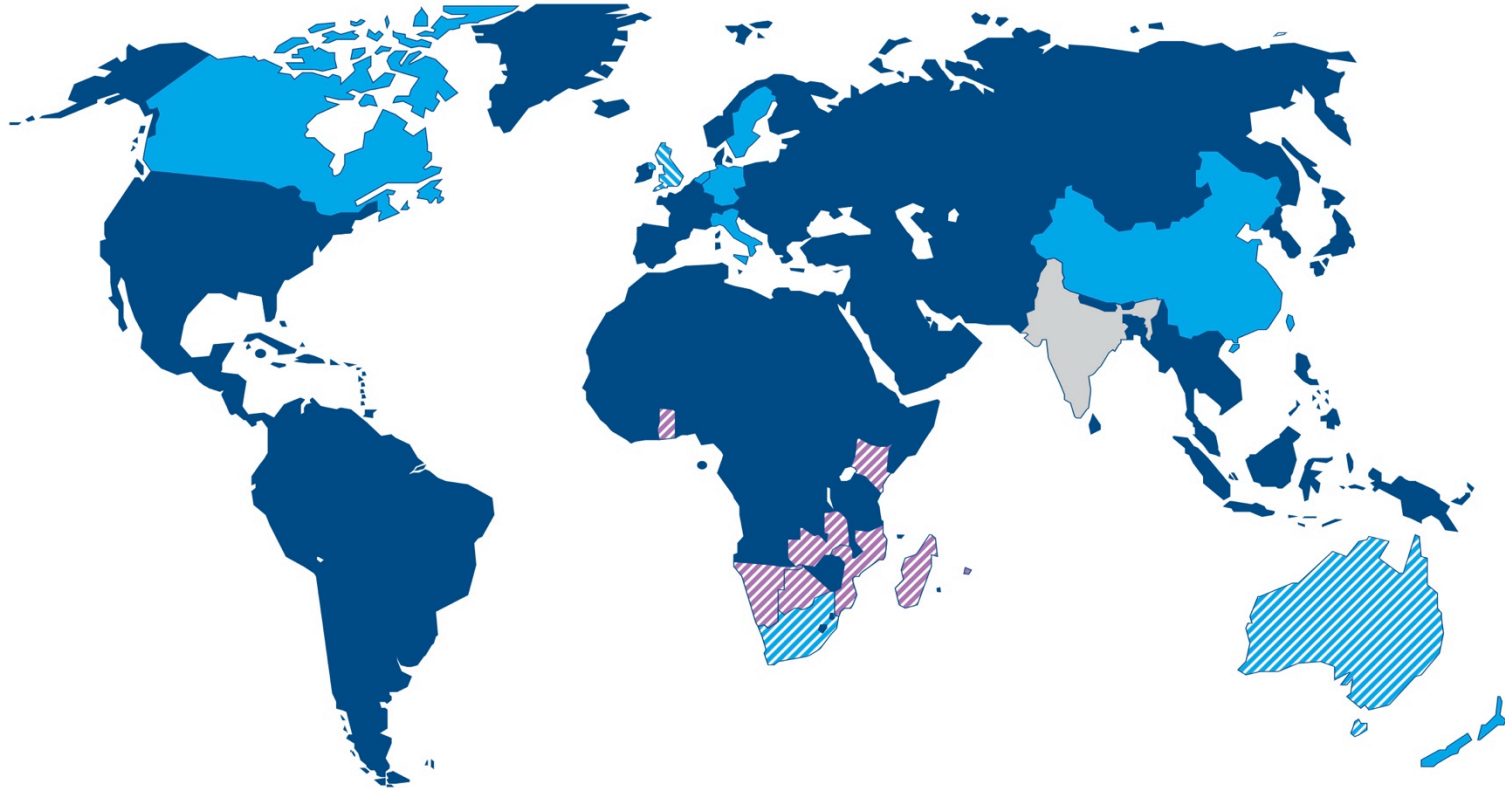# Overview

- SKA project
- SKA telescope design
- SKA SDP package
- SDP data delivery element – DELIV
- DELIV testbed

SKA Global Partnership


Legend:
- ● Full members
- ● Associate members
- ◉ Member SKA Phase 1 and Phase 2 host countries
- ◉ Non-member SKA Phase 2 host countries
- ◉ SKA Headquarters host country

SKA Key Science Questions

- **Probing the Dark Ages**
  - When & how were the first objects in the universe formed?
- **Cosmology and Galaxy Evolution**
  - Nature of Dark Energy and Dark Matter
  - Formation and evolution of galaxies and structure
- **Gravity**
  - What happens to space-time under extreme conditions?
  - Gravity-wave astronomy (pulsar timing arrays)
- **Origin & Evolution of Cosmic Magnetism**
  - Where does magnetism come from?
  - What is its role in cosmic evolution?
- **Cradle of Life**
  - What and where are the conditions for life?
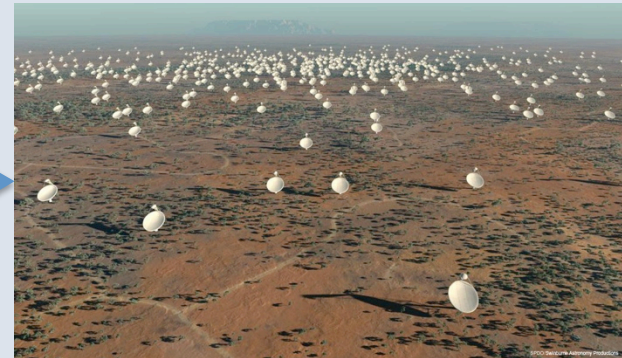 - Does intelligent life exist elsewhere?

SKA Timeline

2010 — 2015 — 2020 — 2025
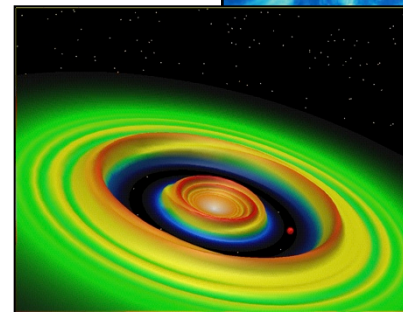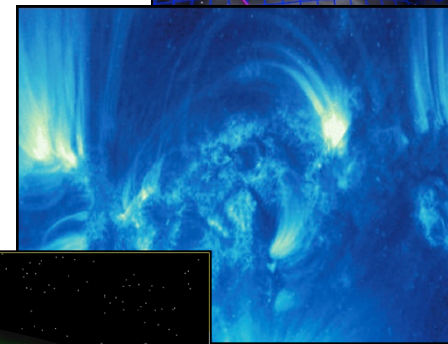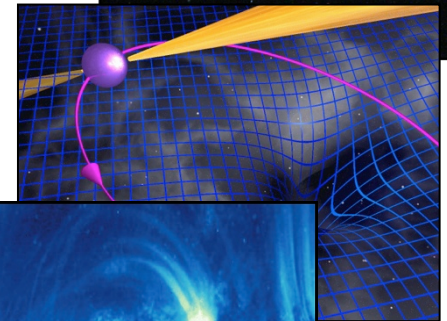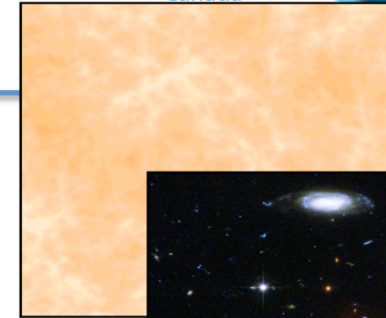
South Africa

€ 70 M

SKA1
Pre-construction

SKA1
250 15-m Dishes

SKA
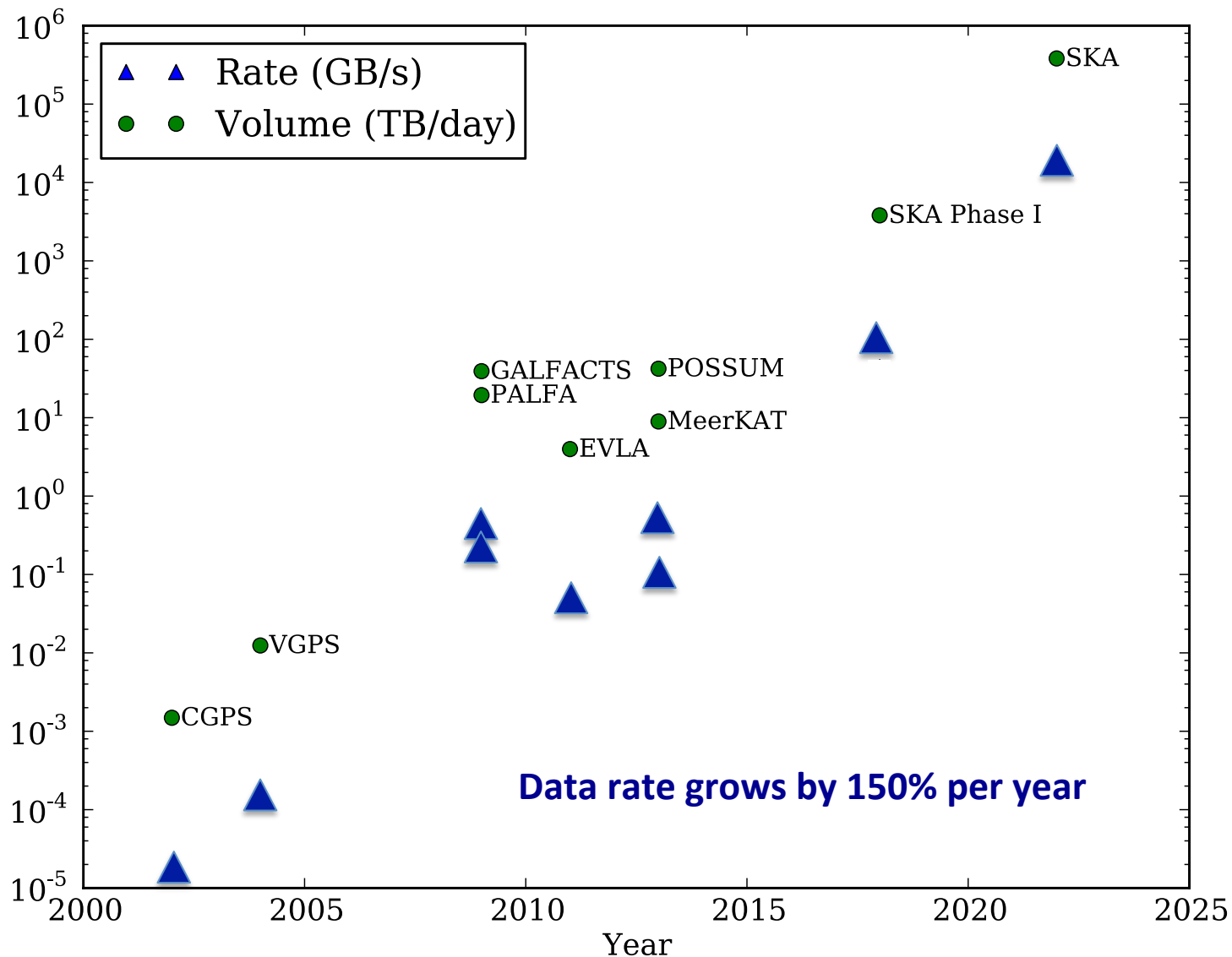2500 15-m Dishes

1%   10%   100%

Australia

SKA
Low-frequency antenna array

# Data Rates and Volumes to Scientists

SKA Design

- Three telescopes: Low, Mid and Survey
  - Each with computing resources
- Design work packages:
  - Assembly, Integration and Verification (AIV)
  - Central Signal Processor (CSP)
  - Dish (DSH)
  - Infrastructure Australia and Africa (INFRA AU/INFRA SA)
  - Low-Frequency Aperture Array (LFAA)
  - Mid-Frequency Aperture Array (MFAA)
  - Signal and Data Transport (SaDT)
  - Science Data Processor (SDP)
  - Telescope Manager (TM)
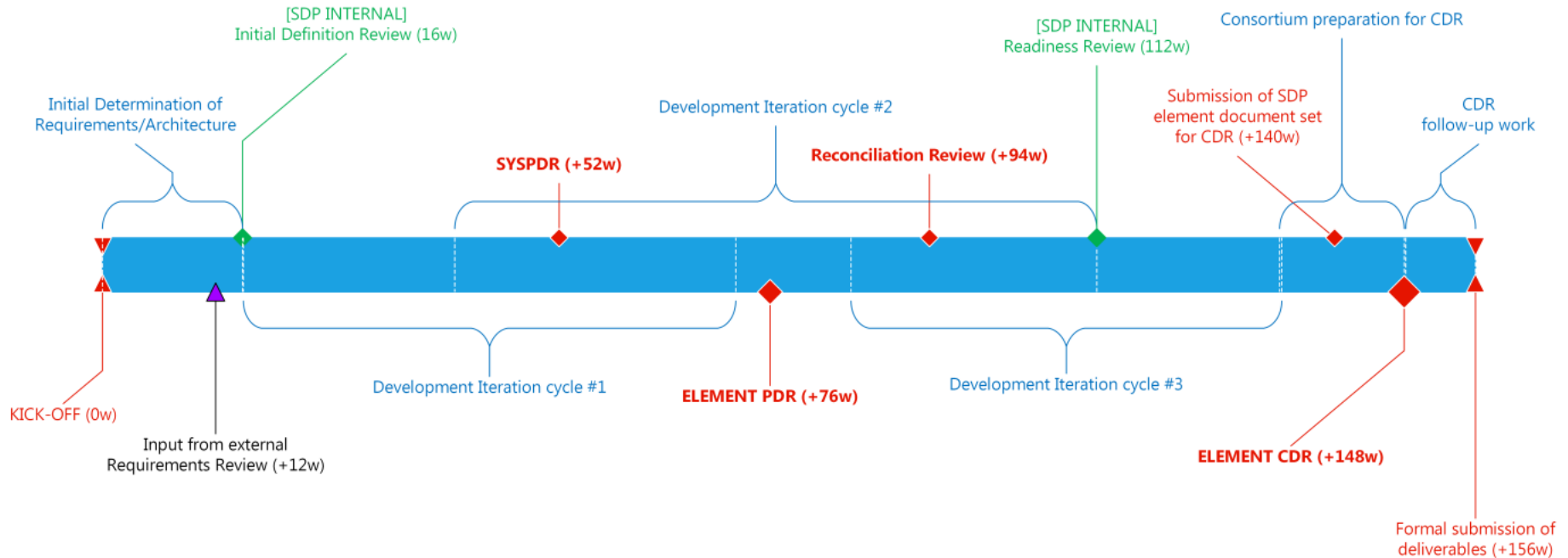 - Wideband Single Pixel Feeds (WBSPF)

SDP Top Level WBS and Management Team
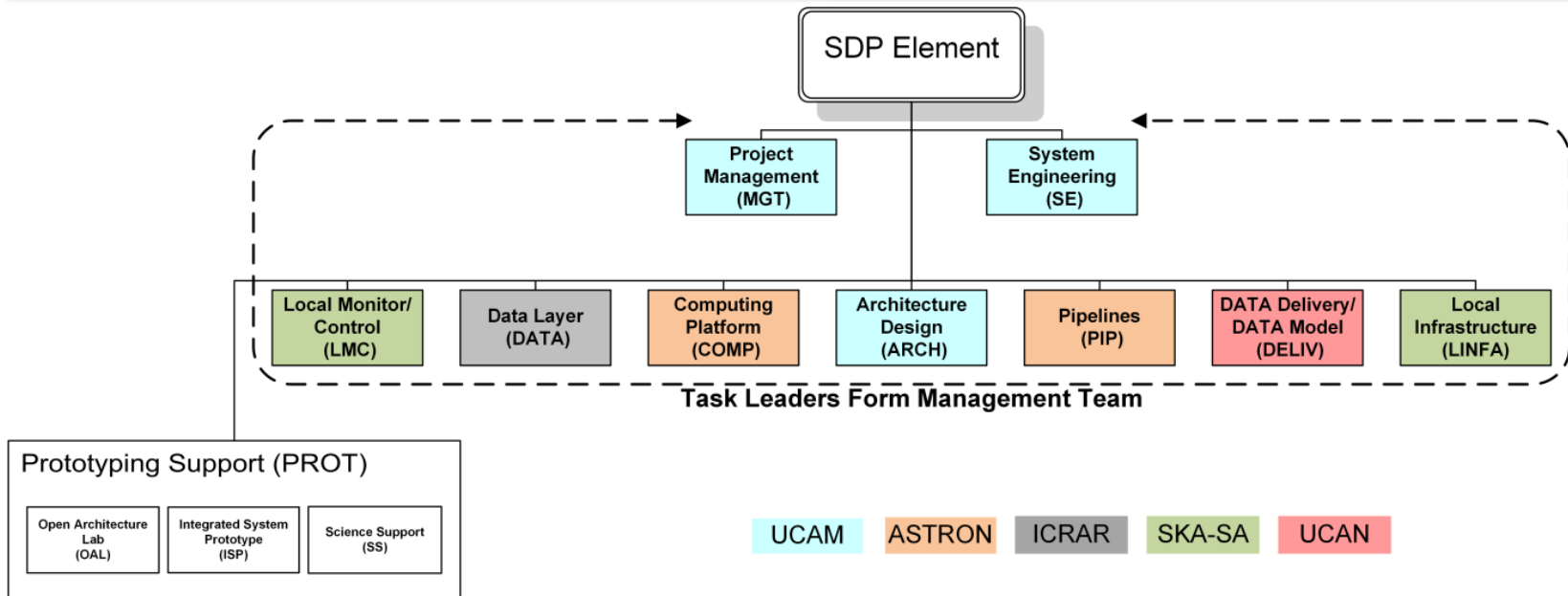
- Lead: Paul Alexander
- PM: Ian Cooper
- PE/Architect: Bojan Nikolic
- SE: Ferdl Graser
- PS: Rosie Bolton

- COMP: Chris Broekema
- PIP: Ronald Nijboer
- DATA: Andreas Wicenec
- DELIV: Rob Simmonds
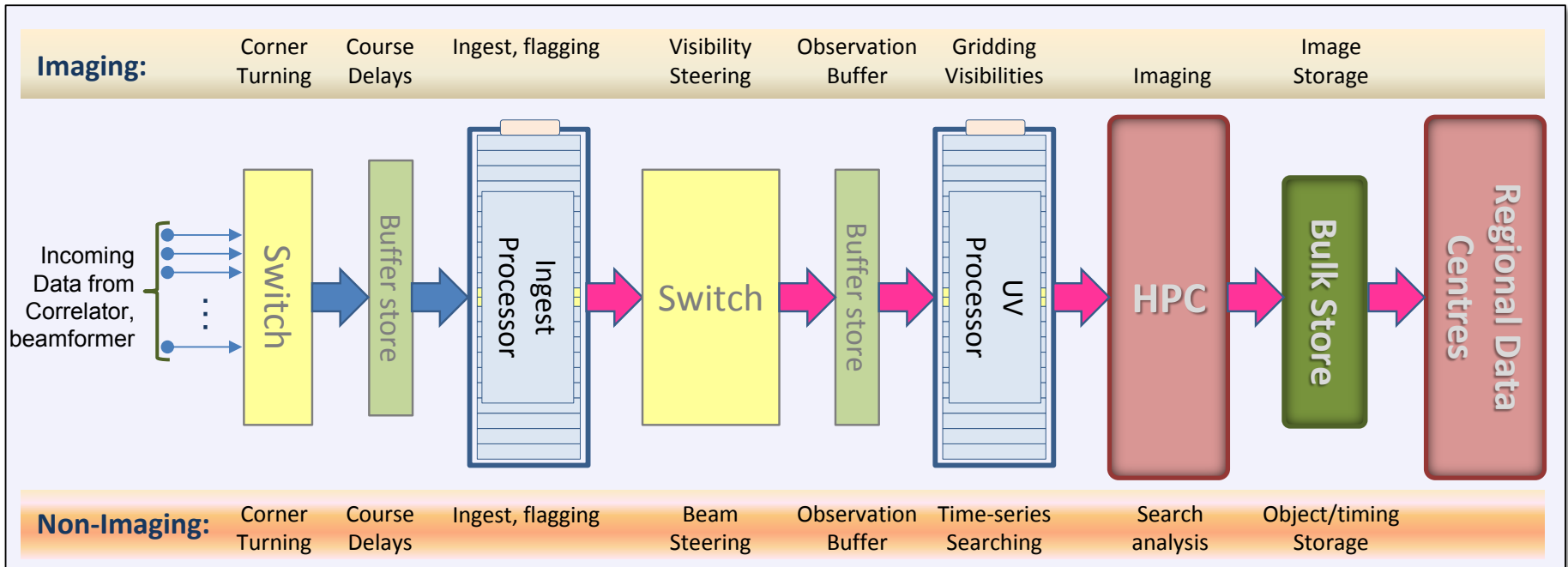- LMC: Simon Ratcliffe
- LINF: Jasper Horrel

SDP Design Schedule

- Expectation: major system changes following re-baselining
- Follow standard SE approach of element PDRs following system PDR
- Baseline element architecture at PDR

SDP: Overall Architecture

- Heterogeneous hardware architecture
- Homogeneous software stack

Example Data Rates and Data Products

- Baseline Design

Element	BL Design (Ingest) (GB/s)	Use Case (maximal) (GB/s)
LFAA	842	245
Survey	4670	995
Mid	1800	255

- Aperture Array Line experiment (e.g. EoR)
  - 5 sq degrees; 170000 channels over 250 MHz bandwidth
    - ~ 30 GB/s reducing quickly to ~ 1GB/s
    - Up to 500 TB UV (Fourier) data; Images (3D) ~ 1.5 TB
- Imaging experiment with long baselines
  - 50 km baseline with the low-frequency AA or SKA1_Survey
    - 1.5 TB/s reducing to ~ 50 GB/s
    - Up to 1000 TB/day to archive if we archive raw UV data
    - Images (3D) ~ 27 TB

DELIV

- Provide science products to end users
- Access data online and move data to where users can perform analysis
- Enable searching for data products
- Explore roles for Regional Centres to support SKA research
- Manage the distribution of data to make best use of available network capacity
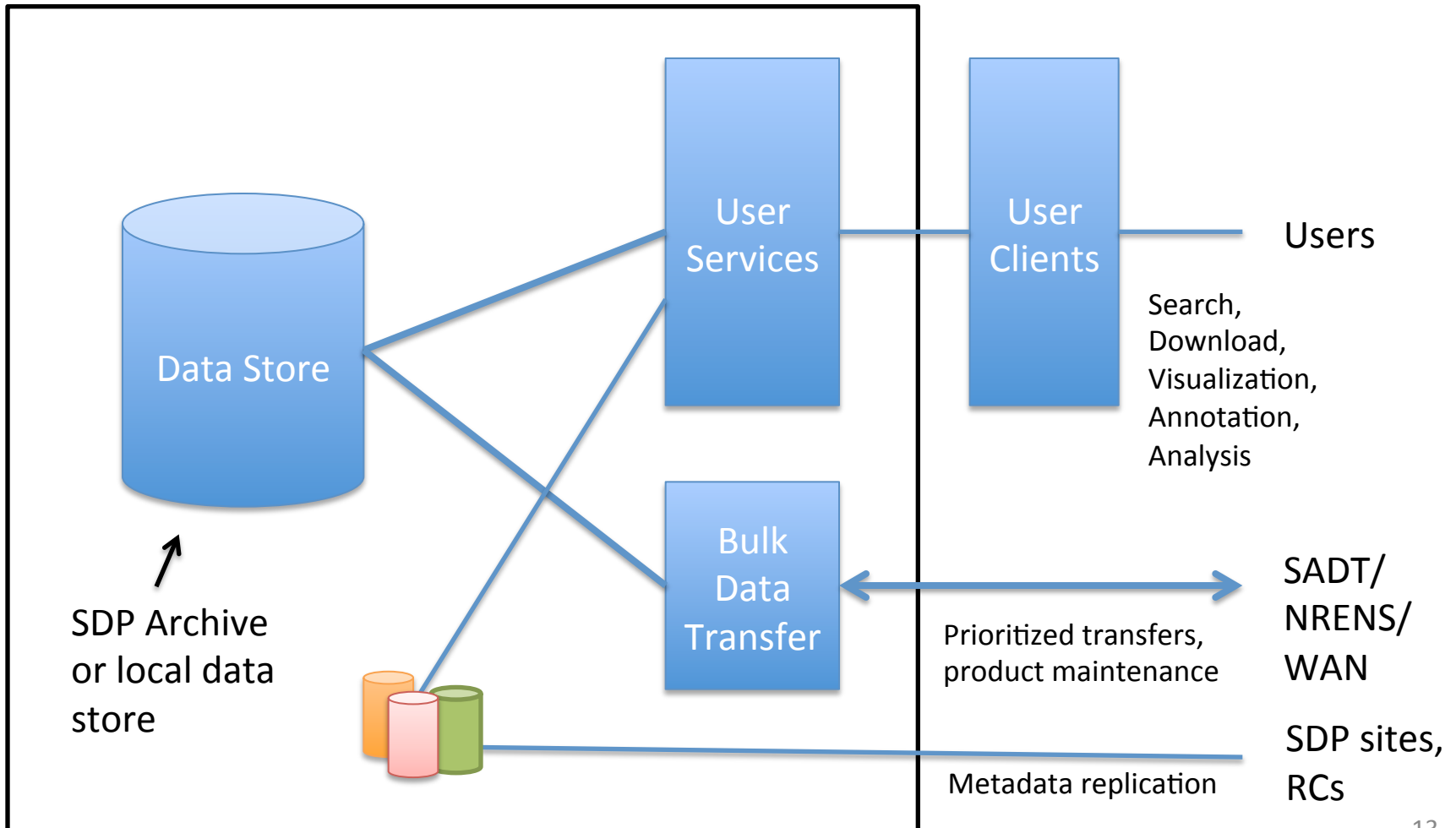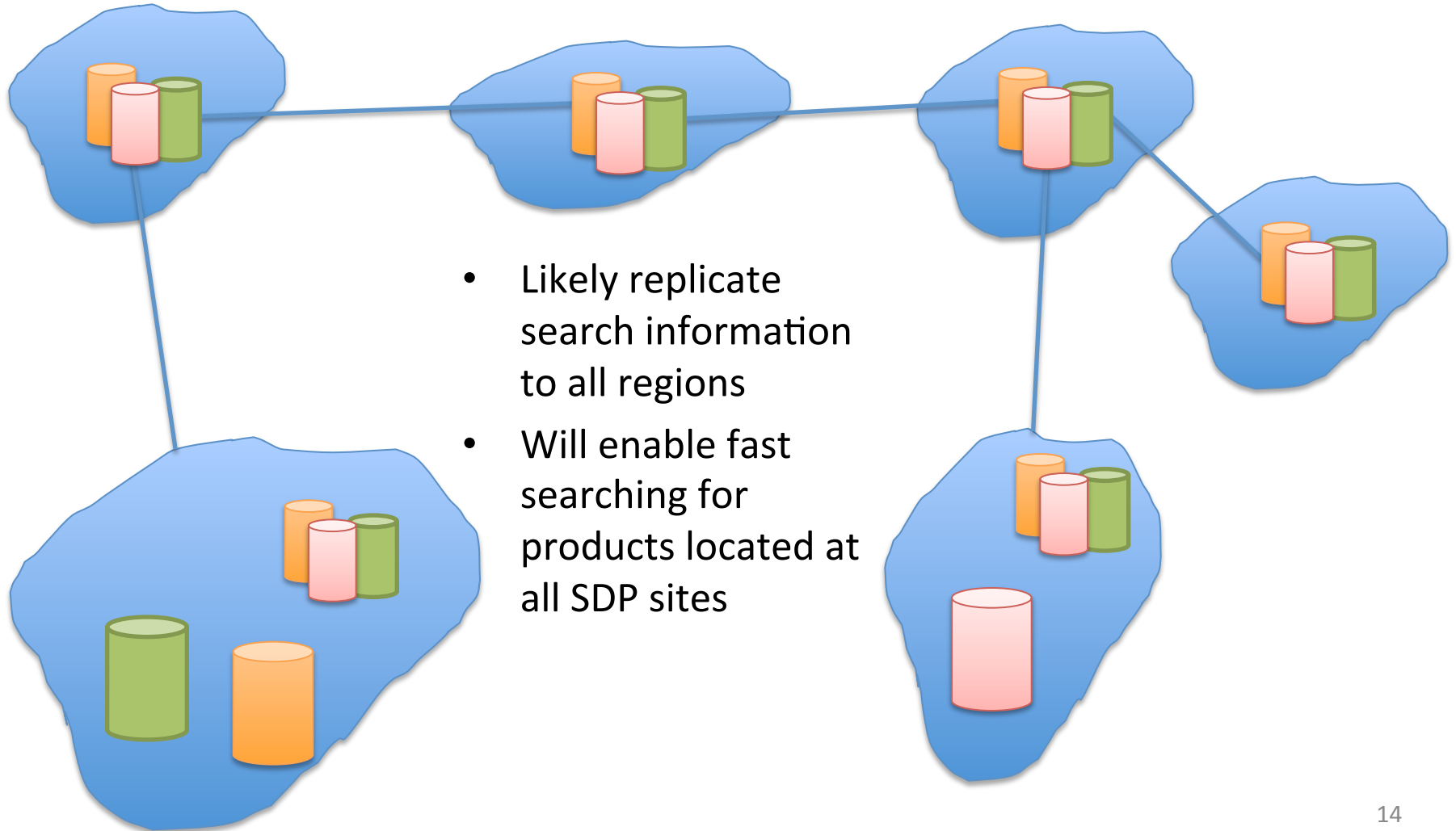
DELIV partners

- Design partners:
  - Canadian University Consortium
  - Oxford eScience Centre
  - SKA-SA (input from SAC)
  - Canadian Astronomy Data Centre
  - ASTRON
- Additional prototyping partners:
  - RackForce
  - CHPC
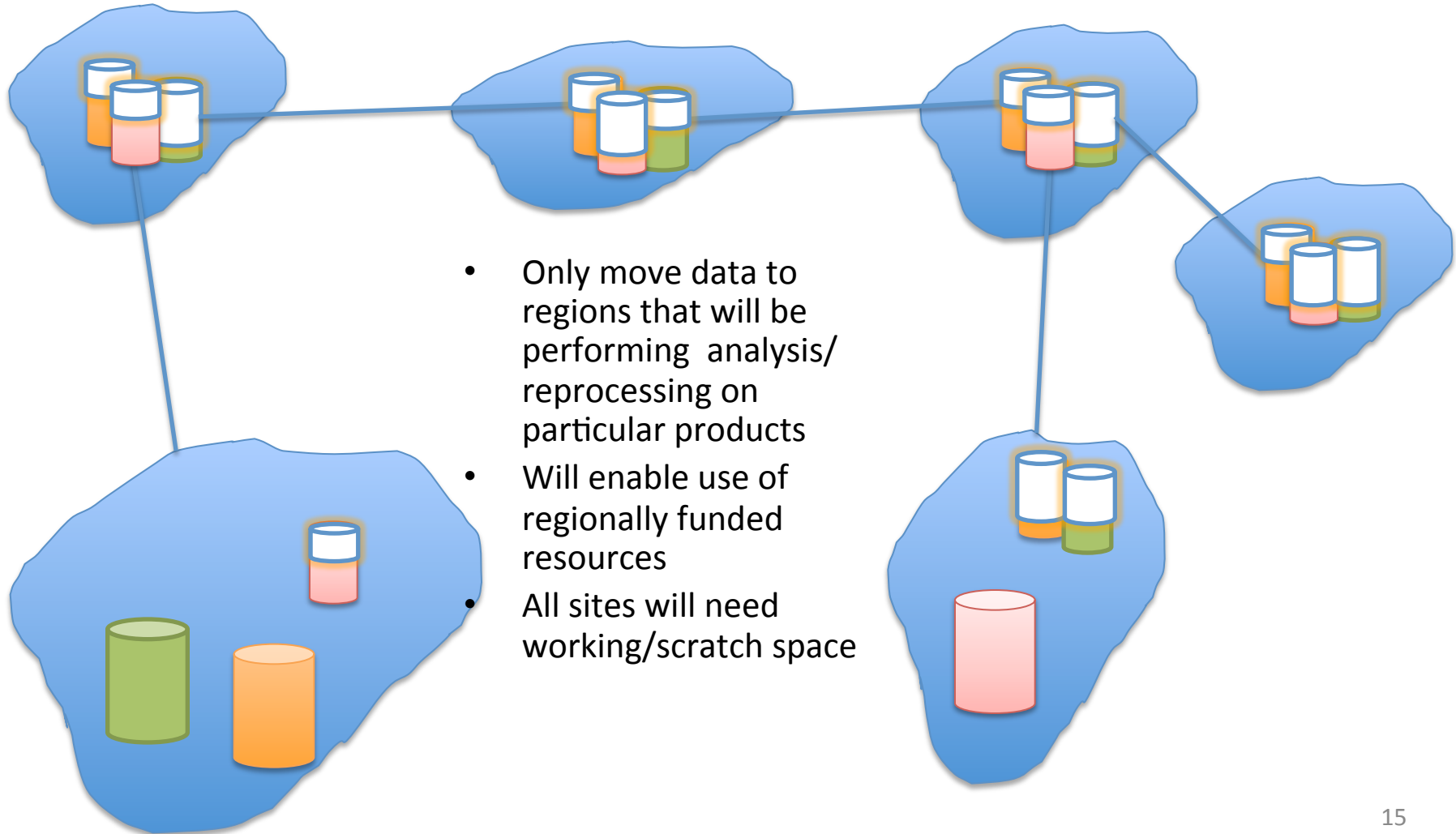 - iVec
  - University of Cambridge
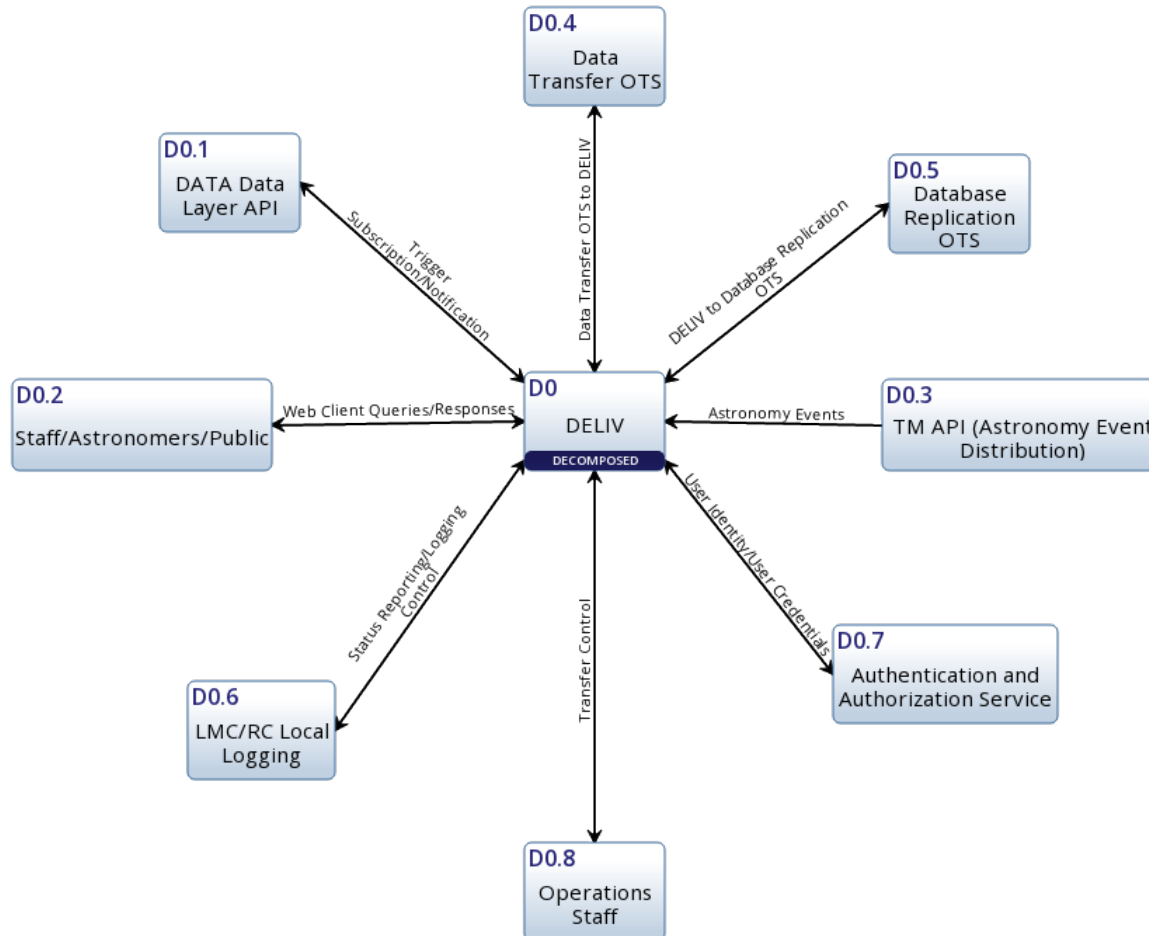
DELIV – Data Architecture

Data Store

SDP Archive or local data store

User Services

User Clients

Bulk Data Transfer

Users

Search, Download, Visualization, Annotation, Analysis

SADT/ NRENS/ WAN

Prioritized transfers, product maintenance

SDP sites, RCs

Metadata replication

13

Search Data Replication

- Likely replicate search information to all regions
- Will enable fast searching for products located at all SDP sites

Data Product Replication

- Only move data to regions that will be performing analysis/reprocessing on particular products
- Will enable use of regionally funded resources
- All sites will need working/scratch space

DELIV Context Diagram

DELIV: Decomposition
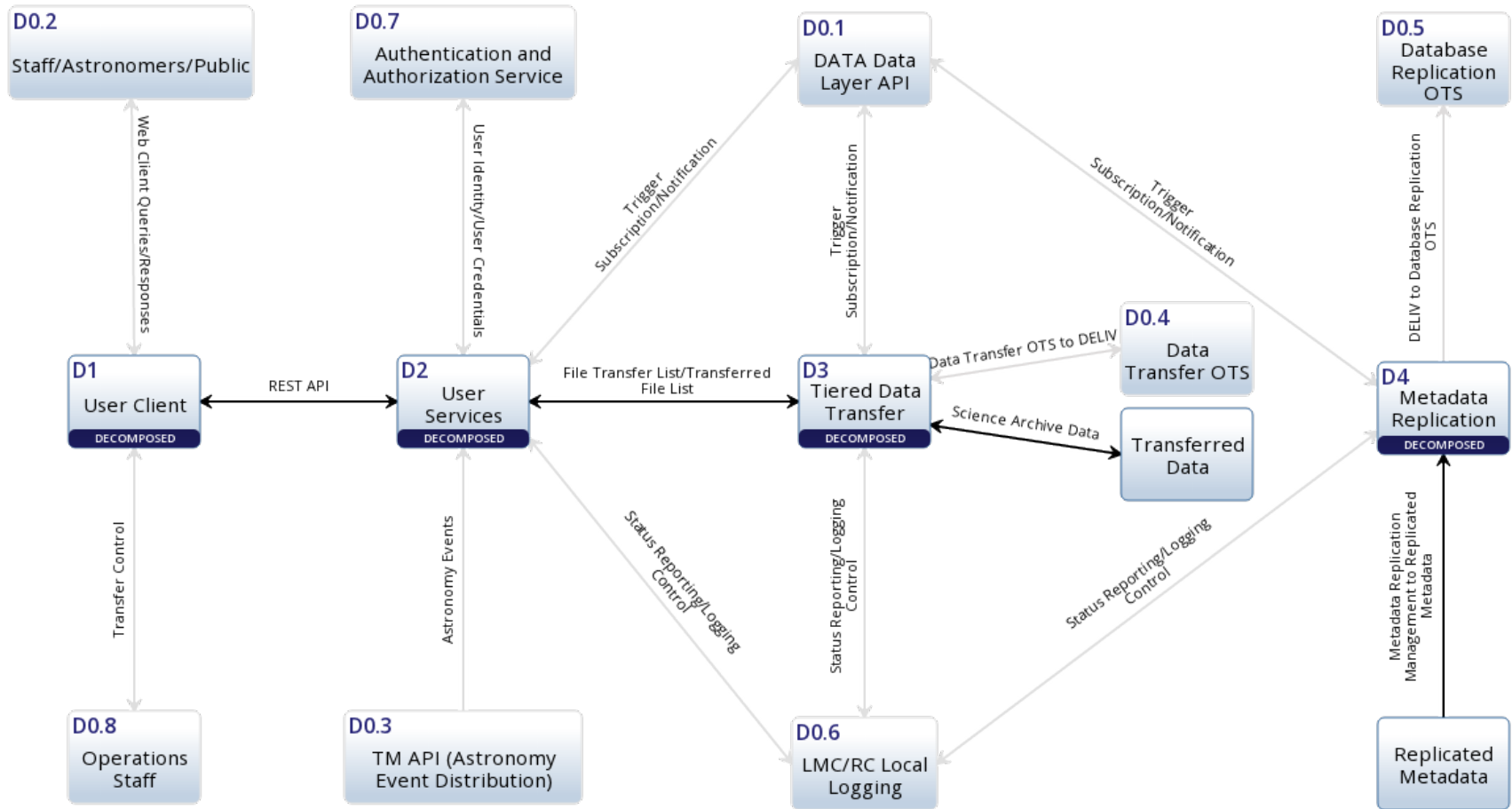
DELIV : Data transfer
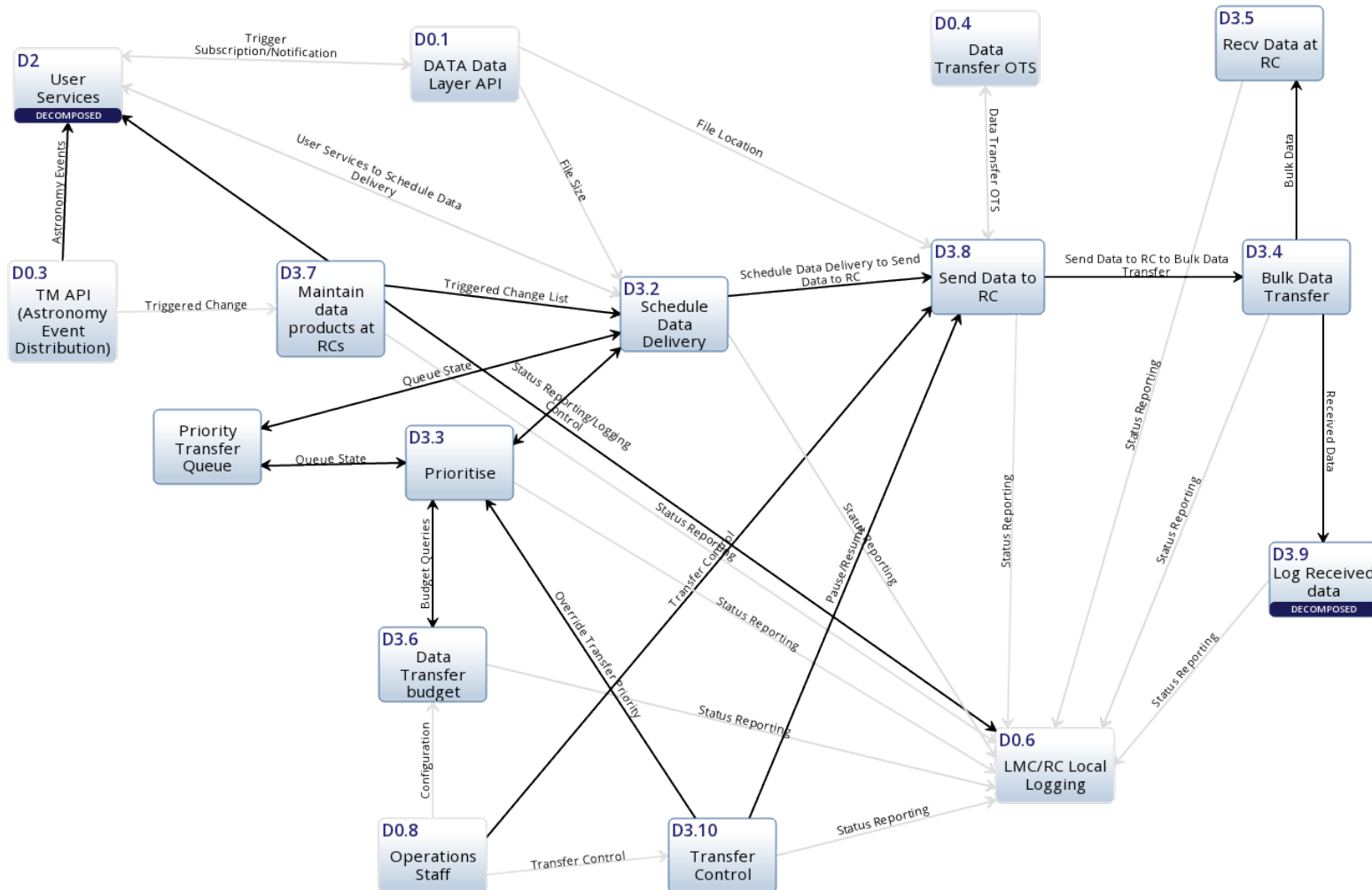
Regional Centres

- Regional Centres not funded within SKA cost cap
- Recommend they provide capabilities to worldwide SKA community
  - Cache/redistribute data, support point to point network links, monitor network links, provide common software stack, enable use of regionally funded systems
- Assume RCs trusted by SKA
  - Enforce access control, log and report data access
- Agreements with SKA office will enable science

Networks : WAN

- SADT responsible for WAN connectivity to SKA
- DELIV looking at optimizing how WAN is used
- WAN needs to carry :
  - Data replication (bulk) and download
  - Data search information
  - Interactive access to main SDP sites
  - "A&A" information from SKA
  - Data access information to SKA
  - VLBI data (4-10Gb/s)

Possible WAN Interface
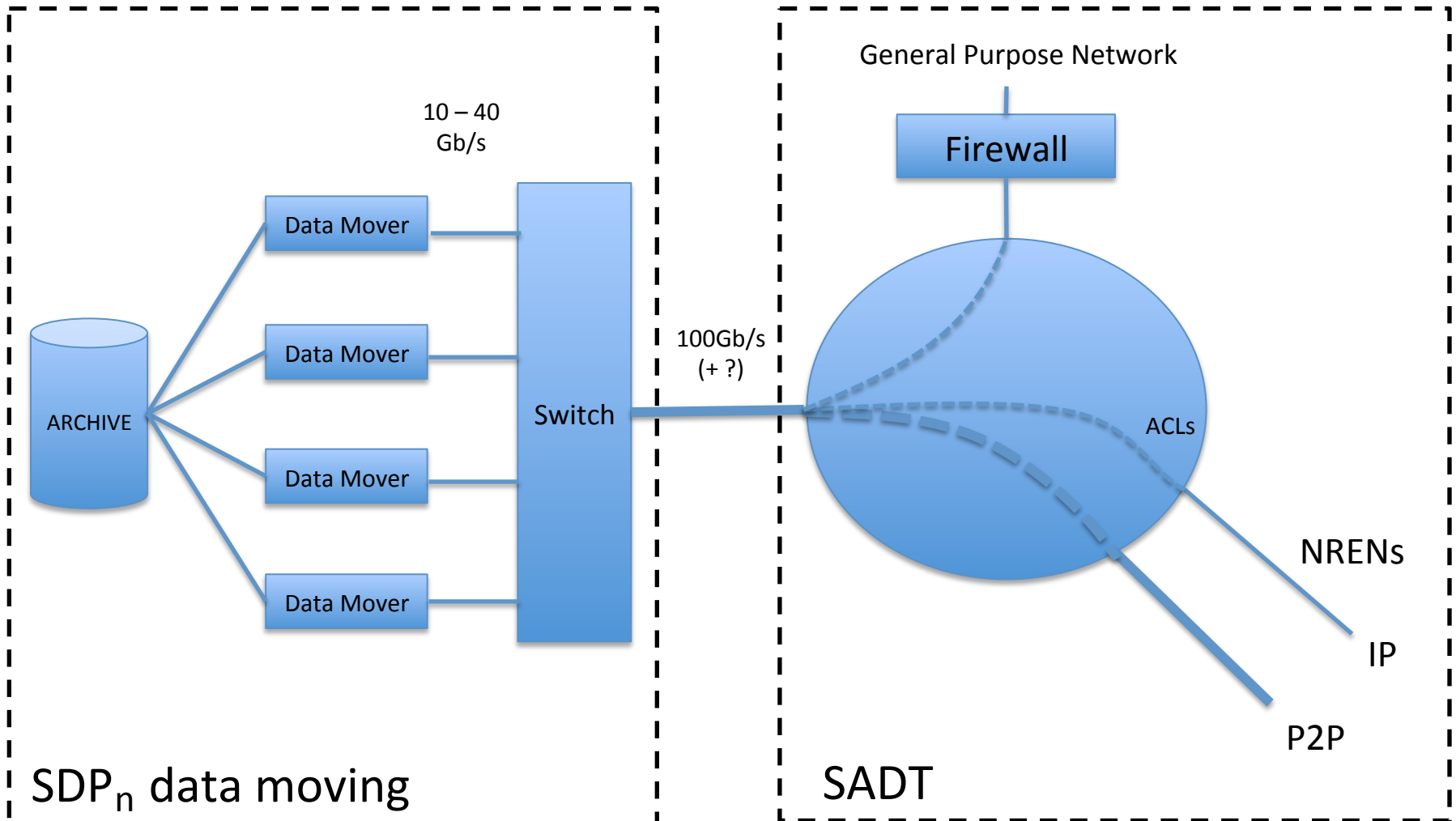
WAN technologies

- WAN bandwidth improvements
  - Butter's Law – bandwidth doubles every 9 months
  - Price stays the same, bandwidth increases
  - Current research networks deploying 100Gb/s
  - Current technology demonstrators - 1.4Tb/s

Other :
- Overlay networks
  - Various uses including segment optimization
- Software Defined Networks (e.g., OpenFlow)
  - Redirect P2P paths when needed
  - Deliver to multiple targets concurrently
- Bandwidth-on-demand
  - Assign lightpaths / guarantee bandwidth on shared paths

Technology exploration

- Level 0 – low level tools and protocols
  - RDMA, SDN, Messaging

- Level 1 – Data Transfer
  - GridFTP, FDT, bbcp, Aspera, …
- Level 2 – Data Distribution and Management
  - iRods, NGAS, OODT, FhEDEx, CEPH, …
- Level 3 – User
  - Portals (Elgg, Drupel, Joomia, ..), Remote Visualization (Pureweb, NICE,…), IVOA tools

- Other
  - Data Models (ObsCore), Processing frameworks

DELIV looking at tool use in big data projects

Web Portal : e.g., Cyberska

- Need interface to search, download and analyze data and enable collaboration

CyberSKA Motivation

- Most SKA key science goals will be achieved via large-scale survey type observing programs
  - Very high data rates and volumes
  - Complex, multi-purpose, processing and analysis
  - Executed by globally distributed teams of researchers
- Drives the need for cyberinfrastructure solutions for
  - Data storage, management and distribution
  - Data processing, analysis and visualization
  - Collaboration tools

  (Tools developed with Calgary Scientific (PureWeb) and IBM Canada)
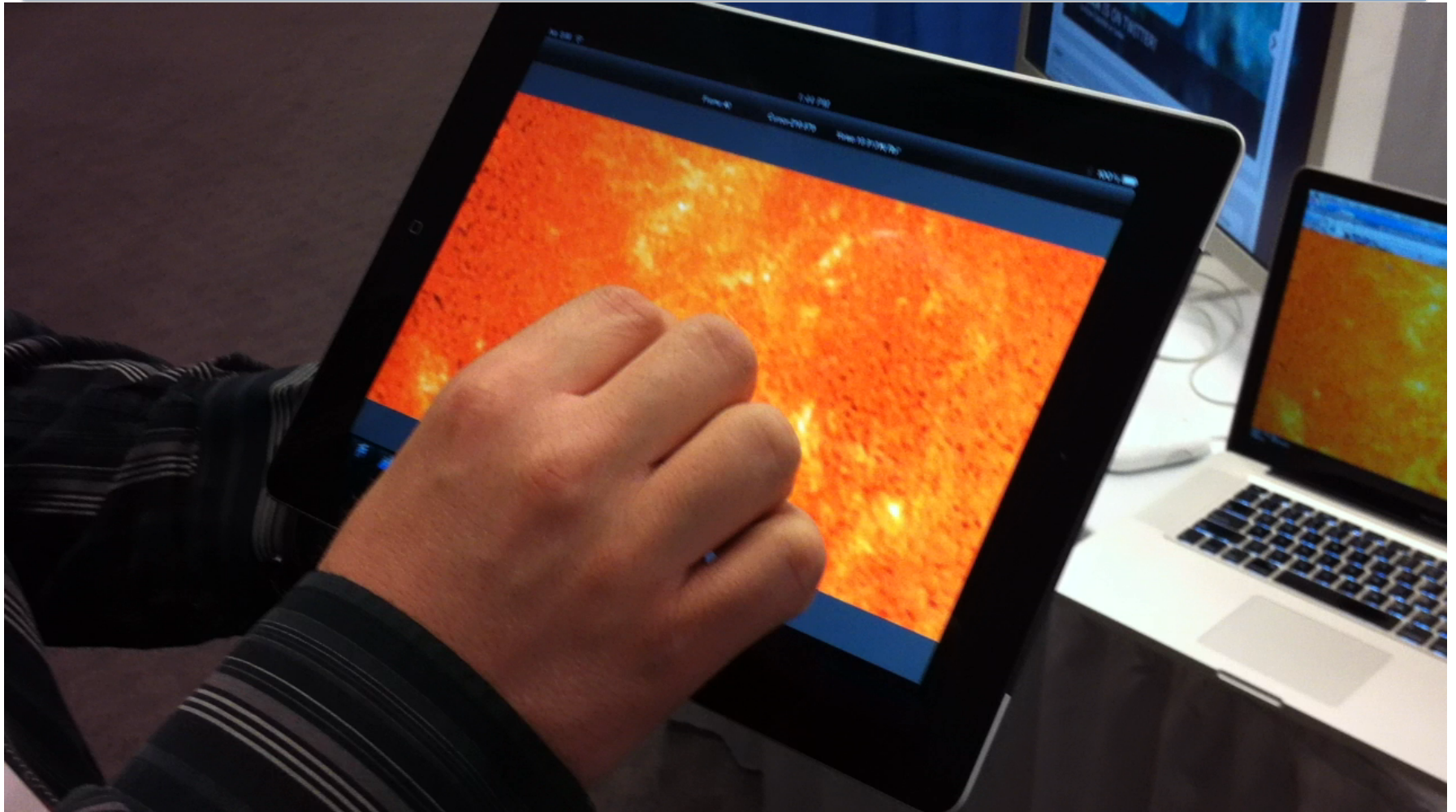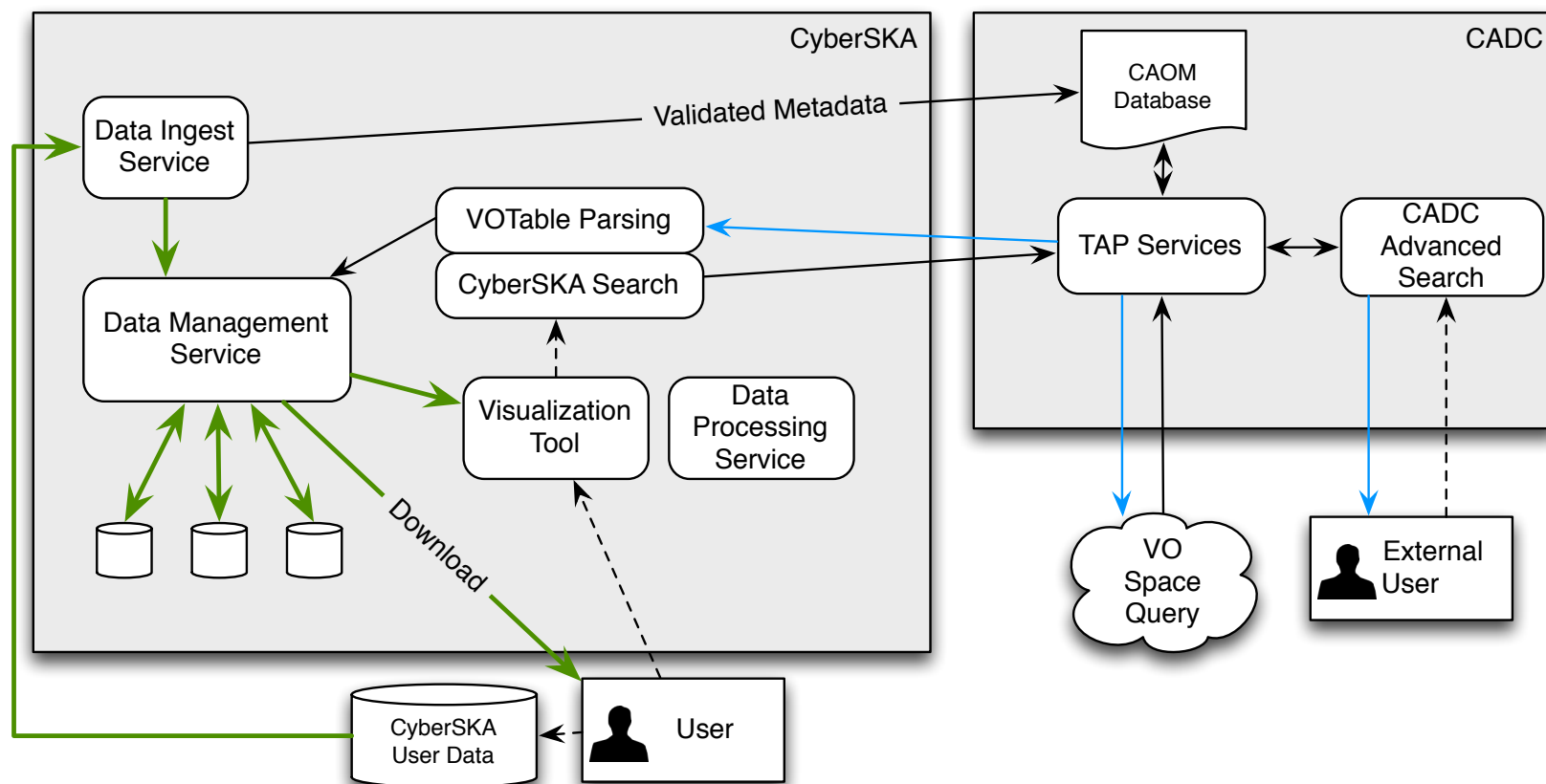
Initial CyberSKA architecture
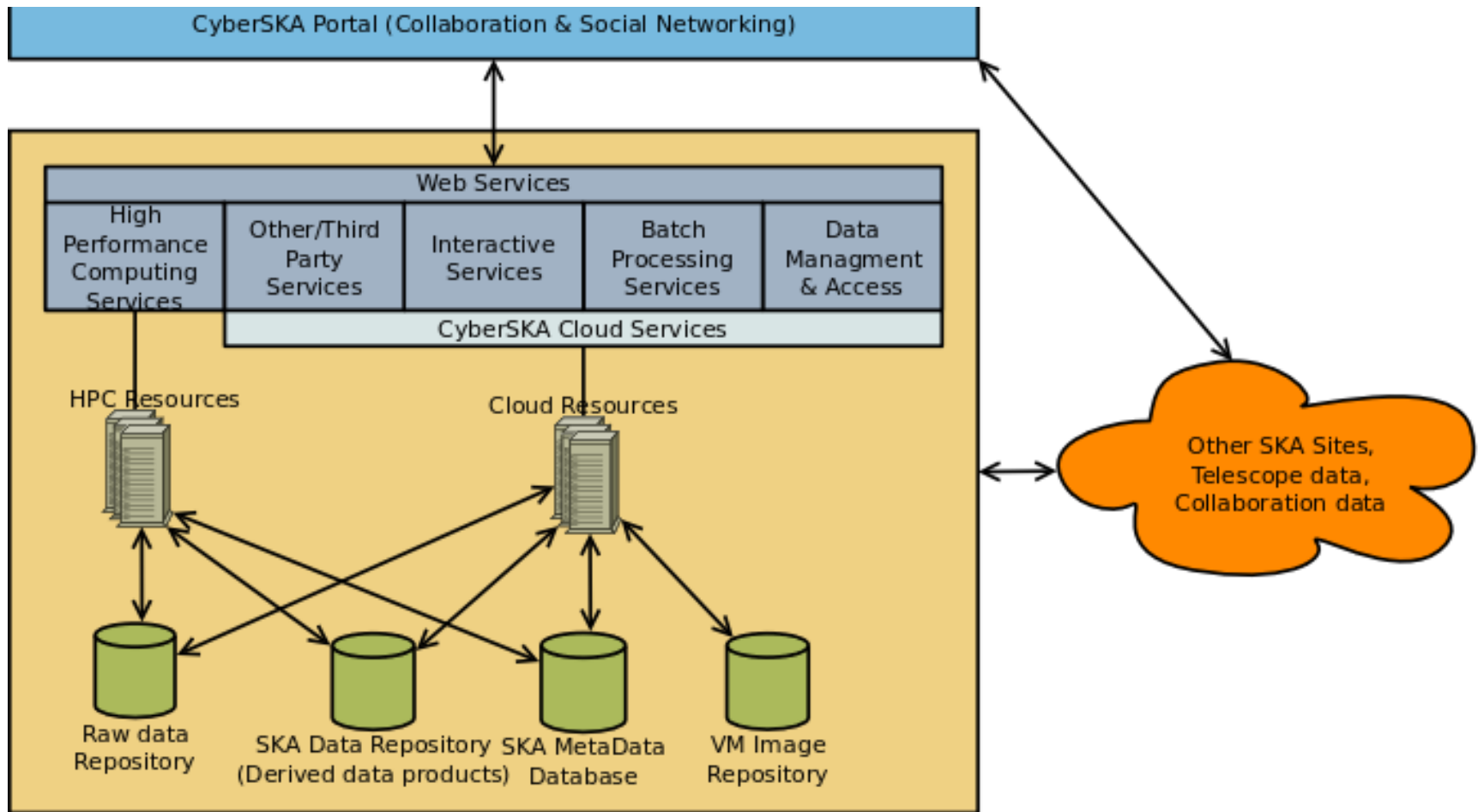
Remote Viewer
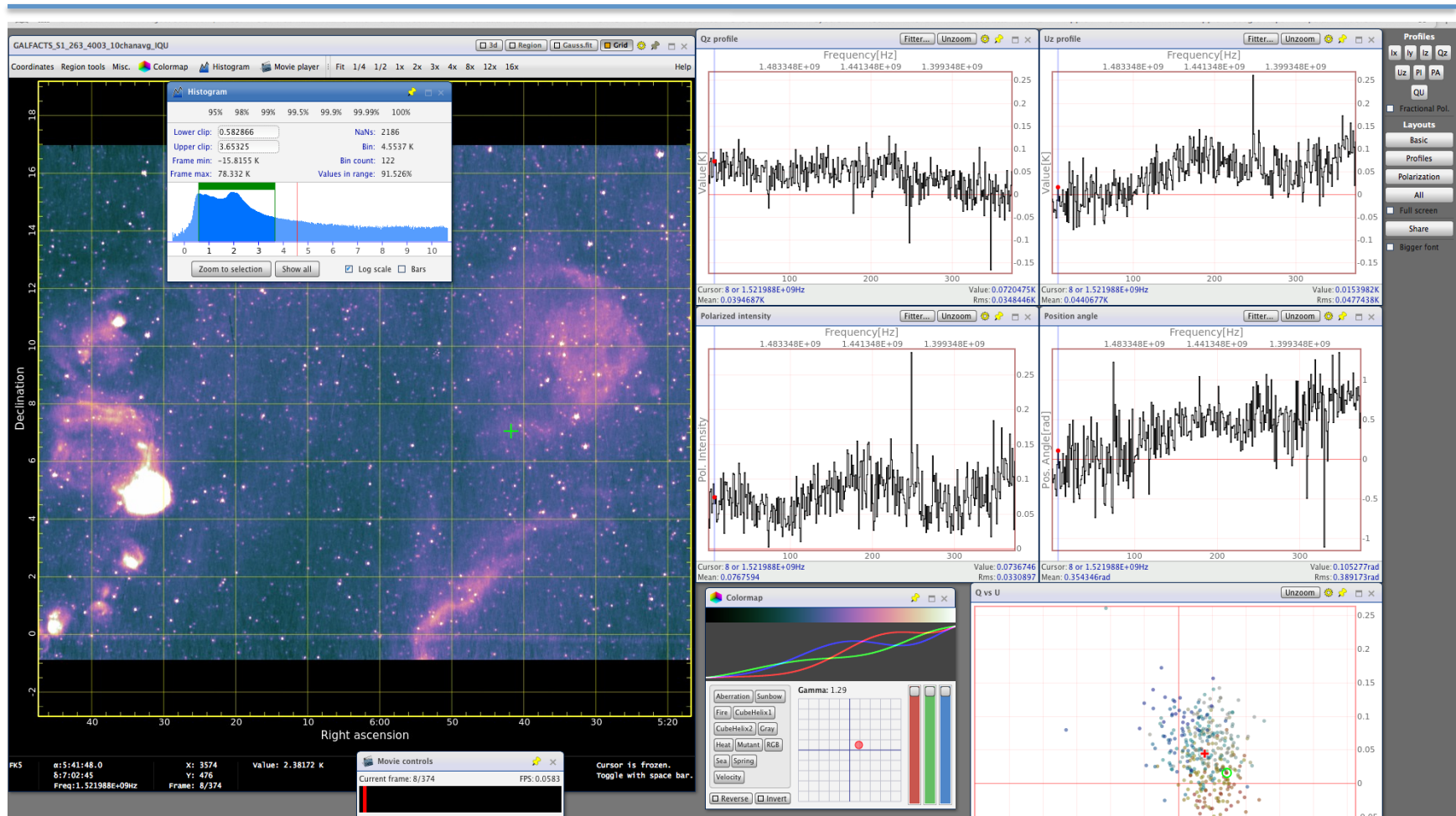
Visualization demo

IVOA interface (CADC)

CyberSKA:
Imaging Survey Use Case

Arecibo Observatory

Expanded Very Large Array (EVLA)

Giant Metrewave Radio Telescope (GMRT)

courtesy of the NAIC - Arecibo Observatory, a facility of the NSF


courtesy of the NRAO (National Radio Astronomy Observatory)

courtesy of the Tata Institute of Fundamental Research

- GALFACTS (Arecibo)
- Deep Polarization Field Surveys (EVLA, GMRT)
- CyberSKA:
  - Used for sharing documents, creating wiki pages, having discussions and bookmarking resources
  - Enables on-line visualization of remote data sets
  - Provides access to GALFACTS survey data and third party applications for running data processing pipelines or source counting
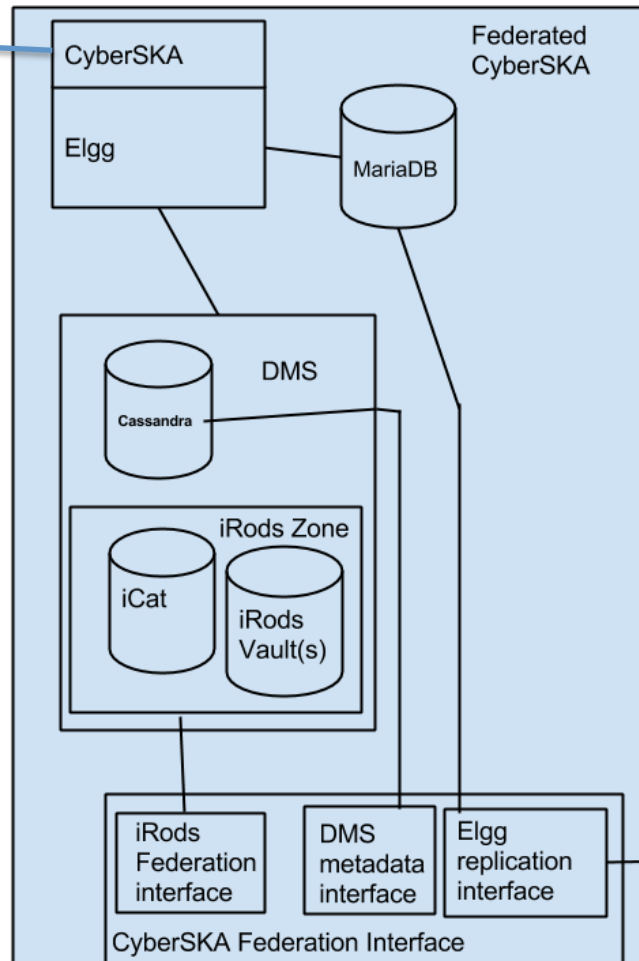
Enabling Discovery

- Pulsar Search Project – 69 global collaborators
  - Collaborative data processing and third-party applications
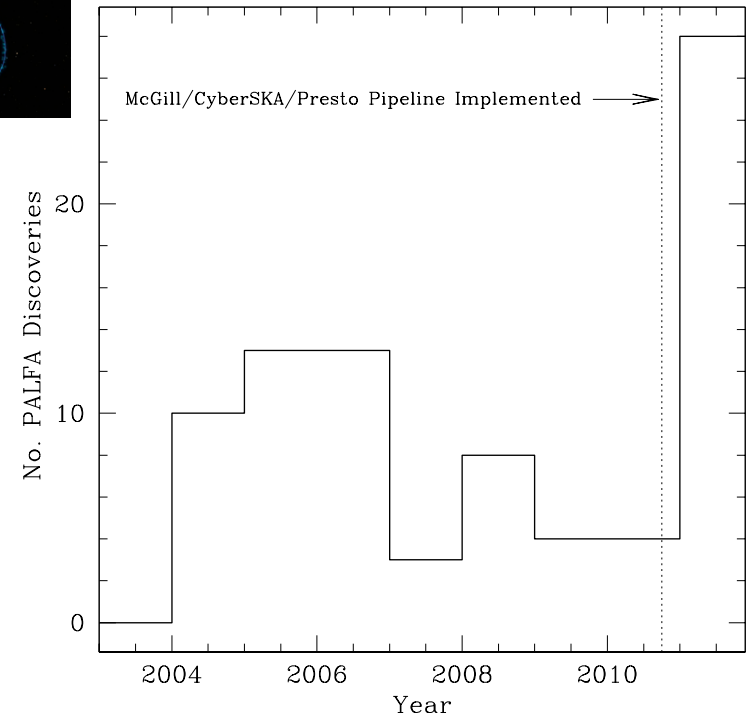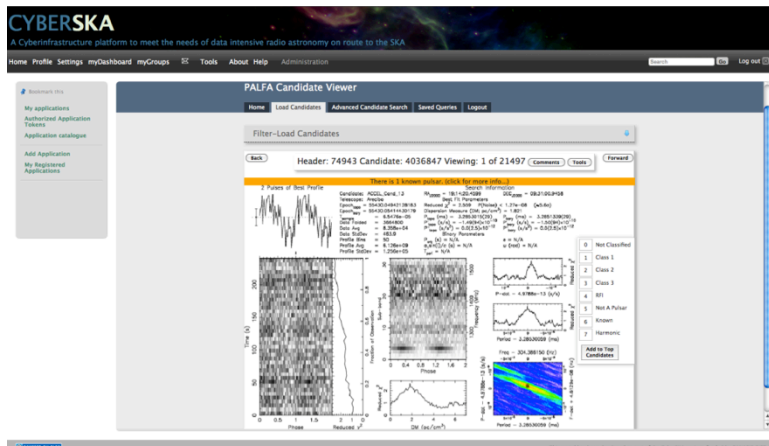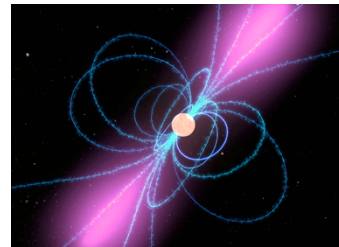
Federated CyberSKA

- Experimental/prototype platform for exploring distributed access
- Portal data shared using multi-master MariaDB
- File metadata shared using Cassandra replicated DB
- Separate iRods zone in at each portal instance

DELIV: Testbed

- Deploying :
  - portal tools for exploration by scientists
  - data movement/management tools to gain understanding of current solutions
    - Aim to integrate best tools in later stages
- Currently running PI tools (federated CyberSKA) in Calgary, at Rackforce in Kelowna and at CHPC in Cape Town.
- Starting testing data movement tools in Calgary, Oxford and at CHPC
- Plan to deploy PI tools at iVec Nov. 2014
- Started discussions with Groningen – host of LOFAR data

Summary

- SKA will produce huge amount of data
- SDP.DELIV defining requirements and architecture for SKA data access by users
- Considering tools and best practices from existing distributed big data projects
- Deploying testbed to gain feedback on interface requirements and explore tools

Contact Information

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