

## **Hardware-CSP Interface**

1. What are the trade-offs between hybrid beam forming and full digital beam forming? Will it ever be feasible to fully digitize the aperture, and is there a true need to do this?
2. What is required for an RF front end? Should it include the “smarts” to find users, track users, and work with the waveforms or just be a dumb directional front end that gets its commands from a smart “waveform” controller?
3. How can spatial channel measurements be incorporated into array and system design?
  - a. How does antenna array design complexity increase when beamwidth is included (in terms of, e.g., tracking algorithms, multiple beams, system efficiency, etc.)
4. How feasible is digital pre-distortion at mmWaves, given the wide signal bandwidths? How can DPD be performed in the context of large-scale phased arrays?
  - a. Are there models of arrays that include the combining networks and how much impact has the coupling/nonlinearity had on the design and system performance?
  - b. Is distortion due to coupling really a second-order effect at mmWave frequencies?

## **Array Architecture**

5. What are the trades between silicon only, Silicon plus GaAs, and Silicon plus GaN technology choices for 5G mmWave arrays? Are there other options?
6. What are the fundamental limits or challenges for phased arrays? (i.e. Thermal management? Production infrastructure? Up-front investment? Semiconductor process maturity?)
7. What is the best information interface to the array? RF? IF? Digital?

## **Commercialization and Deployment**

8. What are the antenna technologies that are candidates for near term, mid-term, and long-term, and what are the risks, challenges, and opportunities associated with getting to a business case that closes?
9. What are baseline performance requirements for these “radio heads” (EIRP, scan volume, NF or sensitivity (G/T), reliability, cost targets, size, weight, and power?)
  - a. What are the trades in terms of antenna size and sensitivity/transmit power (and hence transmit power per element)?
10. What are notional deployment timelines with associated volumes?