EVLA Data Processing PDR

Overview

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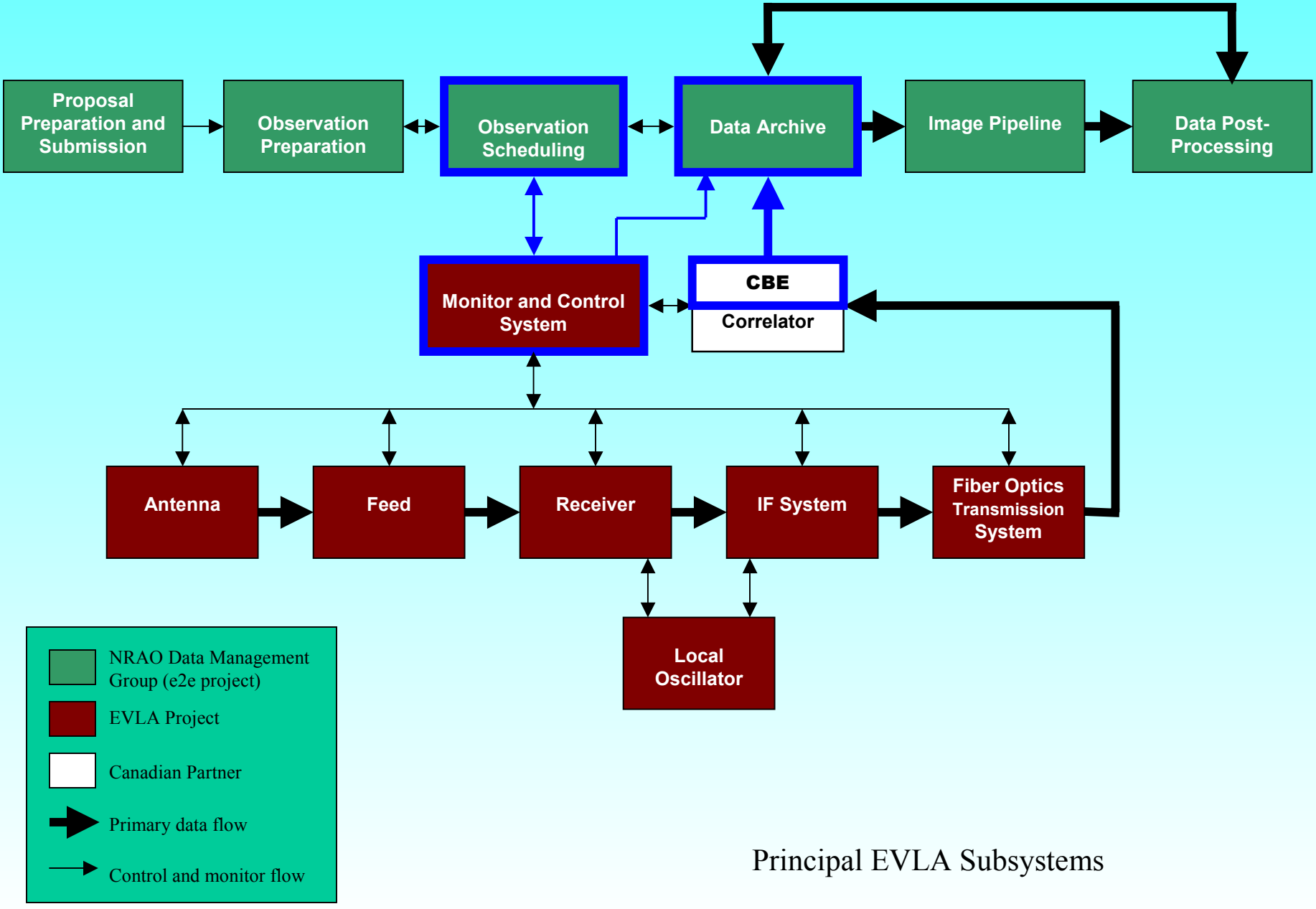
EVLA: Data Management

- EVLA has sub-contracted EVLA data management to NRAO Data Management group
- End-to-end processing needs being addressed by DM End-to-end (e2e) project
- Data reduction needs being addressed by DM AIPS++ project



Principal EVLA Subsystems

End-to-end goals

- Streamline observer access to NRAO telescopes
  - *End to end* management from proposal to science
  - Cross-Observatory consistency
- Greatly improve data products to users of NRAO radio telescopes
  - Provide original, calibrated, and auxiliary data, default images and processing scripts
  - Improve monitoring of instrument behavior
- Greatly improve archive access
  - On-line access to archives of contemporary and historical images, surveys, catalogs, etc.
  - Technical and scientific data mining via web and NVO

To reach these goals, initiated End-to-end Project in July 2001

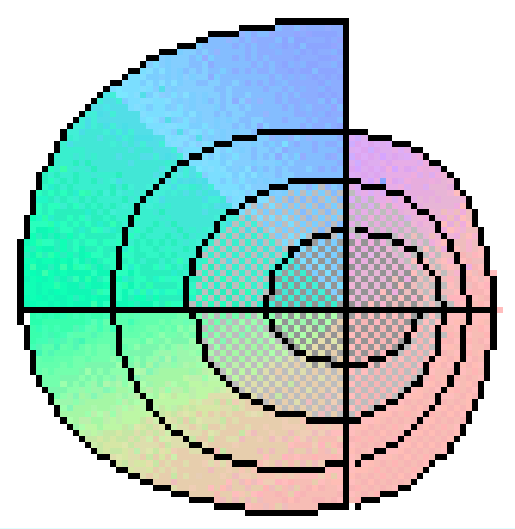
e2e requirements and scope

- Extensive discussion of *first pass* scientific requirements with Scientific Working Group
  - Captured in e2e project book:

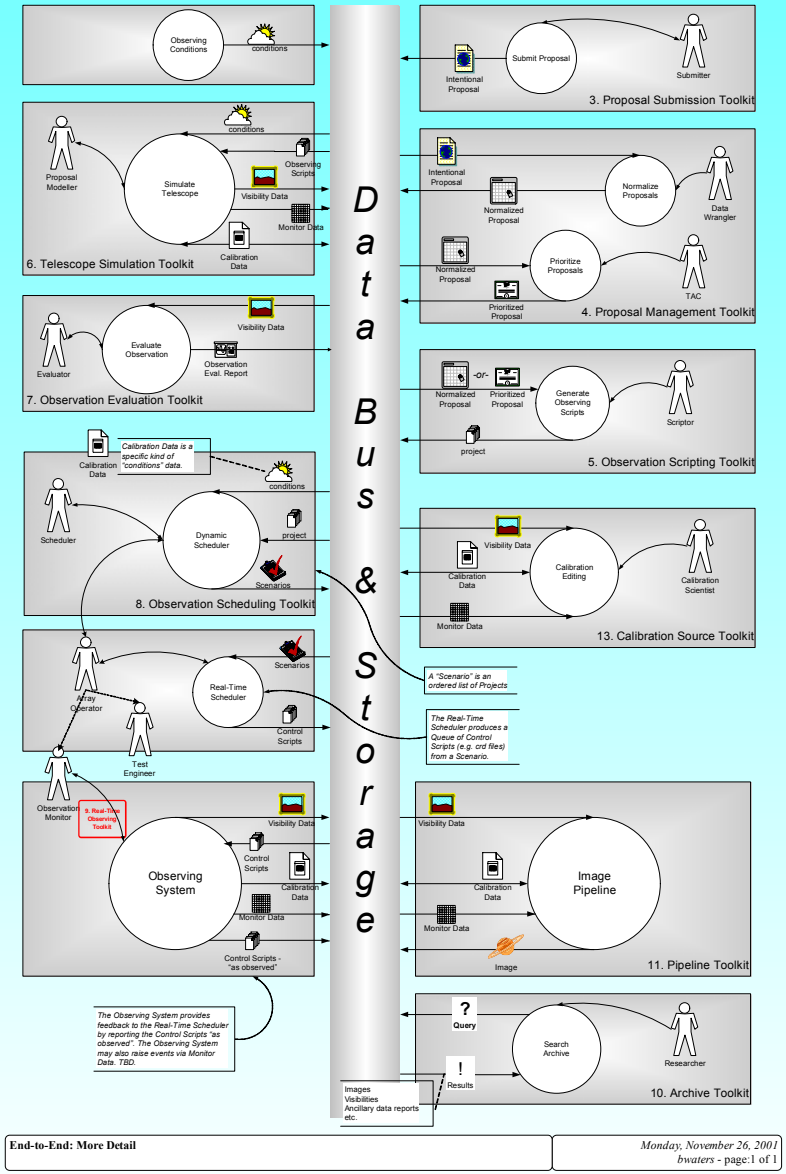
    http://www.nrao.edu/e2e/documents/e2eprojectbook.doc
  - Proceeding on basis of current requirements
  - Description of workflow from proposal to observing script
    - Converted to high level architecture and data flow
- Refine scientific requirements at end of phase 1 (July 2002)
- Commit to design and scope at end of phase 2 (April 2003)
  - First e2e advisory group meeting ~ April 2003
- Spending ~ 15% of budget on planning
  - Good way to mitigate against risk

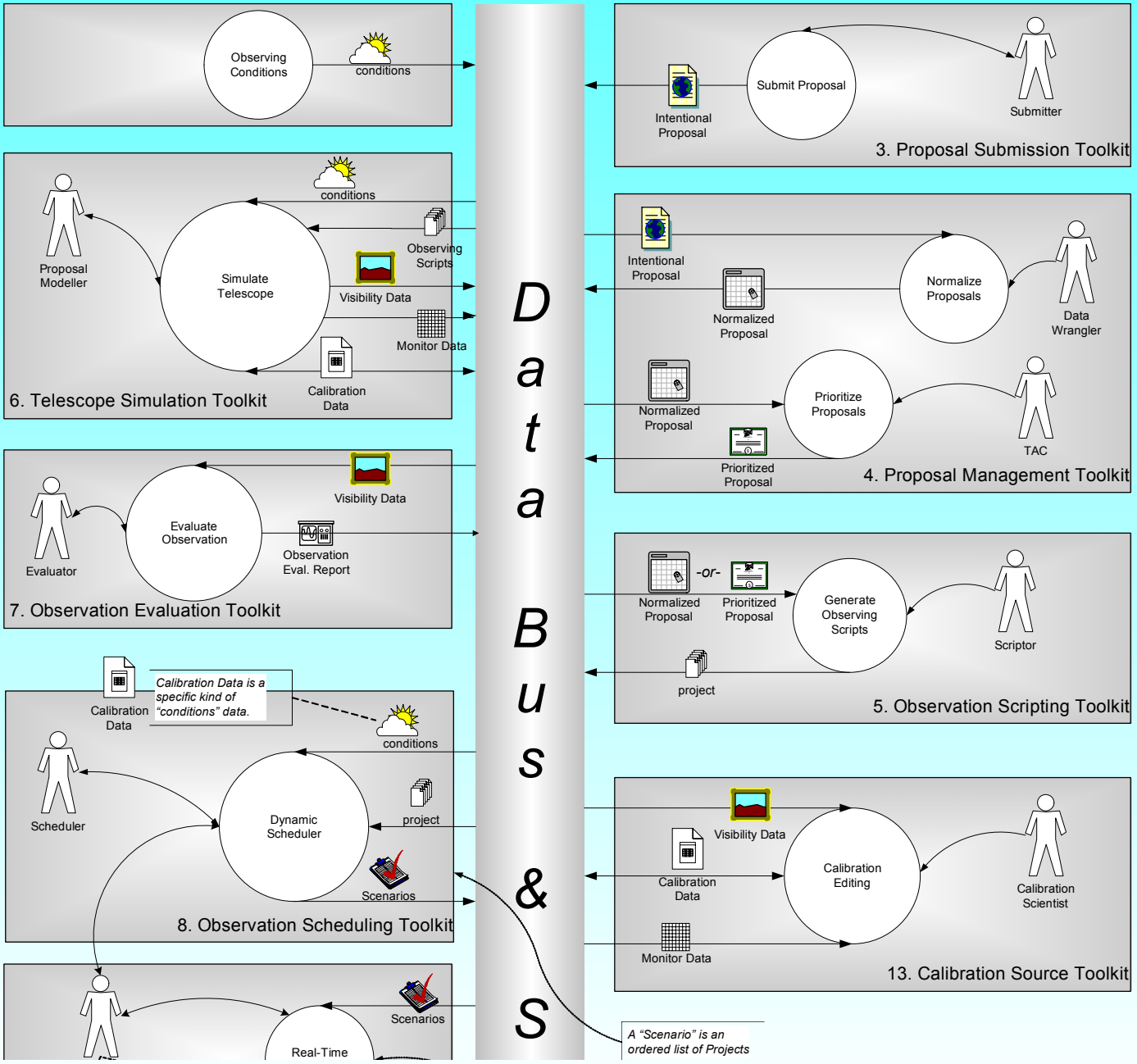
e2e development

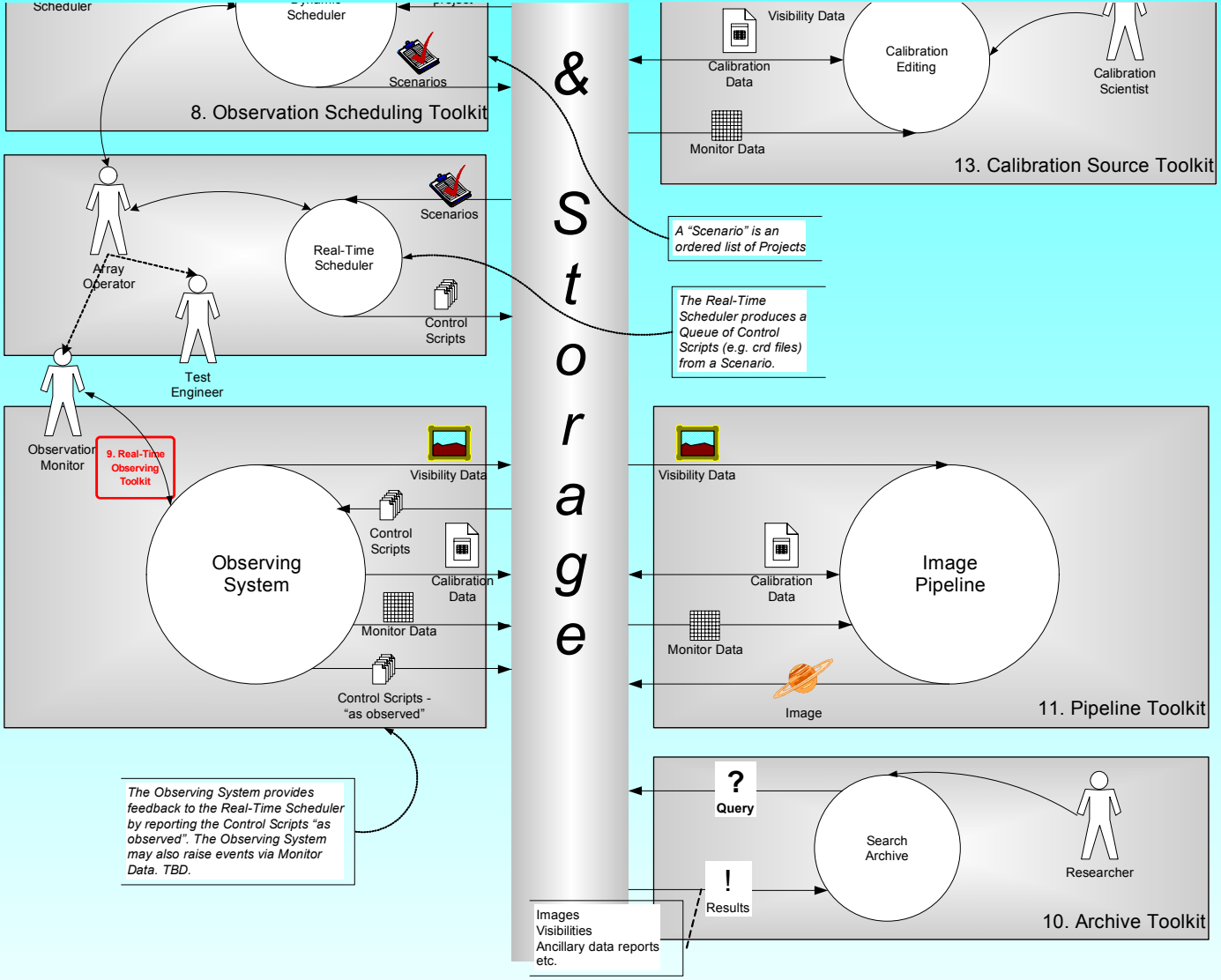
- Current staff
  - John Benson, Tim Cornwell, Boyd Waters, Honglin Ye
  - Lindsey Davis (IRAF, NOAO – to join in Sept, funded by ALMA), another later
  - Doug Tody (IRAF, NOAO – to join in Sept, part of large NSF-funded collaboration)
- Use spiral development model
  - Develop in 9 month phases
    - Get requirements, plan, design, implement, test
    - Review requirements, plan, design, implement, test…..
  - Five year development plan consisting of 7 phases
  - Add new staff incrementally
- Three important principles
  1. Keep it simple
  2. Reuse as much as possible
  3. Deliver new capabilities soon and often



e2e Architectural Diagrams




Observing Conditions
conditions
Data Bus & S
Submit Proposal
Intentional Proposal
Submitter
3. Proposal Submission Toolkit
conditions
Proposal Modeller
Simulate Telescope
Observing Scripts
Visibility Data
Monitor Data
Calibration Data
6. Telescope Simulation Toolkit
Intentional Proposal
Normalized Proposal
Normalize Proposals
Data Wrangler
Normalized Proposal
Prioritize Proposals
TAC
Prioritized Proposal
4. Proposal Management Toolkit
Visibility Data
Evaluator
Evaluate Observation
Observation Eval. Report
7. Observation Evaluation Toolkit
Normalized Proposal
-or-
Prioritized Proposal
Generate Observing Scripts
Scriptor
project
5. Observation Scripting Toolkit
Calibration Data
Calibration Data is a specific kind of "conditions" data.
conditions
Scheduler
Dynamic Scheduler
project
Scenarios
8. Observation Scheduling Toolkit
Visibility Data
Calibration Data
Calibration Editing
Calibration Scientist
Monitor Data
13. Calibration Source Toolkit
Scenarios
Real-Time
A "Scenario" is an ordered list of Projects



End-to-End: More Detail

Overall e2e architecture

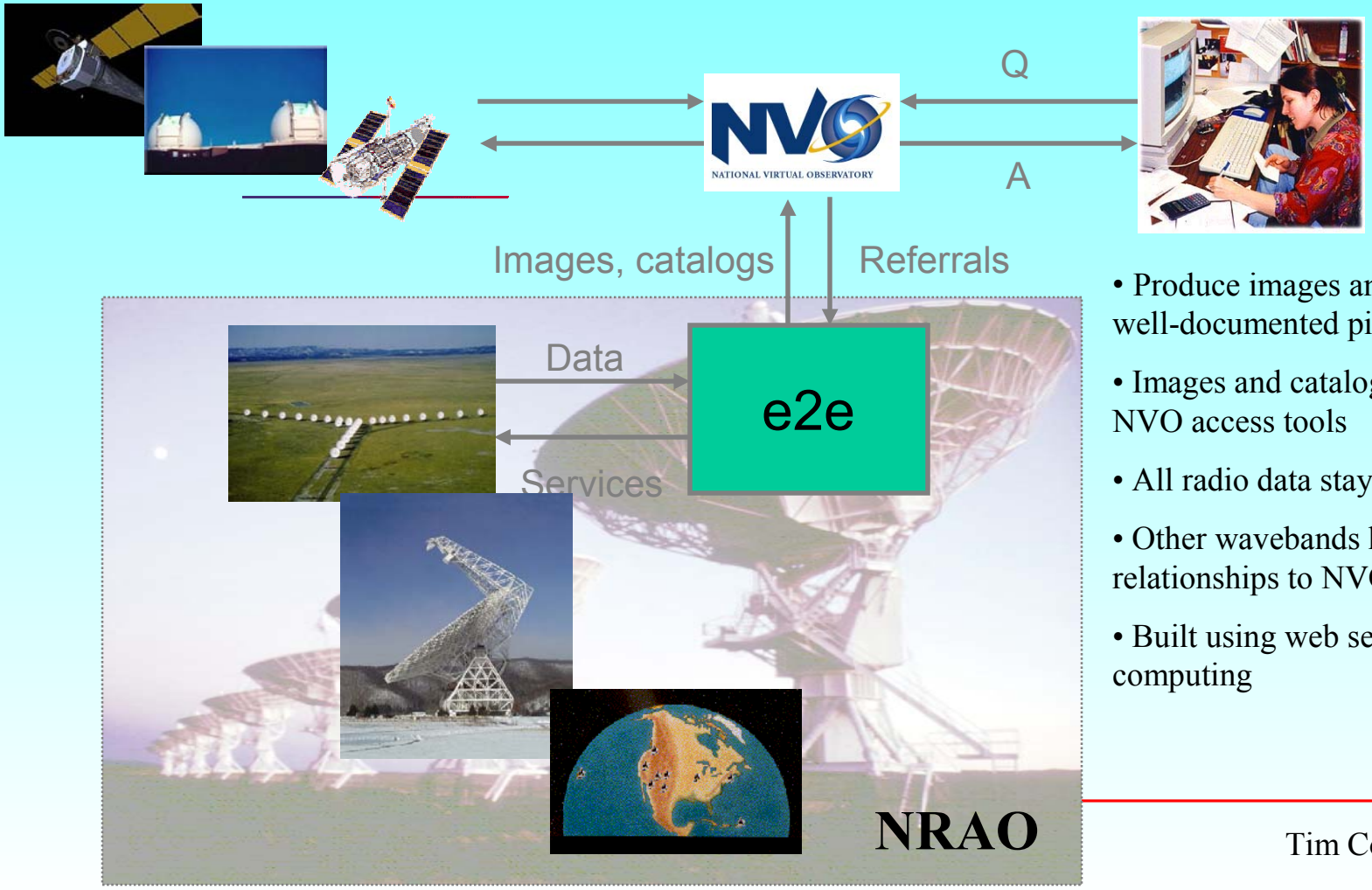
Data flow

Package	How?	Priority	Status
Operational Model	*Document*	*High*	*First version*
Proposal Submission Toolkit	*Web form or Java-based tool*	*Medium*	*Investigation*
Proposal Management Toolkit	*Java-based tools plus database*	*Medium*	*Investigation*
Telescope Simulation Toolkit	*AIPS++ tools*	*High*	*Deferred*
Observation Evaluation Toolkit	*AIPS++ tools*	*Medium*	*Deferred*
Observation Scripting Toolkit	*GBT Observe, GUI editor*	*High*	*Investigation*
Remote Observing Toolkit	*Java, AIPS++ tools*	*Low*	*Deferred*
Observation Scheduling Toolkit	*OMS + local adaptations*	*Low*	*Investigations*
Archive Toolkit	*AIPS++ tables + AIPS++ tools*	*High*	*Prototyping*
Pipeline Toolkit	*Production rule software, AIPS++ tools*	*High*	*Prototyping*
Pipeline heuristics	*Glish scripts as production rules*	*High*	*Prototyping*
Calibration source toolkit	*Ingres db + Java*	*High*	*In development*

Telescopes and projects

- e2e will be retrofitted to all NRAO telescopes (GBT, VLA, VLBA)
- VLA
  - Putting archive on-line now, working towards pipeline processing
- EVLA
  - Sub-contracted to deliver entire e2e system for EVLA (for 18 FTE-years)
  - Close interaction with EVLA project team at all levels
- VLBA
  - Will start moving archive to disk after VLA archive
  - VLBA pipeline processing once AIPS++ can handle it
- GBT
  - Designing archive facility for deployment in GBT early 2003
  - Watching re-engineering of observing script generation
- ALMA
  - Sub-contracted to develop pipeline (framework only) and post-processing
  - Start development July 2002
  - ALMA has own equivalent to all parts of e2e
  - Trying for reuse if possible (*e.g.* Observation Scripting GUI from ALMA)

From NRAO to the National Virtual Observatory



- Produce images and catalogs from well-documented pipeline processing
- Images and catalogs available via NVO access tools
- All radio data stays within NRAO
- Other wavebands have similar relationships to NVO
- Built using web services and grid computing

Relationship of DM to ALMA project

- ALMA has subcontracted development of offline processing and pipeline framework to NRAO
- e2e:
  - Must deliver pipeline framework
  - No other re-use planned
  - Proposal submission, observation scripting will be different
- AIPS++:
  - ALMA processing requirements documents being finalized
  - AIPS++ in baseline plan
  - AIPS++/ALMA tests under way to test compatibility
  - ALMA representative (Gianni Raffi) recently joined AIPS++ Executive Committee

e2e timescales

- Customer requirements
  - EVLA PDR process in 2002, Working M&C by early 2004, Shared risk science 2007
  - ALMA development, Phase II starts this year, runs to 2006
  - GBT archive facility by end of proprietary period (early 2003)
  - NSF funding for archive work Sept 2001 – Sept 2003
  - Project book (*http://www.nrao.edu/e2e*) contains scientific requirements as currently understood
- First cycle of development (ended July 15, 2002)
  - Prototyped VLA archive and pipeline software and facility
  - Started loading VLA archive to disk
  - Improved support for VLA/VLBA calibrator database
  - Design for proposal submission and management
- Second cycle of development (ends in Q2 2003)
  - GBT archive facility
  - Thorough testing of archive and pipeline for VLA
  - Development of prototype observation scripting and scheduling
  - First advisory committee meeting
- End of overall generic development (2006)
  - Working archives, pipelines, ancillary software for VLA, VLBA, GBT
  - First generation for EVLA, ALMA
- Move onto EVLA and ALMA specific development (2006+)

EVLA critical dates

	Due date	Comments
Correlator to Archive		
Data from CBE	Q3 2003	Desirable
Test correlator prototype	Q4 2005	Desirable
Start test first correlator subset at VLA	Q4 2006	Desirable
First science with correlator subset	Q2 2007	Highly desirable
New correlator operational	Q1 2009	Required
M&C to Archive		
Benchtests monitor data	Q1 2003	Desirable
Prototype system on EVLA test antenna	Q2 2003	Desirable
Start observing in transition mode	Q2 2004	Required
Scheduling to and from M&C System		
Start test first correlator subset	Q4 2006	Highly desirable
Post Processing		
Test first correlator subset	Q4 2006	Highly desirable
New correlator operational	Q1 2009	Required

Costing, schedule, deliverables, *etc.*

- Plan is to develop design in all e2e areas to level required to cost the project by end of development cycle 2 (April 2003)
- At that point, e2e commits to requirements, costing, schedule, deliverables
- Scope adjustments will be made at beginning of development cycles as agreed with EVLA

e2e resources

- ALMA numbers estimated by ALMA computing management
  - Seem to be in line with other ground based projects but considerably less than space based
- e2e numbers based upon straw man designs, reuse
- e2e scope will be adjusted to fit resources (~ 55 FTE-years)
- Neither constitute a detailed bottom-up derivation of resources from requirements

Effort (FTE-years)	*ALMA*	*e2e*
Proposal Handling Software	14	5
Scheduling Software	8	15
Pipeline	12	15
Data Archive	12	15
Other	0	5
Total	46	55

De-scoping options

- De-scoping occurs first within toolkits via priorities set by EVLA project
  - Potentially large de-scoping available here
- Next toolkits can be removed
- e2e is committed to provide Pipeline for ALMA
  - Pipeline requires Observation Scripting, Observation Scheduling, Archive
- Core architecture can survive removal of:
  - Telescope Simulation
  - Observation Evaluation
  - Remote Observing
- Spiral development allows these de-scopes to be made incrementally (at the beginning of each development cycle)

AIPS++ resources

- Expect roughly the same level of effort from AIPS++ on EVLA as on VLA currently
- Total effort ~ 10 FTE-years from 2003 to 2009
- Addressing EVLA-specific processing issues

EVLA-specific post processing

- Mostly well-understood and in place
  - AIPS++ package: can reduce VLA data end-to-end
  - BUT final requirements yet to be set
- EVLA-specific areas requiring more development
  - New modes of processing (next slide)
  - Very large data volumes
    - Automated flagging schemes
- Performance issues
  - Ensure that AIPS++ is efficient and fast enough (compare to AIPS)
    - AIPS++/AIPS speed ratio ~ 1 +1/-0.5 (with some outliers!)
  - Develop parallelized applications (*e.g.* imaging, calibration)
    - Well in progress in collaboration with NCSA
  - Develop location independent computing (a.k.a. Grid computing)
    - *e.g.* transparent access to archive and pipelines from remote locations

Examples of EVLA hard processing problems

Fast-slew mosaicing	~10ms data sampling rate. Remove sliding primary beam.
Full bandwidth synthesis	Deconvolve wide bandwidths while accounting for spectral index, polarization, rotation measures, opacity, *etc*.
Full-beam high-fidelity polarization imaging	Correction of time- and angle-dependent beam polarization.
High fidelity imaging	Image and deconvolve at ~ 10^7. Currently about ~ 100 away from this in best possible cases.
Wide-angle full-beam imaging	Huge images, fast data sampling rates, many imaging facets to accommodate non-coplanar baselines
Wide-angle full-beam imaging	Huge images, fast data sampling rates, many imaging facets to accommodate non-coplanar baselines
RFI mitigation	Removal of RFI post-correlation – requires high data rates

e2e status

Package	Status	Who will present
Operational Model	*First version*	*Described in project book*
Proposal Submission Toolkit	*Design complete*	*Honglin*
Proposal Management Toolkit	*Design complete*	*Honglin?*
Telescope Simulation Toolkit	*Design concept exists*	*Described in project book*
Observation Evaluation Toolkit	*Design concept exists*	*Described in project book*
Observation Scripting Toolkit	*Design concept exists*	*Boyd*
Remote Observing Toolkit	*No design yet*	*Tim*
Observation Scheduling Toolkit	*Design concept exists*	*Boyd*
Archive Toolkit	*Prototype complete*	*John*
Pipeline Toolkit	*Prototype complete*	*Tim*
Pipeline heuristics	*Prototype complete*	*Tim*
Calibration source toolkit	*First version complete*	*Honglin*

Risks

- Creeping scope
  - Requires project discipline
  - *e.g.* scientific requirements for post-processing soon
- Lack of engagement by scientific staff
  - Work with DM Project Scientist (Dale Frail), DMSWG
- Observation scripting too hard
  - Develop incrementally
- Pipeline processing cannot be made to work for significant fraction of observations
  - Prototype on VLA: will require some changes to current practices
- Archive = Operational morass
  - Need automation and management staff soon
- Repeat of AIPS++

Lessons learned in AIPS++ project

- Software development:
  - Start new software development projects with realistic expectations
  - Control scope: initial requirements were developed without a reliable costing process
  - Management of distributed software projects is especially demanding
  - Establish firm staffing commitments
  - Continual refinement of processes important: moved to spiral development
- Package deployment:
  - Demonstrate scientific completeness: establishing threads of completeness by matching representative data to reduction scripts
  - User testing is vital: formed active, large Observatory-wide test group
  - Robustness: identifying and fixing defects as submitted
  - Performance must be regularly monitored: established benchmark suite, scheduled regular profiling, targeting known cases of poor performance
  - User interface design is very demanding: conducted one-on-one testing and group surveys
  - Documentation forms a gateway to the package: enlisted help of scientists in writing documentation
  - Training is best way to introduce new users to AIPS++: presenting tutorials to small groups
- Lessons learned applied across the Observatory, ALMA, e2e

Specific changes adopted by e2e

- Spiral model
  - Short development cycle
  - Deliver early and often
- Involvement of scientists
  - Set specifications at beginning of cycle 1
  - AOC scientists tested and advised on Calibrator Source Toolkit
  - Will review and change specifications at beginning of cycle 2
  - Dale Frail will be DM Project Scientist
  - Will be involved in pipeline development, testing of archive and proposal handling during cycle 2
  - Advisory Group meeting at end of cycle 2
- Commit to requirements, plan, costing, schedule
  - Design and development phase (first two cycles) ending in April 2003
  - Schedule, *etc.* then set