Mitigating Interference from Urban Air Mobility Vehicles on Satellite Communication Links by Using Vortex Radiometry

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Outline

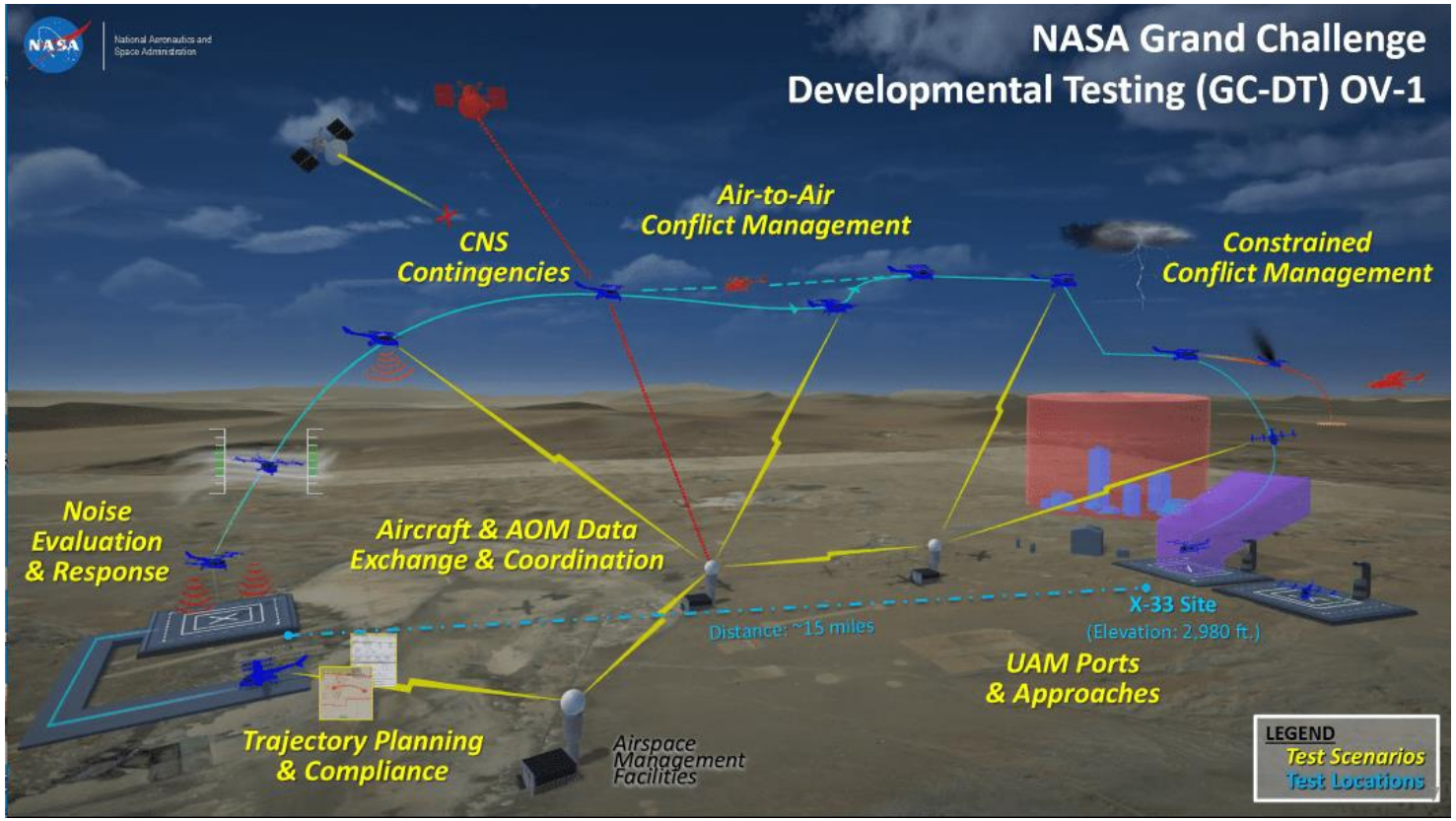
- Urban air mobility
- UAM communication needs
- Potential for disaster
- Fusilli pasta solution
- Vortex radiometry
  - Simulation
  - Prototype

Urban Air Mobility

- Major transportation disruption
  - Package delivery
  - Air taxis
  - Emergency services
- Thousands of vehicles
  - Autonomy required
    - Fully autonomous
    - Remotely piloted
- Communications
  - Secure, reliable and resilient?

UAM communication needs

- Disruption to SATCOM industry
  - Massive number of users
  - Constantly using network
  - All high priority links
- Requires
  - Equally massive increase in satellite assets
  - Seamless integration with terrestrial assets
  - Autonomy (“Cognition”)

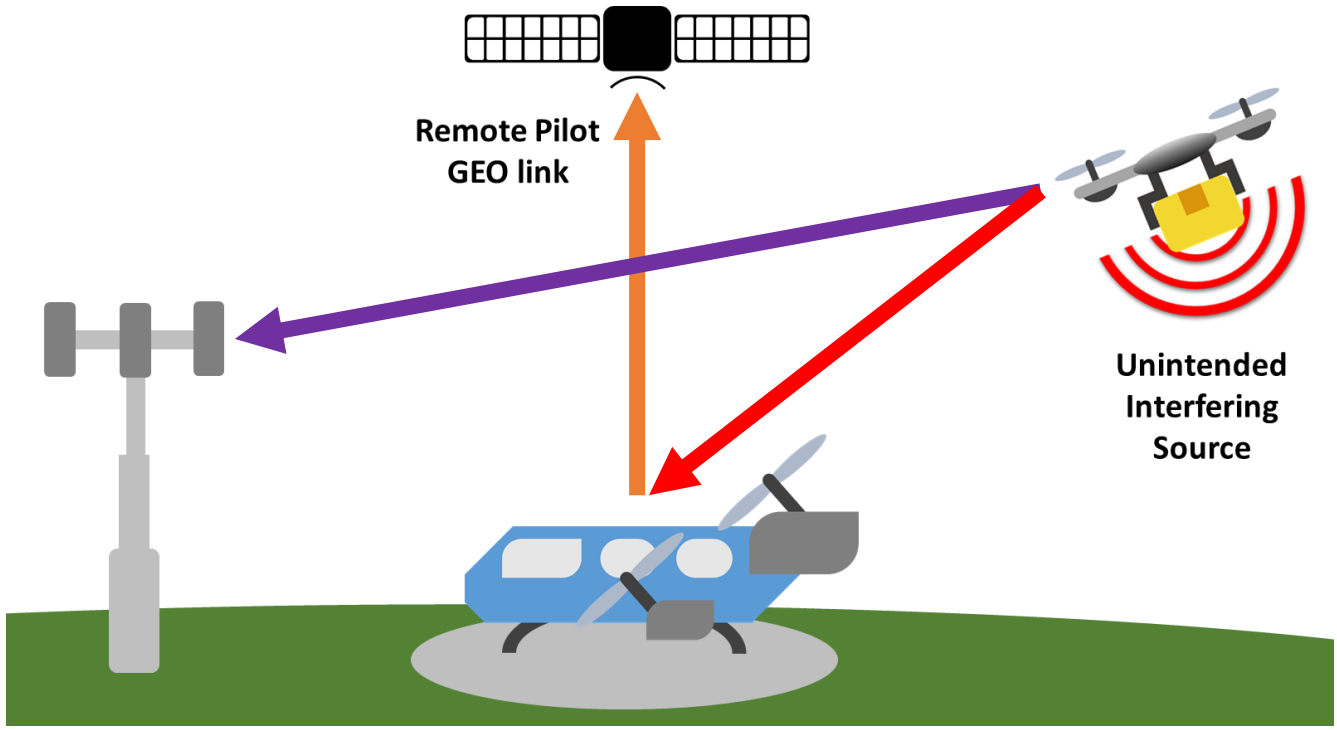


Potential for disaster

- UAM link fades result in…
  - Vehicle loss
  - Destruction of infrastructure
  - Erosion of public trust
- Cognitive algorithms predict fades
  - Most rely on active link statistics
  - Even a millisecond fade can result in disaster
- ***Prediction is not reliable enough for UAM***

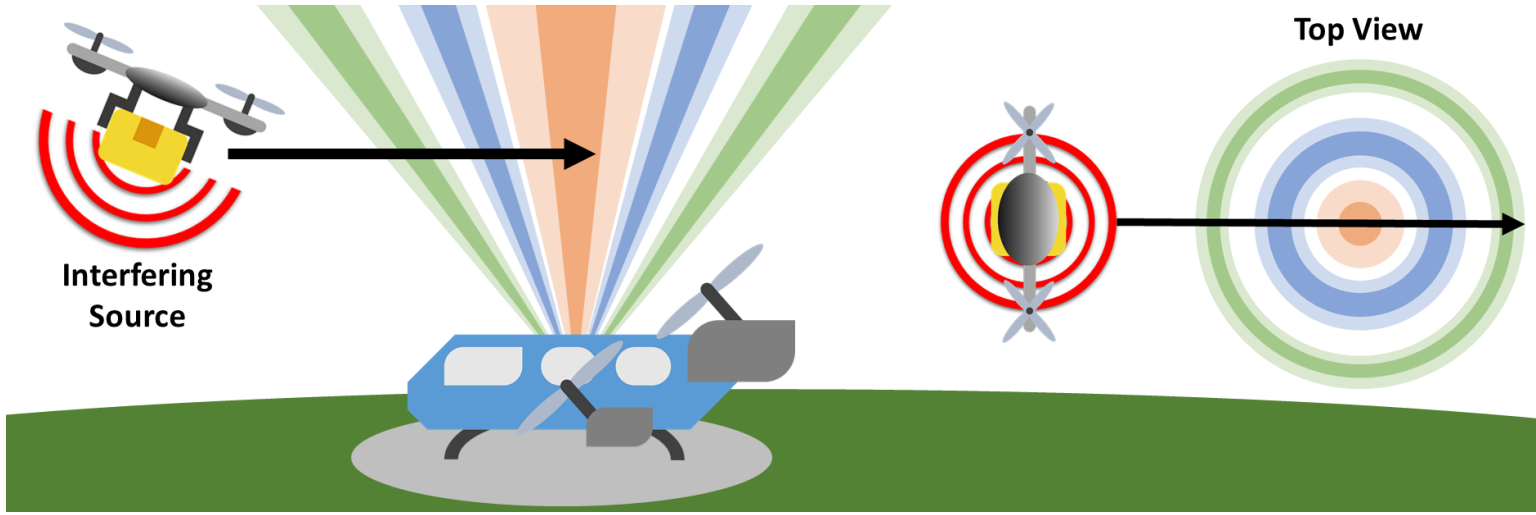
A thought experiment

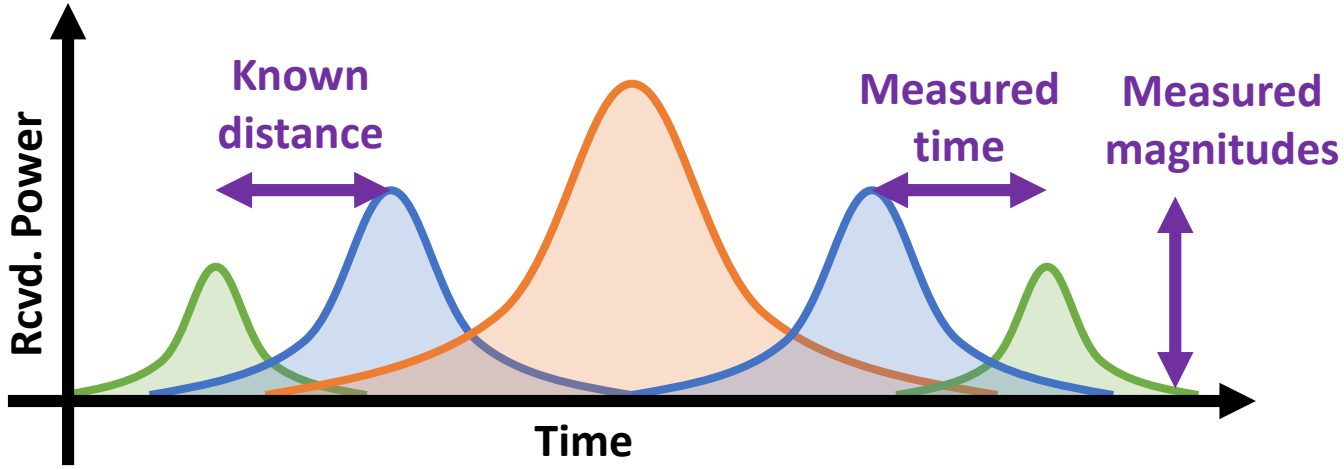
- Remotely piloted air metro
  - Primary SATCOM link
- Autonomous package delivery vehicle
  - Idents metro as cellular base station
  - Receives no response
  - Cognitive algorithm sees poor link
  - Increases TX power
- Results in an interference fade
  - Loss of remote pilot control
  - Vehicle crashes



Fade arrival detection

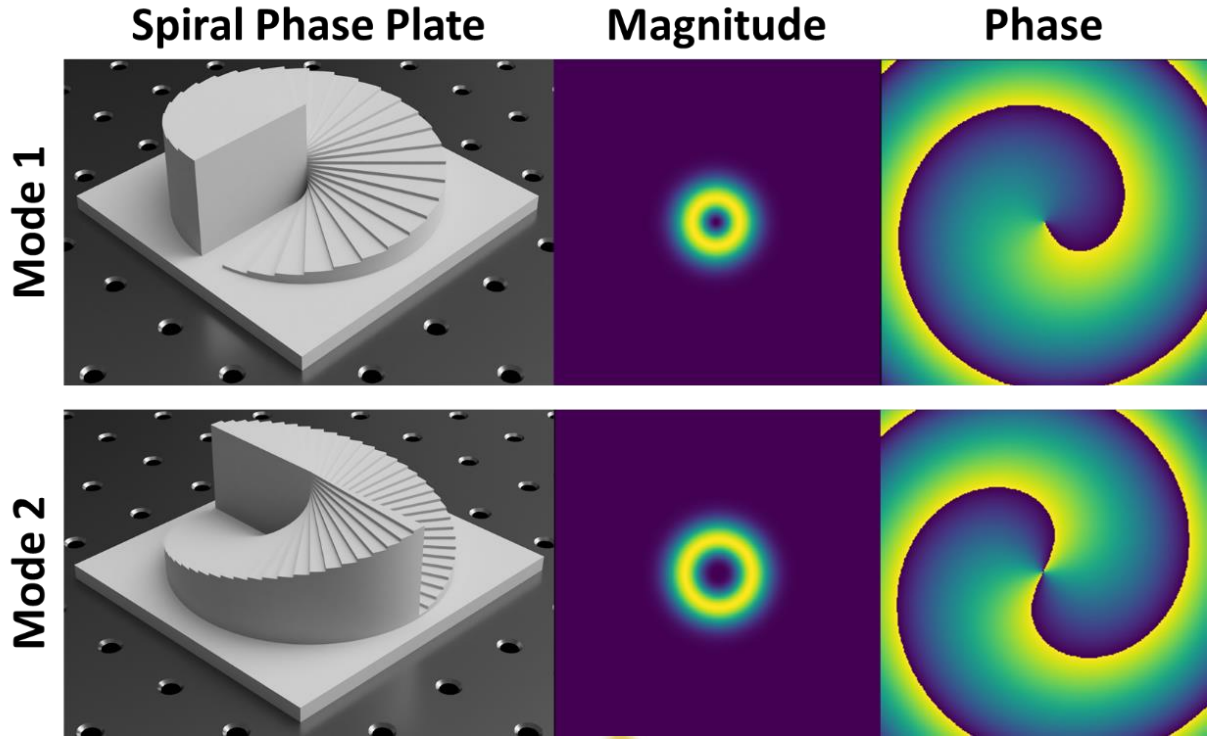
- Need an early warning system
- Concentric ring concept
  - Measure interference at known positions
  - Calculate source velocity, size and time of arrival
- Estimate
  - ***When a fade will occur***
  - ***How long a fade persist for***
  - ***How intense a fade will be***





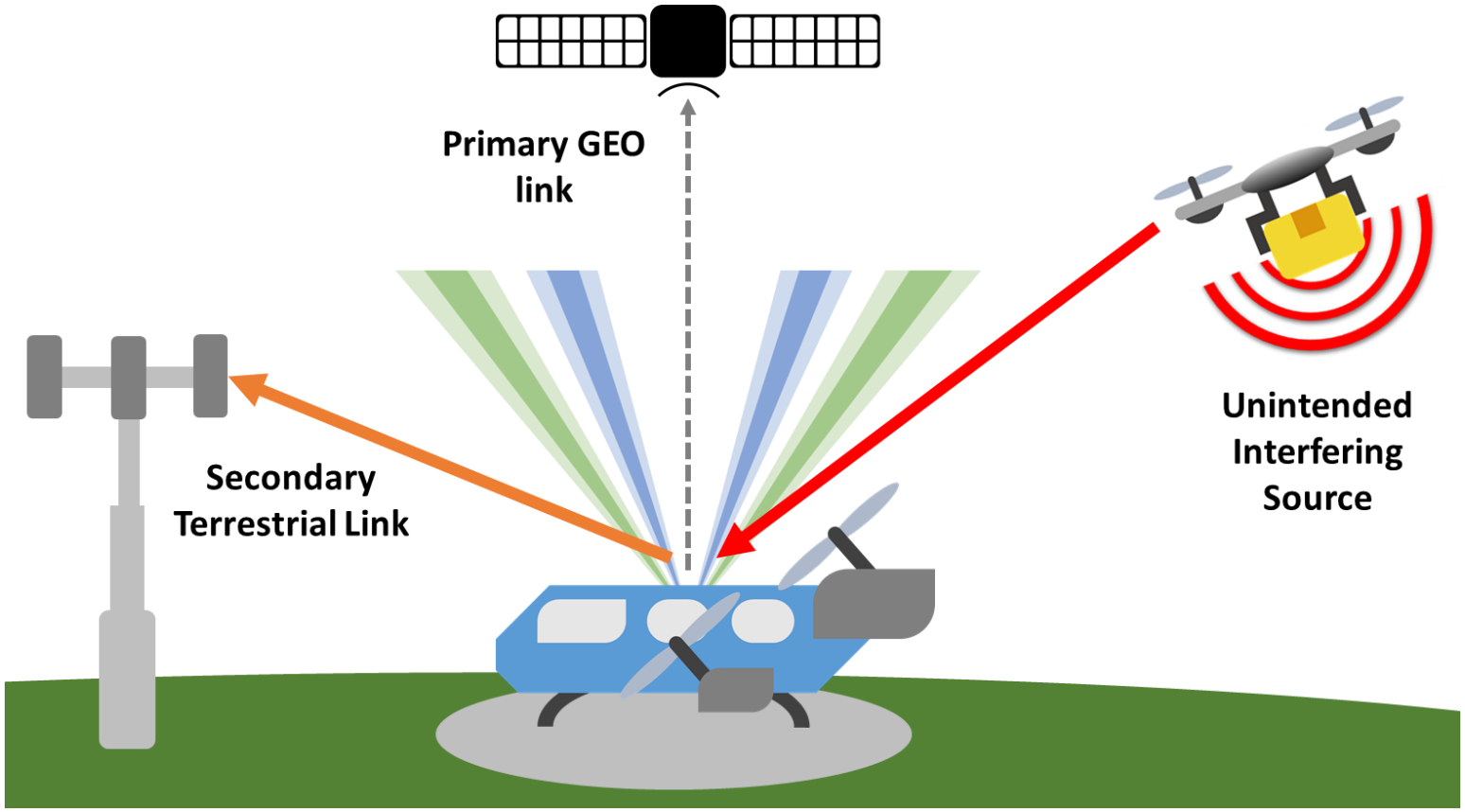
Annular beams: The fusilli solution

- Orbital angular momentum
  - Higher-order Gaussian beams
  - Azimuthal phase variation
  - Central phase dislocation
  - Spiral phase plates, phased arrays…
- Vortex Radiometer
  - Multiple OAM beams
    - Different azimuthal mode numbers
  - Measure received power vs time
  - Estimate interfering properties

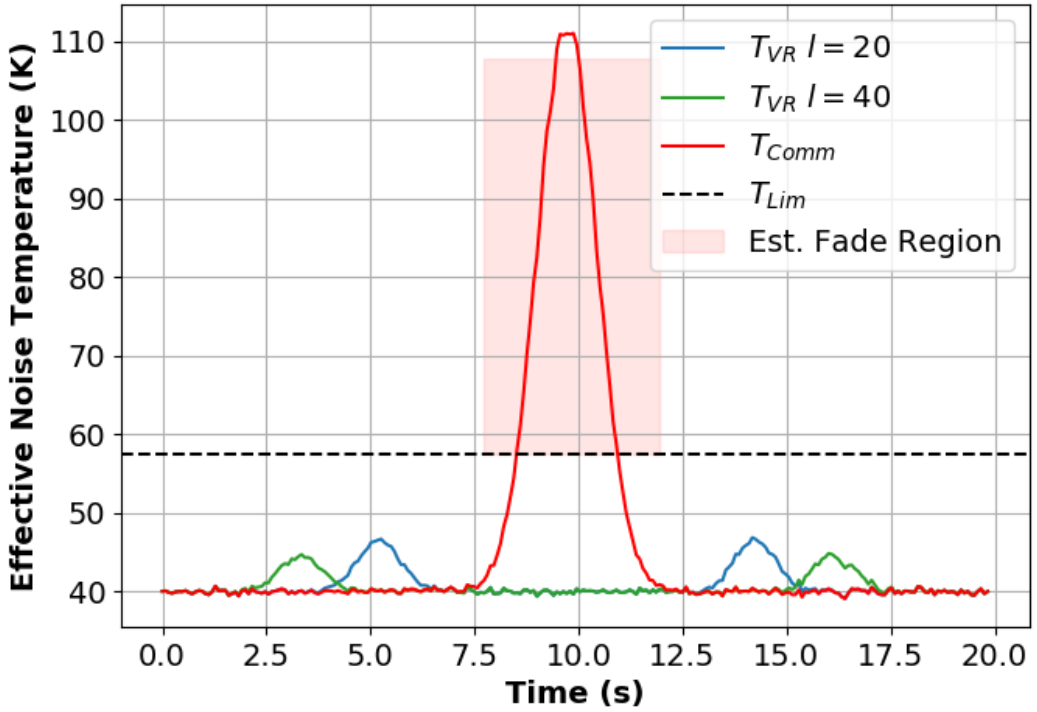


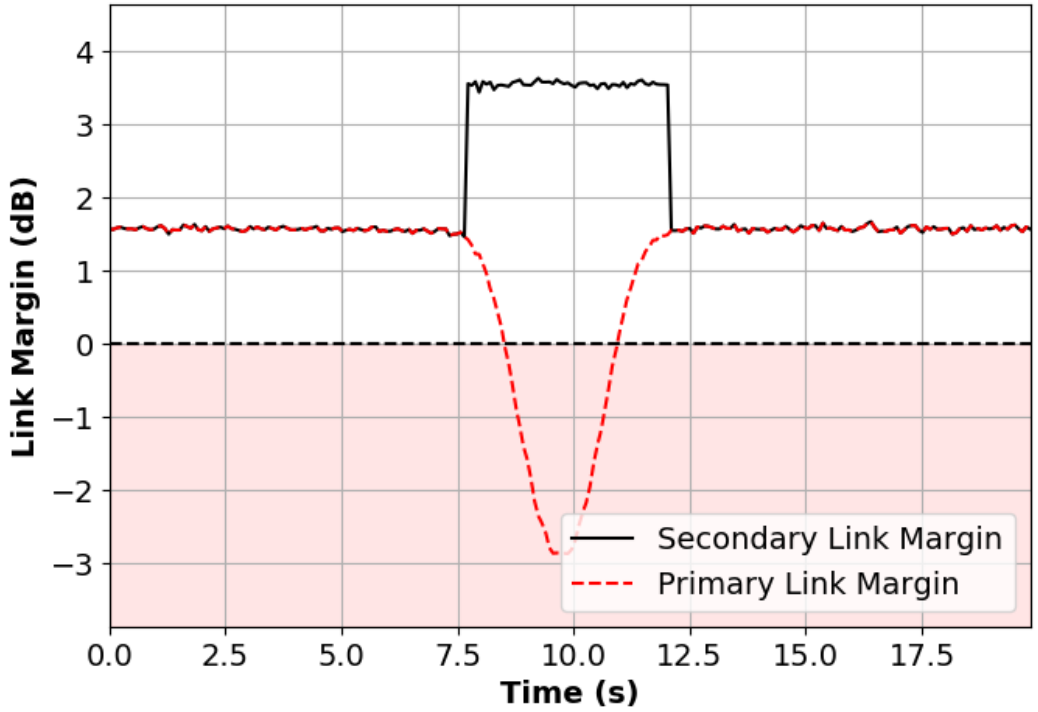
Vortex Radiometry: Example

- Primary SATCOM link
  - 26 GHz
  - 35,786 km - GEO
- Secondary terrestrial link
  - 4 GHz
  - 0.2 km
- Interferer
  - 26 GHz
  - Velocity 50 kts
  - Altitude 6,500 ft (~2km)
  - Effective radius 5 m

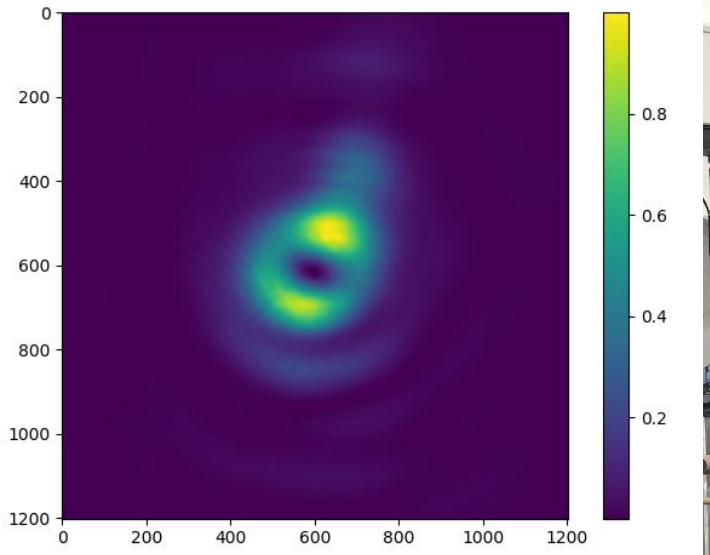


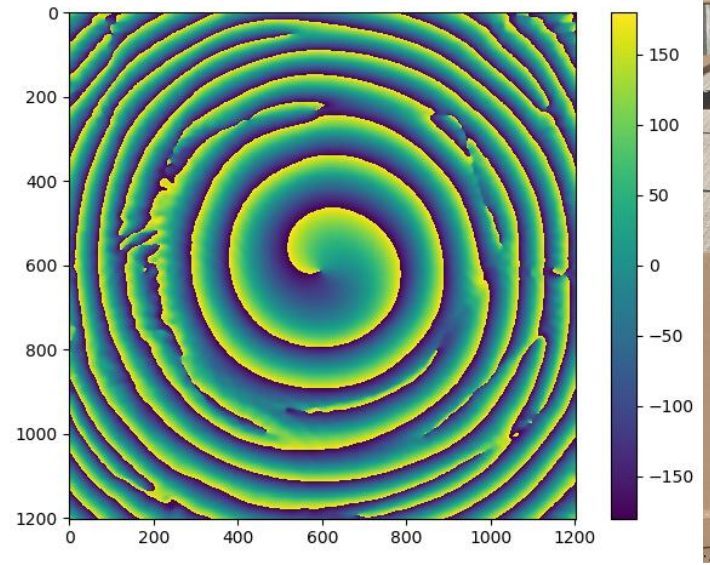
Vortex Radiometry: Results

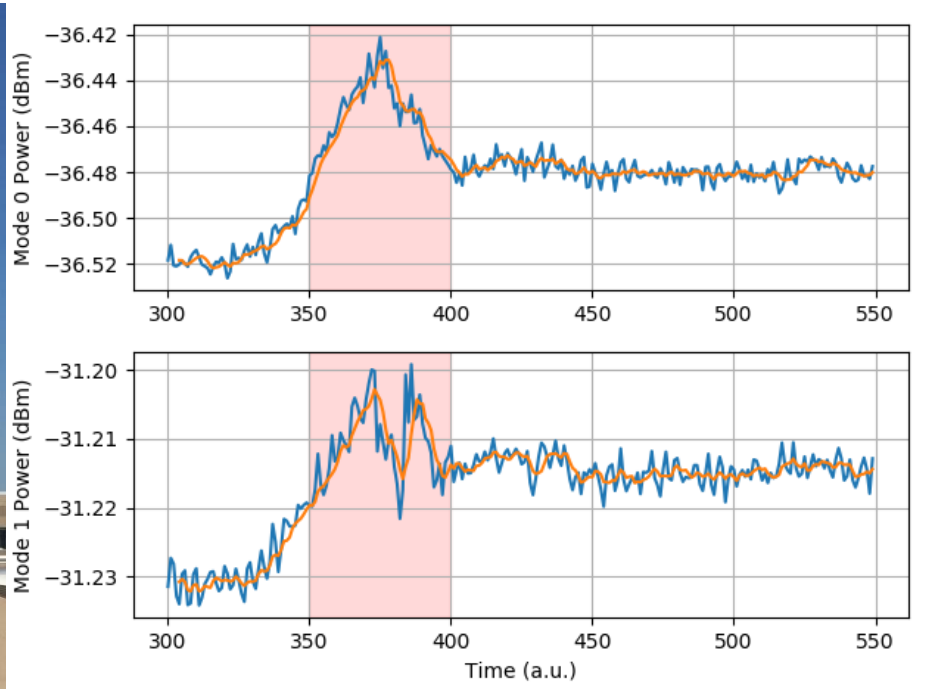




Vortex Radiometer: Trials







Conclusion

- UAM is coming
- ***Prediction based on active link statistics is not resilient enough for UAM***
- Measure fades before occurrence
- Orbital angular momentum enabled vortex radiometer
  - ***When a fade will happen***
  - ***How long a fade will persist for***
  - ***How intense a fade will be***