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For more information: http://cygnss-michigan.org
CYGNSS Team

• University of Michigan
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  – Damen Provost (UM Project Mgr), Linda Chadwick (UM Business Mgr), Bruce Block (UM Technical Mgr)

• Southwest Research Institute
  – John Scherrer (Project Mgr), Randy Rose (Systems Eng), John Eterno (Spacecraft), Debbie Rose (Mission Ops)

• Surrey Satellite Technology US
  – Brian Johnson (DDMI)

• NASA Ames Research Center
  – James Chartres (Deployment Module)

• Science Team
  – Bob Atlas, NOAA; Paul Chang, NOAA; Maria Paola Clarizia (UM/NOC); James Garrison, Purdue U; Scott Gleason, Concordia U; Joel Johnson, Ohio State U; Stephen Katzberg, NASA LaRC (retired); Sharan Majumdar, U-Miami; Perry Samson, UM; Donald Walter, S. Carolina State U; Valery Zavorotny, NOAA; Zorana Jelenak, NOAA
# CYGNSS Schedule

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<th>Mission Timeline</th>
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- **Phase A**: Prep & Assembly
- **Phase B**: System Testing
- **Phase C**: Integration
- **Phase D**: Launch
- **Phase E**: Mission Operations
- **Phase F**: Science Operations

Launch date: 7 May 2013

Ruf, CYGNSS, IOVWST Mtg
CYGNSS Science Goals & Objectives

• CYGNSS Science Goal
  – Understand the coupling between ocean surface properties, moist atmospheric thermodynamics, radiation, and convective dynamics in the inner core of a tropical cyclone (TC)

• CYGNSS Objectives
  – Measure ocean surface wind speed in all precipitating conditions, including those experienced in the TC eyewall
  – Measure ocean surface wind speed in the TC inner core with sufficient frequency to resolve genesis and rapid intensification

• Limitations of current spaceborne ocean surface wind sensors
  – Traditional satellite remote sensing channels for ocean surface winds are significantly attenuated by intense precipitation
  – Traditional LEO polar orbiters have revisit times that are infrequent relative to time scale of rapid intensification phase of TC development

• CYGNSS Uses a new measurement technique and a new satellite mission architecture
GNSS-R Bistatic Radar
Quasi-Specular Surface Scattering

- GPS direct signal provides reference
- Forward scattered signal contains surface info
- Scattering cross-section image measured by UK-DMC-1 spaceborne mission with variable lag correlation and Doppler shift
Performance in Intense Precipitation

- One-way transmissivity through typical tropical storm (5 km freezing level) for: GPS (1.575 GHz), ASCAT (5.255 GHz), QSCAT (13.4 GHz)

- Airborne GNSS wind speed retrieval during overpass of Hurricane Bill on 19 Aug 2009. Strong rain bands (black) do not noticeably affect the GNSS retrieved wind (red)
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<th>Scientific Measurement Estimated Performance</th>
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<td>Measure ocean surface winds under TC conditions</td>
<td>Precip</td>
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<td>Windspeed uncertainty</td>
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<tr>
<td>Measure ocean surface winds in TC inner core with high temporal frequency</td>
<td>Mean revisit time</td>
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<td>Earth coverage</td>
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CYGNSS Constellation

Blue dots are GPS satellites
Yellow dots are CYGNSS Observatories
• **Software model of all critical steps in the wind speed retrieval process:**
  - Dynamic orbit propagators for GPS and CYGNSS constellations
  - Signal generation by GPS transmitter satellites
  - Free space propagation to the specular reflection point on the Earth surface
  - Bi-static forward scattering from the wind driven, roughened ocean surface
  - Receive antenna gain pattern projected onto the Earth surface
  - Link budget for received signal strength
  - Fading and thermal noise statistics of received signal
  - Accuracy, precision and resolution of Delay Doppler Map data product
  - Wind speed retrieval algorithm
Deriving Coverage Mask

- (left) One of 2 nadir antenna patterns projected onto Earth (altitude 500 km, 60° rotation, 28° tilt)
- (center) SNR of received signal (10 m/s WS, 45° inc. angle)
- (right) +8 dB SNR contour with both antennas (meets WS retrieval uncertainty requirement)
CYGNSS Earth Coverage

- 90 min (one orbit) coverage showing all specular reflection contacts by each of 8 s/c
- 24 hr coverage provides nearly gap free spatial sampling within +/- 35 deg orbit inclination
CYGNSS coverage map overlaid on historical record of all named (wind speed >30 kt) storm tracks during 2000-2009. Red indicates Cat 1 or higher TC.
CYGNSS Revisit Time
Requirement is 12 hr mean revisit

- Probability distribution of revisit time for all Earth samples within +/-35° (solid) and for samples of historical storm tracks (dashed).
- Revisit stats derived from PDF demonstrate 4 hr mean storm revisit and ~9 hr to revisit 90% of all storms
Hurricane Overpass Case Study

- Time lapse simulation comparing CYGNSS and ASCAT coverage of Hurricane Frances just before landfall
- Snapshots of all samples taken in 3 hour intervals
- Hurricane inner core shown as large blue dot

7 May 2013 Ruf, CYGNSS, IOVWST Mtg
CYGNSS Observatory (exploded view)
CYGNSS Observatory (1 of 8)

- **Observatory**
  - Power: 48.8 W (EOL margin 30.3%)
  - Comm: 1.25 Mbps S-Band (31% link margin)
  - Mass: 17.6 kg

- **Orbit**
  - Altitude: 500 km
  - Inclination: 35 deg

- **Launch**
  - 6 Oct 2016
Complete Flight Segment with Deployment Module
For more information: http://cygnss-michigan.org