

# Toughening GPS Receivers Against Interference

*Ensuring Signal Reception in Spectrally  
Busy Environments*

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**Rockwell  
Collins**

# Rockwell Collins GPS Heritage and Resilient PNT Context



Handheld Receivers



Micro-DAGR



DAGR

GPS Embedded Modules



ASR

GEM-VI

Digital Beam Former High-AJ GPS

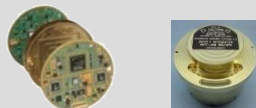


IGAS



DIGAR

Munitions Receivers



Civil Aviation



MMR

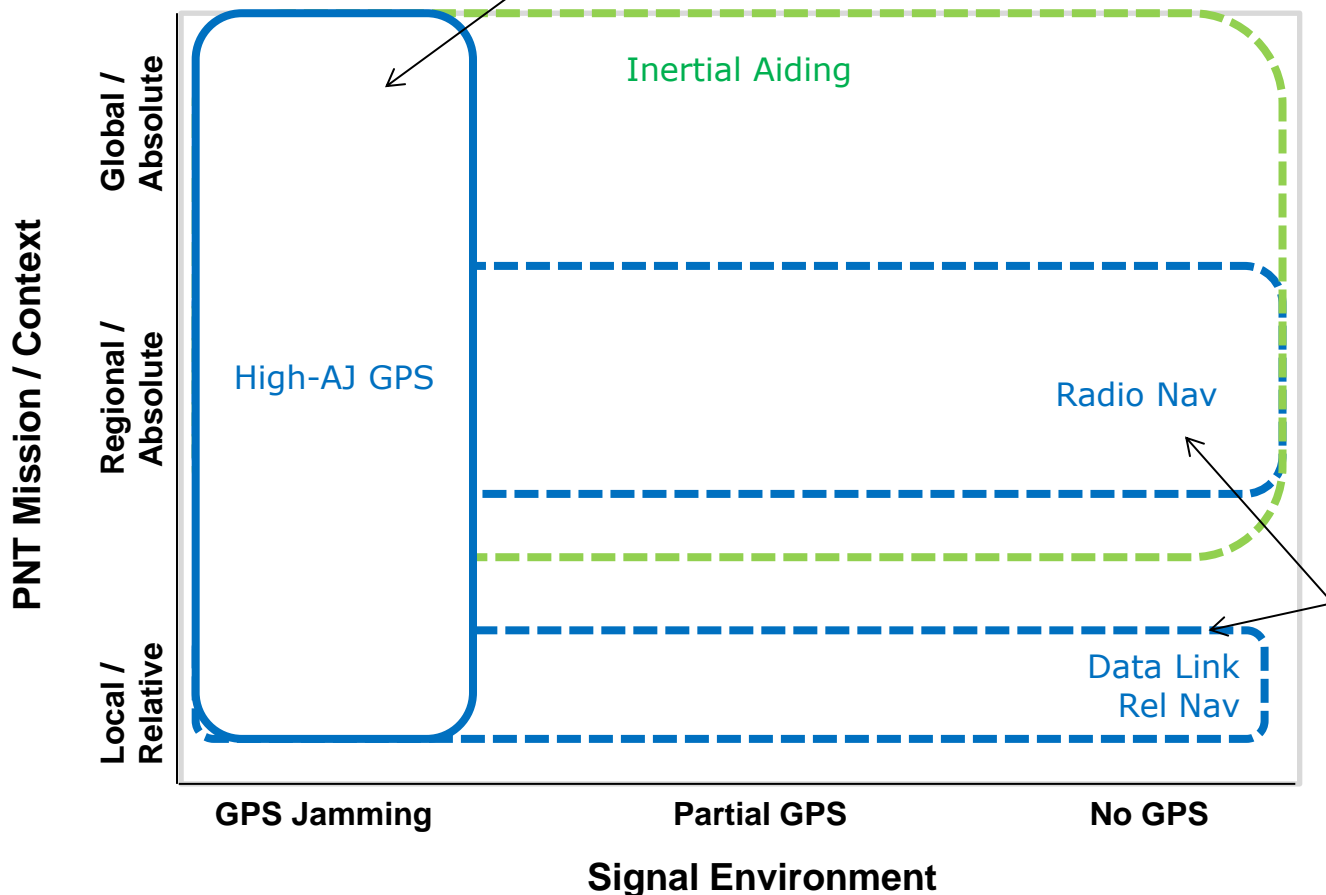
GPS 4000

- Produced the First US DOD User Equipment
- Over 35 Years of Innovative Military and Commercial GPS Research & Development
- Over 900,000 Military GPS Receivers Delivered
  - At the forefront of SAASM GPS delivery across the entire military marketplace (>700k delivered)
  - Handhelds, embedded modules, high anti-jam (AJ) systems
- Leader in commercial aviation GPS
  - Multi-Mode Receiver for Air Transport certified for GBAS CAT-I
  - GPS/WAAS for Business and Regional
- Resilient PNT context
  - Military GPS UE have incorporated AJ capabilities from the earliest days ranging from low-end techniques to high-end adaptive antenna arrays
  - High AJ Digital Beam Former (DBF) GPS systems in high-volume production for military applications, especially for weapon systems

**How can military AJ technology be applied to commercial uses and what are the impediments?**

# Context of GPS Denial and Utility of Current Solutions

- Adaptive array technologies for vehicles & airborne
- Adaptive signal processing for low SWAP applications



Current Radio Nav (e.g., DME, TACAN) and data link ranging (e.g. Link-16) solutions do not achieve GPS levels of accuracy, coverage, etc. so can only be considered a GPS replacement for some applications

# Military GPS Receivers & Anti-Jam Protection

**Digital Beam Forming AJ**  
(90 - 120+ dB)

**DIGAR**  **SABR** 

**Antenna Nulling AJ**  
(60 - 90 dB)

 **Artillery GPS/AJ** 

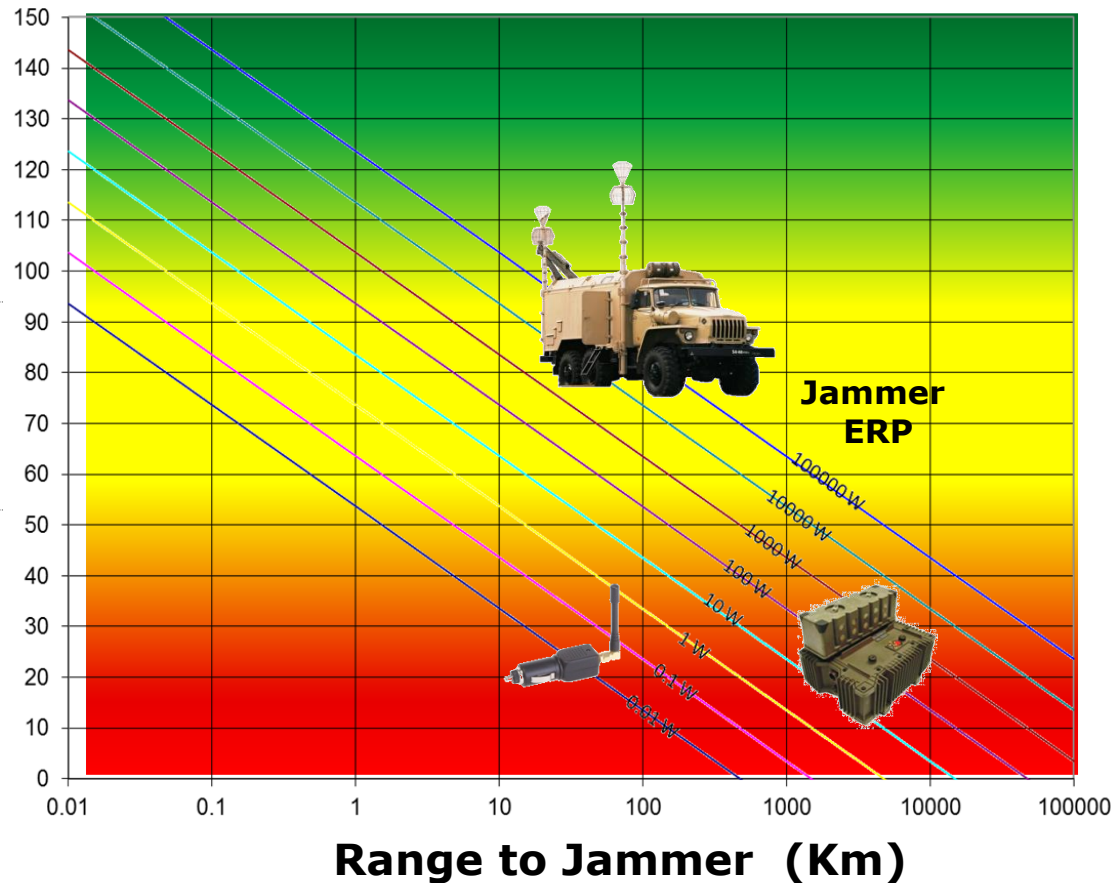
**DSP Based AJ**  
(30-55 dB)

 **MPE-S**  **Micro DAGR**

**Micro-GRAM**  **DAGR** 

**GPS AJ  
(dB)**

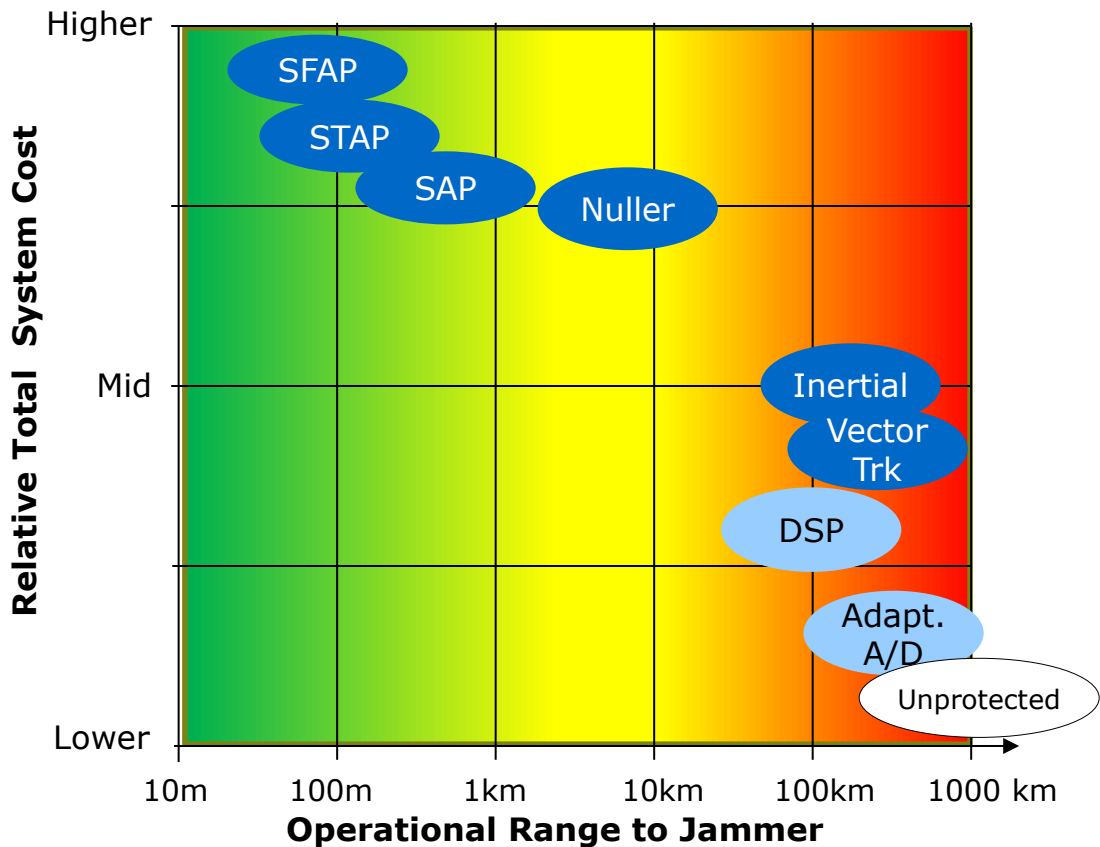
**J/S vs. Jammer Power & Range**



**Highly capable, affordable GPS AJ solutions are available today**

J/S capabilities are dependent on jammer type and tracking state

# GPS AJ Solution Effectiveness & Relative Cost



Assumes 100W EIRP and free space propagation; actual performance depends on number and type of jammers

- Effective against all jammer types
- Effective against only specific jammer types

- Adaptive antenna array techniques provide most effective anti-jam
- Adaptive nulling does not require inertial attitude input, but may result in distorted measurements
- Digital Beam Forming techniques require inertial attitude for beam steering but are compatible with high accuracy positioning techniques
  - Spatial Adaptive Processing (SAP)
  - Space-Time Adaptive Processing (STAP)
  - Space-Frequency Adaptive Processing (SFAP)
  - Also provides multipath mitigation
- Inertially-aided and vector tracking loops provide modest AJ but complement adaptive array techniques
- Digital Signal Processing (DSP) such as adaptive notch filters are highly effective against narrow band jammers
- Adaptive threshold A/D converter techniques are effective against narrow-band interference and pulses

## Discussion

- Technology maturity
  - DBF AJ technology is proven and is compatible with high accuracy/integrity applications (e.g. as demonstrated by JPALS flight trials)
  - DBF technology could be of benefit to critical infrastructure (e.g., GBAS ground stations, timing, survey)
- Costs
  - Integration of adaptive arrays costs onto existing platforms dominate the costs
  - Unit cost of AJ is dropping, and may be a relatively small fraction of total PNT unit cost, so becomes particularly viable for new installations
- Roadblocks:
  - US ITAR restrictions—despite fact that adaptive array capabilities are now widely available (universities, etc.)
    - European Community has created an exception for AJ on civil aircraft
  - Users are unlikely to adopt absent some sort of mandate or clear economic rationale