SKAO

KubeCon | CloudNativeCon North America 2023

“The stars look very different today”
Kubernetes and Cloud Native at the SKAO

Rohini Joshi - Operations Data Scientist, SKAO

Ugur Yilmaz, Piers Harding, Marco Bartolini

November 9, 2023 | Chicago, Illinois

About myself

Engineer, developer

Product Owner, Product management and architecture support

Kubernetes enthusiast

Domain driven design (!)

www.skao.int

Hello! Find me on LinkedIn or rohini.joshi@skao.int

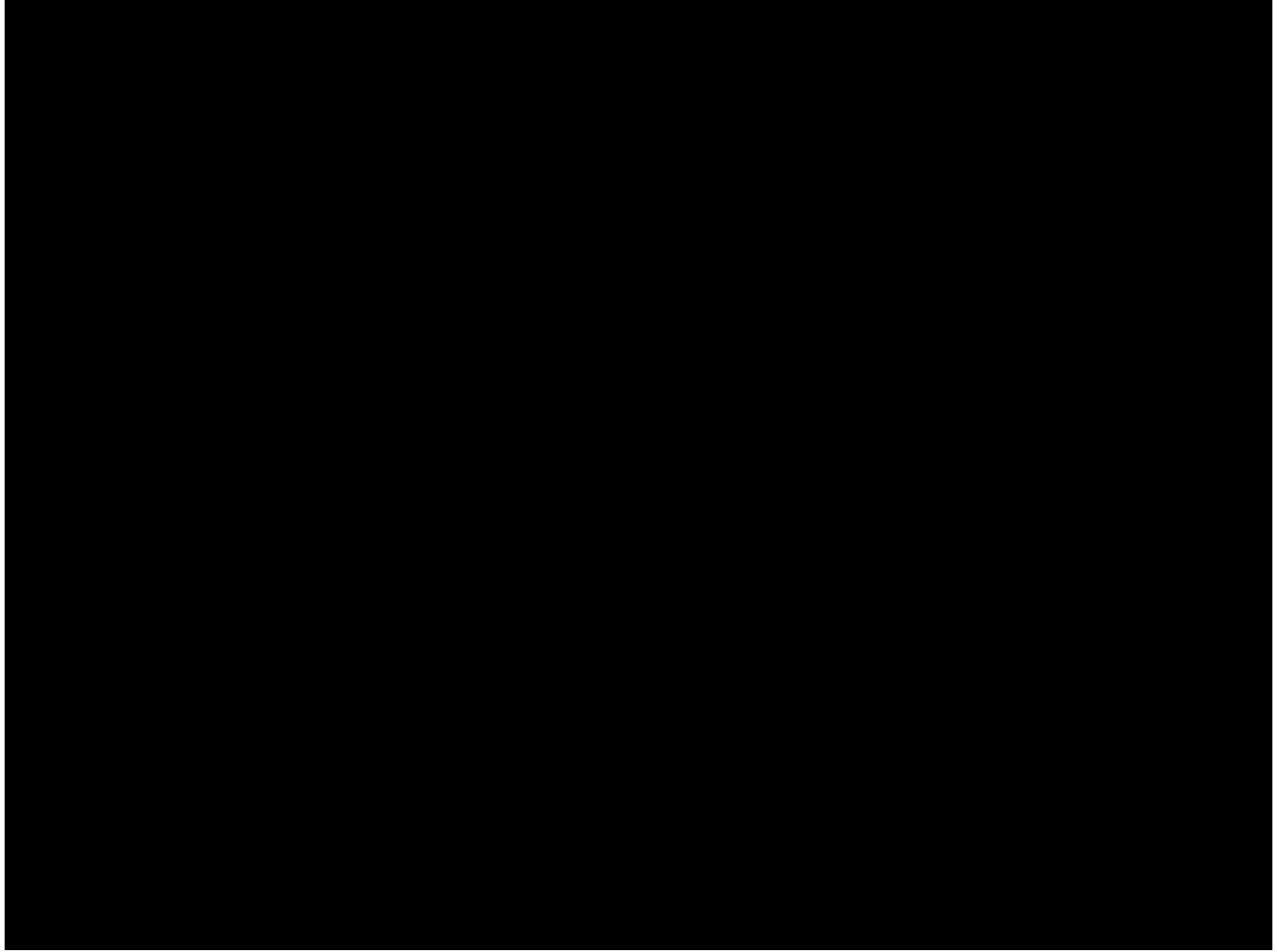
Jodrell Bank, Cheshire, UK. Photo captured by Nick Rees

The star studded journey we're going on today...

- The SKA Observatory is...
  - Why is it important?
- Cloud native architectures to help tackle some of our challenges

Composite image of the SKA telescopes, blending real hardware already on site with artist's impressions.

- How we went from clunky manual clusters to classy Kubernetes clusters with ClusterAPI



SKAO Mission

"The SKAO's mission is to build and operate cutting-edge radio telescopes to transform our understanding of the Universe, and deliver benefits to society through global collaboration and innovation."

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

The SKA project in numbers

€1.3 BILLION
CONSTRUCTION COST (2021 €)

131,072 ANTENNAS
IN WESTERN AUSTRALIA

710 PETABYTES PER YEAR
OF SCIENCE DATA DELIVERED TO SCIENCE USERS

€0.7 BILLION
FIRST 10 YEARS OF OPERATIONS COST (2021 €)

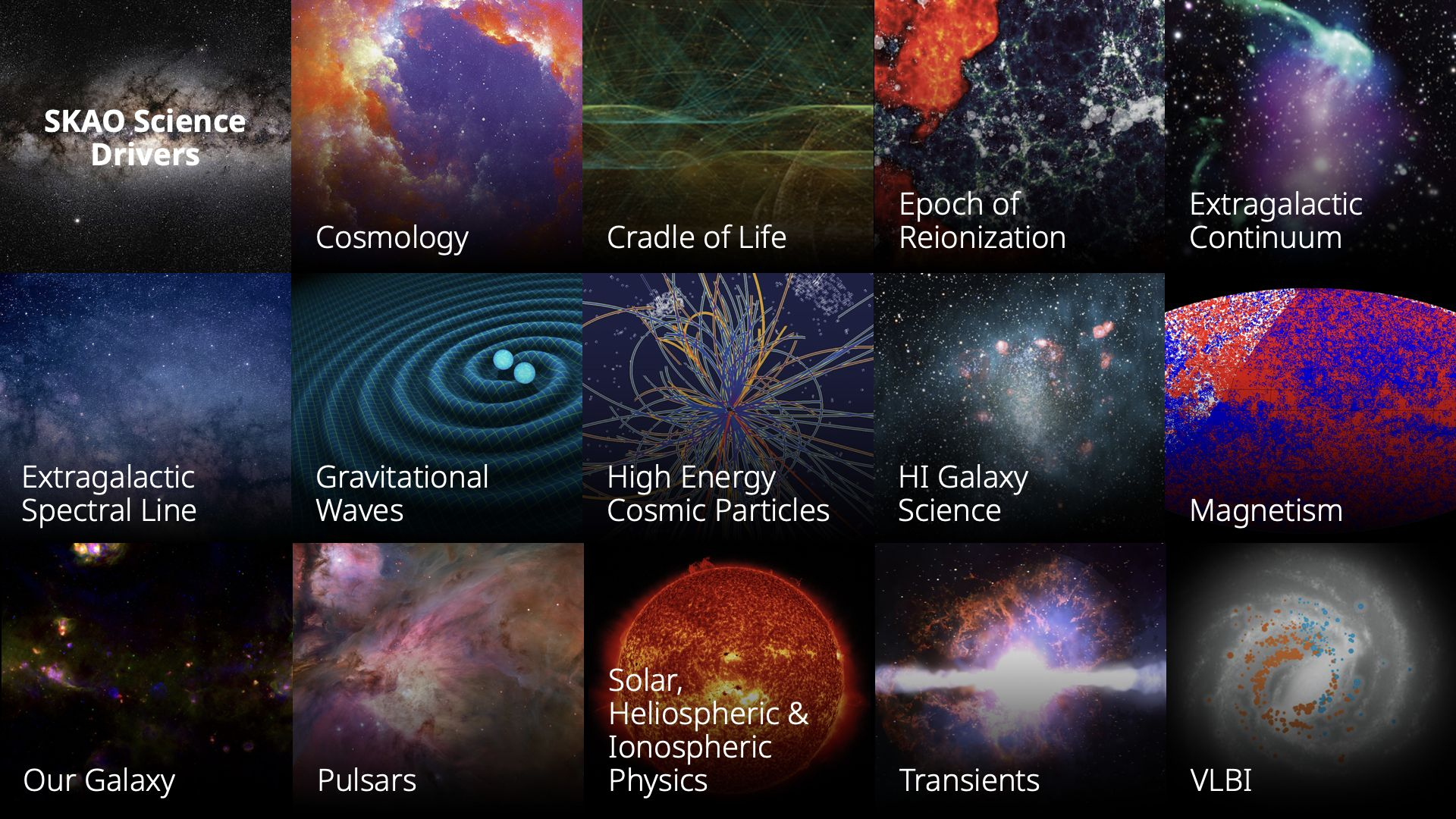
197 DISHES
IN SOUTH AFRICA (INCLUDING 64 MEERKAT DISHES)

1 GLOBAL NETWORK
OF DATA CENTRES TO DELIVER SCIENCE-READY DATA PRODUCTS TO END-USERS

8 YEARS
TO CONSTRUCT

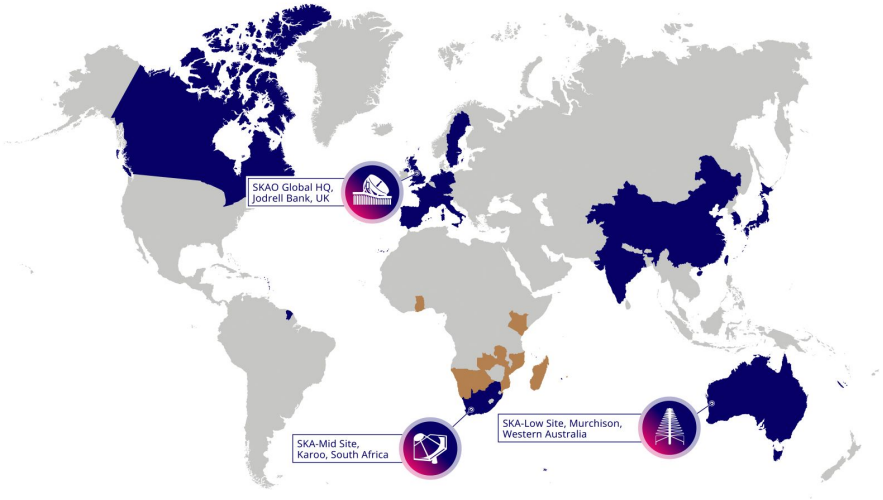
16 COUNTRIES
PARTICIPATING IN 2023

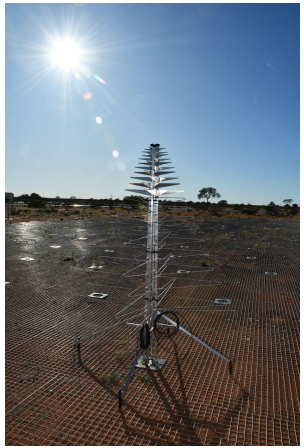
50+ YEARS
OF TRANSFORMATIONAL SCIENCE


SKAO Science Drivers
Cosmology
Cradle of Life
Epoch of Reionization
Extragalactic Continuum
Extragalactic Spectral Line
Gravitational Waves
High Energy Cosmic Particles
HI Galaxy Science
Magnetism
Our Galaxy
Pulsars
Solar, Heliospheric & Ionospheric Physics
Transients
VLBI

SKA Observatory

- World's largest radio observatory
- Intergovernmental Organisation with growing global membership
- Under construction now, operational 2026 (full 2028)
- Array locations in South Africa and Australia

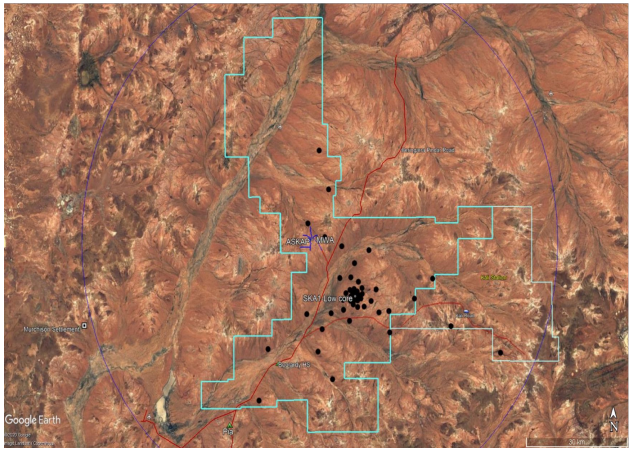


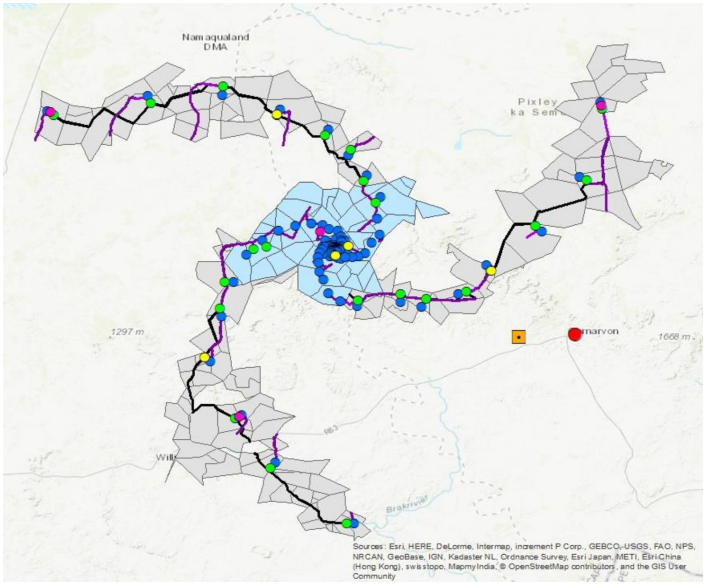


130,000 antennas spread over ~60km in WA, 100 MHz Frequency range

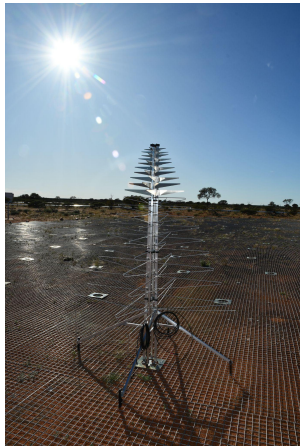
197 Dishes spread over ~100km in SA, ~GHz Frequency range

SKA-Mid in South Africa





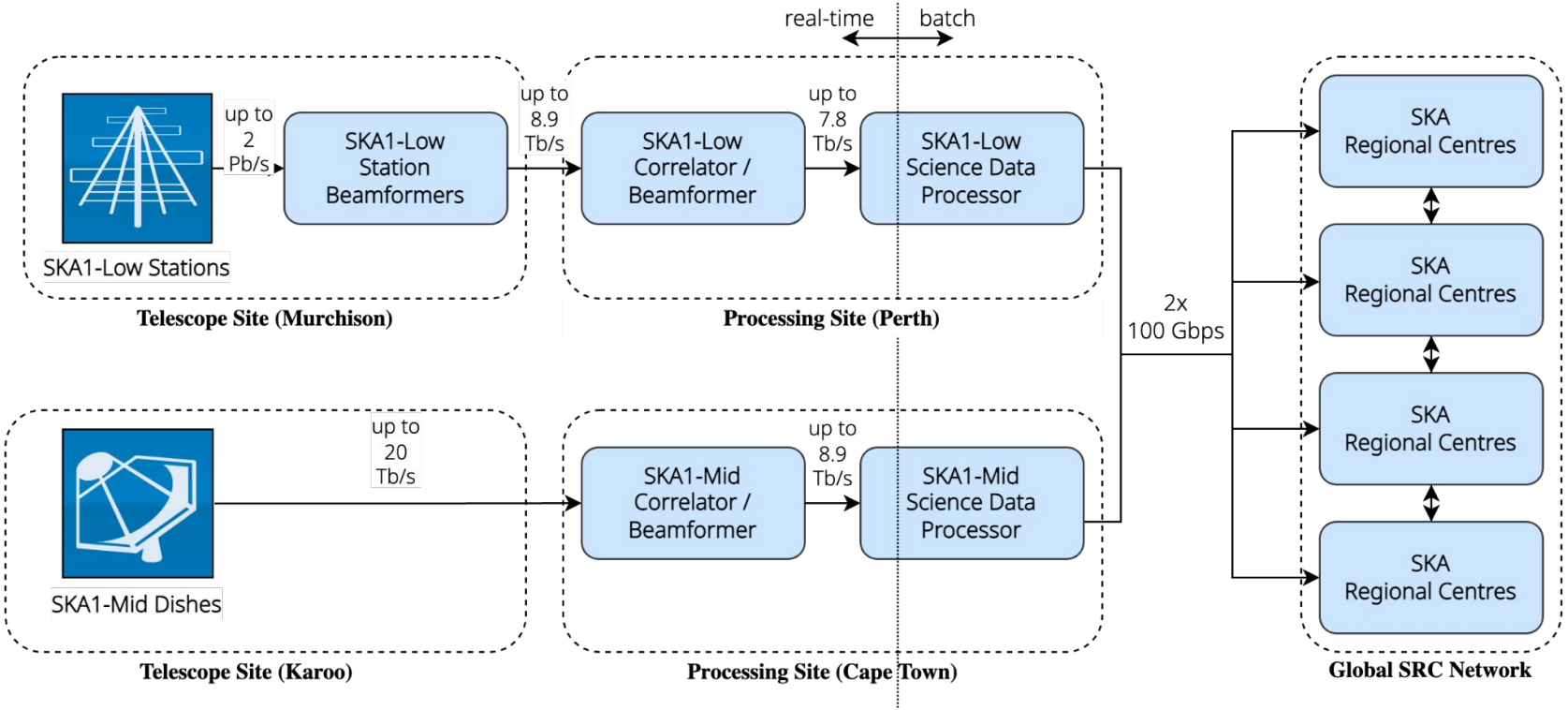
- *131,072 log-periodic antennas, spread across 512 stations*
- *Frequency range: 50 MHz - 350 MHz*
- *Maximum distance between antenna stations: 74km*



- *197 fully steerable dishes, including the existing MeerKAT dishes*
- *Frequency range: 350 MHz - 15.4 GHz*
- *Maximum distance between dishes: 150km*

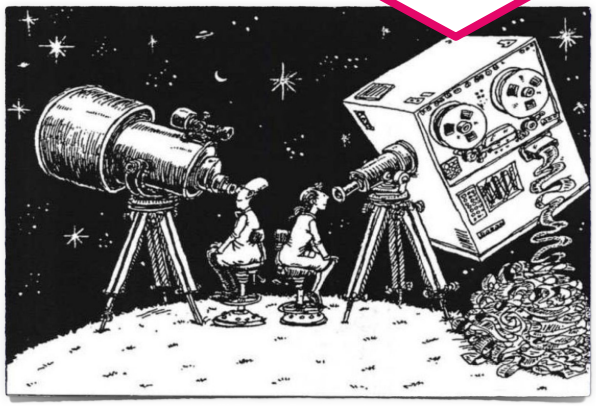
SKA-Low in Australia

SKA Data Flow



Staged Rollout Plan

Software will drive all aspects of the SKA observatory …

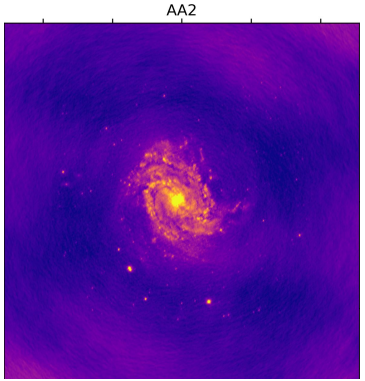


The software will need to scale and keep up as we build the instrument

Rome wasn't built in a day…

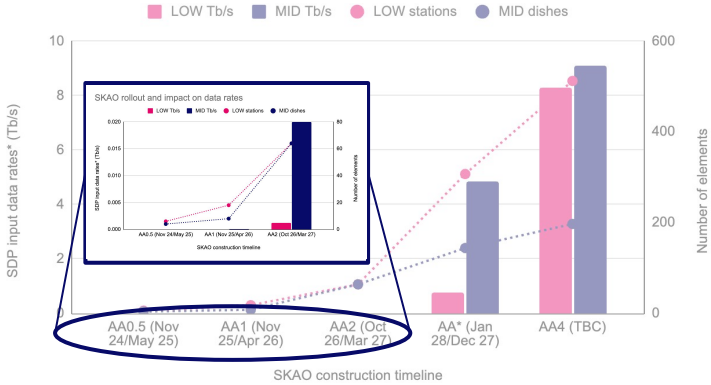
AA 0.5 → AA 1 → AA 2 → AA * → AA 4

Build, deploy, test, verify a working system at each Array Assembly



Simulation of the M83 galaxy, as might be observed by SKA-Mid for AA2. For demonstration purposes only
Credit: Sarrvesh Sridhar

SKAO rollout and impact on data rates



*Approximation, indicative trend for data rates

Staged Rollout Plan

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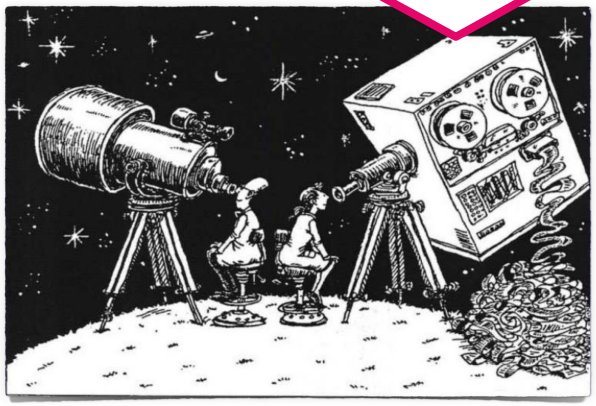

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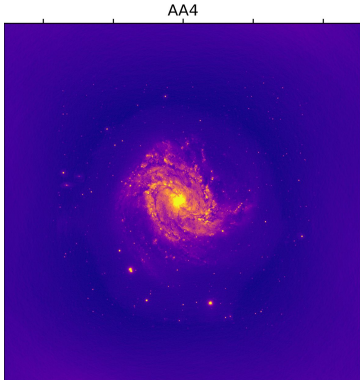

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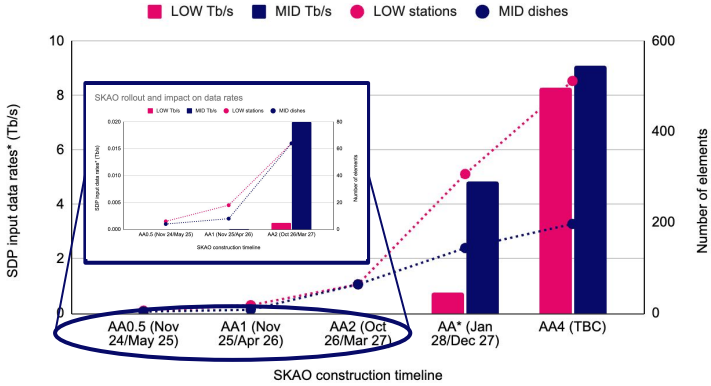

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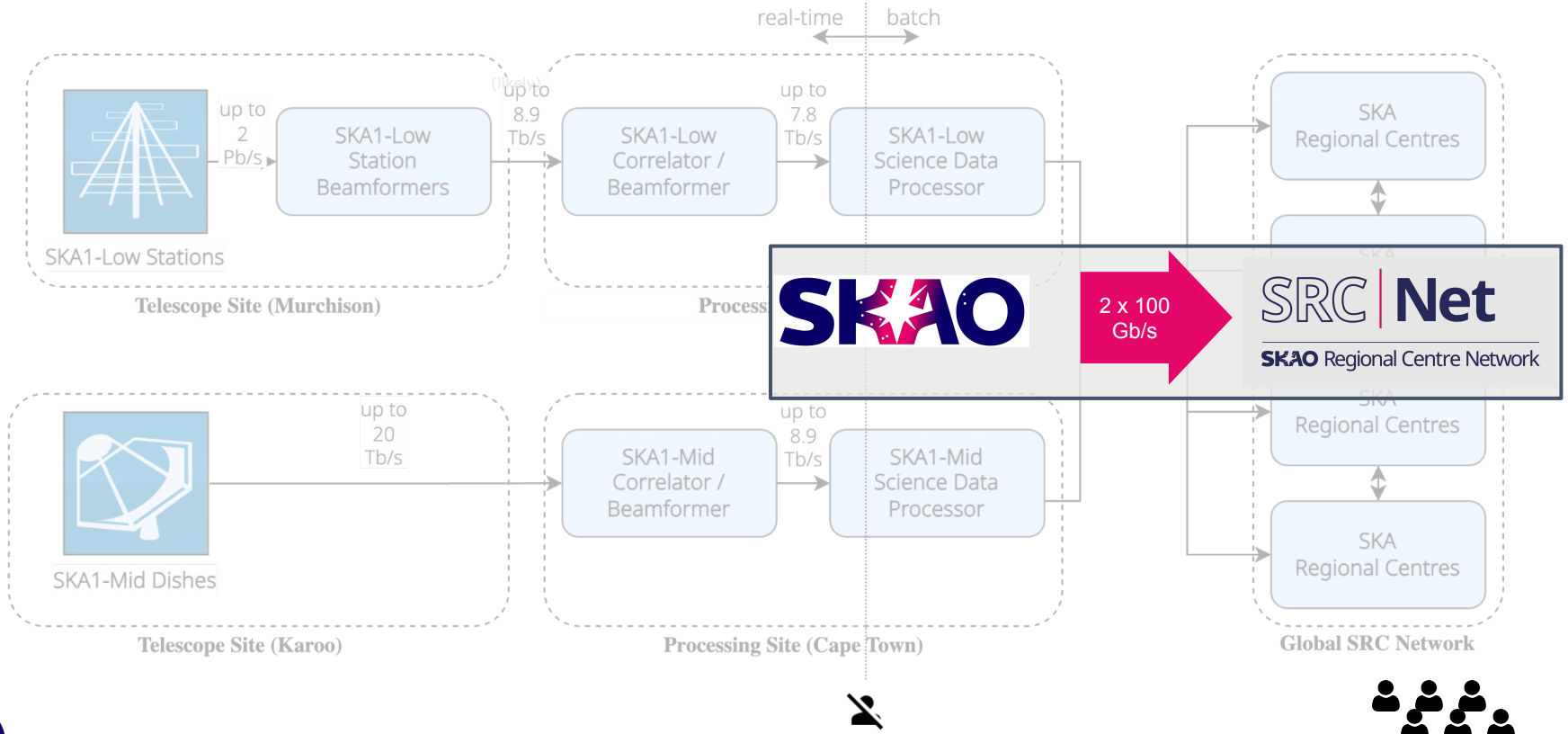
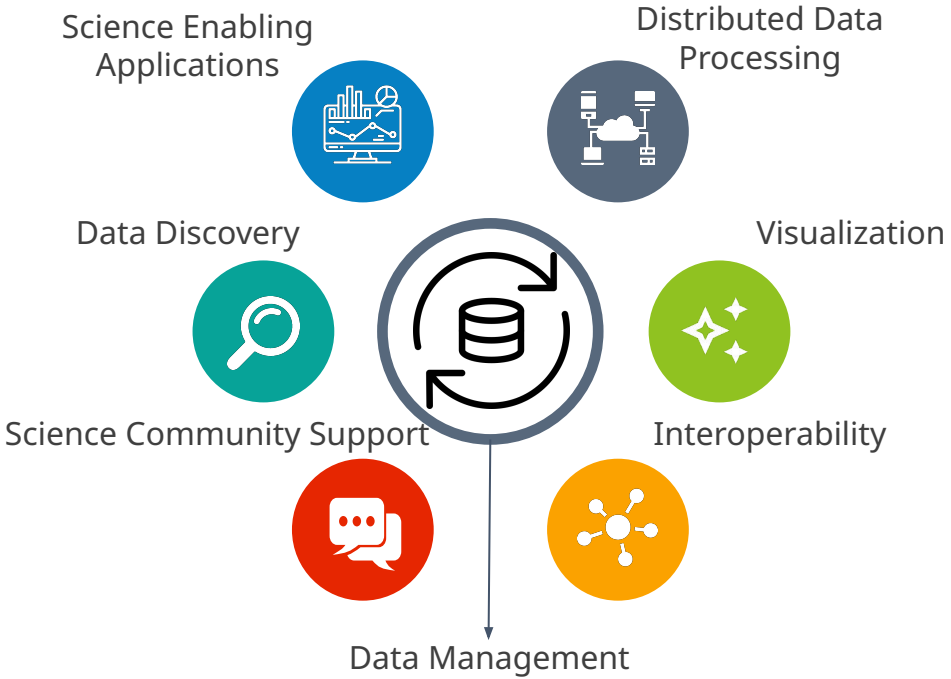
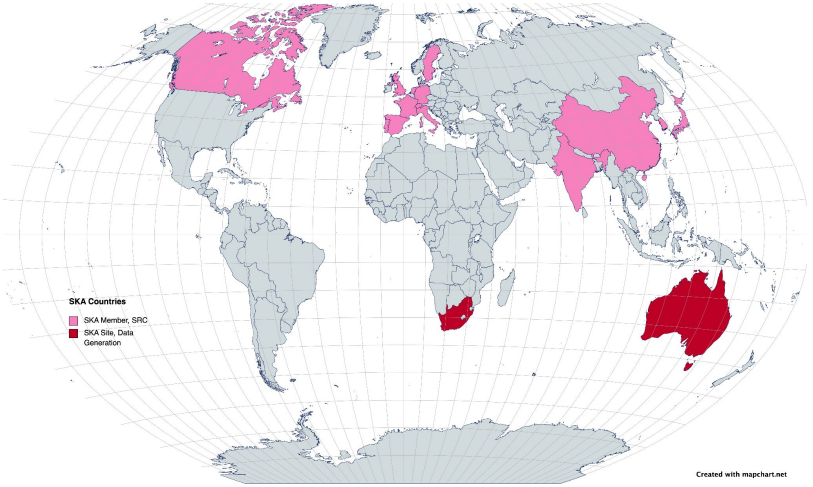
SKA Data Flow



Big Data, Bigger Science

SRC | Net
SKAO Regional Centre Network





SKA Regional Centre Core Capabilities

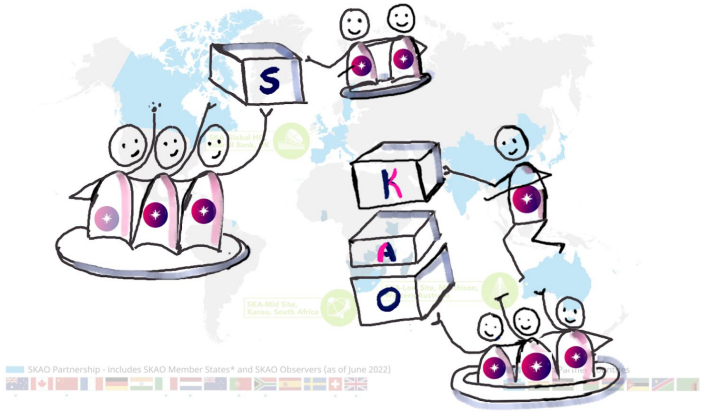
Cloud native architecture for SKAO

Architecture challenges

Highly distributed and diverse project

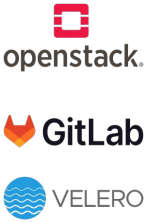
SKA Regional Centres: Distributed governance structure and distributed physical infrastructure pose unique challenges

“How can a Cloud Native architecture and strategy help us deliver to a consistent level of quality, and efficiently use resources available, on time, on budget”

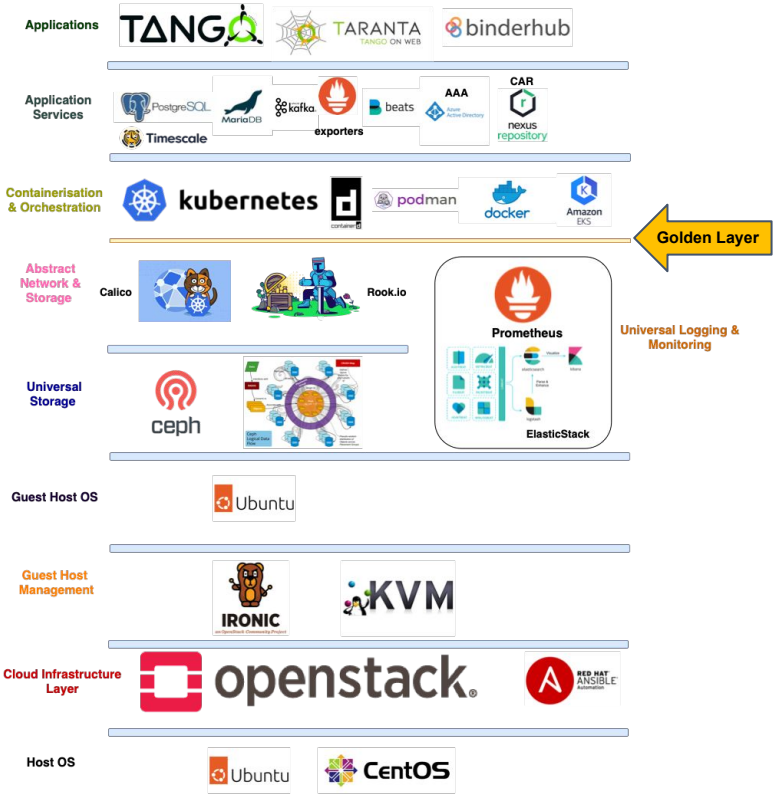


When hardware met software

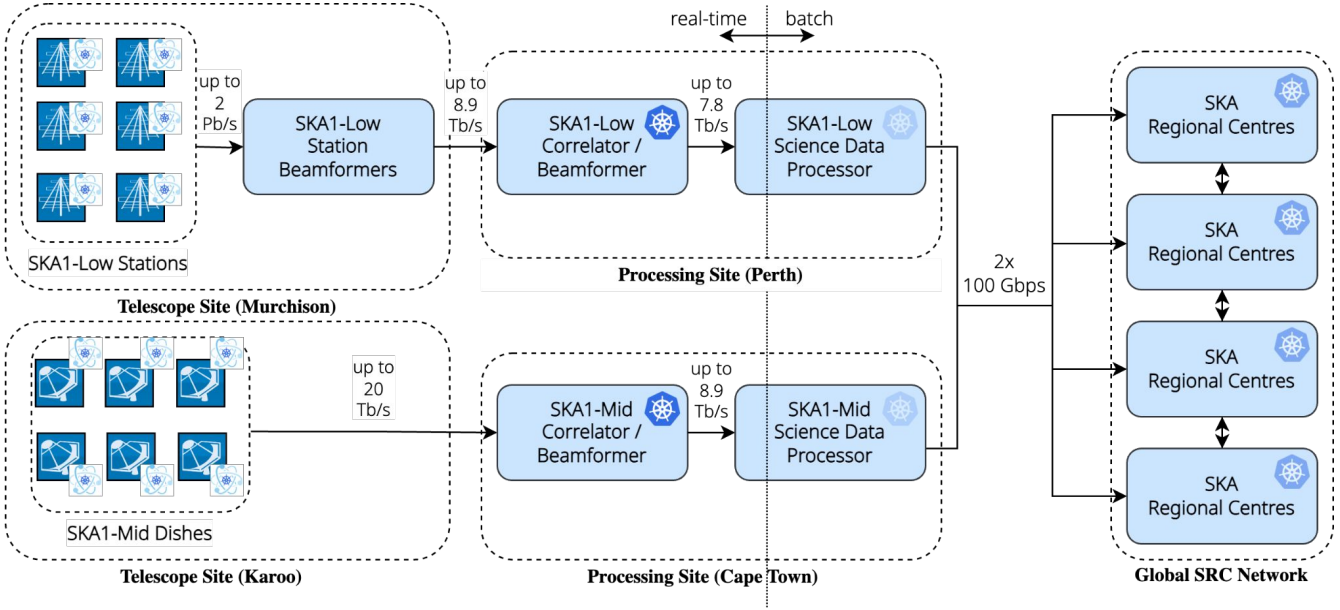
- Orchestration layer to abstract and schedule the primitives of compute, storage, and network resources.
- Abstraction allows us to focus on the API with the platform, largely shielding developers from the hardware complexities.



Cloud native architecture adoption



When hardware met software



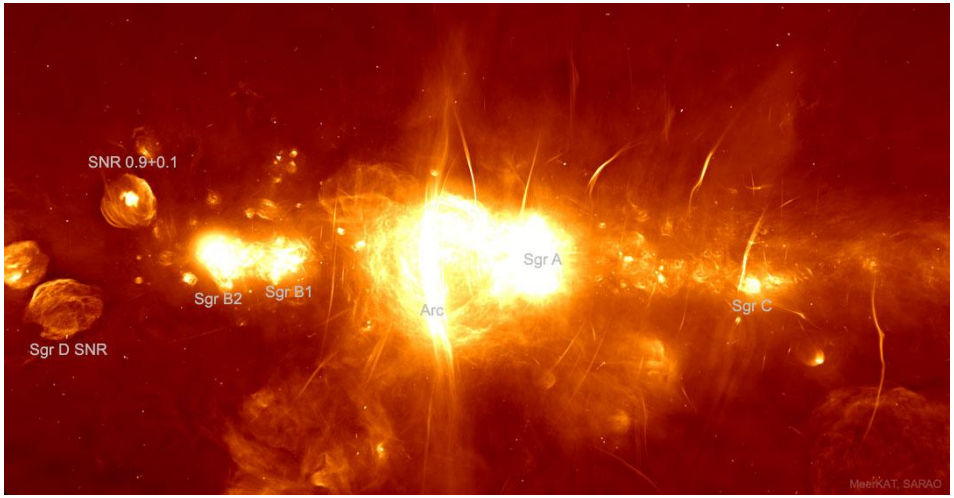
- Single node clusters on the edge to operate the dishes and stations
- Control system cluster to orchestrate the activities between the elements and downstream data processing
- Science data processor supporting multiple execution engines producing data products
- *Heterogeneous clusters hosting SKA Regional Centre services**

** hopefully*

Cloud native architecture

Standardisation, portability, abstraction

Using Cloud Native tools to help us “speak the same language”, achieve interoperability



The Galactic Center in Radio from one of our precursor instruments, MeerKAT
Image Credit: SARAO

Clunky to Classy (Clusters)

Infrastructure

Openstack projects at STFC Cloud, RAL

- **TechOps project**
  Gitlab CI/CD runners, Binderhub, Dev/Test/QA/Integration/Staging Environments, Cloud Dev Environments (Coder), Logging and Monitoring

- **SRC project**
  Prototype deployments of tools and services needed for SRCNet

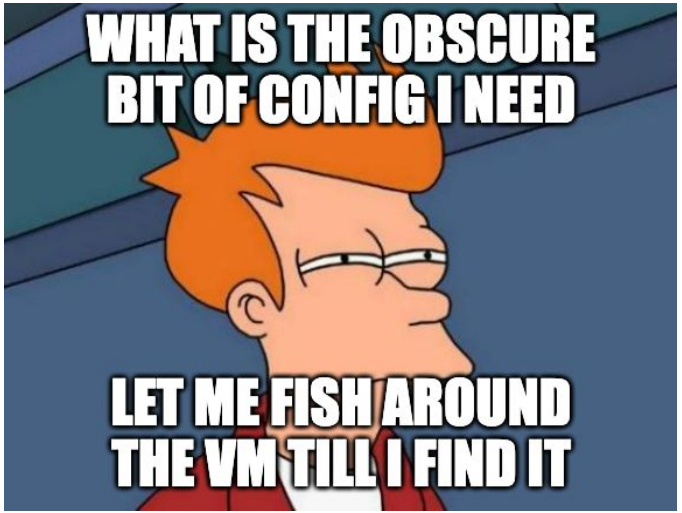
openstack™ CLOUD SOFTWARE

iris

UKRI Science and Technology Facilities Council

What existed before

- Both Openstack projects contained manually deployed clusters
- Difficult to maintain
  - Upgrades infrequent/missing, configuration drift
  - Difficult to manage payload applications
  - No portability or protection against infra failure
  - Single purpose clusters
  - Reluctance to touch for new people

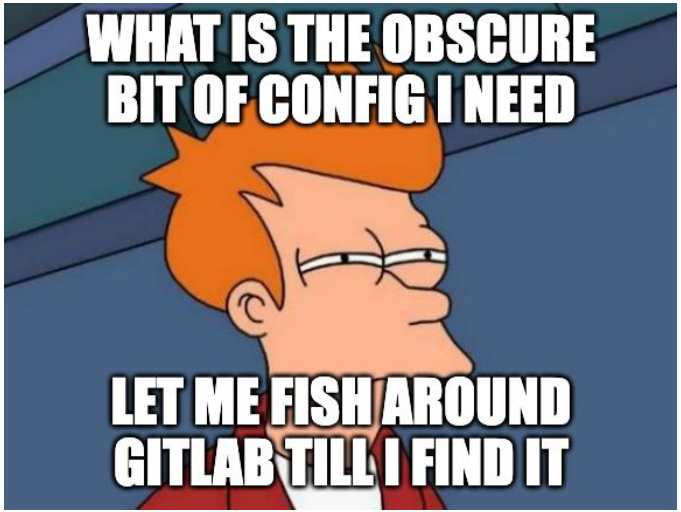


Before

What exists now

- TechOps project
  Staging and production CAPI clusters serving the > 25 development teams

- SRC project
  Multi purpose HA CAPI cluster, services separated by namespaces, reusing internal tooling developed for the above



Infrastructure as Code, progress!

iris

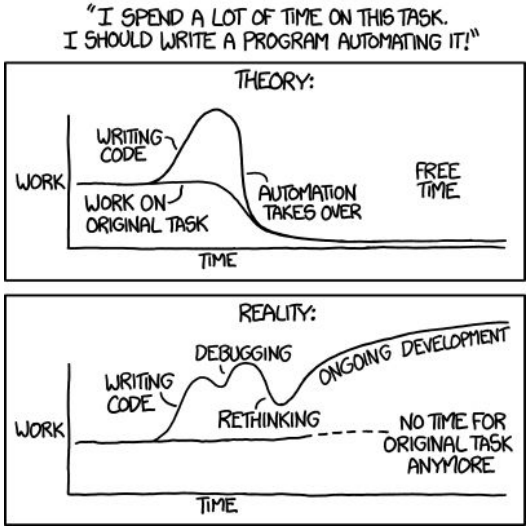
UKRI Science and Technology Facilities Council

How we went about it

Ansible roles modularly defined for all stages of cluster rollout, and service and application deployment.

“Matching” Ansible playbooks, with a set of makefiles for execution and variable management

Made the transition in both projects at the same time



https://m.xkcd.com/1319/

How we went about it

```
73  create-workload-cluster: check-hosts  ## Template workload manifest and deploy the cluster
74      ansible-playbook $(PLAYBOOKS_DIR)/clusterapi/playbooks/create-workload.yml \
75      -i $(INVENTORY) $(ANSIBLE_PLAYBOOK_ARGUMENTS) $(ANSIBLE_EXTRA_VARS) \
76      --extra-vars "target_hosts=$(PLAYBOOKS_HOSTS) " \
77      --extra-vars "delegate_hosts=$(DELEGATE_HOSTS)" \
78      --extra-vars "capi_apply_manifest=$(CAPI_APPLY)"
```

https://gitlab.com/ska-telescope/sdi/ska-ser-ansible-collections/-/blob/main/resources/jobs/clusterapi.mk?ref_type=heads#L73

```
1  #!/usr/bin/env ansible-playbook
2  ---
3  - name: Create the workload cluster
4    hosts: "{{ target_hosts }}"
5    vars:
6      target_hosts: localhost
7      delegate_hosts: localhost
8    pre_tasks:
9      - name: Check workload cluster
10       ansible.builtin.include_role:
11         name: ska_collections.clusterapi.createworkload
12         tasks_from: check-configs.yml
13         public: true
14   roles:
15     - createworkload
16   environment:
17     KUBECONFIG: "{{ capi_kubeconfig | default(lookup('ansible.builtin.env', 'KUBECONFIG', default=k
18
```

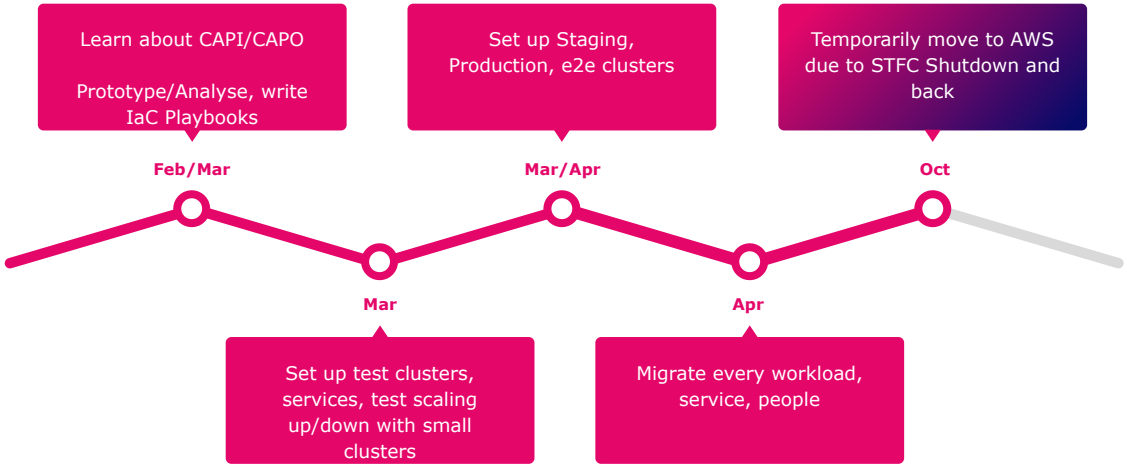
https://gitlab.com/ska-telescope/sdi/ska-ser-ansible-collections/-/blob/main/ansible_collections/ska_collections/clusterapi/playbooks/create-workload.yml?ref_type=heads

ska-ser-ansible-collections / ansible_collections / ska_collections / clusterapi / roles /

Name	Last commit
..	
calico	ST-1561: Code review and rebase changes
clusterapi	ST-1558: Normalized Makefile variables ar
clusterinventory	ST-1638: Code review
configcapo	ST-1584 comments
containerd	ST-1694: Adding separate playbook to cle
createworkload	ST-1672: Added support for clusterapi inje
imagebuilder	ST-1558: Cleaned up opensatack cloud ge
kubeconfig	ST-1717: Configurable kube-state-metrics

https://gitlab.com/ska-telescope/sdi/ska-ser-ansible-collections/-/tree/main/ansible_collections/ska_collections/clusterapi/roles?ref_type=heads

Making the move



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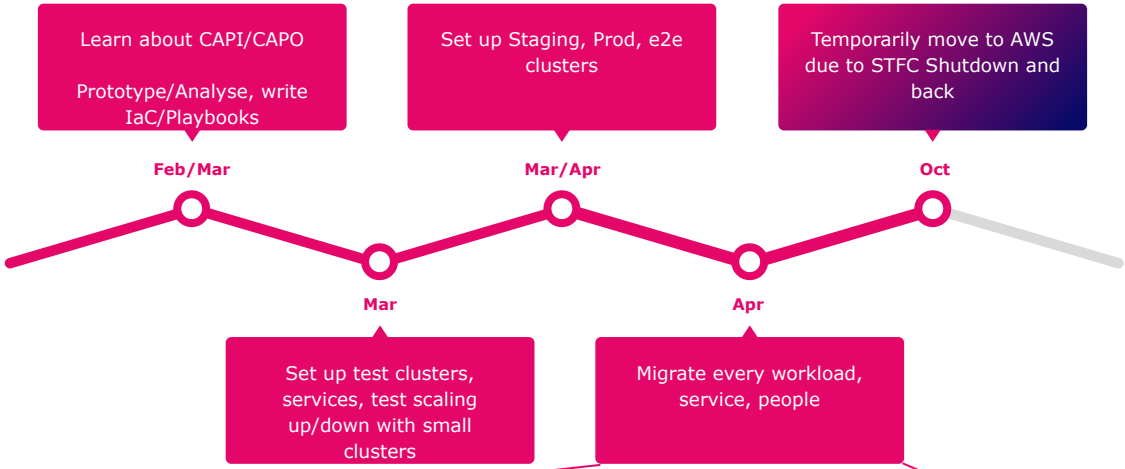

A week away

- Redeploy workloads on CAPI cluster
- Testing testing testing
- Scale up, down

A day away

- Slack updates
- Document implications
- kubeconfigs

It's time!

- Swap Ingress
- Test, and wait...

Making the move

Learn about CAPI/CAPO

Prototype/Analyse, write IaC/Playbooks

Set up Staging, Prod, e2e clusters

Temporarily move to AWS due to STFC Shutdown and back

Feb/Mar

Mar/Apr

Oct

Mar

Apr

Set up test clusters, services, test scaling up/down with small clusters

Migrate every workload, service, people

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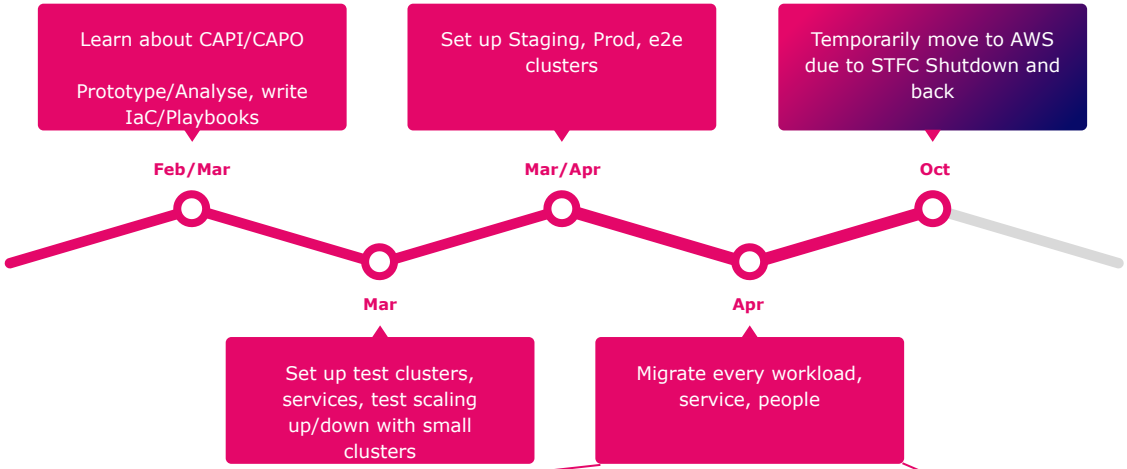

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CAPI cluster recipes in the SRC project

Modular Ansible roles allowed us to pick ‘n’ mix

- Deploy CAPI management cluster
- Install CAPO controller
- Deploy CAPI workload cluster
- Bootstrap the workload cluster
  - Ingress
  - ArgoCD
  - Jupyterhub
  - Rook
  - MetalLB
  - Multus CNI

Learn, improve Ansible knowledge within the team

Life is better

Meadow of possibilities!

- Maintenance
  - Junior members are taking more initiative!
- Scaling Out
  - Switching nodes, patches
  - Scaling up ahead of Demos, On demand clusters
- Pre/Post Hooks, ArgoCD

But...

- Reliance on a management cluster
- Bare-metal clusters are important to us
- Pre/Post Customisations (ArgoCD)
  - Experimental Features such as ClusterClass

Approaching the work

- Incremental changes vs incremental improvements

- Pros and cons lists can be a great *starting* point. But what worked well for us was asking more probing questions

- Why do we want to do this? What are the reasons for this change?
- Why should we do this now?
- What are the least number of new technologies we could involve to satisfy the whys above?
- What technical challenges may happen partway through that may cause us to stop this work? Can we do something to prevent that scenario?
- What happens if we don't do it?
- We should not do this because...

Incremental improvements still feeling overwhelming?

- Establish the groundwork before implementation
- Engage with the people
- Ask for help!

Personal takeaways

- +1 for technical people acknowledging and leaning into the social challenges

- The CN landscape is varied and rich …big and overwhelming
  - On the plus side, this means there is no one right way
  - Remember to engage with the people

- Stick to the simple straightforward path, keeping the focus on stable, reliable solutions

Still interested?

Some open questions

- How can we/our applications be making better use of storage resources?
- Can service mesh solutions help us federate a network of SRCs? What are the security implications our SRC nodes will have to consider with this approach?
- How can we easily and securely implement control systems at the edge?
- How can we improve engagement between the Research community and the wider CNCF community?

Curious About…

yugabyteDB

Follow the project and our cloud native journey, we're only getting started!

Find us on https://www.skao.int/ Want to come work for us?
Check out Ugur's talk from Monday

Scan me for the Recruitment portal!

The Galactic center as photographed by Pablo Carrillo from the SKA-Low Site in Australia

Thank you!

Feedback Appreciated!

KubeCon | CloudNativeCon North America 2023

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