THE SKA DISH SPF AND LMC INTERACTION DESIGN: INTERFACES, SIMULATION, TESTING AND INTEGRATION

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INTRODUCTION

SKA Dish
The Square Kilometre Array (SKA) project is responsible for developing the SKA Observatory, the world's largest radiotelescope ever built: eventually two arrays of radio antennas - SKA1-Mid and SKA1-Low - will be installed in the South Africa's Karoo region and Western Australia's Murchison Shire, each covering a different range of radio frequencies. In particular SKA1-Mid array will comprise 133 15m diameter dish antennas observing in the 350 MHz-14 GHz range, each locally managed by a Local Monitoring and Control (LMC) system and remotely orchestrated by the SKA Telescope Manager (TM) system.

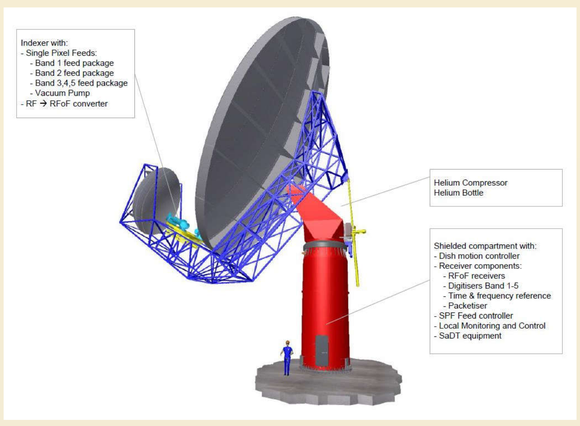

Figure 1 SKA Dish antenna overview

Dish sub-elements
Four sub-elements can be identified in the SKA-Mid1 dish element:
Dish Structure (DS): antenna structure and optics, feed indexer, servo systems, power distribution and safety systems
Single Pixel Feed (SPF): feed packages (OMTs, LNAs, helium cooling and vacuum system and relative controllers
Receiver (SPFRx): RF digitizer and relative controllers
Local Monitoring and Control (LMC): subsystem for each dish antenna that deals with the management, monitoring and control of the operation as orchestrated by the Telescope Manager (TM)

Single Pixel Feed (SPF) sub-element is primarily responsible for converting the electromagnetic (EM) signals focused by the reflectors to radio frequency (RF) signals that can be digitised.
A SPF controller, i.e. a single controller located in the pedestal, controls and monitors all three feed packages, helium and vacuum systems.
Dish Local Monitor and Control (LMC) consists of a commercial off the shelf controller that serves as a single point of entry for all control and monitoring messages to the outside. Besides configuring the static configurations of the Dish sub-elements, it also relays the real-time pointing control and applies local pointing corrections. For the monitoring, it aggregates and filters monitoring data as set up from the external (central) controller. The LMC allows for a drill-down capability for maintainers to access detailed diagnostic information of sub-elements on request.

Dish Interfaces
The functional monitoring and control interfaces between DS, SPFRx and SPF are described in the LMC-sub-element Interface Control Documents (ICDs) ([1], [2], [3] respectively),
The interfaces between LMC and other sub-elements, except for DS, are defined in terms of Tango commands and attributes exposed by each device server.

METHODS

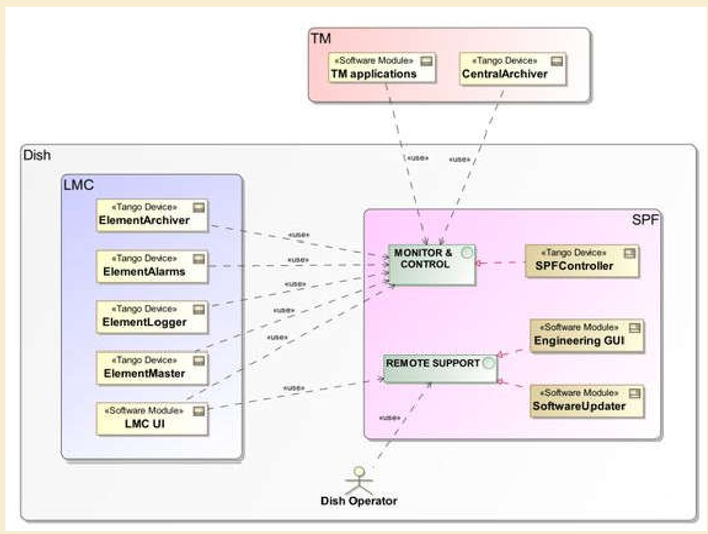

Figure 2 LMC-SPF interfaces, components and users

ICD document revision and update
During various iterations of software development cycle, the functional monitoring and control interface with SPF (Figure 2) as described in the ICD document [5] which has been revised, modified and integrated several times according to continuous requirements refining and to the adopted TANGO control framework specifications.

Early integration
Considering the impossibility to schedule the development of the sub-systems so that they are all finished at the same time, an early integration approach has been adopted in order to reduce inherent project risk by testing interface definition and common assumptions validity using **software device emulators**, as proposed in [5] for LMC integration and standalone qualification (Figure 3).
Early tests of the LMC-SPF interface were carried out in June 2017 during a face-to-face meeting between LMC and SPFC teams, using software emulators based on LMC/SPFC ICD.

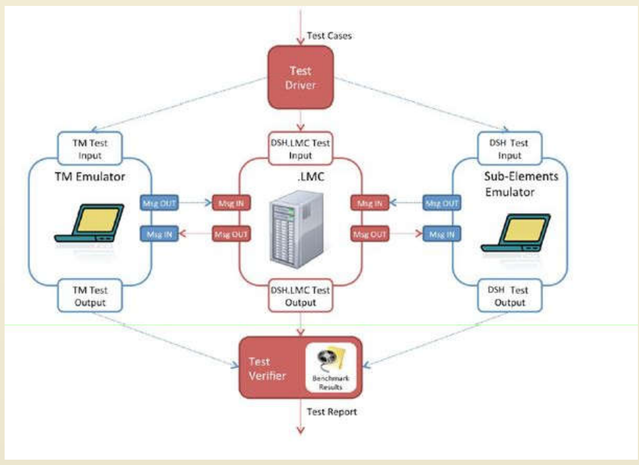

Figure 3 A possible DISH.LMC Test Infrastructure

A basic **prototype Engineering GUI** to monitor and control SPF parameters, organized according LMC-SPF ICD was built with Taurusform tool, after having been simulated via throw-away mock-ups implemented as an interactive PDF and used to get feedback from end users and stakeholders.

Tango systems located behind firewalls
Except for the database, Tango uses dynamic allocated port numbers for communicating between clients and servers. This means it is very difficult to know which ports to open in a firewall unless you can open all ports to and from certain hosts. Different solutions have been proposed to this such as the use of the REST API to communicate through the firewall (this is HTTP based and uses only one port), or a proxy which crosses firewall but the latter solution does not seem mature enough. If you use the REST API you cannot use the other APIs (Python, C++ and Java) through the firewall.
Several tests have been carried out in order to try and interface remote Tango systems by setting different firewall ports configurations, both via SSH port forwarding and VPN between Tango VMs located in Trieste (Italy), Catania (Italy) and Stellenbosch (South Africa).

RESULTS

The performed **early-integration** activities have greatly contributed to dish **LMC-SPF interface testing, revision and update**.
They are to be considered as an important effort in sub-elements interface definition and verification towards Dish integration as defined in [5] and [7].
The same approach will be soon adopted with the other two Dish sub-elements: DS and SPFRx.
Connection tests have been carried out between remote Tango systems located behind firewalls by setting different **firewall port configurations**, and by using **SSH port forwarding** or **VPN**.
SSH port forwarding proved to be awkward and limited (we noticed ZMQ issues), while VPN seemed to solve the problem, apart from some additional latency issues.
Prototype GUIs to monitor and control SPF parameters, organized according LMC-SPF ICD were built testing and evaluating different Taurus UI tools. Some possible issue as regards **role-based access control** to privileged attributed has been noticed.

CONCLUSIONS

The SKA project has recently entered Critical Design Review stage of pre-construction in which final software design and qualification are expected in mid 2018 before proceeding to construction phase.
Considerable efforts have been dedicated to LMC software and dish interfaces update also to ensure a high-degree of compliancy with the still-evolving SKA standards and with the SKA adopted Tango controls framework.
Software implementation is in advanced status for some components of Dish sub-elements while others are awaiting for progresses in design and interface consolidation. In order to overcome different components maturity, for interface definition and testing purposes device emulators have to be developed and used for interfaces and sub-elements testing and integration. The same approach will soon be adopted with the other two Dish sub-elements: DS and SPFRx and possibly with TM element.

REFERENCES

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