



Australian Government
Geoscience AustraliaPositioning
Australia

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

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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)



$$P_{r,f}^{s} = \rho_{r}^{s} + c\left(\delta_{r}^{q} - \delta_{r}^{s}\right) + \mathbf{v}_{r}^{s} + \mu_{f}\mathbf{I}_{r}^{s} + \mathbf{v}_{r,f}^{q} + \mathbf{v}_{f}^{s} + \mathbf{v}_{r,f}^{s} + \mathbf$$



Ginan – Functional Architecture



Scripts + Visualisation

• 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 (AR) – Multi constellation



Dual Frequency uncombined PPP – Multi constellation (v2)







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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:

- 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 realtime like with files

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AL+BDS;IGS;ESP;40.5900;356.2900;0;1;magicG
<pre>STR;SSRC00GMV0;RTCM-SSR CoM;RTCM</pre>
3.1;1059(5),1060(5),1065(5),1066(5),1242(5
AL+BDS;IGS;ESP;40.5900;356.2900;0;1;magicG
<pre>STR;SSRC00CNE0;RTCM-SSR CoM;RTCM</pre>
3.1;1059(5),1060(5),1065(5),1066(5),1242(5
65(5),1266(5),1267(5),1270(5);0;GPS+GLO+GA
WIZARD;none;B;N;9000;
<pre>STR;SSRA00CNE0;RTCM-SSR APC;RTCM</pre>
3.1;1059(5),1060(5),1065(5),1066(5),1242(5
65(5),1266(5),1267(5),1270(5);0;GPS+GLO+GA
WIZARD:none:B:N:9000:
STR;SSRA00GAA0;Ginan SSR Beta Not for
3.3;1059(10),1060(10);0;GPS;GA Products;AU
STR;SSRA00GAA1;Ginan SSR Beta Not for
3.3;1059(10),1060(10);0;GPS;GA Products;AU
STR;SSRA00GAA2;Ginan SSR Beta Not for
3.3;1059(10),1060(10);0;GPS;GA Products;AU
ENDSOURCETABLE



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

Ginan

open source software and

correction

products and streams

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Geo

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

Giving precise positioning to the Internet of Things (IoT) for new applications

As an aid to teaching GNSS technology for space navigation and surveying courses **Colemia**

As a toolkit to help solve complex position, navigation and timing research challenges

Work to maintain and improve Australia's geodetic datums

Improve the performance of crustal movement and earthquake monitoring

To monitor the performance of networks of continuously operating reference stations (CORS)

> Detection of geohazards such as tsunamis, cyclones and space weather events through ionospheric disturbance monitoring

On-selling correction products and streams with value-adding services

> Calculating precise positions for general surveying, mapping and spatial related purposes

> > Making the user platform part of systems to bring precise positioning to mobile consumer devices e.g. phones, tablets. (Android, iOS)

 Running the user platform as embedded software for autonomous vehicles (land, sea, air, space)

Precise orbit determination for LEO satellite fleets

Ground truthing objects to assist with space situational awareness

An alternative source of positioning data to check the performance of SouthPAN

As part of a system to monitor the performance of GNSS signals over the South Pacific

Use products such as the ZTD file to improve weather forecasting and climate change monitoring



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



