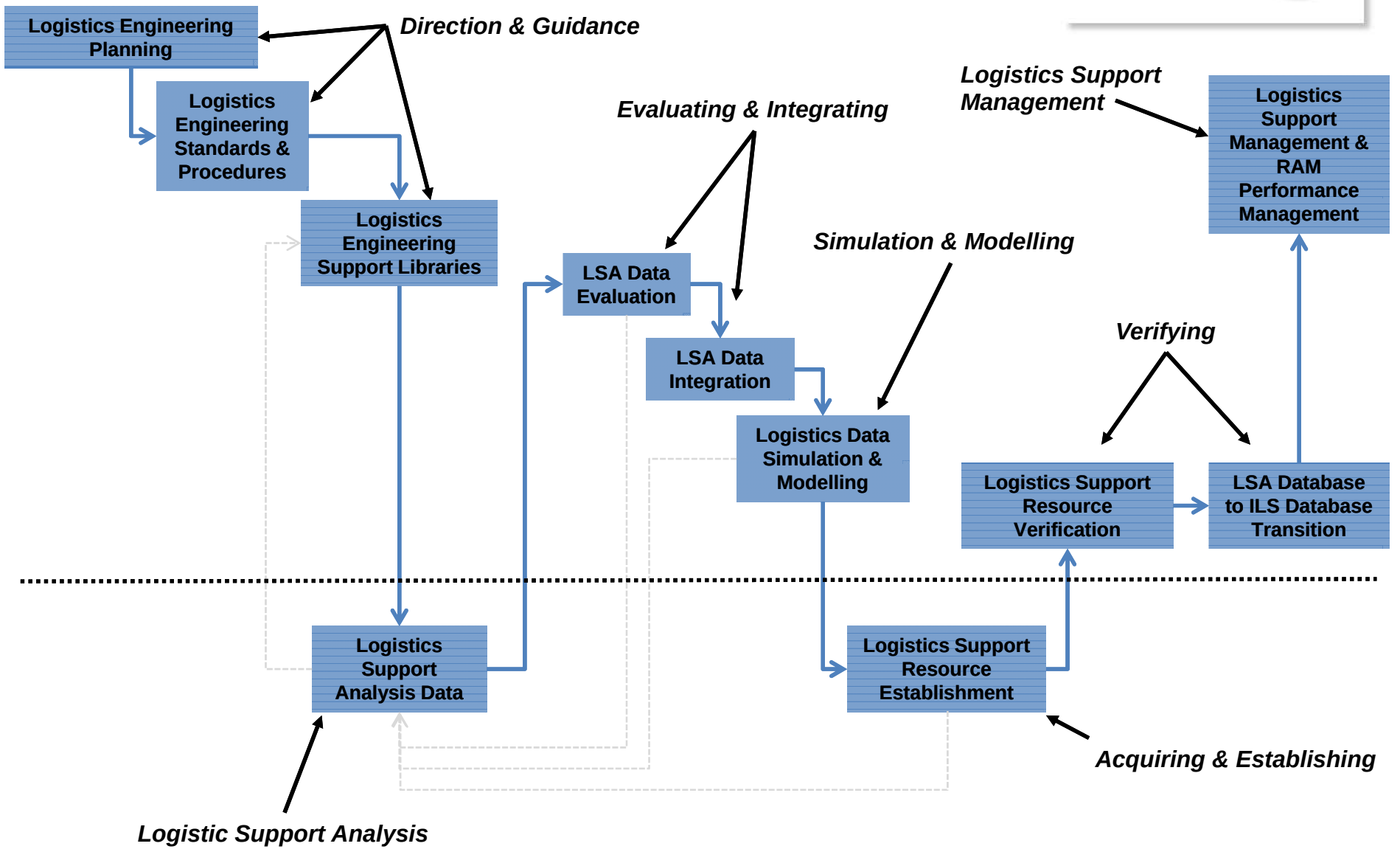
Scope of work



Logistics engineering

KAT-7 & MeerKAT

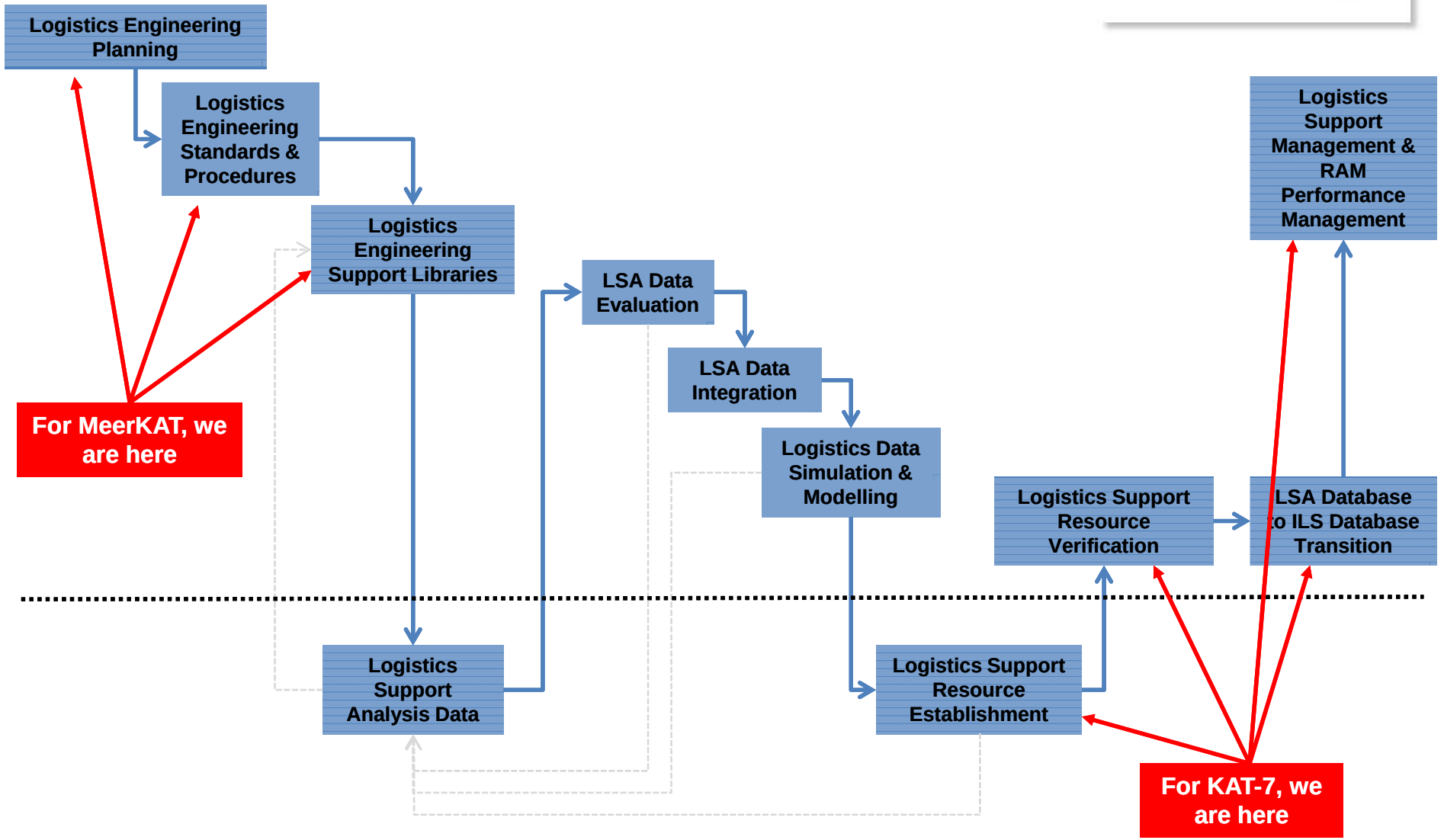
Scope of work (3)



Logistics engineering

KAT-7 & MeerKAT

Current status / Progress

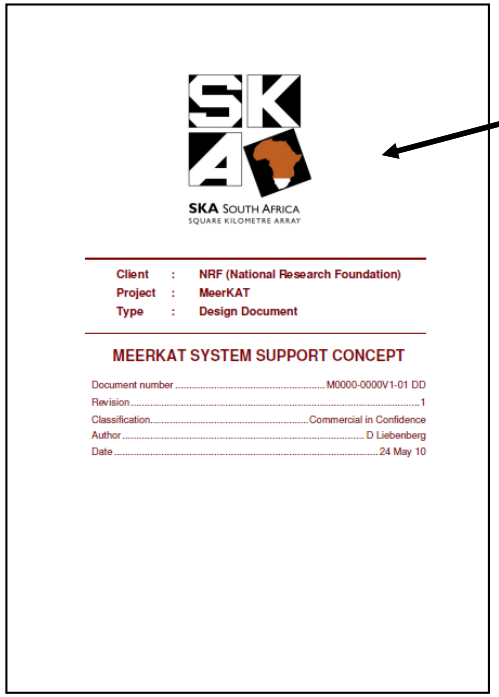


Level 5 Direction & Guidance

Actual Approved MeerKAT Documents

Logistic Engineering Planning

Logistic Engineering Standards & Procedures

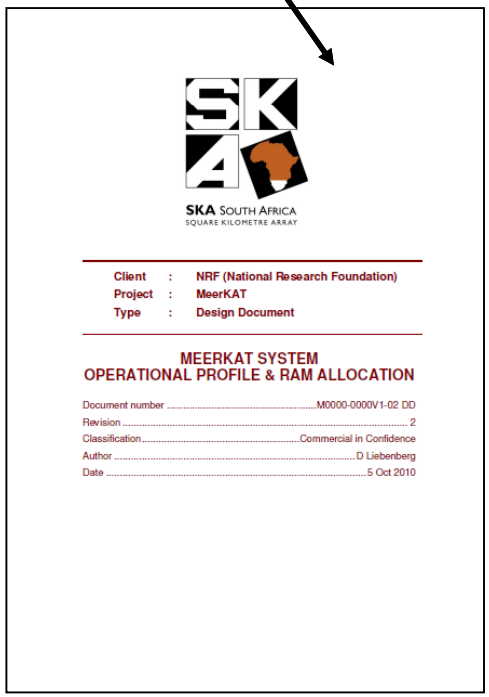


SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

Client : NRF (National Research Foundation)
Project : MeerKAT
Type : Design Document

MEERKAT SYSTEM SUPPORT CONCEPT

Document number ..... M0000-0000V1-01 DD
Revision 1
Classification ..... Commercial in Confidence
Author ..... D Liebenberg
Date ..... 24 May 10

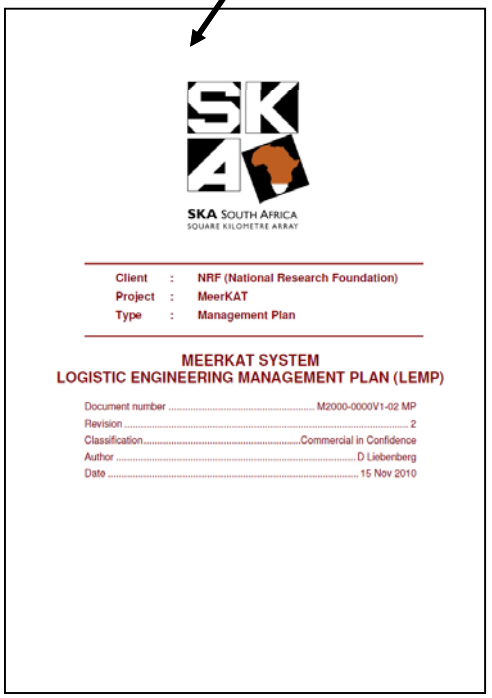


SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

Client : NRF (National Research Foundation)
Project : MeerKAT
Type : Design Document

MEERKAT SYSTEM
OPERATIONAL PROFILE & RAM ALLOCATION

Document number ..... M0000-0000V1-02 DD
Revision 2
Classification ..... Commercial in Confidence
Author ..... D Liebenberg
Date ..... 5 Oct 2010



SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

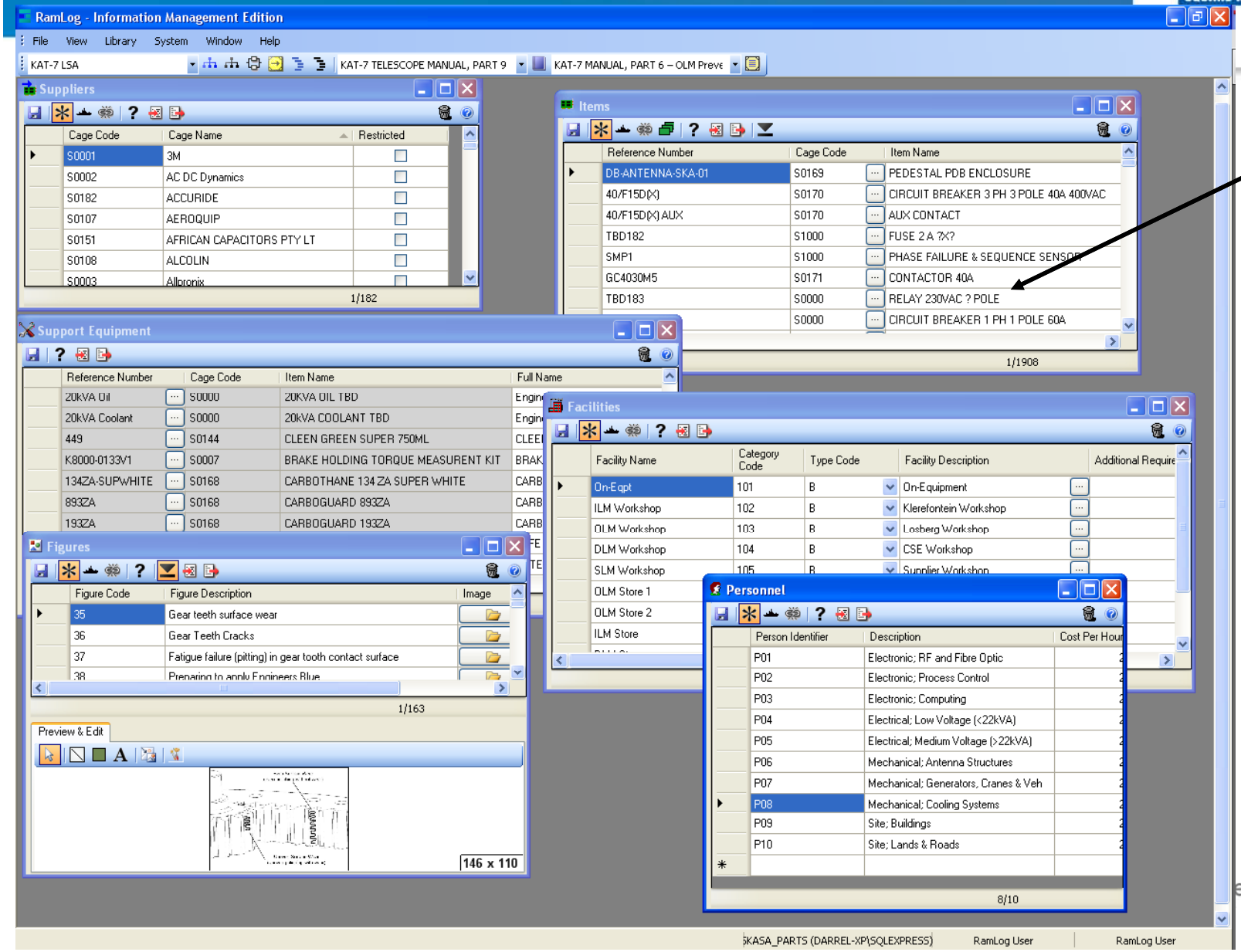
Client : NRF (National Research Foundation)
Project : MeerKAT
Type : Management Plan

MEERKAT SYSTEM
LOGISTIC ENGINEERING MANAGEMENT PLAN (LEMP)

Document number ..... M2000-0000V1-02 MP
Revision 2
Classification ..... Commercial in Confidence
Author ..... D Liebenberg
Date ..... 15 Nov 2010

Level 5 Direction & Guidance

Actual KAT-7 Data

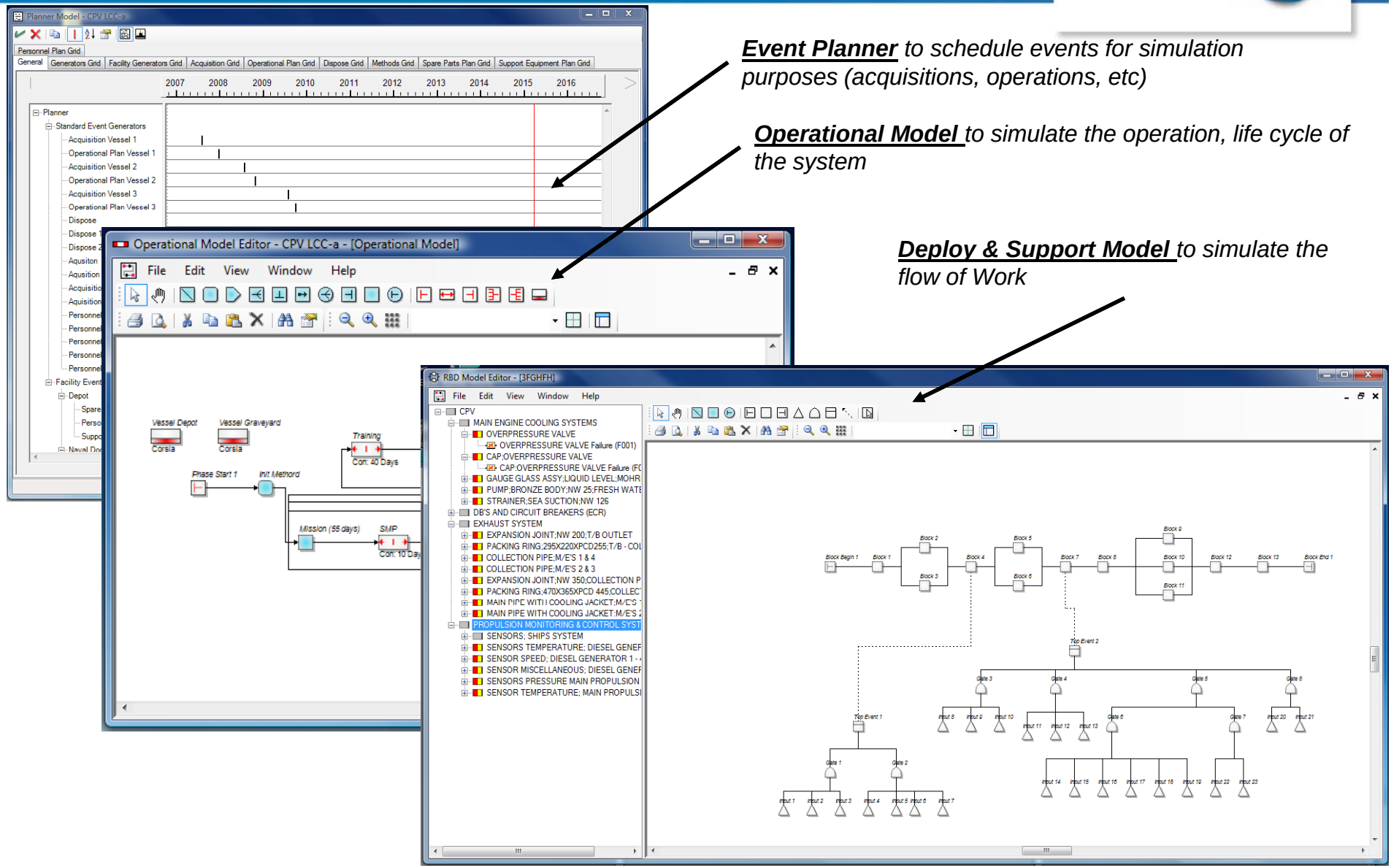


Logistic Engineering Support Libraries

- ***Suppliers***
- ***Items***
- ***Support Equipment***
- ***Facilities***
- ***Pictures***
- ***Personnel***

est radio telescope

Level 5 Simulation & Modelling

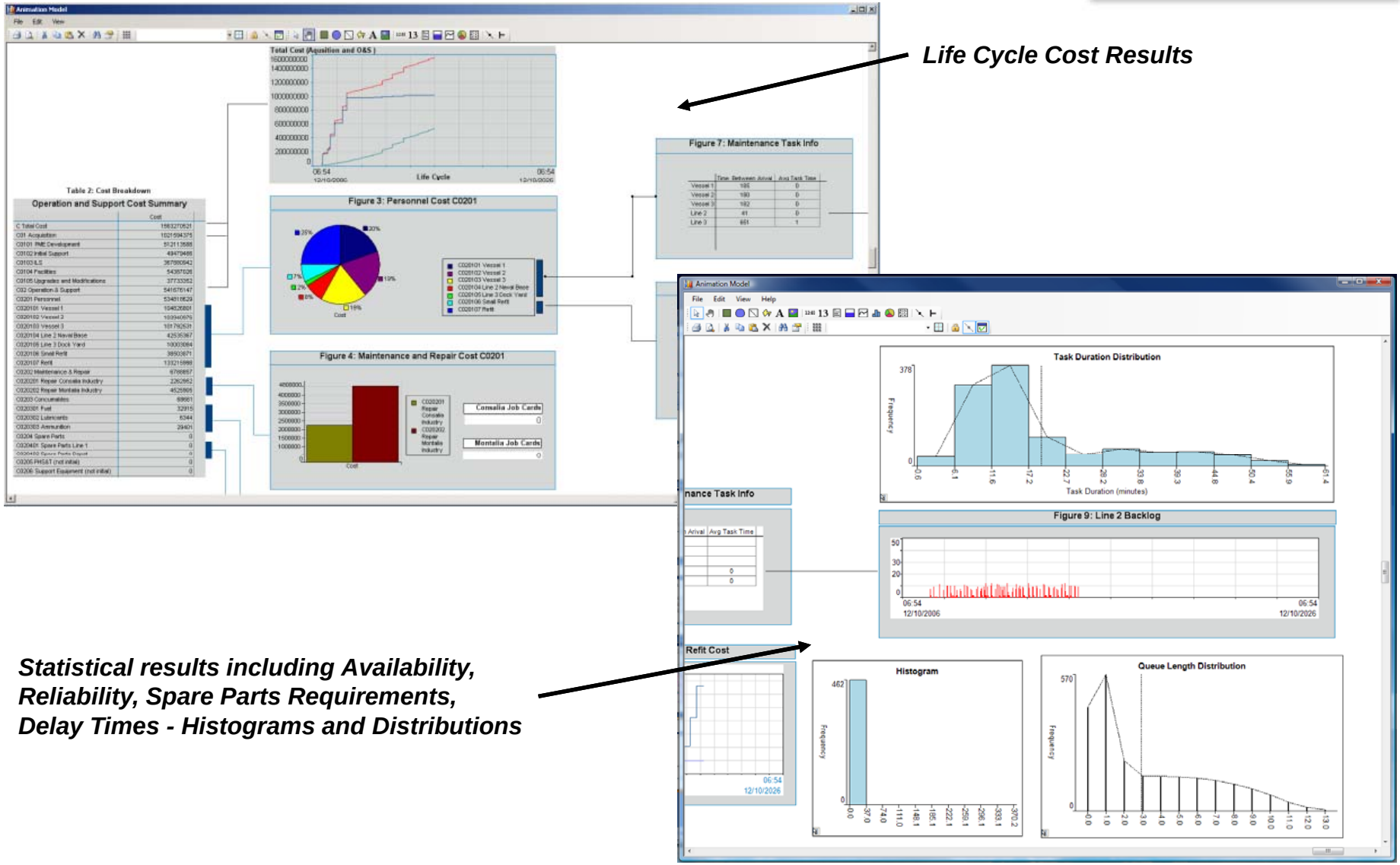


Event Planner *to schedule events for simulation purposes (acquisitions, operations, etc)*

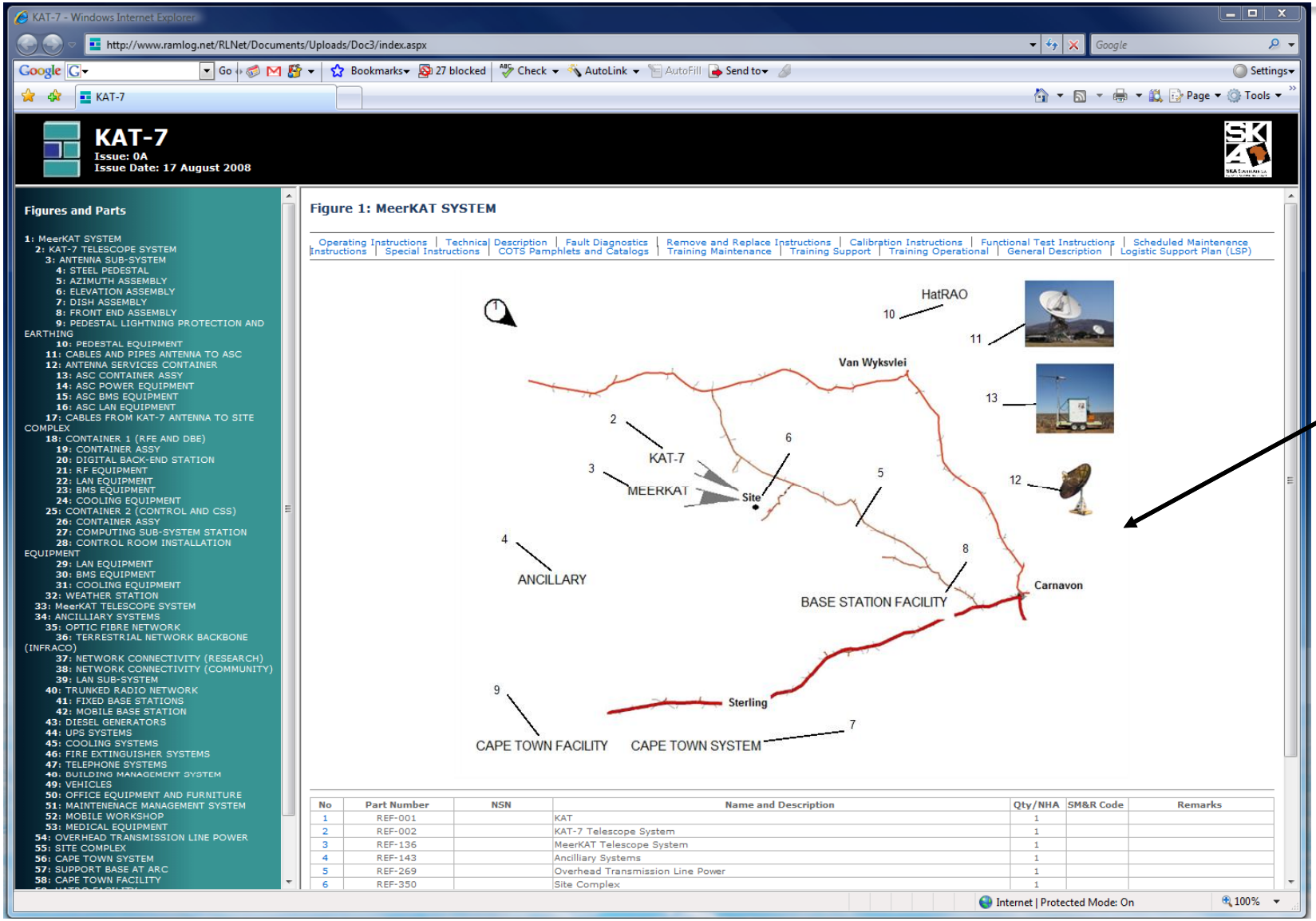
Operational Model *to simulate the operation, life cycle of the system*

Deploy & Support Model *to simulate the flow of Work*

Level 5 Simulation & Modelling (2)

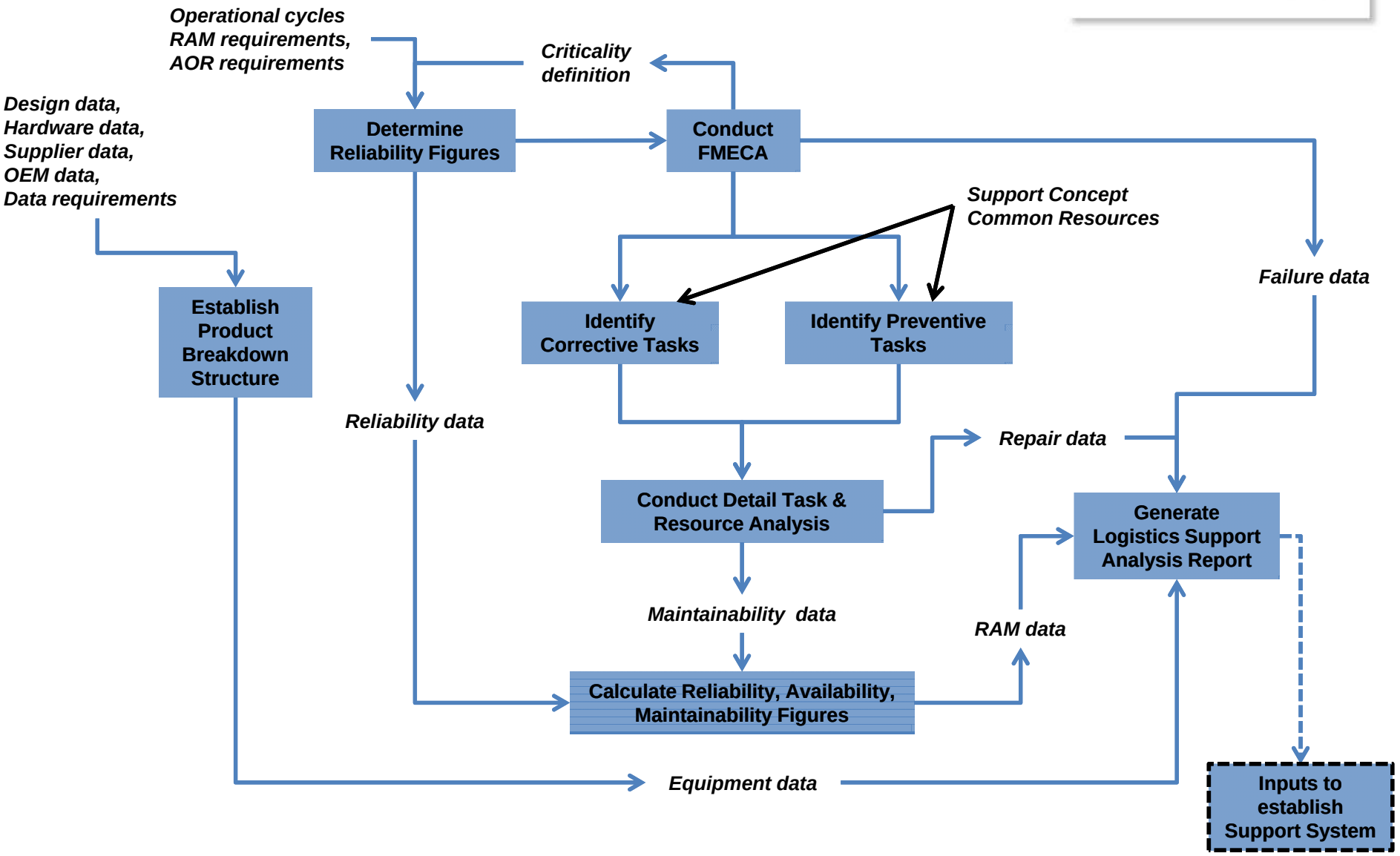


Level 5 Support Management



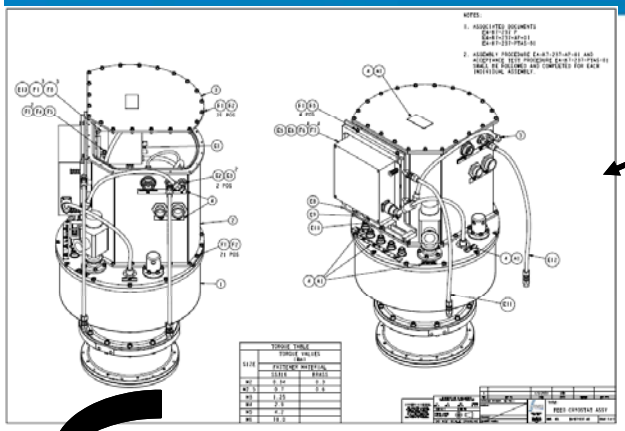
Support Management System

Level 4 Logistic Support Analysis



Level 4 Logistic Support Analysis

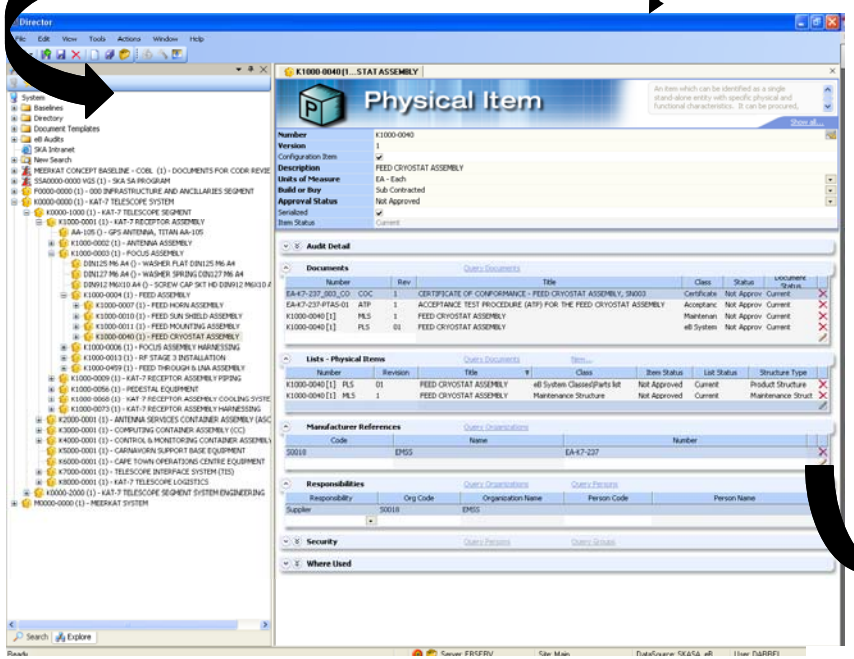
Product Breakdown Structure

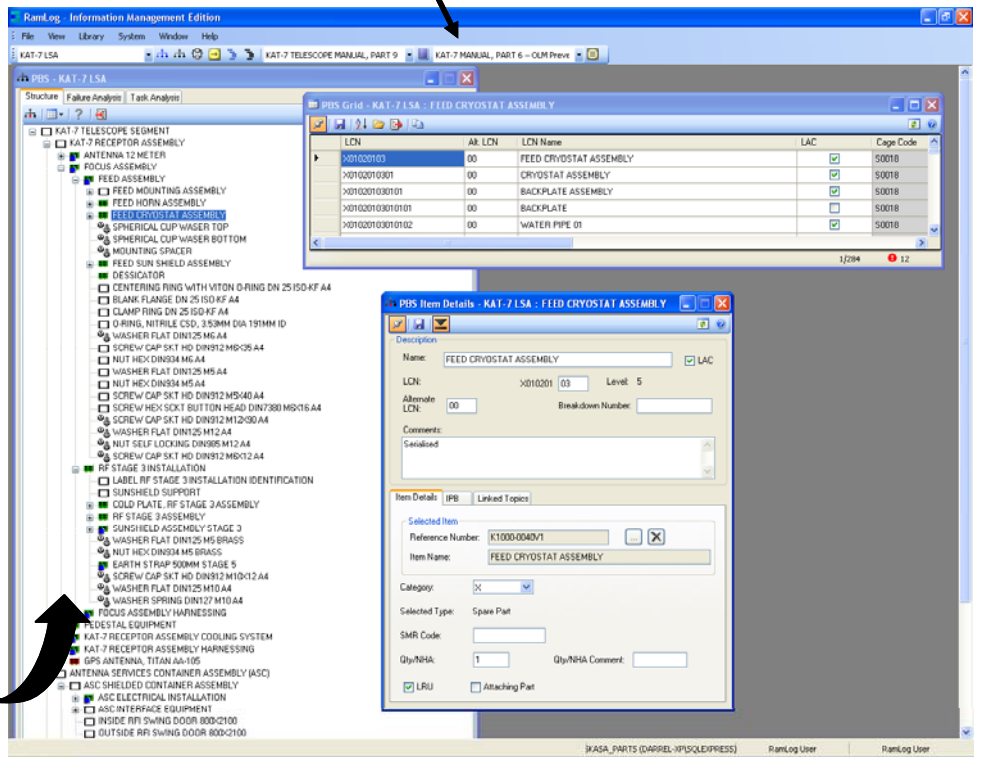


Hardware Data (Original Equipment Manufacturer)

Configuration Management Data (eB)

Logistic Product Breakdown Structure (Ramlog)



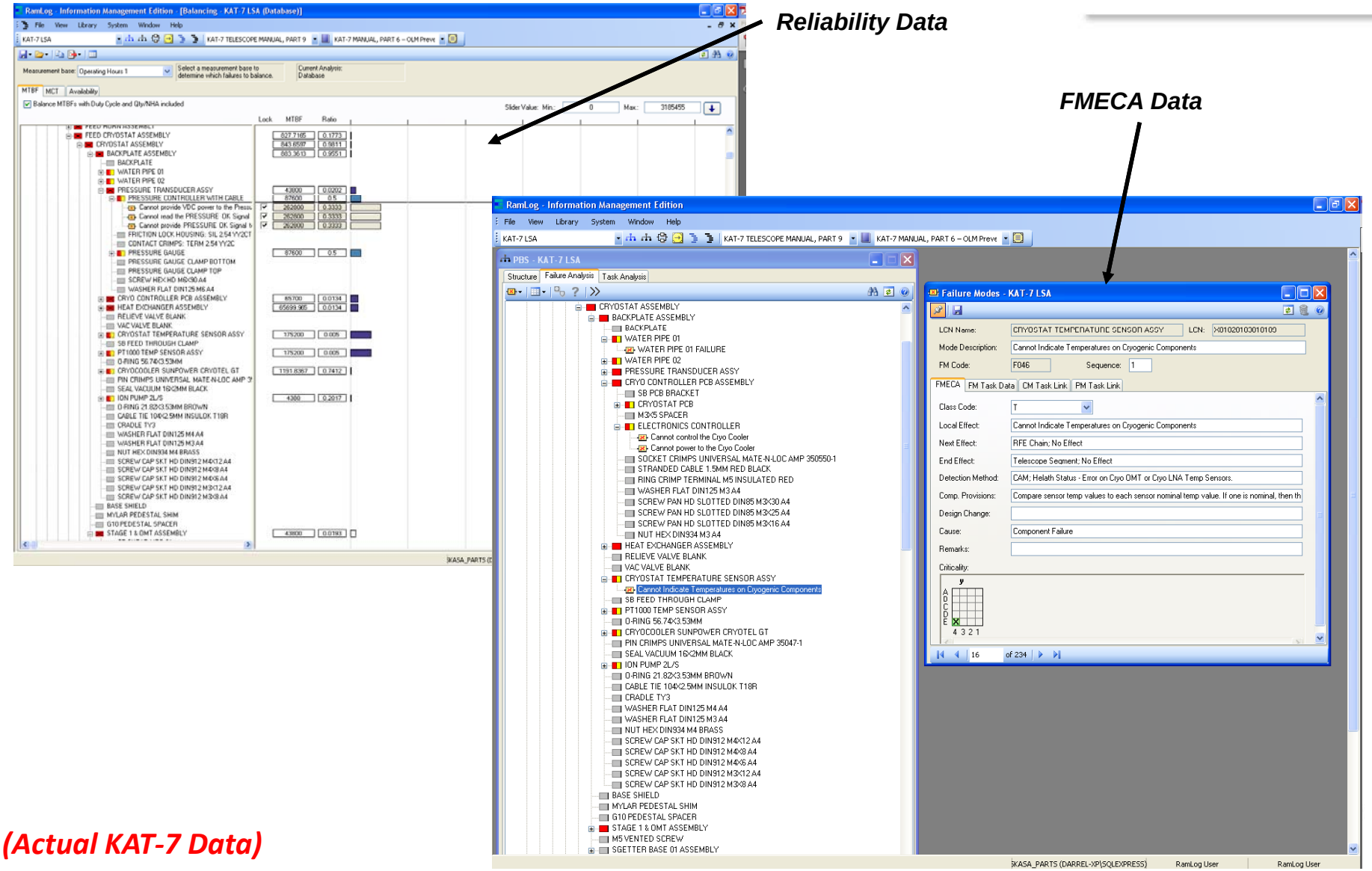


(Actual KAT-7 Data)

*OEM = **O**riginal **E**quipment **M**anufacturer*
eB = Configuration Management Software used by SKA SA
Ramlog = Reliability, Availability and Maintainability Modelling Software used by SKA SA

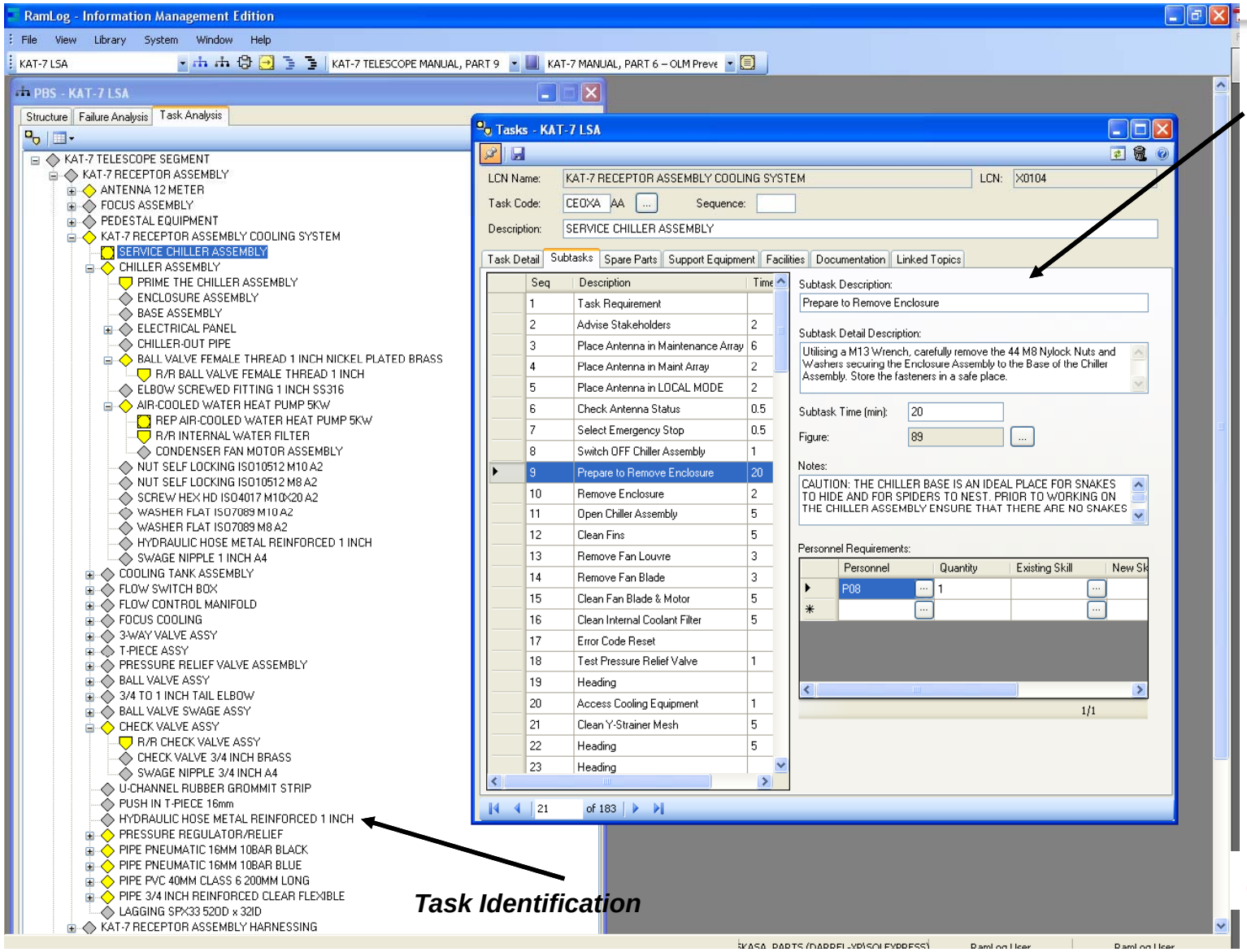
Level 4 Logistic Support Analysis

Reliability & FMECA



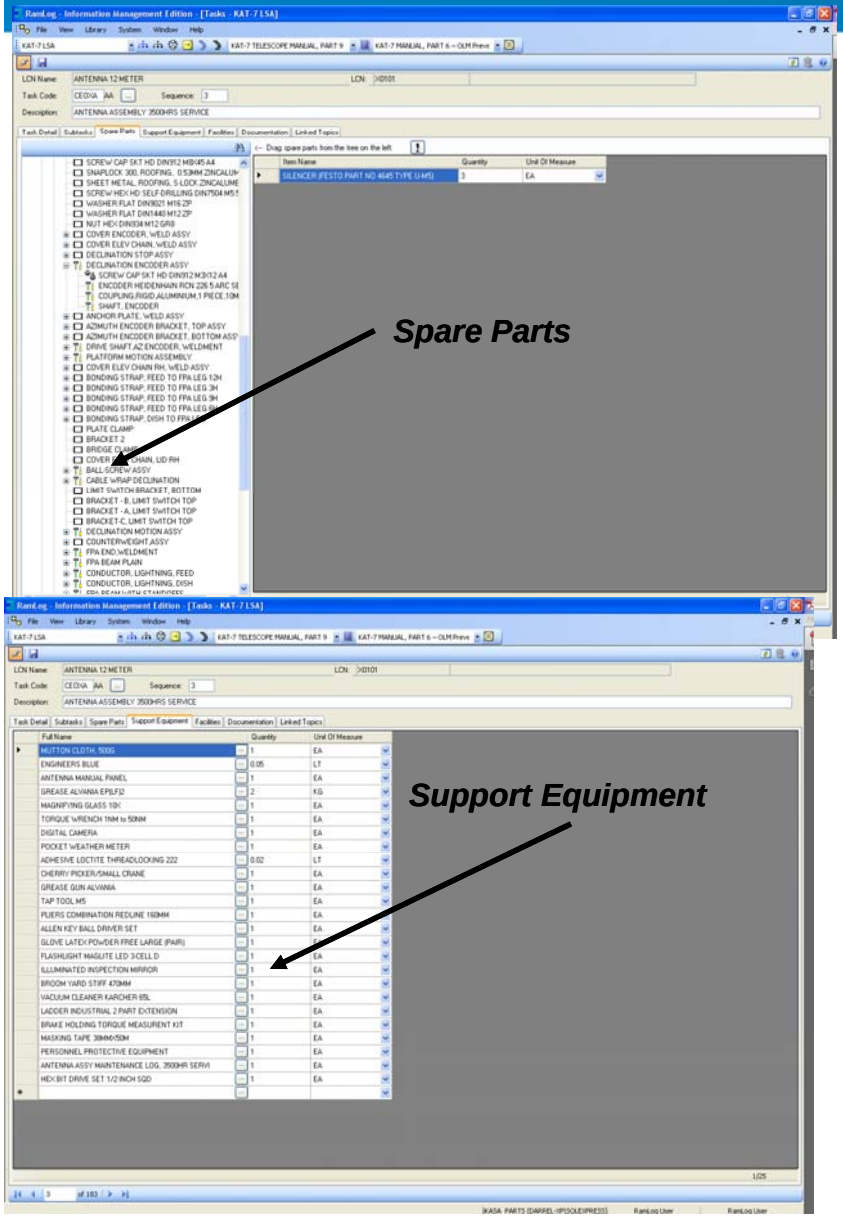
Level 4 Logistic Support Analysis

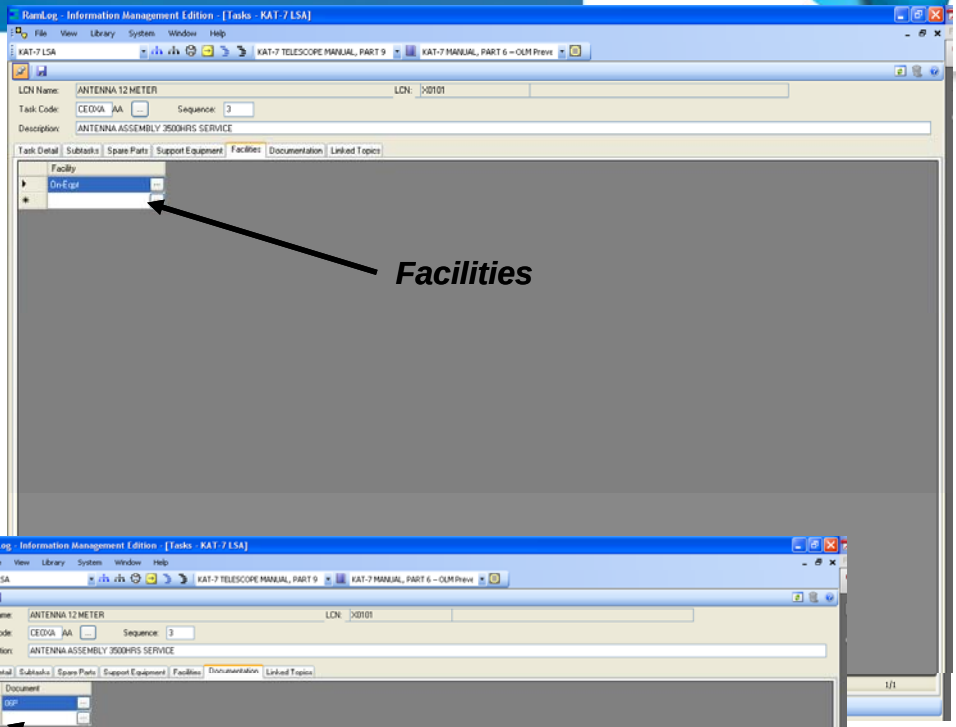
Task Analysis

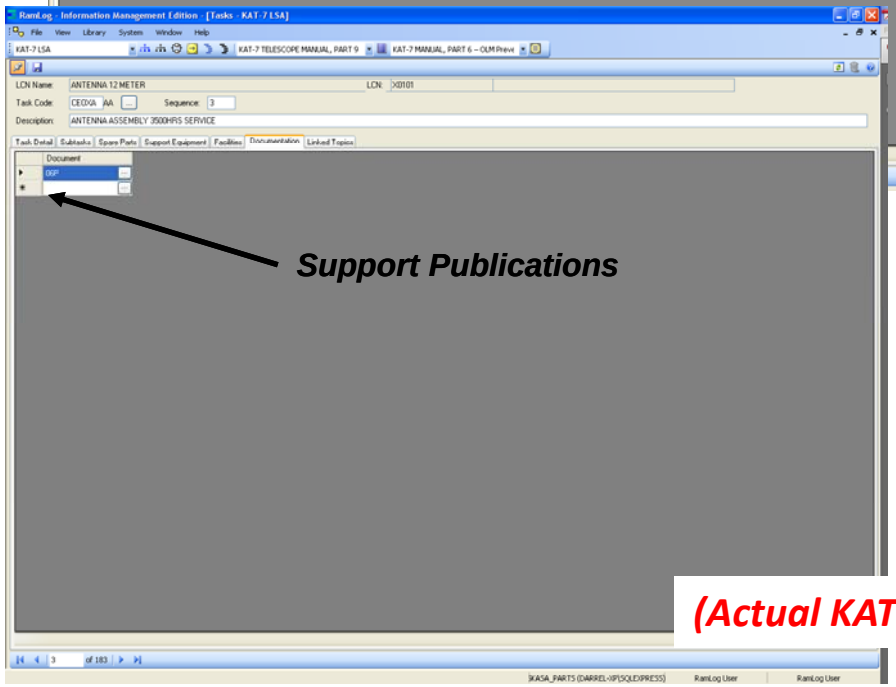


Level 4 Logistic Support Analysis

Resource Analysis







(Actual KAT-7 Data)

Level 4 Logistic Support Analysis

Support Publications

Maintenance Manual

SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

Client	:	**NRF (National Research Foundation)**
Project	:	**KAT-7**
Type	:	**HANDBOOK**

KAT-7 TELESCOPE SEGMENT MANUAL (INTERIM)
PART 6 – OLM PREVENTIVE MAINTENANCE

Document number ..... K0000-1000V1-06PM HA
Revision ..... F
Classification ..... Commercial in Confidence
Author ..... D Liebenberg
Date ..... 13 Apr 2011

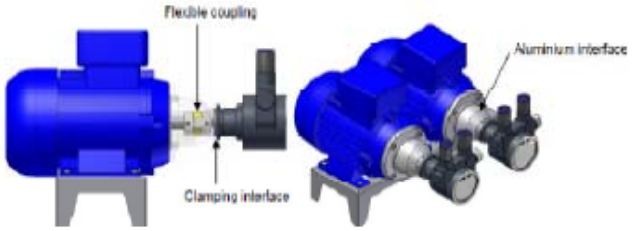


Figure 66 – Clamping Interface on the Pump & Motor Assembly

CAUTION: TAKE CARE NOT TO DISLODGE OR DAMAGE THE SUPPLY AND RETURN PIPES TO THE ROTARY VANE PUMPS.

24. Utilising a medium Phillips Screw Driver, unscrew the Clamping Interface securing the Rotary Vane Pump to the Pump Interface.

25. Remove the Rotary Vane Pump from the Aluminium Pump Interface. It may be stuck and may need some force to remove. Utilising a soft faced Hammer, strike the Rotary Vane Pump until it comes off. Half of the Rotex Coupling should come out as it is attached to the Rotary Vane Pump shaft with a M5 Grub Screw. The other half of the Rotex Coupling is attached to the Motor shaft.

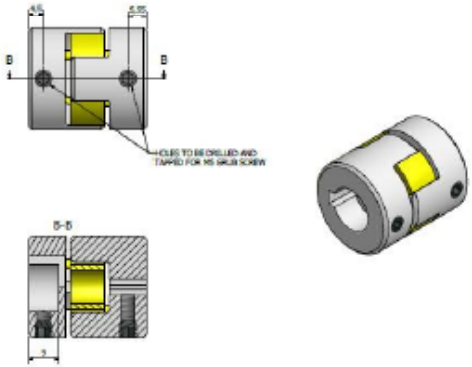


Figure 67 – Rotex Coupling

(Actual KAT-7 Data)

Level 4 Logistic Support Analysis

Support Publications (2)

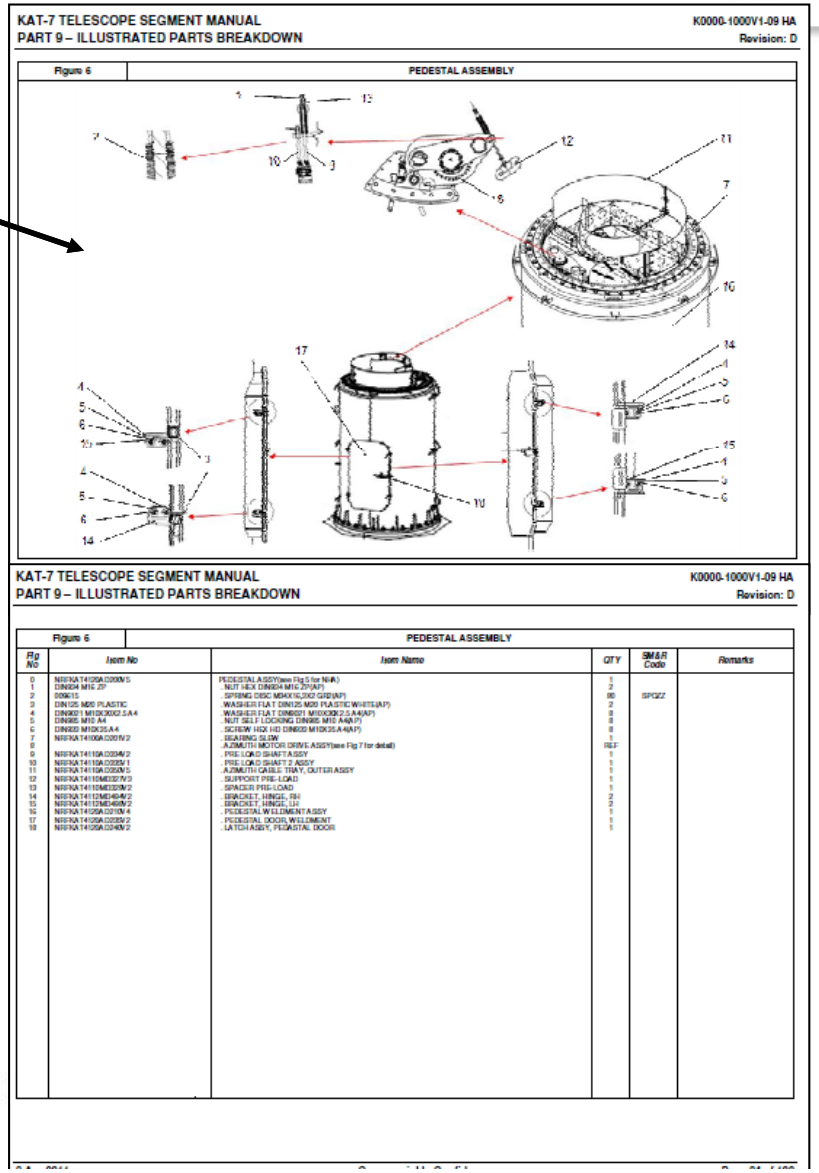
Illustrated Parts Breakdown

SKA SOUTH AFRICA
SQUARE KILOMETRE ARRAY

Client : NRF (National Research Foundation)
Project : KAT-7
Type: HANDBOOK

KAT-7 TELESCOPE SEGMENT MANUAL (INTERIM)
PART 9 – ILLUSTRATED PARTS BREAKDOWN

Document number ..... K0000-1000V1-09 HA
Revision ..... D
Classification ..... Commercial in Confidence
Author ..... D Liebenberg
Date ..... 8 Apr 2011



KAT-7 TELESCOPE SEGMENT MANUAL
PART 9 – ILLUSTRATED PARTS BREAKDOWN
K0000-1000V1-09 HA
Revision: D

Figure 6 PEDESTAL ASSEMBLY

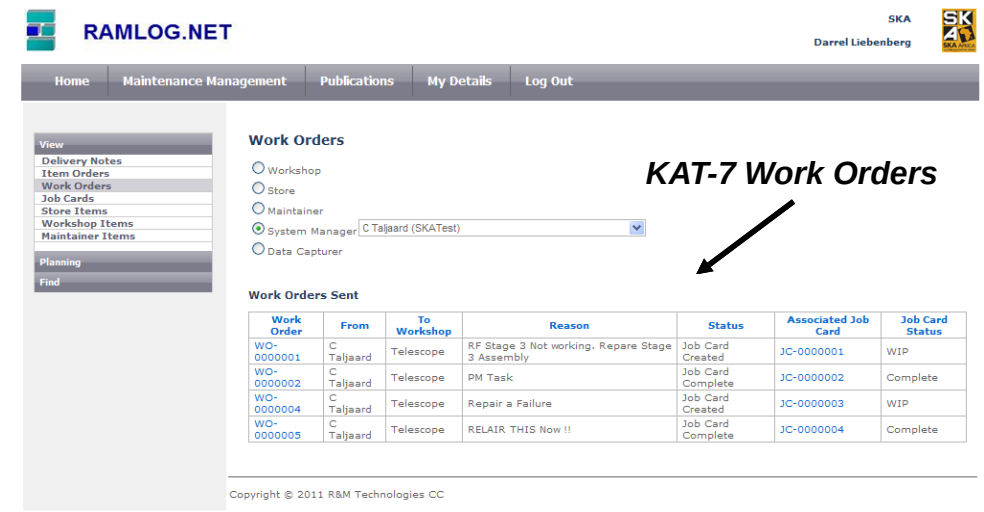
KAT-7 TELESCOPE SEGMENT MANUAL
PART 9 – ILLUSTRATED PARTS BREAKDOWN
K0000-1000V1-09 HA
Revision: D

Figure 6 PEDESTAL ASSEMBLY

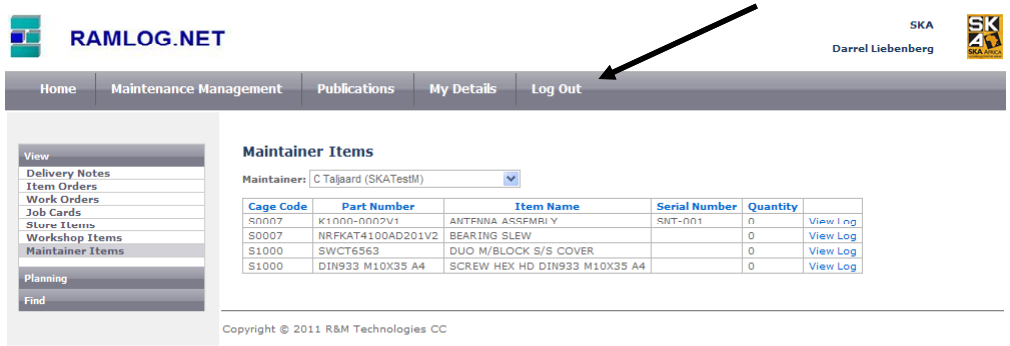
Fig NO	Item No	Item Name	QTY	SM&R Code	Remarks
0	NRFKAT-4105A-D200V-5	PEDESTAL ASSY(see Fig 5 for N/A)	1		
1	DIN934 M16 ZP	NUT HEX DIN934 M16 ZP(AP)	2		
2	009615	SPRING DISC M34X16.2X2 GRD(AP)	80	SPQZZ	
3	DIN125 M20 PLASTIC	WASHER FLAT DIN125 M20 PLASTIC WHITE(AP)	2		
4	DIN9021 M12X30X2.5A4	WASHER FLAT DIN9021 M12X30X2.5 A4(AP)	8		
5	DIN985 M10 A4	NUT SELF LOCKING DIN985 M10 A4(AP)	8		
6	DIN933 M10X35 A4	SCREW HEX HD DIN933 M10X35 A4(AP)	8		
7	NRFKAT-4106A-D201V-2	BEARING SLEW	1		
8		AZIMUTH MOTOR DRIVE ASSY(see Fig 7 for detail)	REF		
9	NRFKAT-4110A-D204V-2	PRE LOAD SHAFT ASSY	1		
10	NRFKAT-4110A-D223V-1	PRE LOAD SHAFT 2 ASSY	1		
11	NRFKAT-4112A-D250V-1	AZIMUTH CABLE TRAY, OUTER ASSY	1		
12	NRFKAT-4110M-D227V-3	SUPPORT PRE-LOAD	1		
13	NRFKAT-4110M-D229V-2	SPACER PRE-LOAD	1		
14	NRFKAT-4112M-D494V-2	BRACKET, HINGE, RH	2		
15	NRFKAT-4112M-D495V-2	BRACKET, HINGE, LH	2		
16	NRFKAT-4105A-D210V-4	PEDESTAL WELDMENT ASSY	1		
17	NRFKAT-4105A-D223V-2	PEDESTAL DOOR, WELDMENT	1		
18	NRFKAT-4105A-D245V-2	LATCH ASSY, PEDASTAL DOOR	1		

(Actual KAT-7 Data)

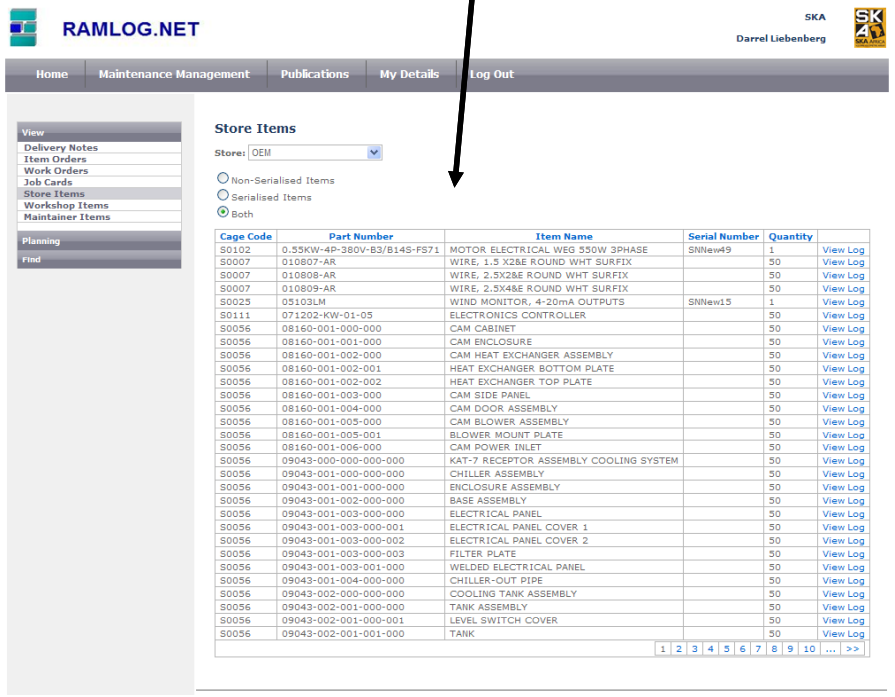
Maintenance Management



KAT-7 Work Orders



KAT-7 Maintainer Inventory



KAT-7 Store Items

(Actual KAT-7 Data)

Logistics engineering

System reliability analysis

"Design for Support; Design the Support & Support the Design"

- System reliability requirements
  - The system shall have critical failures for less than 5% of annual operating time, where a critical failure is defined as a failure which results in the system not being available for science observations OR more than 10% of array elements not being available for science observations
  - The system shall have a mean time between critical failures of ≥684hours
  - The system shall have a critical mean time to repair of ≤36hrs
- FMECA for all sub-systems to identify failure modes
- Allocate MTBF and MTTR for each subsystem based on FMECA
- Calculate system downtime and availability to check if requirements are met

*FMECA = **F**ailure **M**odes, **E**ffects and **C**riticality **A**nalysis*
*MTBF = **M**ean **T**ime **B**etween **F**ailures*
*MTTR = **M**ean **T**ime **t**o **R**epair. MTTR numbers include logistical system delays.*

Logistics engineering

Comparative reliability allocation for FMECA

Table 1: Comparative reliability allocation for FMECA

		MTBF (months)	MTTR (hours)	Downtime (hours/year)	# of failures/year for system
Receptor	3 receivers + compressor	5	8	_	154
	Digitizer	24	6	_	32
	Antenna positioner	18	12	_	43
Site	Antenna power reticulation	6	8	16	2
	Antenna fibre reticulation	60	48	9.6	0.2
	Power source	60	120	24	0.2
Processor Building	Correlator & Time Frequency Reference	4	8	24	3
	Karoo Array Processor Building	24	48	24	0.5
	Control & Monitoring system	8	8	12	2
	Science processor	8	8	12	2
Remote CAM link		12	24	24	1

MTTR numbers include logistical system delays.

Logistics engineering

Assumptions for comparative reliability allocation for FMECA

Table 2: Assumptions for comparative reliability allocation for FMECA

		Assumption
Receptor	3 receivers + compressor	Swap-out of hot spares to enable 8-hour repair time
	Digitizer	Swap out failed units
	Antenna positioner	Chiller requirements and concept similar to KAT-7
Site	Antenna power reticulation	
	Antenna fibre reticulation	
	Power source	Built-in redundancy, as per infrastructure concept design
Processor Building	Correlator & TFR	Hot-swappable ROACH units
	Karoo Array Processor Building	Built-in redundancy, as per infrastructure concept design
	Control & Monitoring system	
	Science processor	
Remote CAM link		

Logistics engineering

Results: System reliability analysis

- Total number of hours downtime per year = 145, resulting in a critical availability of 98.3%, which meets the requirement of 95%.
- Number of critical failures is approximately 10, resulting in MTBF of approximately 880 hours, which meets the requirement of ≥684hours.
- The MTTR of critical failures is 18.5 hours, which meets the requirement of ≤36 hours.
- Results show that the maintenance cost is driven by the receptors – specifically the receiver sub-system.
- Allocation of comparative reliability (Table 1) implies a MTBF of 2,456 hours for individual receptors. Resulting MTTR for individual receptors is 8.5 hours.
- For the system as a whole, the reliability allocation in Table 1 results in a total number of approx. 240 failures per year.