Data model as agile basis for evolving calibration software

Gijs Verdoes Kleijn for Hugo Buddelmeijer
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WP lead Imaging Pipelines, MICADO Data Flow Team
OmegaCEN family business

- Astro-IT expertise center
- WISE information systems
- Data center (Petabyte scale, with CIT)

| Instrument   | 1st light | System     | 1st light |
|--------------|-----------|------------|-----------|
| OCAM@VST     | 2011      | AstroWISE  | 2006      |
| MUSE@VLT     | 2014      | MuseWISE   | 2013      |
| Euclid       | 2022      | EuclidDPS  | 2018      |
| MICADO       | 2025      | MicadoWISE | 2022      |
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Calibration scientist: gaining insight by trend analysis over years of observations
Glue for evolving system [instrument hardware, calibration software]

| Basic reqs: | FIXED FOREVER (MICADO: 50uas, 20mmag) |
|-------------|---------------------------------------|
| Phase:      | design & implementation                |
|             | operations                             |
| instrument hardware: | evolving detailed specs           |
|             | degradation, unpredicted behavior      |
| instrument calib plan: | evolving calibration reqs          |
|             | update                                |
| calibration software: | adapt recipes and pipeline            |
|             | commissioning -> major update         |
|             | early operations -> adapt all         |
|             | routine -> refine all based on insight from years-of-data |
### Evolving system [instrument hardware, calibration software]

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**Diagram:**
- OCAM@VST with AstroWISE, early operations 2011-2012
Evolving system [instrument hardware, calibration software]

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OCAM@VST with AstroWISE, early operations 2011-2012

“Calibrate instrument, not data”
Solution: link it all in a data model centric digital framework

Data Model in machine readable framework

- Calibration reqs
  - Calibration Plan
  - data items
  - software recipe specs

Calibration reqs (accuracy & precision data item,...)
Calibration Plan (procedure, duration, prerequisites,...)
data items (data classes & dependencies,...)
software recipe specs (algorithm, procedure, validation,...)

Calib Framework -> Instrument -> System
- 2005 ODOCO: Tex+Python -> OCAM@VST -> AstroWISE
- 2010 NoName: xml+Python -> MUSE@VLT -> MuseWISE
- 2017 Calib Framework: Sphinx -> Euclid -> EuclidDPS
- 2020 CalibCADO Framework -> MICADO -> MicadoWISE

Instrument team readable!
Extremely Large Telescope & MICADO Near-IR imager+spectrograph

1.5B€, 100s people

75m

MICADO

27 Sep 19
Extremely Large Telescope & MICADO Near-IR imager + spectrograph

Actively controlled telescope + PSF:
- 40 meter: 1000 alignable segments
- Adaptive optics ($\geq$2 deformable mirrors)

Gravity-invariant instrument:
- 3 imaging modes, 1 spectro (slit)
- 5 wheels (incl. 30 filters)
- Atmospheric Dispersion Corrector (moving glass)
- 9 H4RG detectors (1.5 and 4 mas pixels)

Data flow rate / 24hrs:
- $\leq 1E4$ raw exposures
- $\leq 6.7$ Tbyte
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"First ever" versus "minimal calibration time"

Calibrate instrument with maximum use science data
CalibCADO Framework: implementation

Details in “Using VODML with MICADO”, Buddelmeijer, Sat Oct 12, IVOA DM WG at DOT
New in CalibCADO: integrated specification of data simulator & pipeline prototype

VODSL: Data model
VODML: Data model
PYTHON: pipeline prototyping
SQL: archiving

FITS: imaging data
YAML: instrument model for data simulator
RST: consortium documentation
PDF: ESO documentation

Instrument team readable!

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Conclusions

Data-model-centric **Calibration Plan** is agile glue for consistent evolution of instrument & calibration software.
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Data-model-centric **Calibration Plan** is agile glue for consistent evolution of instrument & calibration software

- ELT+MICADO: unprecedented active control, size, cost
  - **Calibration Plan** ever more important
  - Implemented CP in software with agile VO data modelling
  - Shared instrument model data simulator and calibration pipeline
    - opens way to bayesian calibration
Data-model-centric **Calibration Plan** is agile glue for consistent evolution of instrument & calibration software

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@IVOA: 3 Data Model talks: Dabin, Buddelmeijer, Nutma!
Example outputs facilitated by data model + framework

ODOCO Calibration Framework for OmegaCAM, 2004

Monitoring the Photometric Calibration

Auto-generated MICADO ESO recipe diagram here
Scratch slides after this one
Outline

1. OmegaCEN family business
2. Evolving instrument systems
3. ELT-MICADO’s unprecedented active control & size
4. Approach to evolving calibration software development: framework
5. Framework smaak: MICADO
6. Hugo’s add to family business: integrated detailed design of simulator & pipeline
7. Closing punch
Pipeline and data simulator share instrument model specification documents.

- Instrument Model
- Data Model + Machine readable framework
- Specification documents
- Data Simulator
- Simulated Data
- Pipeline prototypes

Diagram showing the relationship between pipeline prototypes, simulated data, and data simulator, with the instrument model sharing specification documents.