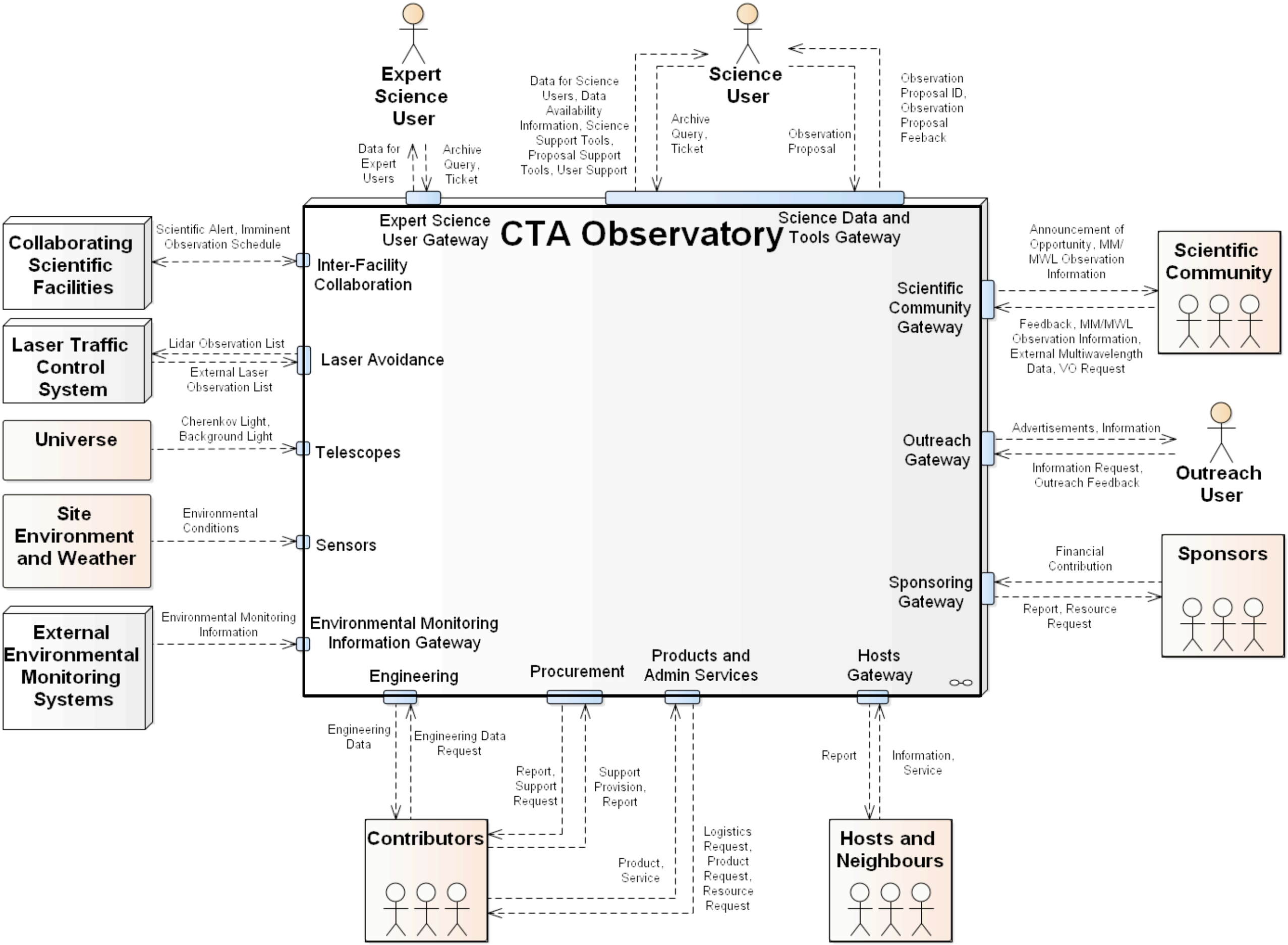
DPPS & OES

Data Processing and Observation Execution

Karl Kosack


Expert Science User
Science User
Data for Expert Users
Archive Query, Ticket
Data for Science Users, Data Availability Information, Science Support Tools, Proposal Support Tools, User Support
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Observation Proposal
Observation Proposal ID, Observation Proposal Feeback
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Scientific Alert, Imminent Observation Schedule
Inter-Facility Collaboration
Laser Traffic Control System
Lidar Observation List
External Laser Observation List
Laser Avoidance
Universe
Cherenkov Light, Background Light
Telescopes
Site Environment and Weather
Environmental Conditions
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Scientific Community Gateway
Announcement of Opportunity, MM/MWL Observation Information
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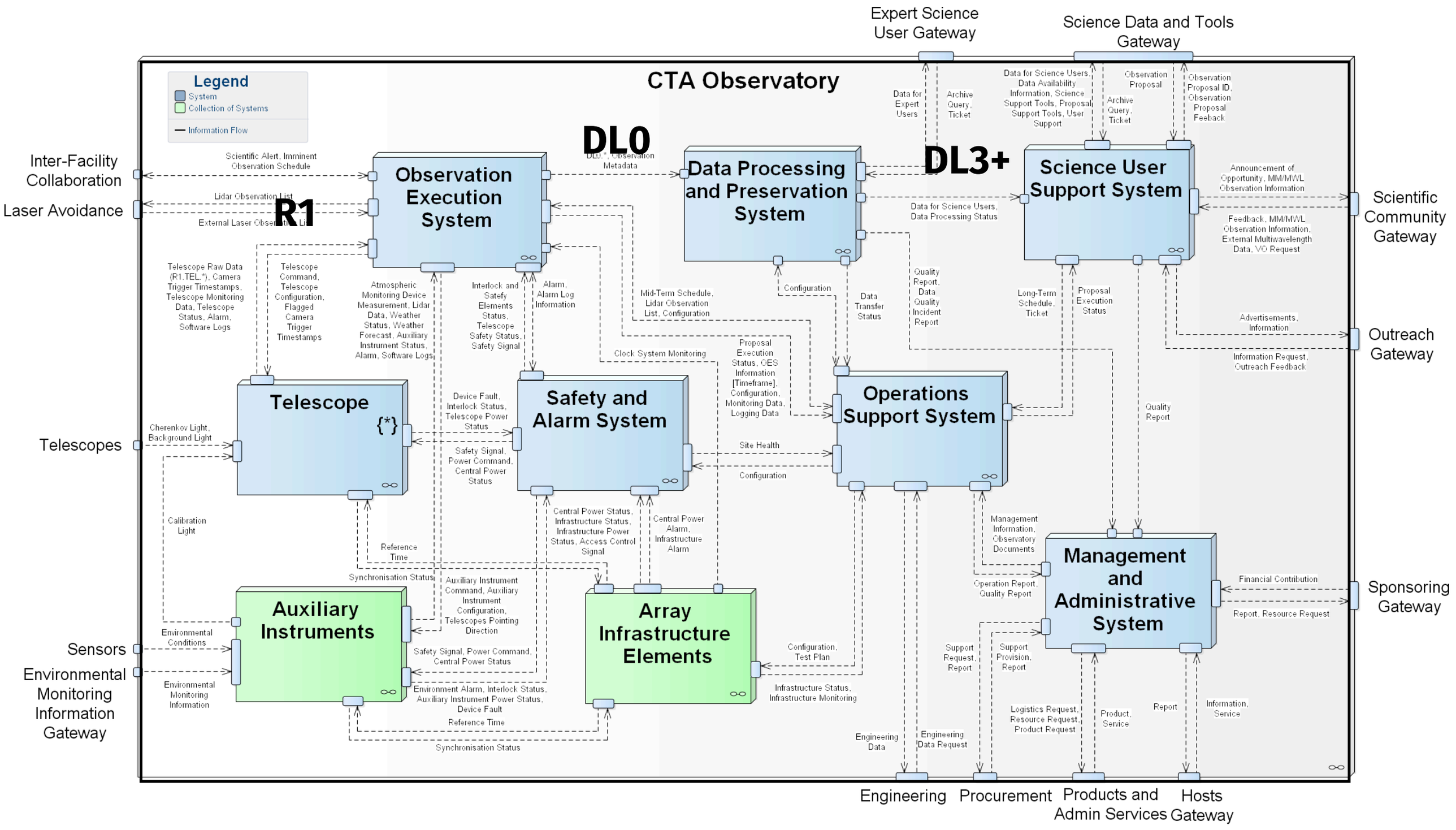
Outreach Gateway
Advertisements, Information
Information Request, Outreach Feedback
Outreach User
Sponsoring Gateway
Financial Contribution
Report, Resource Request
Sponsors
Engineering
Procurement
Products and Admin Services
Hosts Gateway
Engineering Data
Engineering Data Request
Report, Support Request
Support Provision, Report
Product, Service
Logistics Request, Product Request, Resource Request
Report
Information, Service
Contributors
Hosts and Neighbours


CTA Observatory
Legend
System
Collection of Systems
Information Flow
DL0
DL3+
R1
Observation Execution System
Data Processing and Preservation System
Science User Support System
Telescope
{*}
Safety and Alarm System
Operations Support System
Auxiliary Instruments
Array Infrastructure Elements
Management and Administrative System
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Alarm, Alarm Log Information
Mid-Term Schedule, Lidar Observation List, Configuration
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Clock System Monitoring
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Device Fault, Interlock Status, Telescope Power Status
Safety Signal, Power Command, Central Power Status
Site Health
Configuration
Cherenkov Light, Background Light
Calibration Light
Central Power Status, Infrastructure Status, Infrastructure Power Status, Access Control Signal
Central Power Alarm, Infrastructure Alarm
Reference Time
Synchronisation Status
Auxiliary Instrument Command, Auxiliary Instrument Configuration, Telescopes Pointing Direction
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Configuration, Test Plan
Infrastructure Status, Infrastructure Monitoring
Management Information, Observatory Documents
Operation Report, Quality Report
Financial Contribution
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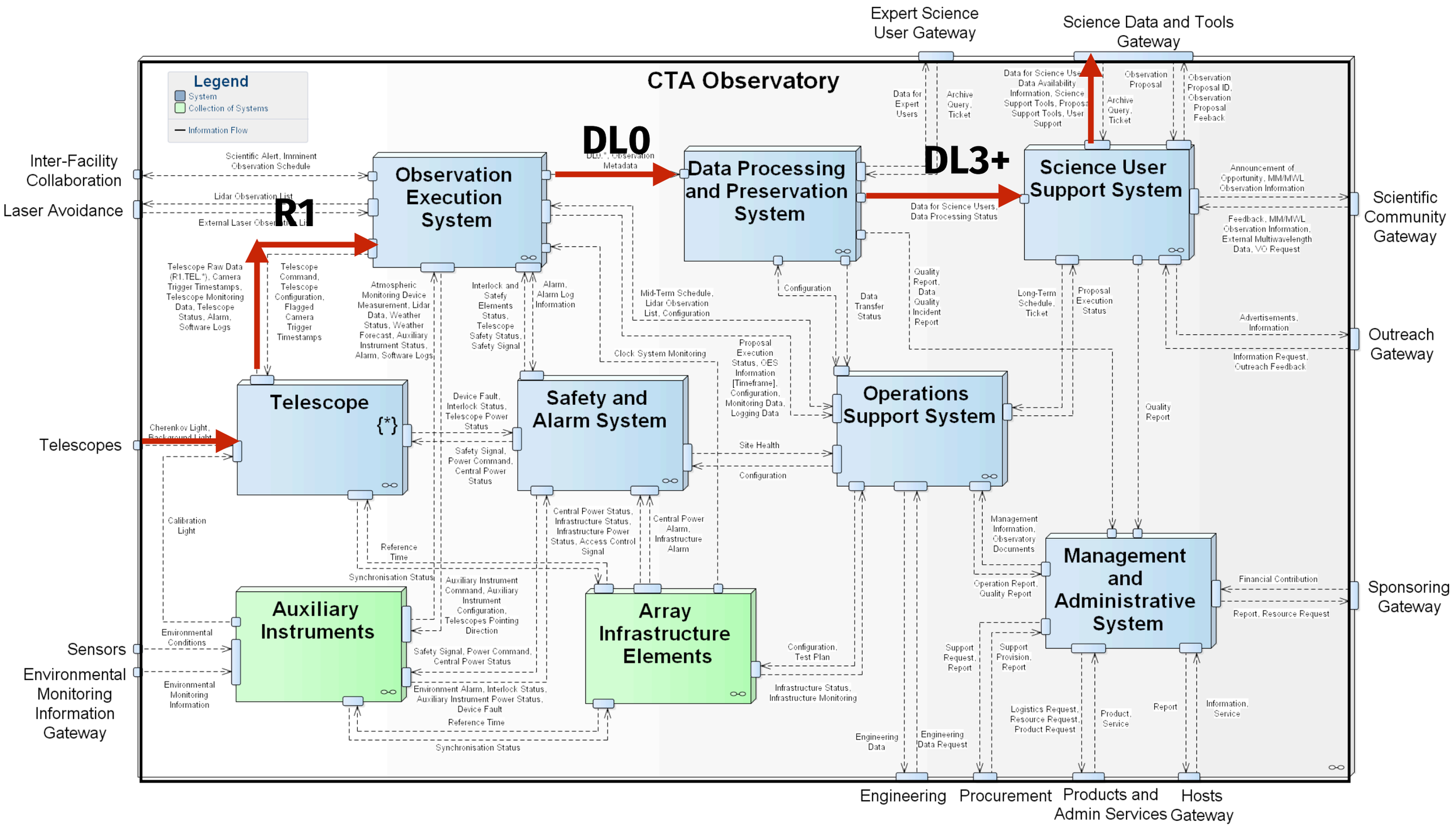
Support Request, Report
Support Provision, Report
Logistics Request, Resource Request, Product Request
Product, Service
Report
Information, Service
Engineering Data
Engineering Data Request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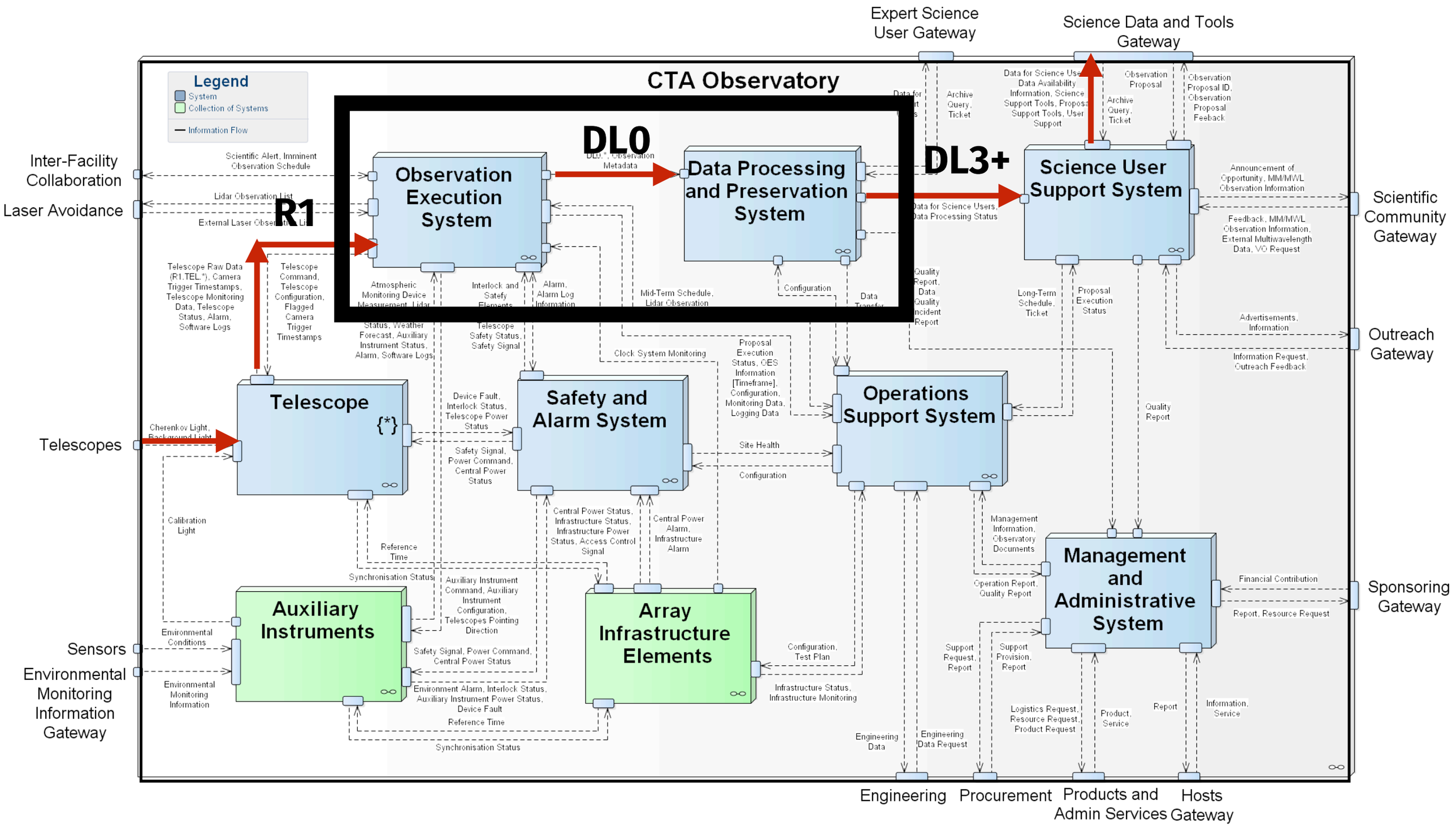
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Internal Data-related systems

Observation Execution System (OES)

Scheduling
Array Control
Data Handling
level A analysis
Monitoring
Operator GUI
...

1Gb/s

Data Processing and Preservation System (DPPS)

Archive
Pipeline
Level B+C analysis
Computing Mgmt.
Simulations
Data Quality
Experts Gateway
Data Transfer

Operations Support

Master Configuration Database

Data Levels: amount of processing

MCs are somewhere here right now

Pipeline starts here
Will need to eventually produce data here to be compatible with "real" CTA data

Reconstructed Events
(many reconstructions and parameters, no more telescopes)

Science Data:
Classified Events (final reconstruction), IRFs

R0 *(raw low-level)* camera data transmitted from telescope to central servers. R0 content and format is internal to each camera and is specified and coordinated between individual camera teams.

R1 *(raw common)* data output by an individual camera functional unit to the camera DAQ functional unit. This is the first level of data seen by the ACTL system and is therefore as common as possible between all cameras/hardware. Exceptionally, some R1 data may be stored for engineering purposes.

DL0 *(raw archived)* all archival data from the data acquisition hardware/software. This is the first level of data that are stored in the bulk archive. This includes both camera event data and technical data from other subsystems, such as non-camera devices or software.

DL1 *(processed)* processed DL0 data that may still include some TEL data and parameters derived from them. For example this includes calibrated image charge, Hillas parameters, and a usable telescope pattern. This is only optionally stored in the archive.

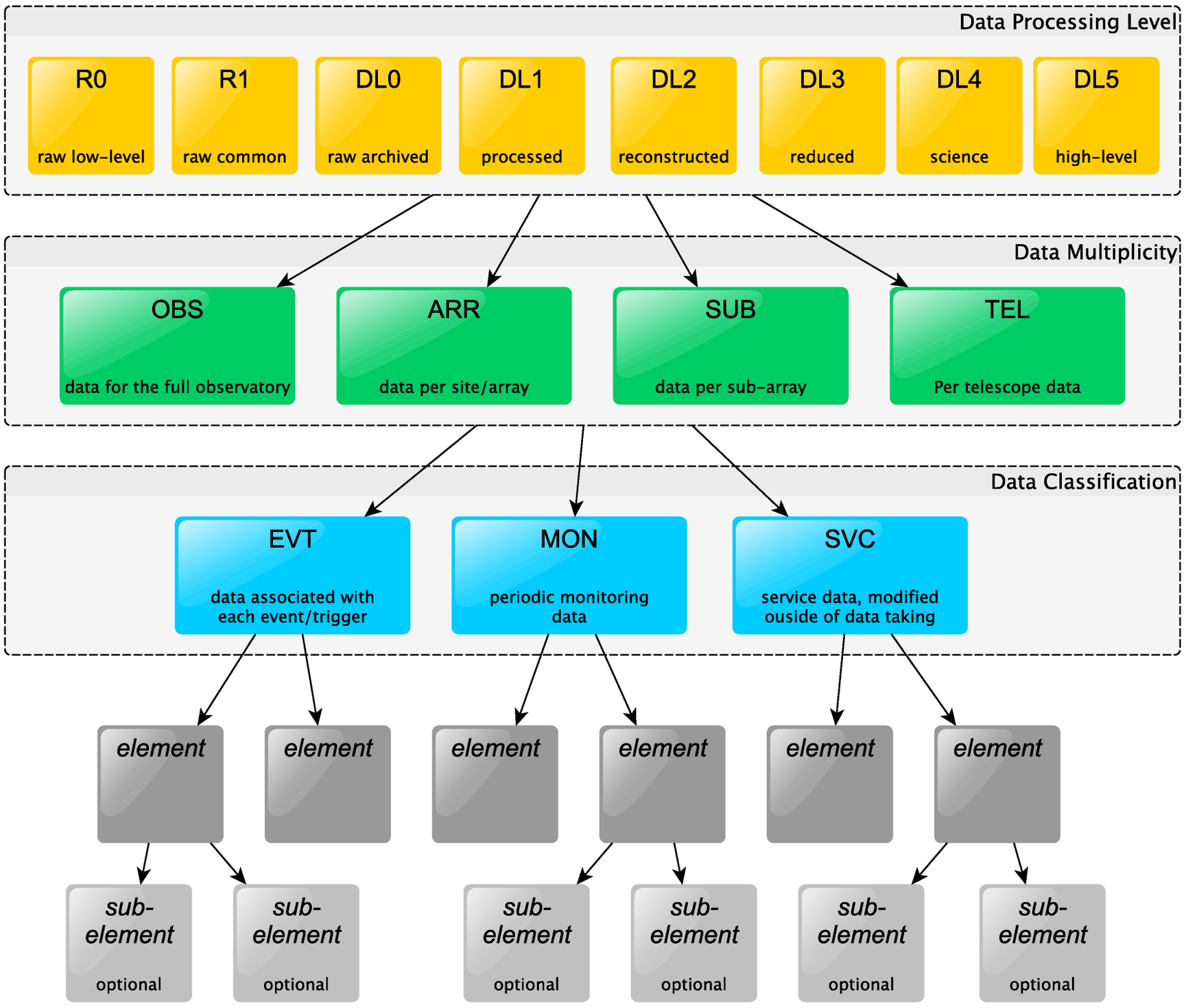
DL2 *(reconstructed)* reconstructed shower parameters such as energy, direction, particle ID, and related signal discrimination parameters. At this point, no TEL information is stored. For each event this information may be repeated for multiple reconstruction and discrimination methods. This is only optionally stored in the archive. At this point, telescope-wise info is generally dropped.

DL3 *(reduced)* Sets of selected (e.g. gamma-ray candidates, electron candidates, selected hadron candidates, etc.) events with a single final set of reconstruction and discrimination parameters, along with associated instrumental response characterizations and any technical data needed for science analysis.

DL4 *(science)* binned data products like spectra, sky maps, or light curves, along with associated data (source models, fit results, etc).

DL5 *(high-level)* high-level or “legacy” observatory data, such as CTA survey sky maps or the CTA source catalog.

Data Naming



For example:

DL0.TEL.EVT:
all eventwise data from cameras

DL0.SUB.EVT:
central trigger data

DL0.TEL.MON:
telescope monitoring data

DL0.TEL.SVC:
telescope configuration/ calibration tables

DL0.*.EVT Data Format

Document under prep:

- define the minimal R1.*.EVT schema
- define the *maximal* DL0.*.EVT schema (limited by link)
- call for data format prototypes
- define evaluation and down-selection procedure

Associated data volume simulator notebook

Name	Type	Shape	Unit	Description
event_id	uint64	(1)	-	The event ID assigned by the SWAT (primary key)
trig_time_s	uint32	(1)	s (TAI)	telescope trigger time, seconds since reference
trig_time_qns	uint32	(1)	0.25 ns	telescope trigger time, quarter-nanoseconds since trig_time_s
trig_type	uint8	(1)	-	trigger type identifier, encoding the trigger class and sub-class
image	int16	(N_{pix})	DC	the time-integrated image
pix_status	uint8	(N_{pix})	-	See definition below (§2.4)
trace	int16	(K_{tr}, N_{samp})	DC	traces for all pixels that have the DVR flag (bit 2) high in pix_status

PRELIMINARY

Note that this is about the limit of what we can store per event and still transfer data off site!

Some comparison criteria:

Maintenence/ longevity

Criterion
Format is open standard?
Documentation: compete API docs?
Is the format documented sufficiently to re-implement a reader if the original API is lost?
When Created?
Standard defined by whom?
Used outside of CTA?
Currently maintained-by?
Long-term maintenance plan?
Multiple implementations?
Manpower needed to to change computing environment/compiler
Dependencies

Data and Schema flexibility

Criterion
Schema defined how?
Self-descriptive?
Supports required data types
Can store per-item units/scales
table-like API
Support and performance of variable-length fields
Supports multi-dimensional array types
Supports nested data types
Supports rich meta-data/headers
Supports arbitrary meta-data (no schema needed)
Can add/change meta-data in existing file?
Multiple datasets in a single file?
Supports schema evolution
Manpower needed to update data model

Technical and Architecture

Criterion
Machine architecture independence?
Multi-compiler support
Multi-platform support
API Language bindings
Detection of data corruption
Recovery from data corruption
Endianness support
Efficient row (event-wise) data access?
Efficient column (one data item for all events) access?
Parallel read access?
Parallel write access?
Takes advantage of data pre-fetching?
Data are loaded contiguously in memory?
Cache friendlieness?
Support for vectorization (SIMD)?
Requires all events in file to be in memory?

Performance

Criterion
Column-wise chunk size (N-rows)
Write performance, Row-Wise (MB/s)
Write performance, Column-Wise (MB/s)
Read performance, Row-wise (MB/s)
Read performance, Column-wise (MB/s)
Compression: internal or external?
Compression: ratio achieved?
Compression: recommended method?
Peak Memory Usage:

ctapipe status

General Status

Trace Integration:

- Support so far 4 methods (*NeighborPeakIntegrator* as default)
- Missing MARS/EventDisplay style *GradientPredictionIntegrator*: to be implemented (see #

Image Processing:

- Hillas (code recently cleaned up, sped up, but still needs some refactoring)
- Tail Cuts: now supports standard + MARS definition, support for optimized thresholds per camera
- Wavelet Cleaning: 2D method working and ready to be merged into standard pipeline (waiting for better implementation of backend code). 3D method to be done.

Reconstruction:

- Plane-Intersection: implemented and working
- ImPACT template model: implemented and working, but needs template generation for full production

General Framework:

- Mostly ok, but still a lot of (re)design needed. Small dev meeting / telecon soon. (restarting normal telecons)

Upcoming Refactorings

IO sources (need so far to support 4+ file formats)

- EventFileReader and x_event_source() being merged into common interface (see PR#613)
- future: support both single-event, and table of events, for different use cases

Merging in of Pipeline steering scripts and related classes

- EventPreparer (helper to produce DL1 outputs)
- scripts for:
  - reconstruction,
  - training of energy and classification
  - cut optimization + IRF production + sensitivity and diagnostics

Unification of DL2 outputs

- currently "proprietary" HDF5 tables (Tino), just need some work to make compliant with the CTA standards (add event_id, rename some columns, etc.)

More to come, as CTA standards and Architecture are developed...