SCS Space and SKA

View of South African Industry

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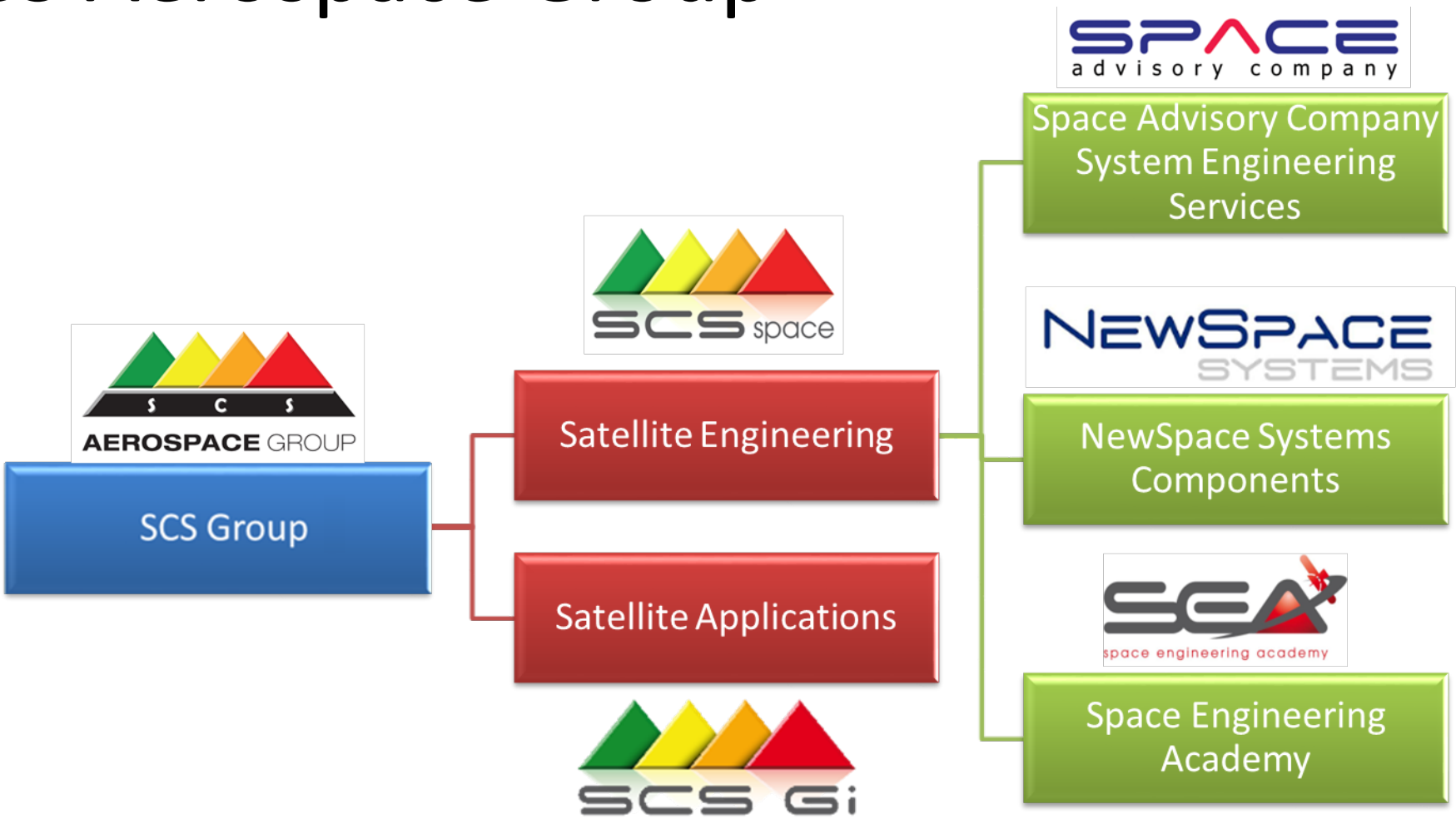
www.scs-space.com

3rd MIDPREP/AAMID Workshop. Cape Town, South Africa. 09 March 2016

SCS Aerospace Group



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SKA SQUARE KILOMETRE ARRAY SDP SCIENCE DATA PROCESSOR

SCS Aerospace Group

SCS Aerospace Group is a South African company with expertise in the design, develop, manufacture, test, launch and operation of Remote Sensing and Earth Observation Satellites

- The team has a **proven track record** successfully delivering large, complex, **highly technical, multi-disciplinary systems** and programmes internationally
- Our knowledge based on **industry experience** supported by a strong management and delivery capability
- We provide **professional and expert technical and engineering services** of a verified high quality
- We tailored the design to **ensure successful programme outcome**
- Team achieves results due to **extensive experience** working on **multiple successful programmes**

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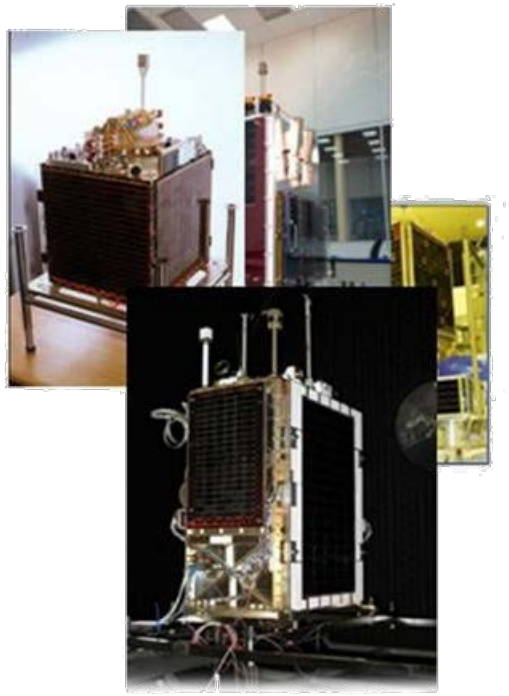
SCS Space

SCS Space focusses on delivering systems and sub-system solutions and products to the market

- The satellite engineering team has more than 20 years experience in micro- and mini-satellites
- Satellites have been designed, built, tested, launched and operated
- The team designs satellites with major components selected from the international market, but also has the in-house capability to deliver all major components
- The latest operational satellite has been launched in 2014 and is operating as expected (customer reserves right on any announcements)



Micro Satellites
50 kg to 200 kg

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Space Advisory Company (SAC) & SKA

- Why is SCS (and SAC) interested in the SKA project?
  - Management of data at globally distributed ground stations and processing sites
  - Processing large data volumes for near real-time satellite data applications
  - Distribution of large data volumes to globally distributed end-users
- This led to a natural interest in the Science Data Processor.
- SAC is involved in the following areas:
  - Systems Engineering (main focus)
  - Compute Platform
  - Delivery System
  - Data Layer work package

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SDP Challenge unique among comparable astronomy systems

- SDP is an intrinsic element of the SKA telescopes; not a separately scheduled remote processing facility. Hence:
- The computational requirements to process the incoming data into scientific useful data products are significantly greater (~ two orders of magnitude) than the largest systems currently used in astronomy.

Atacama Large Millimetre Array (ALMA), Chile

MeerKAT, Northern Cape, South Africa.

SDP Challenge is unique among comparable systems in astronomy:

- Computing hardware capital costs and operational costs associated with compute hardware become very important considerations.
- A high degree of parallelism need to be applied to the processing of each observation. Unlike typical situation at radio-interferometric facilities where many observations are processed in parallel but with a limited degree of parallelism in the processing of each observation.
- Very high raw data rate makes it unlikely to be kept permanently. Petabytes of data generated from 197 dishes (19306 baselines); 65536 frequency channels; very high data rates; long integration periods. Temporary storage duration needs to be minimised (~ 6 hours) implies data processing and QA needs automation with little or no human intervention.

SDP challenge

- The SDP will need to perform some data processing within strict deadlines (e.g., around 15s for real-time calibration).
- Over the telescope's 50-year lifespan, the SDP must have sufficient flexibility to allow for continual long term improvement and upgrades as key science objectives and SDP element requirements evolve. If the antenna arrays are upgraded, then the SDP will need a corresponding upgrade in processing ability.
- The lifetime of the telescope, the lifetime of the compute hardware, and need to minimise power consumption, will require the SDP hardware element to be refreshed or completely replaced on a relatively frequent timescale (~5 years). The software may need corresponding updates.

SDP Scope

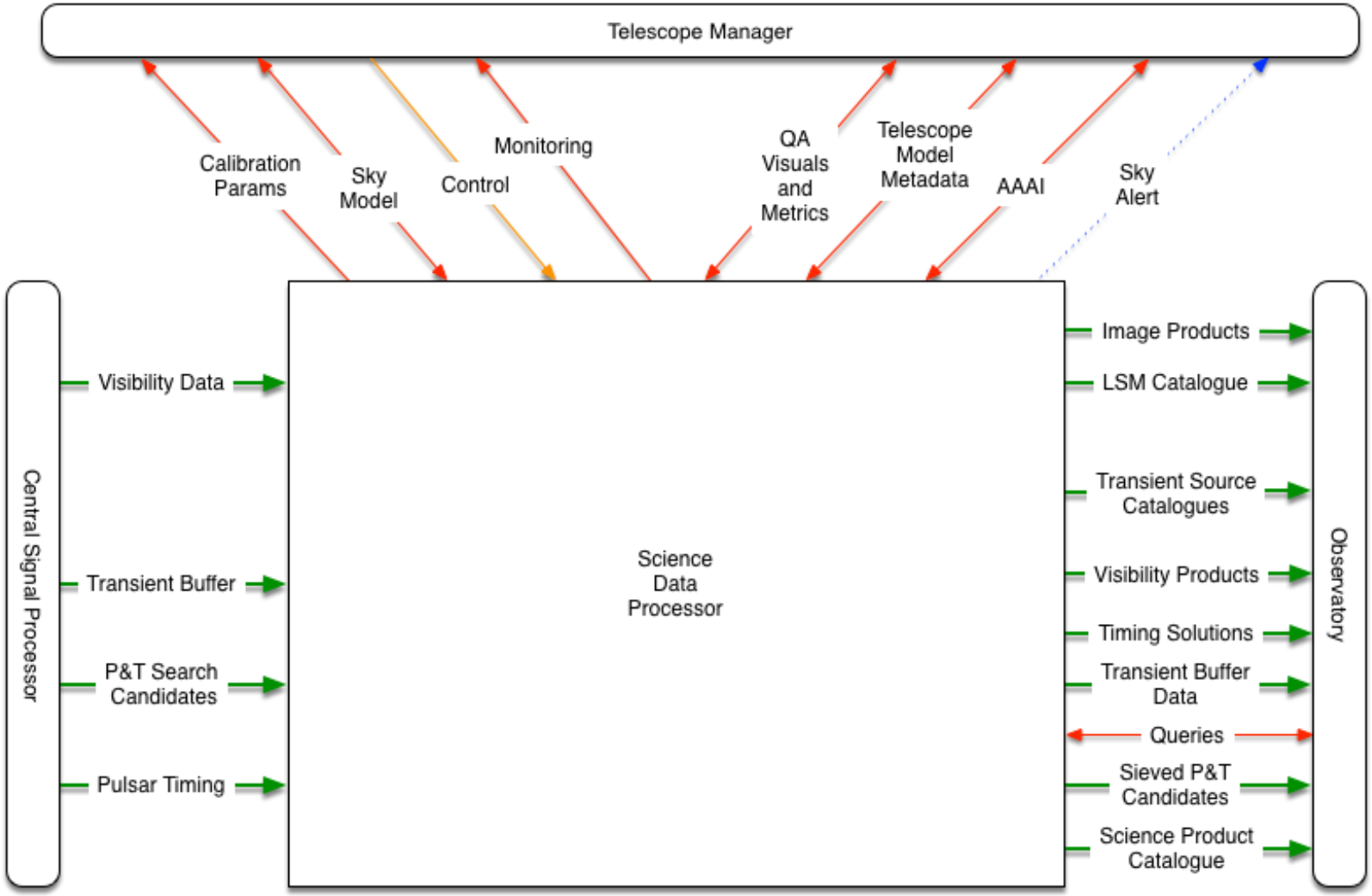
SDP is responsible for the (real-time) **processing of various observed data** into

- science-ready data products,
- the long term preservation of these data products and
- the delivery of these products to end-users and regional science and engineering centres across the globe.

SDP is also responsible for (real-time) **computing feed-back information** to the SKA system for

- calibration solutions,
- the generation of alerts,
- providing additional metadata to describe provenance of data and QA information to assess the efficacy and scientific quality of the processing

SDP Scope



SDP Scope Concept Diagram illustrating how raw astronomic data is input from the CSP and combined with data and metadata input from the TM to process and output as Science Products which can be queried.

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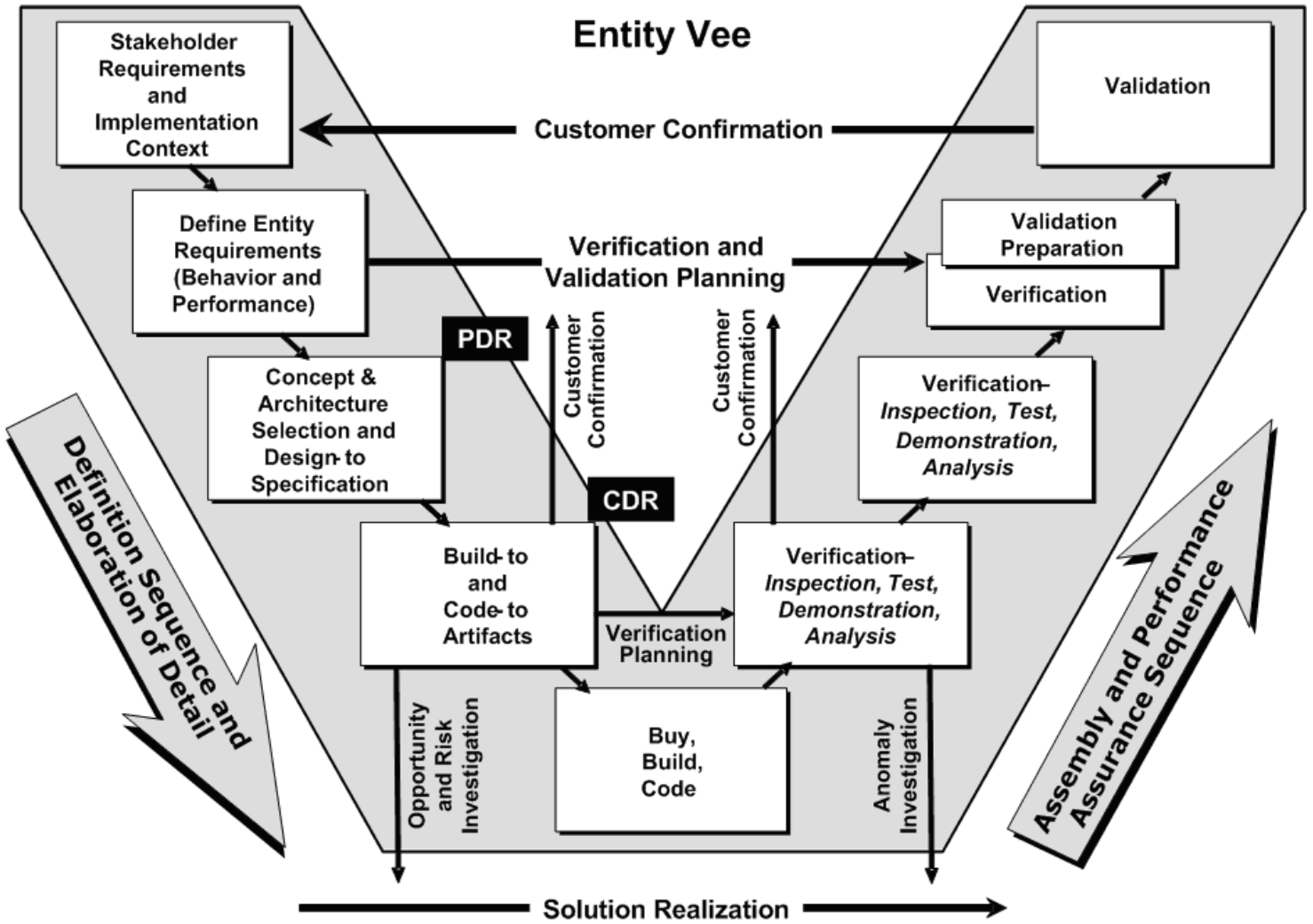
SDP Systems Engineering

- Key activities leading up to PDR
  - Requirements analysis
  - Modelling (functions, products, interfaces, requirements, use cases, etc.)
  - Parametric modelling
    - Performance, Power and Cost
  - Risk Analysis
  - Interface Management
- Key activities leading up to CDR
  - Design Verification (by test, by analysis, etc.)

System “V” Development Cycle Diagram



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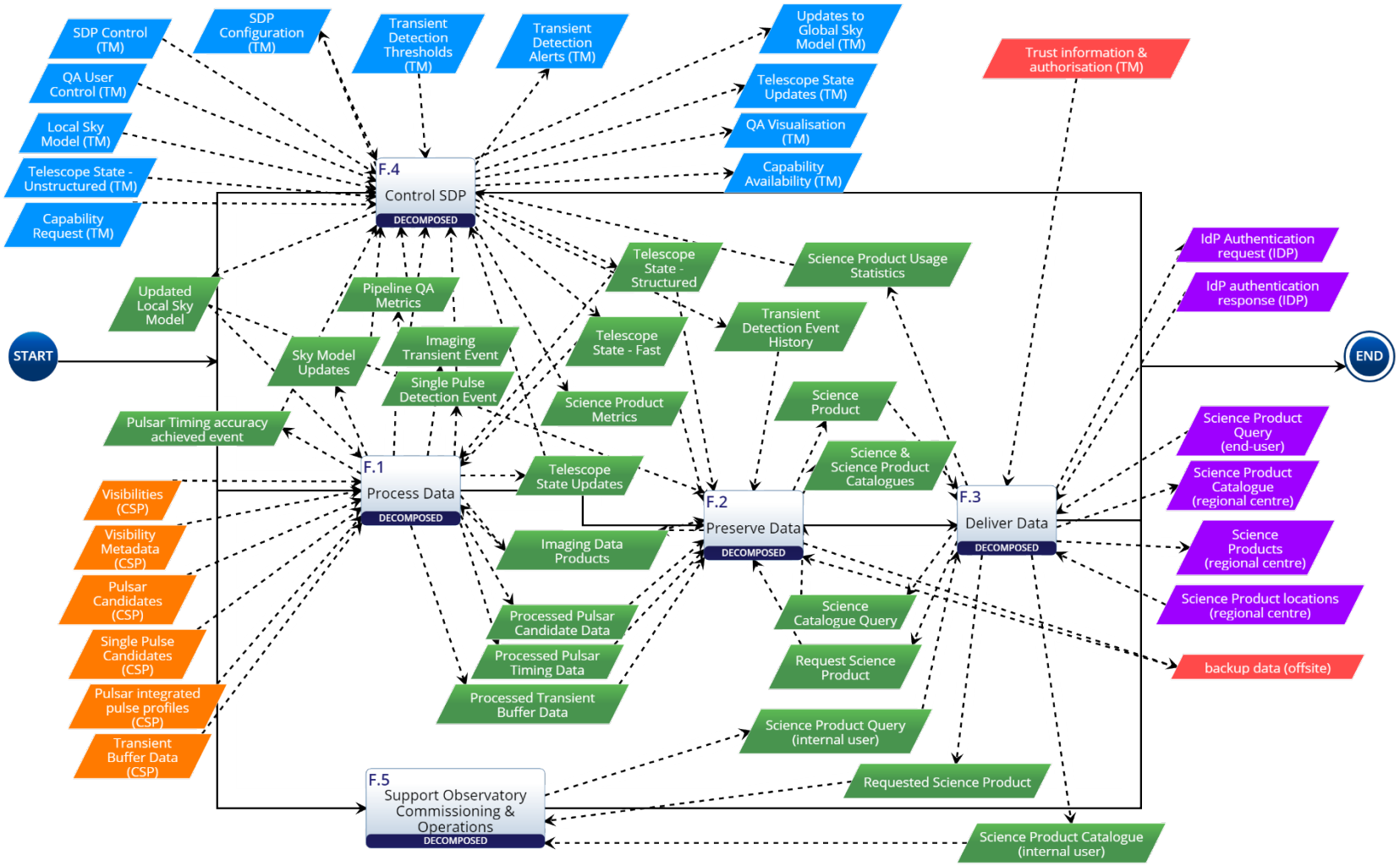
SDP modelling – Functional Model



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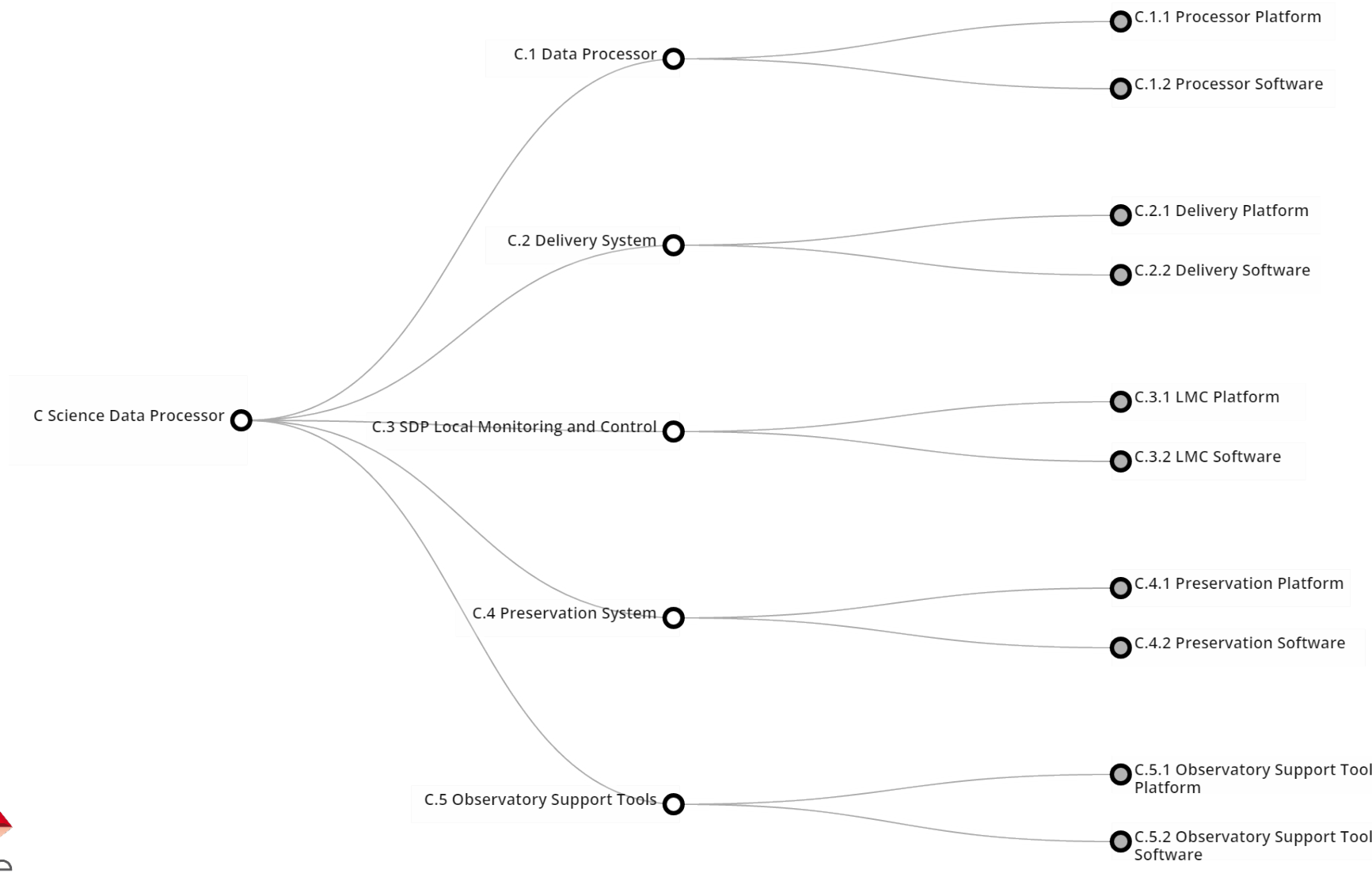
SDP modelling – Product Breakdown



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SDP modelling – Allocations

Functions \ Products	C Science Data Processor	C.1 Data Processor	C.1.1 Processor Platform	C.1.2 Processor Software	C.2 Delivery System	C.2.1 Delivery Platform	C.2.2 Delivery Software	C.3 SDP Local Monitoring and Control	C.3.1 LMC Platform	C.3.2 LMC Software	C.4 Preservation System	C.4.1 Preservation Platform	C.4.2 Preservation Software	C.5 Observatory Support Tools	C.5.1 Observatory Support Tools Platform	C.5.2 Observatory Support Tools Software
F SDP Functions	X															
F.1 Process Data		X														
F.1.1 Switching			X													
F.1.2 Receive Visibilities			X	X												
F.1.3 Pre-process Fast			X	X												
F.1.4 Calibrate Real-time			X	X												
F.1.5 Image Fast			X	X												
F.1.6 Detect Imaging Transient Candidates			X	X												
F.1.7 Buffer Data			X	X												
F.1.8 Pre-process data			X	X												
F.1.9 Calibrate and Image			X	X												
F.1.10 Receive Pulsar Timing Profiles			X	X												
F.1.11 Receive Pulsar Candidates			X	X												
F.1.12 Receive Transient Buffer			X	X												
F.1.13 Process Pulsar Timing			X	X												
F.1.14 Process Pulsar Candidates			X	X												
F.1.15 Process Transient Buffer			X	X												
F.1.16 Manage Data Lifecycle			X	X												
F.1.17 Execute Processing				X												
F.2 Preserve Data											X					
F.2.1 Persist Science Products												X				
F.2.2 Index Science Products													X			
F.2.3 Stage data products												X	X			
F.2.4 Backup Science Products												X				
F.3 Deliver Data					X											
F.3.1 AAAI							X									
F.3.2 Prepare Science Products						X	X									
F.3.3 Query and Request Data						X	X									
F.3.4 Deliver Data to User						X	X									
F.4 Control SDP								X								
F.4.1 Visualise Quality Assessment Metrics									X	X						
F.4.2 Manage Local Telescope State									X	X						
F.4.3 Aggregate QA Metrics									X	X						
F.4.4 Manage Local Sky Model									X	X						
F.4.5 Produce Fast Telescope State									X	X						
F.4.6 Master Control									X	X						
F.4.7 Manage Science Events									X	X						
F.5 Support Observatory Commissioning & Operations														X		
F.5.1 Allow Observatory Access to Query																X
F.5.2 Allow Observatory Access to Request and Deliver																X
F.5.3 Visualise Data															X	X
F.5.4 Analyse Data															X	X
F.5.5 Create and Maintain Pipelines															X	X

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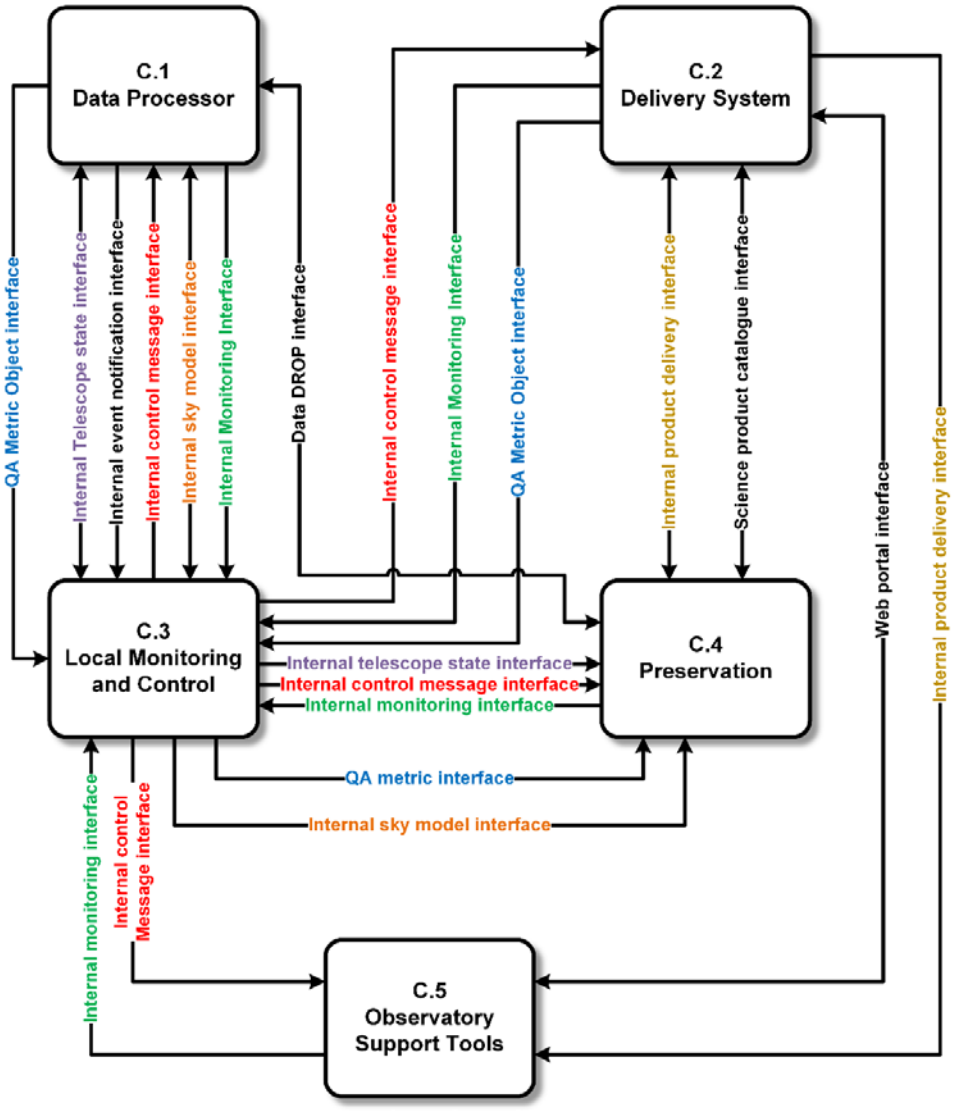
SDP modelling – internal interfaces



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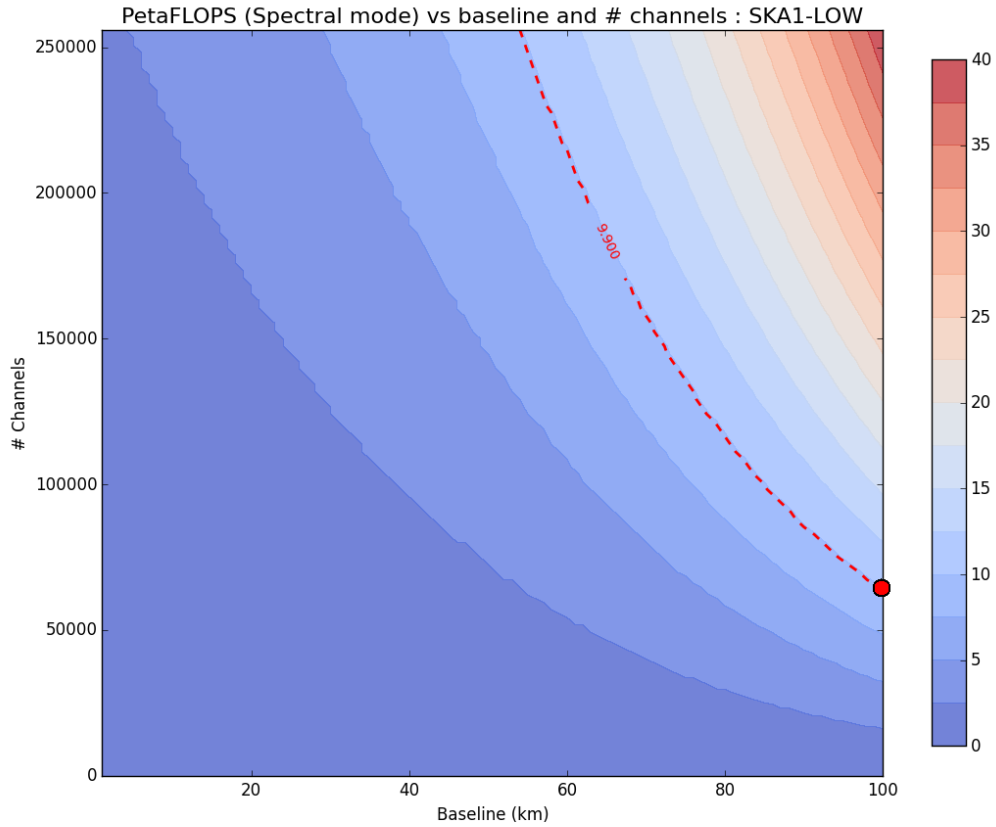
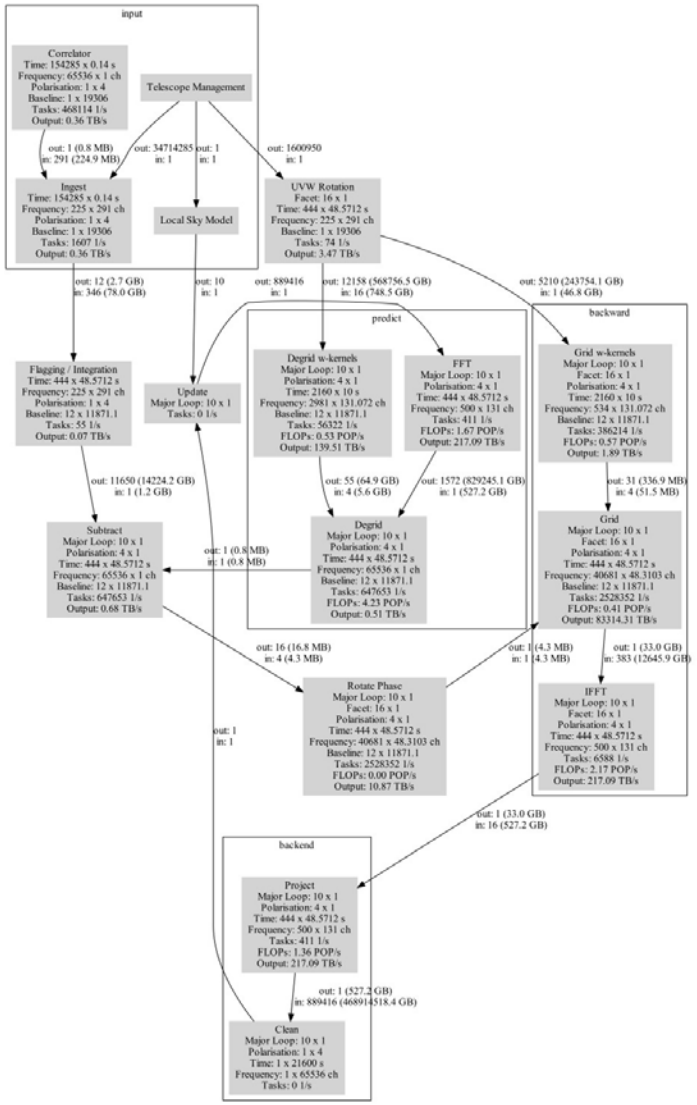
SDP modelling – Performance Model





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Lessons learn working on SKA1 SDP

- Start as early as possible (now) with Systems Engineering
  - Requirements traceability (from science requirements)
    - Allows assessment of impact to science when trade-offs are analysed.
  - Model performance and cost as detailed as you can and keep evolving the model
    - Model cost end-to-end, i.e. from receiver to end-user.
      - For SKA1 the cost of processing, preserving and distributing the data was underestimated before. Major trade-offs now have to be made to fit the budget.
  - Risk driven and iterative approach to manage the project is working well for SDP, the reasons are mainly:
    - Lots of unknown or poorly defined areas (for good reasons) at system level and therefore evolving system level design impacts the SDP design and project planning.
    - Risks and problems are uncovered layer by layer and plans need to be re-adjusted accordingly.

Thank you


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