FLIGHT COMMUNICATIONS SYSTEMS SECTION

We engineer cost-effective spaceborne communications systems, services and products including direct-to-Earth (DTE) and proximity relay links for NASA/JPL and non-NASA missions. We develop, deliver and support software-defined radios (SDRs), spacecraft and airborne antennas, RF power amplifiers, and related products for RF system applications. We also specialize in optical communications, including sensitive single-photon detectors and isolation platforms for accurate pointing. We develop telecom concepts and demonstrate them for infusion into operational ground and space systems of NASA missions and for DARPA and other agencies.

The JPL Communications, Tracking and Radar Division performs scientific investigations, advanced technology research, engineering developments and system implementations encompassing space telecommunications, tracking and active remote sensing using electromagnetic waves. The Division develops and operates systems to provide high data capacity coupled with precision tracking at low cost with operational reliability and autonomy to support diverse mission needs for point-to-point operation; planetary relays; in situ and proximity communication during entry, descent and landing (EDL); surface operations; high-capacity backbone links; and interspacecraft tracking and communication in distributed systems and multiple space vehicle formations. Systems used for communications and tracking are utilized for scientific benefit in fields as diverse as radio astronomy, planetary science, geophysics and quantum physics. Active remote sensing, utilizing many disciplines common to communication and tracking, supports NASA Earth and solar system exploration strategic science goals and includes allimeters, scatterometers, real- and synthetic-aperture radars, and precise spacecraft-to-spacecraft measurement systems.

Areas of expertise include:
- Tracking systems analysis for design and performance.
- Interferometric radio and optical systems.
- Flight hardware design, build, assembly and test.
- Atomic frequency reference design, fabrication and test.
- Measurement and modeling of ionosphere and atmosphere.
- GNSS data analysis and precise orbit determination.
- Geophysics, astrophysics and fundamental physics.

JPL projects we support include:
- Gravity Recovery and Climate Experiment Follow-On (2017 launch) laser and microwave instruments
- Deep Space Atomic Clock (2018) payload
- COSMIC-2 (2016) radio occultation instruments
- Gravity Recovery and Interior Laboratory (GRAIL) payload system
- Global Differential GPS real-time positioning (ongoing)

JPL projects we support include:
- Lasercom for the Lunar Atmosphere and Dust Environment Explorer (LADEE) and Laser Communications Relay Demonstration (LCRD).
- SDRs for Mars proximity links between the Curiosity rover to Mars Reconnaissance Orbiter (MRO).
- Other SDR missions include NASA’s Mars Atmosphere and Volatile Evolution (MAVEN) mission and ExoMars’ Trace Gas Orbiter for the European-led ExoMars mission. In the future, the Universal Space Transponder will serve as proximity link for Mars and also relay data to Earth.

Areas of expertise include:
- An in-depth and broad expertise in all aspects of optical communications design and implementation.
- Spacecraft antenna R&D and electromagnetic theory.
- Spacecraft RF electronics, microwave components and interconnects, and telecom system integration and test.
- Microwave solid-state power amplifiers, traveling wave tube amplifiers and Extended Interaction Klystrons, high- and low-voltage power supplies, and RF microwave design.
- Spacecraft transponders, low-frequency analog and digital design and RF integrated circuits.
- In situ, proximity and relay communication radios; digital signal processing; digital design; and mobile communications.
- Telecom systems engineering support and mission planning; assembly, test and launch operations testing support; mission proposal support; and telecom tools adaptation and evaluation.
- Flight communications system leadership and engineering for all project life cycle phases.

For more information, visit www.jpl.nasa.gov

The twin GRAIL spacecraft used a GPS-like ranging code to precisely determine their separation (left). The global GNSS ground network (bottom right) supports precise positioning; a typical antenna installation is shown above.

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Facilities
- Quantum Research and Development Laboratory
- Frequency Standards and Test Laboratory
- Optical Communications Laboratory
- Radar Development Laboratory
- Precision Tracking Sensor and GPS Development Laboratory
- Flight RF Advanced Microelectronics Laboratory
- Mesa Antenna Range
- Deep Space Network RF Development and Test Laboratory

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The ins (left) and Universal Space Transponder (right) provide precise position and timing data to the Global Navigation Satellite System (GNSS) for tracking and communications. The Global Positioning System (GPS) satellites transmit radio-frequency signals that are essential for deep space missions; radiometric- and laser-ranging measurement systems and development, and fabrication of precise frequency and time systems; both hardware and software; engineering, design and development, and fabrication of precise frequency and time systems; radiometric- and laser-ranging measurement systems and arraying technologies; measurement of spacecraft and naturally occurring radio-frequency signals that are essential for deep space navigation; operation of global navigation satellite system (GNSS) tracking infrastructure and data processing for research, analysis, and operations; scientific research in the areas of planetary dynamics, astrophysics, astrometry and radio astronomy, gravitation- al waves, geophysics, and fundamental physics.

Areas of expertise include:
- Tracking systems analysis for design and performance.
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- Telecom systems engineering support and mission planning; assembly, test and launch operations testing support; mission proposal support; and telecom tools adaptation and evaluation.
- Flight communications system leadership and engineering for all project life cycle phases.
Areas of expertise include:

- System engineering and implementations for advanced communication architectures, tracking and remote sensing instruments for ground and space networks and systems.
- Electromagnetic theory and techniques.
- Next-generation communications architectures and technologies for future deep space and planetary proximity systems, including modulation systems, source and channel coding algorithms and protocols, quantum and optical communication technologies, signal and data processing techniques, and communications information theory.
- Precision tracking and position sensing techniques, technologies, operational systems and data processors, including frequency and timing, Global Positioning System (GPS), very long baseline interferometry, and signal processing/correlation.
- Flight and ground communication systems for JPL missions, including antennas, arrays, transponders, proximity radios, signal processors and RF amplifiers.
- Active RF remote sensing instruments, radars, and associated ground data processing algorithms and data processing systems.
- Spectrum engineering and RF interference analyses.

Areas of expertise include:

- Definition of novel communication architectures, including interplanetary communication networks.
- Communication systems theory and prototype development, using the most advanced signal processing techniques.
- Radar and radio science observations in close collaboration with the science community.
- Development of quantum technologies for clocks, atom interferometry and other quantum-based instruments.
- Spectrum engineering to allow compatible and efficient use of the RF spectrum by JPL missions and projects.

We have a heritage of significant achievements in the development of new technologies for space communications: modulation schemes, error-correcting codes, receivers, advanced signal processing, ground-based planetary radar, atomic clocks and quantum technologies, and radio science. We define new deep space telecom architectures and space networking, and manage spectrum allocations. We develop new telecom concepts that advance the state of the art, and we demonstrate them for infusion into operational ground and space systems of NASA missions and for DARP and other agencies.

Our work has benefited a number of NASA projects: error-correcting codes for many missions for more than 30 years; data compression and proximity protocols from Mars Exploration Rovers to Mars Science Laboratory; support for the Lunar Atmosphere and Dust Environment Explorer (LADEE) and receivers for the Laser Communications Relay Demonstration (LCRD); Deep Space Atomic Clock (DSAC); radio science for Cassini, Juno, and Gravity Recovery and Interior Laboratory (GRAIL) missions, and for monitoring potential asteroid impacts.

Areas of expertise include:

- World-leading cryogenic low-noise amplifiers.
- High-power transmitters operating in excess of 500 kW CW.
- High-speed real-time digital signal processing and software-defined ground receivers.
- RF active and passive systems, feeds, amplifiers, filters, isolators, circulators, and diplexers.
- Large antenna arrays and control systems.
- Antenna mechanical, structural, and civil systems.
- Large ground system antenna construction electronics integration and test.
- Antenna metrology, radio astronomy, and radio science using deep space communications links.
- Ground antennas and front-end systems engineering.

We provide engineering development, implementation, and maintenance of high-reliability state-of-the-art technologies for the telecommunications systems of the Deep Space Network (DSN) in support of NASA’s space science missions. Our engineers design and develop all aspects of a ground communications system including the RF/microwave optics and feeds, cryogenic low-noise amplifiers, high-power RF transmitters, digital receivers, mechanical/structural elements of large antennas and antenna construction, and precision antenna pointing utilizing advanced servo controllers. We have fielded world-leading low-noise receivers, duplexed with transmitting systems radiating in excess of 150 kW and solar system radar in excess of 500 kW. Our future developments include optical communications research and demonstrations. New capabilities for the DSN are continuously added to meet the growing demand of the fleet of deep space missions. Optical communications ground systems that work in tandem with the current RF systems are being developed to meet the high data rate requirements that are part of multi-spectral instruments to be flown in the future.

Areas of expertise include:

- Radar remote sensing concept and technique development.
- Advanced radar RF and digital technology development.
- Operational and experimental airborne radar systems.
- Advanced radar processing algorithm and processor development.
- Advanced landing radar development.
- Radar remote sensing science for the cryosphere, ocean, atmosphere, biosphere and solid Earth.

We conduct research, development and flight missions in the field of airborne and spaceborne remote sensing radar for NASA and other government agencies, including synthetic-aperture radar (SAR) imaging, interferometric measurements, altimetry, Earth and planetary sounders, scatterometry, and cloud and rain radars. The section is also a leader in the area of planetary landing radars. The radar program is aimed at Earth and planetary science missions, with emphasis on first-of-a-kind radar systems and cutting-edge technology.

Accomplishments include the first civilian spaceborne SAR (SeaSat, 1978), planetary radar mapping of Venus (Magellan, 1992) and Titan (Cassini, continuing since 2004), generation of the world’s first high-resolution digital elevation map using single-pass interferometry (Shuttle Radar Topography Mission, 2000), the landing radar for Mars Science Laboratory (2012), and multiple pioneering Earth science missions (NSCAT, QuikSCAT, CloudSat, and Aquarius). Multiple additional Earth and planetary missions will soon launch or are planned, including RapidScat on the International Space Station, the Soil Moisture Active Passive mission, the Surface Water and Ocean Topography mission, the Mars 2020 lander mission, and a sounder to penetrate the icy moons of Jupiter.