



Telescope Manager (TM) Consortium : from Stellenbosch to Rotterdam (and beyond...)

Yashwant Gupta
Team Lead for TM

SKA Engineering Meeting, Rotterdam, 12th Jun 2017

Outline



- **TM roles & responsibilities : overview**
- **TM organization : sub-packages, who's doing what**
- **Progress since Stellenbosch meeting : highlights**
- **Future plans till CDR**
- **Risks and issues**

TM Roles & Responsibilities



TM will enable 3 operational capabilities:

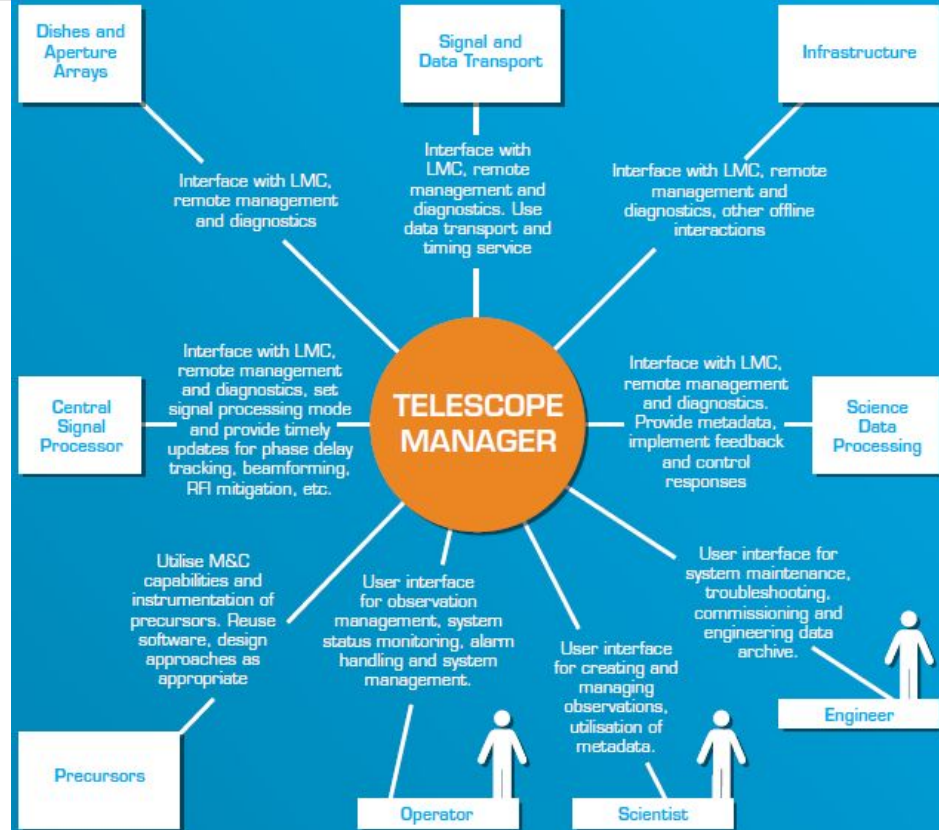
- **Management of astronomical observations:** proposal submission, scheduling, observation preparation and execution management.
- **Management of the telescope hardware & software subsystems:** for astronomical observations and entire instrument life-cycle, including all Element LMC interactions.
- **Management of the data to support system operations and all stakeholders:** System state parameters and metadata, telescope behavioural model, archival of M&C data, forensic tool for diagnostics, operator & engineer UIs.

TM as the nerve centre of the SKA telescopes

TM Talks to Every Element



- TM is the central brain + nervous system of the SKA telescope.
- Interacts with and controls elements of the observatory.
- Plays the central role in carrying out the observations and managing the observatory resources.
- All inter-element “conversation” is to be routed via TM.



TM sub-packages and their roles



To support these capabilities, TM is organised into the following sub-packages :

- Telescope Management (TelMgt) : Engineering management of the instrument.
- Observation Management (ObsMgt) : Usage of the instrument for astronomical observations.
- Local Monitor and Control (LMC) : Monitoring & Control of Telescope Manager itself.
- Local Infrastructure (LINFRA) : Computational, communications, power & facilities infrastructure for TM.
- Prototyping (Proto) : Development of the prototypes needed for validation of the design process.
- User Interface Development (UI) : TM wide UI development and technology exploration.
- Authentication and Authorisation (A&A) : for TM needs, with applications at project wide level.

+ Supporting work packages :

- System Engineering : Engineering artifacts related to requirements, architecture & interfaces.
- Project Management : Consortium coordination.

TM Consortium : Partners and Roles



LMC, A&A,
GUI (INAF,
Italy)

Observation Management
(UKATC , UK)

Telescope Management
(NCRA , India)

Infrastructure (Engage SKA
Consortium , Portugal)

Project Management
(NCRA, India)

System Engineering (SKA SA, South Africa)

Prototyping (All; coordinated by NCRA, India)

Review, support
(CSIRO , Australia ; NRC, Canada)



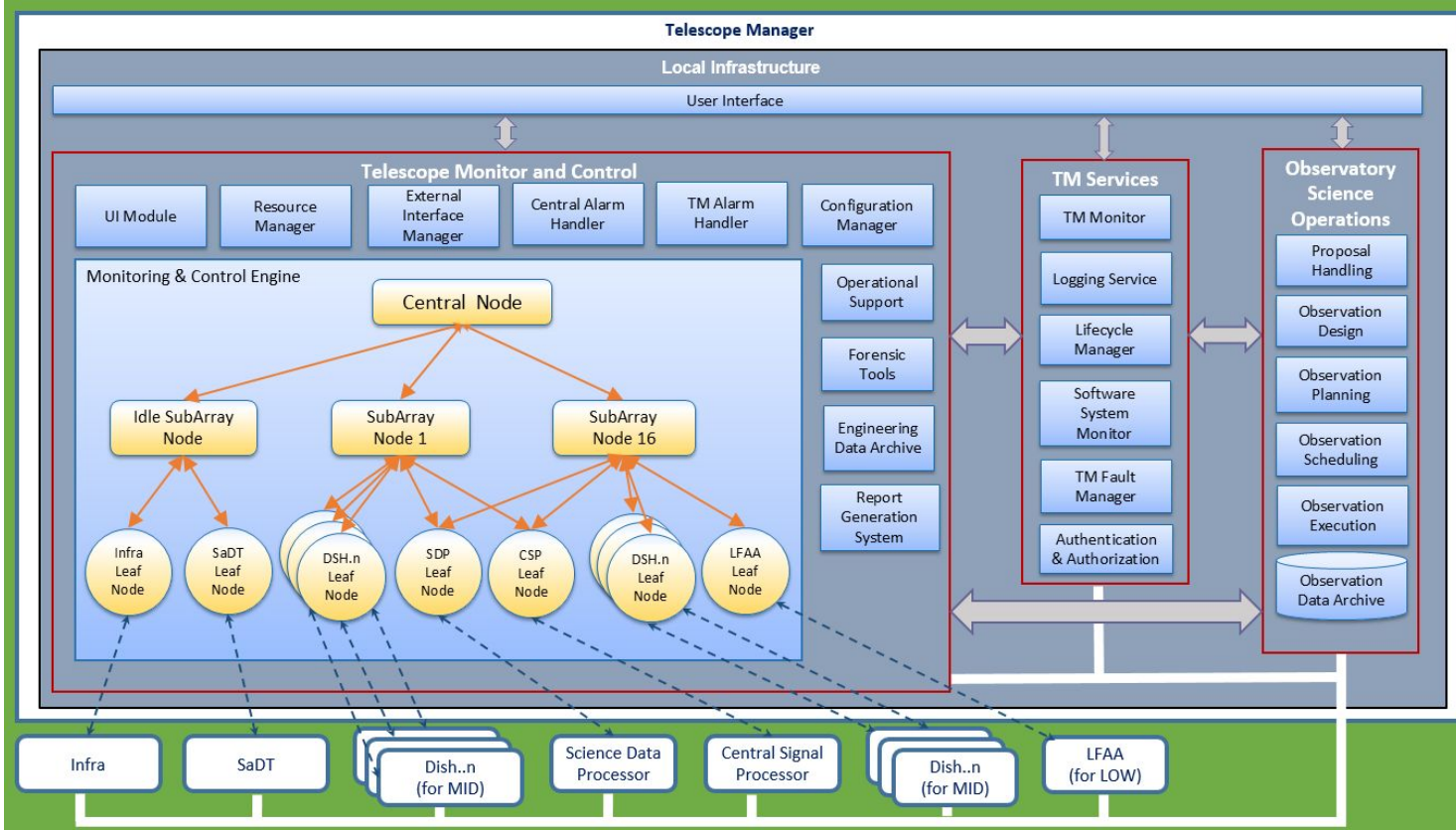
PERSISTENT



TM : High Level PBS

TM Product Breakdown Structure (PBS)

- Telescope Monitor and Control (TMC)
- Observatory Science Operations (OSO)
- TM Services



Progress Since Stellenbosch Meeting



Significant work and achievements since last SKA Engineering meeting :

- **TM Design Baseline** (M17) achieved in Jan 2017, baselined **TM DR** and **7 Internal ICDs**
- **Requirements baseline** for 4 sub-elements completed :
 - TM.ObsMgt, TM.TelMgt & TM.LMC (M18) in Nov 2016 and TM.LINFRA (M20) in Jan 2017.
- Participated in the **SKA Software Architecture Workshop** in Jan 2017, **adopted the SEI approach** for software dominated products.
- **Evaluation** of MeerKAT and GMRT M&C systems as possible options for SKA TM.
- **Requirement Engineering** : First iteration of **TM compliance** to L1 Rev 10 submitted, impact on TM Design of L1 Rev 10 - detailed study ongoing.
- Good Progress on **External ICDs** but some issues still to be resolved.
- **Prototyping** : most of the targeted work is complete, report delivered in Oct 2016 (M22) followed by another version in Apr 2017. Main emphasis has been to reduce design risk.
- Major contributions to the **Control System Guidelines Document**, Rev 01 has been released.
- **Costing** : Version of TM Cost Model submitted in Mar 2017 with a substantial cost saving, followed by another version earlier this month.

SEI Approach : Impact on TM

- **SKA Software Architecture Workshop (Jan 2017) adopted the SEI approach (ECP-170001)**
- **Welcome the new move, but it has significant impact on TM !**
 - Major reorientation of the design teams and their effort because of change of emphasis of deliverables – more emphasis on quality than detail of design.
 - Use of Mission Threads and Quality Attributes – new buzzwords !
 - All this has produced some flux in the regular work of TM Consortium :
 - Had to change the final set of deliverables for TM CDR.
 - Have impact on timelines, new CDR Closure timeline is Jun 2018 vs Dec 2017.
 - SEI “Views and Beyond” Approach for documenting architecture.
 - Conducted Mission Thread Workshops (MTW) to identify System-of-System (SOS) challenges and overarching quality attributes.
 - Conducted Quality Attribute Workshop (QAW) to identify key Quality Attribute Scenarios
 - Reorganisation of products and deliverables of TM

Precursor/Pathfinder Evaluation



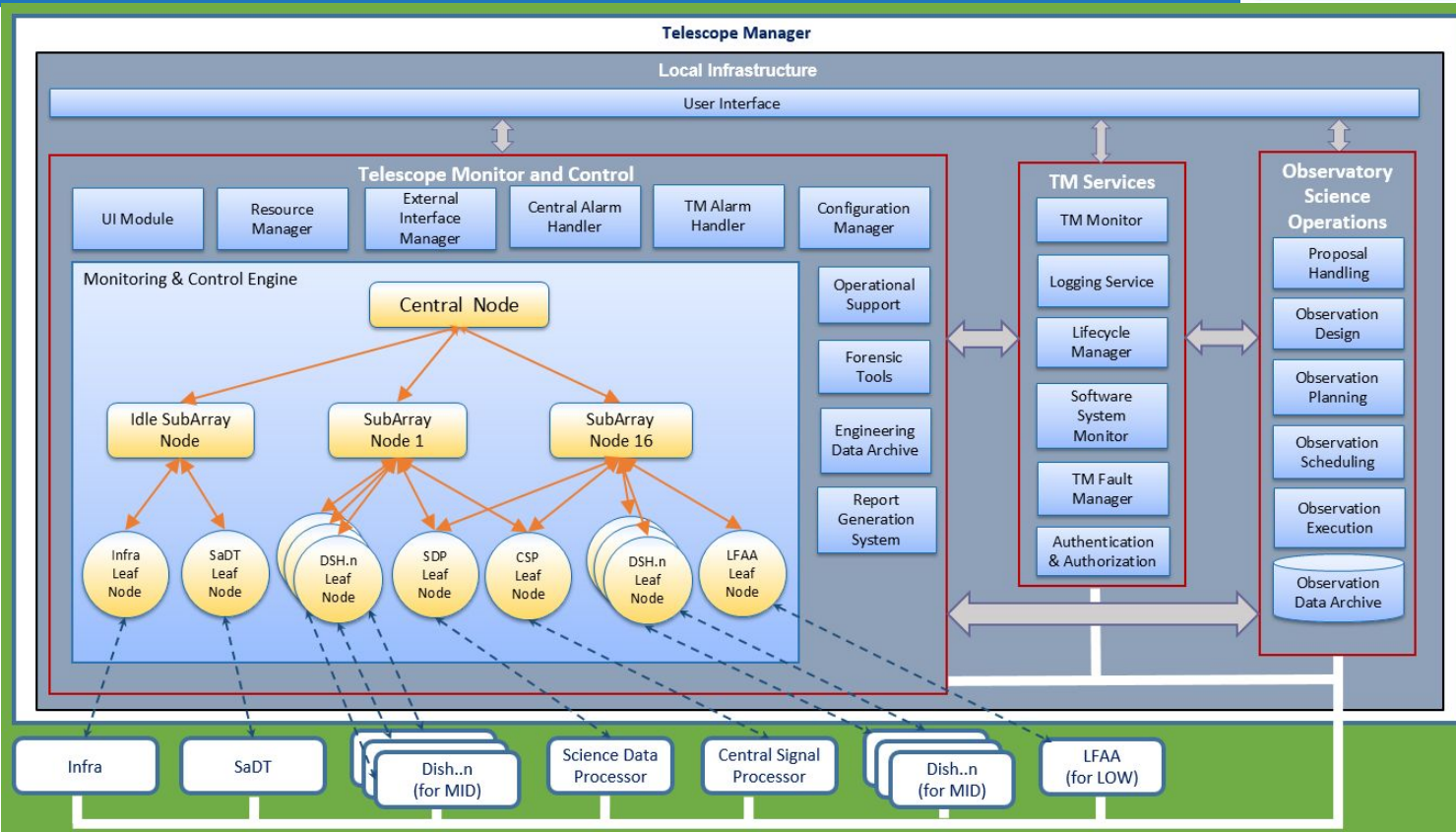
- In Oct 2016, the TM Board formed a TM Resolution Team (RT) to analyse two M&C system implementations (MeerKAT and GMRT), to see how precursor / pathfinder technologies and software can be incorporated into the development of TM.
- Options explored : full re-use, partial re-use, no re-use
- The report from the RT discussed and accepted by the TM Board in May 2017.
- Final recommendation : Full re-use not suitable; continue the present design effort, with MeerKAT as the reference architecture; identify specific areas in updated PBS that can benefit from existing implementation in the MeerKAT and GMRT systems.
- Approach to absorbing the output of the TM Evaluation Report / Impact of this going forward :
 - Continue with ongoing architecture development and detailing
 - For areas where there are gaps or multiple options, look at the reference architecture
 - Look for opportunities to simplify the architecture and eliminate risks.
 - Look for opportunities to reduce costs, by re-use of precursor / pathfinder concepts, where sensible.

Progress in design activities

TM : High Level Organisation



TELESCOPE MANAGER



Update on Observation Management



- PBS item corresponding to Observation Management sub-package identified as “Observatory Science Operations (OSO) Software”
- Covers essentially the same scope : Proposing, Planning, Designing, Scheduling, Executing and Tracking Observations
- Consists of a set of separate tools inter-operating via a Shared Data Pattern (persisted in the Observation Data Archive).
- Tools cover activities at GHQ and both telescope sites, consistent with
 - Creation of “Observation Management Systems” under Global Observatory in SKAO PBS (ECP 160057)

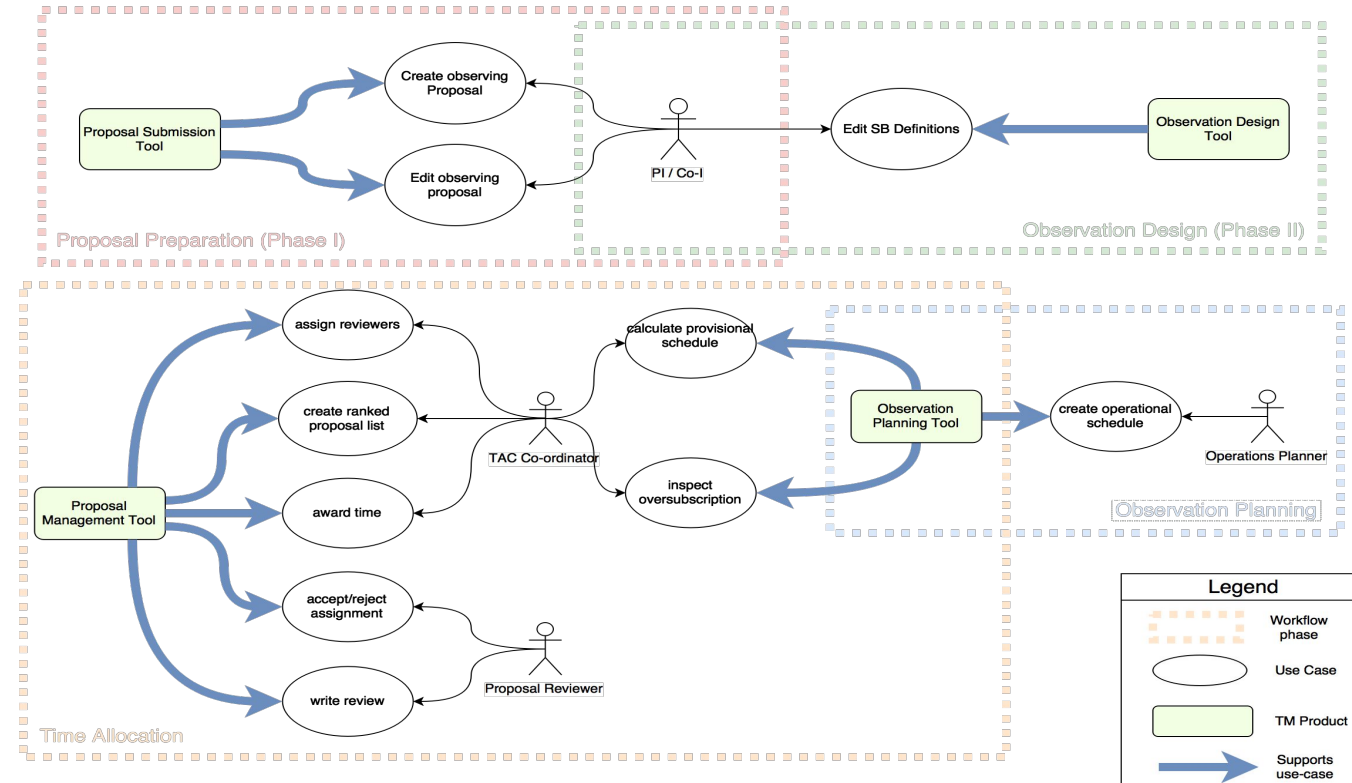
Observation Management Progress



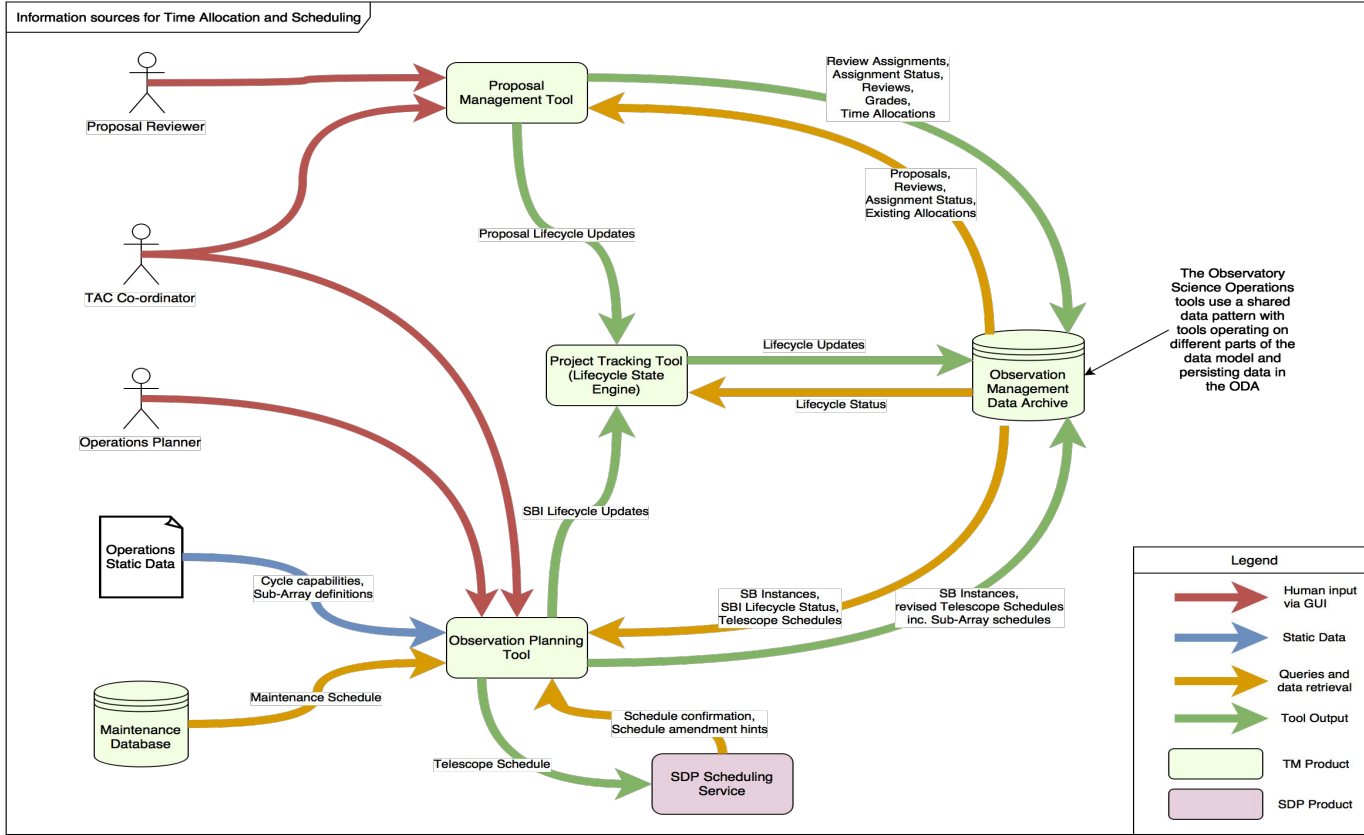
- OSO Requirements derived from L1 Rev10 are presently in internal review.
- Held two Mission Thread workshops:
 - from proposal submission to short-term plan.
 - from short-term plan to project completion.
- Held Quality Attribute Workshop for OSO software to determine key quality attributes.
- Currently working on SEI “Views” for OSO software.
- Agreed basics of processing planning interface with SDP.
 - Currently elaborating these for the ICD.
- SKA-level and TM-level issues identified have been catalogued in SKA and TM decision logs respectively.
 - And under discussion.

Products for Proposing to Planning

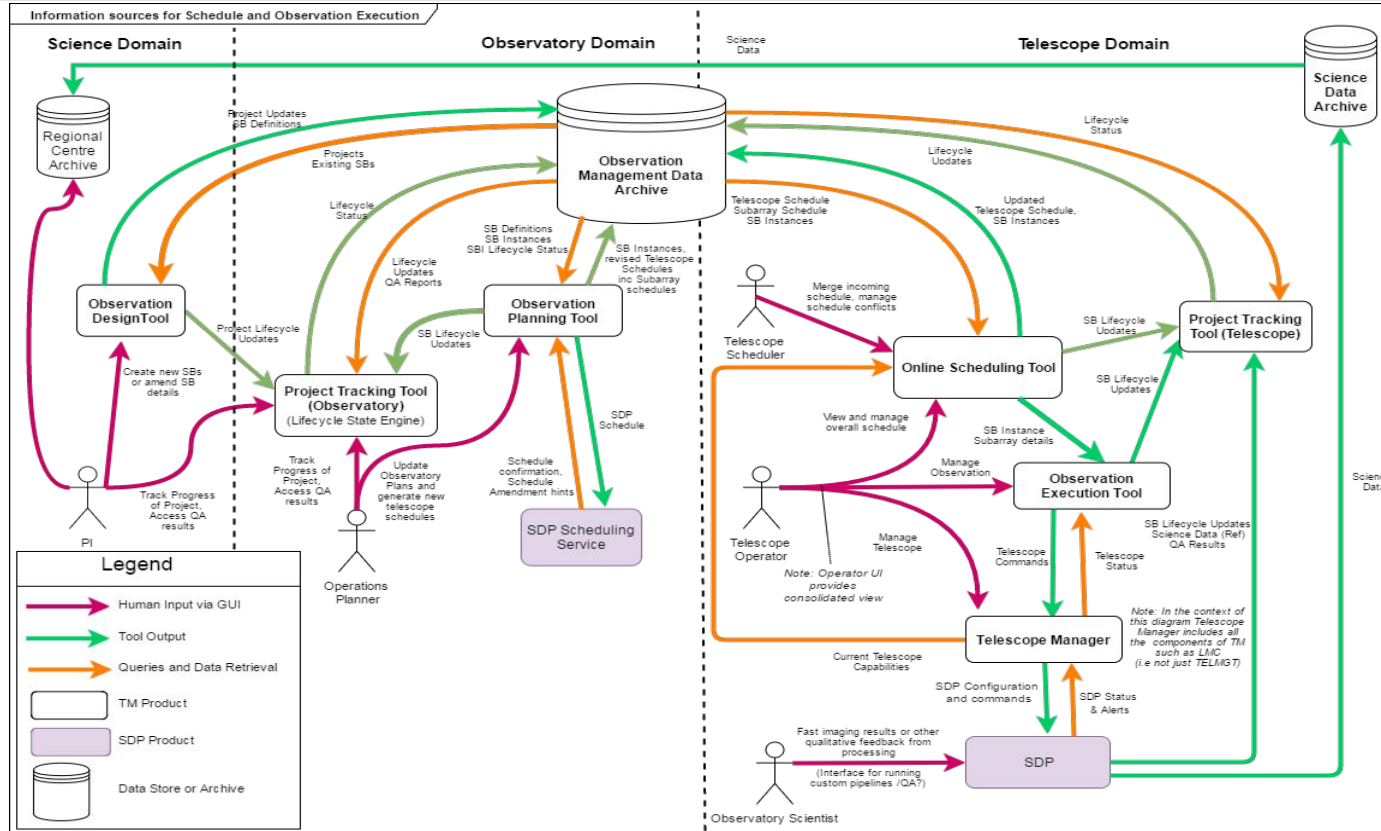
Actors, use-cases and TM product allocation



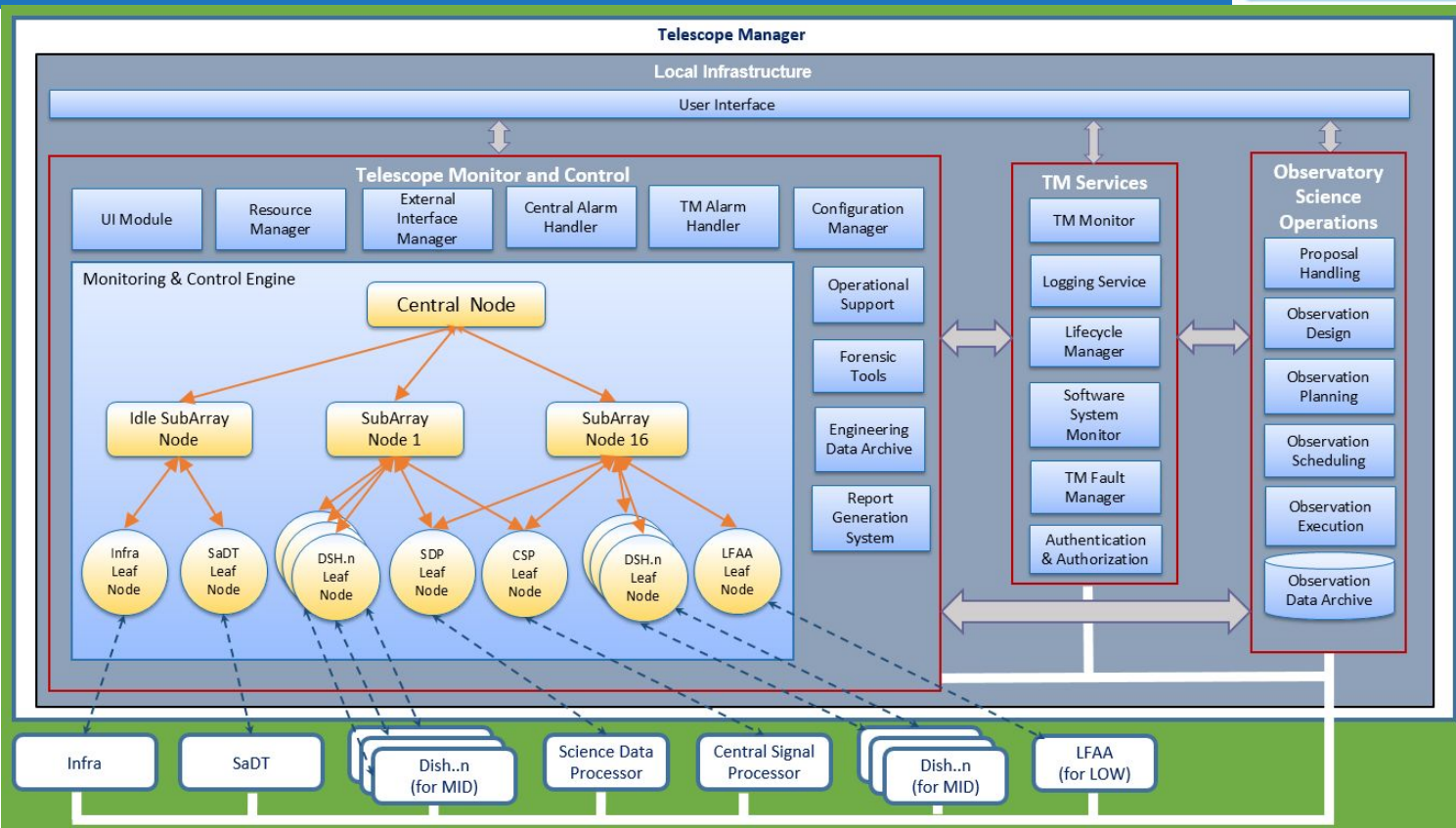
Time Allocation and Planning



Scheduling and Observation Execution



TM : High Level Organisation



Telescope Management Update : Architecture and Design



- Identified the PBS item corresponding to this work package as “Telescope Monitor and Control (TMC) Software” Product; major functionality remains the same :
 - Telescope Control and Monitoring
 - Alarm Detection and Handling
 - Data Archiving
 - Maintain Telescope Instrumental Configuration Data
 - Resource Management
- **Refinement of scope of TMC**
 - Removed ***TelMgt Lifecycle Manager*** to avoid the overlap with scope of “TM Services”.
 - ***Fault Manager*** renamed and re-scoped to ***Central AlarmHandler*** to align with SKA CS Guidelines.
 - **Addition** of ***TM AlarmHandler*** to detect and handle TM alarms.
- **Incorporated learnings** from the Precursor (MeerKAT) and Pathfinder (GMRT) systems.
- **Mitigated** risks and incorporated **learnings** through prototyping activities.

TelMgt Prototyping



- Monitoring & Control (M&C) and Engg Data Archive (EDA) prototypes
 - Worked on the performance analysis and scalability aspects
 - Extended the scope of M&C Prototype to workout network throughput estimates for communication between TANGO client and server.
- Prototyping to evaluate UI technologies is in progress
- Additional inputs for TM work, from Indo-SA collaboration project :
 - Work on LMC Interface Simulation Framework for supporting enabling systems.
 - System developed is available for use by the SKA community

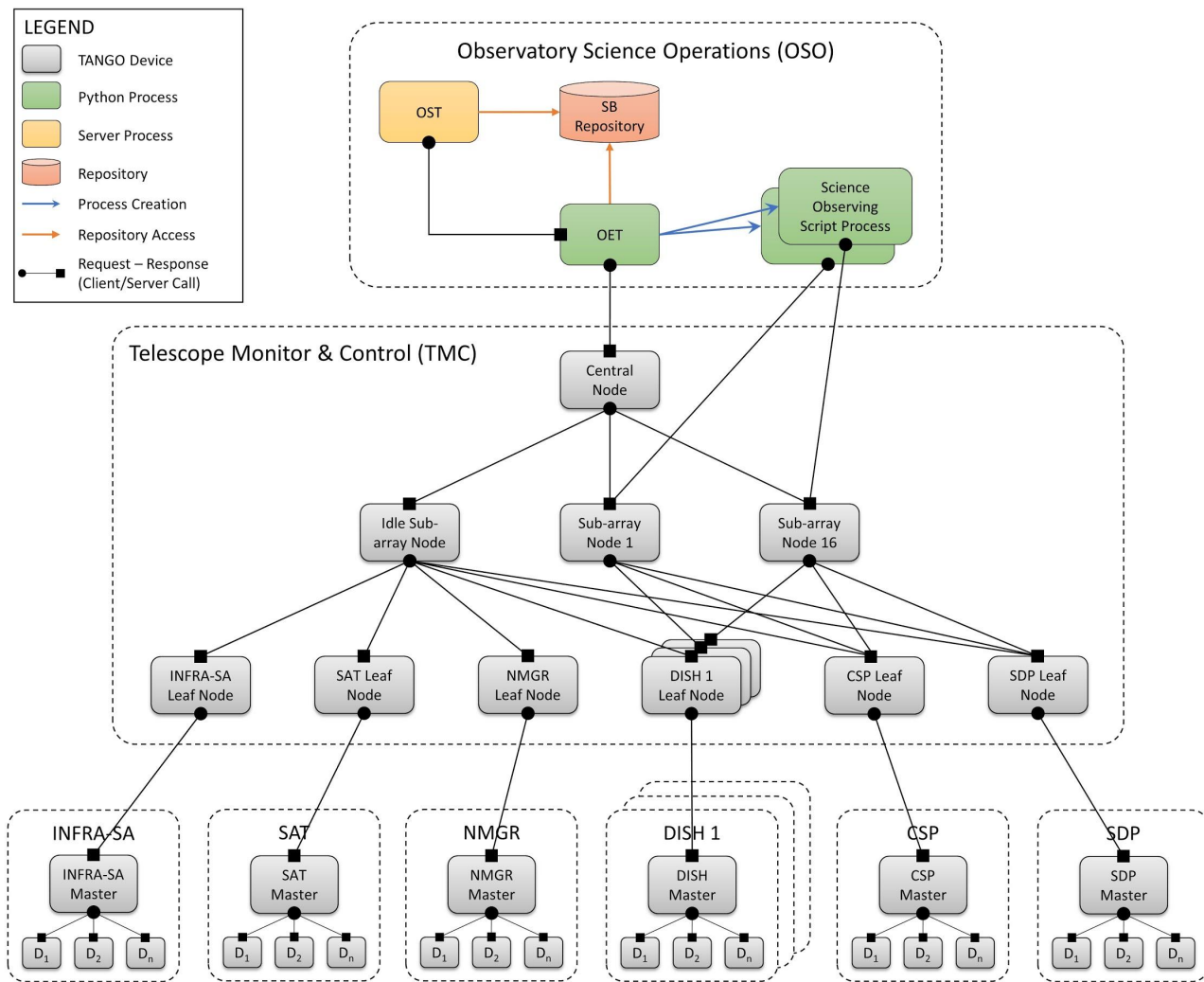
Telescope Management Progress



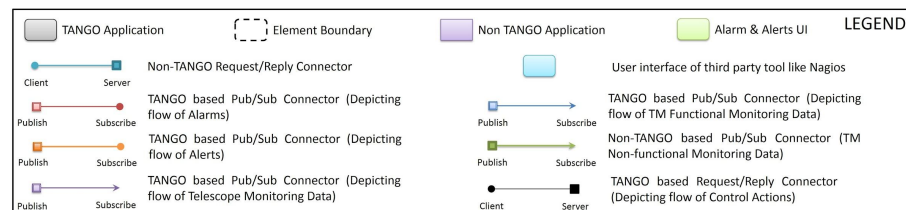
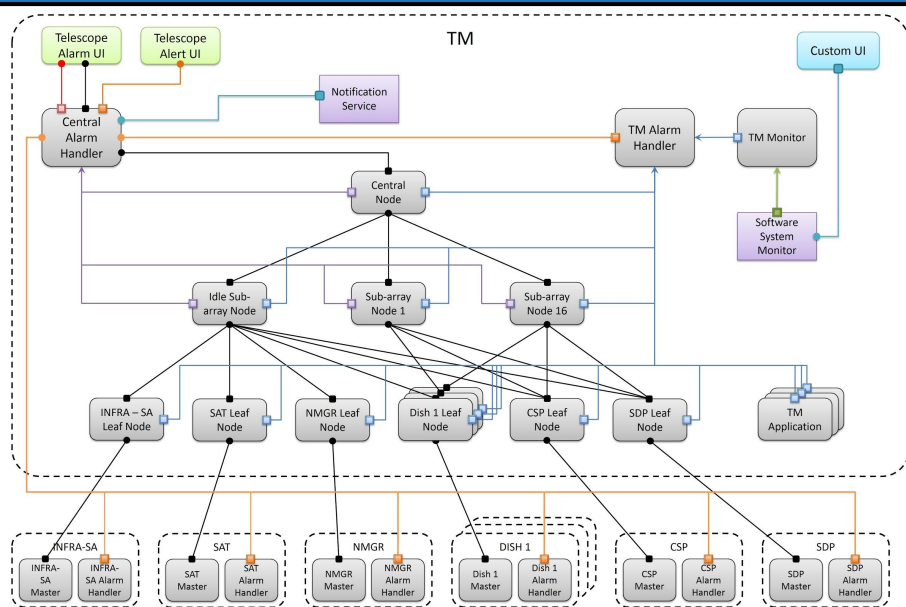
- TMC Requirements derived from L1 Rev. 10 are currently under internal review.
- **Mission Thread Workshop**
 - Observation Execution and Monitoring - **Done**
 - Telescope Monitoring and Fault Management - **Done**
- **Quality Attribute Workshop**
 - Identified **key Quality Attribute Scenarios** for Telescope Monitor and Control.
- Identified and worked a set of **Views** to be part of TMC Software Architecture Document.
 - Telescope Alarm Detection and Handling View - **Reviewed**, comments being addressed.
 - TM Archiving View - **Under Review**
 - TM Storage & Databases View - **Under Review**
 - TM System Configuration View - **In Progress**
 - Observations Control Flow View - **In Progress**
 - SKA Life-cycle view - **In Progress**
 - User Command and Control for Telescope Operations (Telescope Monitoring View Packet) - **In Progress**
- SKA and TM level architectural issues identified and catalogued in SKA and TM decision logs respectively.
 - Some of the issues are under discussion.

Obs Execution & Monitoring Architecture

- OST selects a SB from the short term plan and instructs OET to execute the selected SB.
- OET instructs the Central Node to activate a Subarray with selected Dishes.
- OET instantiates a new process for executing Observing script corresponding to the selected SB.
- Execution of observing script results into invocation of commands at the Subarray Node.
- Subarray Node translates the command into corresponding Element command(s) and instructs Element Master (via Element Leaf Node) to execute it.

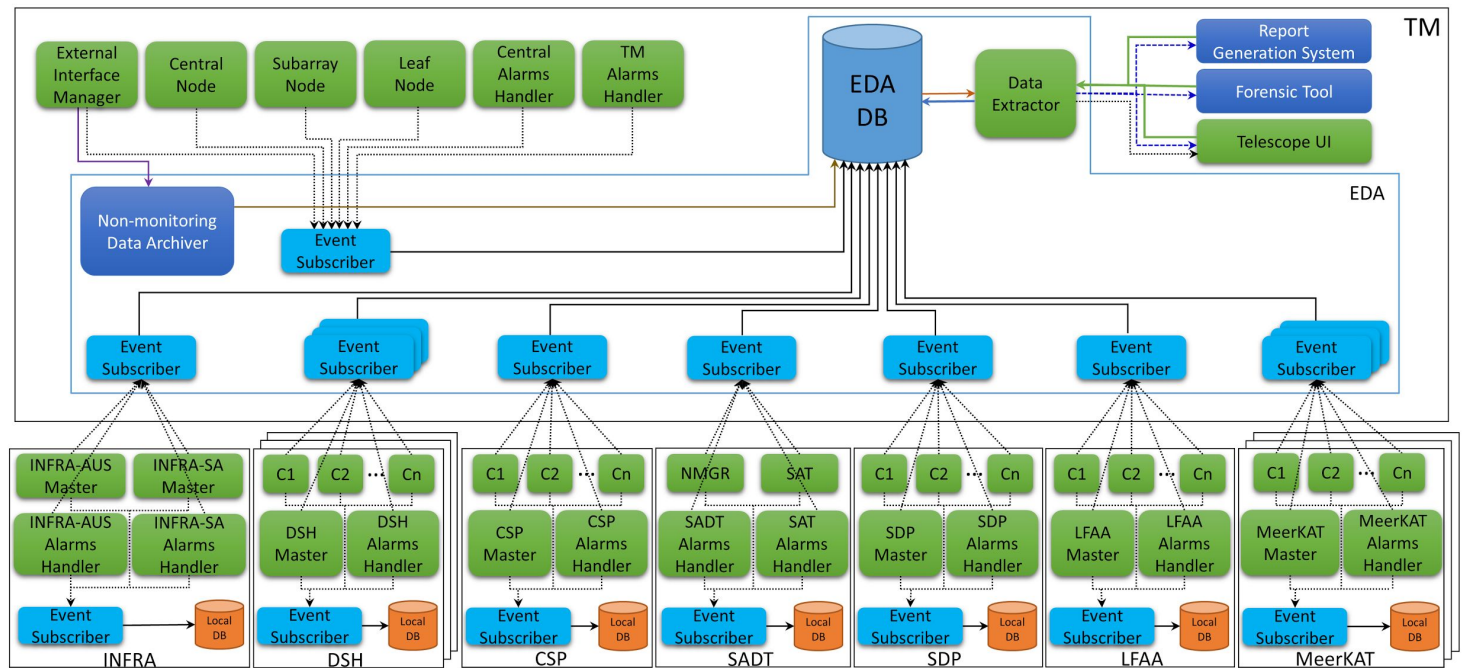


Alarm Detection and Handling Architecture



- Aligned with IEC 62682 standard.
- Separate component for management of Telescope Alarms and TM Alerts.
- Element level alert detection is delegated to each Element.
- All Element alerts, that TM need to know of, are interpreted within the Element and are reported by the Element AlarmHandler.
- The Central AlarmHandler connects only to the Element AlarmHandlers and not to various lower level monitoring points (attributes) exposed by Element TANGO Devices.
- The Central AlarmHandler manages the operator interaction with alarms and the alarm lifecycle according to IEC 62682.

Data Archiving Architecture



LEGEND

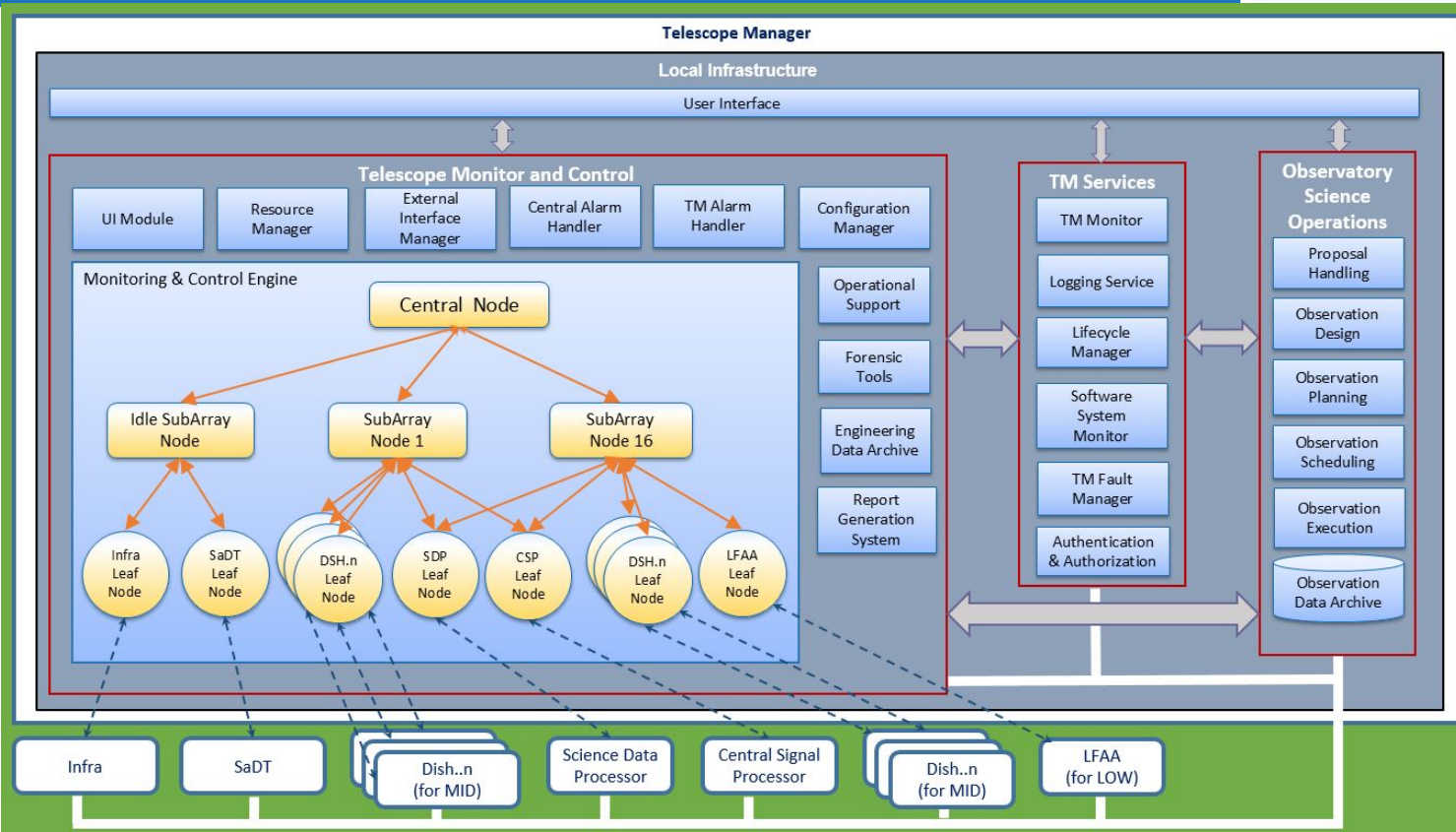


- Archival of all Element data *centrally* at TM.
- Monitoring data archived through Pub/Sub mechanism using *HDB++ Archiving Tool*.
- Non-monitoring data archived through API mechanism using *Custom solution*.
- Data retrieval for analysis, diagnostics & reporting from EDA DB using *Data Extractor*.
- Dedicated *EventSubscriber(s)* deployed *centrally* at TM for each Element to archive the data.

TM : High Level Organisation



TELESCOPE MANAGER

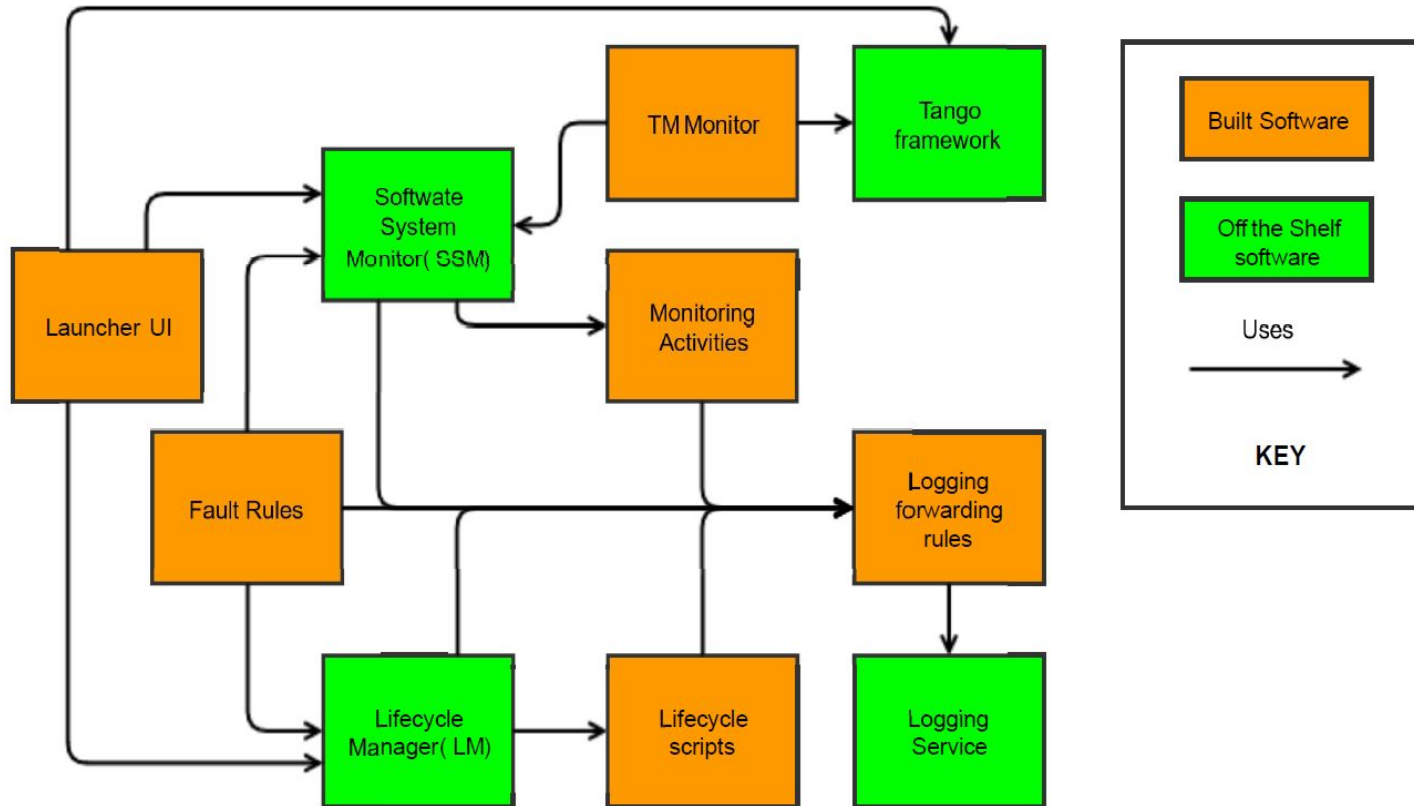


LMC: Monitoring and Controlling the Telescope Manager



- Even TM needs to be monitored and controlled in order to ensure its continuous and proper operation (and therefore that of the whole SKA Telescope) and in specific it needs:
 - **Generic Monitoring:**
 - Monitor resources and performance in a distributed computer network (network services, host resources and so on).
 - **Lifecycle Management:**
 - Upgrade/Downgrade, Start-Up/Configure, Kill and Restart.
 - **Logging Service:**
 - Provide an architecture for storage of TM log messages, a forwarding mechanism and strategy and technology for visualizing/browsing and inspecting logs.
 - **Fault Management:**
 - When not directly handled by the TANGO facility.
- Many best practises available for monitor and control of such TANGO based control systems.
- All the above deliverables (and a few more) are combined into a PBS item called “**TM Services**”.

TM Services : “Use Module” View

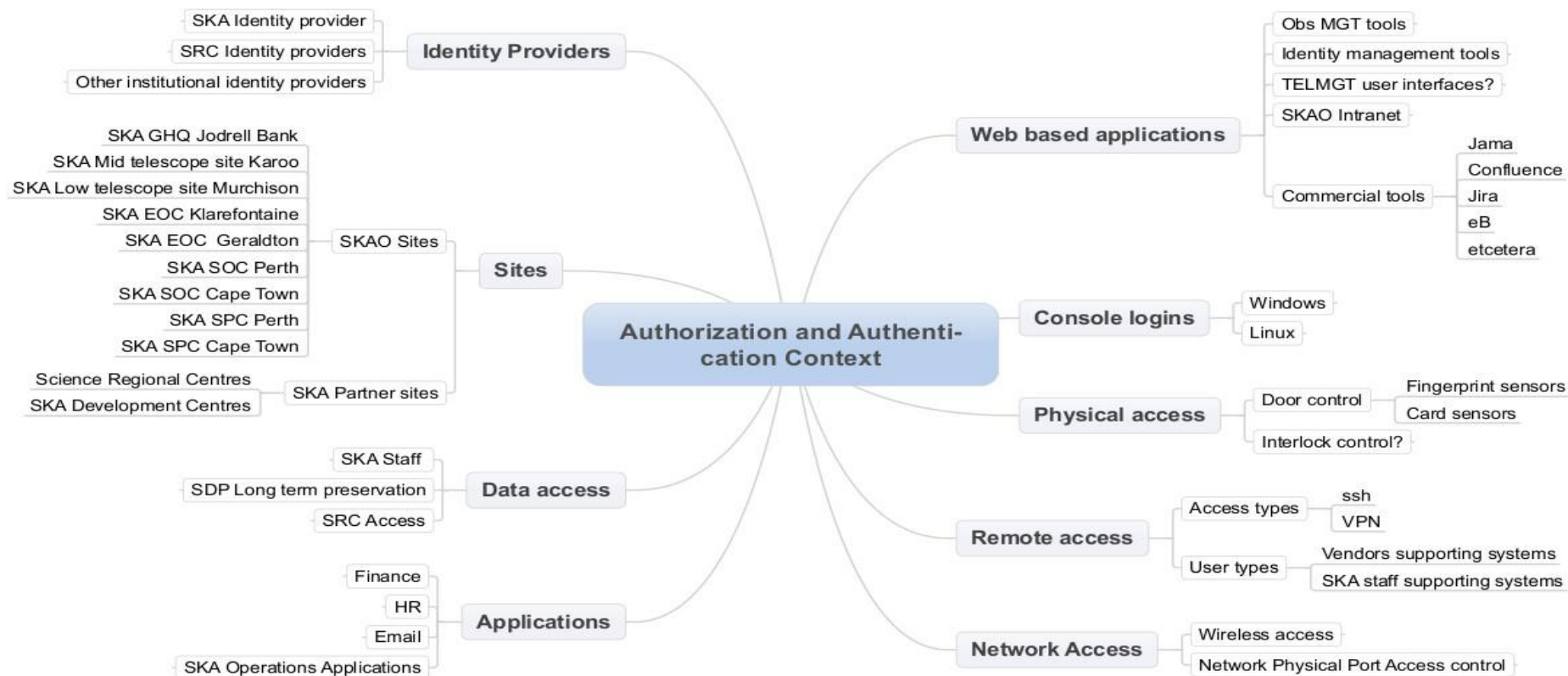


LMC : Progress

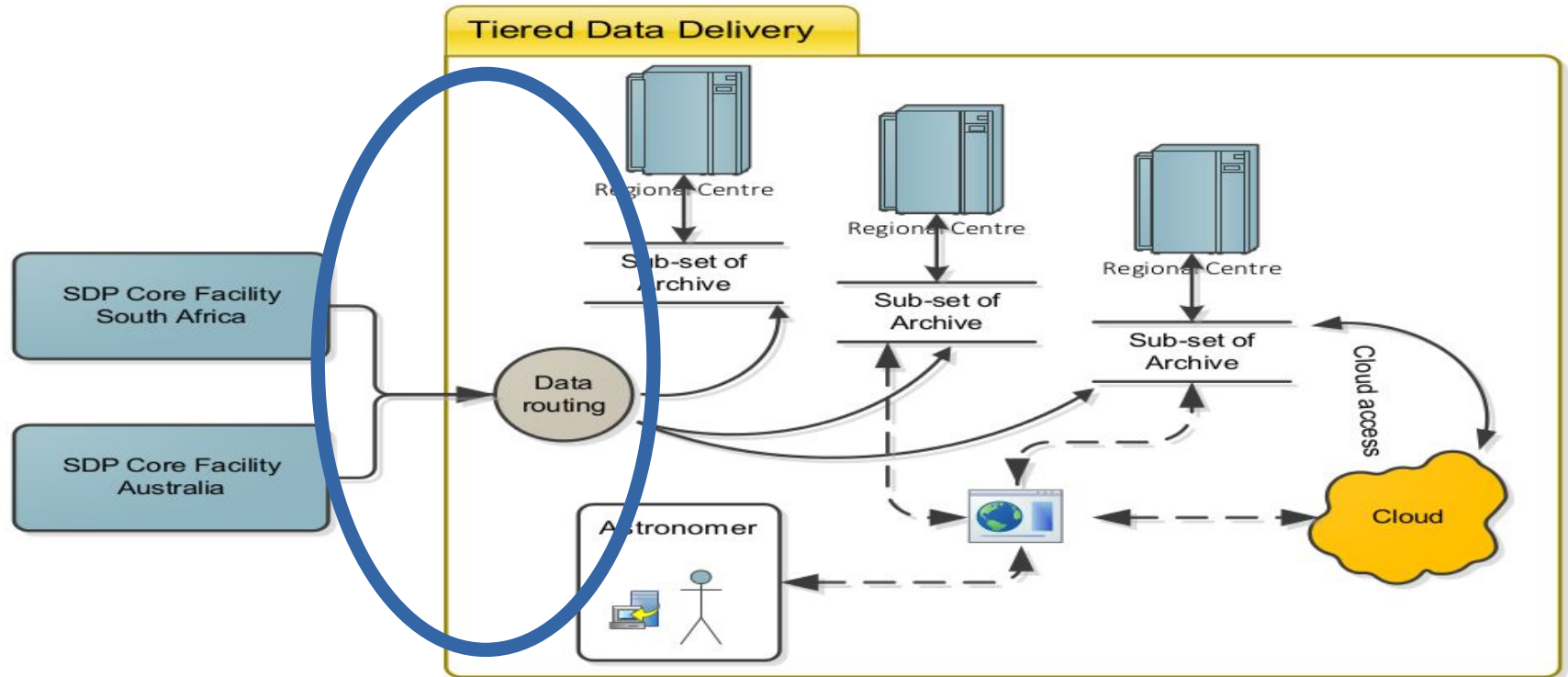


- **Requirements Specification (RS)** is being derived from the TM/OSO RS
- **Mission Thread Workshop**
 - TM lifecycle (startup, shutdown, upgrades) - **Done**
 - 5 quality attributes found
 - Most important one is the **Maintainability!**
- **Software Architecture Document (SAD):** 8 Views developed
- **Detailed Design and prototype is completed for :**
 - Software system Monitor
 - Fault management
 - Lifecycle management
 - Logging service

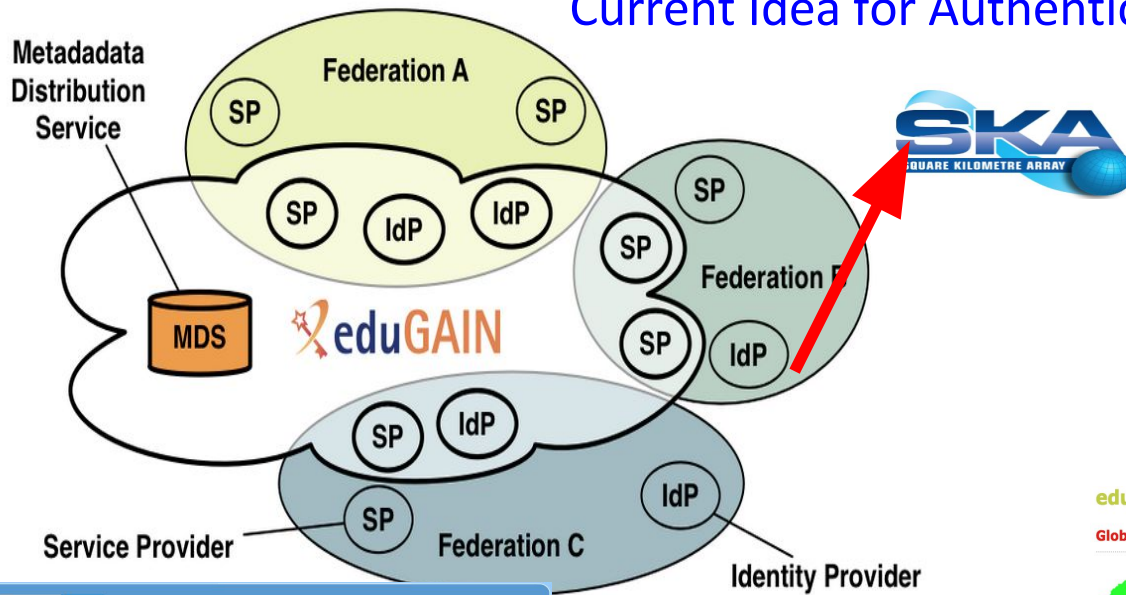
SKA A&A context



SKA and the SRDCs



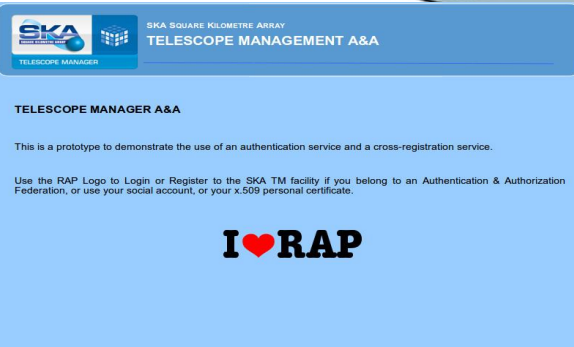
Current Idea for Authentication









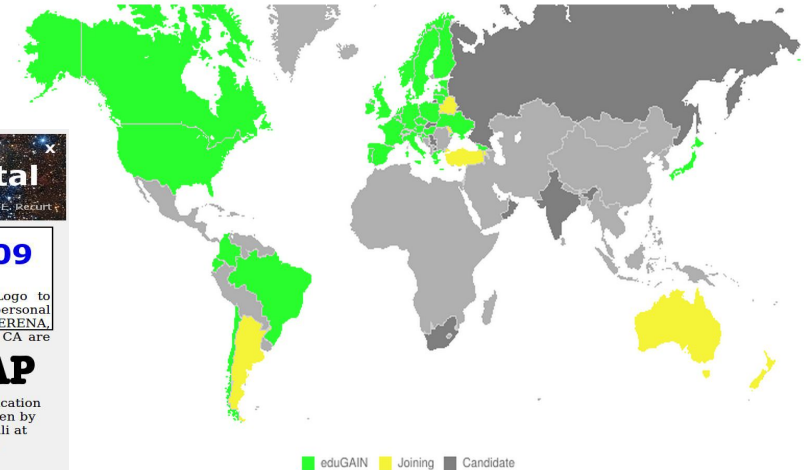
STANDARD TECHNOLOGIES
will allow to operate also in
the REGIONAL CENTERS!

eduGAIN membership status

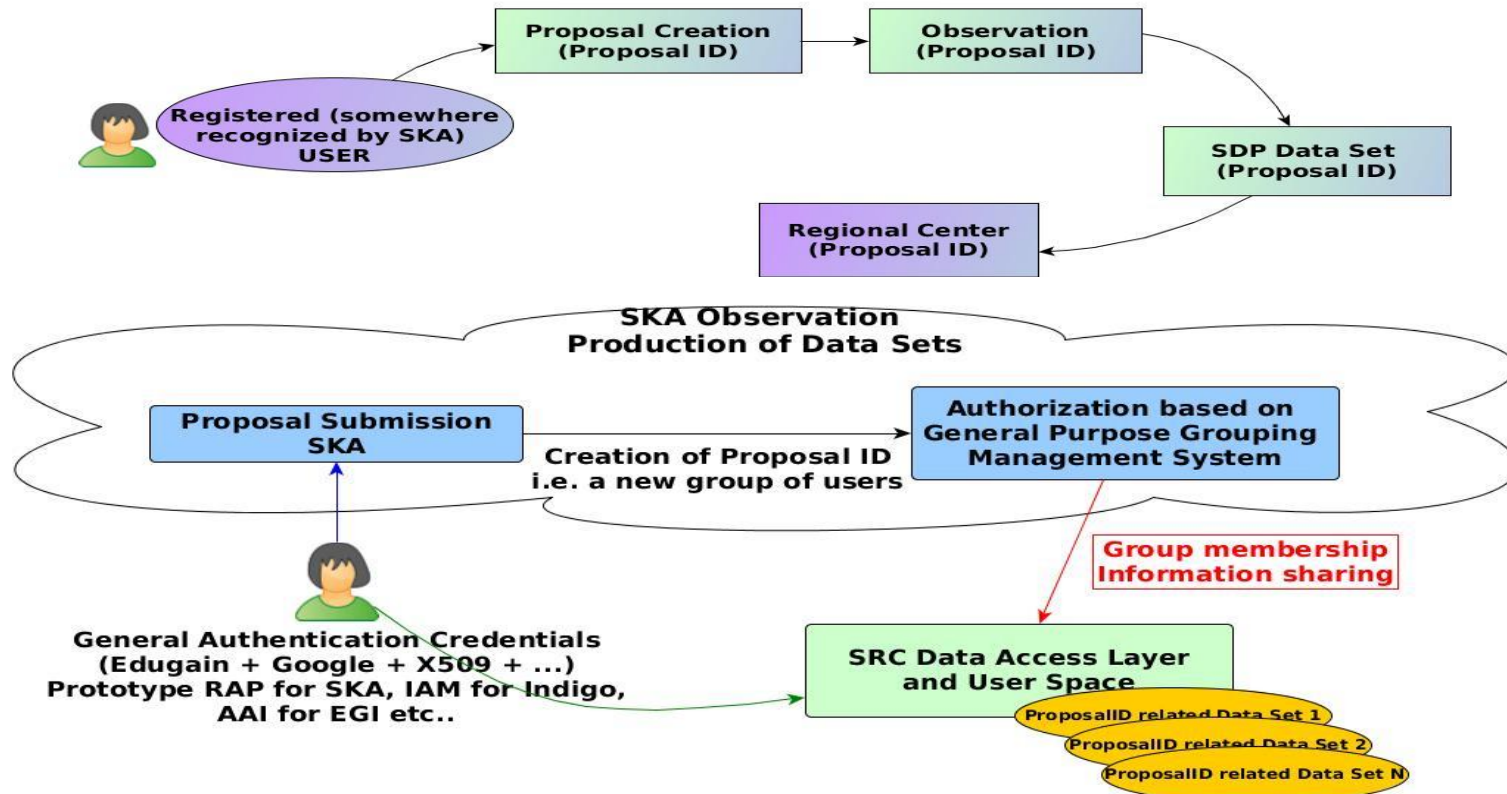
Global



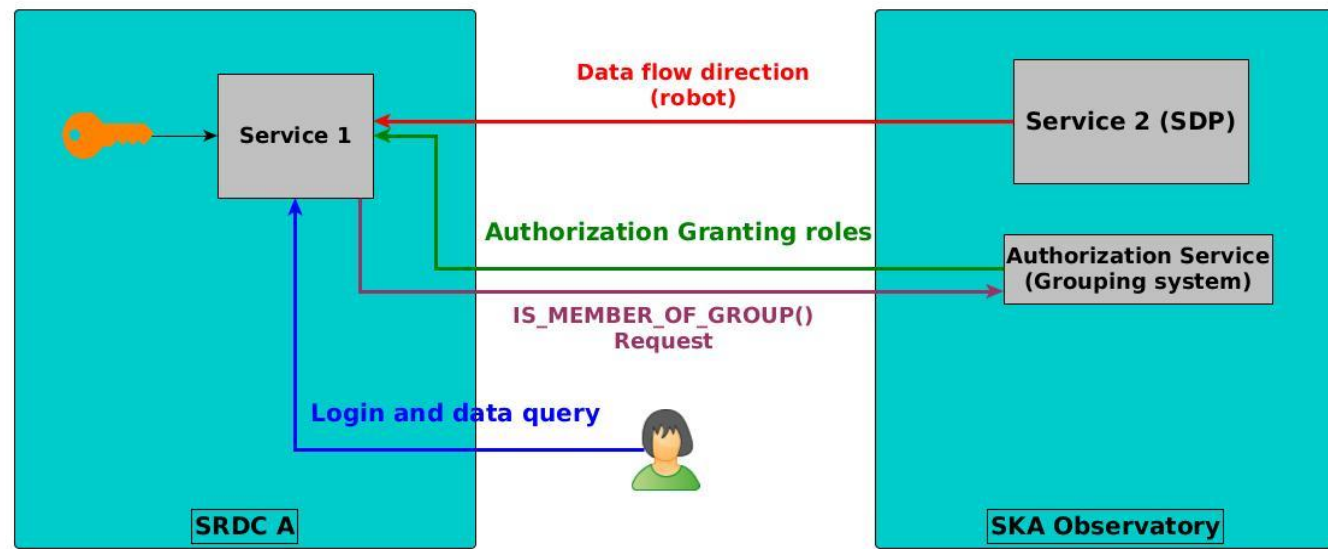
<h1>Remote Authentication Portal</h1> <p>Image Credit : Copyright: colonbarani/L. Reza</p>		
 <p>Use the eduGAIN Logo to Login or Register to the RAP facility if you belong to an eduGAIN</p>	 <p>Use the Google Logo to Login or Register to the RAP facility with your social identity.</p>	 <p>Use the X.509 Logo to Login with your personal certificate (TERENA, GARR and INFN CA are</p>
 <p>Use the Local Logo to Login with your self registered account.</p>	 <p>Login with your Username and the received RAP Token, if your remote providers is unreachable.</p>	 <p>Remote Authentication Portal was written by Franco Tiarrelli at INAF-IRA</p>



A&A : Prototype Schema



Foreseen mechanism for Authorization -- will use some form of group management system



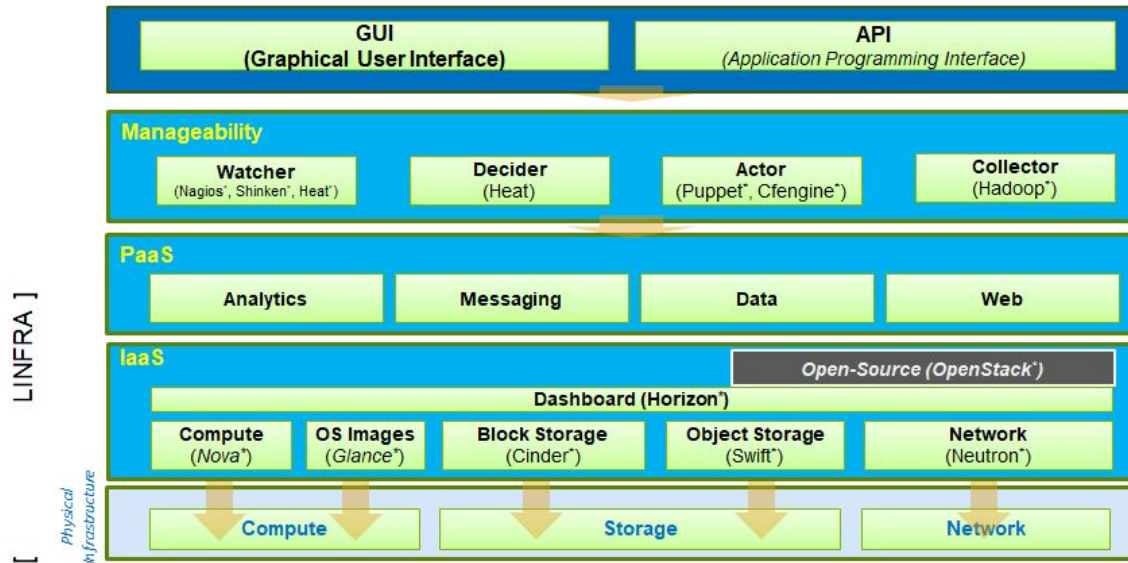
Interoperable Authorization Requirements

- 1) To allow for restricted access certain resources
Only a certain set of individuals may access certain resources
 - 2) To allow certain individuals to set the access rules on resources
The owner(s) of the resources need to manage the access rules
 - 3) To be able to re-use granting rules between resources
Projects must authorize access to a variety of proprietary resources
 - 4) To be able manage granting rules at a single location
Projects should not have to update each resource on a change to a re-used grant
 - 5) To be able to reference remote granting rules
Proprietary resources should not be confined to a single institution
- Courtesy of B. Major

Local Infra (LINFRA) Support for TM



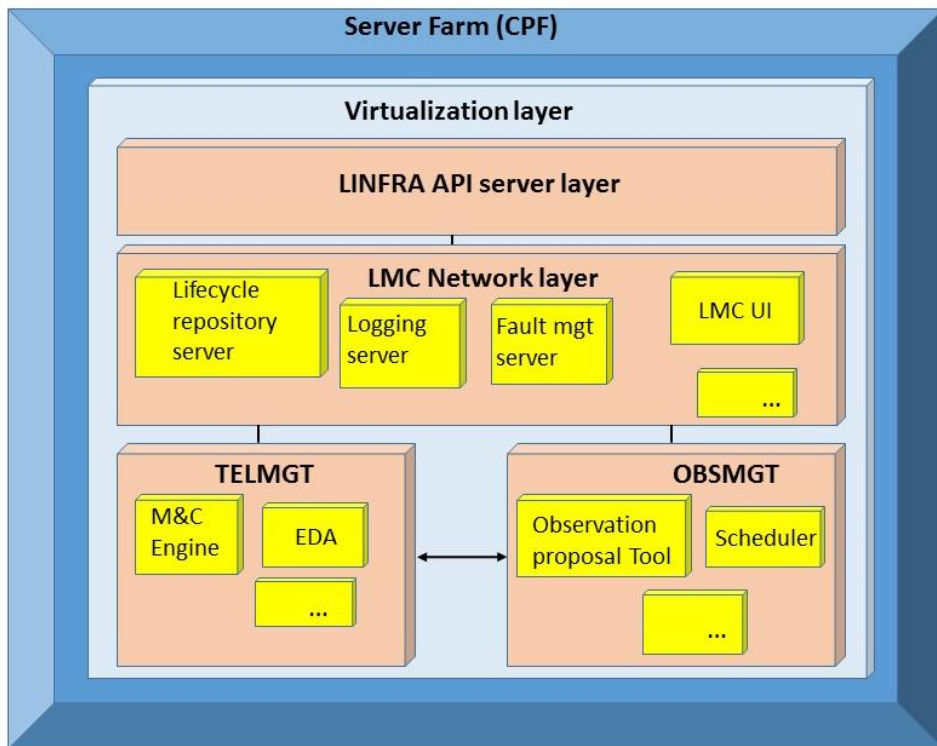
- Infrastructure design and deployment planning & sizing : compute, storage & network.
- OpenStack technologies for automated deployment, fail-over, patch management.
- Robust design: per TM component analysis (performance, reliability, availability, failure modes, security, power, RFI)
- Integration of technology stacks , IaaS/PaaS.
- Possibility of service broker if required.



TM.LINFRA Progress



- **Requirements Specification (RS)** settled - impact on QoS
- LINFRA design to be incorporated in **TM services SAD**
- **Design work** : develop further virtualization + deployment view
 - Assess impact of Dependability : RAMS /FMECA
- **SFMEA** --> needed in coordination with other TM work packages
- **Harmonization with SDP** - work ongoing to identify commonalities in technologies
- To study impact of A&A -- Openstack Keystone ?



Telescope Model : Progress



- Work on the Telescope Model* started in 2014 but was suspended for some time due to lack of clarity; it has been resurrected now.
- TM team formed to work on the Telescope Model and interact with the SKAO.
- Document outlining the concept and scope of the Telescope Model* generated and agreed upon with the SKAO.
- List of the items under Telescope Model being consolidated and refined.
 - Discussion during Engg meeting will begin the process of firming up the content.
- Current TM architecture includes features that address most of the concerns e.g. acquiring and publishing information items, model execution, versioning and timeline view support.

* The Telescope Model is the set of computational models and parameter data used within the signal processing chain to adjust the processing so as to produce the correct and required data products from received signals, including the parametric algorithms and calibration computations required to derive these information items. Taken together, these items characterise the behavior of the interferometer.

Prototyping



➤ Purpose:

- Evaluation of technology
- Risk reduction
- Clarifying architectural concepts or design evaluation
- Improving Requirements Capture
- Qualification or assessment of metrics
- Not meant to be reusable or evolutionary

TELMGT (Online system) Prototypes

1. M&C Engine Prototype
2. Test Environment
3. LMC Interface Simulator Framework - **can be extended into an evolutionary prototype to develop LMC Base Classes.**
4. Engineering Data Archive
5. (Database) Development Environ Prototype

ObsMgt (Offline system) Prototypes

1. Scripting Layer & ObsMgt-TelMgt Interface
2. Observation Planning and Scheduling
3. Proposal Handling Tool
4. Observation Management Data Archive
5. Authentication and Authorization (A&A)

LMC Prototypes

1. Software System Monitor Prototype
2. Lifecycle Control Prototype

LINFRA Prototypes

1. **Virtualization +service INFRA layer - to start hardware procurement - harmonization with SDP**

GUI Prototypes

1. **Graphical User Interface Prototype - In Progress**

Prototyping : Outcome, Current Status and Roadmap



- **Key outcomes and learnings :**
 - Design and requirement concepts refined (especially internal interfaces) and are being used to inform the architecture and have proven helpful in views development.
 - Study of alternative tools and recommendations for preferred choices emerged : e.g. Cassandra/HDB++ for archiving, Nagios for infra monitoring.
 - Use of TANGO for the proposed TM Architecture has been validated.
- Most of the prototypes have been **completed** to original plans, except LINFRA.
- **Outcomes** for completed prototypes documented, internally reviewed & **submitted** to the SKAO.
 - Prototyping Report (Rev 01) submitted in Oct 2016 followed by Rev 02 in Apr 2017
 - Feedback received recently, to be discussed within consortium
- **Future Plans**
 - LINFRA prototyping completion
 - GUI prototyping - evaluate various technology frameworks.
 - Further performance evaluation of the TelMgt EDA prototype based on bandwidth

User Interfaces : Definition & Progress



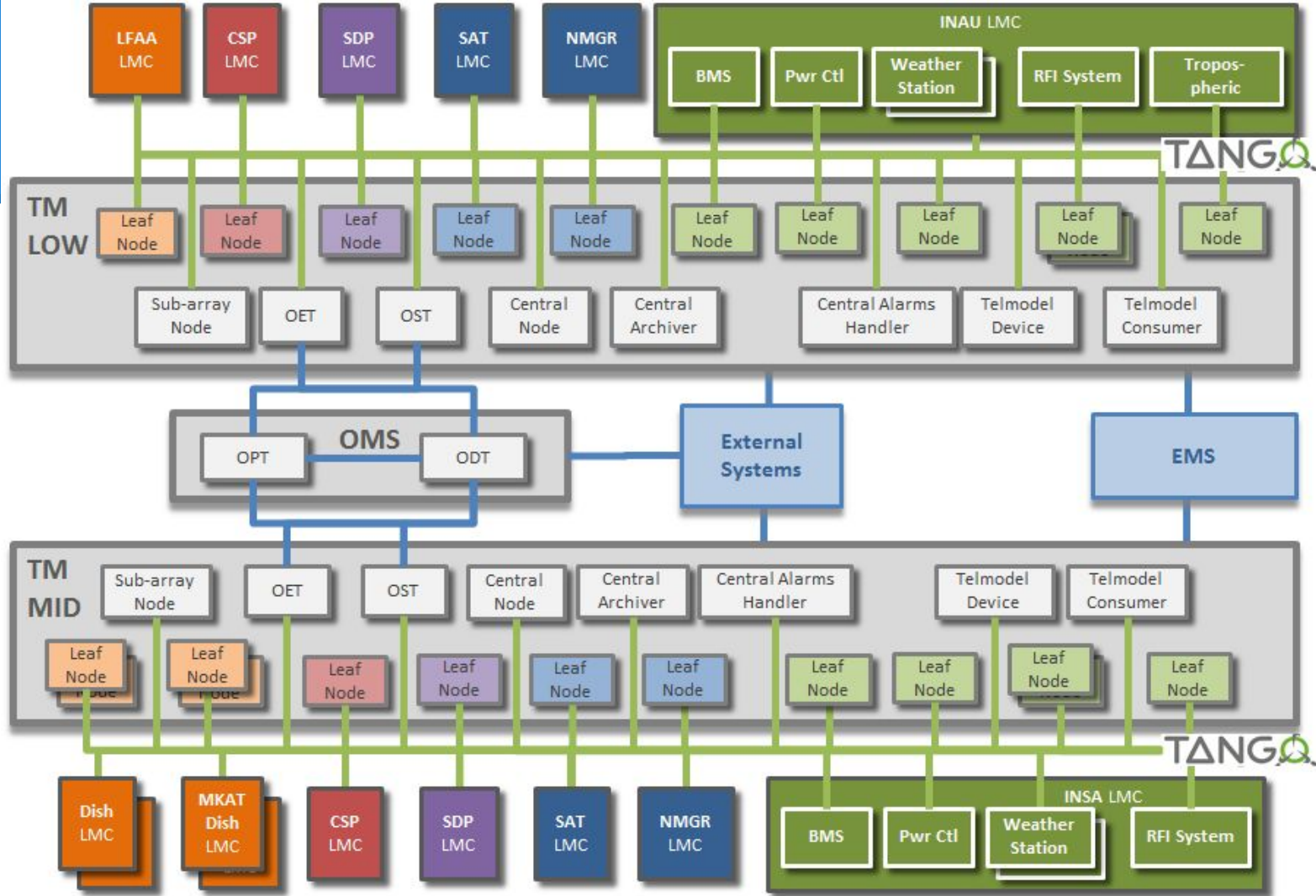
- **UI Core Team (UICT)** was chartered to provide strategic support and refinement plus harmonization of documents, methods, artifacts from the **user point of view**.
- Important **achievements** so far:
 - Analysis of **MeerKAT UIs**
 - Analysis of **User Roles of MeerKAT**
 - Analysis of **Medicina Radio Observatory (Italy)**
 - Explored usage **scenarios**
 - Extended **user-level use cases**
 - to cover control room activities
 - **alarm mgmt & quality assessment** of Obs
 - Defined **storyboards and sketches** of UIs
- **Deliverables for CDR**
 - **UI Design Principles** (customization suitable for the SKA of usability and visualization design principles - to be used as a guide for developers)
 - **User-level Use Cases** (highlighting what users of the control room UI need to be able to decide and to do)
 - covering alarm mgmt, assessment of impact of failures on Obs, monitoring of health status of telescope
 - **Interaction Scenarios and Storyboards** (concrete explorations of possible usages of the control room UI that are likely to raise usability/architectural issues - with sketches of possible UIs)
 - same areas as above
 - **Quality Attribute Scenarios**: focusing on usability and its impact on architecture
 - **Evaluation of potential technologies for UI**

Requirements Engineering and External Interfaces: Updates



- Updating requirements from SKA System Requirements Rev 10.
- Staged approach: architectural significant changes (internally reviewed), design impact changes (in progress), other low impact changes.
- Dependencies: Functional analysis including SKA_Common (as well as LOW & MID Telescopes) to inform boundary between TM LOW & MID and Observatory Management System (OMS), EMS.
- ICDs to be updated for June 2017:
 - SKA1-Mid TM to Dish ICD - done,
 - SKA1-Mid TM to INSA ICD - late,
 - SKA1-Low TM to INAU ICD - late
 - TM to SADT ICD – late,
 - OMS to TM MID & TM LOW – late.
- Further updates planned for all ICDs for CDR:
 - Complete interface implementation details,
 - Update per latest SKA Control System Guidelines.

External Interfaces



External Interfaces - Issues



- CSP - TM: MID Frequency slice architecture impacts interface.
- SDP - TM: Telescope state information interface: New requirement of TM providing historic data to SDP needs to be addressed.
- SKA1-Low TM - LFAA:
 - Some concepts (defined in the ICD) should be reflected in the main design.
 - Detail of beam control to be added to ICD.
- TM - SADT
 - At present not compliant to SKA Control System Guidelines.
- SKA1-Mid TM - INSA: At present partial compliance to SKA Control System Guidelines.
- SKA1-Low TM - INAU: Not compliant to SKA Control System Guidelines - needs to be resolved.

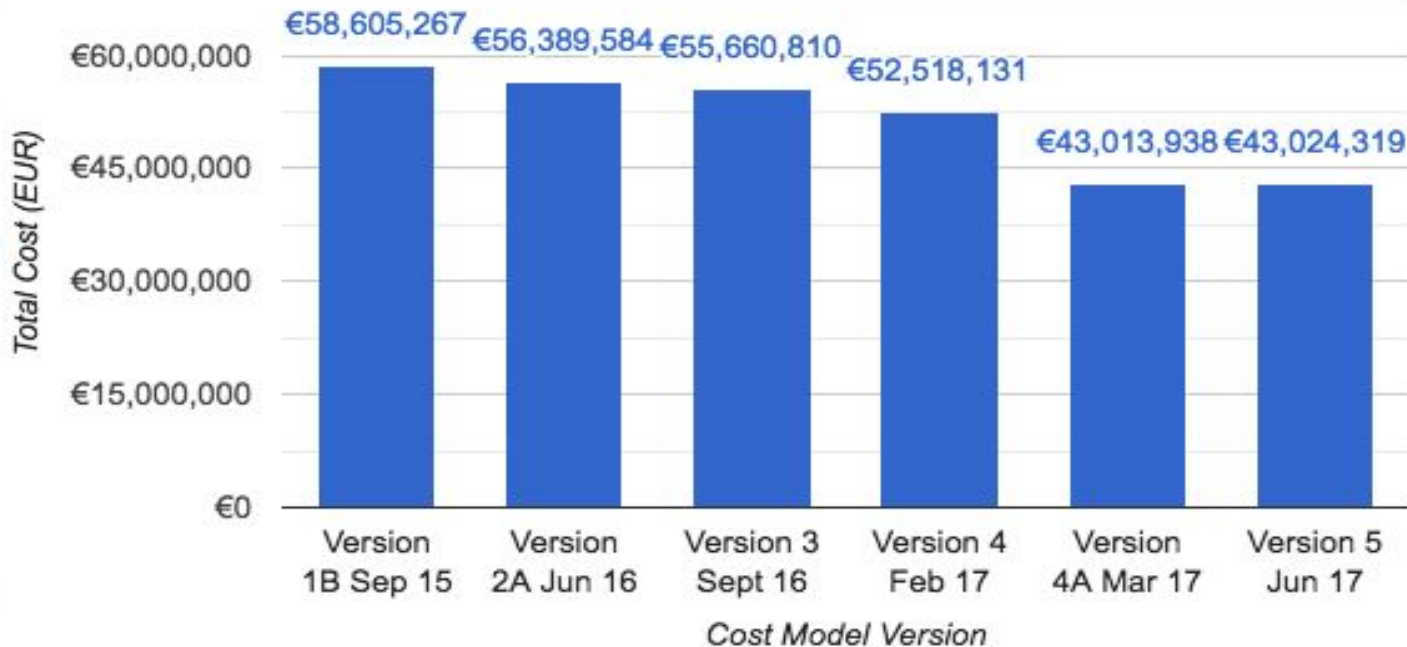
LMC Standardisation to Control System Guidelines - TM involvement



- As it is clear TM interacts with all elements via their LMCs. The need to have a standard interface for this was envisaged early in 2014 and TM took the lead towards this LMC Standardisation, building up a community of practice with all LMC teams, which led to development of
 - LMC Roles & Responsibilities (LSR): relative roles of TM and LMC's
 - LMC Interface Guidelines (LIG) Documents : guidelines for all TM-LMC interactions
- TM & SKAO held a joint workshop in March 2015 on LMC Standardisation and Frameworks Technology; followed by several other workshops by SKAO with individual consortia
- Major Version of LIG & LSR released early 2016
- Plans to develop a wider “standards” document for SKAO (ANT team set-up)
- This has evolved further into the SKA CS Guidelines document set (May 2017) :
 - SKA1 Control System Guidelines
 - SKA1 TANGO Naming Convention
 - SKA1 TANGO Developer Guidelines

Cost Model : Long-term evolution

Total Cost Revision Comparison (includes mgt reserves)



- Cost reduction from €55.6 M to €43 M
- Saving €12.6 i.e. ~23%

TM Cost Updates : What's New



- **Revision of cost estimates has been an important exercise**
- **New submissions in Feb-Mar 2017 and Jun 2017**
- **Major differences from previous submission (Sep 2016) :**
 - Labour rates and travel costs better harmonised -- reduced overheads (now agree better with SDP).
 - Travel, non-labour largely standardised throughout work packages.
 - Contingency reworked -- reduced significantly leading to cost reduction across most TM work packages.
 - WBS dictionary developed to provide transparency into deliverables, scope, cost etc.
 - WBS aligned with project-wide WBS, Management Reserves included explicitly.
 - Array release costs introduced explicitly.
- **Further plans for cost savings**
 - Explore possibilities of reuse of work done at precursors & pathfinders.
 - To look more carefully TM.LINFRA costs, including harmonisation with other efforts (SDP).
 - ObsMgt savings are being explored in consultation with the SKAO.

Future Plans & Milestones : Till CDR



ID	Milestone Title	Milestone Date	Deliverables
M30	Internal Review - Requirements Documentation Pack	June 2017	TM MID & LOW RS, Observatory Science Operations RS, A&A RS
M31	Internal Review - TM Services Documentation Pack	August 2017	TM Services RS, TM Services Software Architecture, TM Services ICD
M32	Internal Review - Telescope Monitor and Control Documentation Pack	September 2017	TMC Software Architecture, TelMgt-ObsMgt ICD, GUI Design Information Pack
M33	Internal Review - Observatory Science Operations and A&A Documentation Pack	October 2017	OSO Software Architecture, A&A DR, A&A ICD
M34	Internal Review - Management, Test and Compliance Documentation Pack	November 2017	Cost, Schedule, Construction, Maintenance, Dependability, Risk, Test Plans, Acceptance Procedures, Compliance Reports
M35	CDR Submission	January 2018	Submission according to SoW
M36	CDR Review	March 2018	Agreement in terms of set of actions to close for CDR
M37	CDR Closure	June 2018	CDR Baseline

Risks and Issues



- **Telescope Model (TelMod) definition not yet crystallised -- needs some more work**
- **Authentication and Authorization (A&A) -- full scope vis-a-vis SKA Observatory needs clarified**
- **GUI :** Missing some usability-related issues in architecture of TM + some liaison with other consortia
- **TM construction plan Vs AIV Roll-out schedule : still some unresolved issues**
- **Interface to SDP for planning:**
 - Work in progress but quite late.
- **Uncertainties remain for operational processes:**
 - Slowly being clarified.
 - Designing for modifiability.
- **Sub-array use – ensuring efficient use of resources:**
 - Discussions and ideas ongoing.
- **Some External Interface definition still lagging**
- **Significant delay in LINFRA prototyping activity**
- **Schedule under pressure**
 - Appears a bit challenging to complete the planned milestones in time.



Thank You