

REQUEST FOR EXPERIMENTAL RADIO LICENSE(S) FOR ORCA EXPERIMENTAL COMMUNICATIONS SATELLITE PAYLOAD

Requested by Iowa Space Grant Consortium

Purpose

This experimental license is hereby requested in support of the Orbiting Radio Communications Asset, referred to hereafter as “ORCA”, a low-earth orbit experimental satellite dedicated to research and development of earth-space-earth communications in the 2 to 2500 MHz frequency range. A secondary mission is the exploration of radio physics from an orbital platform. The satellite is to be owned and operated by the Iowa Space Grant Consortium (ISCG), a non-profit consortium of universities.

Description of Spacecraft Payload

The payload consists of a pair of Rockwell Collins Inc. 95V-1 VME transceiver modules, two 10 watt wideband linear power amplifiers, and a suite of selectable dipole (low frequency, <200 MHz), monopole (>200 MHz), and log spiral (high frequency, >200 MHz) antennas. The maximum gain of the antenna suite is +6 dbi in the main 60 degree bandwidth of the high frequency log spiral antennas. The transceivers are continuously tunable across the entire 2-2500 MHz tuning range. The receive function may also be used from 0.005 to 2 MHz, but no transmit capability is possible in that range. The spacecraft will also be equipped with a standard telemetry, tracking and control (TT&C) transceiver system independent of the spacecraft. The TT&C link is used for spacecraft command and control, as well as the payload uplink and downlink. The payload may also be used as an experimental data uplink and downlink on any authorized frequency.

The key transmitter performance specifications are:

Maximum output power: +40 dbm (10 watts)

Minimum/Maximum antenna gain: -30/+6 dbi

Harmonic suppression: -37 dbc

Spurious suppression: >70 dbc

Bandwidth: Programmable from 100 Hz to 300 KHz

Modulation: AM, FM, OOK, PSK, FSK

Specific Frequency Authorization Requests

This experimental license application requests permission to operate in the following frequency bands on a non-interfering basis:

1. Amateur radio bands from 1.6 to 2300 MHz
2. Existing ISM and unlicensed frequency allocations from 6.78 to 2483 MHz
3. Existing VHF and UHF television channels 2 – 60

The requested frequencies and the calculated power levels at the earth's surface from the anticipated 500 mile altitude low-earth orbit are show in Table 1. Each class of authorization request is analyzed and described separately.

Service	Frequency MHz	Path Loss @500 Smi, DB	Satellite EIRP, DBM	Power at Surface @500 SMi, DBM	Power at Surface @500 SMi, DBuv, AF=0 db	Grade A TV Cov., DBuv	Ratio Satellite/T V, DB	Grade B TV Cov., DBuv	Ratio Satellite/T V, DB
ISM	6.78	107	33	-74	33				
ISM	13.56	113	35	-78	29				
ISM	27.12	119	37	-82	25				
ISM	40.68	123	37	-86	21				
TV Ch2	54	125	35	-90	17	68	-51	47	-30
TV Ch4	72	128	36	-92	15	68	-53	47	-32
TV Ch5	76	128	36	-92	15	68	-53	47	-32
TV Ch6	88	129	39	-90	17	68	-51	47	-30
TV Ch7	174	135	40	-95	12	71	-59	56	-44
TV Ch13	216	137	40	-97	10	71	-61	56	-46
TV Ch14	470	144	43	-101	6	74	-68	64	-58
TV Ch60	700	147	44	-103	4	74	-70	64	-60
Unlic	915	150	45	-105	2				
Unlic	2450	158	45	-113	-6				

Table 1 – Requested Frequencies and Link Power Budget

Authorization to Utilize Amateur Radio Frequency Authorizations

Permission is requested to use all amateur radio frequency authorizations below 2500 MHz. The usage of amateur frequencies will be executed in full compliance with applicable regulations, especially the following:

1. Licensed amateur operators will be in control of any transmissions utilizing the amateur bands
2. Any use of the amateur bands will be of an experimental communications research nature only

3. Every effort will be made to avoid interfering with ongoing amateur communications, in accordance with the customary use of the amateur bands, including listening from orbit to activity on the selected channel before transmitting
4. All transmissions using the amateur bands will be logged to a publicly accessible internet site
5. Emission types may include any modulation necessary to accomplish the research aims, within the frequency authorizations
6. Transmissions may include one-way earth-space or space-earth, or full-duplex “repeater” earth-space-earth or space-earth-space modes using one or two bands simultaneously

Authorization to Utilize ISM and Unlicensed Bands

Permission is requested to utilize the existing frequency authorizations for Industrial, Scientific and Medical (ISM) and unlicensed use. These allocations span HF through 2400 MHz, as shown in Table 1. Experimental transmissions utilizing the ISM and unlicensed bands will be used in accordance with the following guidelines:

1. Any interference to ORCA experimental operations from other services operating in these ranges will be considered acceptable and unavoidable; ORCA will endeavor to locate its experiments to minimize such interference
2. All transmissions using the ISM and unlicensed will be logged and available to the FCC via internet
3. Emission types may include any modulation necessary to accomplish the research aims, within the frequency authorizations
4. Transmissions may include one-way earth-space or space-earth, or full-duplex “repeater” earth-space-earth or space-earth-space modes using one or two bands simultaneously
5. Per the calculated field strengths from Table 1, we anticipate little interference to other terrestrial users in the requested bands

Authorization to Utilize Television Broadcast Bands

Permission is requested to utilize existing frequency allocations in the television broadcast service. The requested authority will utilize US television channels 2-60, assuming that channels 61-69 have been reallocated to other services during the requested term of this experimental license.

The applicant realizes and understands the extreme sensitivity of the broadcast services to interference of any type. However, the proposed experimental uses generate signal power levels at the earth’s surface that, very conservatively, are at least 30 db below the Grade B signal television level minimums. It is well-known that visible and audible interference effects are not detectable if the NTSC signal-to-interference ratio is at least

25 db, and hence in the worst case, the calculated interference will be less than the detectable level.

More specifically, the applicant proposes to utilize television channels 2-60 for experimental earth/space communications in accordance with the following conditions and limitations:

1. Channels 2-60 shall be used as deemed necessary by the experiment being conducted
2. Only the following portions of the television channel shall be used:
 - A. Lower band edge to visual carrier (0 to +1.25 MHz) but not including the visual carrier frequency, e.g., the vestigial sideband
 - B. Visual carrier to chroma subcarrier (+1.25 to +4.83 MHz), but not including the visual carrier or chroma subcarrier frequencies, e.g., the video spectrum
3. The minimum downlink power necessary for the experiment shall be used; it is anticipated that far less than the maximum power of 10 watts will be required for downlink tests, given that only locally unused channels will be used to avoid interference to the experiment.
4. Any uplink experiments conducted will utilize only locally unused channels. Risk of interference to the satellite-received signals is wholly acceptable to the applicant, and will be mitigated by a prudent choice of experimental signal types, choice of vacant channel, and ambient spectrum statistics.
6. All transmissions using the television broadcast allocations will be logged and available to the FCC via internet
7. Emission types may include any modulation necessary to accomplish the research aims, within the frequency authorizations
8. Transmissions may include one-way earth-space or space-earth, or full-duplex “repeater” earth-space-earth or space-earth-space modes using one or two bands simultaneously

Special Operating Restrictions and Limitations

The following special operating restrictions and limitations shall be applicable to all operations of the ORCA spacecraft, regardless of frequency allocation:

1. All operations are to be conducted on a non-interfering basis on the authorized frequencies only; transmit operation will cease immediately upon notification of interference, and resume only with the concurrence of the FCC
2. The orbital mechanics of the ORCA spacecraft limit the transmit time (and hence potential interference time) over any location in the world to the following recurring 10 hour pattern:

5 minutes coverage
85 minutes no coverage

10 minutes coverage
80 minutes no coverage
5 minutes coverage
415 minutes no coverage

Thus, in a 600 minute cycle, a given location is in-view of the satellite for only 20 minutes, or 3.3% of the time.

3. The spacecraft batteries can support full power transmit (10 watts) for approximately 10 minutes, requiring 3 orbits (270 minutes) for full recharge from a depleted state. Thus a payload failure cannot place the transmitter into a “runaway” condition without first causing failure of the power system.
4. All transmissions will be logged, including frequency, emission, power, antenna, start and stop times/dates, and spacecraft GPS location.
5. Transmitters will be locked to a GPS frequency reference, used for the tunable synthesizer reference.
6. An independent onboard frequency counter will be used to verify that the transmitted frequency matches the selected frequency; mismatch will cause immediate transmitter shutdown and an alarm to the ground control station.
7. Absolute payload control is maintained via the independent TT&C link; the payload may be disabled at any time via the TT&C link
8. Uplink instructions for the transmitter are encrypted using PGP to prevent unauthorized commandeering of the transmitter
9. Transmissions may only be made using a script uploaded from the ground control station, and verified as authentic
10. It is anticipated that most of the on-orbit time will be spent in the receive mode, with only occasional transmissions (< 1% transmission time)

Spacecraft Status

The ORCA spacecraft is currently in the preliminary design phase, as is the payload equipment. The payload will consist primarily of commercial-off-the-shelf (COTS) equipment with selective radiation hardening of critical circuits/components.

Term of License

The ORCA spacecraft is anticipated to be launched in September, 2002. A minimum on orbit life of 1 year is planned, with up to three years possible. Hence a three year experimental license is requested, beginning 1 September 2002.

However, due to the complex schedule uncertainties of financing, designing, building and launching a satellite, license grant is requested immediately for the three year term beginning in 2002.