Toughening GPS Receivers Against Interference

Ensuring Signal Reception in Spectrally Busy Environments

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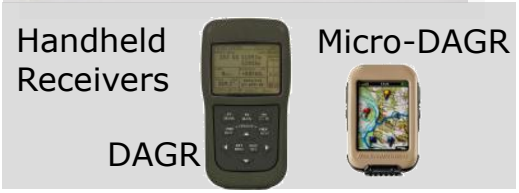
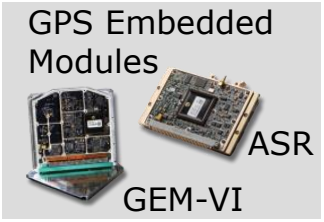
Rockwell Collins GPS Heritage and Resilient PNT Context



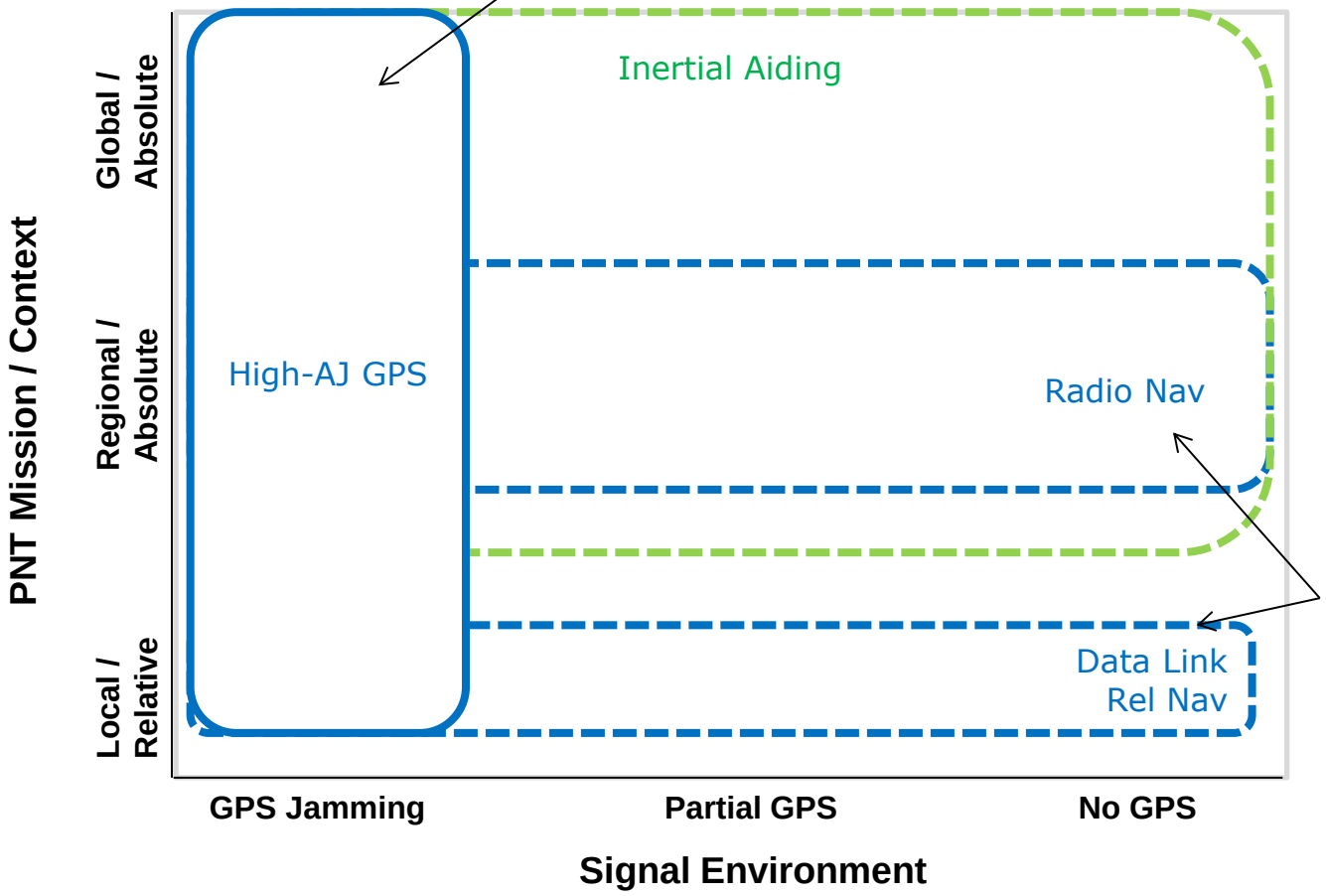


- Produced the First US DOD User Equipment
- Over 35 Years of Innovative Military and Commercial GPS Research & Development
- Over 900,000 Military GPS Receivers Delivered
  - At the forefront of SAASM GPS delivery across the entire military marketplace (>700k delivered)
  - Handhelds, embedded modules, 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

IGAS

Antenna Nulling AJ

(60 - 90 dB)

Artillery GPS/AJ

DSP Based AJ

(30-55 dB)

MPE-S

Micro DAGR

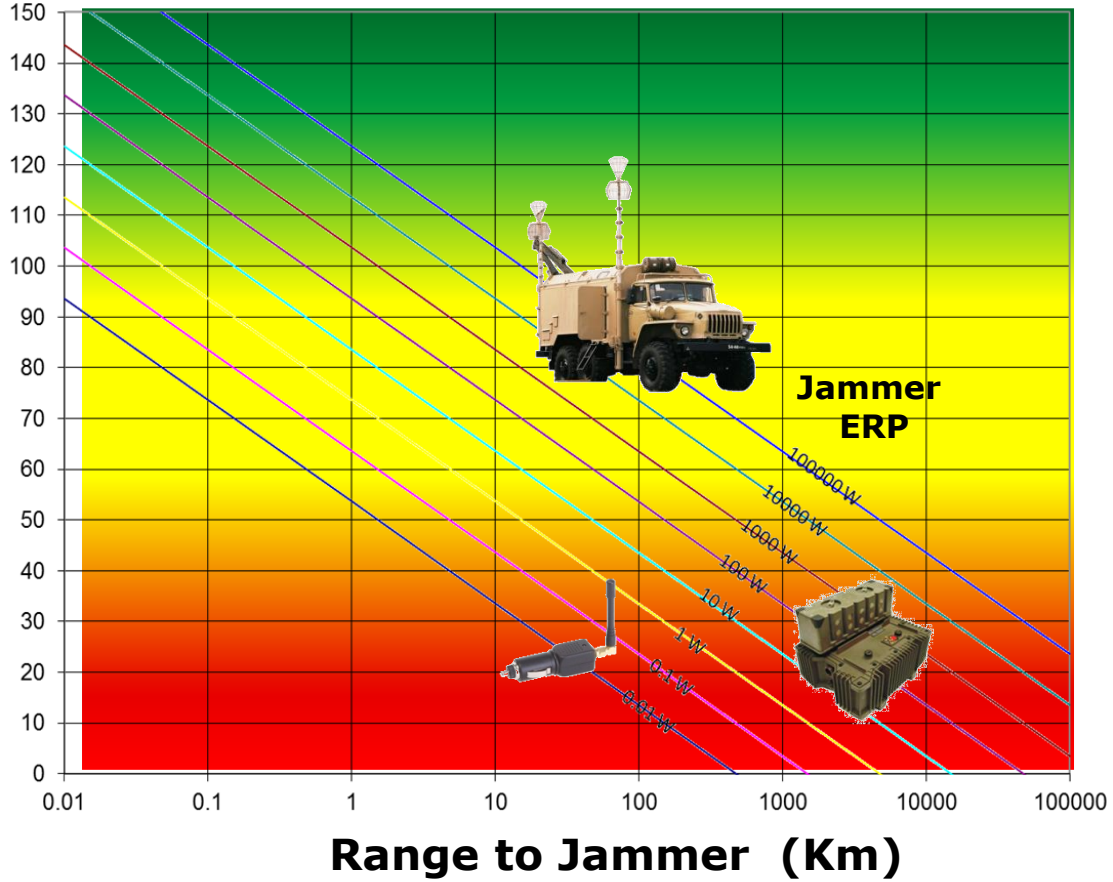
Micro-GRAM

DAGR

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

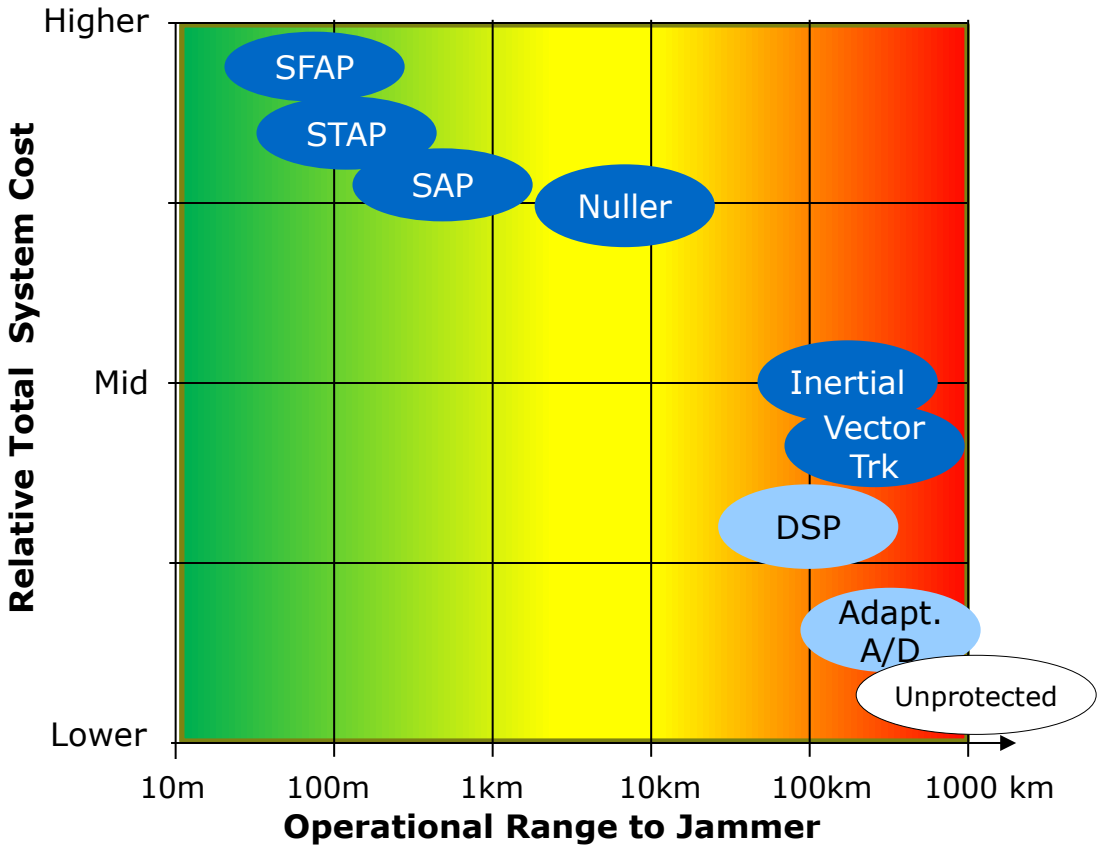
GPS AJ (dB)

J/S vs. Jammer Power & Range



Highly capable, affordable GPS AJ solutions are available today

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