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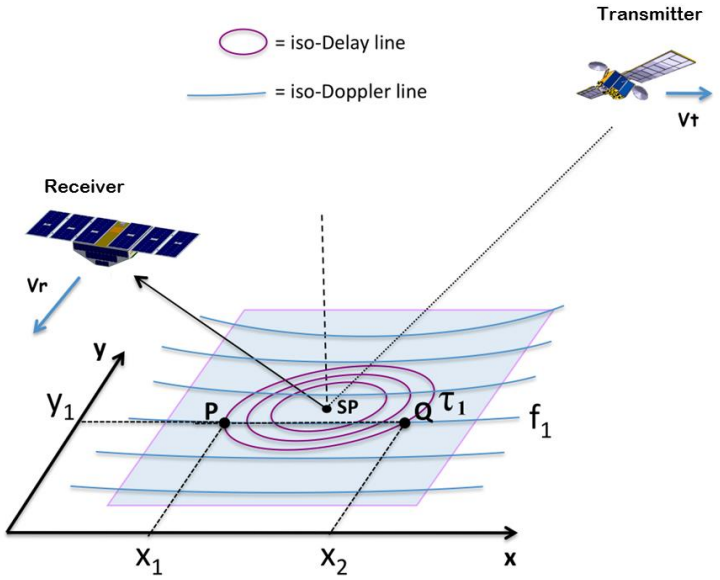
Next Generation GNSS Bistatic Radar Receiver

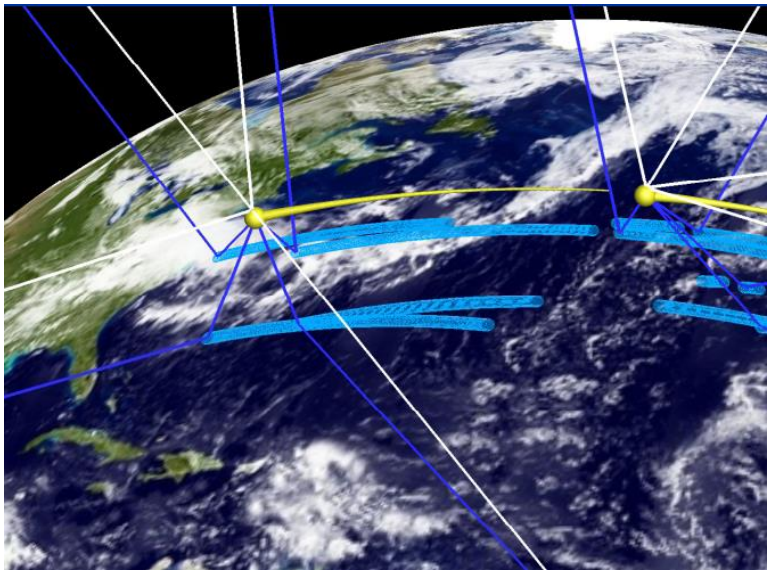
Chris Ruf (UM), Principal Investigator
Ryan Miller (UM), Systems Engineer/Firmware
Darren McKague (UM), Project Manager
Andrew O'Brien (OSU), Signal Processing Algorithms
Chi-Chih Chen (OSU), Antenna
Roger Backhus (UM), Receiver
Line van Nieuwstadt (UM), LNA
Rachel Norris (UM), LNA
Eric Loria (OSU), Signal Processing Algorithms

SPACE PHYSICS RESEARCH LABORATORY
ElectroScience LABORATORY
NASA
ESTO
Earth Science Technology Office

Overview of NGRx Project

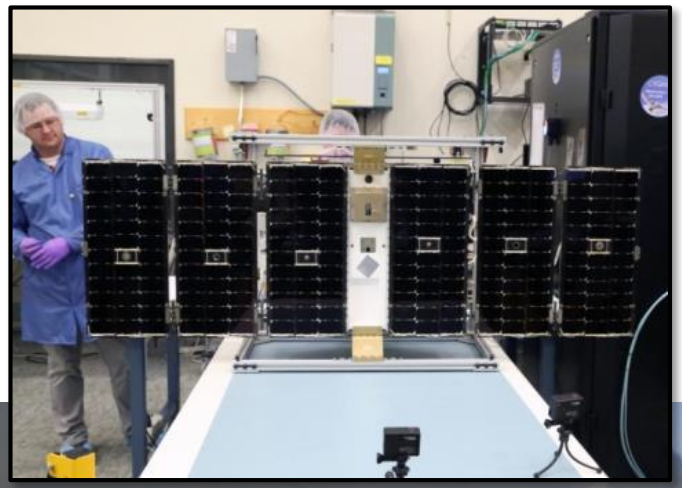
- Develop a next generation GNSS bistatic radar receiver capable of processing signals transmitted by both GPS and Galileo satellites, including both low (L1/E1) and high (L5/E5) bandwidth signals



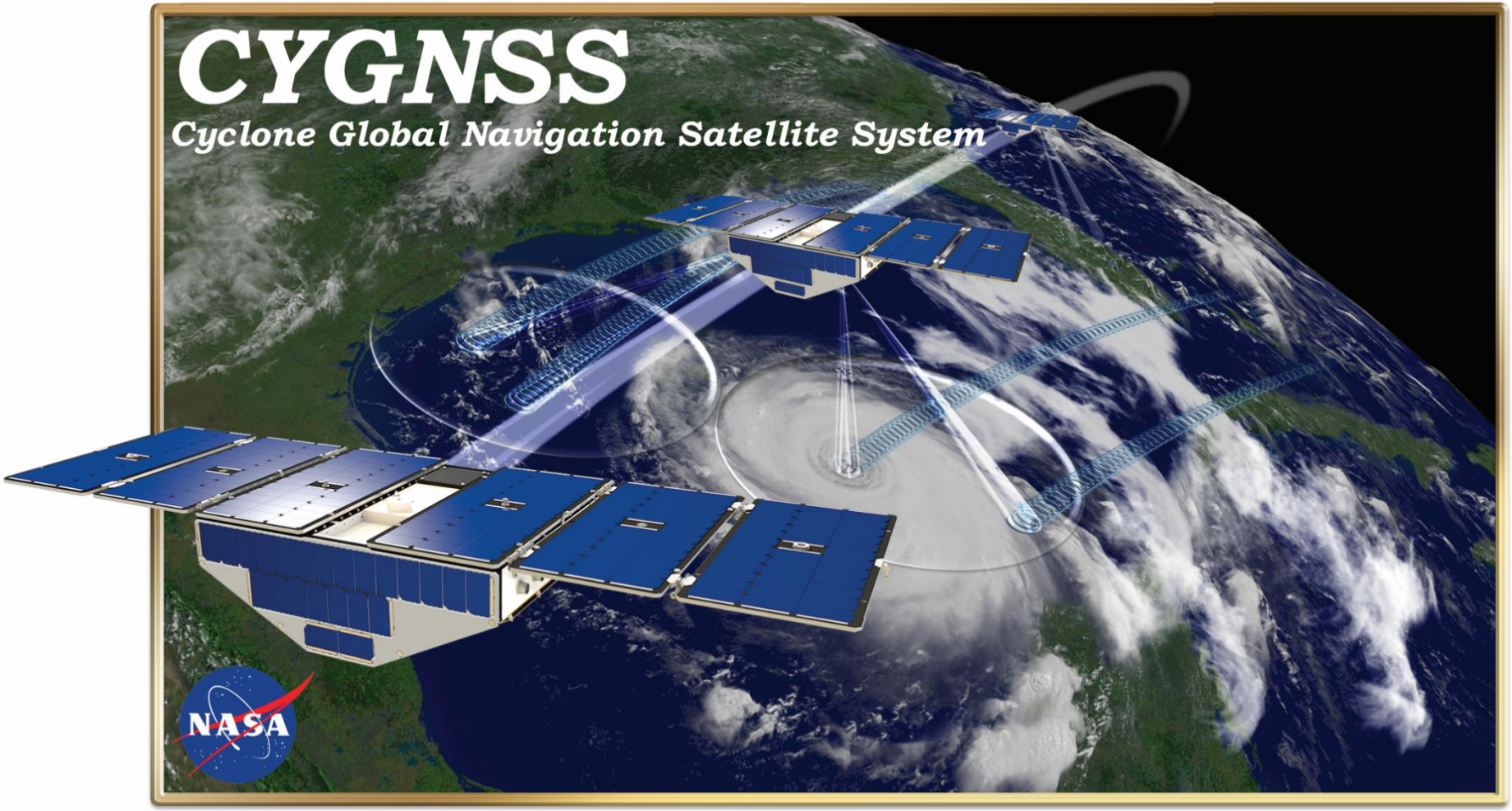


- Raise technology readiness from TRL-4 to TRL-6

CYGNSS Pre-launch Development

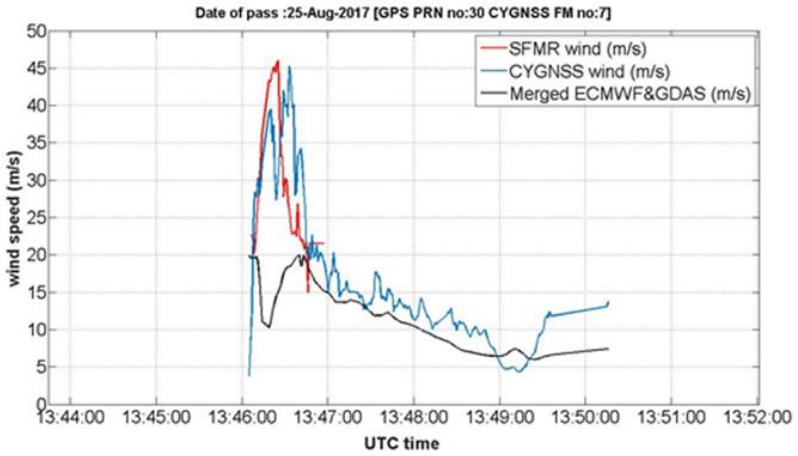


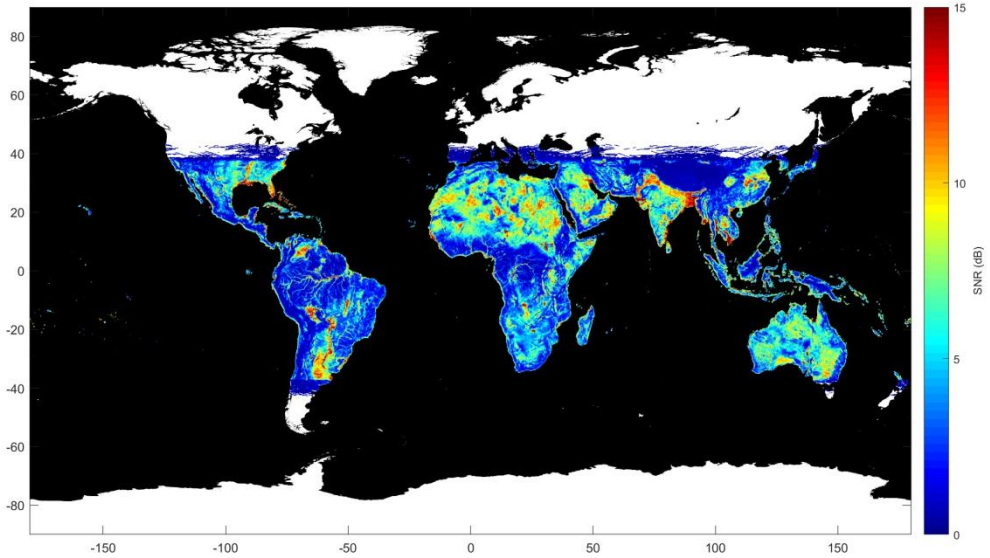
CYGNSS Earth Venture Mission (launched 15 Dec 2016)

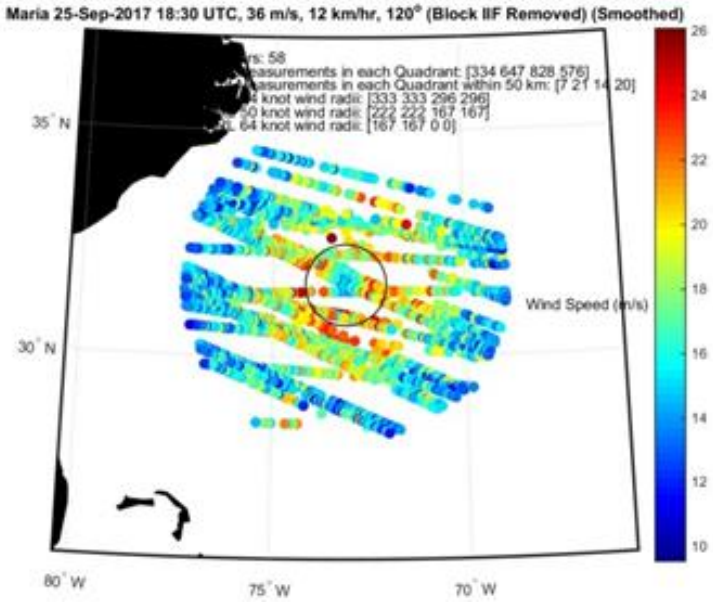


CYGNSS On-Orbit Performance

- **(right) Hurricane L2 Windspeed Obs**
  - (top) Harvey Overpass, 25 Aug ’17
  - (bot) Maria 3-hr composite, 25 Sep ’17
- **(bot) Land L1 SNR Obs**
  - 1 month composite of global coverage over full +/- 38^{o} latitude







Comparison Between CYGNSS and IIP NGRx

CYGNSS

- Engineering Design
  - GPS L1 scattered signals
  - 4 simultaneous receive channels
  - Co-pol antenna
- Science data products
  - 15 km resolution
  - 7 hr mean revisit (8 s/c constellation)
  - Co-pol scattering cross section
  - O(100 cm) sea surface height uncert.
- Enabling science applications
  - Ocean surface wind speed
  - Land surface soil moisture

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IIP Next Gen GNSS-R Receiver

- Engineering Design
  - GPS L1&L5, Galileo E1&E5
  - 20 simultaneous receive channels
  - Co- and X-pol antenna
- Science data products
  - 5 km resolution
  - 2 hr mean revisit (8 s/c constellation)
  - Co- and X-pol scattering cross section
  - O(10 cm) sea surface height uncert.
- Enabling science applications
  - Ocean surface wind speed (w/ improved temporal/spatial res)
  - Land surface soil moisture (w/ improved temporal/spatial res and improved vegetation discrimination)
  - Sea level height/tsunami detection
  - Sea ice draft/sea ice mass

IIP Subsystem Development

- Antennas (dual pol'z)
- LNA (improved internal cal)
- Receiver (more parallel channels and bandwidth)
- Digital Processor (optimized architecture)
- Reflection Processing and Navigation Algorithms (streamlined algorithms)

Next Generation GNSS Bistatic Radar Receiver

PI: Christopher Ruf, Univ. Michigan

Objective

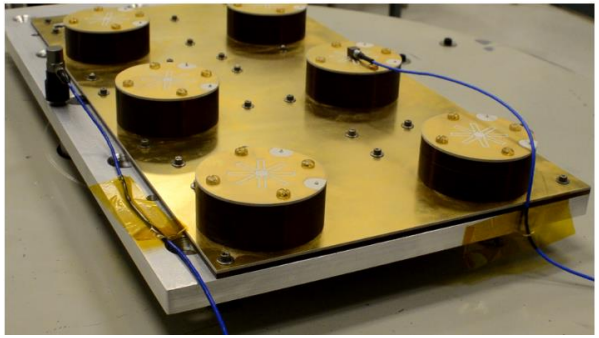
Prototype next generation GNSS-R bistatic radar receiver to improve

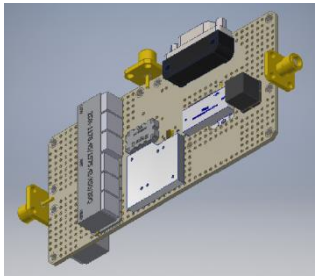
- Spatial resolution of GNSS-R measurements x5
- Altimetric resolution x10, and

Temporal sampling x2 (minimum) to x4 (goal) beyond current capability

Expand current GNSS-R antenna and receiver capabilities to support the use of additional transmit signals from both GPS and Galileo as well as both L1/E1 and L5/E5

Increase number of software defined radar processing channels from 4 (current) to 7 (minimum) or 14 (goal)





(left) Vibration testing of prototype next gen GNSS-R antenna
(right) Brassboard design of next gen LNA/Cal module

Approach

Synch and trigger front end/back end interface for high duty cycle calibration

Integrate Ligado notch rejection filter

Design new antenna for all carriers (L1, E1, L5, E5)

Redesign CYGNSS receiver digital back end using state-of-the-art flight qualified signal processing devices

Increase clock rate to handle wider bandwidth L5/E5 signals

Increase memory size and gate count to handle wider parallel processing bus

CoIs: A. O'Brien and C. Chen, OSU

Key Milestones

• Define major susbsystem requirements	03/17
• Reflectometry and navigation antenna CDR	09/17
• Brassboard (functional) receiver CDR	01/18
• Antenna fabrication and chamber test	09/18
• Brassboard receiver fabrication and functional test	10/18
• Engineering model (form-fit-function) receiver CDR	12/18
• Antenna environmental test	12/18
• Engineering model receiver fabrication and environmental test	12/19

$TRL_{in} = 4$

Path to Future Flight Opportunities

- CYGNSS Mission Status
  - Ocean winds data product public release to PO.DAAC
  - Preliminary looks at assimilation of data into HWRF (hurricane forecast model) show positive skill impact
  - Numerous other science investigations on-going (tropical convection, MJO, altimetry, soil moisture, flood inundation)
- 2017 NAS Earth Science Decadal Survey highest priority science and applications objectives
  - Changing water cycle, droughts and floods, air-sea energy & momentum fluxes, improving weather forecasts, sea level rise