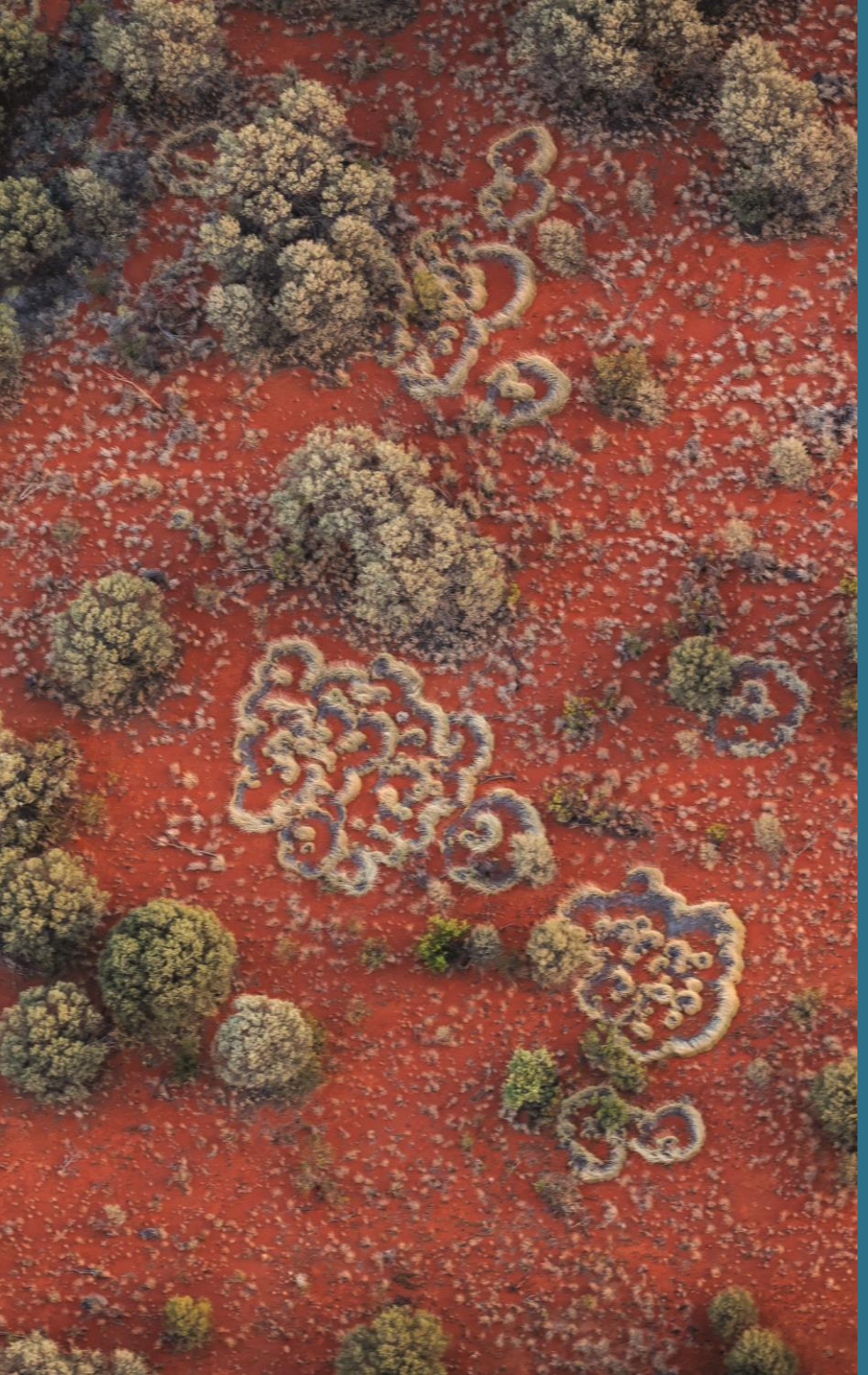

Australian Government
Geoscience Australia

Positioning Australia

Open-source Precise Point Positioning (PPP) with Ginan v2

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GINAN

Overview

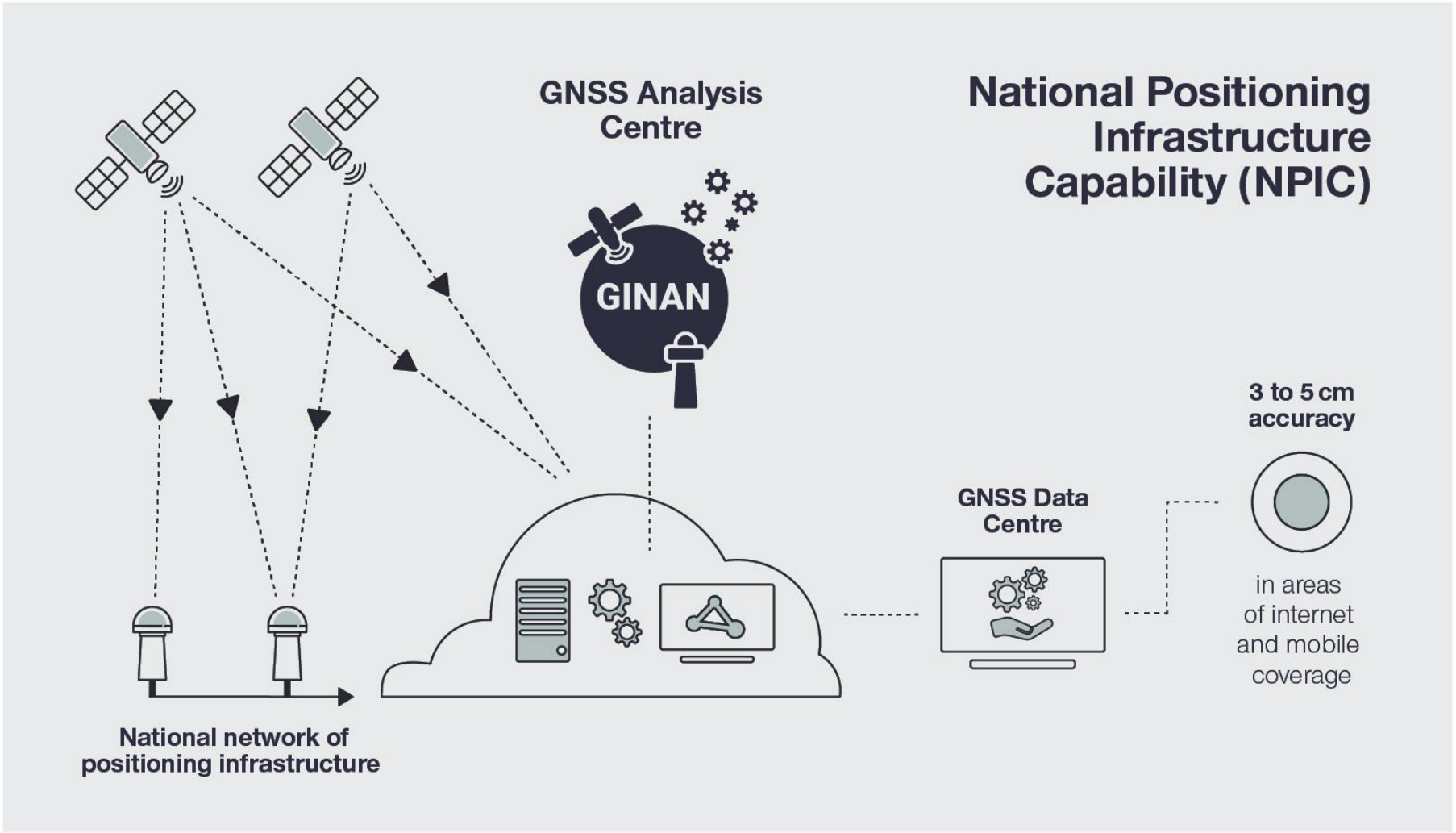
- What is Ginan
- How it works
- Current capabilities
- Ginan in operations
- Case Study – “Ginan in a box”
- Project timeline – What’s next

The Ginan Name

- Ginan comes from the Wardaman people of Northern Territory
- Is a Wardaman word for a red dilly-bag filled with songs of knowledge
- Is the fifth-brightest star in the Southern Cross
- The Southern Cross helped the First Australians to navigate

Positioning Australia (PA)
National Positioning Infrastructure Capability (NPIC)

“Accurate and reliable positioning for everyone”



Ginan - Geoscience Australia's (GA) GNSS Analysis Centre Software

- Part of GA's Positioning Australia (PA) National Positioning Infrastructure Capability (NPIC)
- Open-source software toolkit for precise positioning and navigation
- Multi-GNSS data processing and analysis capability
- Undifferenced, State Space Representation (SSR) using Precise Point Positioning (PPP) methodology
- Capable of delivering precise positioning products and services for post processed and real-time applications
- Enables centimetre level accuracy positioning in areas with mobile phone/internet coverage

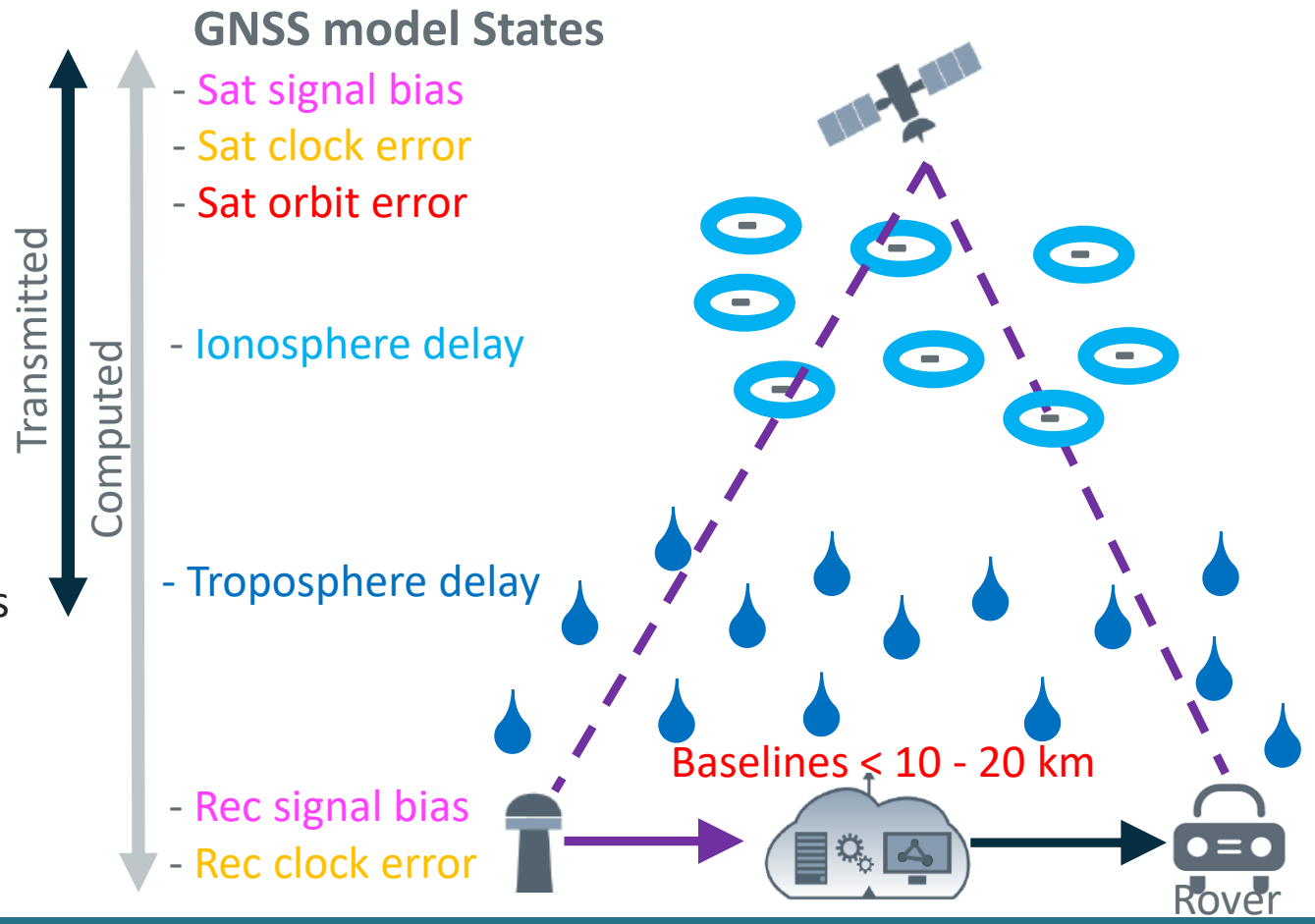
Methodology - PPP (SSR) vs RTK (OSR)

$$P_{r,f}^{s} = \rho_r^s + c\left(\delta\tau_r^q - \delta\tau^s\right) + T_r^s + \mu_f I_r^s + d_{r,f}^q + d_f^s + O^s + \varepsilon_{r,f}^s$$

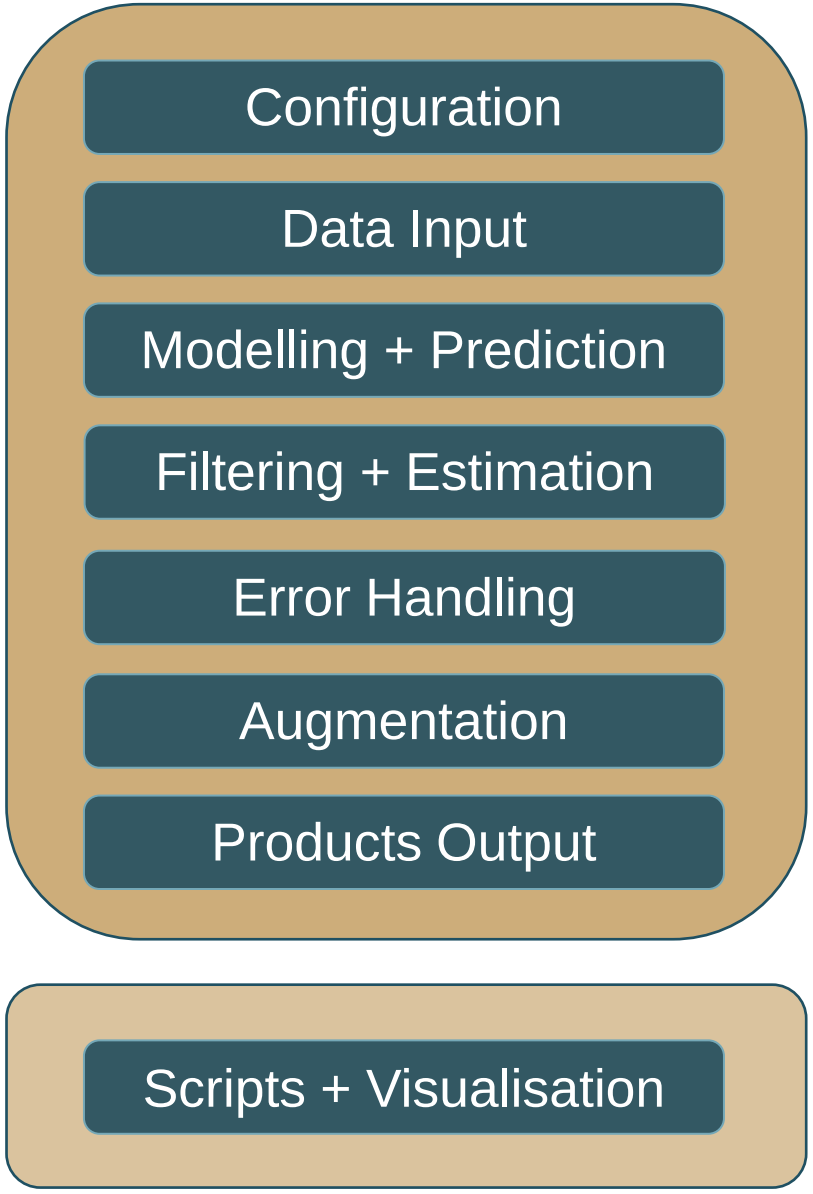
- P - Observed range between satellite & receiver
- ρ - Geometric distance between satellite and receiver *
- c - Speed of light
- $\delta\tau$ - Receiver and satellite clock offsets
- T - Troposphere delay between satellite and receiver
- μ - Frequency dependent ionosphere delay factor
- I - Ionosphere delay between satellite and receiver
- d - Receiver and satellite hardware signal biases
- O - Satellite orbit errors
- ε - Range measurement noise

s, r, f, q – satellite, receiver, frequency, constellation indices

* The geometric range ρ is what is used for positioning
More precisely known ρ's == more precise positioning

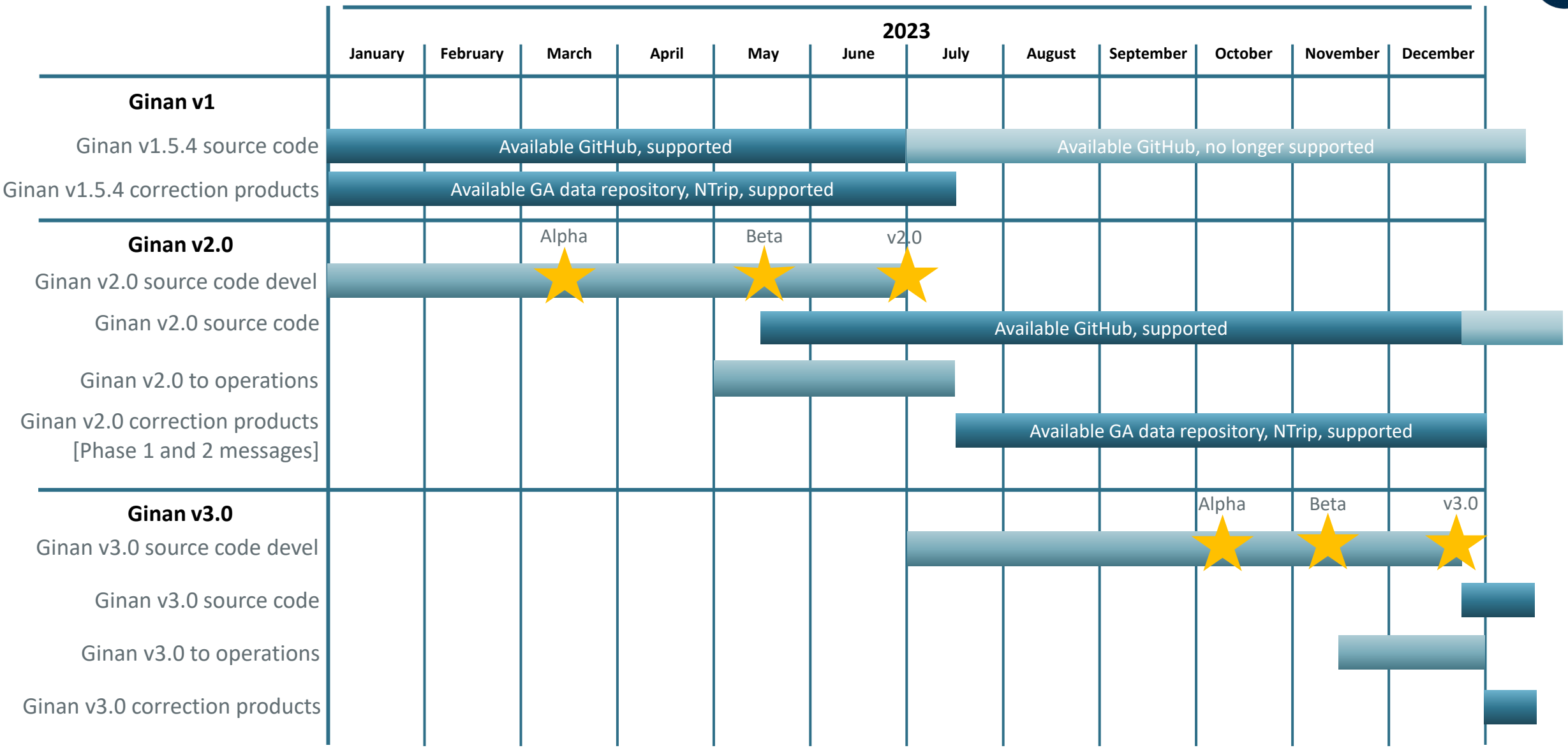


Ginan – Functional Architecture



- **Configuration**:
  - Standard Yet Another Markup Language (YAML)
- **Input**:
  - File based for Post Processing (PP) or Streams for Real Time (RT) processing
- **Observations**:
  - Always Un-Differenced (UD)
  - Combined Ionosphere Free (IF) form, or Un-Combined (UC)
  - Dual frequency (IF), or Multi-frequency UC
  - Multi-constellation: GPS, GLO, GAL, QZS, BDS (SBAS in dev)
- **Measurement model**:
  - Positions, Clocks, Phase/Code biases, Troposphere, Ionosphere, PCO, PCV, phase windup, Antenna Ecc, Tides, Relativity, …….
- **Filtering and Estimation**:
  - Robust Kalman filter
  - Flexible full GNSS observation model State estimation
  - Backwards Smoothing (Fixed Lag and Full RTS)
- **Output**: Industry standard file products or RTCM3 stream based

Ginan - Development & Operations timeline

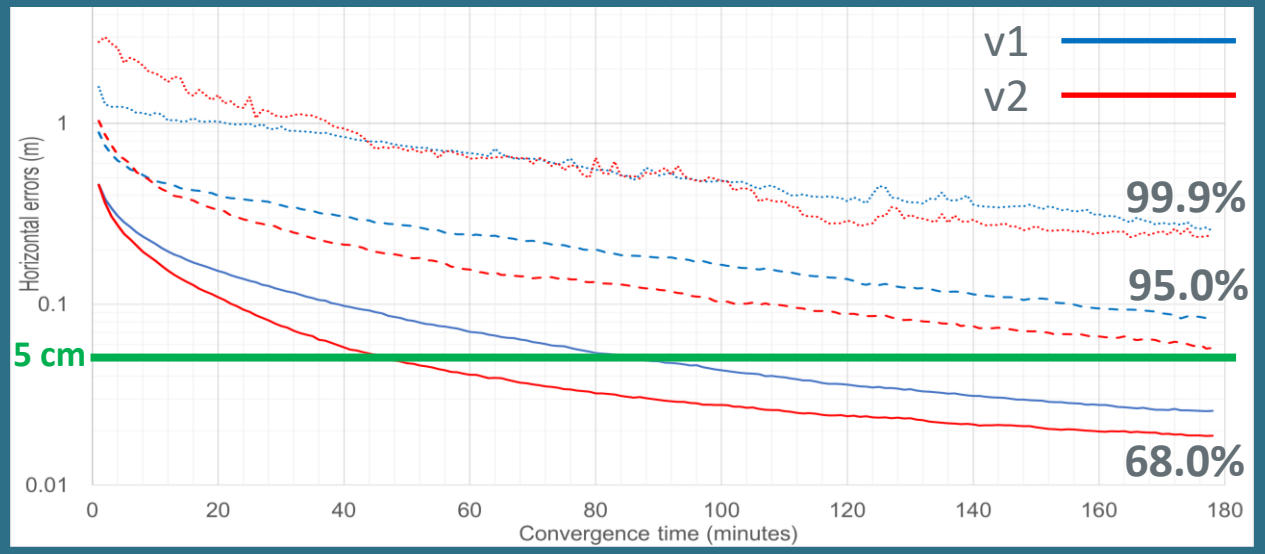


Ginan: v1 vs v2

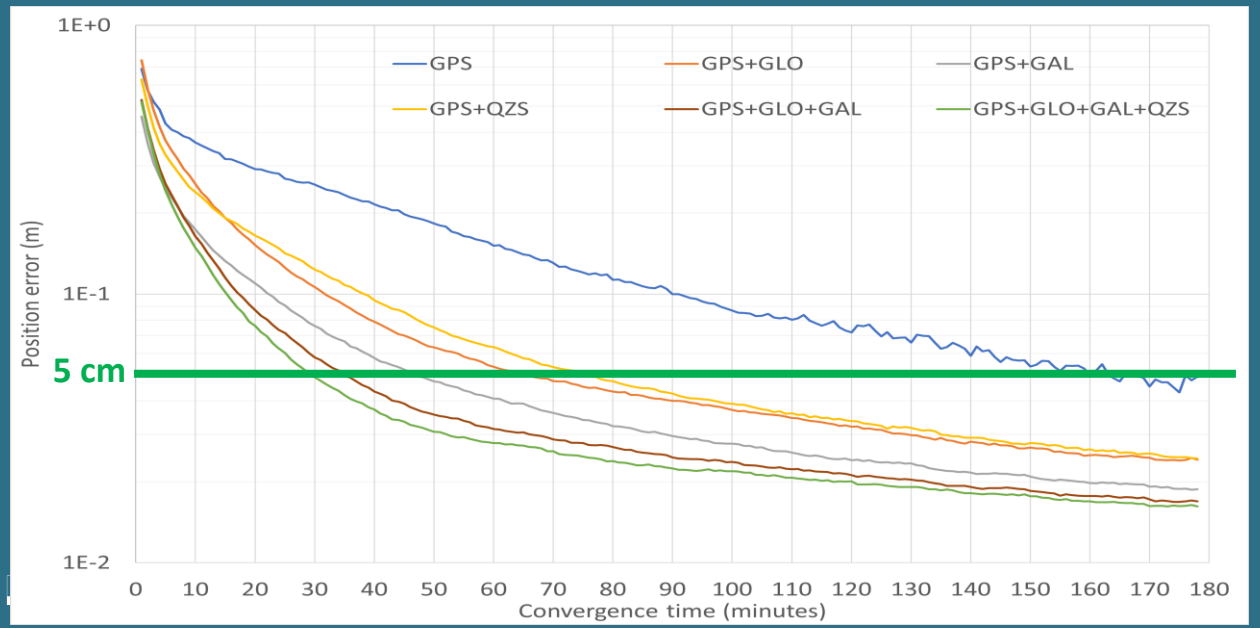
- Unified User and Network operation modes (One Observation Model & Filter)
- More GNSS constellations – Full Multi-Constellation capability (Ex SBAS)
- Better internal frequency indexing (complete Multi-Frequency capability)
- UnDifferenced / UnCombined (UDUC) processing (v1 was Combined IF only)
- CPP integrated and coupled Precise Orbit Determination (POD) capability
- More robust data handling in filter cycle slip and outlier detection and removal
- Complete RTCM3 phase 1 and Phase 2 message decoding and encoding
- SLR data handling fully implemented
- Model & Performance improvements

Ginan Performance: v1 vs v2

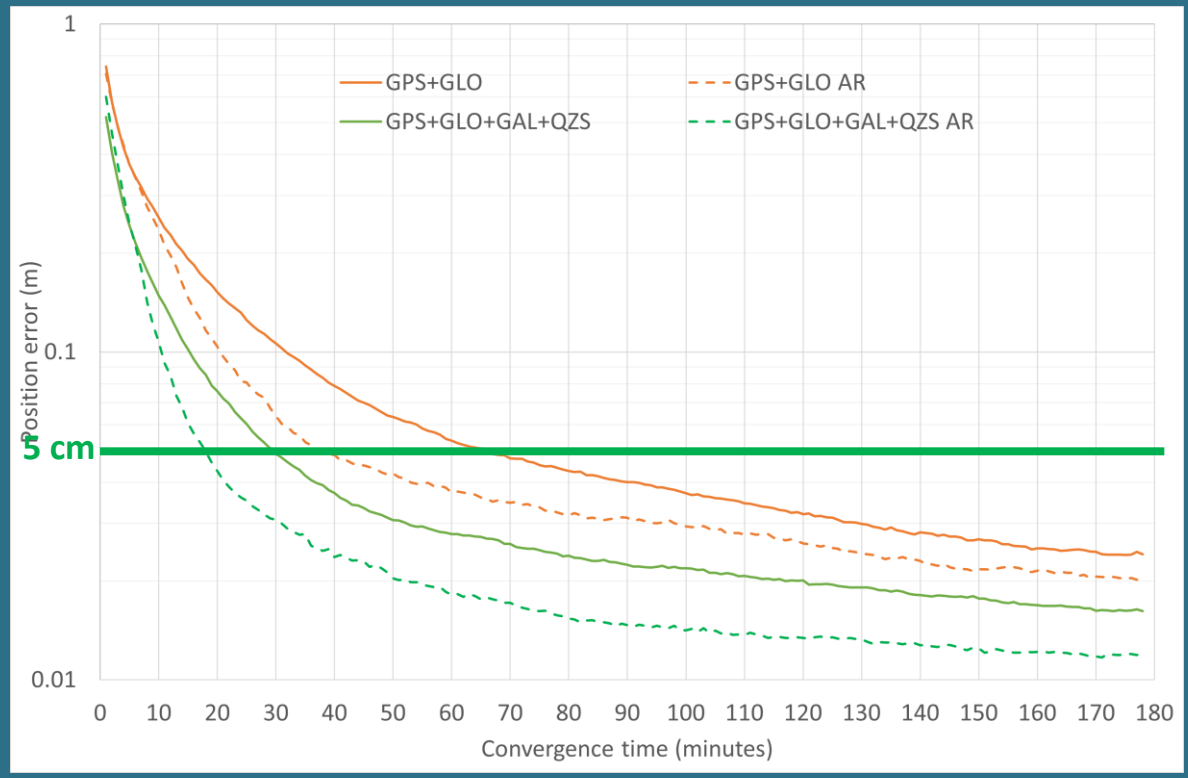
Dual frequency uncombined PPP vs IF PPP in Ginan (ie. v1 vs v2)



Dual Frequency uncombined PPP – Multi constellation (v2)



Dual Frequency uncombined PPP (AR) – Multi constellation



Ginan - Operational System

- Operational Ginan system is built on top of the infrastructure used to maintain GA's NPIC data repository
- A Kubernetes (*k8s*) computing "cluster" via Amazon (*AWS EKS*) is used to run Ginan in individual "pods"
- Resources on the cluster are controlled by Terraform (Infrastructure-as-code)

File-based Products

The files we output are created by Ginan five times per day:

- **Daily** for the **Rapid** Orbits, Clocks and CORS Positions
- **6-hourly** for the **Ultra-rapid** Orbits and CORS Positions

The process is split into **individual steps** or tasks controlled by **Argo**

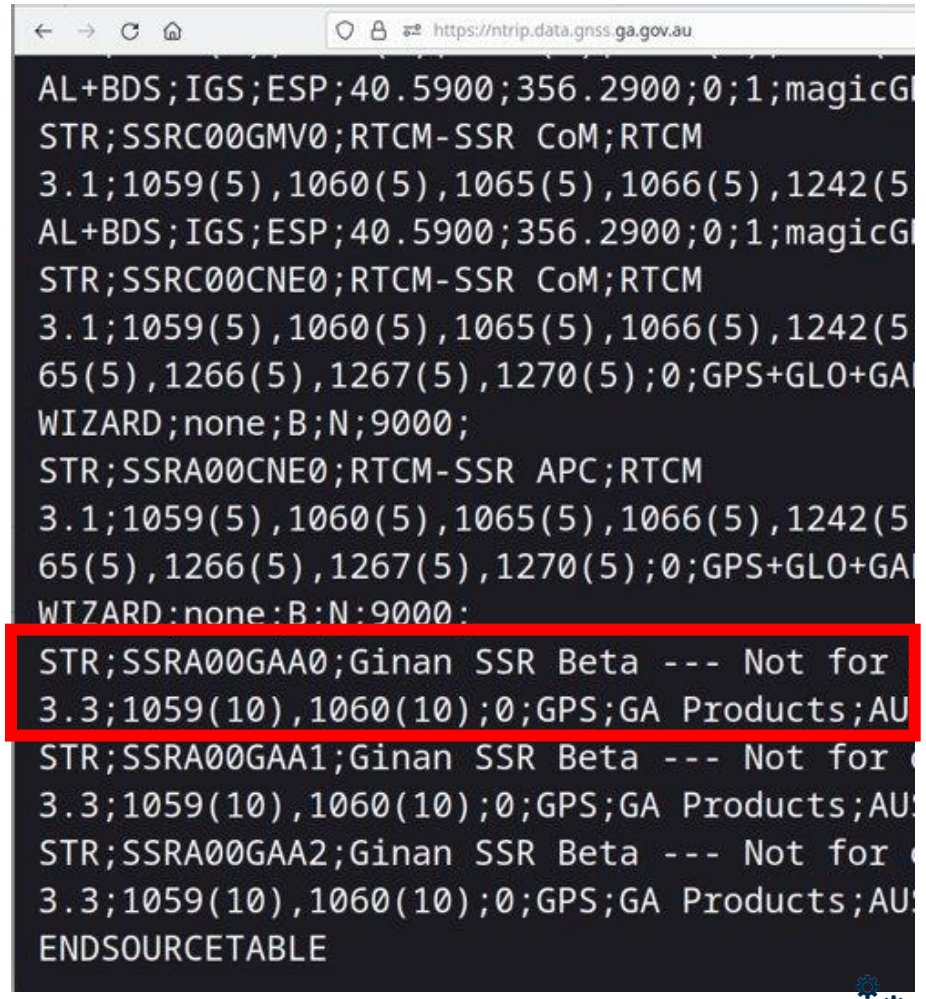
Argo is an orchestration / workflow engine used within Kubernetes to create the necessary resources to run the "Ginan jobs"

Real-Time Services

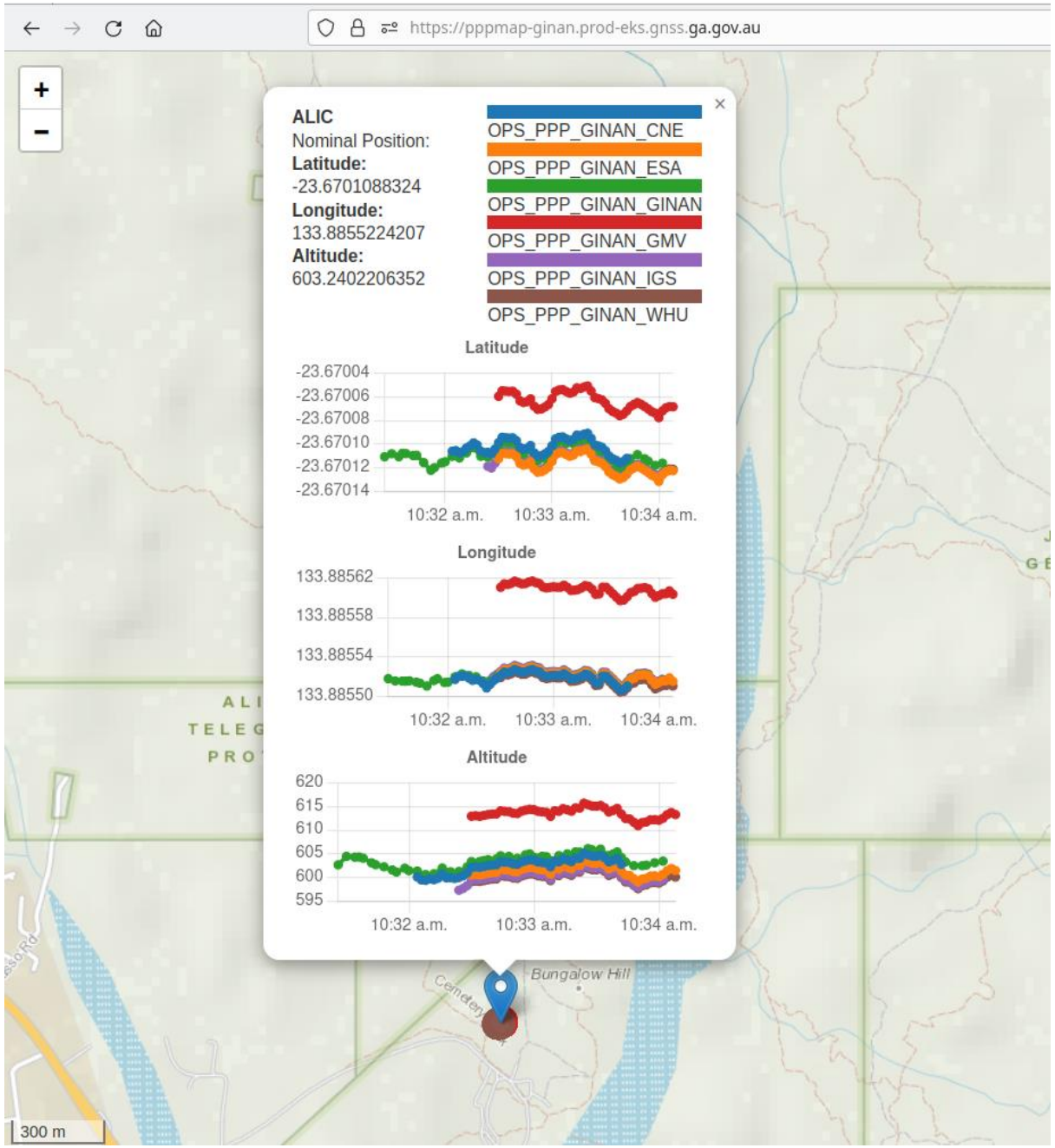
We run Ginan continuously (multiple instances) to:

1. Produce an **RTCM correction stream** broadcasting **1059** and **1060** messages
2. Output **real-time PPP results** from a handful of CORS stations

- Both of these are modules directly described by Terraform code
  - No scheduling / orchestration needed for real-time like with files



Monitoring



Ginan Information

Source code is available at GitHub and we support native builds on:

- Linux
- Mac
- Windows (via WSL – Windows Subsystem for Linux)

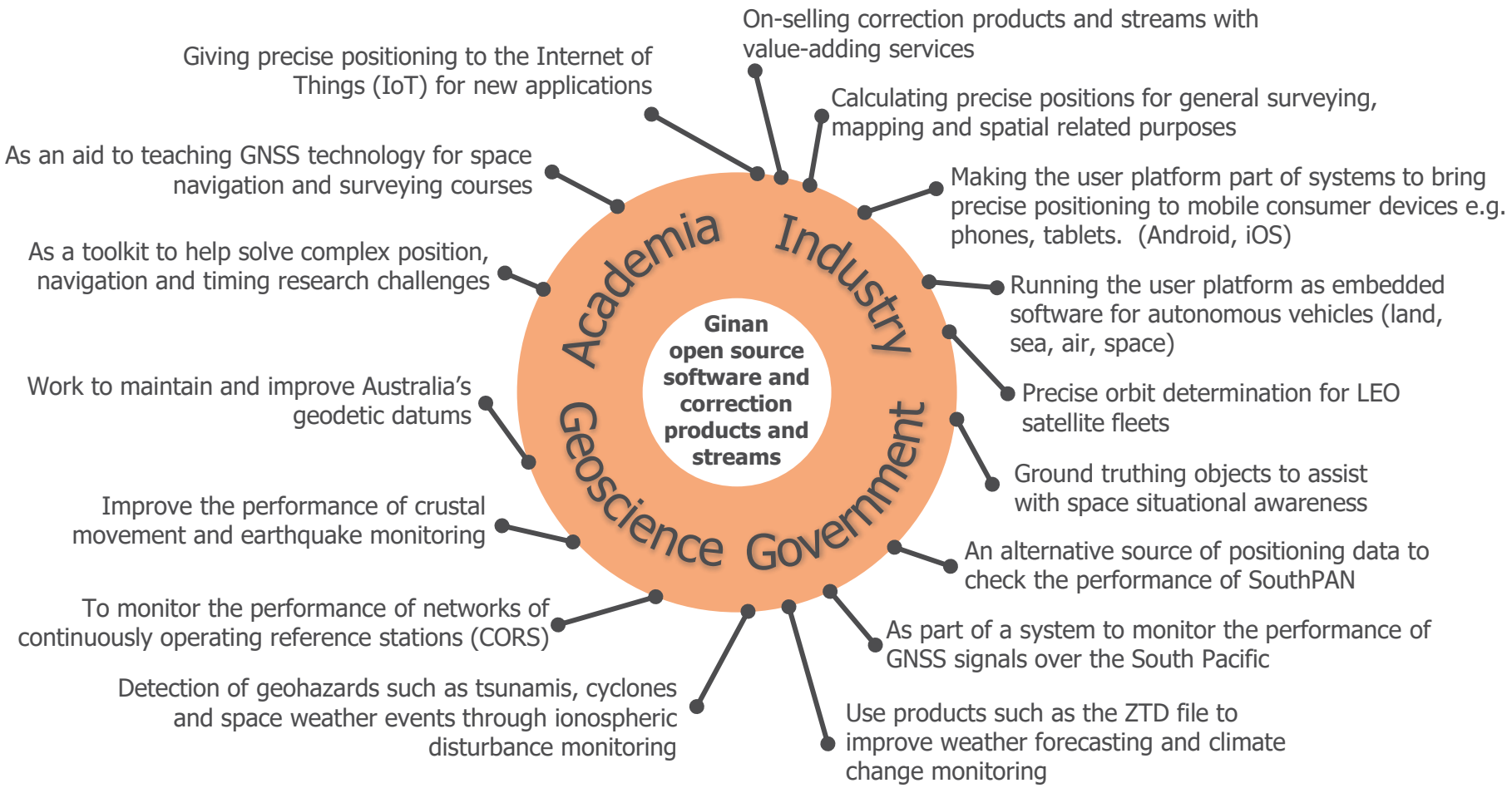
Docker Image

Playlist of Installation Videos

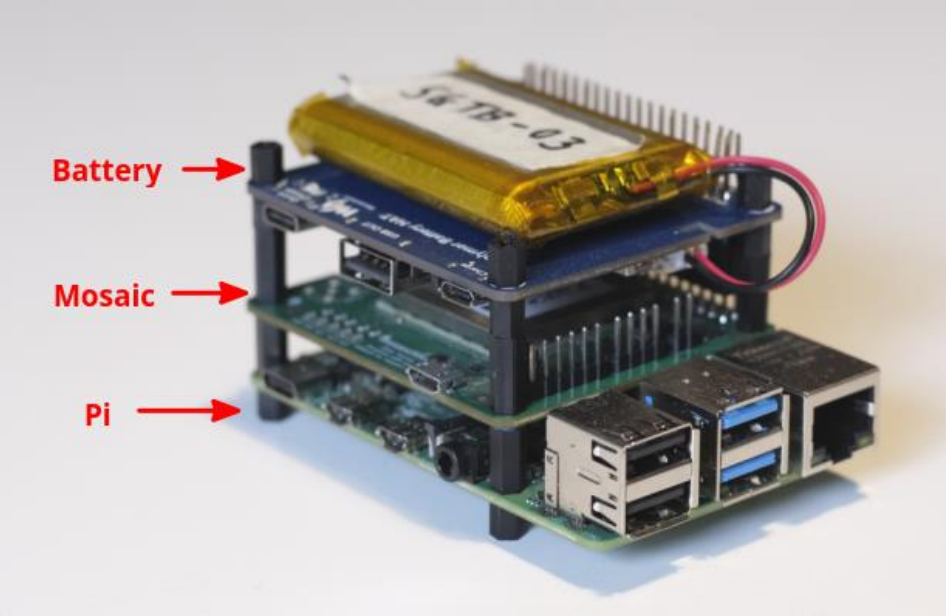
Links available at the Link Tree: https://linktr.ee/ginan_GA

Ginan Use Cases

16 use cases identified to date + 1: Cal-Val



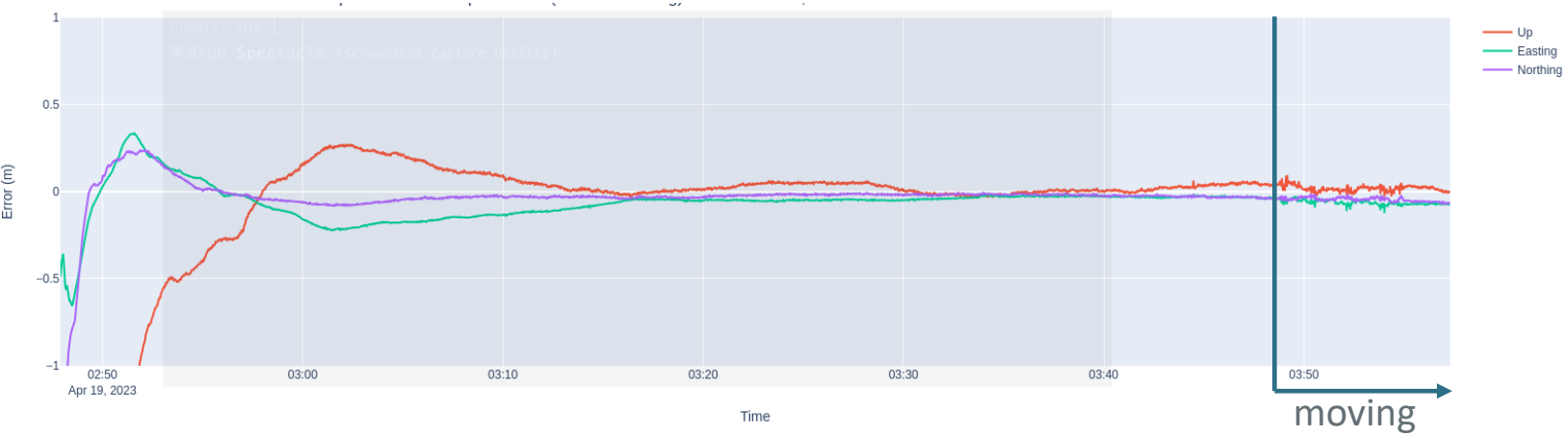
Ginan in a Box
Embedded software for kinematic positioning and Navigation



Ginan embedded configuration
Ginan in a box

- Ginan running on a Raspberry Pi Arm64 processor
- Septentrio Mosaic Multi-GNSS receiver

Albert Park, Melbourne - Ginan in a Box kinematic positioning test



Ginan Multi-GNSS PPP wrt reference differential RTK trajectory

Horz RMS = 0.021m

Vert RMS = 0.109m

*After removing the stationary convergence data

Ginan v3 – What's Next

- Compact SSR / IGS SSR correction formats
- PPP-RTK capability
- LEO obit estimation capability
- Multi-solution combination capability
- Web / Graphical User Interface
- Much more testing and validation