FIG WORKING WEEK 2025
AND Locate25 THE NATIONAL GEOSPATIAL CONFERENCE
Collaboration, Innovation and Resilience: Championing a Digital Generation
FIG Geospatial Council of Australia
Brisbane, Australia 6–10 April

Structural Health Monitoring with GNSS and IMU Technology Precision Solutions for Modern Infrastructure

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Overview

Why Monitor Bridges and Buildings with GNSS?

The Advantages of GNSS in Structural Monitoring

Bridging the Gap: Accuracy vs. Real-Time

Receiver Choice: It's Not About the Brand

Testing with Lower-Cost Antennas

Integrated Monitoring Concept

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Why Monitor Bridges and Buildings with GNSS?

Why Monitor Infrastructure – and Why with GNSS?

- **Infrastructure ages – stress increases**
- **Early detection prevents accidents and saves costs**
- **GNSS enables continuous, high-precision, remote monitoring**
- **Suitable for bridges, dams, towers, high-rises**

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The Advantages of GNSS in Structural Monitoring

Why GNSS? Accuracy, Continuity, and Scalability

- RTK: real-time monitoring with ~1–2 cm accuracy
- Post-processing: ~1–2 mm accuracy for critical structures
- No need for physical contact with the structure
- Works even in remote and hard-to-reach locations
- Scalable for long-term, unattended observation

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Bridging the Gap: Accuracy vs. Real-Time

RTK Is Not Precise Enough – Postprocessing Is Not Fast Enough

- **RTK: real-time but limited to ~1–2 cm**
- **Postprocessing: highly precise (~1–2 mm) but delayed**
- **Critical infrastructures require both: high accuracy and real-time response**
- **Our approach: bridging both worlds with navXperience technology**

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Choosing the Right GNSS Receiver

Receiver Matters – Field Testing with Leading GNSS Modules

- **Accuracy depends on receiver quality and antenna performance**
- **Test candidates: Trimble, Leica, u-blox, Unicore**
- **All receivers tested with our 3G+C Reference Antenna (navXperience)**
- **Evaluation based on repeatability, precision, and signal robustness**

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Receiver Models Used in RTK Field Testing with 3G+C reference

- Trimble: Trimble NetR9 (lunder 9.000 US$)
- → Reference station GNSS receiver, multi-frequency, high-precision RTK
- Leica: Leica GR50 (lunder 9.000 US$)
- → Professional GNSS reference receiver, full RTK support
- u-blox: u-blox ZED-F9P (lunder 300 US$)
- → Compact, cost-effective RTK-capable multi-band receiver
- Unicore: Unicore UM980 (lunder 300 US$)
- → High-performance, RTK-enabled multi-constellation GNSS receiver

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Receiver Choice: It's Not About the Brand

- Continued testing with u-blox ZED-F9P and Unicore UM980
- Earlier tests included Trimble NetR9 and Leica GR50
- Identical results in accuracy, stability, and repeatability
- Conclusion: Signal processing quality is equal across all models in our use case

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Testing with Lower-Cost Antennas

- Compared 3G+C Antenna with two more affordable models
- [1] Mid-sized antenna (~same size as 3G+C) → approx. 200 USD
- [2] Small-form-factor antenna → <30 USD
- Same receiver, same RTK setup – only the antenna was changed
- Results shown on next slide

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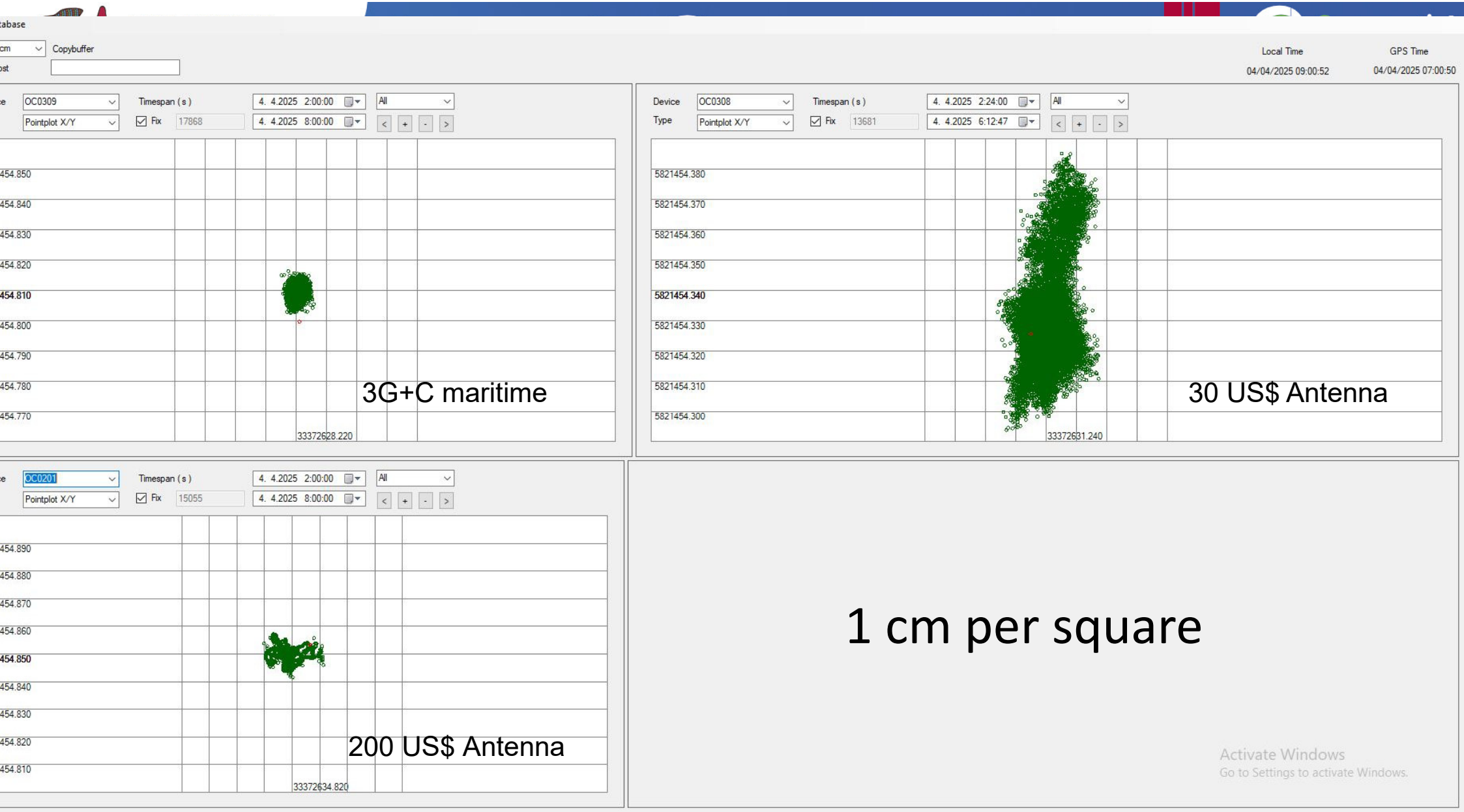
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200 US$ Antenna
1 cm per square
Activate Windows
Go to Settings to activate Windows.

Pushing Beyond RTK – Filtering for Higher Precision

- RTK gives us ~1 cm spread – still too high for critical monitoring
- Solution: apply filtering to improve stability and precision
- Strategy: use moving averages over 120 or 600 seconds
- Detect short-term changes relative to long-term baseline
- Enables near real-time anomaly detection with higher confidence

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Integrated Monitoring Concept – Reliable, Accurate, Real-Time

- RTK GNSS for real-time position tracking
- Post-processed data to validate and benchmark real-time results
- IMU (Inertial Measurement Unit) for vibration and tilt detection
- Environmental sensors to provide context (temperature, wind, humidity)
- Data fusion & filtering (e.g. Kalman filter) for enhanced reliability
- Goal: a scalable, high-confidence monitoring system for infrastructure safety

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Thank you very much for your attention

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