

tangram

An open platform for modular, real-time air traffic management research

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Context and motivation: Real-time ATM research

Objective:

- **Testing algorithms on live data streams** (most existing work is on historical data)
- Validating research prototypes in operational environments

Challenge: Existing solutions are either:

- Proprietary and closed solutions (commercial platforms, e.g. FlightRadar24)
- Infrastructure not ready for real-time capabilities (e.g. OpenSky Network)
- Any custom solution is complex to deploy and maintain (not suitable for researchers/students)

We want to create an **open, modular platform**
that researchers can easily **deploy, extend, and use** for real-time ATM research

Initial project: Real-time turbulence detection based on Mode S data

- Proof of concept with Michel Khalaf (Master student, 2021-2022)
- Live demo with Bordeaux ACC in May 2022

Reality check:

- Performance issues with multiple concurrent users
- Maintenance burden too high for a Master student (and supervisors...)
- Python limitations for real-time processing

We need infrastructure that enables research, not infrastructure that becomes the research

Funding obtained in 2023 to develop a proper platform

Dutch Research Council (NWO) Open Science Fund

Key architectural decisions:

- **Redis pub/sub**: Decoupled message-based communication
- **Backend plugins**: Installable Python packages via entry points
- **Frontend plugins**: Dynamic Vue components loaded at runtime
- **Performance-critical parts in Rust**: jet1090 for ADS-B/Mode S decoding, etc.
- **Distributed and configuration-driven** (Linux, MacOS, containers, Nix, etc.)

Philosophy: tangram is a set of components that communicate through messages



A month before the deadline (2025)

Xavier Olive, Junzi Sun, Xiaogang Huang, and Michel Khalaf
tangram, an open platform for modular, real-time air traffic management research
Journal of Open Source Software, 10 (115), 2025
<https://doi.org/10.21105/joss.08662>

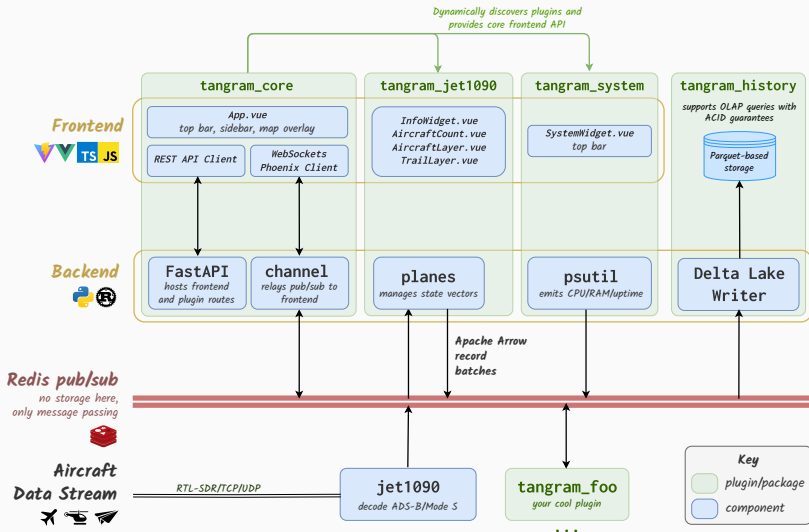
Major refactoring with/by Abraham to improve stability and usability

This is how it should work:

```
uv run tangram serve --config tangram.yaml
```

and now it does!

Overall architecture



So let's run it live!

Disclaimer:

This is a live demonstration.

Unexpected behaviour is expected!

So let's run it live!

Disclaimer:

This is a live demonstration.

Unexpected behaviour is expected!

No SLO! No target reliability! This is intended for research

Just restart when it breaks :)

Broader applications:

- Separation monitoring
- Unstable approach detection
- GNSS jamming detection
- Extended airport performance analysis

Simulation integration:

- Visualisation frontend for simulators
- Apply real-time analysis to simulated traffic
- Urban Air Mobility (UAM) with 3D rendering

Brainstorming last spring during Open Science in Aviation workshop:

- Airspace occupancy and regulations
- Emission monitoring and inefficiency detection
- Inject simulation results into real-time traffic
- Trajectory prediction, including uncertainty quantification
- Anomaly detection (ghosts, unusual trajectories)
- Include voice feed analysis (ATC communications)
- Impact of rocket launches on air traffic

(and more crazy ideas that make research fun!)

Try it yourself!

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Platform and documentation: <https://mode-s.org/tangram>

Code repository: <https://github.com/open-aviation/tangram>