SRI International

*SRI is a world-leading independent R&D organization*

- Founded by Stanford University in 1946
  - A nonprofit corporation
  - Independent in 1970; changed name from Stanford Research Institute to SRI International in 1977
- Sarnoff Corporation acquired in 1987
  (formerly RCA Laboratories)
- 2,000 staff members combined
  - 900 with advanced degrees
  - More than 20 offices worldwide, including Sarnoff India and SRI Taiwan
- Consolidated 2006 revenue: $411 million
SRI Focus Areas

Multidisciplinary teams leverage developments from SRI’s core technology and research areas

- Advanced Materials
- Microsystems
- Nanotechnology
- Engineering and Systems
- Information Technology
- Biotechnology
- Health, Education, and Economic Policy

SRI’s Value Creation Process™
Deep Technical Capabilities

SRI applies interdisciplinary skills to provide solutions to client needs

- Information and computing
- Networks and communication
- Automation and robotics
- Intelligence systems
- Data collection and measurement
- Homeland security
- Automotive
- Energy and environment
- Marine science and technology
- Advanced materials and structures
- Medical devices
- Computational biology
- Biosciences
- Product development
- Education, health, and economic policy
- Complementary capabilities at Sarnoff
- Speech recognition and translation
SRI Technology and Inventions

- The First Computer Mouse
- Micro-volcanoes for Protein Analysis
- Handheld, Speech-based Language Translation
- High-performance Polymers
- SRI-operated Sondrestrom Research Facility in Greenland
- Hydrogen Fuel Cells
- Molecularly Imprinted Polymer Gas Sensors
- Mobile Ad Hoc Wireless Networks for First Responders
SRI Space Engineering Systems Laboratory

- Picosatellite Payload Development
- Earth Station
- Life Test System
SRI Big Dish Antennas

• **150-foot dish**
  - Tracking capability: 1°/s
  - Resolution: 0.01°
  - Elevation: 3° to 87°
  - Frequency: Up to ~1.5 GHz

• **60-foot dish**
  - Tracking capability:
    - 4°/s azimuth
    - 1°/s elevation
  - Resolution: 0.04°
  - Frequency: Up to ~3 GHz
Picosatellite Communications
Current CubeSat Communications Paradigm

- **Communication frequencies**
  - Amateur
  - Dedicated
  - ISM

- **Equipment**
  - Off-the-shelf components
  - Amateur radios
  - ISM radios

- **Earth stations**
  - Amateur stations
  - Individual lab stations

ICOM 910H
Lessons Learned from Previous Launches

• Large numbers of small satellites
  – Problems with satellite localization

• Similar frequencies
  – Satellite discrimination issues

• Higher frequencies
  – Require better pointing accuracy

• Spread spectrum radios
  – Latency and handshaking make communication more difficult
Future Directions in Picosatellite Communications

• Upgraded Current Capabilities
• Inter-Satellite Communications
• Ground Station Networking
• Software Defined Radio
• Phased Array Antennas
Upgraded Current Capabilities

• Higher Frequencies
  – Potential for greater throughput
  – Better pointing accuracy required
  – Fewer off-the-shelf resources

• Optical Frequencies
  – No FCC license necessary
  – Potentially more data throughput

• Antennas
  – Directional antennas provide more efficient radiation patterns
  – Microstrip antennas require very little space
  – Memory alloy structures for deployable antennas
Inter-Satellite Communications

• **Network Standards**
  – Allow for possibility of communication between different types of physical links

• **Ad Hoc Networking**
  – Enables dynamic networking between satellites

• **Better Link Margins**
  – Lower power communications with better data throughput

• **Dedicated Inter-Satellite Frequencies**
  – Allows increased security

• **Data Forwarding**
  – Allows access to real-time data while satellite is not visible

• **Dedicated Communication Satellite**
  – A larger dedicated communication satellite could allow low power picosatellite communications
Ground Station Networking

• Advantages
  – Increased operations for ground station operators
  – More data throughput
  – Takes advantage of idle earth stations
  – Allows participation without individual earth stations

• Disadvantages
  – Requires standard equipment
  – Security concerns
  – FCC licenses require transmission only over US

• GENSO
Software Defined Radio

• Advantages
  – Specialized modulation schemes available
  – Enables multiple comm links on one satellite
  – Enables policy-based communication
  – Requires less dedicated hardware
  – Flexibility

• Disadvantages
  – Much longer development time
  – Not necessarily compatible with other ground stations
Phased Array Antennas

• Phased Array Antennas
  – By delaying the feed to each antenna element, constructive and destructive interference result in the ability to “steer a beam” with very fine precision, and little waste radiation in undesired directions

• Advanced Modular Incoherent Scatter Radar (AMISR)
  – NSF-sponsored installation for space weather
  – Collaborative effort, led by SRI
  – 430 to 450 MHz
Phased Array Antennas

Ground-based

- Beamforming
- Simultaneous tracking of multiple satellites
- Simultaneous tracking at multiple frequencies

AMISR Antenna Elements
Phased Array Antennas

Satellite-based

- **Inter-Satellite Links**
  - Patch antennas on multiple sides could communicate with several satellites in different locations at once
  - Either attitude determination or stabilization could allow dynamic links

- **Satellite-to-Ground Link**
  - Attitude and orbit knowledge enable beam pointing, which means less power is required
Backup Information
Information and Computing

Pioneering next-generation, disruptive technologies

- **Speech**
  - Recognition and translation
  - Natural language understanding

- **Networks and distributed computing**
  - Information security
  - Mobile and wireless communications

- **Artificial intelligence**
  - Intelligent assistance
  - Vision systems
  - Collaborative mobile robots

- **System reliability**
  - Formal methods for design and analysis
  - IC and complex system verification

- **Software systems**
  - Intelligent project planning and tracking
  - Decision aids

1964–1968: SRI’s Doug Engelbart and team invented the computer mouse and demonstrated the foundations of personal computing

Handheld, speech-based language translation
Networks and Communication

Operationally effective systems for government and commercial clients

- **Network-centric systems**
  - Intelligent planning
  - Self-configuring information flows
  - Wireless, mobile, ad hoc networks
  - Modeling and simulation of networks and communications

- **Testing and training**
  - Instrumentation for military testing and training
  - Live-virtual-constructive training systems

- **Intelligent system applications**
  - Distributed speech
  - Distributed natural language
  - Distributed robots

- **Secure networks**
Automation and Robotics
From the world’s first reasoning robot to the latest advances

• Advanced materials for automation
  – Electroactive polymer “artificial muscle”
  – RF (radio frequency) tags

• Robots
  – Inspection systems
  – Micro robots
  – Collaborative robots

• Robotics
  – Video and image understanding
  – Machine vision systems for document understanding
  – Manufacturing and materials handling

• Transport: diamagnetic levitation
  – Ultra-clean transport
  – Medical laboratory automation
Intelligence Systems

Meeting national defense and other needs from field support to end-to-end, secure information management systems

• Signal technology
  – National intelligence processing and reporting systems
  – Advanced signal processing and geolocation algorithms

• Intelligence and information systems
  – Computer tools, simulations, and networks in support of information warfare and tactical intelligence systems
  – Simulation suites for intelligence collection systems

• Communications and signal technology
  – Communications system design, development, signal processing, and testbeds
  – Advanced terrestrial and space antenna systems

• Information operations
  – Offensive and defensive
Data Collection and Measurement

State-of-the-art sensing and information processing

• Radio frequency systems
  – Radio and astronomical measurements
  – Foliage- and ground-penetrating radar
  – Over-the-horizon radar

• Intelligent pattern recognition
  – Radar
  – Multisensor

• Sensors
  – Custom wireless embedded sensors
  – Signal processing

• Environmental impact
  – Analyses
  – Planning and systems design
Energy and Environment
From basic research to pilot tests and commercialization

• Energy
  – Long-life batteries
  – Fuel cells
  – Solar cells
  – Hydrogen fuel generation, storage, and distribution

• Environment
  – Waste destruction
  – Potable water production
  – Biodegradable materials
  – Microsensors and systems
  – Noise suppression and vibration control
  – Ultrasensitive hazardous materials detection
  – Handheld biological and chemical sensors
Advanced Materials and Structures
From basic research to pilot tests and commercialization

• **Materials**
  - Nano materials
  - Polymers
  - Coatings and ceramics
  - High-temperature materials
  - OLEDs (organic light-emitting diodes)

• **Processes**
  - Catalysis
  - Analytical chemistry
  - Optical technologies

• **Microstructures**
  - Nano devices and microelectronics
  - MEMS and NEMS

• **Structural design**
  - Blast containment
  - Structural testing and failure mechanics