RoDAR: The first GNSS receiver-based anti-jam solution

Rod MacLeod

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OEM7 GNSS Receivers

GPS Anti Jam Technology GAJT

Robust Dual Antenna Receiver RoDAR

SPAN Deeply Coupled GNSS + INS

Mission success depends on being able to operate in Delayed/Disconnected, Intermittent, & Limited Conditions.

NovAtel offers a variety of solutions that maximizes operations:

OEM7 GNSS Receivers

Multi-Constellation, Multi-Frequency, High Precision, High Dynamics.
Situational Awareness: analyse GNSS signals and interference

GPS Anti Jam Technology - GAJT

Protects GPS L1 & L2 (inc. M-Code), Galileo E1, QZSS L1 & L2, & SBAS L1
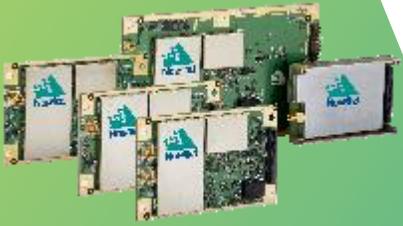*Situational Awareness: jammer power and direction-finding*

Robust Dual Antenna Receiver - RoDAR

Single null on L1 and L5
Plus the features of an OEM7 receiver

SPAN Deeply Coupled GNSS-INS

Deep Coupling gets the best out of both sensors

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Receiver based protection

NovAtel's commercially available solutions for robust PNT

### GRIT (GNSS Resilience and Integrity Technology)

- **GNSS Spoofing Detection**
  Spoofing alerts, even before receiver 'captured'

- **GNSS Interference Toolkit**
  View the spectrum; inspect / filter out interference

- **Time-Tagged Digitized Samples**
  For SIGINT and interference location
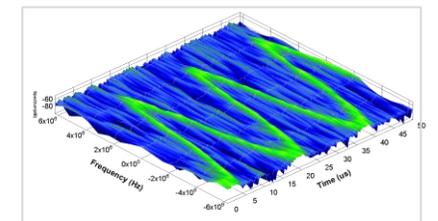
RODAR (Robust Dual Antenna Receiver)

- Anti-jam on OEM7 Dual Antenna receivers

- Full Nulling algorithm in the firmware of the receiver

- Additional High Availability PNT positioning

RoDAR enabled OEM718D /OEM7720 based products
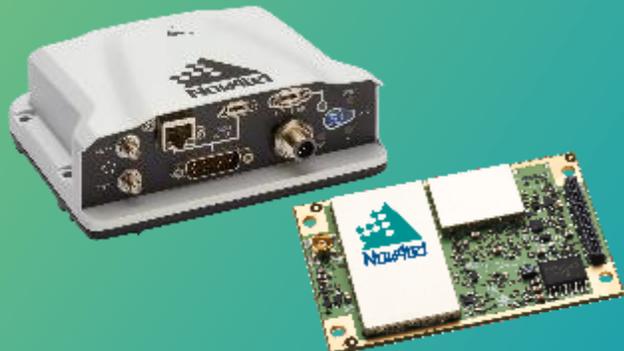
GNSS Resilience and Integrity Technology (GRIT) on all OEM7 Receivers
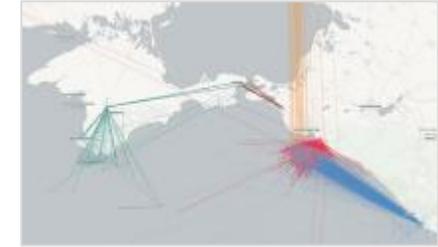
Spoofing Detection
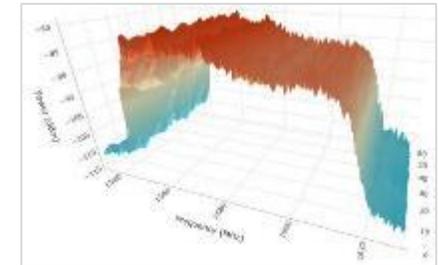
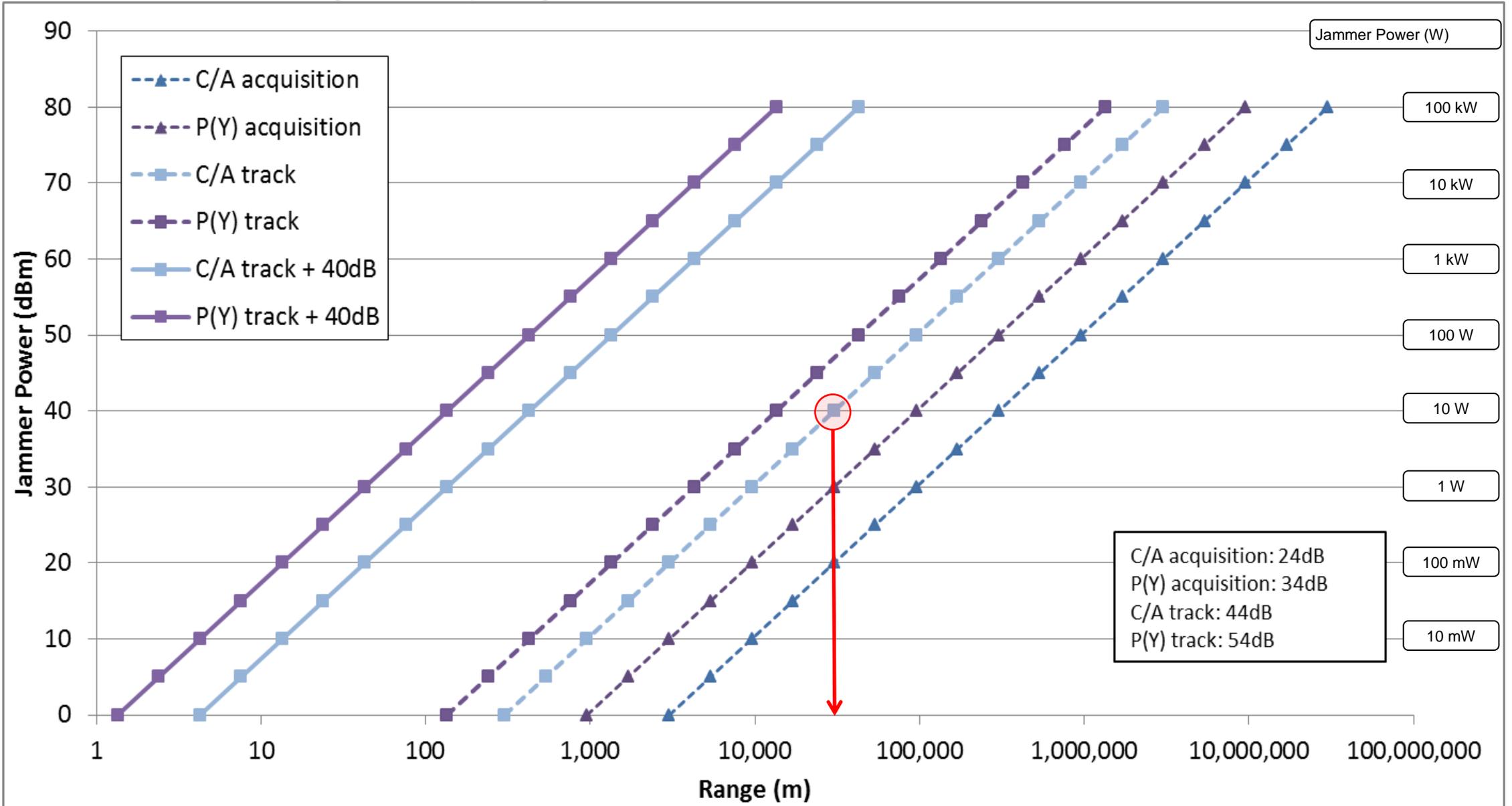
Interference Toolkit

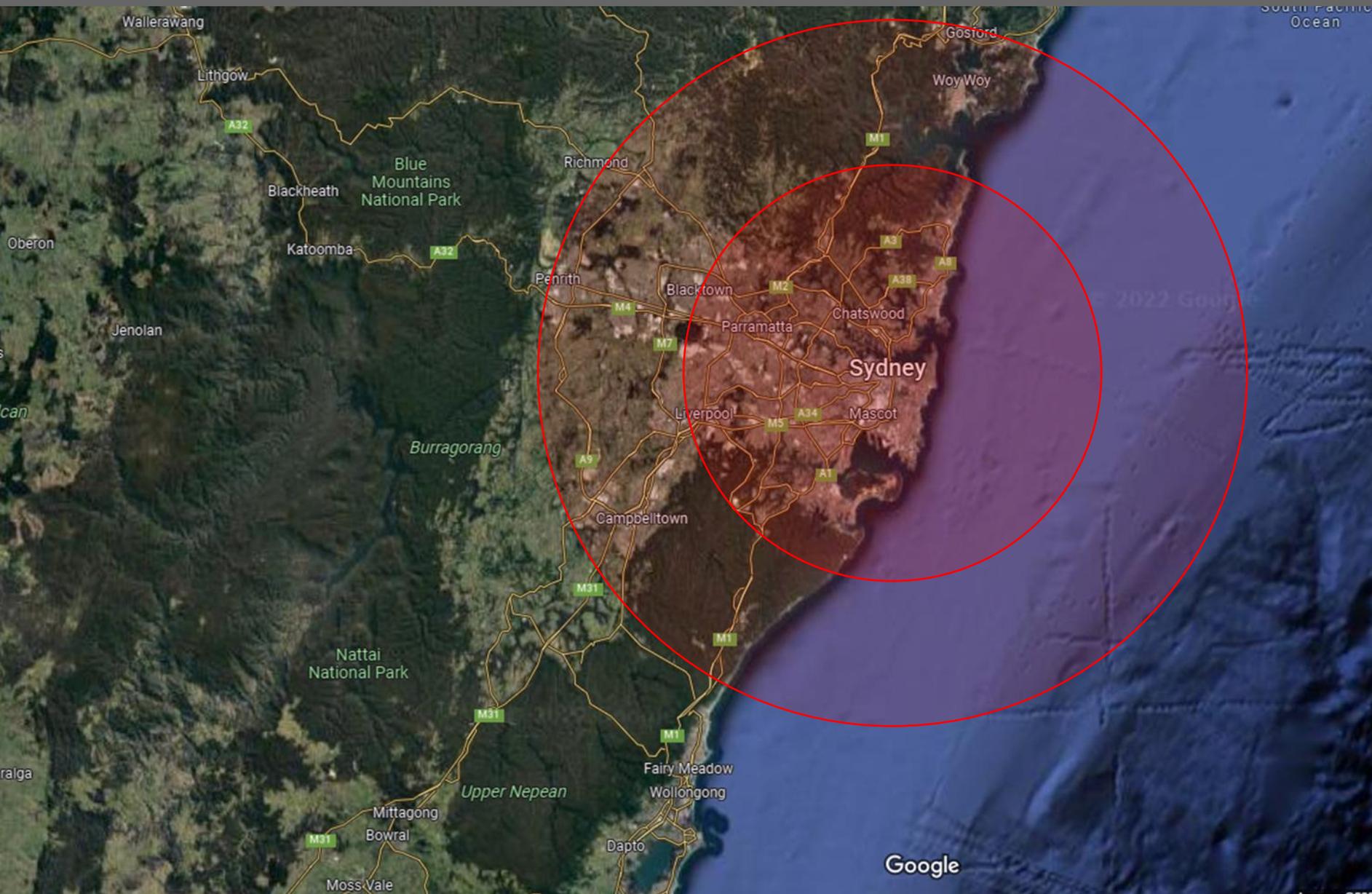

Time Tagged Samples

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The GPS Jamming Threat

The Jamming Threat

RF interference can significantly degrade GNSS

A 10 Watt jammer can deny GNSS for up to 50 km

GAJT – Traditional GPS Anti-Jam Technology

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GAJT – GPS Anti-Jam Technology

Controlled reception pattern antenna (CRPA) and electronics
- Replaces traditional antenna
- Uses space-frequency adaptive processing (SFAP) to protect against a wide range of jammers

Protection
- GPS L1 & L2 (incl M-Code & SAASM), Galileo E1, QZSS L1 & L2, and SBAS L1
- GAJT-AE2 also protects GPS L5, Galileo E5a, SBAS L5 and NavIC L5
- Fixed latency choices (good timing performance)
- Simultaneously counter multiple jammers

Situational Awareness
- Jammer power indication
- Jammer Direction-Finding

In Service & Available Now
- Land, Sea and Air.
- Thousands operational worldwide
- Mature supply chain. Short lead-time. Reliable.
- Canadian Export License needed

GAJT-410ML / GAJT-410MS
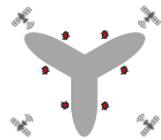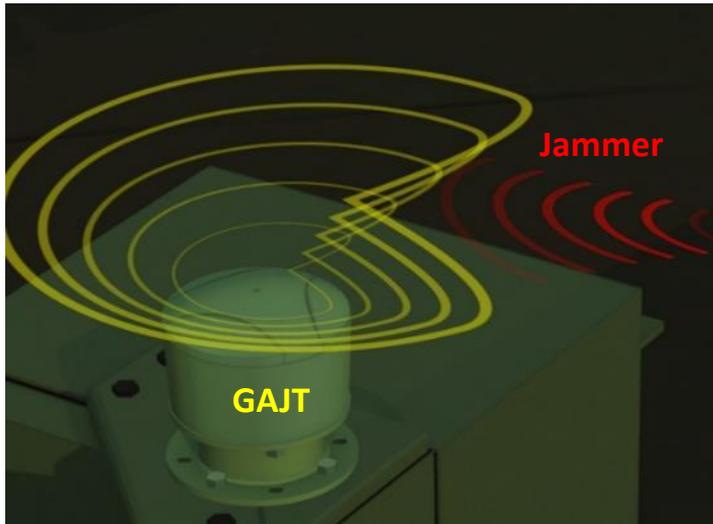*4-element CRPA*

GAJT-710ML / GAJT-710MS
7-element CRPA

GAJT-AE-N/R & GAJT-AE2
Separate 4-element CRPA

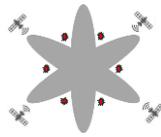**HEXAGON**

GPS Anti-Jam Technology (GAJT)

How GAJT Works

GAJT defeats jammers by making nulls towards the interference, simultaneously on GPS L1, L2 or for AE2 on GPS L5

- 7 elements (GAJT-710ML/MS): up to 6 nulls
- 4 elements (GAJT-AE & GAJT-410): up to 3 nulls

Jammer

GAJT

4 elements: 3 nulls

7 elements: 6 nulls

The Benefits of GAJT

40 dB cancellation. You can get 70 x closer to the jammer than before ("rule of thumb").

Situation Awareness. Message shows that jamming is there – even if GAJT is defeating it.

Direction Finding. Points towards interference (separate display)

Unprotected
No satellites seen
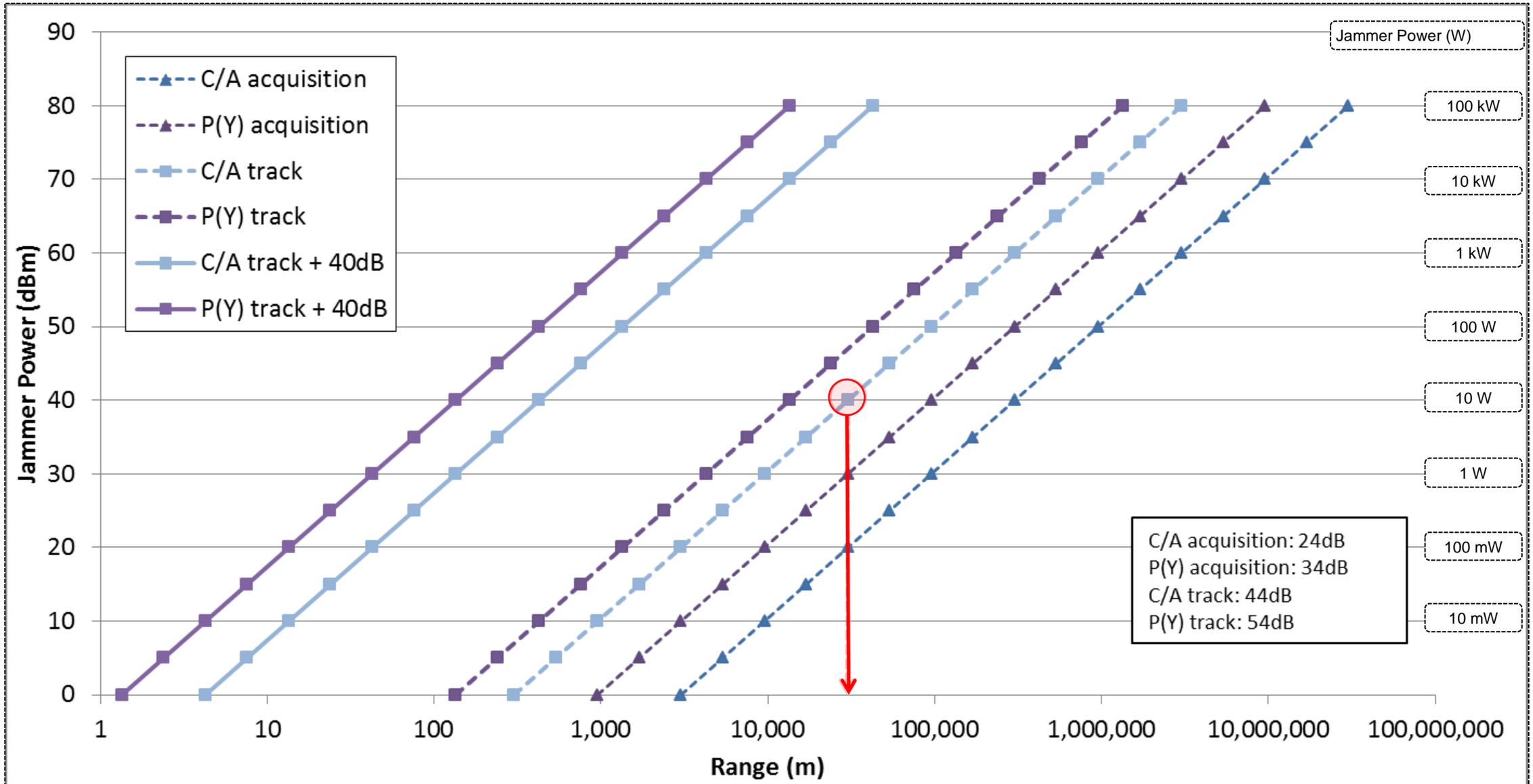
Protected by GAJT
Working properly

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Example: GAJT-710ML as part of the Mounted Assured PNT (Positioning, Navigation and Timing) System (MAPS) Generation 1
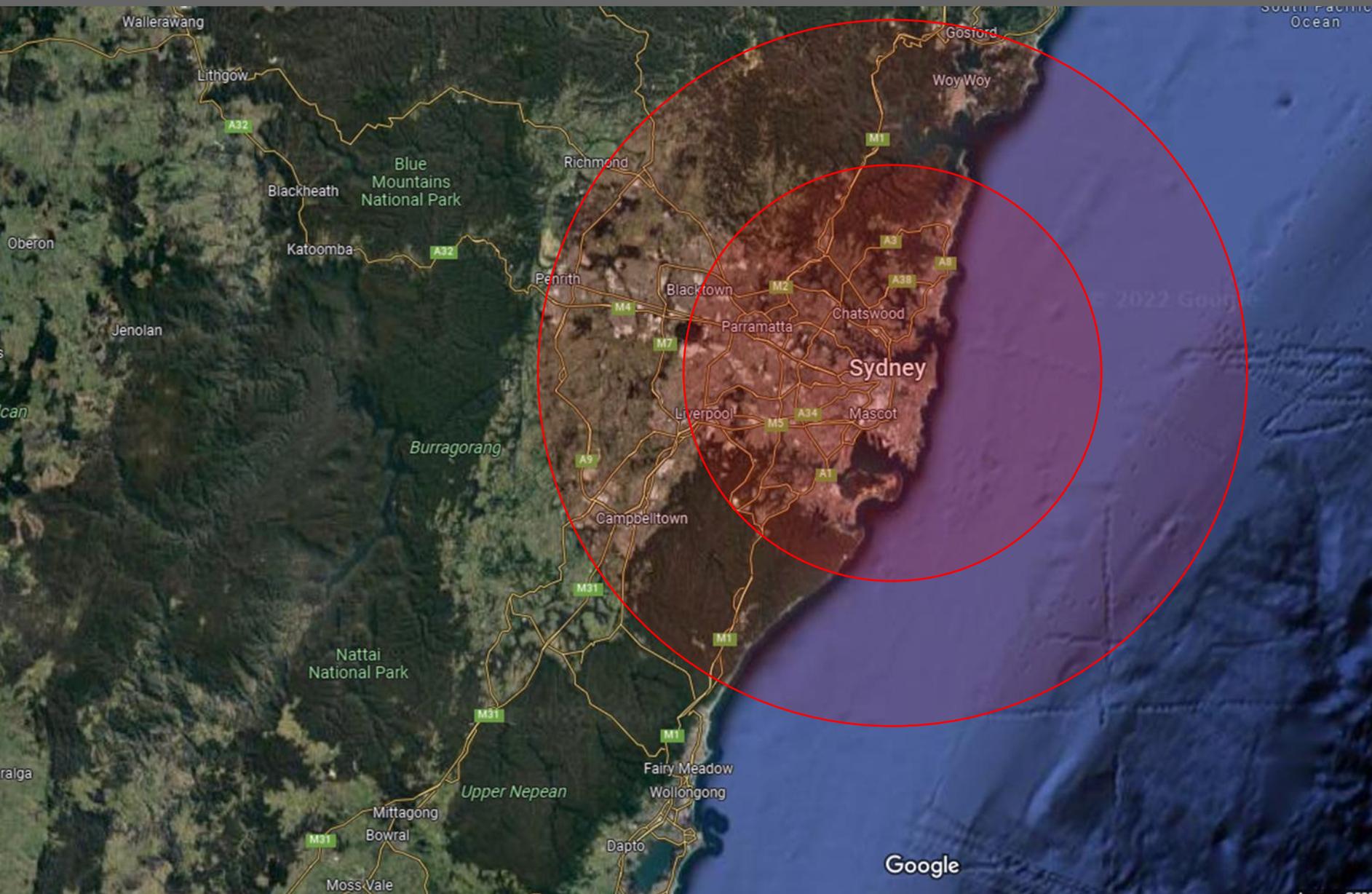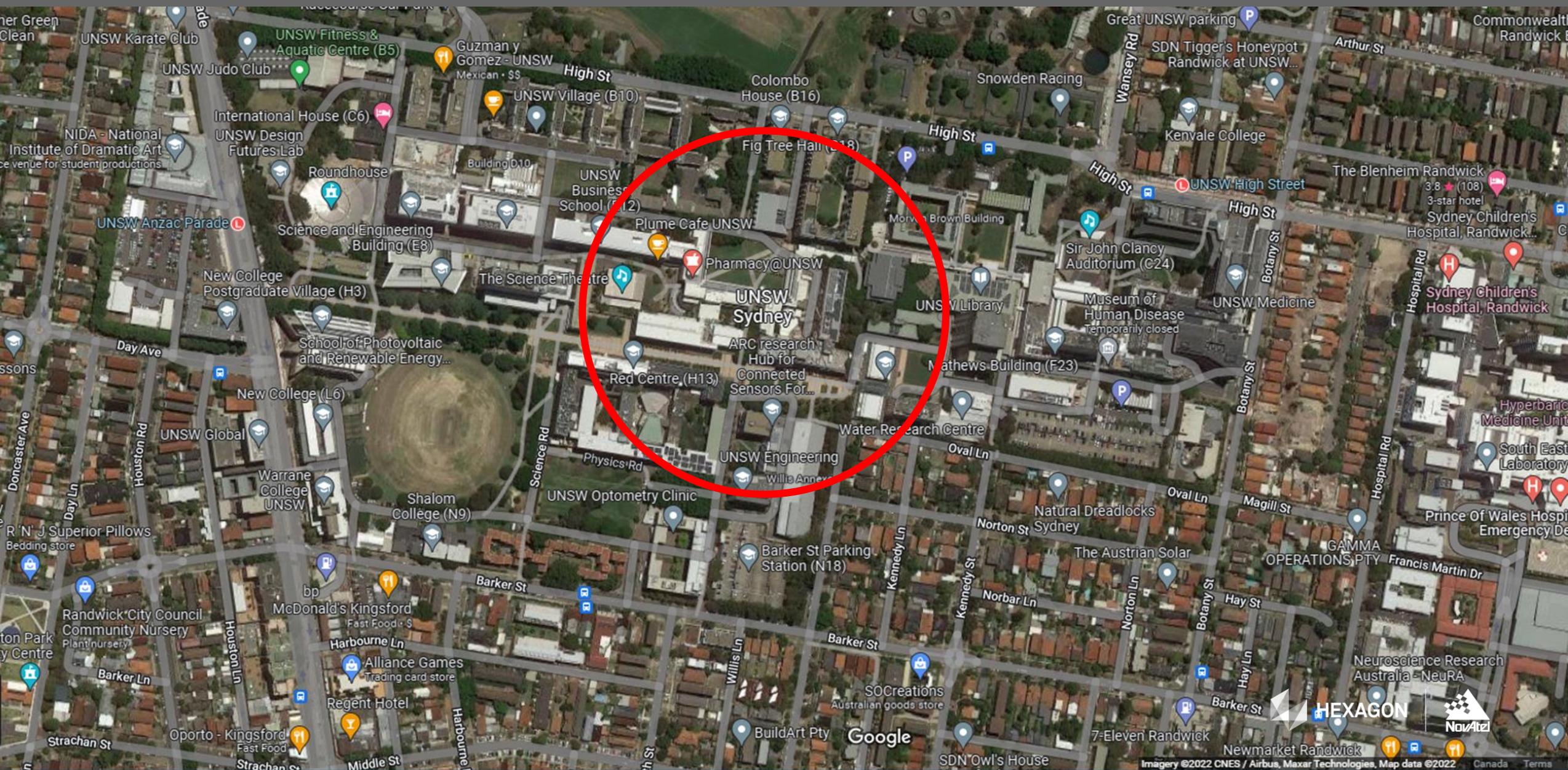
Image courtesy of US Army

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40dB of jamming mitigation can significantly improve range of operations

A 10 Watt jammer can deny GNSS for up to 50 km

With 40 dB of protection we can navigate to within 100s of meters of the jammer

RODAR: Receiver Based Spatial Processing

Robust Dual Antenna Receiver (RoDAR)

- Anti-jam systems offer high levels of protection, but SWaP (Size, Weight & Power), system complexity and export controls limit use.

- There is a need for a low SWaP solution in commercial applications like small unmanned aerial vehicles (UAVs), last mile delivery robots and other autonomous machines.

- **RoDAR** – Receiver built-in anti-jamming protection
  - No military export controls from Canada or US. Commercial export controls only
  - Firmware upgradeable on some existing receivers
  - Requires antenna array
    - Two Antcom antennas mounted 8.5cm apart
    - Conformal antenna options available

71 mm

46 mm

Receiver based AJ

85 mm

2 Antennas

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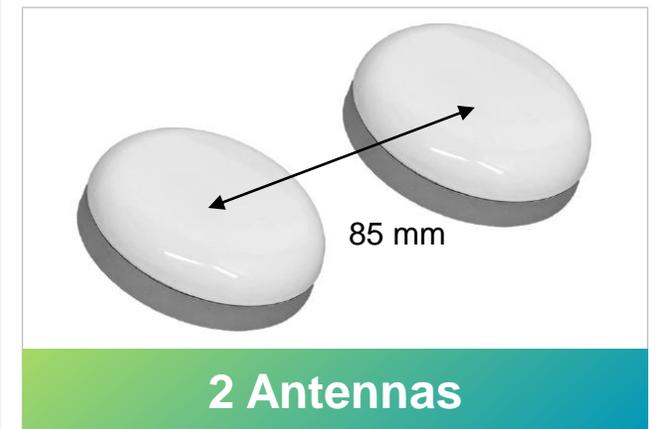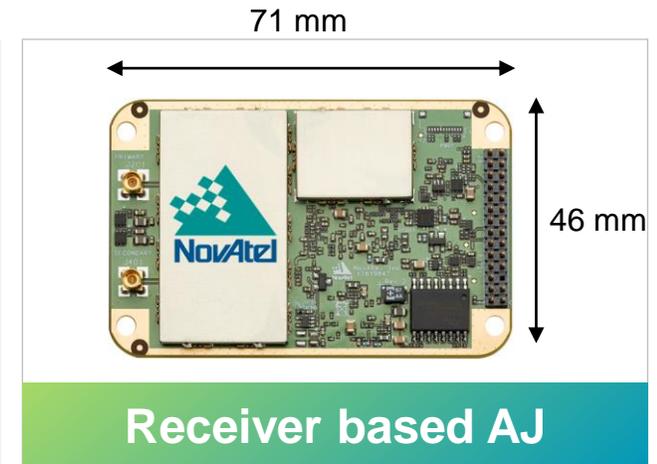
Dual-Antenna based Jammer Mitigation

All done in the NovAtel ASIC

- Operates as a dual input receiver in benign environments

- When jamming is detected:
  - RoDAR is automatically activated

  - Antenna 2 input used to dynamically null jamming present on Antenna 1

  - Resultant IF samples are jammer free and passed to the Tracking and PVT solution software

  - Increases power consumption by <4 Watts

GNSS Satellites

Interference

Null
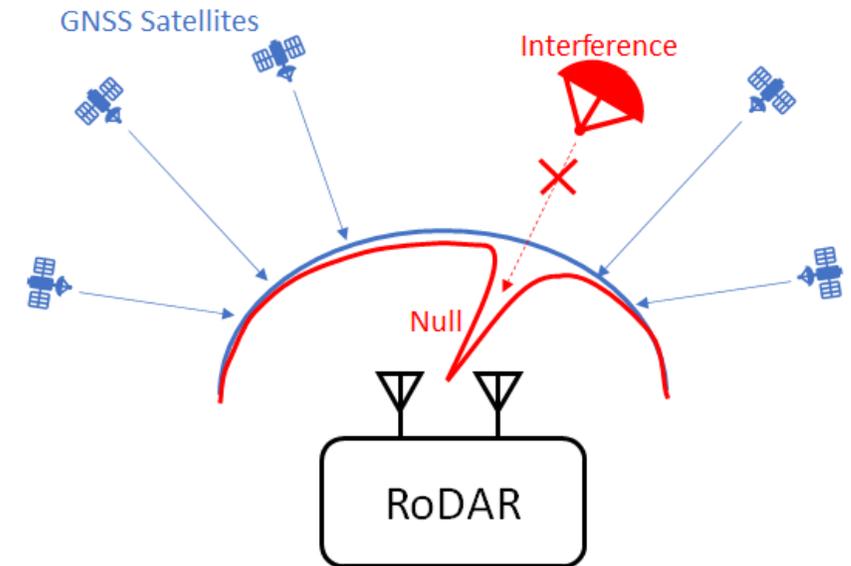
RoDAR

RoDAR changes the gain pattern to attenuate interference

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Example: RoDAR protection vs Jammer Power - Chirp

1 Input jammer power increases until non-RoDAR solution is denied

2 Input jammer power continues to increase until RoDAR protected solution is denied

3 The RoDAR receiver provides approximately an additional 34 dB of jammer protection

Input Power
— L1 In-Band Power

RoDAR
— 3D St Dev

Non-RoDAR
— 3D St Dev

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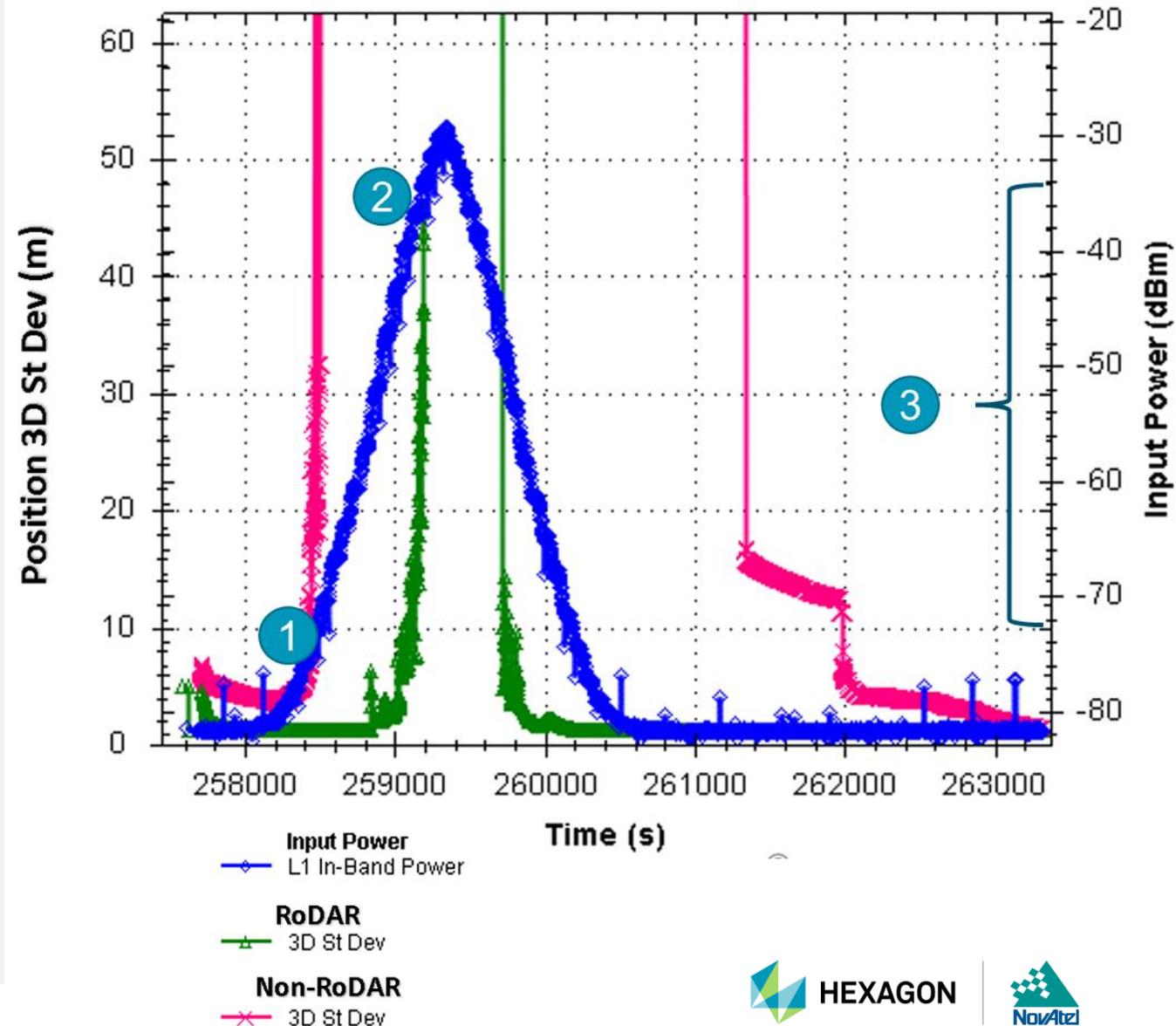
RoDAR - Key Features For Jamming Mitigation

- **Anti-Jamming Feature**
  - Dynamic protection against single L1 and L5 jammers
    - Null-Steering follows jammer
  - **OEM718D**
    - Protects L1 band simultaneously with L5 band.
    - Can use all MCMF in PNT solution
  - **OEM7720 / PwrPak7D**
    - Protects L5 (E5a sub-band) simultaneously with L5 (E5b sub-band)
    - Can use all MCMF in PNT solution

- **GNSS Interference & Resilience Technology (GRIT)**
  - Identify interference locations and types
  - Programable filtering
  - Time-tagged digitized samples

- **Multi-Frequency Multi-Constellation (MCMF)**
  - Robustness by using GNSS signals across multiple constellations and bands
  - Independent signal acquisition for multiple constellations in each band
    - L1, L2 and L5 bands
    - GPS, GLONASS, Galileo, BeiDou, QZSS, SBAS constellations supported

- **Resilience by using High Availability Firmware**
  - Uses MCMF independent signal acquisition
  - Provides independent PVT on various frequencies and constellations

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UAV Example: Resilience by High-Capability OEM7 GNSS Receivers

High Availability Firmware (FW) hardens the reported position in a contested environment.

Trajectory for Instantaneous Logs - Non-HA L5 FW

Trajectory for Instantaneous Logs - HA L5 FW
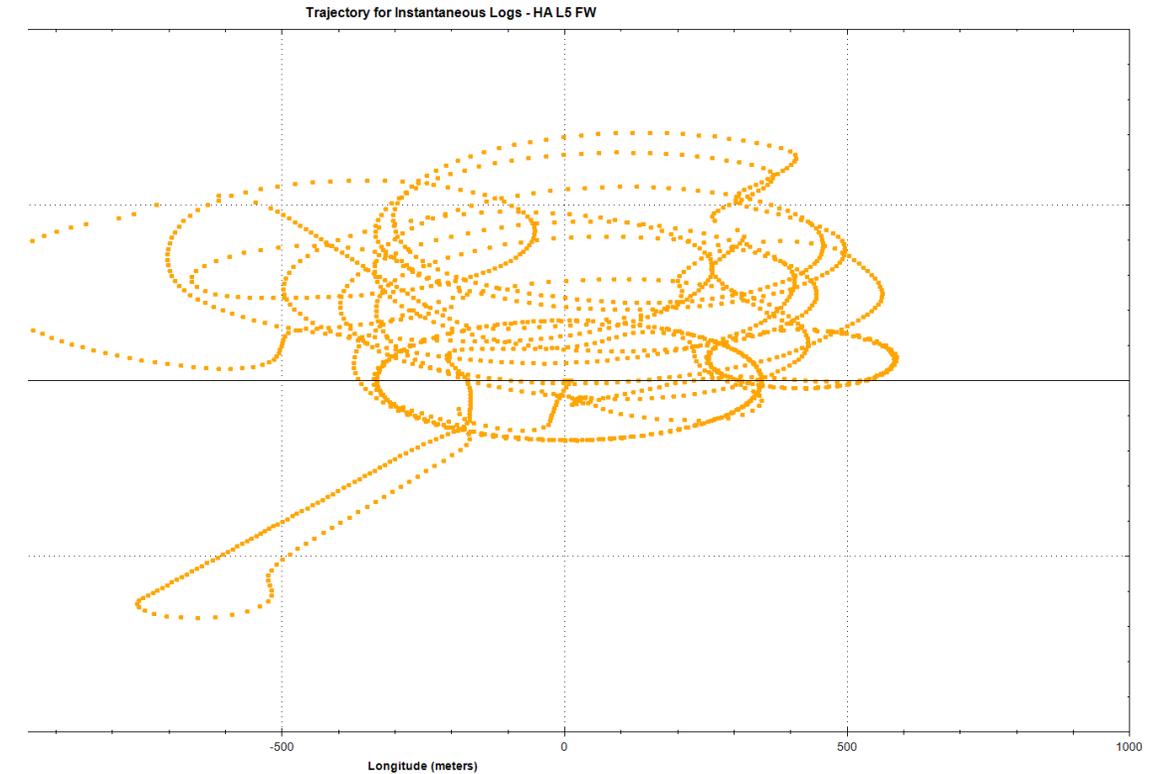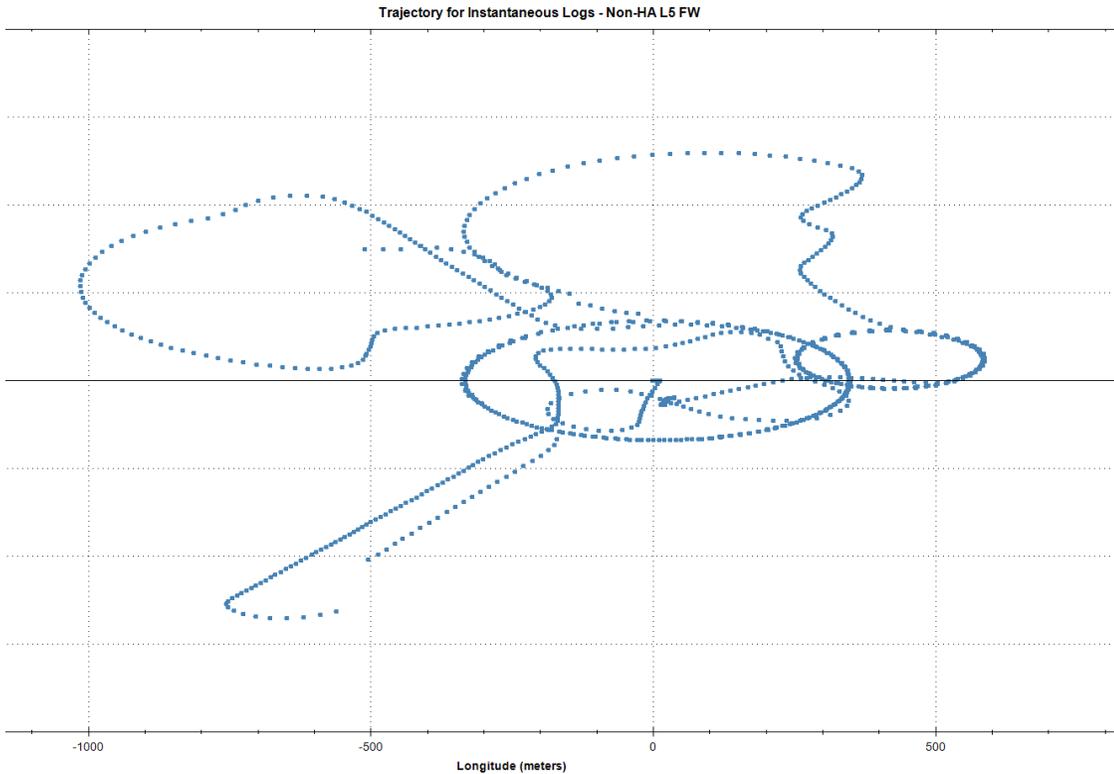
Standard FW. Gaps and position jumps (which might be rejected by autopilot)

High Availability FW. No gaps, position maintained throughout

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Robust Dual Antenna Receiver

Summary

- Robust dual antenna receiver firmware can be installed on NovAtel's dual-antenna receiver cards

- Enables receiver-based anti-jam capability when using a 2-element CRPA or 2 independent antennas

- Smallest size, weight and power (SWaP) anti-jam solution possible

- >30 dB nominal protection

- Not ITAR/Canada Controlled Goods - subject to commercial export controls only

Receiver based AJ

2 element CRPA

GNSS Resilience and Integrity Technology (GRIT)
- Interference detection & mitigation
- Spoofing detection
- Time tagged A/D samples

GAJT
- Anti-jam antennas (4 and 7 elements)

RoDAR
- Receiver based commercial anti-jam

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Thank you