



# Software Strumentale: Alte Energie, SKA e precursori:

## **OACT**

Alessandro Costa



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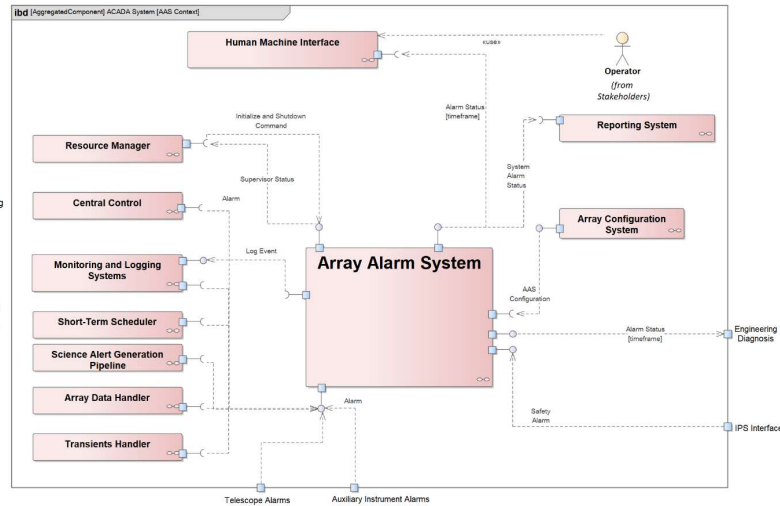
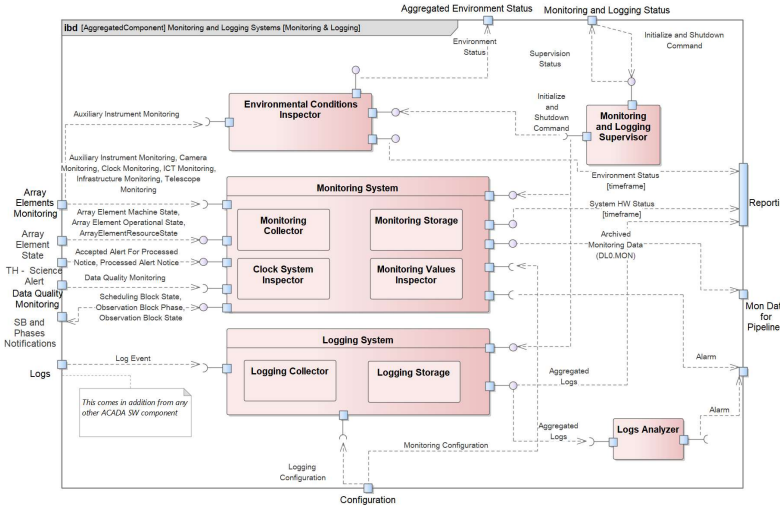
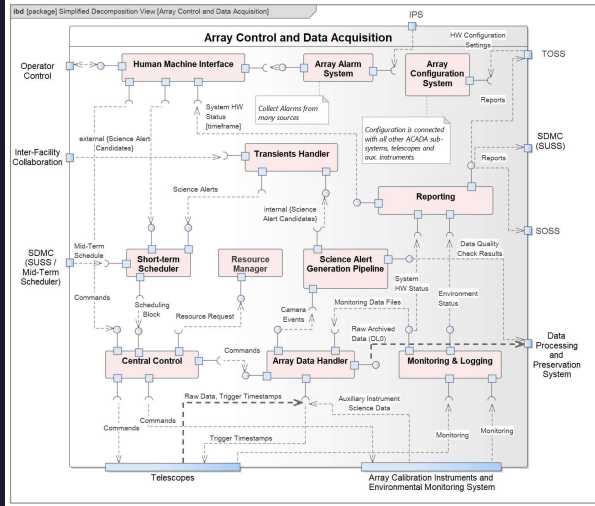
LOFAR TMSS

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CONCLUSIONS

# CTAO

## Array Control and Data Acquisition (ACADA)



# Array Control and Data Acquisition (ACADA)

INAF OACT Activities: Design and implementation of the

- ✓ Monitoring
- ✓ Logging
- ✓ Alarm Systems

## Technological collaborations established

- Université de Genève
- Desy
- CTAO
- Institute of Space Sciences (ICE), CSIC





# CTAO Monitoring Logging Alarm



## MON

## ALARM

MON (Monitoring and Logging) is the subsystem responsible for monitoring the overall Array System (at either CTA-N or CTA-S) through the acquisition of monitoring and logging points from Array Elements and ACADA subsystems

It is responsible for:  
gathering, filtering exposing and persisting alarms in ACADA.

✓ Internet of Things Technologies

✓ **Big Data**

✓ Data characterized by large Volume , Velocity , Value

✓ Modern SW Design Pattern application

✓ DevOPs and QA : supported by best practices and modern tools

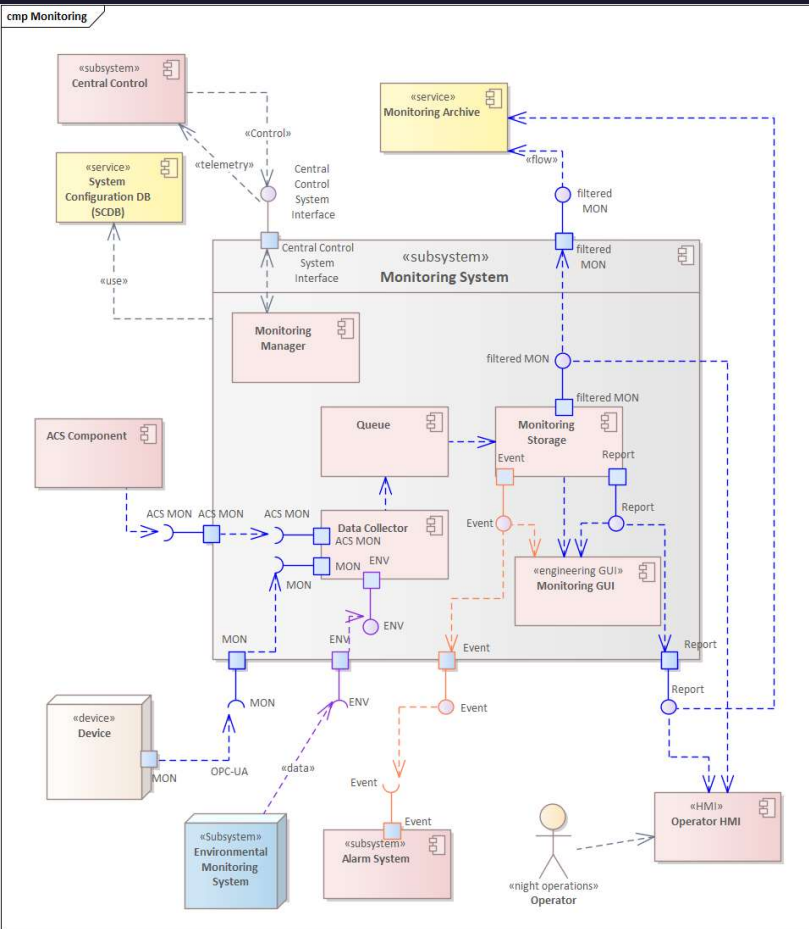




# ASTRI Mini-Array



# ASTRI Mini-Array MLA



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## ✓ Data Collector

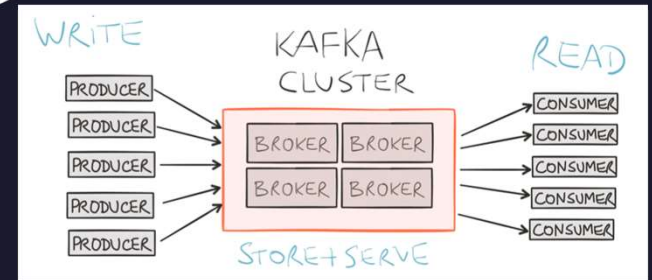
- ✓ OPC-UA , SNMP
- ✓ ACS



- ✓ Internet of Things Technologies
- ✓ Modern SW Design Pattern application
- ✓ DevOps and QA : supported by best practices and modern tools

## ✓ Data Streaming

- ✓ Kafka streams Message Broker Engine
- ✓ "Fast Data"



## ✓ Storage

- ✓ Fast Data Writing and Query optimization through: Data Modeling and Best Practices

- Open Source**
- Peer-to-Peer Architecture**
- No Single point of Failure**
- Highly Available and Fault Tolerant**
- Flexible and distributed,**
- Tunable Consistency**



# SKA LMC



Indexer  
SPF Band  
Feeds  
Vacuum  
pump



Helium compr.

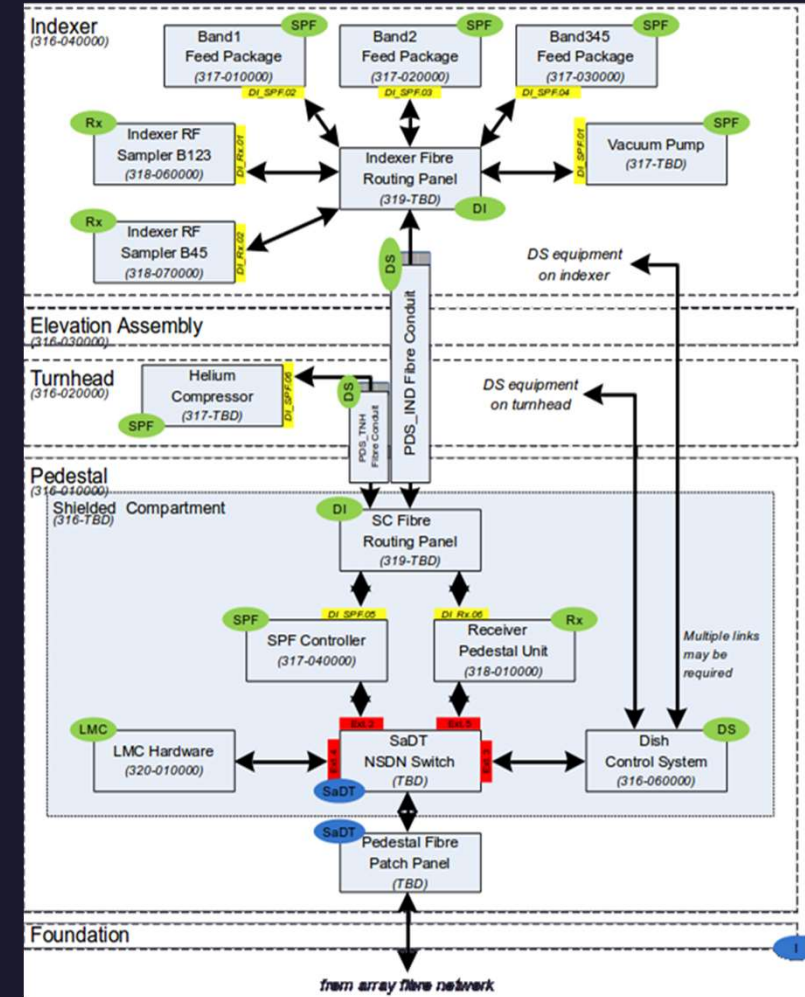
Shielded compartment  
Dish motion systems,  
Receiver components (digitizers,  
time/freq ref, software controller)  
SPF software controller  
LMC software  
SaDT equipment

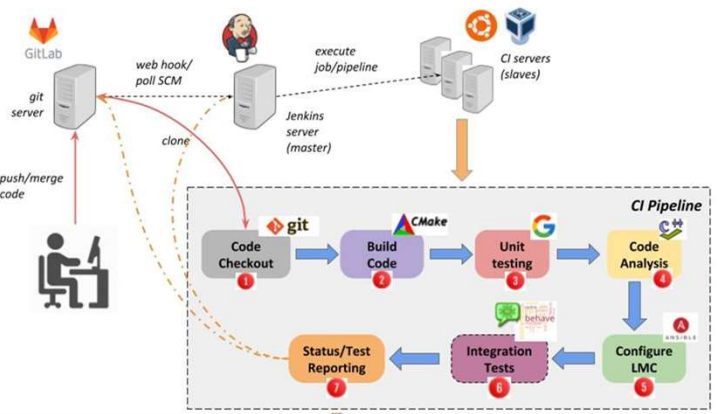
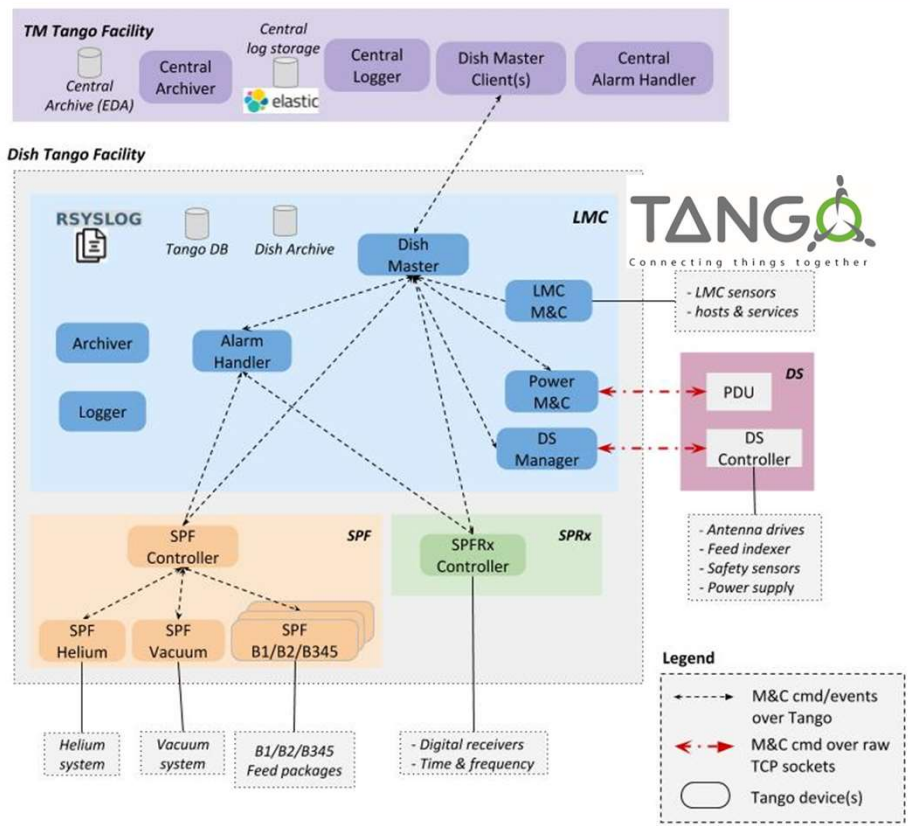
■ **LMC TEAM (C.TRIGILIO, S.RIGGI, A.INGALLINERA, F.SCHILLIRÒ)**

- ✓ Joined SKA Dish Consortium pre-construction in 2013
- ✓ LMC CDR completed in 2018
- ✓ Post-CDR activities (integration tests on MPI dish for Dish CDR)
- ✓ Joined MeerKAT+ project in 2021

■ **MAIN RESPONSIBILITIES**

- ✓ DESIGN AND DEVELOPMENT OF LOCAL MONITORING AND CONTROL (LMC) SOFTWARE (M&C, LOGGING, ALARM) FOR SKA DISHES
- ✓ STANDARDIZATION OF M&C ARCHITECTURE PATTERNS & SOFTWARE FRAMEWORK WITHIN SKA



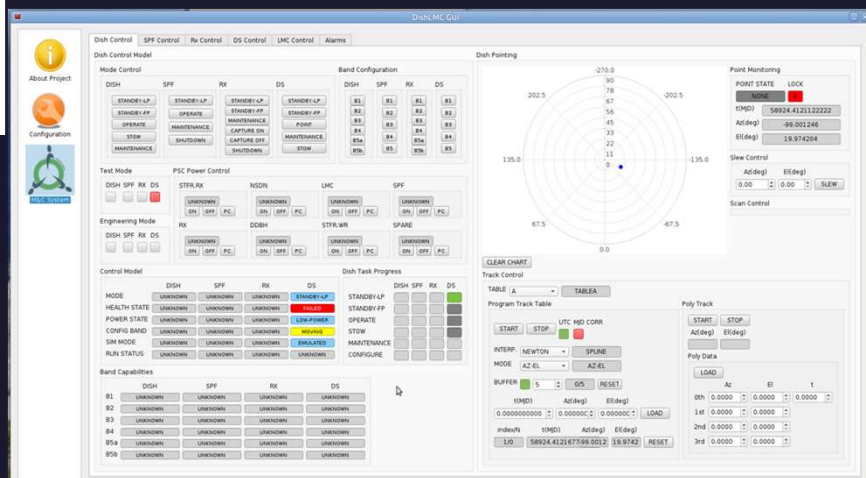


## MAIN EXPERTISES GAINED/STRENGTHENED

- COLLABORATIVE WORK IN LARGE INTERNATIONAL TEAMS
- M&C DESIGN, SYSTEM ENGINEERING, SYSML
- TANGO CONTROL FRAMEWORK, M&C LIBRARIES & TOOLS (E.G. NAGIOS, RSYSLOG)
- UI DEVELOPMENT (QT)
- SOFTWARE DEVEL/CONFIG PRACTISES (E.G. CI) AND TOOLS (E.G. GIT, JENKINS, ANSIBLE), CONTAINER & VIRTUALIZATION TOOLS (E.G. DOCKER, SINGULARITY)

## SCIENTIFIC/INDUSTRIAL COLLABORATIONS ESTABLISHED

- INAF TRIESTE, TERAMO, ARCETRI
- SOCIETÀ AEROSPAZIALE MEDITERRANEA (SAM), EIE GROUP
- SKAO, SARAO



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# LOFAR TMISS



# LOFAR TMSS

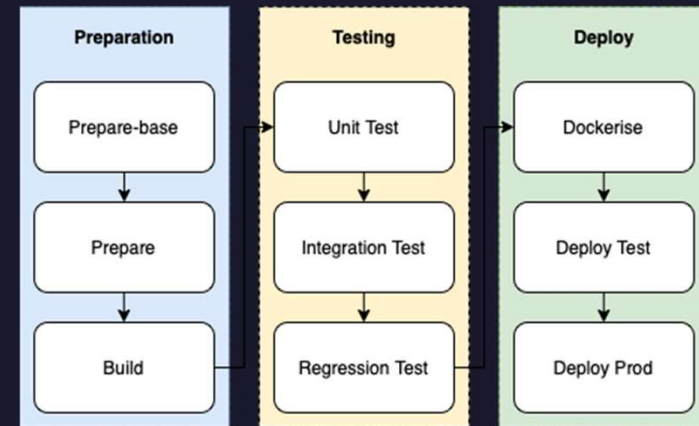


## TMSS (Telescope Manager Specification System)

supplies **one interface** and an **integrated process** for:

- ✓ Specification
- ✓ Scheduling
- ✓ Reporting

with data flow enhancements, that improve the **efficiency** and **automation** of LOFAR operations.



- Modern Open Source Web Technologies
- DevOps & QA: supported by best practices and modern tools
  - Unit tests, Integration Tests, Regression Tests With GitLAB CI Pipelines
  - Test Coverage measurements (QA) and Refactoring are improving the Code Quality and robustness.
- Scrum AGILE development process, Issue tracking : Jira, Project Management : Confluent



# PREDICTIVE MAINTENANCE



# Predictive Maintenance for Array of Cherenkov Telescopes

## Technological collaborations established

- UNICT Department of Electrical Electronic and Computer Engineering (DIEEI)

Funded by INAF DS & UNICT



The predictive maintenance system allows to minimize the array downtime, to increase the telescopes sub-components longevity and to reduce the costs due to unforeseen maintenance.

- Fault Tree Analysis (FTA)



- Digital Twins



- Unsupervised Learning for anomaly detection



- Google Colab



- Industry 4.0

## Digital Twins Definition Language

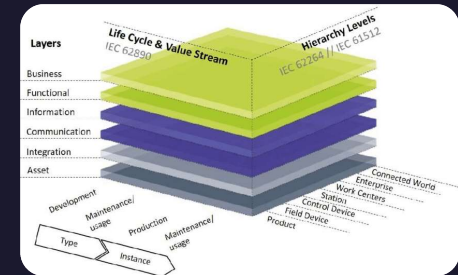
The Digital Twins Definition Language (DTDL) is a language for describing digital twins. It is developed by Microsoft.

- DTDL

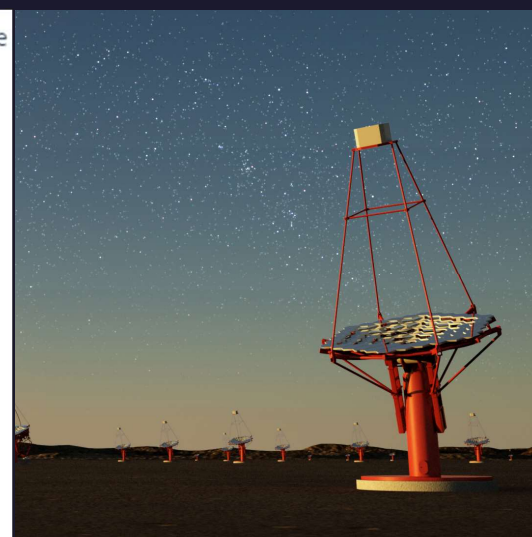
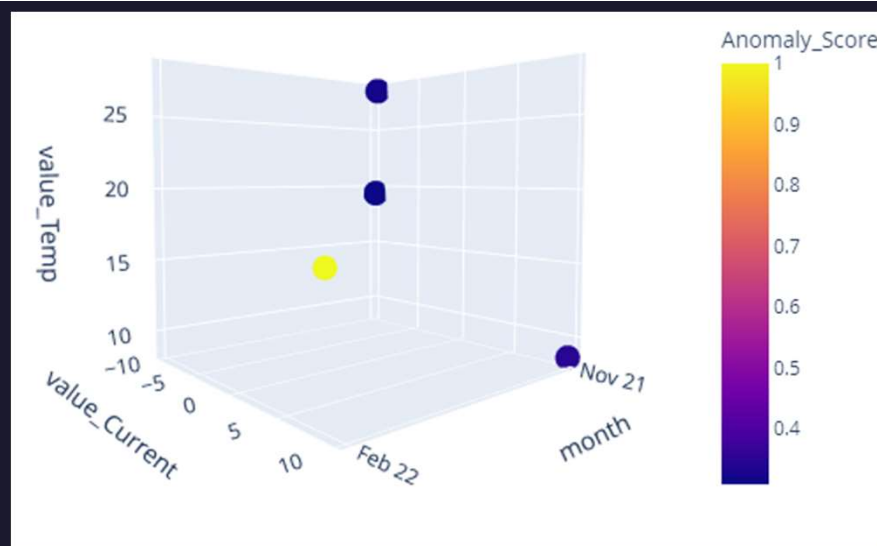
- Azure Digital Twins

- Azure Machine Learning Studio

- NodeOPCUA



As an example of the failure event that occurred on February 2022. (The telescope brake failed). Our model would have signaled this at November 2021, based on the engine temperature, torque, current and status information. This would have prevented the telescope engine from breaking and would have reduced the telescope's down time.



# PdM System

For implementing the PdM System unsupervised learning models are chosen because the data in our possession do not present information related to the failures of our telescope.

The algorithms used are:

- CBLO
- PCA
- Knn
- IForest



# Conclusions

A Team with Knowledge and Experience on :

Interface Design and Definition

Design Patterns

Agile Programming

DevOps approach 'Development and Operations' (Testing and Implementations)

Supported by sw tools and Best Practices GitLab, Maven, Gradle  
Jenkins Sonar Qube, Docker, Singularity

**M&C frameworks: ACS, TANGO in the Most Innovative Telescope Arrays**

Industry 4.0 Digital Twins & Unsupervised Learning for anomaly detection

BIG DATA & Internet of Things



# Team



Alessandro Costa



Pietro Bruno



Salvatore Gambadoro



Stefano Germani



Alessandro Grillo



Federico Incardona



Adriano Ingallinera



Kevin Munari



Mario Raciti



Simone Riggi



Francesco Schilliró



Corrado Trigilio



Fabio Vitello

Software  
Strumentale:  
Alte Energie,  
SKA e precursori:

**OACT**



Thank You

Alessandro Costa

