Overview of the Orbiting Radio Communications Asset (ORCA) Mission

Mr. Darby G. Cooper
neoStar Astronautics
2951 Marina Bay Drive, Suite 130-187
League City, Texas 77573
281-538-6048
email: dgcooper@neostar-astro.com

Mr. William J. Byrd
Iowa Space Grant Consortium
408 Town Engineering
Ames, Iowa 50011
515-294-3106
email: wbyrd@iastate.edu

Mr. Robert Sternowski
Rockwell Collins
855 35th Street NE
Cedar Rapids, Iowa 52498
319-295-5736
email: rhsterno@collins.rockwell.com

Abstract. The Orbiting Radio Communications Asset (ORCA) mission is a commercial mission being designed and built by neoStar Astronautics in cooperation with the Iowa Space Grant Consortium and Rockwell Collins. The mission will utilize advanced technology digital radio equipment provided by Rockwell to survey the low Earth orbit radio spectrum. This survey is of interest to both the commercial communications industry and to the scientific radio astronomy community. In addition to the survey, the spacecraft will provide an on-orbit transmit and receive test platform for advanced communications technologies that can be fully reprogrammed from the control station. A significant feature of the ORCA mission is the involvement of students from the Iowa Space Grant Consortium in all aspects of the mission design, development, and operations.

Mission Overview

The ORCA mission will place a small satellite in a high inclination low Earth orbit that will cover the majority of populated regions of the Earth and provide at least one year of on-orbit operations. The spacecraft will be the first in a new line of high technology small satellites developed by neoStar Astronautics. The principle payload is a digitally programmable radio transceiver developed by Rockwell Collins. This payload will allow commercial users to test and validate various communication schemes including modulation waveforms, transmit power levels, and to study the effect of various atmospheric properties on radio transmissions. This payload will also allow background noise measurements to be taken over a wide spectrum of radio frequencies. Additional scientific payloads will study the properties of the ionosphere that effect radio communications and provide a means to study lightning by observing the interaction of lightning with the ionosphere.

It is intended to launch the mission as a secondary payload. The current conceptual design is compatible with the Pegasus or Taurus launch vehicles but minor refinements would allow the spacecraft to be launched by the Ariane or Delta launch vehicles.

The mission preliminary design is scheduled to begin in late 1998 with a launch planned in 2000. Funding for the ORCA mission is currently being sought from interested members of the communications industry as well as other potential users. Funding for the scientific aspects of the mission are also being sought from government sources.

Payload Description

The unique payload design comprises the heart of the ORCA mission equipment. A dual suite of digitally programmable communications equipment supports a wide variety of communications technology, scientific experiments, sounding, radio astronomy, noise measurement, etc. Each 6U VME-packaged element of the payload is RS-422 controlled and power managed from the CPU. Experimental commands and data return are provided by the S-band TT&C link from mission control.

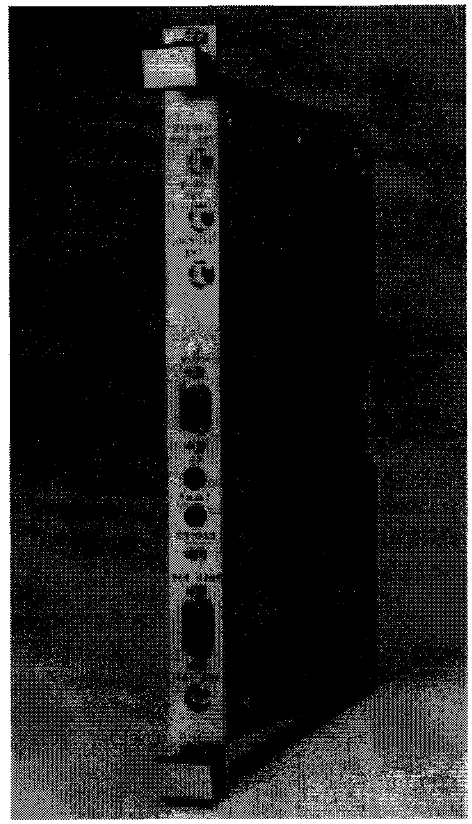

Figure 1. Rockwell Collins 95V-1 Receiver

The communications portion of the ORCA payload consists of dual transceivers matrix switched to one of three antennas. Dual GPS receivers provide precision location, time and frequency reference. The science portion of the payload includes a dedicated low frequency (<10 kHz) receiver and a particle detector.

The antenna array consists of a wideband log periodic antennas spanning 200 to 2500 MHz and a 20 meter long dipole for frequencies below 100 MHz, with transmit capability down to approximately 2 MHz. All three antennas are suitable for transmit and receive. Crosspoint matrix switching is provided by an RS-422 controlled latching relay matrix assembly.

The transceivers are modified versions of Rockwell Collins' latest direct conversion receiver (DCR) 95V-1 design. The transceiver tunes in 1 Hertz increments, contains 251 FIR bandpass filters, has a fully programmable (via uplink) triple DSP processor section, and incorporates a tracking front end preselector to minimize the risk of overload from terrestrial signals. Transmit waveforms are generated from the 95V-1's synthesizer and a Rockwell Collins wideband vector modulator integrated circuit. The vector modulator allows synthesizing virtually any on-channel waveform from quadrature DSP words.

The power amplifiers are 10 watt (average) solid-state wideband designs, capable of operating into the broadband antenna VSWR. Higher peak and burst powers are possible, limited by the bus power source. A passive matching network flattens the long dipole impedance to maximize power transfer. Solid-state transmit/receive (T/R) switches rapidly switch the antenna between receive and transmit for time-critical sounding experiments.

Dual-redundant Rockwell Collins GPS receivers with patch antennas provide precision location, time, and frequency reference for all experiments. Output is provided via RS-422 bus to the payload CPU.

Other unique features of the ORCA payload include:

- Post-processing by the payload CPU, with uplinked software
- FFT post-processing within the 95V-1 receivers and the payload CPU
- Repeater and store-and-forward modes for any waveform
- Dual receiver and dual transmitter operational modes
- Employment of the ORCA transmitters as high speed downlinks
- Reliable, commercial off-the-shelf equipment with special hardening
- Common RS-422 interfaces provide modular design

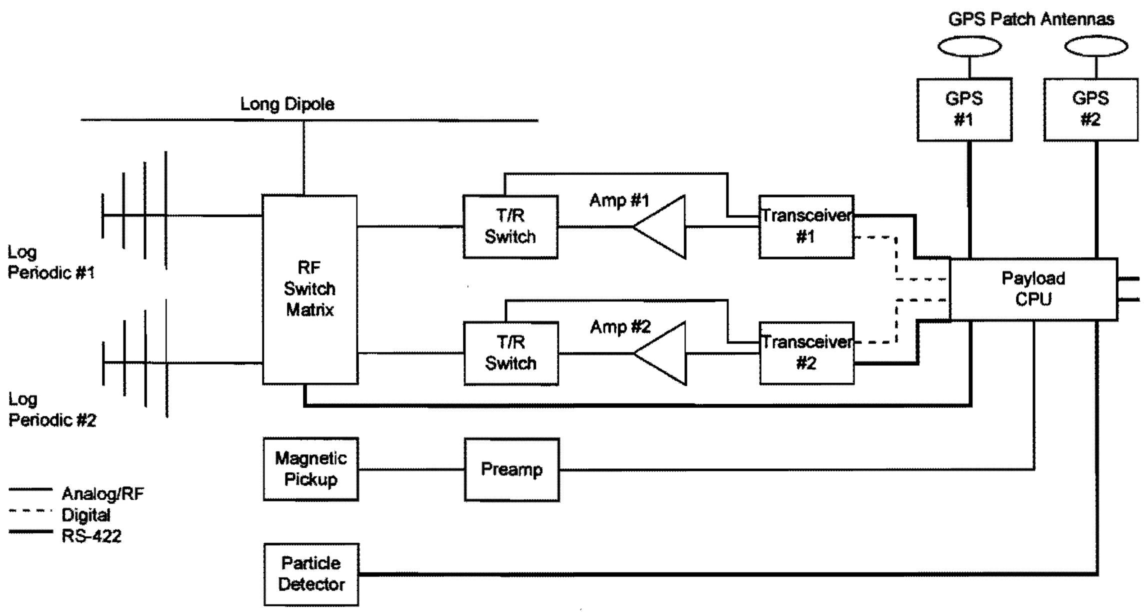

Figure 2. ORCA Payload Block Diagram

Spacecraft Description

The ORCA spacecraft has overall fundamental dimensions of 28 inches by 28 inches by 32 inches. The central body contains the spacecraft electronics and other hardware, and provides attachment locations for the primary antennas. The solar arrays are attached to the central body and will deploy to a fixed configuration once on-orbit. This configuration will provide approximately 90 W total continuous power, of which approximately 15 W will be continuously available to the payload with additional power being available by duty cycle management. Total spacecraft weight is 200 lbs.

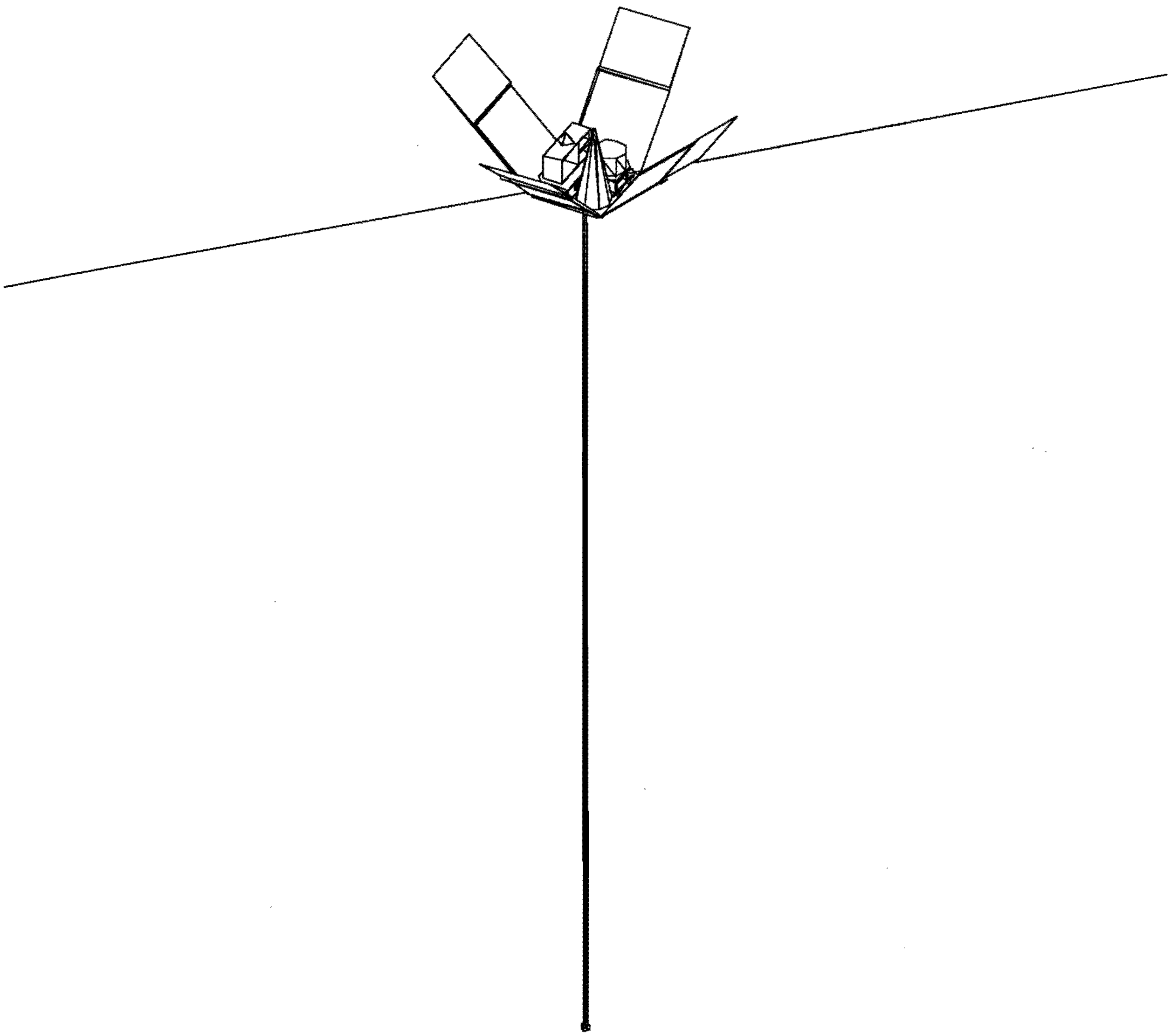

Figure 3. ORCA Spacecraft (Conceptual)

The spacecraft provides simple attitude control via gravity-gradient stabilization and magnetic torq rods. Spacecraft attitude will be measured with a space qualified 3-axis magnetometer. This will provide Earth pointing to within 10° at very low cost and with limited requirements for on-board computing and few operational requirements.

Power is generated by silicon solar arrays that are deployed to a fixed angle with respect to the spacecraft body. This provides better thermal management and allows the array area to be increased by the addition of "extensions" that increase the length of the array with respect to body mounted arrays. The deployment also allows the primary antenna to be mounted in a more compact configuration while still allowing a clear field of view once on-orbit. Again, silicon provides power generation at a low cost and the simple deployment allows increased power generation without the use of costly and complex solar tracking systems. Power storage will be based on commercial Ni-Cd cells.

Spacecraft communication with the ground is provided via the payload transceiver. Redundancy is provided by a largely off-the-shelf system utilizing transmitters, receivers, bit synchronizer, and tone decoder all from the same vendor. Space qualified antennas were also selected to provide hemispherical coverage for the critical command link. A custom based interface circuit will be required to provide interface to the spacecraft computer.

On-board processing will be provided by a commercial single-board computer operating in a PCI backplane. The selected computer is based on the PowerPC 603. The PCI backplane will support twelve serial data and command interfaces to other devices on-board the spacecraft as well as acquiring engineering telemetry. VxWorks will be used as the real-time operating system and has space flight heritage from the Mars Pathfinder lander. This provides a robust, highly flexible, and well supported development environment for the flight code that will be developed in C.

Spacecraft structure will be a straightforward design that centers on an electronics enclosure that provides 6U and 3U slots for most spacecraft electronic equipment as well as the payload. The structure provides for attachment of other equipment in a simple shelf arrangement. Aluminum construction is planned to provide for simplicity of manufacture, integration, and thermal management.

The spacecraft can be configured to be accommodated by a number of launch vehicles, but is currently configured for secondary launch on a Pegasus or Taurus launch vehicle.

Student Involvement

The Iowa Space Grant Consortium (ISGC) is part of the NASA Space Grant College and Fellowship program. Now in its ninth year, the ISGC has worked hard to build a genuine "team spirit" among its fifteen academic, industrial and outreach affiliates. Some of the ISGC projects cut across the academic lines to build strong research collaborations. One such project was the Iowa Joint Experiment in Microgravity Solidification (IJEMS). This student-built science experiment flew onboard the space shuttle in September 1995. Students from the University of Iowa and Iowa State University worked with faculty researchers from both schools and the US Department of Energy's Ames Laboratory to complete the project.

With the IJEMS project successfully completed, the ISGC has taken on a more ambitious new project with ORCA. In this case, the ISGC is serving as the prime contractor to coordinate the design, build, test, launch, and operation of the satellite. Rockwell Collins (an ISGC industrial affiliate) recognized the need for an orbiting radio laboratory. As an industry leader in communications, Rockwell is well positioned to assist in the marketing of this facility. Through the ISGC, they have become familiar with neoStar Astronautics (another ISGC industrial affiliate) and their interests and capabilities. neoStar Astronautics is beginning a new line of spacecraft and ORCA will serve as an ideal first mission. Both industrial affiliates have used ISGC students in the past through various scholarship and fellowship programs. As the ORCA project proceeds, students from all four ISGC academic institutions will be able to compete for positions on the ORCA team at neoStar Astronautics in Houston.

In addition to the student support at neoStar Astronautics during the design, build, and test phases, the operations phase will also utilize ISGC students. The concept involves development of a ground station in Iowa where students will support ORCA spacecraft operations. This capability will be made available to other spacecraft operators as a supplemental ground station. The intent is to build a self-sustaining program for students to learn first-hand about spacecraft systems and operations by actually doing the work.

Several science objectives are part of the ORCA mission as well. Science in the areas of radio astronomy, plasma waves and particle detection provide opportunities for students. The principle investigators involve two of the four ISGC academic institutions. However, students from all four universities will have the opportunity to be involved in the design and development of spacecraft instrumentation as well as data analysis.

This hands-on experience will prove beneficial for the students involved in the ORCA project. Experience with the IJEMS project demonstrated that these students are strong candidates for employment after graduation. Their success in the project will help to maintain strength in the ISGC industrial team and provide valuable support for continuing future student opportunities at these companies.

Status Summary

The conceptual mission definition was completed by neoStar Astronautics in January 1998. Further work to refine the ORCA mission is on-going by the partners. The Iowa Space Grant Consortium is working to define the scientific research goals and the student involvement in the program, as well as securing a launch. Rockwell is working to refine the payload and solicit support from other members of the communication industry. neoStar Astronautics continues to refine the spacecraft and mission components as part of its ongoing development effort for small satellites.

Current development activities are focused on demonstrating payload and spacecraft data system functionality. A prototype system has been integrated at the neoStar Astronautics facility in Houston and performance evaluations are on-going.

Author Biographies

Darby G. Cooper, ORCA program manager at neoStar Astronautics, League City, Texas. Current responsibilities include program management and research and development activities in support of small and nano satellites.

William J. Byrd, Director, Iowa Space Grant Consortium, Ames, Iowa. Current responsibilities include the oversight of the NASA Space Grant program for Iowa, including university research, K-12 education programs, and public outreach.

Robert H. Sternowski, Programs Manager Advanced Technology Programs, Rockwell International Collins Avionics & Communications Division, Cedar Rapids, Iowa. Current responsibilities include management of various research and development activities in communications technology.