SKAO

From SKA to SKAO

Early Progress in the SKA Project Construction

Juande Santander-Vela,
Head of Software Product Management

ICALEPCS'21 (October 2021)

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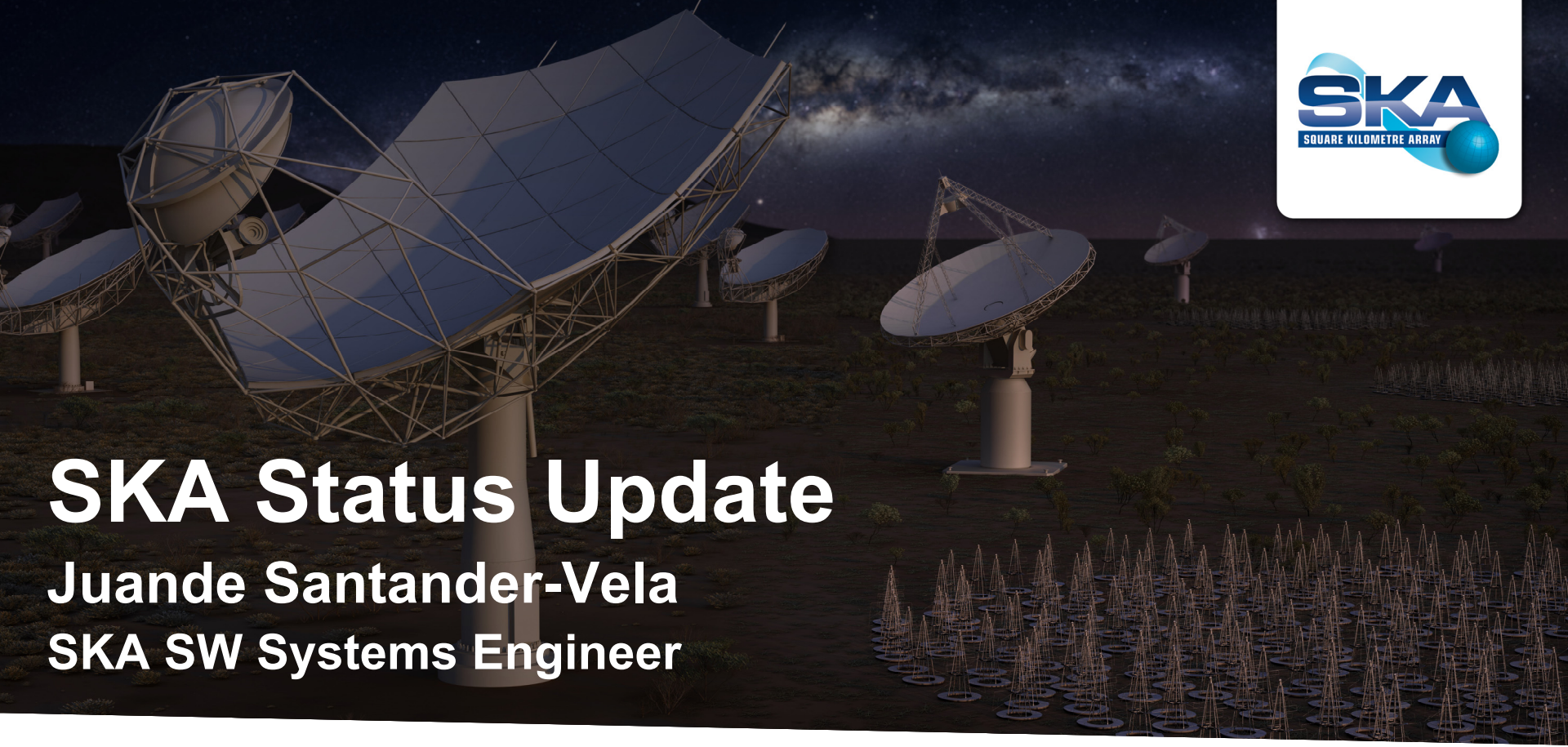

SKA Status Update

Juande Santander-Vela

SKA SW Systems Engineer

SQUARE KILOMETRE ARRAY

Exploring the Universe with the worlds' largest radio telescope

ICALEPCS2017

Barcelona · Spain, October 8-13 · Palau de Congressos de Catalunya

16th International Conference on Accelerator and Large Experimental Physics Control Systems

4 Years Ago!

SKA Status Update

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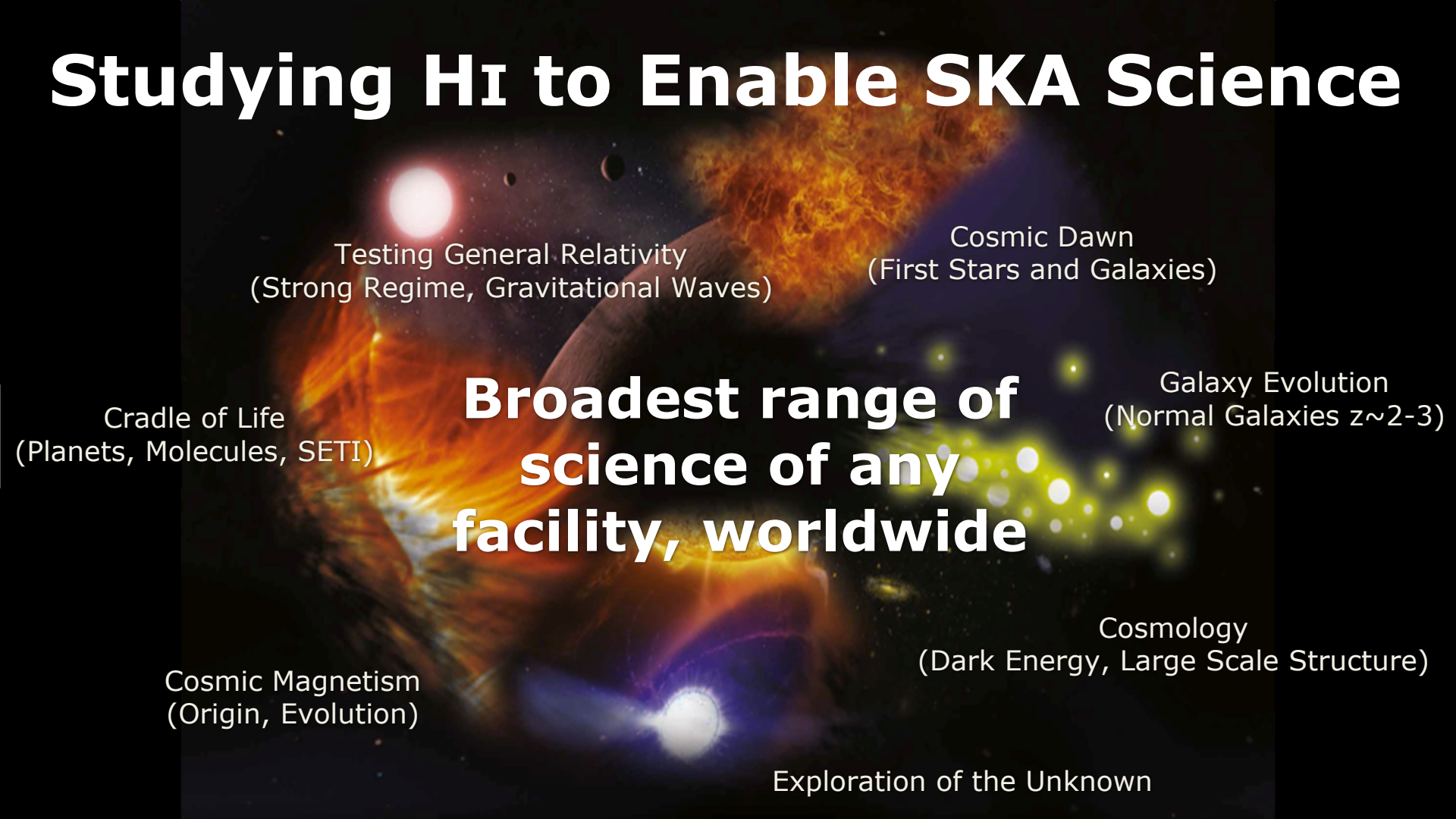
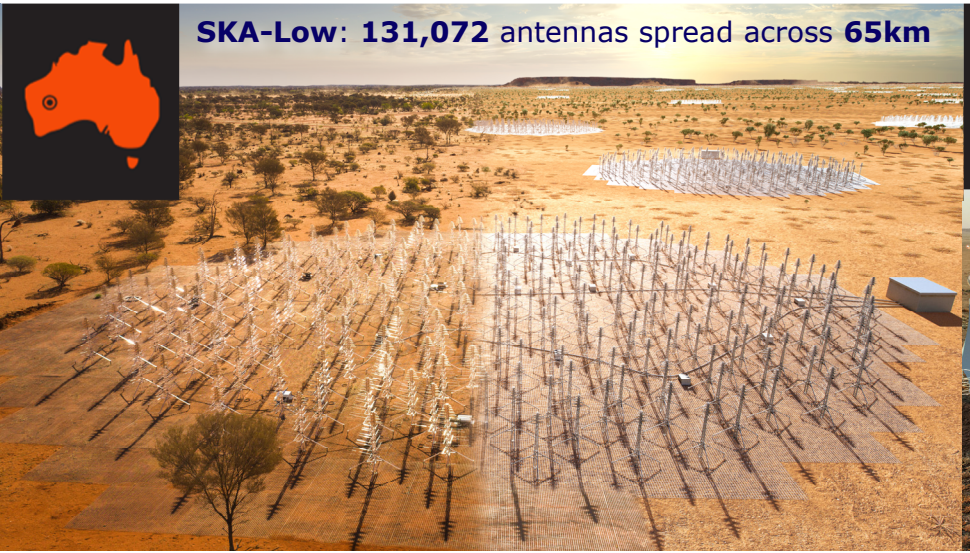
The SKA Project and SKA telescopes

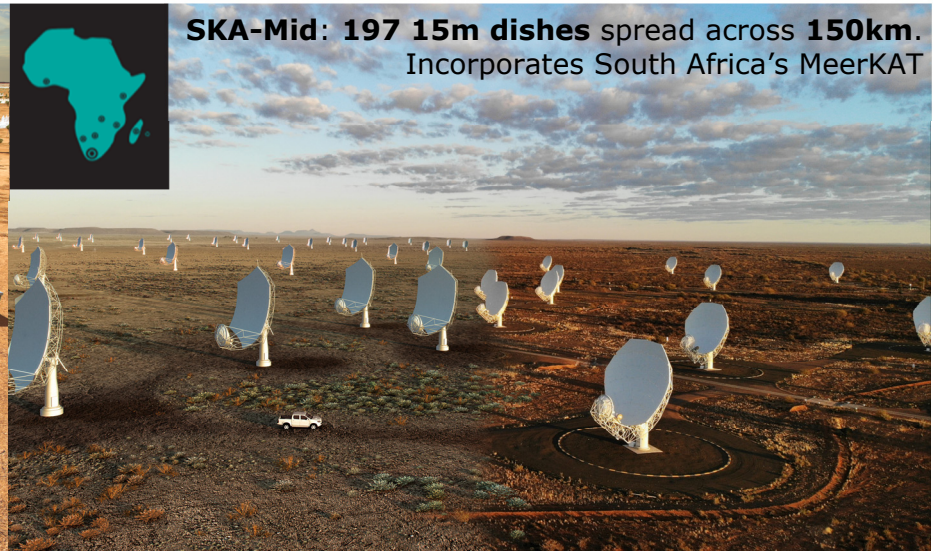
Studying HI to Enable SKA Science



SKAO and SKA Telescopes

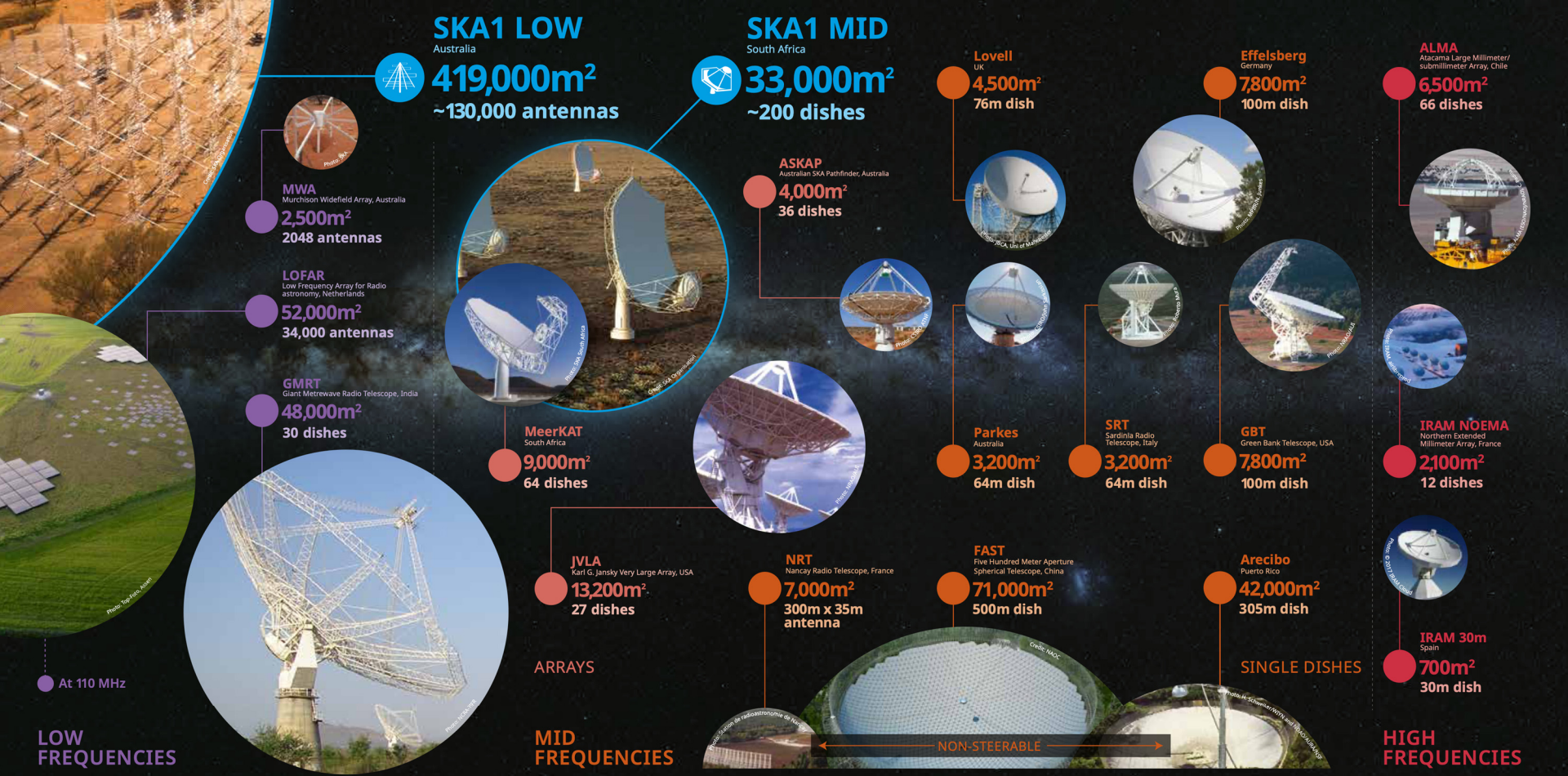
- A **global collaboration of 16 countries** which will build and operate the next-generation radio astronomy observatory
- Will be supported by a **global network of SKA Regional Centres** providing access to SKAO data
- 7-8 year construction schedule. Cost ~€2B (2020 euros) **for first 10 years**





SKA Phase 2: 2500 dishes across Africa; 1,000,000 antennas across Australia

Largest collecting area of any radio array in the world

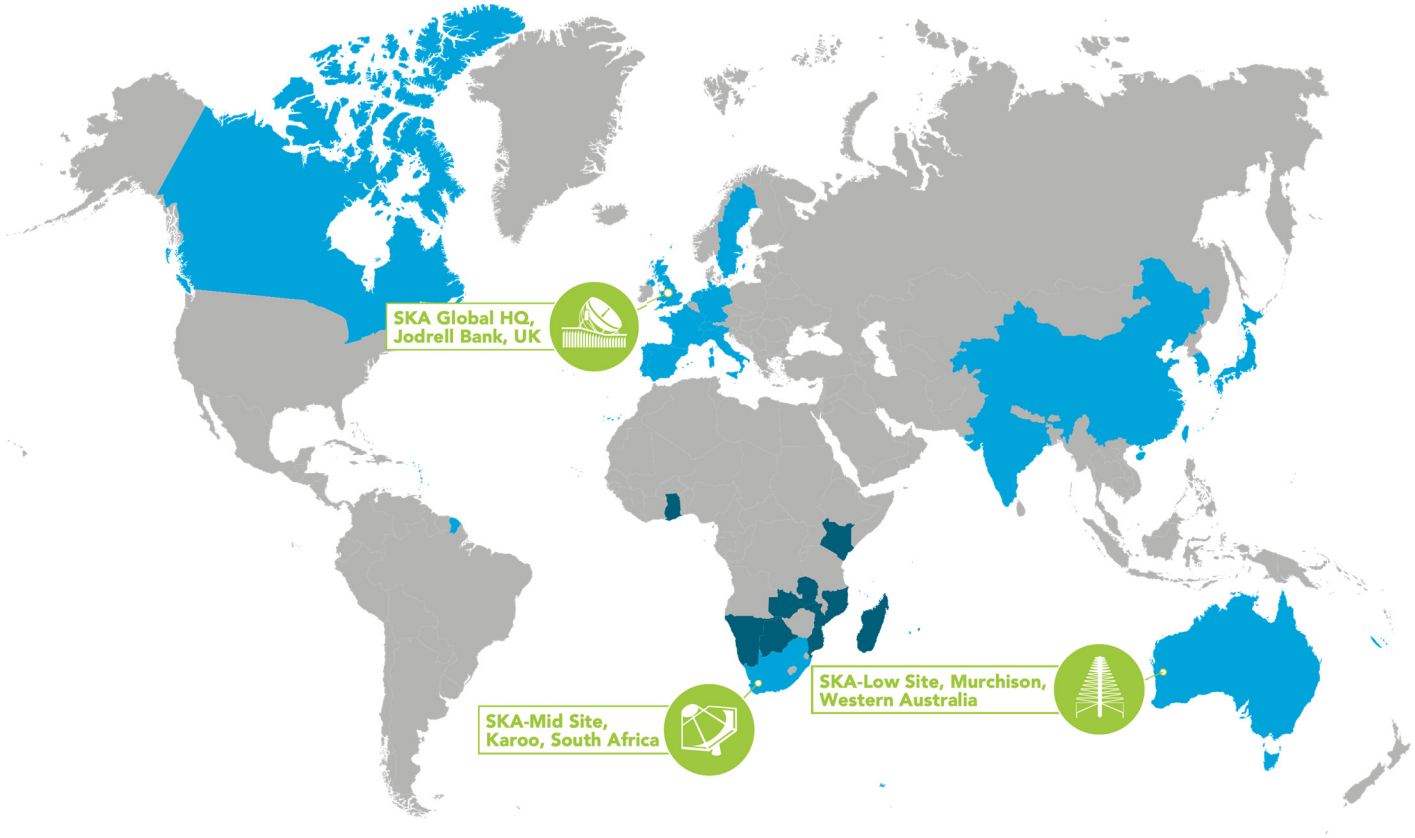


The Square Kilometre Array (SKA) will be the world's largest radio telescope, revolutionising our understanding of the Universe. The SKA will be built in two phases - SKA1 and SKA2 - starting in 2018, with SKA1 representing a fraction of the full SKA. SKA1 will include two instruments - SKA1 MID and SKA1 LOW - observing the Universe at different frequencies.

A telescope's capacity to receive faint signals - called sensitivity - depends on its collecting area, the bigger the better. But just like you can't compare radio telescopes and optical telescopes, comparison only works between telescopes working in similar frequencies, hence the different categories above.

The collecting area is just one aspect of a telescope's capability though. Arrays like the SKA have an advantage over single dish telescopes: by being spread over long distances, they simulate a virtual dish the size of that distance and so can see smaller details in the sky, this is called resolution.

SKAO and SKA Project World Map



SKA Partners – includes Members of the SKA Organisation – precursor to the SKAO –, current SKAO Member States*, and SKAO Observers (as of June 2021)

African Partner Countries

From SKA to SKAO and Start of Construction

SKA Project Timeline

SKA Project Timeline

SKA Project Timeline

2015 2017 2019 2021 2023

2015 2016 2017 2018 2019 2020 2021 2022 2023

NOW

5. Preliminary Design

5.1. Element Preliminary Design Reviews
Thu 1 Jan 2015 - Sat 31 Dec 2016

5.2. SKA Science Book
Fri 16 Sep 2016

5.3. System Preliminary Design Review
Fri 16 Dec 2016

6. IGO Treaty

6.1. IGO Negotiations Start
Mon 12 Oct 2015

6.2. IGO Treaty Initialing
Fri 25 May 2018

6.3. IGO Treaty Signature
Tue 12 Mar 2019

6.4. IGO Treaty Enters into Force
Fri 15 Jan 2021

6.5. First SKAO Council
Thu 4 Feb 2021

6.6. Transfer of SKA Organisation into SKAO
Sat 1 May 2021

7. Critical Design Reviews

SKA Project Timeline

Distributed nature and very resilient staff have help us a lot against COVID-19 schedule impacts!

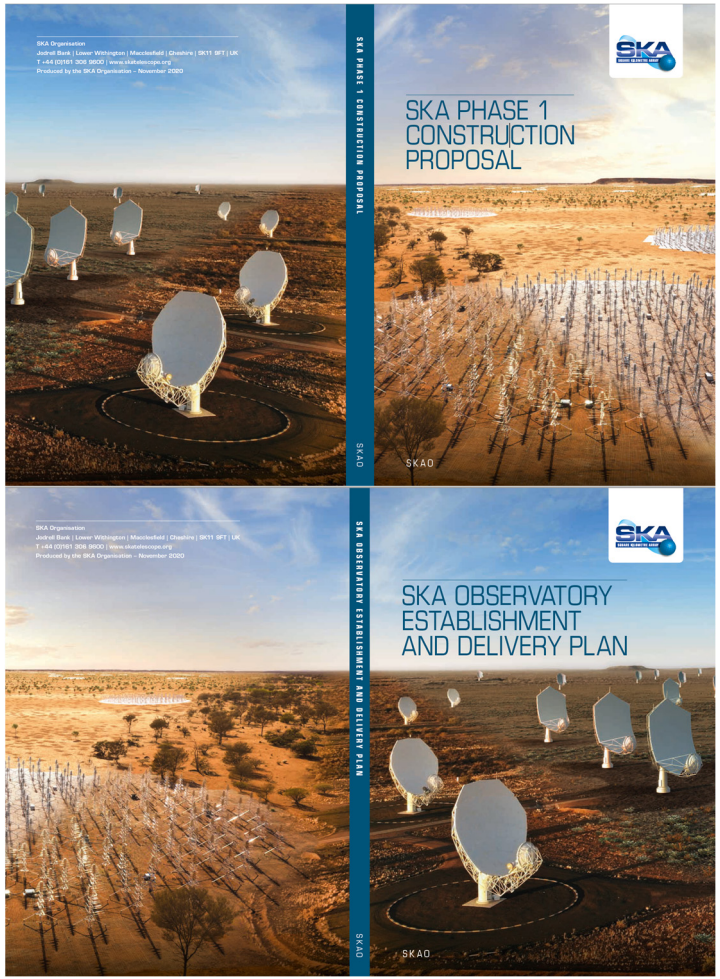
SKA Project Timeline

Distributed nature and very resilient staff have help us a lot against COVID-19 schedule impacts!

SKA Project Timeline

Documentation Submitted to Council for Approval

- SKA Observatory Establishment & Delivery Plan
  - Details staffing and costs for the SKA Observatory own delivery and supporting functions: Business enabling functions, Observatory operations, Observatory development, and Construction support.
- SKA Phase 1 Construction Proposal
  - Describes the science requirements for the project; what the scope of the project is; how the project will be executed, monitored, and controlled; wider benefits of the project to society; and a guide to the detailed project documentation, reference information, and its organisation



Recommendation

The Director-General recommends that the SKA Observatory Council approves *the commencement of the Construction of SKA-1 as described in the Technical Document and in accordance with the* ***Construction Proposal*** *(Project Execution Plan documents Revision 2) and the Staged Delivery Plan (Project Execution Plan documents Revision 3) and supported by the* ***Observatory Establishment and Delivery Plan****, recognising that the robust financial approvals, risk management and change management processes already in place will ensure that the financial commitments and deliverables of the Project remain clear and within the bounds of good governance.*

We recognise and acknowledge the Indigenous peoples and cultures that have traditionally lived on the lands on which our facilities are located.

SKAO

www.skao.int

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Approved! **To in July 1st 2021!**

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SKAO

~30 years to this moment!

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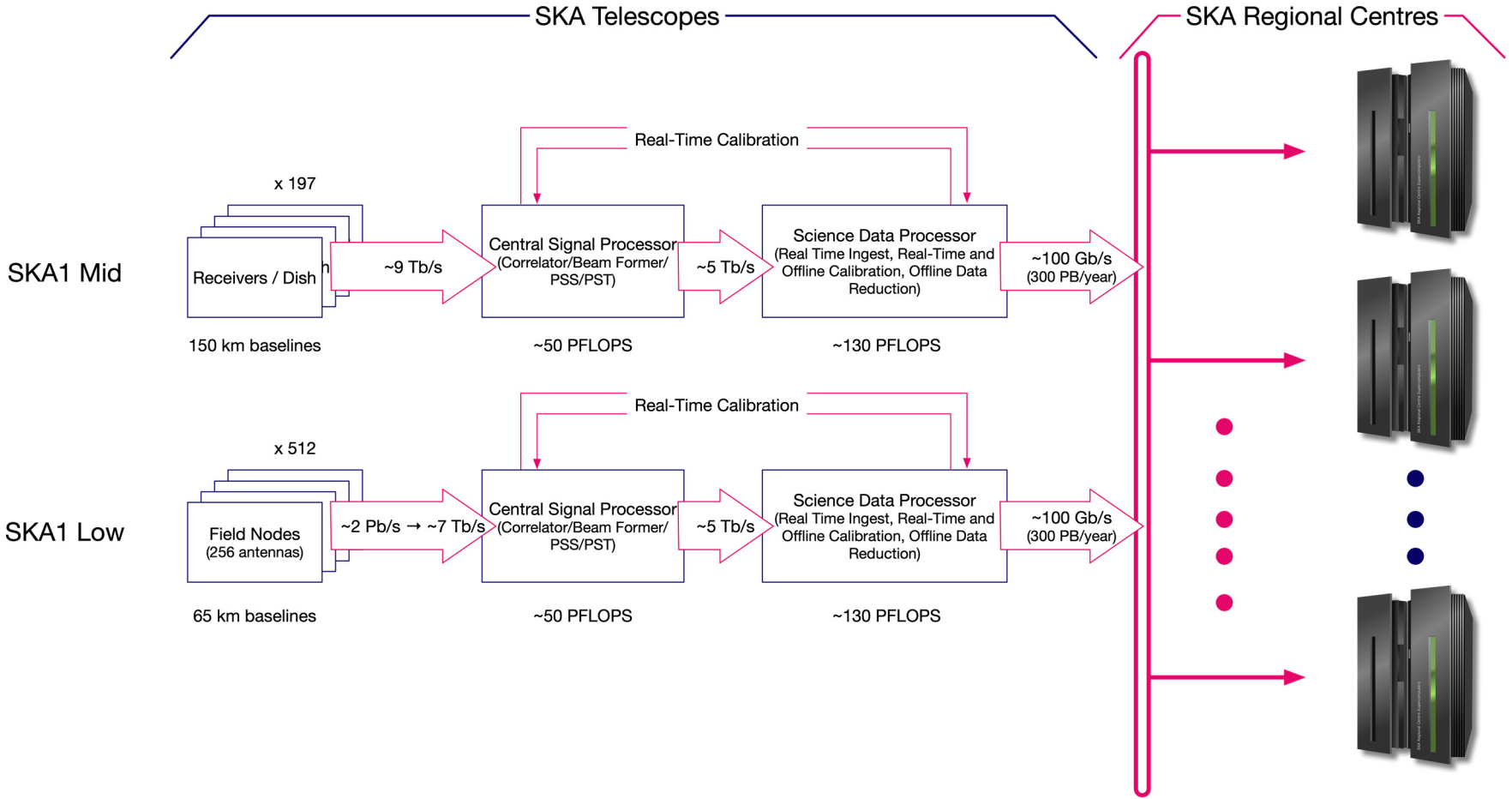
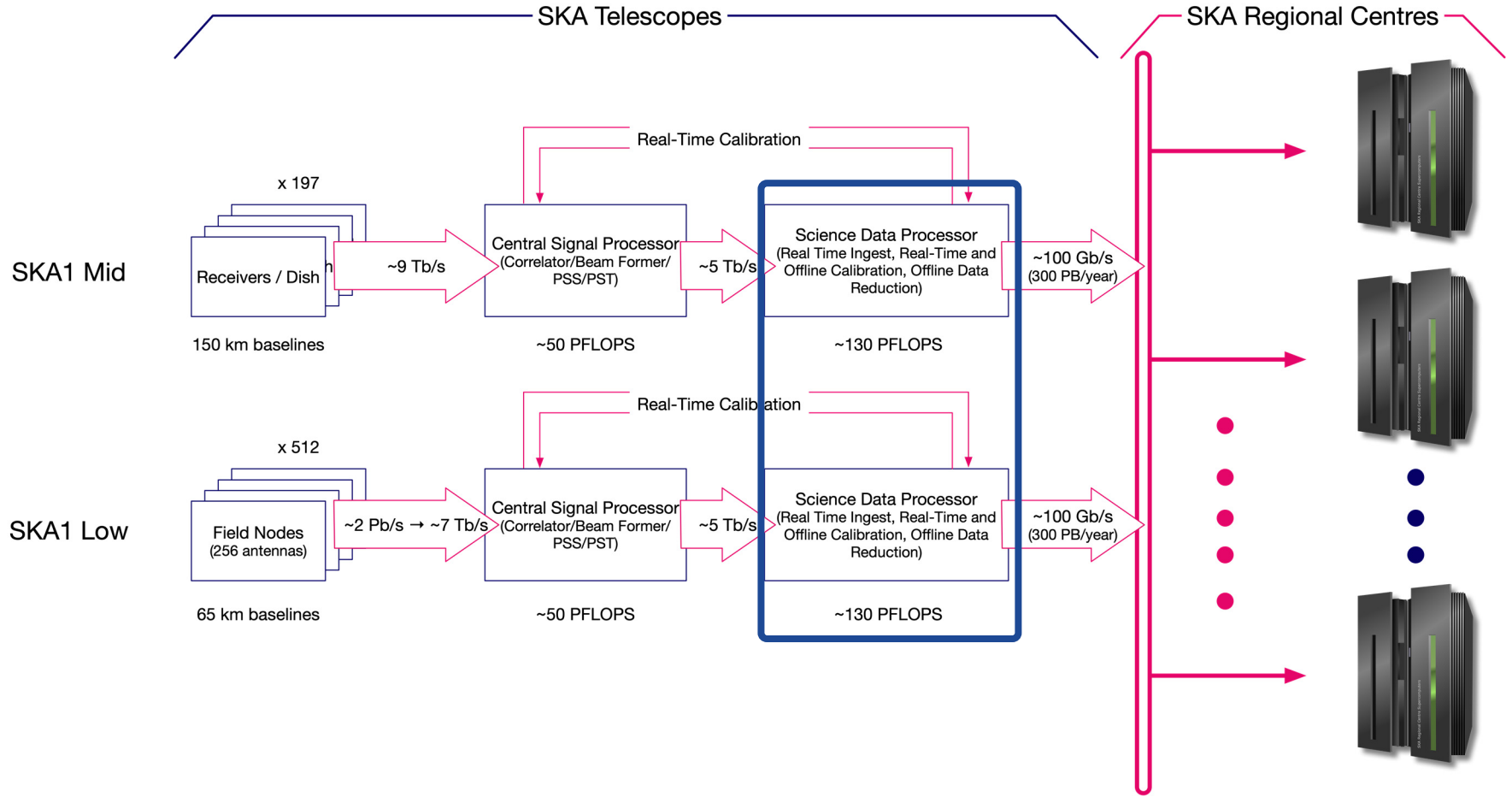
Role of Software in the SKA Project

Software and the SKA



Software and the SKA



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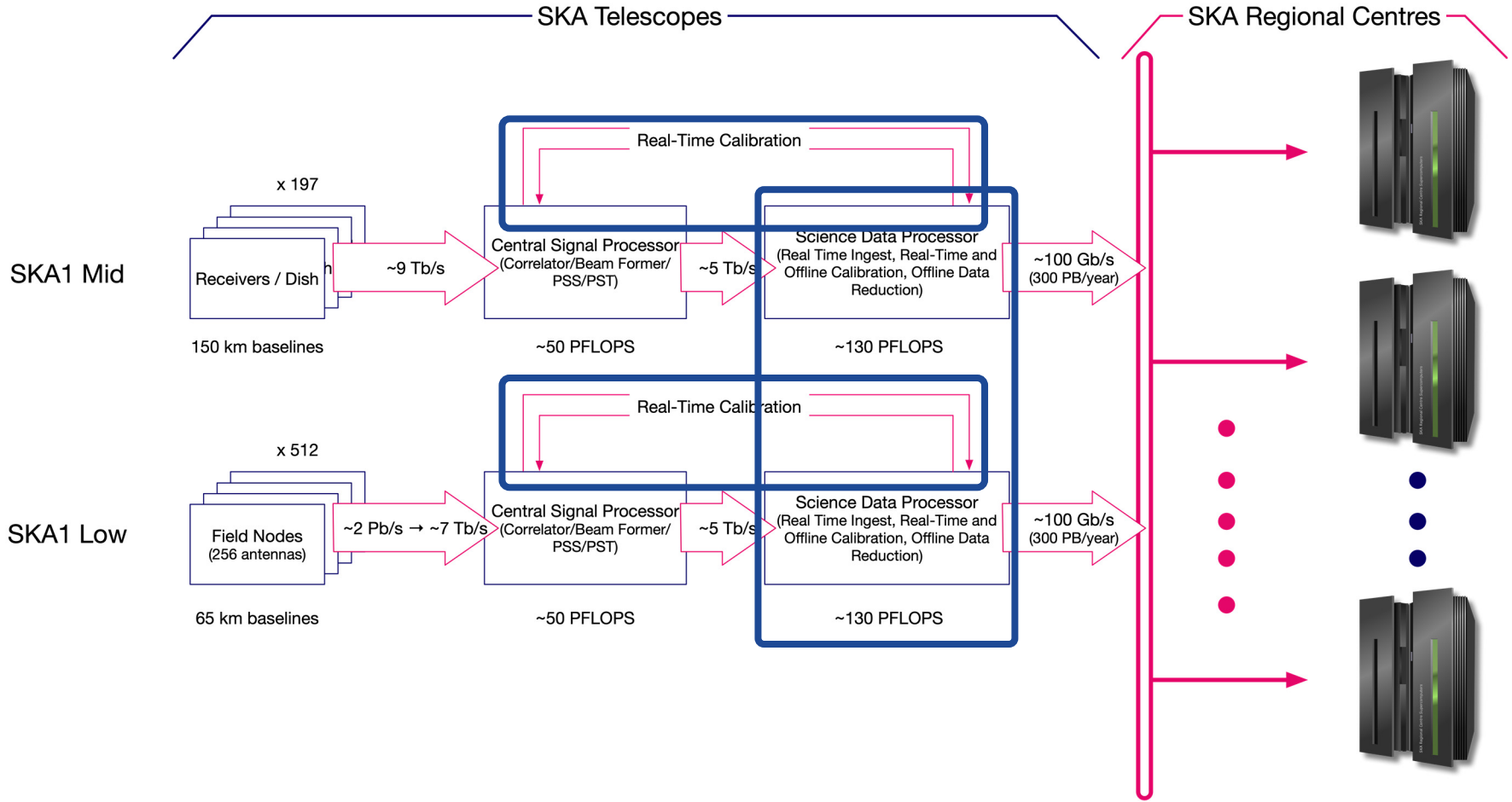

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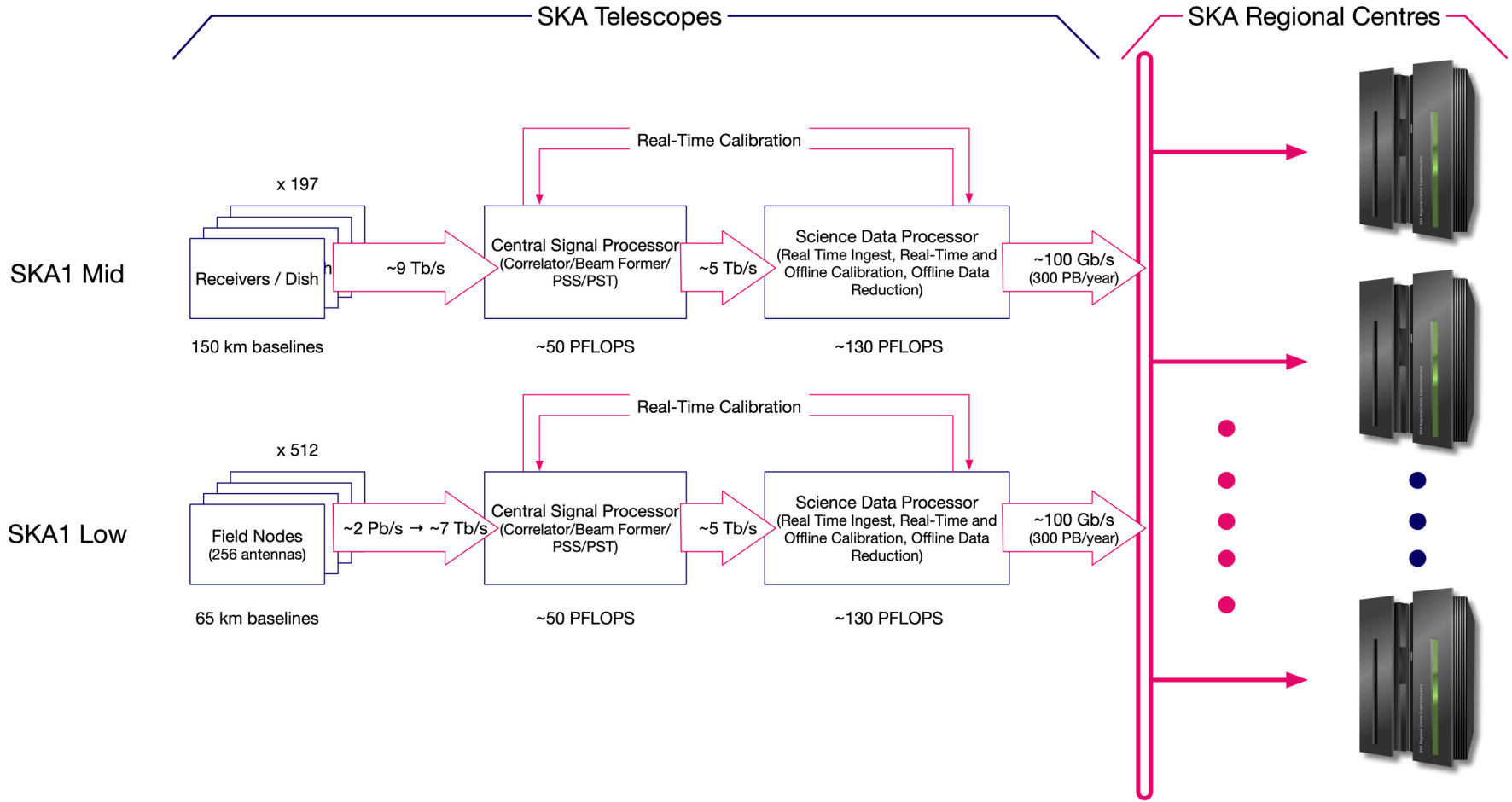

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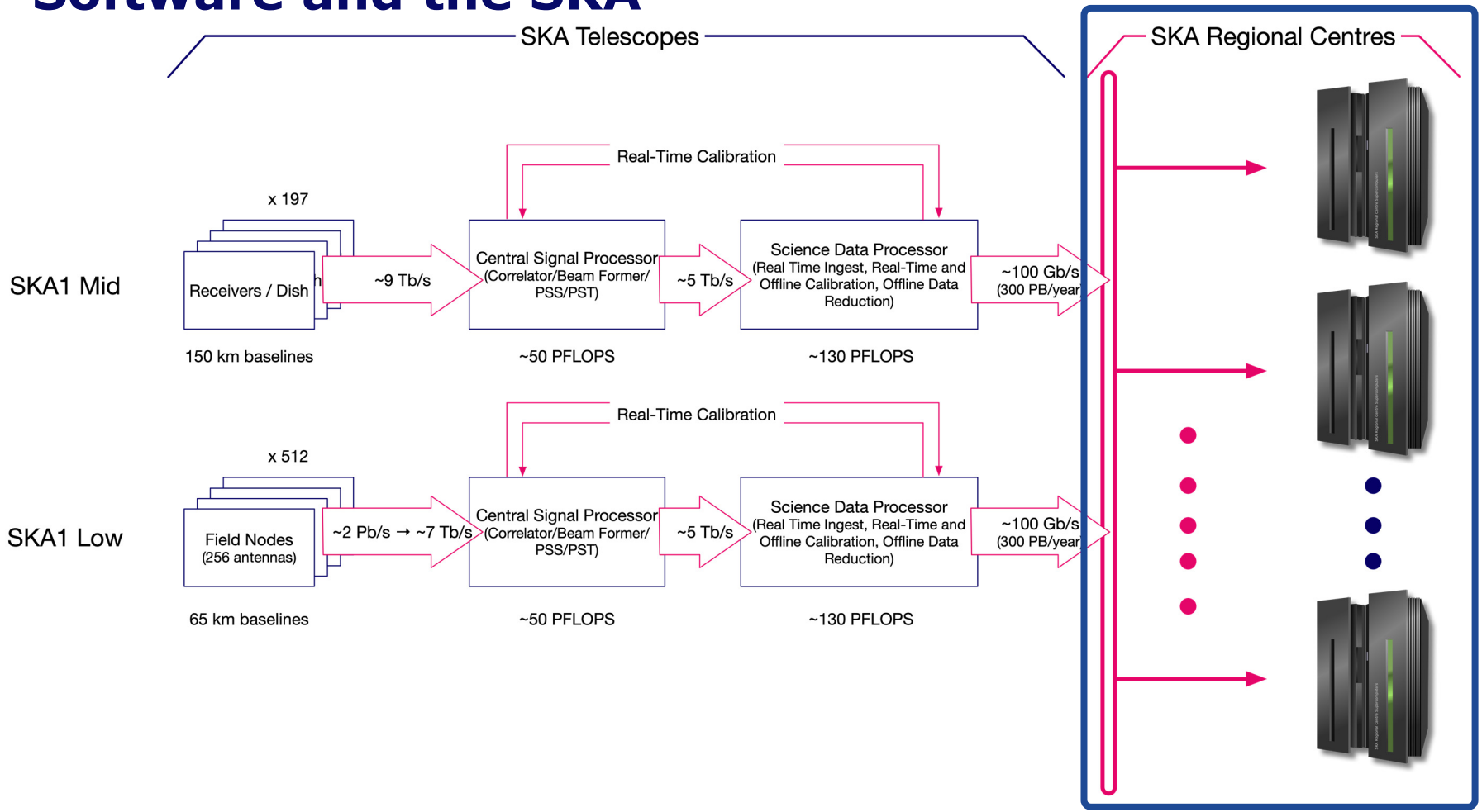

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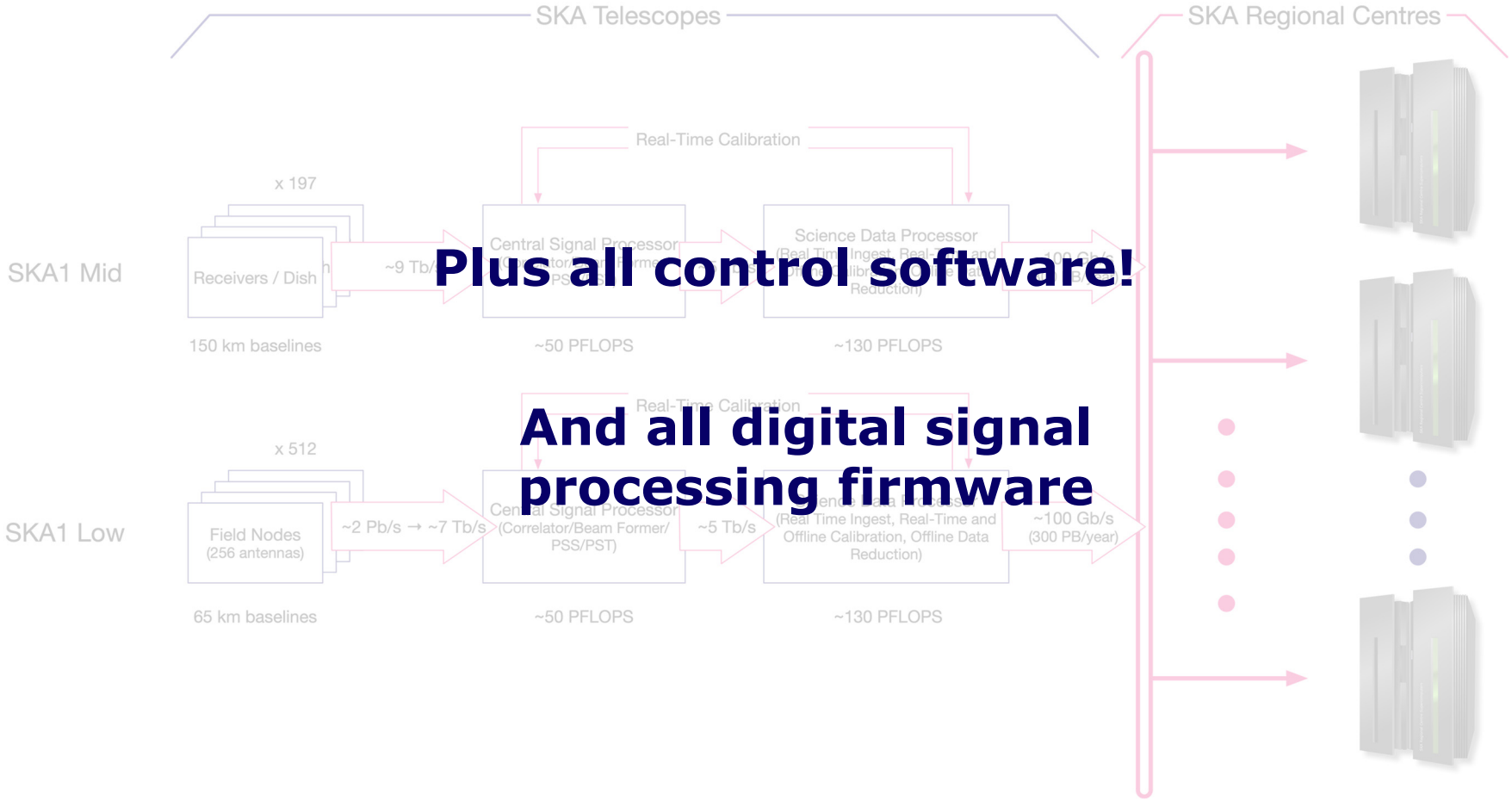


Plus all control software!

And all digital signal processing firmware

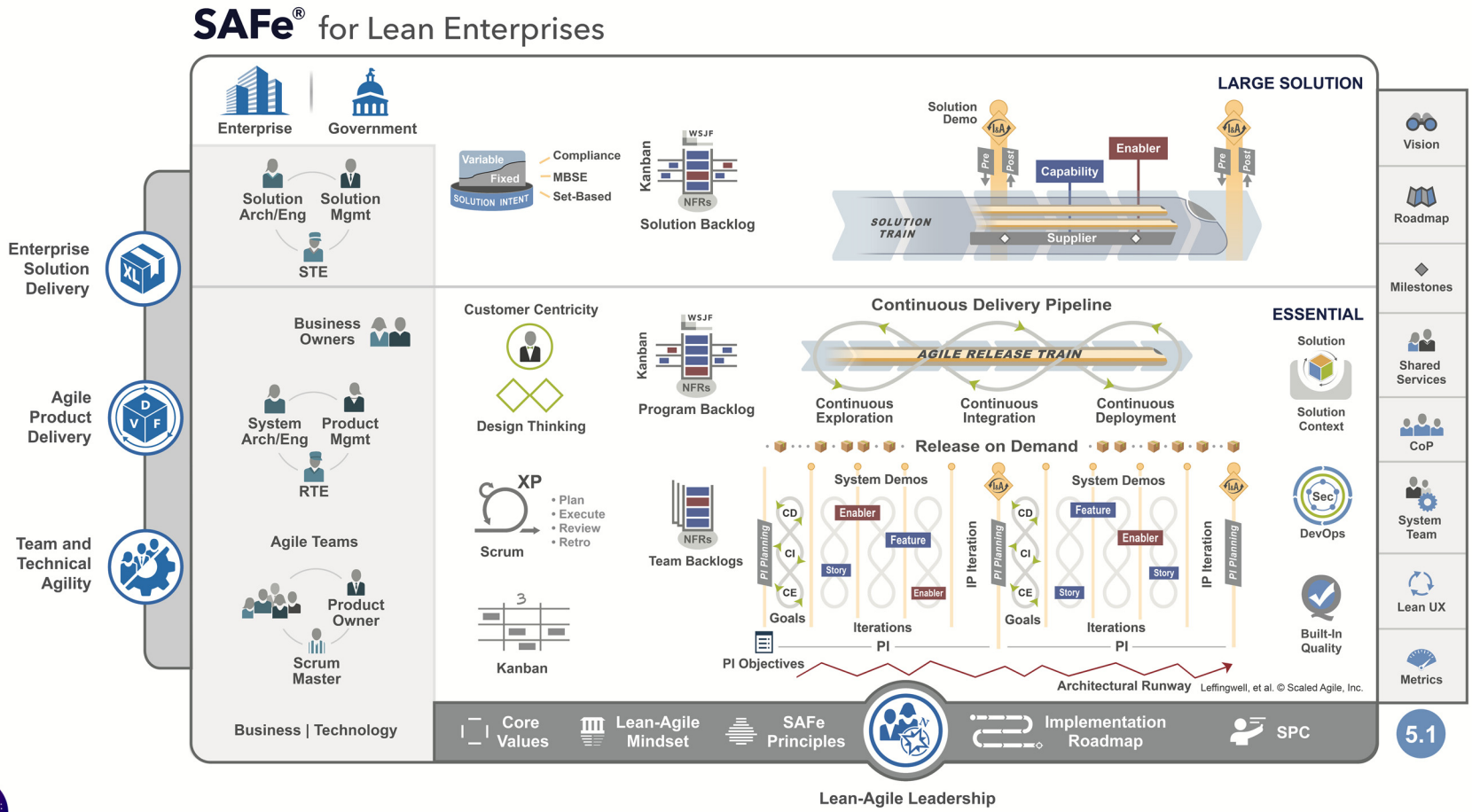
Current Status

The progress so far…

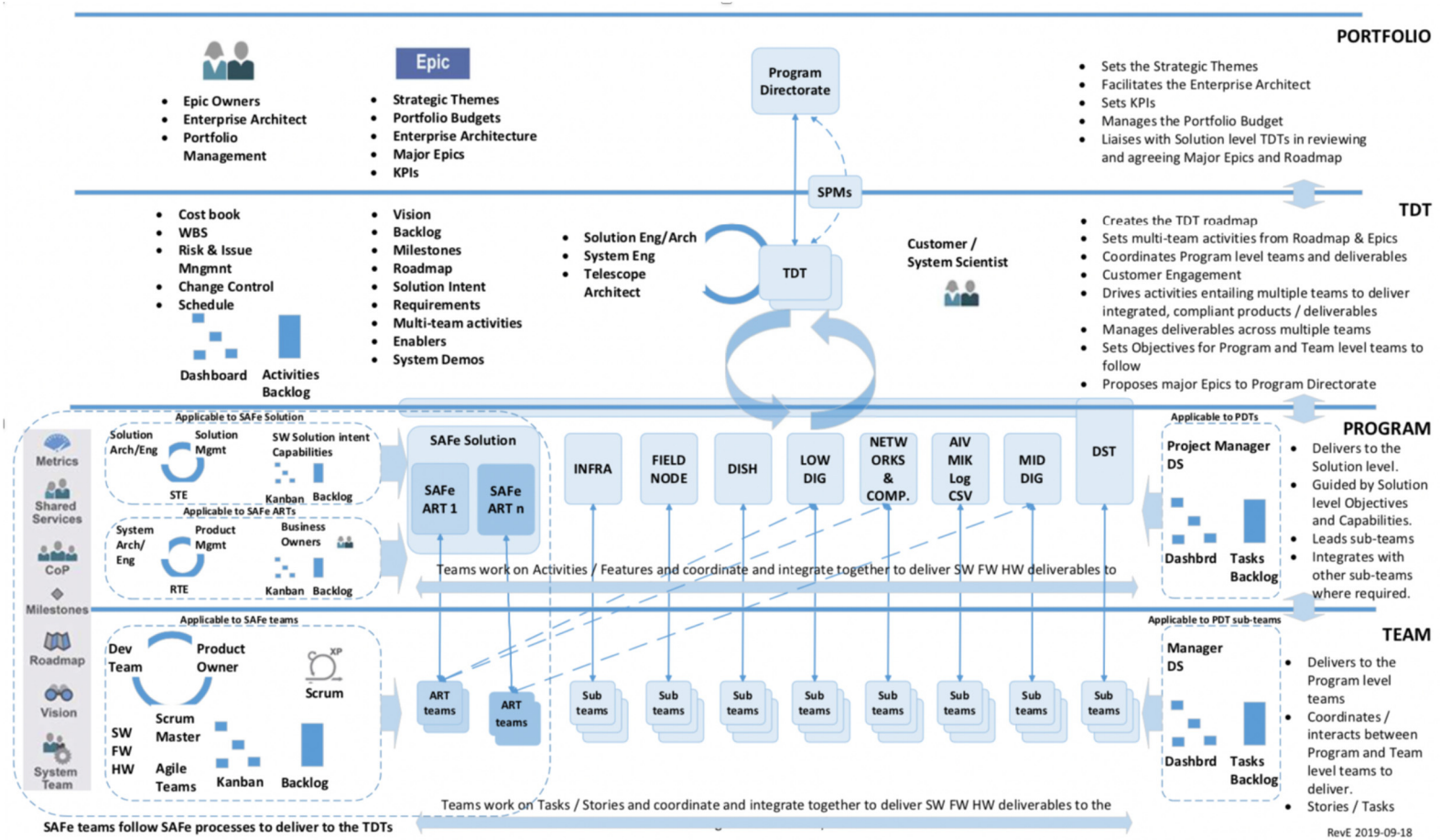
Scaling Agile Teams: SKA and SAFe

- Work with teams started in August 2018
  - Currently executing PI12!
- From one train to three trains:
  - Data Processing
  - Observation Management & Controls (Correlators)
  - Services (Platform, Networks, System)

Scaling Agile Teams: SKA and SAFe

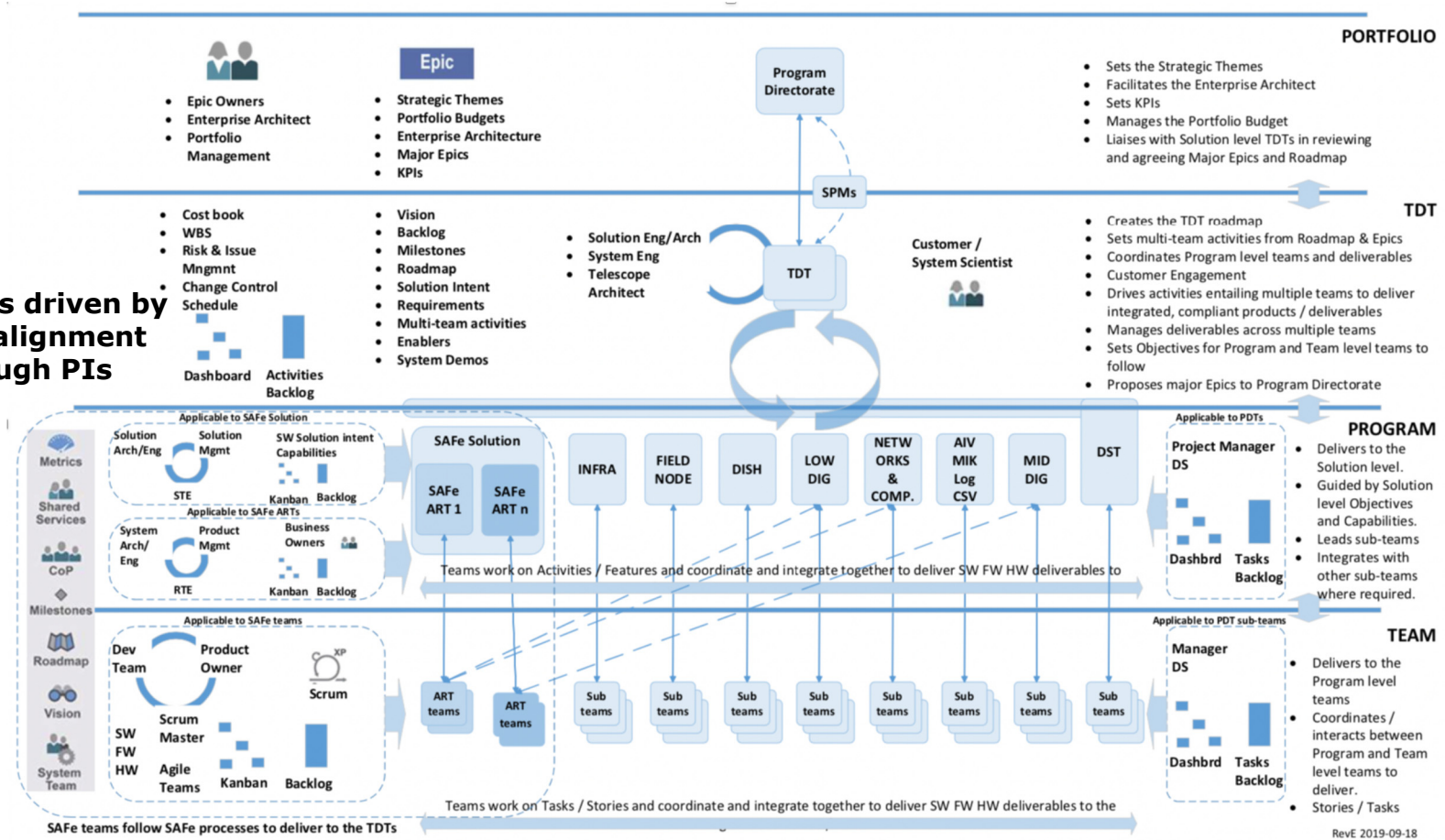


Telescope Delivery Teams



Telescope Delivery Teams

Priorities driven by TDTs; alignment through PIs



Telescope Delivery Teams

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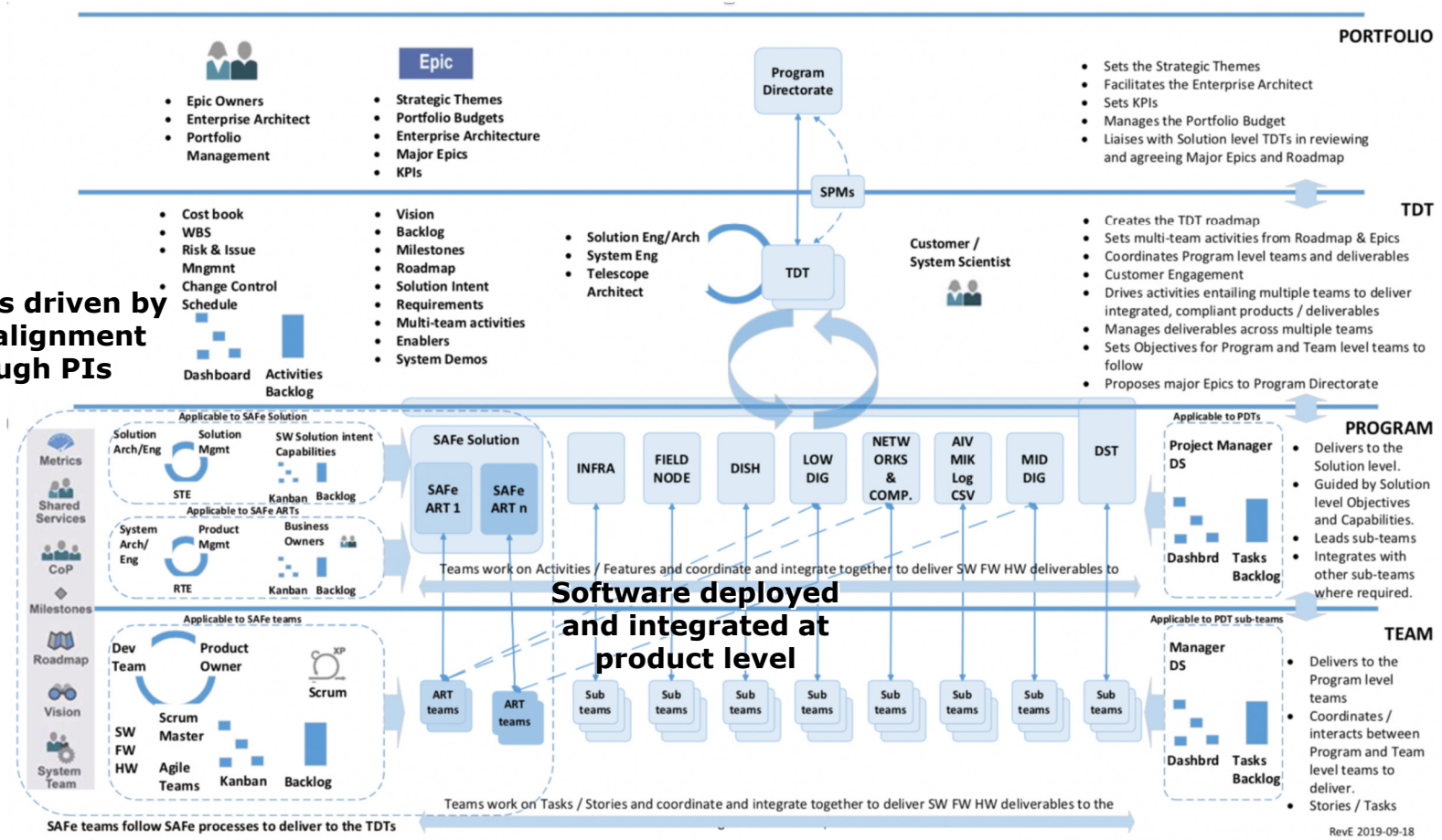
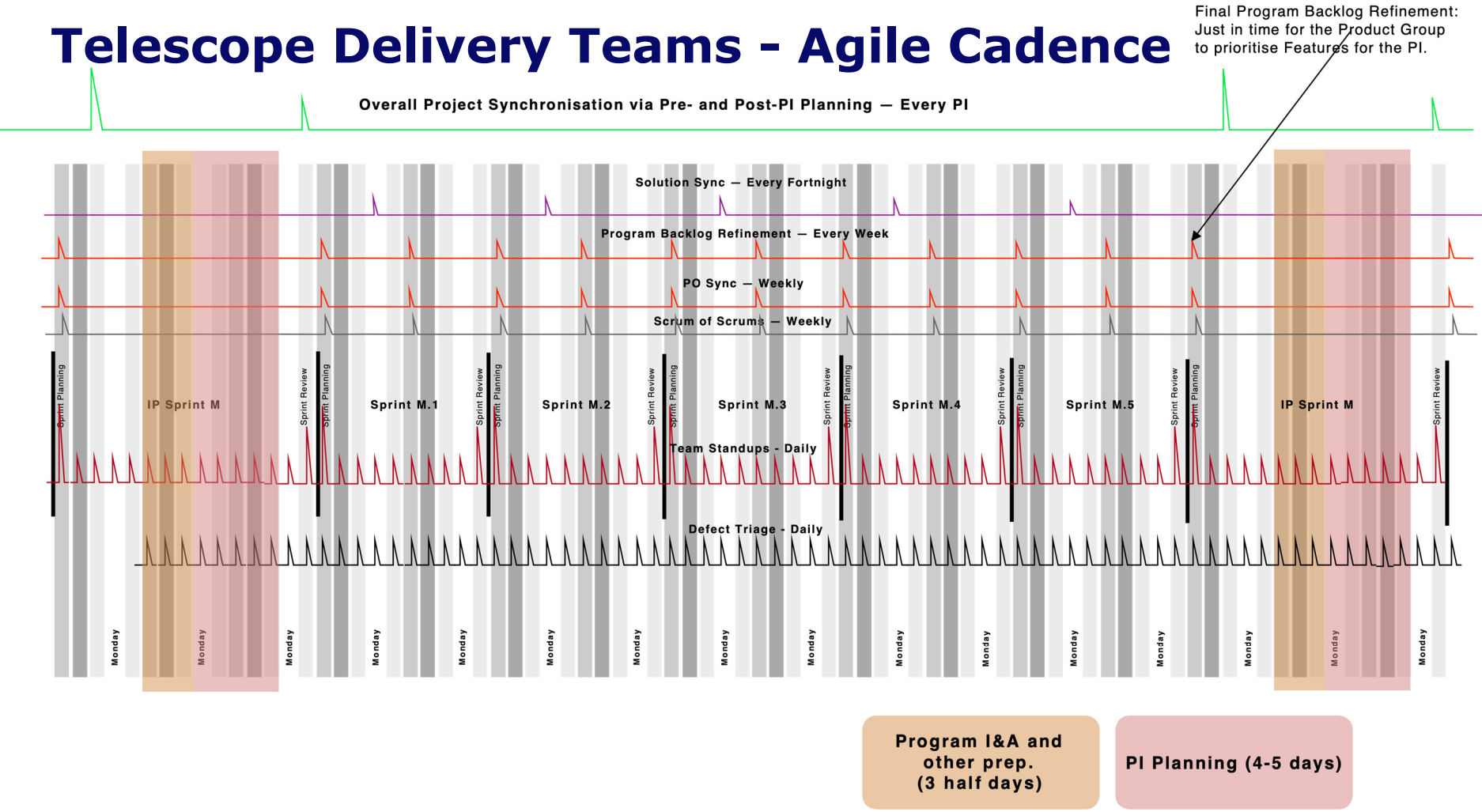


Telescope Delivery Teams - Agile Cadence



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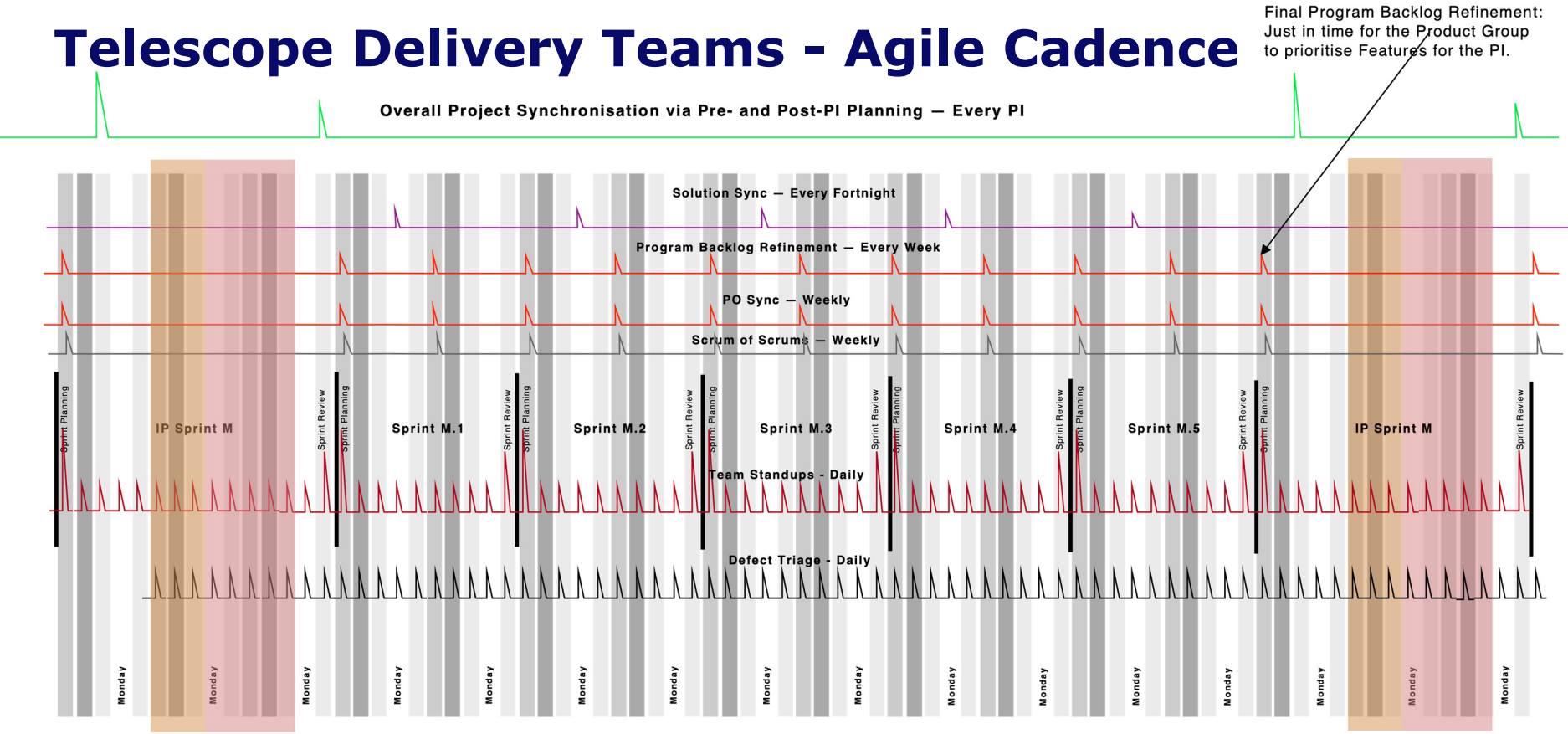
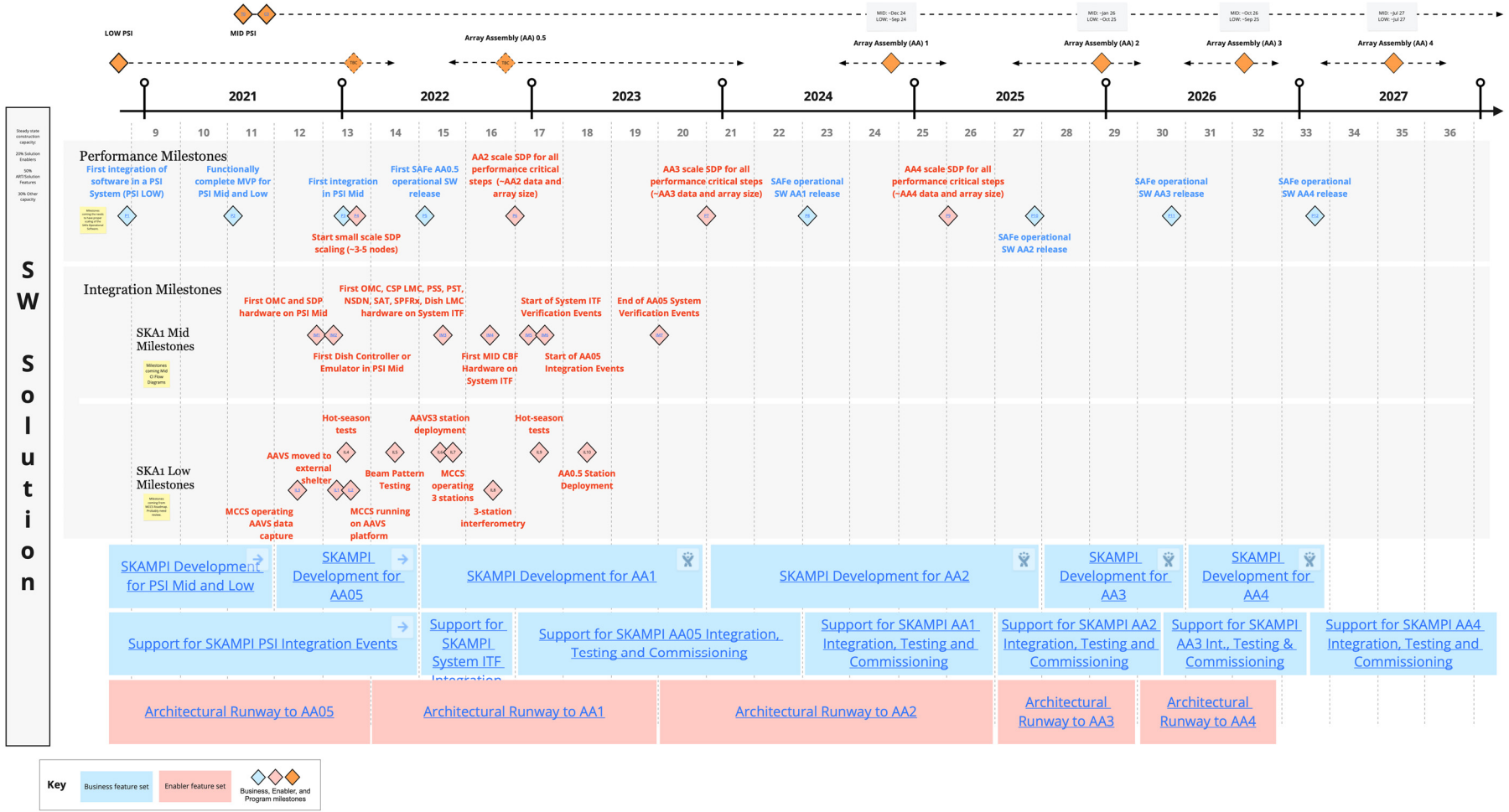


TDTs now doing PI planning based on the Agile software experience!

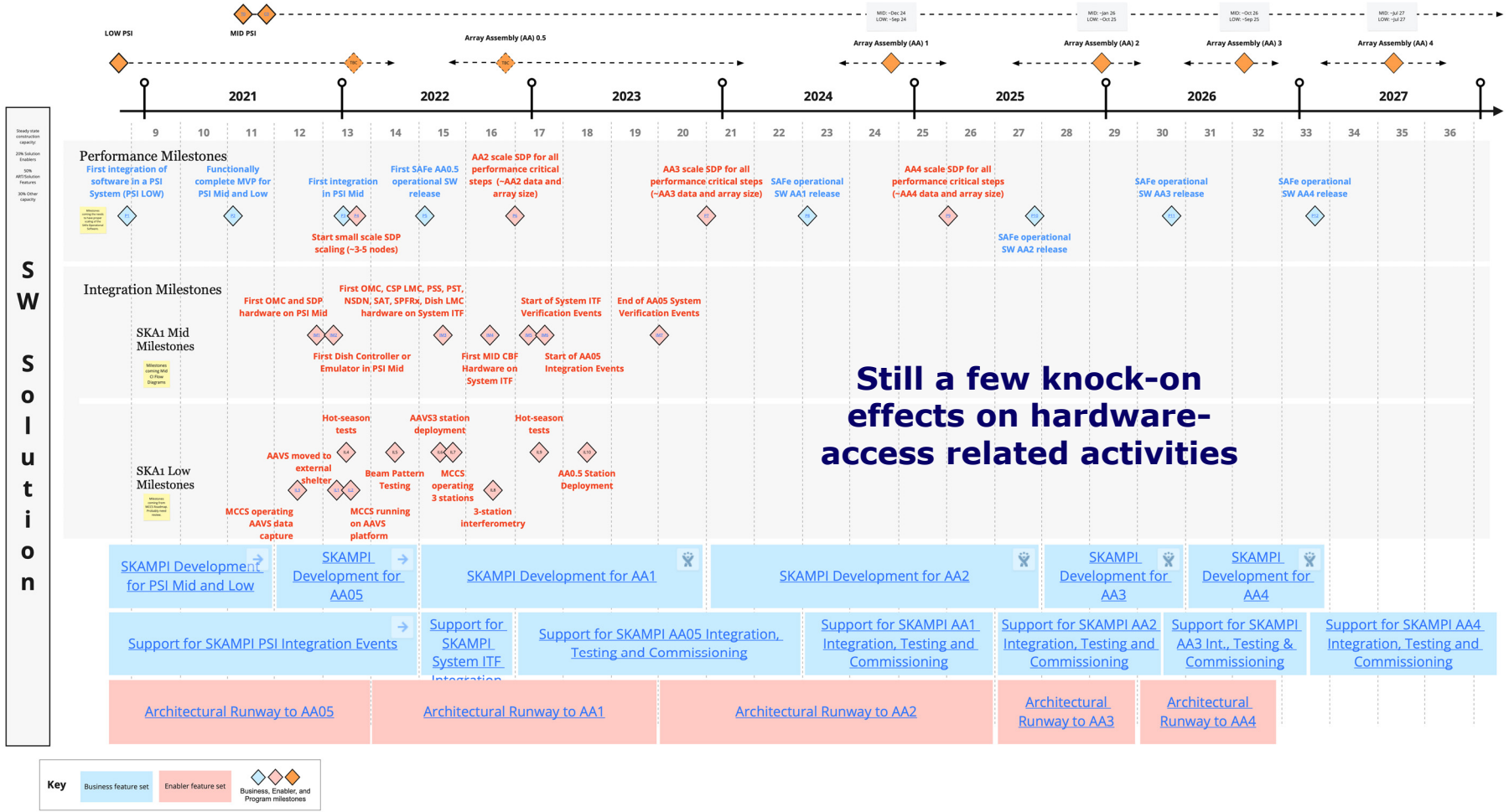
Program I&A and other prep. (3 half days)

PI Planning (4-5 days)

SKA Roadmap


LOW PSI
MID PSI
Array Assembly (AA) 0.5
Array Assembly (AA) 1
Array Assembly (AA) 2
Array Assembly (AA) 3
Array Assembly (AA) 4
2021
2022
2023
2024
2025
2026
2027
9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Performance Milestones
First integration of software in a PSI System (PSI LOW)
Functionally complete MVP for PSI Mid and Low
First integration in PSI Mid
Start small scale SDP scaling (~3-5 nodes)
First SAFe AA0.5 operational SW release
AA2 scale SDP for all performance critical steps (~AA2 data and array size)
AA3 scale SDP for all performance critical steps (~AA3 data and array size)
SAFe operational SW AA1 release
AA4 scale SDP for all performance critical steps (~AA4 data and array size)
SAFe operational SW AA2 release
SAFe operational SW AA3 release
SAFe operational SW AA4 release
Integration Milestones
SKA1 Mid Milestones
First OMC and SDP hardware on PSI Mid
First Dish Controller or Emulator in PSI Mid
First OMC, CSP LMC, PSS, PST, NSDN, SAT, SPFRx, Dish LMC hardware on System ITF
First MID CBF Hardware on System ITF
Start of System ITF Verification Events
Start of AA05 Integration Events
End of AA05 System Verification Events
SKA1 Low Milestones
MCCS operating AAVS data capture
AAVS moved to external shelter
MCCS running on AAVS platform
Beam Pattern Testing
AAVS3 station deployment
MCCS operating 3 stations
3-station interferometry
Hot-season tests
Hot-season tests
AA0.5 Station Deployment
SW Solution
SKAMPI Development for PSI Mid and Low
SKAMPI Development for AA05
SKAMPI Development for AA1
SKAMPI Development for AA2
SKAMPI Development for AA3
SKAMPI Development for AA4
Support for SKAMPI PSI Integration Events
Support for SKAMPI System ITF Integration
Support for SKAMPI AA05 Integration, Testing and Commissioning
Support for SKAMPI AA1 Integration, Testing and Commissioning
Support for SKAMPI AA2 Integration, Testing and Commissioning
Support for SKAMPI AA3 Int., Testing & Commissioning
Support for SKAMPI AA4 Integration, Testing and Commissioning
Architectural Runway to AA05
Architectural Runway to AA1
Architectural Runway to AA2
Architectural Runway to AA3
Architectural Runway to AA4
Key
Business feature set
Enabler feature set
Business, Enabler, and Program milestones

SKA Roadmap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Array Assembly (AA) 3
Array Assembly (AA) 4
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2023
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Beam Pattern Testing
AAVS3 station deployment
MCCS operating 3 stations
3-station interferometry
Hot-season tests
Hot-season tests
AA0.5 Station Deployment
Still a few knock-on effects on hardware-access related activities
SW Solution
SKAMPI Development for PSI Mid and Low
SKAMPI Development for AA05
SKAMPI Development for AA1
SKAMPI Development for AA2
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SKAMPI Development for AA4
Support for SKAMPI PSI Integration Events
Support for SKAMPI System ITF Integration
Support for SKAMPI AA05 Integration, Testing and Commissioning
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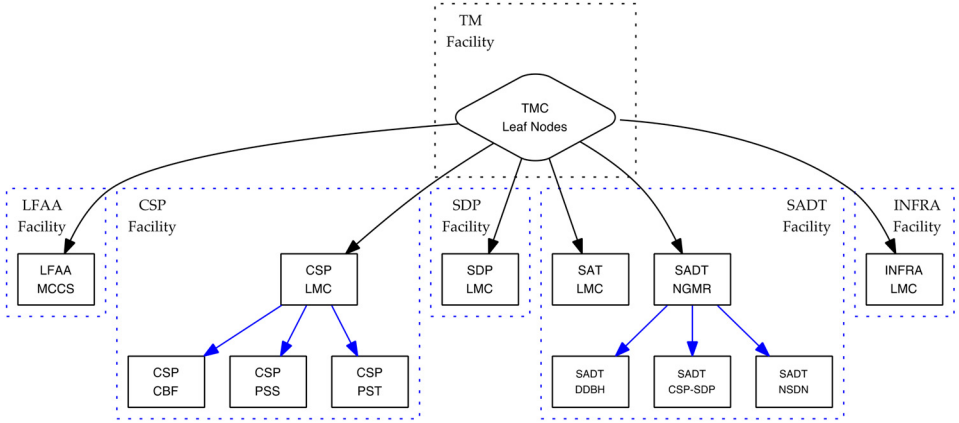
Support for SKAMPI AA2 Integration, Testing and Commissioning
Support for SKAMPI AA3 Int., Testing & Commissioning
Support for SKAMPI AA4 Integration, Testing and Commissioning
Architectural Runway to AA05
Architectural Runway to AA1
Architectural Runway to AA2
Architectural Runway to AA3
Architectural Runway to AA4
Key
Business feature set
Enabler feature set
Business, Enabler, and Program milestones

Prototyping System Integration: SKAMPI

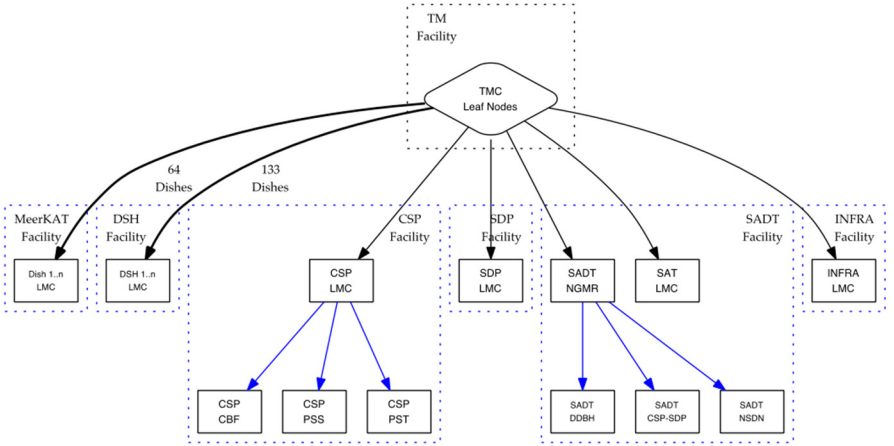
- **SKAMPI:** SKA MVP **Prototype** Integration
  - Sometimes referred to as SKA MVP **Product** Integration!
    - Points to the idea that we want to productise it, so that it becomes easy to manage
- Mixture of technologies
  - TANGO for control
  - OCI Containers/Kubernetes/Helm for deployment
  - Gitlab CI/CD for testing
  - Mostly Python, with a bit of C/C++ for some devices/software

SKA1 Control Hierarchies

SKA1-Low



SKA1-Mid



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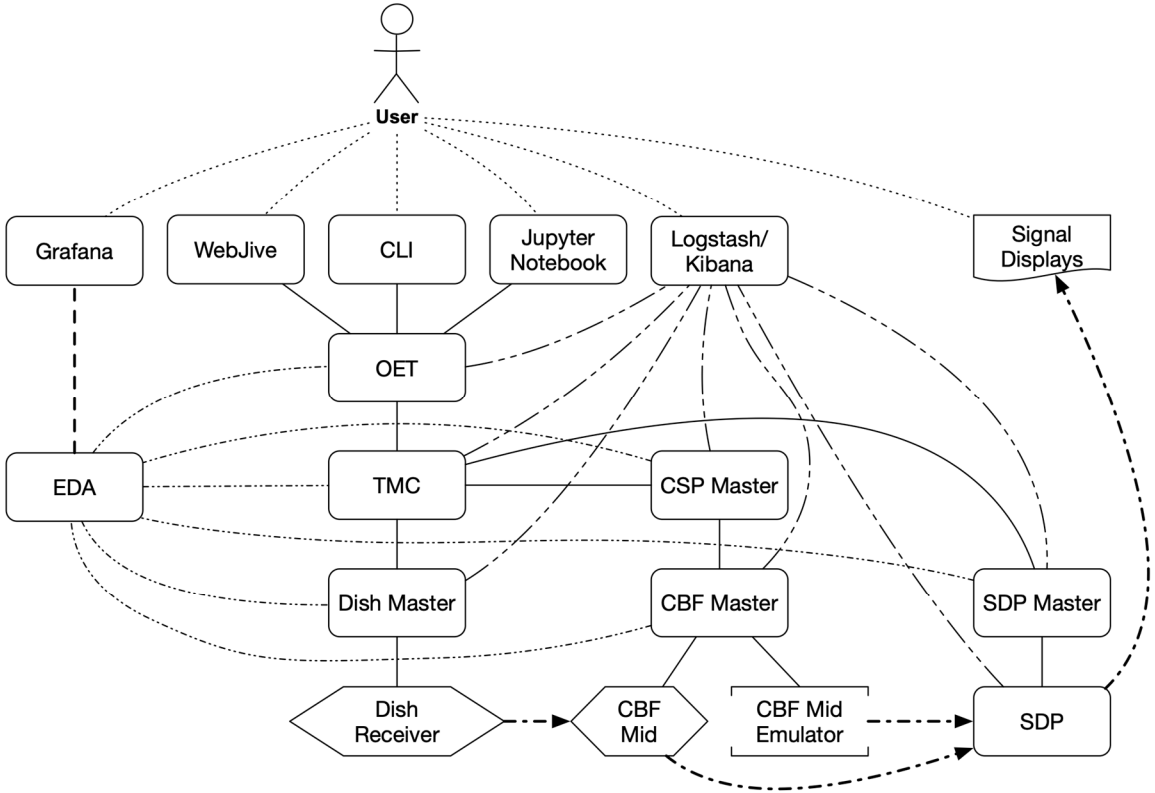

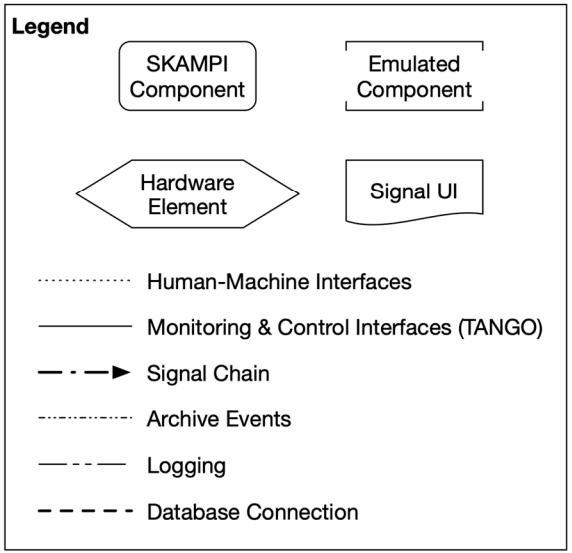

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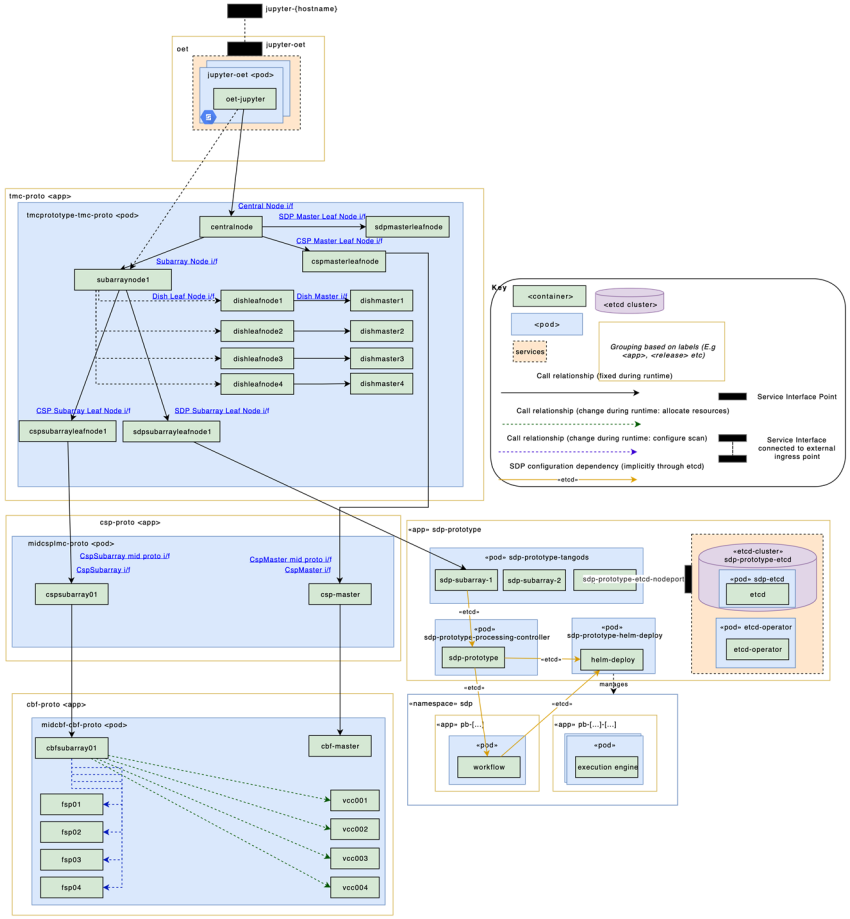

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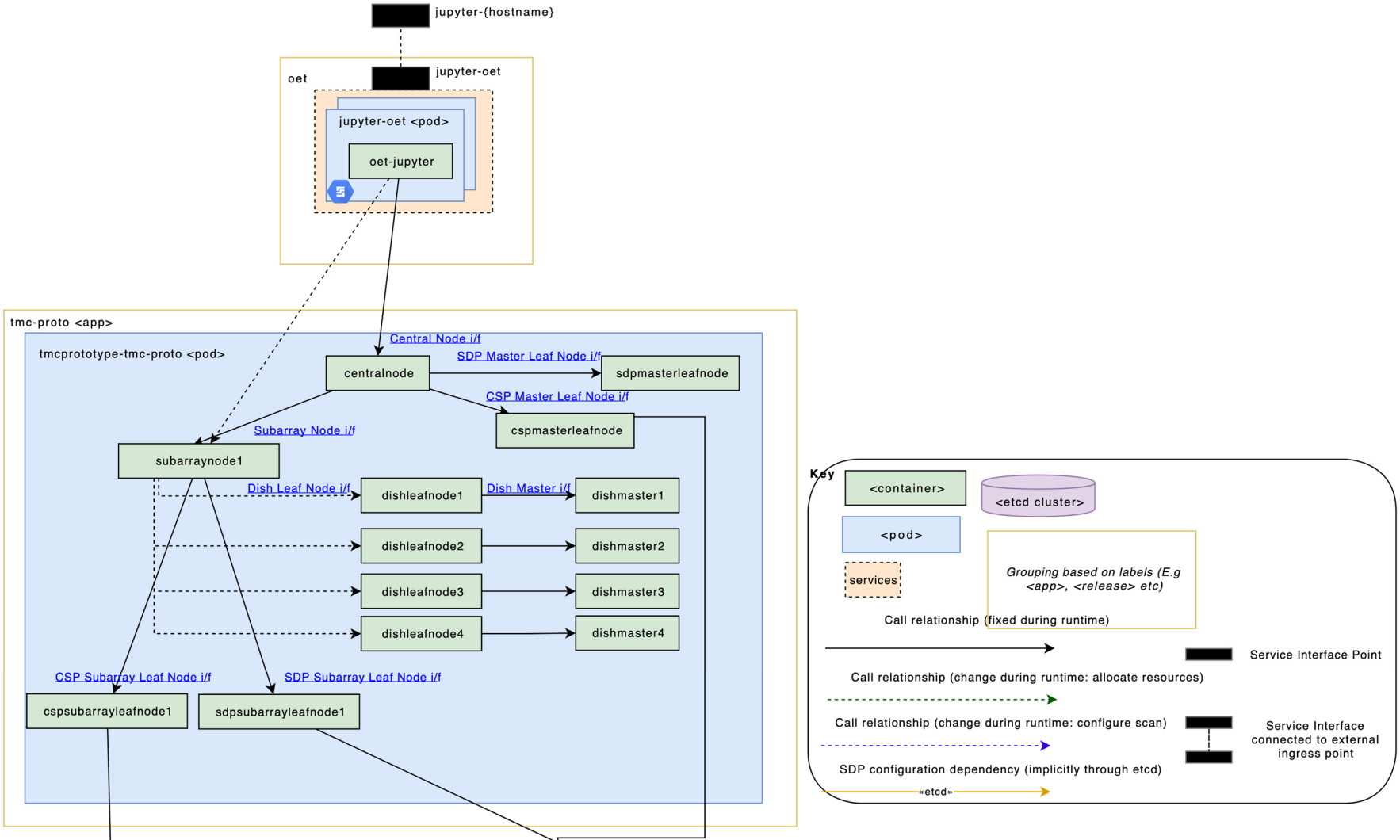
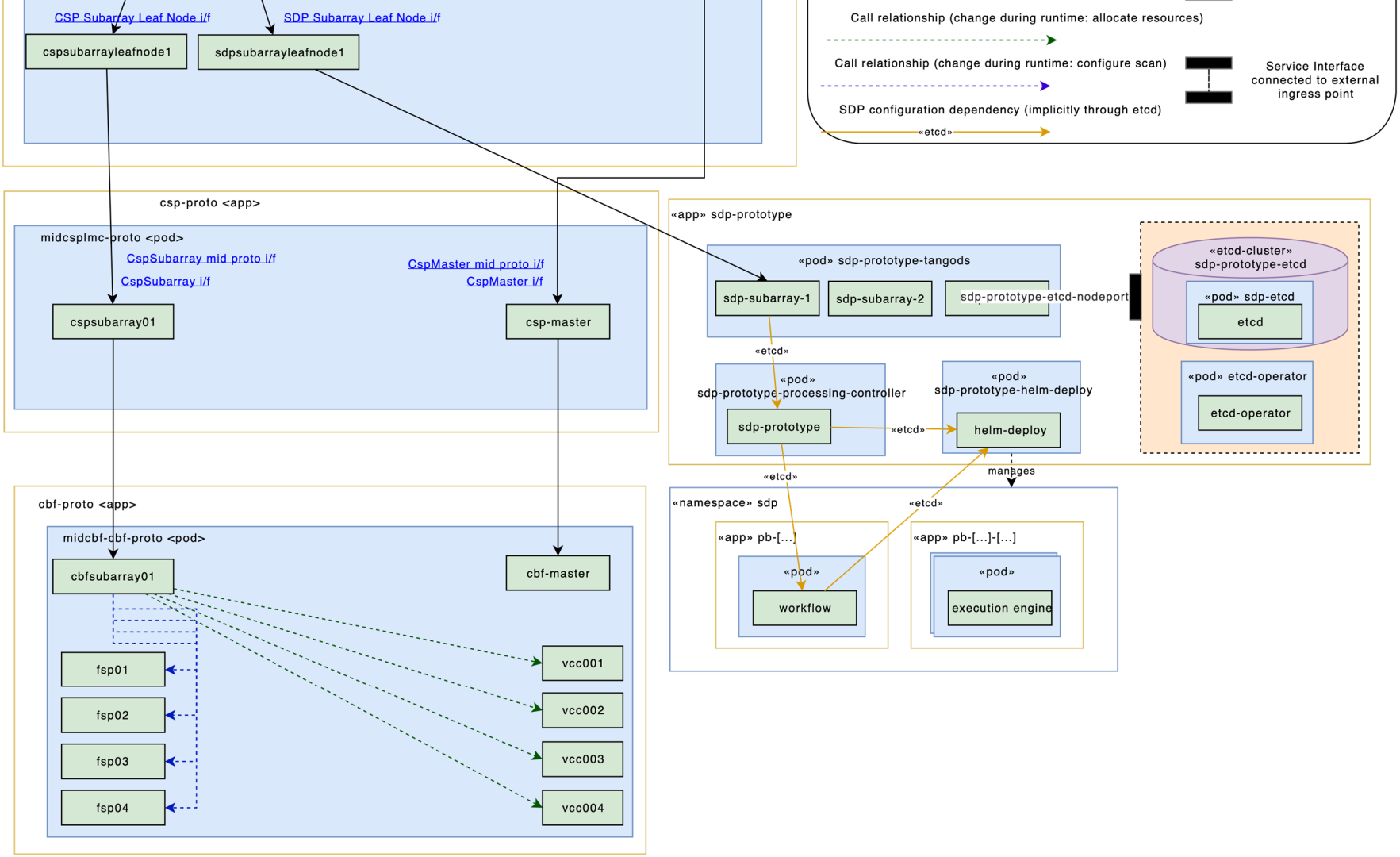

jupyter-{hostname}
oet
jupyter-oet
jupyter-oet <pod>
oet-jupyter
tmc-proto <app>
tmcprototype-tmc-proto <pod>
Central Node i/f
centralnode
SDP Master Leaf Node i/f
sdpmasterleafnode
CSP Master Leaf Node i/f
cspmasterleafnode
Subarray Node i/f
subarraynode1
Dish Leaf Node i/f
dishleafnode1
Dish Master i/f
dishmaster1
dishleafnode2
dishmaster2
dishleafnode3
dishmaster3
dishleafnode4
dishmaster4
CSP Subarray Leaf Node i/f
SDP Subarray Leaf Node i/f
cspsubarrayleafnode1
sdpsubarrayleafnode1
Key
<container>
<etcd cluster>
<pod>
services
Grouping based on labels (E.g <app>, <release> etc)
Call relationship (fixed during runtime)
Service Interface Point
Call relationship (change during runtime: allocate resources)
Call relationship (change during runtime: configure scan)
Service Interface connected to external ingress point
SDP configuration dependency (implicitly through etcd)
«etcd»


CSP Subarray Leaf Node i/f
SDP Subarray Leaf Node i/f
cspsubarrayleafnode1
sdpsubarrayleafnode1
Call relationship (change during runtime: allocate resources)
Call relationship (change during runtime: configure scan)
Service Interface connected to external ingress point
SDP configuration dependency (implicitly through etcd)
«etcd»
csp-proto <app>
midcsplmc-proto <pod>
CspSubarray mid proto i/f
CspSubarray i/f
CspMaster mid proto i/f
CspMaster i/f
cspsubarray01
csp-master
«app» sdp-prototype
«pod» sdp-prototype-tangods
sdp-subarray-1
sdp-subarray-2
sdp-prototype-etcd-nodeport
«etcd-cluster» sdp-prototype-etcd
«pod» sdp-etcd
etcd
«pod» etcd-operator
etcd-operator
«pod» sdp-prototype-processing-controller
sdp-prototype
«pod» sdp-prototype-helm-deploy
helm-deploy
manages
«namespace» sdp
«app» pb-[…]
«pod»
workflow
«app» pb-[…]-[…]
execution engine
cbf-proto <app>
midcbf-cbf-proto <pod>
cbfsubarray01
cbf-master
fsp01
fsp02
fsp03
fsp04
vcc001
vcc002
vcc003
vcc004

Challenges

Challenges

- Using TANGO in a very event-oriented way
  - Finding some edge cases around the event mechanism
    - Requires sustained effort directly on TANGO
- Containerisation and orchestration challenges
  - TANGO Device Server granularity
  - Helm chart granularity
  - Native TANGO support?
- Computing scaling challenges
  - Mostly coming from current granularity overhead
- Team scaling challenges
  - Need to have even better alignment on **what needs to be done**, and **how** it needs to be done
  - Identifying suitable rules for contribution and release management

Challenges

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    - Requires sustained effort directly on TANGO
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  - TANGO Device Server granularity
  - Helm chart granularity
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Finding about this now, working on fixes on time!

Next Steps

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- Keep aligning the Construction Proposal’s Integrated Product Schedule (hardware oriented) with the Software Roadmap (functionality oriented)
- Finish contracting to move from bridging to construction funding
- Provide appropriate level of effort to the System and Platform teams
  - Setting up the contracting framework should help with this
- Keep improving our TANGO base
- Keep iterating on SKAMPI → SKAO Telescope Software

Related Contributions

Interesting talks and posters relevant to the SKA project around ICALEPCS’21

SKA at ICALEPCS'21

Code	Speaker	Organisation	Title
MOAL03	Juande Santander-Vela	SKAO	From SKA to SKAO: Early Progress in the SKA Project Construction
TUBL02	Samuel Twum	SARAO	Implementing an Event Tracing Solution With Consistently Formatted Logs for the SKA Telescope Control System
TUBR02	Sonja Vrcic	SKAO	Design Patterns for the SKA Control System
TUBL04	Matteo Di Carlo	INAF/OAAB Teramo	Continuous Integration-Continuous Delivery (CI-CD) Practices at SKA

SKA-related at ICALEPCS'21

Code	Speaker	Organisation	Title
MOAR03	Thomas Juerges	ASTRON/SKAO	LOFAR2.0: Station Control Upgrade
FRAR01	Mikel Eguiraun	MAX IV	Taranta, the No-Code Web Dashboard in Production
MOPV046	Thijs Snijder	ASTRON	Tango Controls Device Attribute extension in Python3

TANGO-related at ICALEPCS'21

Code	Speaker	Organisation	Title
TUBL03	Piotr Pawel Goryl	S2Innovation	Tango Controls RFCs
FRAR01	Mikel Eguiraun	MAX IV	Taranta, the No-Code Web Dashboard in Production
MOPV025	Jean-Luc Pons	ESRF	TangoGraphQL: A GraphQL binding for Tango control system Web-based applications
MOPV034	Michal Liszcz et al.	S2Innovation/ ESRF/MAX IV	Migration of Tango Controls Source Code Repositories
MOPV046	Thijs Snijder	ASTRON	Tango Controls Device Attribute extension in Python3

Thank you!
Questions?

We recognise and acknowledge the Indigenous peoples and cultures that have traditionally lived on the lands on which our facilities are located.

SKAO

www.skao.int

Thanks to the SKA SAFe Solution Team, SKAO TDTs, our developers, and the TANGO Collaboration

In the memory of my father-in-law, Demetrio Sababa

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