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WIRELESS AND MICROWAVE CIRCUITS AND SYSTEMS

Reconfigurable Circuitry as an Enabler for Real-Time Adaptive Spectrum Usage

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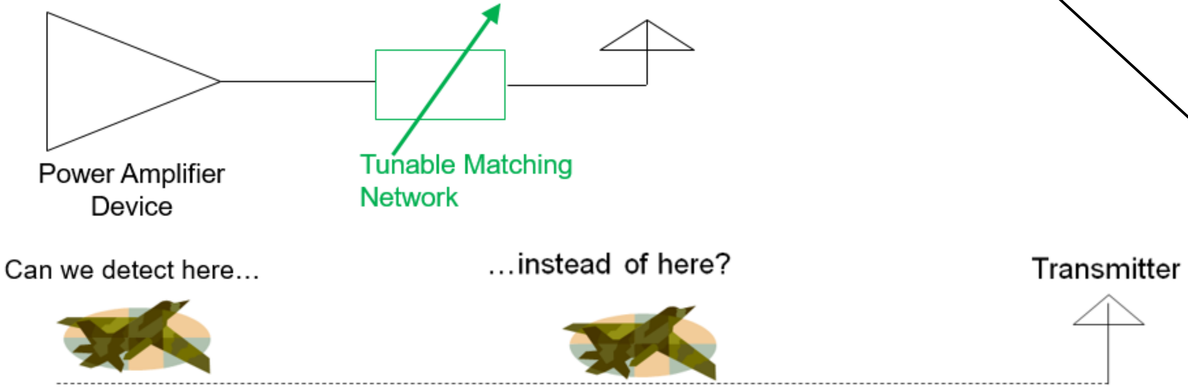
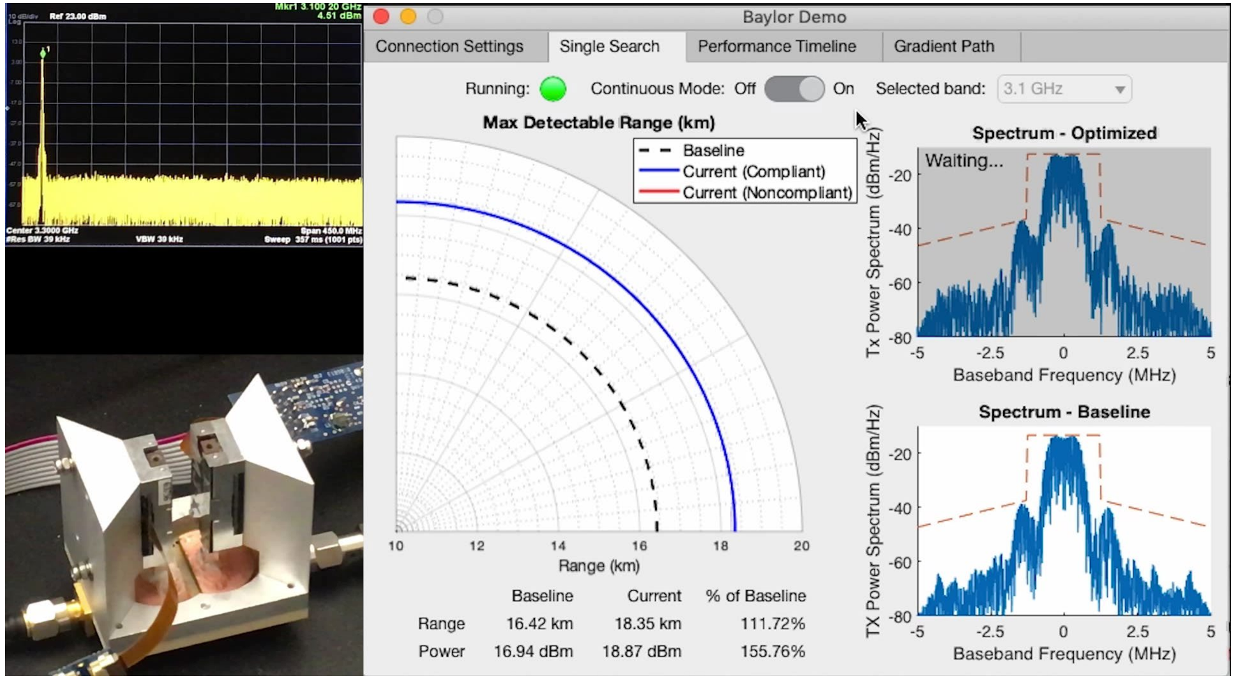
Reconfigurable Circuits Enabling Iterative Spectrum Policy

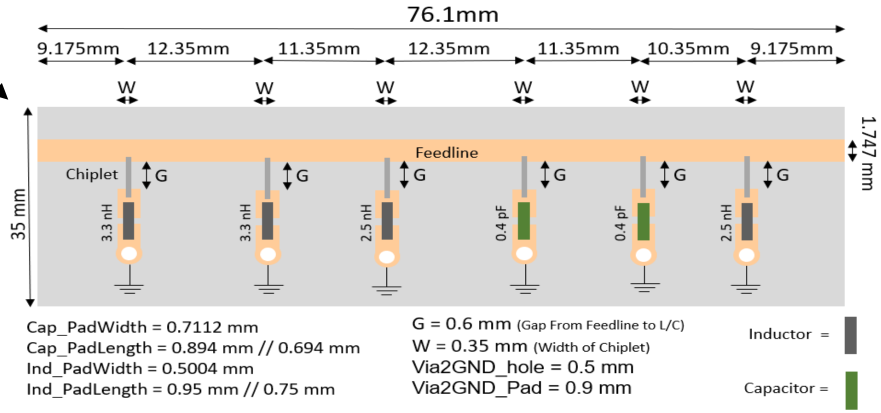
- Iterative (moving from rigid to real-time adaptive) spectrum policy could be limited by rigid circuitry.
- Example due to lack of circuit reconfigurability:
  - S-band military radar loses range when changing in frequency to avoid wireless communication.
  - 24 GHz 5G network must turn off to avoid passive sensors during operation.
- Potential impact of reconfigurable circuitry in these scenarios:
  - S-band radar reconfigures its circuitry within a millisecond after frequency changes to maintain detection range.
  - 24 GHz 5G network redistributes its spatial/spectral usage through an Artificially Intelligent Power Amplifier Array (AIPAA) to maintain needed transmission range while avoiding interference.

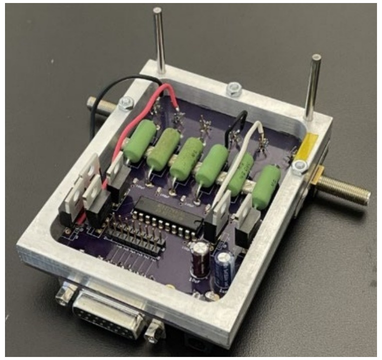
Example 1: Fast Radar Optimizations

- Intelligently controlled power-amplifier reconfigurable impedance tuner re-maximizes transmitter output power (and range) upon changes in frequency.
- Faster impedance tuners can be made out of electrically actuated devices and can reconfigure completely in under 600 μs.









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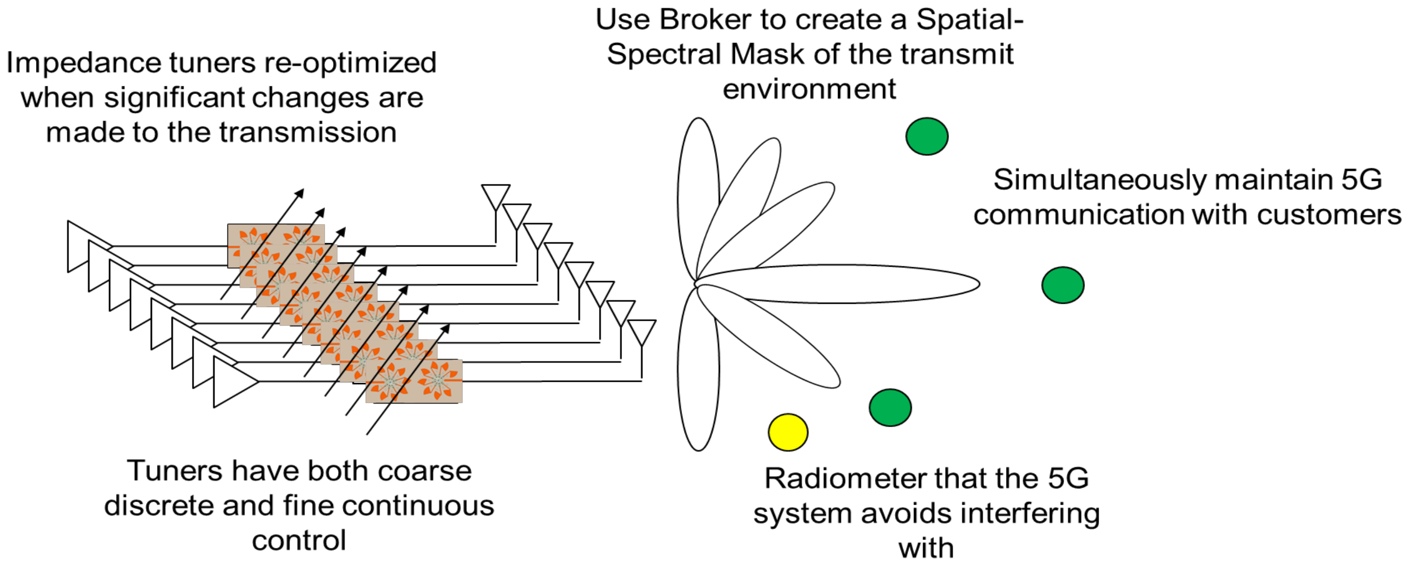
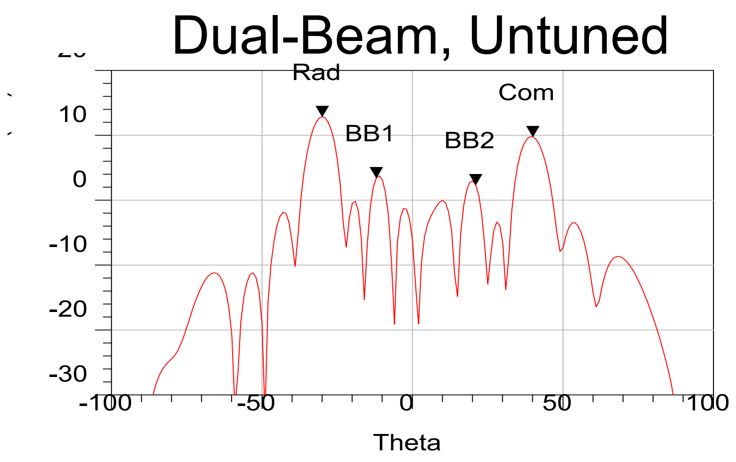
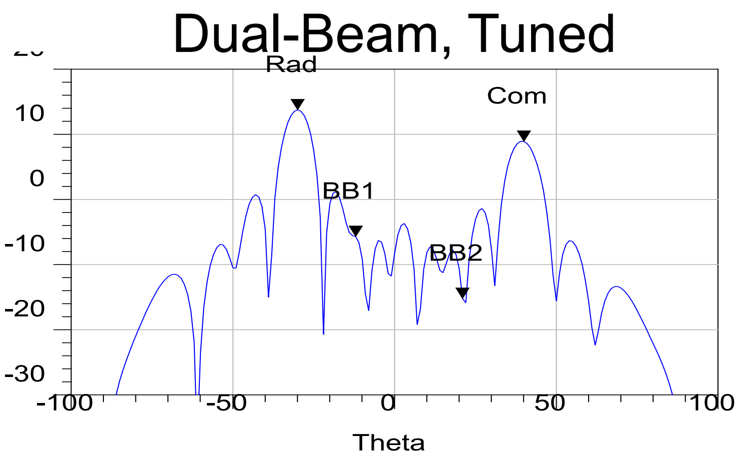
Example 2: Artificially Intelligent Power Amplifier Array

- 5G mm-wave transmitter application is shown, but can also apply to radar.
- Reconfigurable impedance tuner between each power amplifier and transmitter antenna.
- Can optimize for gain or power-added efficiency (PAE) while meeting spatial-spectral mask requirements from the broker.
- Circuit tuning impacts transmissions*.

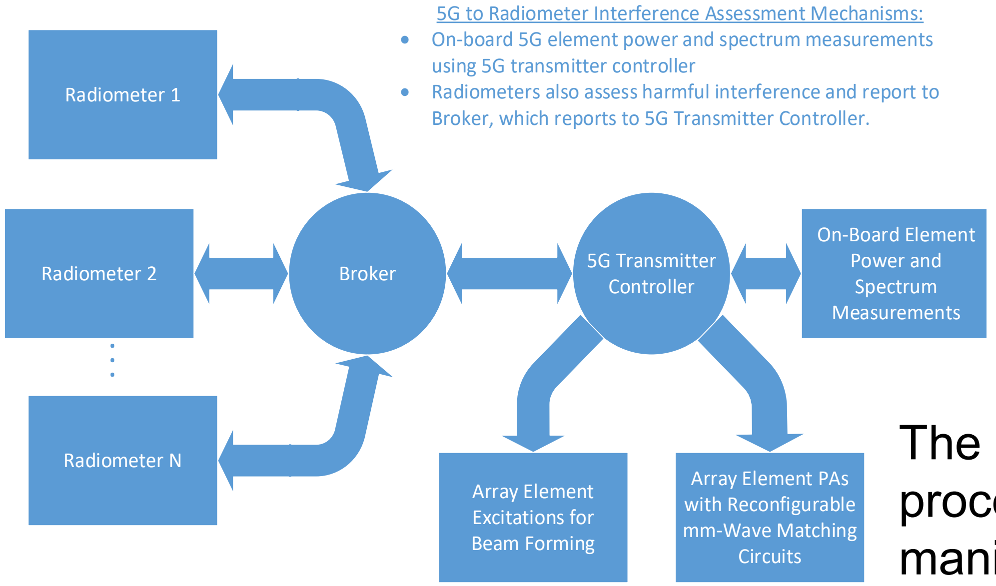
*P. Rodriguez Garcia, accepted for publication in *IEEE Transactions on Aerospace and Elec. Systems*, 2022.







Example 3: Spatial-Spectral Broker*

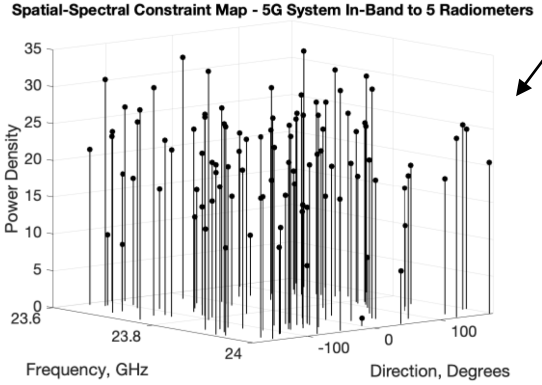


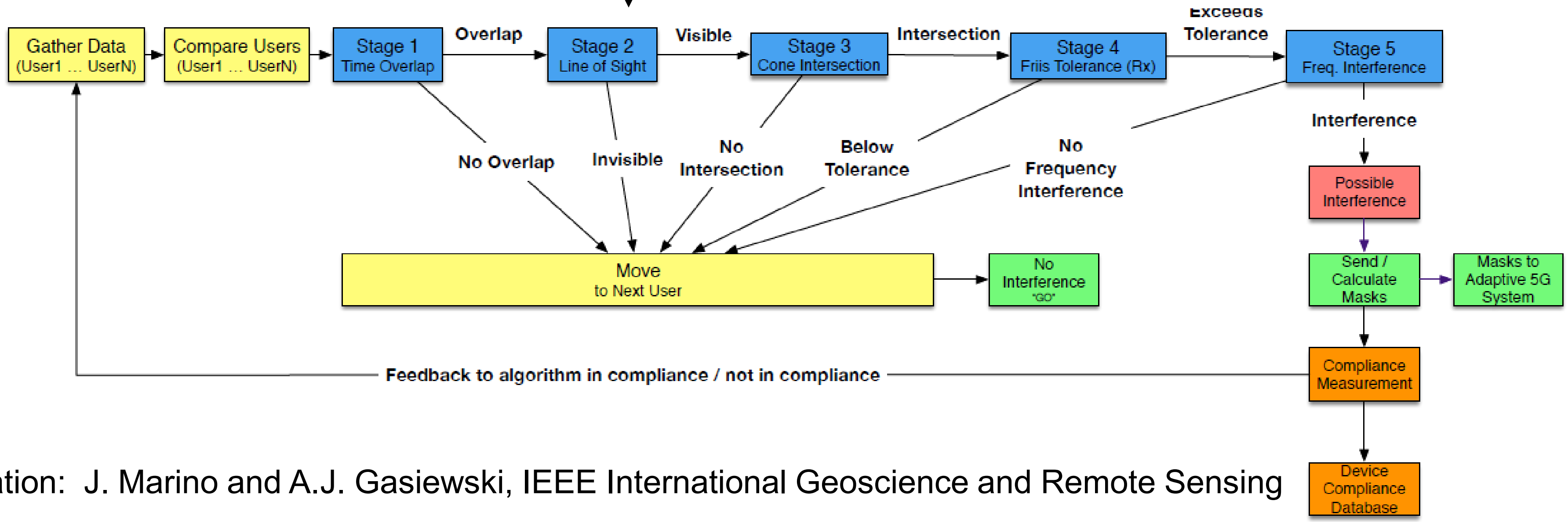
A manifold request is submitted by each spectrum user.

Data Requested	Units
Date / Time	(24 hour time), start and stop time
Latitude	decimal degrees
Longitude	decimal degrees
Altitude	meters
Center Frequency	Hz
Bandwidth	Hz
Azimuth	degrees
Elevation	degrees
Transmitter Power	dBm
Receiver Power Tolerance	dBm
Antenna Gain	dBi
Time Interval Request	seconds
Interference Frequencies	Hz
Interference Levels	dBm

The broker uses a culling process to compare manifold requests.

A spatial-spectral mask is given to the active transmitter for circuit/array optimization.





*Based on initial spectral broker publication: J. Marino and A.J. Gasiewski, IEEE International Geoscience and Remote Sensing Symposium, 2017.

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Conclusions

- Iterative spectrum usage must progress from completely rigid spectrum use to as close to real-time assignment as possible (governed by the scenario).
- Adaptive spectrum usage is enabled or limited by circuit reconfigurability.
- Emerging circuit reconfiguration capabilities will enable adaptive use of two critical spectrum areas:
  - S-band radar sharing with 5G: High-power, fast tunable reconfigurable circuits and Artificially Intelligent Power Amplifier Array (for radar transmitters)
  - Passive weather sensing with 24 GHz 5G: Spectral broker and AIPAA