# ELT Control System and Taurus Scheme Plugins

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# Background

# Extremely Large Telescope

The Extremely Large Telescope (ELT) is a 39 meters optical telescope under construction in the Chilean Atacama desert.

The control software is under advanced development and the system is slowly taking shape for first light in 2030.

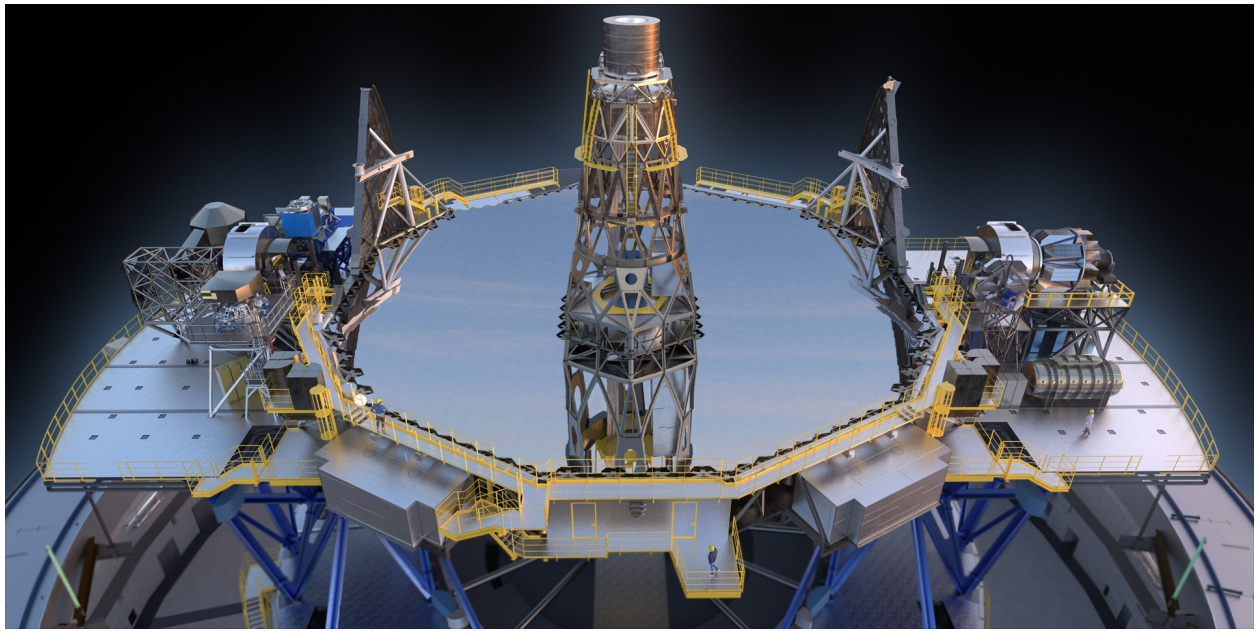
ESO is directly responsible for coordination functions and control strategies requiring astronomical domain knowledge.

Industrial contractors are instead developing the low-level control of individual subsystems.

Current progress: Dome cladding in progress, doors to be installed. Main Structure well under progress, manual azimuth tested. Spider for M2 seen on top.

# Extremely Large Telescope

- M1 mirror: primary reflector, 798 hexagonal segments, each with 3 actuators, 6 edge sensors, 9 warping harness. 1 Hz order of corrections. Deformations.
- M4 mirror: 2.4 m, 5000 actuators, 1 kHz. Adaptive Optics atmospheric corrections.
- M5 mirror: Elliptical mirror, 2.7 by 2.2 m 10 Hz: Wind vibrations on telescope.
- The telescope performs a cascade control loop where each mirror is able to perform a bandwidth of corrections.
- Two instruments platforms, each with capacity for 3 instruments.



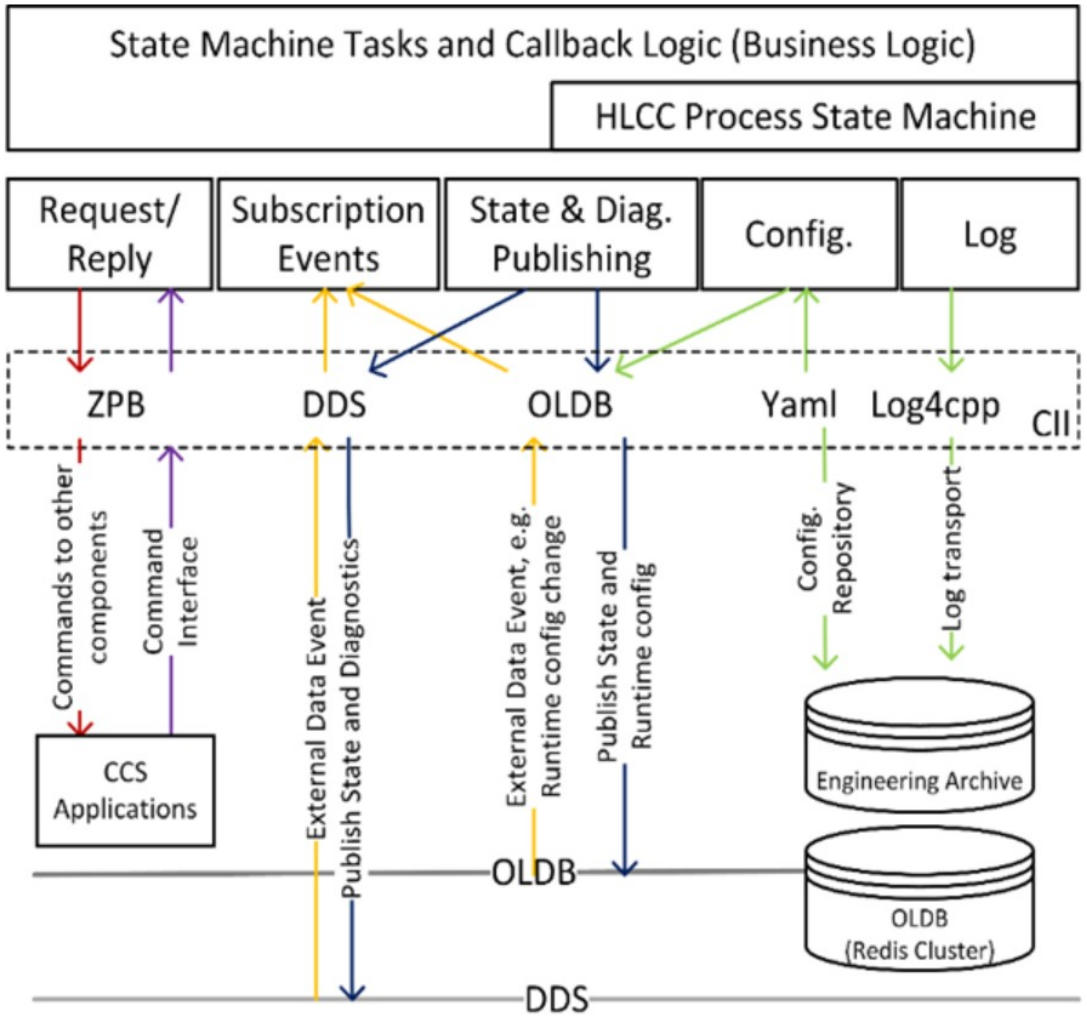
CG render. Main structure (blue structure), instruments platforms on the sides. Central tower holds M3, M4 and M5. M2 is not visible.

# Control System Middleware

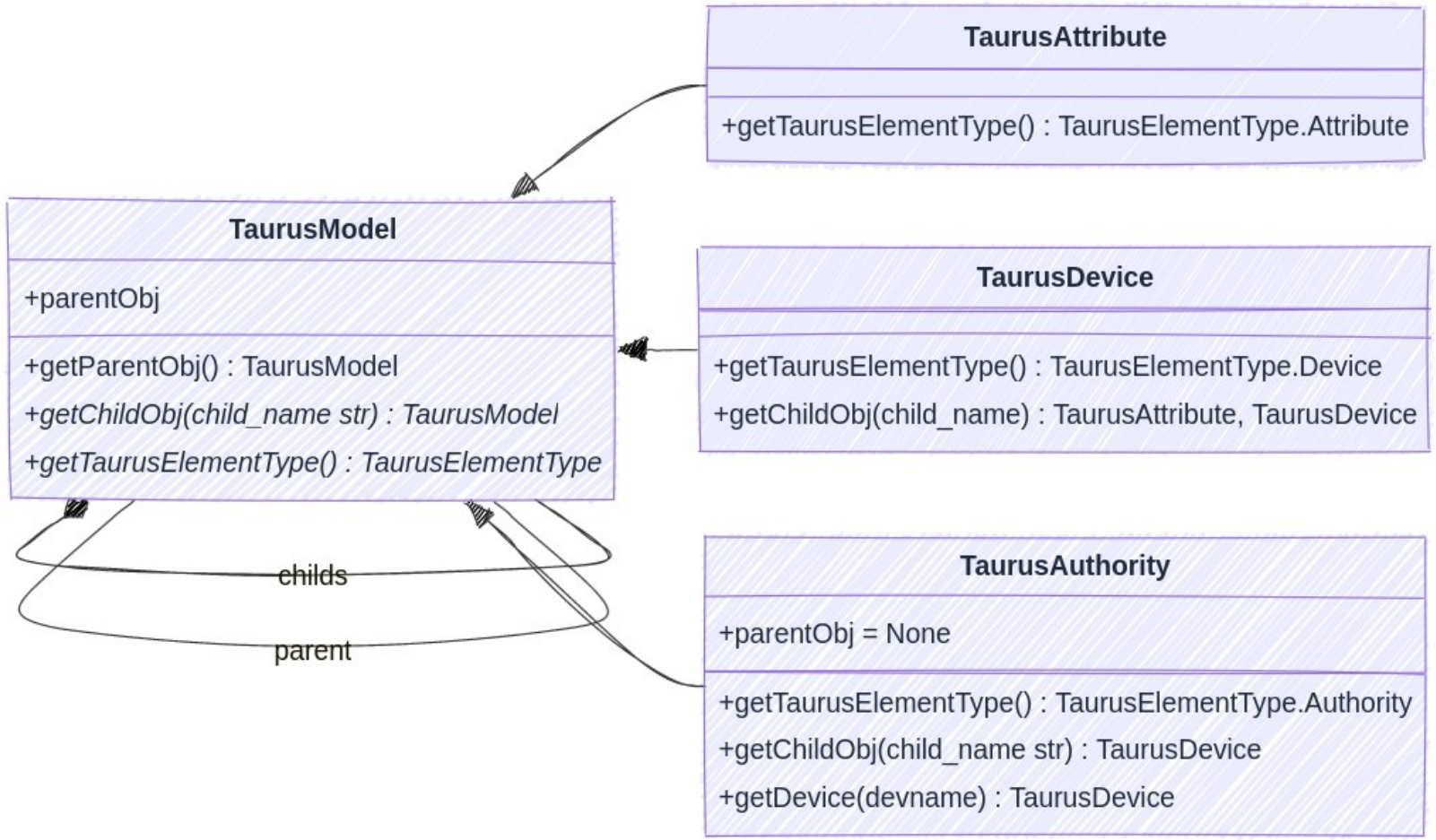
Each subsystem has functions that control and configure a low-level control system; and estimators, which translate raw values into the state data in the astronomy domain.

The functions and estimators communicate via three middlewares: zpb, dds, and a database.

- ZeroMQ + ProtocolBuffers for Commands.
- DDS for fast data publishing.
- OLDB for visibility, events and state publishing.



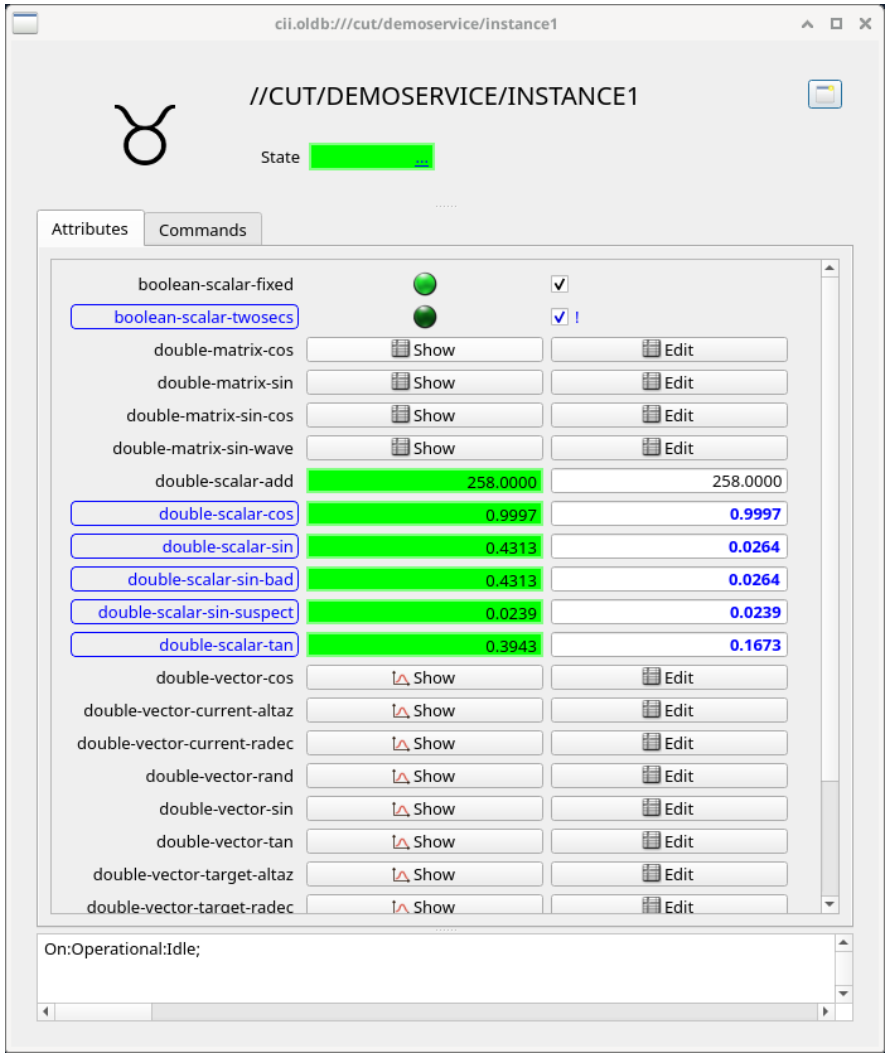
# Taurus Scheme Model


TaurusAttribute
+getTaurusElementType() : TaurusElementType.Attribute
TaurusModel
+parentObj
+getParentObj() : TaurusModel
+getChildObj(child_name str) : TaurusModel
+getTaurusElementType() : TaurusElementType
TaurusDevice
+getTaurusElementType() : TaurusElementType.Device
+getChildObj(child_name) : TaurusAttribute, TaurusDevice
childs
parent
TaurusAuthority
+parentObj = None
+getTaurusElementType() : TaurusElementType.Authority
+getChildObj(child_name str) : TaurusDevice
+getDevice(devname) : TaurusDevice

# OLDB Scheme Plugin

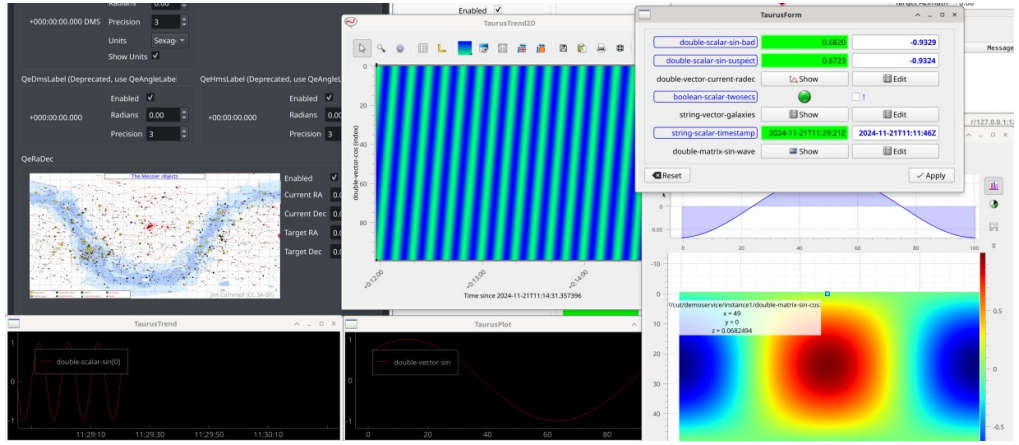
# OLDB Scheme Plugin

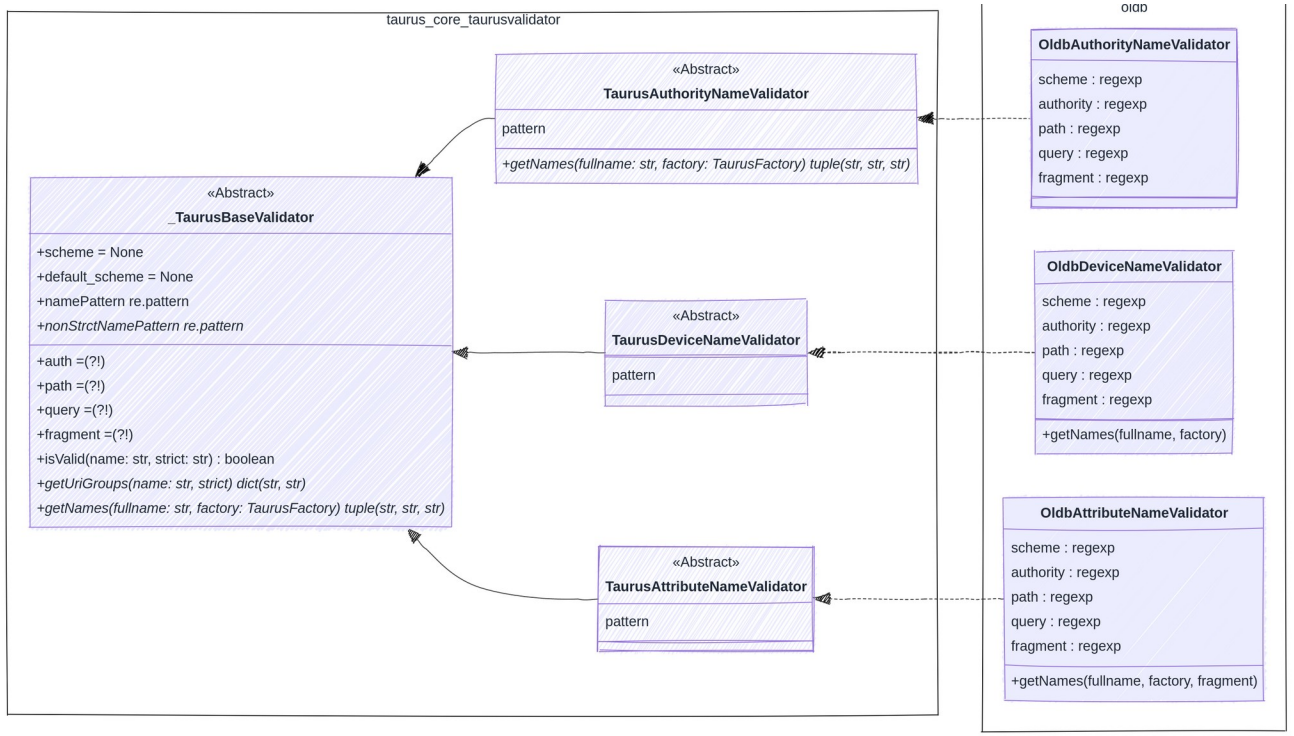
- OLDB is a Redis-based solution for system data. Its purpose is observability. GUIs data access and monitoring use the OLDB. It offloads clients from estimators into a scalable solution.
- First scheme plug-in to be developed, most mature. Contacted community and received guidance on how to proceed.
- Initial support for read/poll operation as prototype (2020). Finished prototype with subscription implemented.



# OLDB Scheme Plugin

- Supports:
  - Attributes (bool, int[8,16,32,64], uint[8,16,32,64], float, double, strings, vectors, matrices)
  - Read, write, poll, subscription, reconnection.
- Pending integration:
  - Device, missing attribute

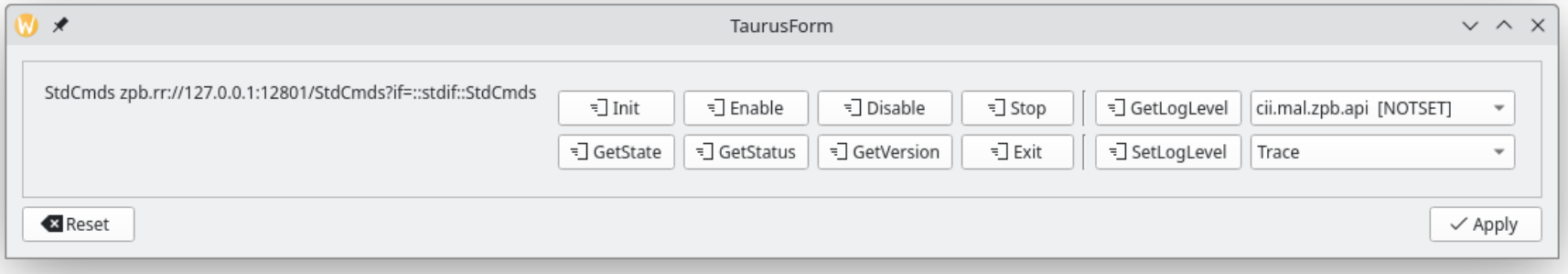




# MAL Request Reply Plugin

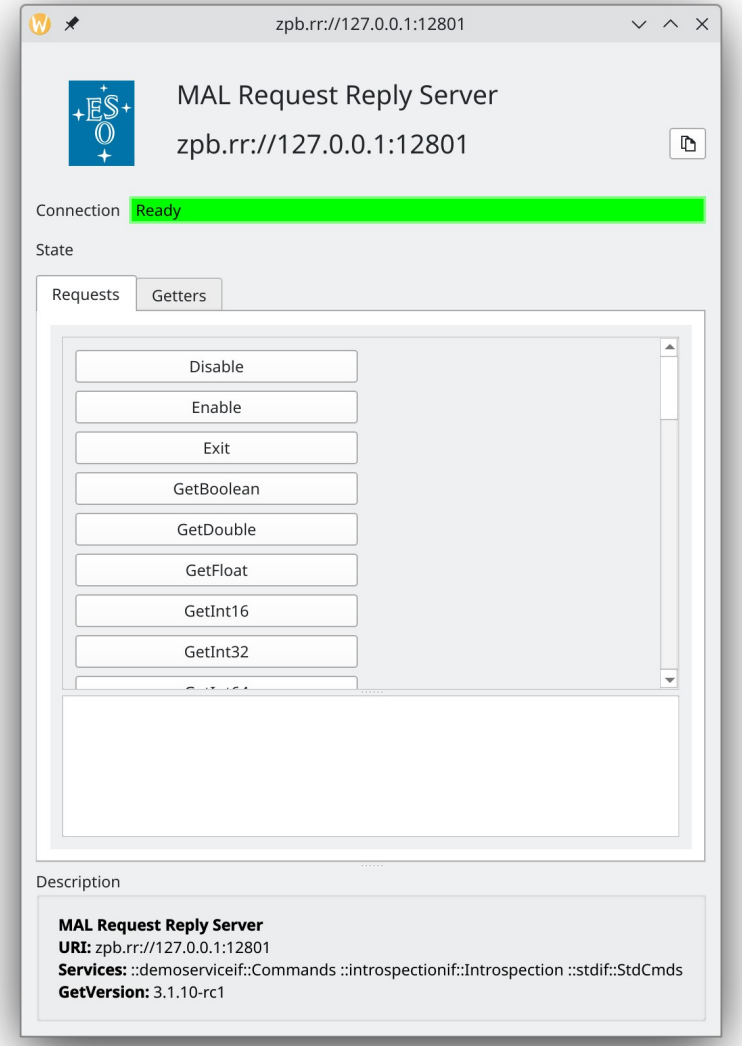
# MAL Request Reply Plugin

- Middleware Abstraction Layer (MAL) provides a Request Reply (RR) RPC solution: an interface definition language and a ZeroMQ+ProtocolBuffers middleware implementation.
- Previous to creating the plugin, a small library to eliminate boilerplate code on handling MAL RR within a GUI.
- 2023 started development of MAL Request Reply Plugin. Architecture of ELT CS needed modification. Introspection was added.



# MAL Request Reply Plugin

- Several classes of Taurus that uses Commands are Tango dependent.
- Adapt or replace. Chose to adapt (duck-typing) to learn. Currently we are creating alternatives for the affected widgets/panels.
  - New TaurusDevicePanel (another plugin)
  - New TaurusAsyncCommandButton



# MAL Request Reply Plugin

- Supports:
  - Device
  - Request execution (command_inout)
  - Request query (command_query)
  - List of Request (command_list)
  - state, status.
- Pending: Attributes (for Getters without arguments)

# MAL Publisher Subscription Plugin

# MAL Publisher Subscription Plugin

The capability of MAL for structure definitions in its interface definition language is reused in its PubSub solution. Structures are the definitions of topics published.

MAL initially supported RTI DDS. but it switched to fastdds approx. 3 years ago.

Implements only the Subscription of the Pub/Sub pattern.

Since DDS is intended for fast data transmission, throttling incomming data is a confiurable, via a default or particular to the Attribute.

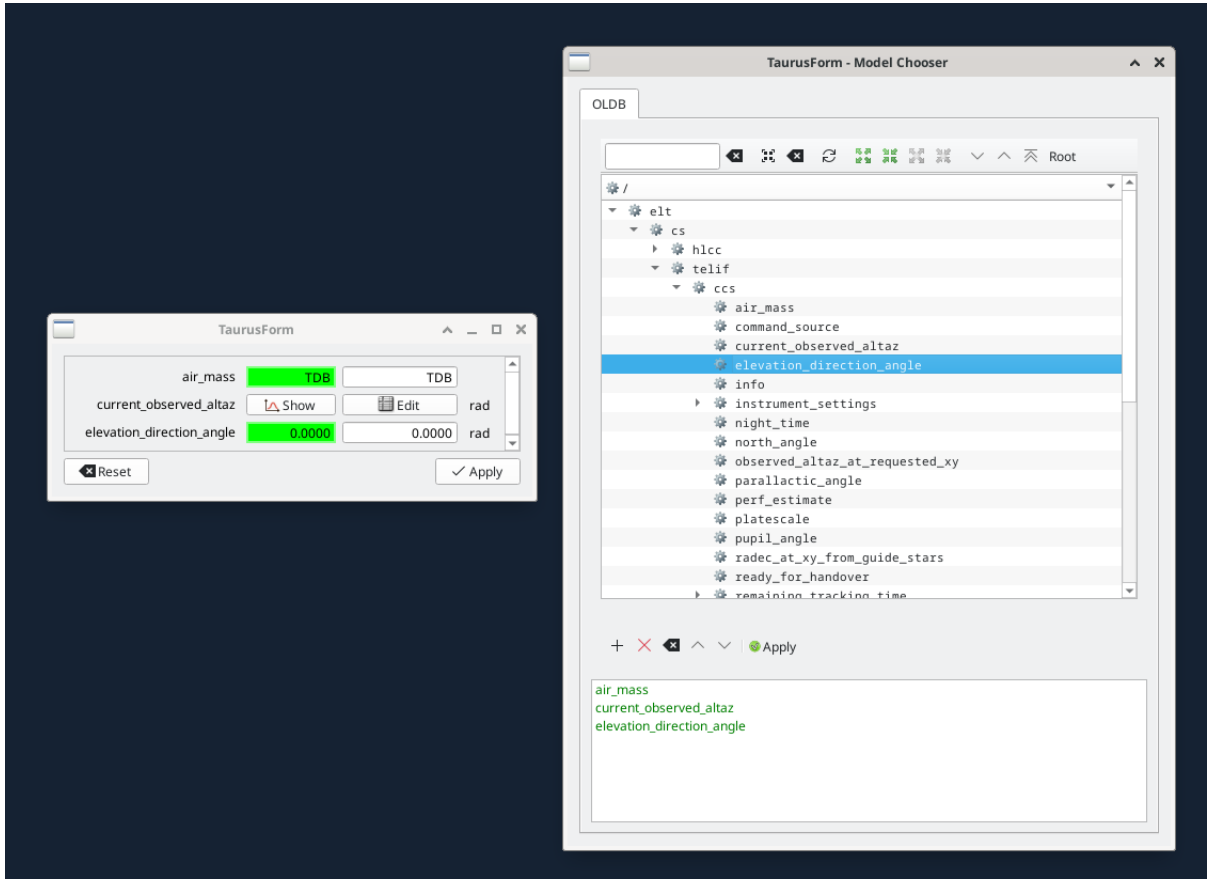
The plugin is still under development, but it has been release for testing and feedback.

Supports: Attributes: bool, string, timestamp, int[8,16,32,64], uint[8,16,32,64], float, double. Arrays of the previous datatypes.

# Lessons Learned

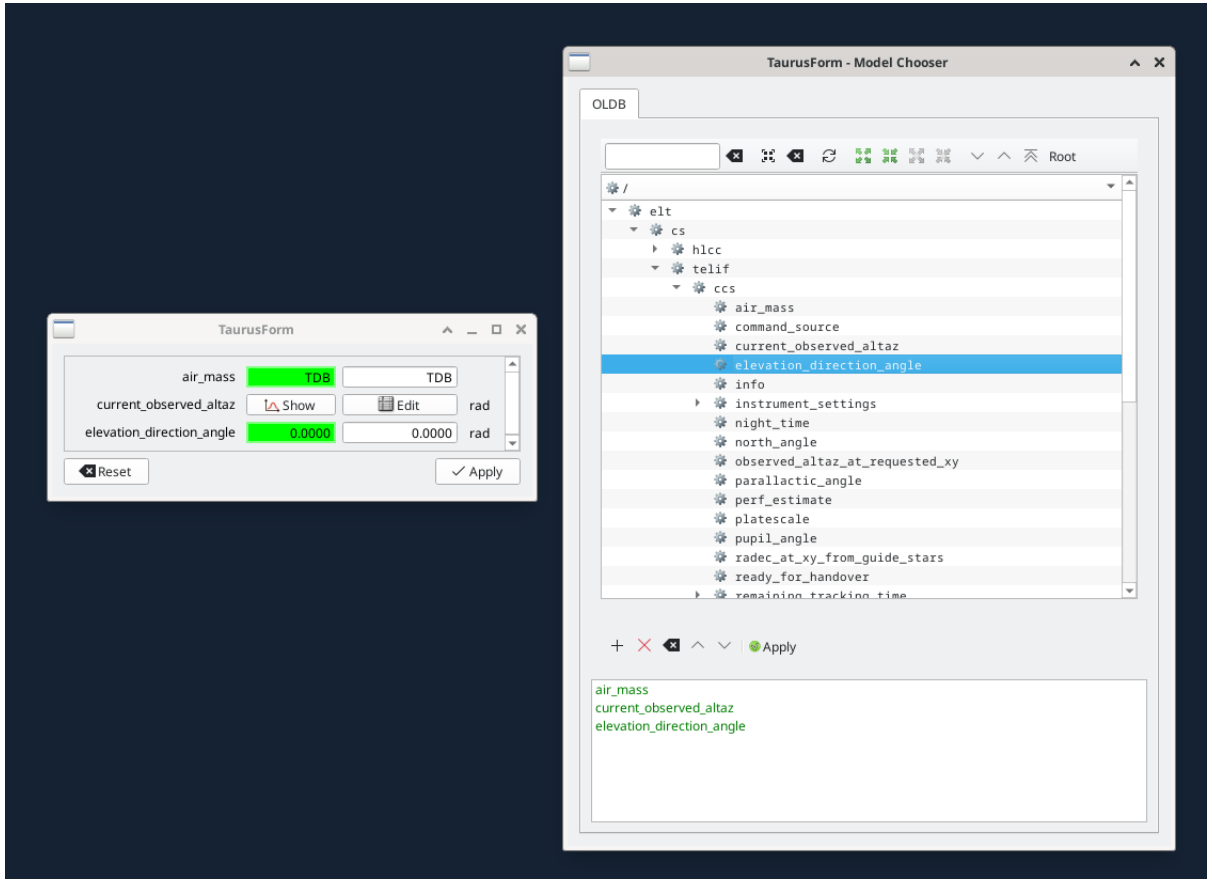
# Lessons Learned

- A model that supports Attributes can be implemented in an incremental manner:
  - URI Validators is the first and most important step.
  - Continue with read method. There is a simple example in the h5file scheme.
  - Datatype support can be added in stages (basic data types, vectors, matrices).
- Model Chooser makes any Scheme Plugin visible and more accessible. Give priority to its development as well.



# Lessons Learned

- Fragment overuse add too much complexity to URI parsing.
- Separate model fragment/query from model view.
- Plugins make use of python wheel entry points. Make sure you are using pip install or ensure your build system does.
- Remember: scheme plugins maps datatypes from control system to python/taurus on read(), and python/taurus to control system on write().



# See also


- Hoffstadt, A. et al., “Taurus Integration to ELT Control Software”, these proc. SPIE 13101-142 (2024)
- Chiozzi, G. et al., “The ELT high level coordination and control”, Proc. SPIE 12189-48 (2022)
- Tamai, R. et al., "ESO’s ELT halfway through construction ", these proc. SPIE 13094-43 (2024)

# Thank you!

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