C-C RIDER REVISITED

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C-C Rider – The Basic Concept

- Single-band, In-band Transponder
  - Uplink: 5650-5670 MHz
  - Downlink: 5830-5850 MHz
- Wide Bandwidth Available
  - Up to 20 MHz
- Uplink & Downlink Share One Antenna

About the C-C Rider name:

- C-Band to C-band package to RIDE on future satellites
- A famous Blues song written by Ma Rainey in the 1920's

CC-Rider – The Concept

- Develop user ground-based hardware in parallel with the Spacecraft
- Last year's paper presented a number of options: LEO vs HEO, dish vs phased array, bent-pipe vs regenerator, etc.
- This year we focus on the concept for AMSAT's next project: EAGLE

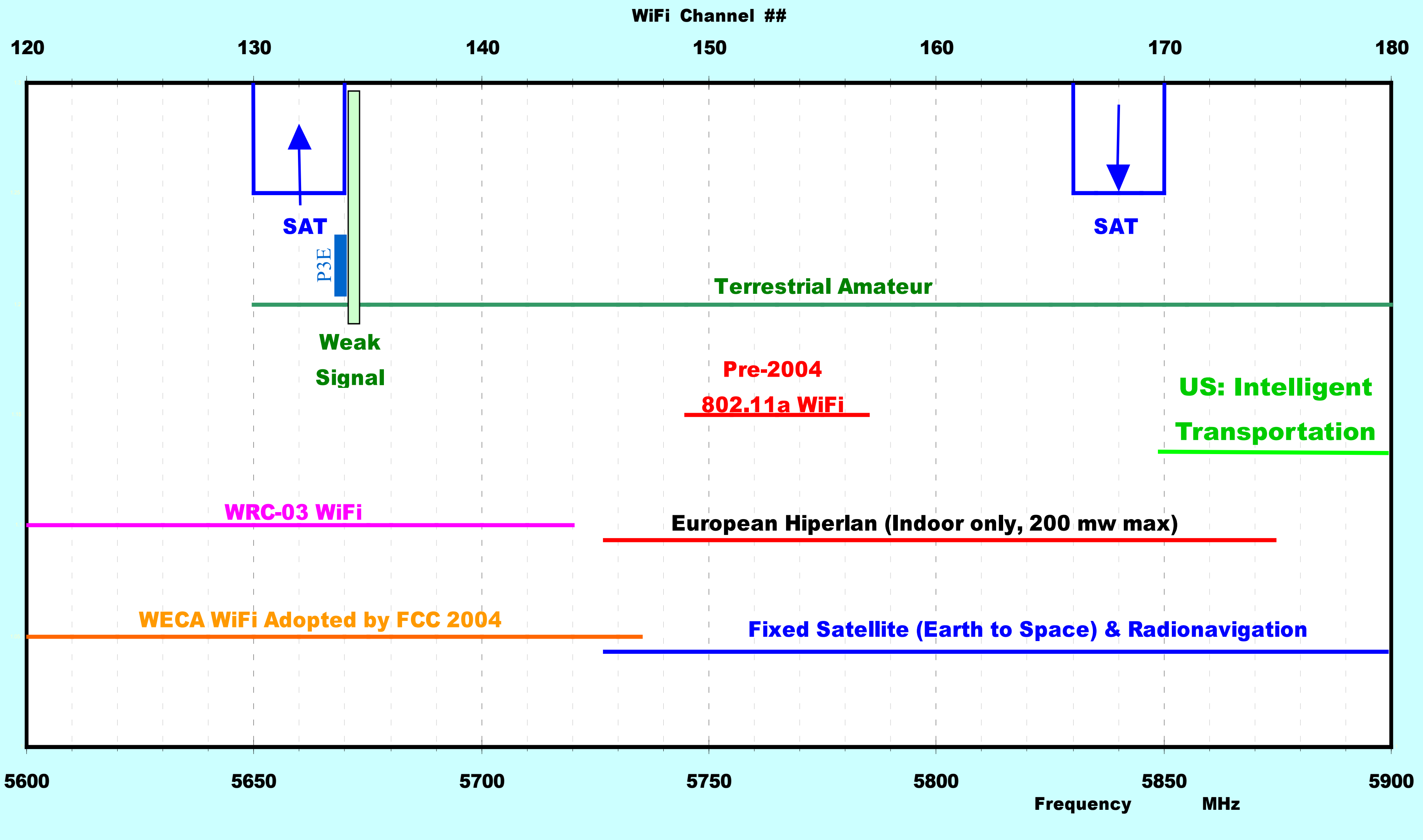
United States Microwave Allocations

Amateur Service		Amateur-Satellite Service	
Band (MHz)	**Bandwidth (MHz)**	**Band (MHz)**	**Bandwidth (MHz)**
1240-1300	60	**1260-1270 ↑**	**10**
2300-2310 2390-2450	10 60	**-** **2400-2450**	**-** **50**
3300-3500	200	**3400-3410**	**10**
5650-5925	275	**5650-5670 ↑** **5830-5850 ↓**	**20** **20**
10000-10500	500	**10450-10500**	**50**
24000-24250	250	**24000-24050**	**50**

↑ means Earth-to-Space (uplink) direction only
↓ means Space-to-Earth (downlink)direction only

(Thanks to W4RI for table)

An Expanded Look at the C-Band (5.6 – 5.9 GHz) Microwave Picture



Why C-Band?

- If we don’t use it, we will lose it !!!
  - This region of the spectrum is under **INTENSE** scrutiny by the commercial world.
- It is the lowest frequency band that can support wide bandwidth links.
  - Digital Voice, Video, Multimedia, ???
- The paired Uplink and Downlink frequencies are a truly unique resource.
- Amateurs need the challenge to develop new technology and not grow stagnant.

etcetera

How bad will 802.11a QRM be? (1)

- **The 802.11a users overlay the UPLINK band. Therefore we need to look at the noise level as seen from space.**
- **WiFi uses CDMA techniques with a maximum throughput of 54 Mb/sec (just like 802.11g on 2.4 GHz).**
- **The total bandwidth available to WiFi is 550 MHz (5150-5350 MHz and 5450-5800 MHz – the 5350-5450 MHz chunk is reserved for Radio Navigation).**

How bad will 802.11a QRM be? (2)

- Assume that WiFi users fill their allocation uniformly. The signals from the many users will be non-coherent, like wide-band noise.
- The population of the USA = 294 million, and Canada = 32 million. Assume one C-band xmtr per person, operating 16 hours/day.
- This would mean that at any time there might be ~ 217,000,000 transmitters on the air.

How bad will 802.11a QRM be? (3)

- **802.11a transmitters have low gain indoor antennas. Assume that each transmitter emits 1 mW EIRP (outside the building).**
- **217 million transmitters will look like a 217 kW transmitter spread over 550 MHz, equivalent to**

$$\frac{(217 \bullet 10^6 \text{ xmtrs}) \bullet (1 \text{ mW/xmtr})}{(550 \text{ MHz})}$$

$$= 0.39 \text{ mW/Hz radiated}$$

Errata – On Pg.92 in the Proceedings, the 316 transmitter number is a typo – it should read 217. Sorry !!

How bad will 802.11a QRM be? (4)

- Path loss from the earth to HEO @ 40,000 km distance = -196 dB.
- And assume spacecraft antenna gain of +19 dB

$\therefore$ Net loss = -177 dB = a factor of $2 \bullet 10^{-18}$.

- Combining all these numbers the spacecraft might see

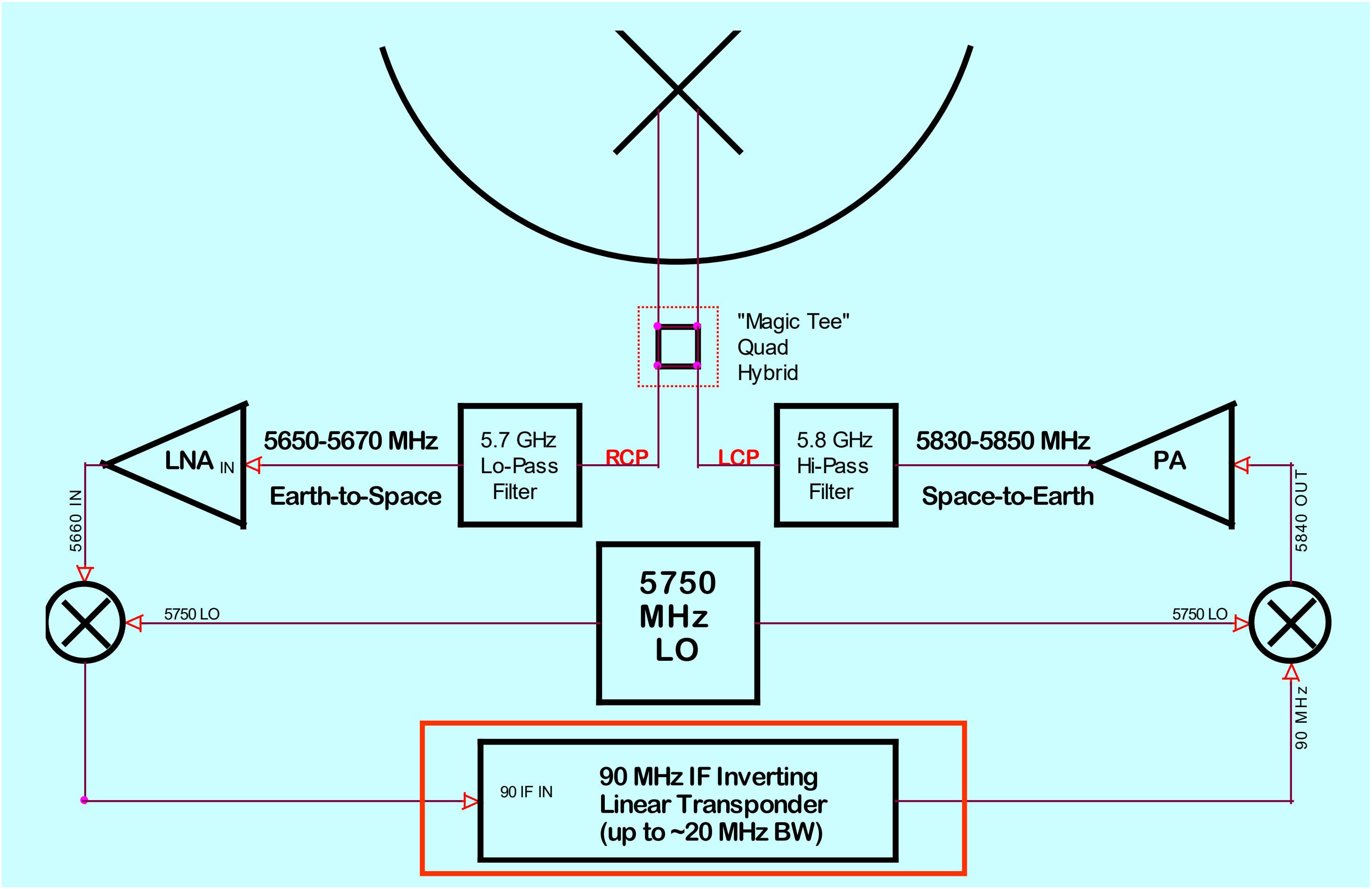
$(0.39 \text{ mW/Hz}) \bullet (2 \bullet 10^{-18} \text{ Loss}) = 7.8 \bullet 10^{-22} \text{ Watts/Hz}$

- Which is equivalent to an added noise contribution of

$$T_{802.11} = (7.8 \bullet 10^{-22} \text{ Watts/Hz})/k = 57\ {}^{o}\text{K}$$

where k = Boltzman's constant = $1.38 \bullet 10^{-23}$ W/Hz/ ºK.

Last Year's Basic Concept

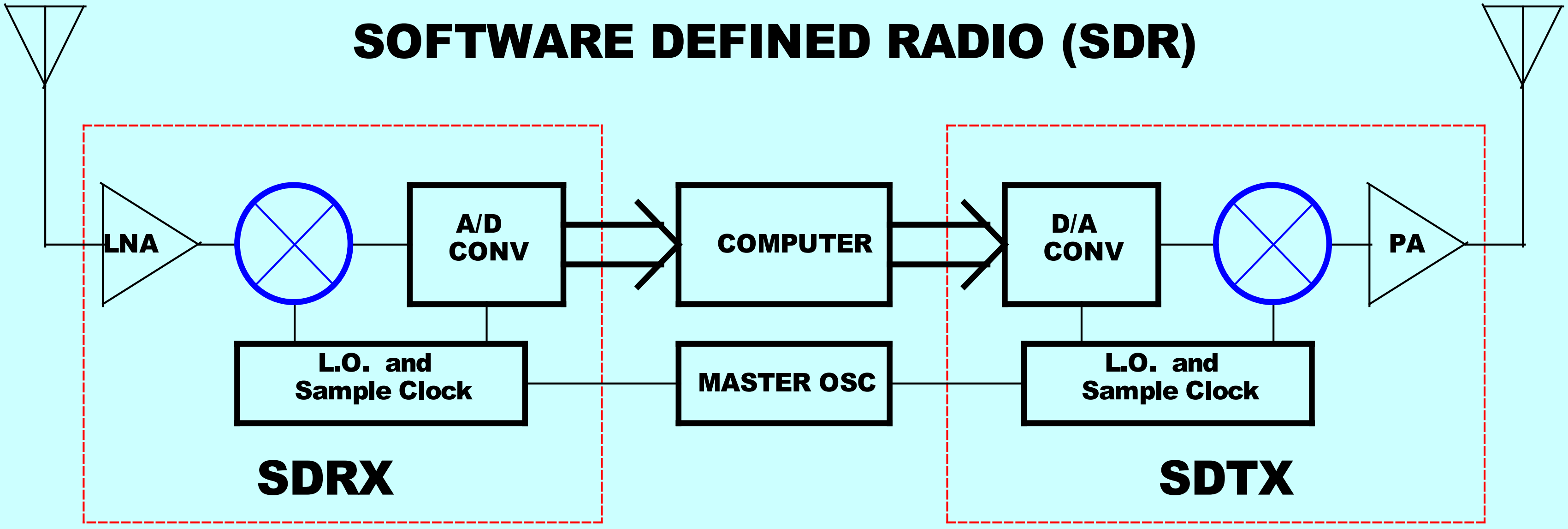


The Red IF Box might be digital

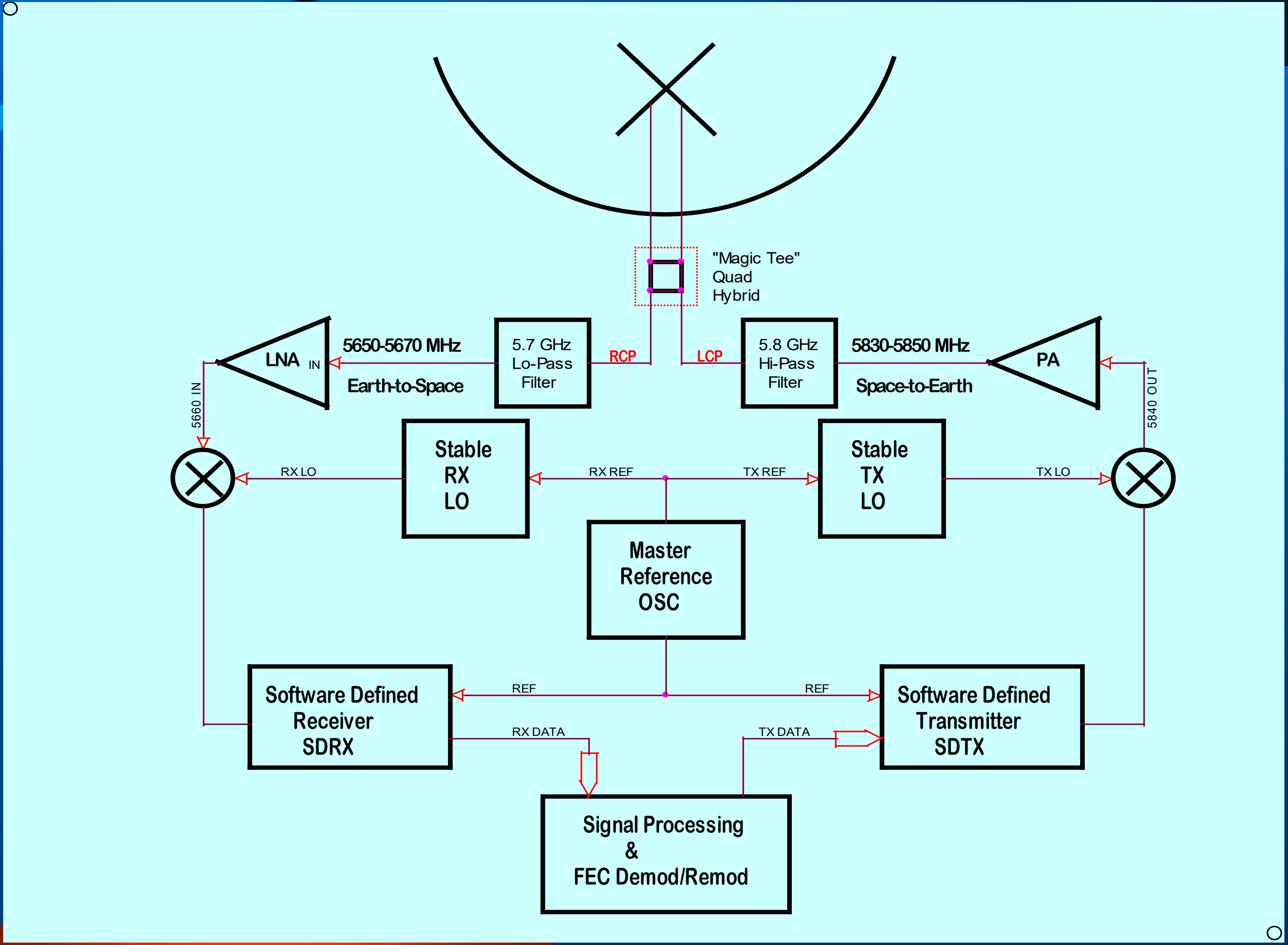
- Digital Signals
- Coding
- Error Correction
- Multiple User Access

A Breakthrough New Transponder Idea:

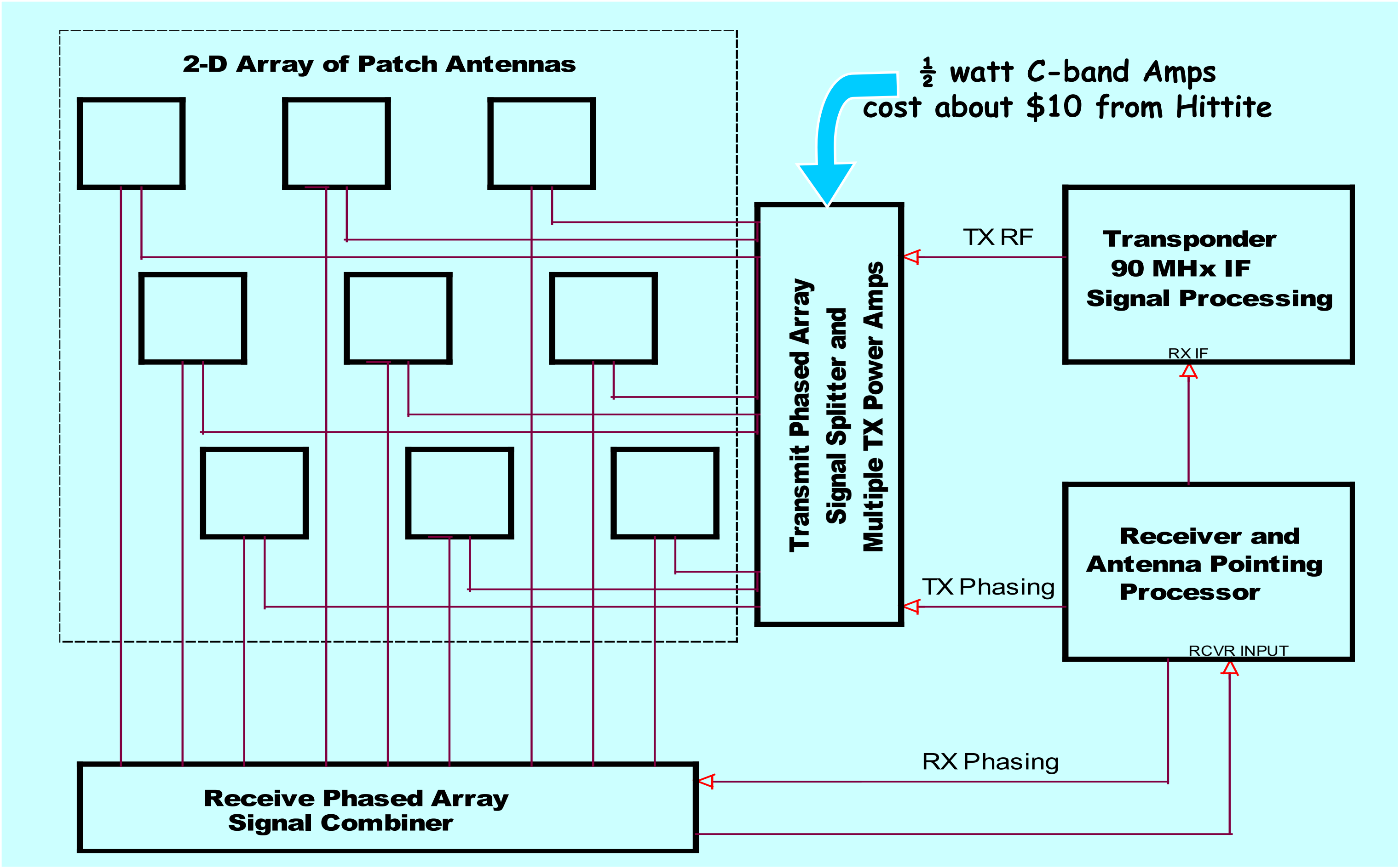
The Software Defined Transponder !



Resulting in a CC-Rider like this:

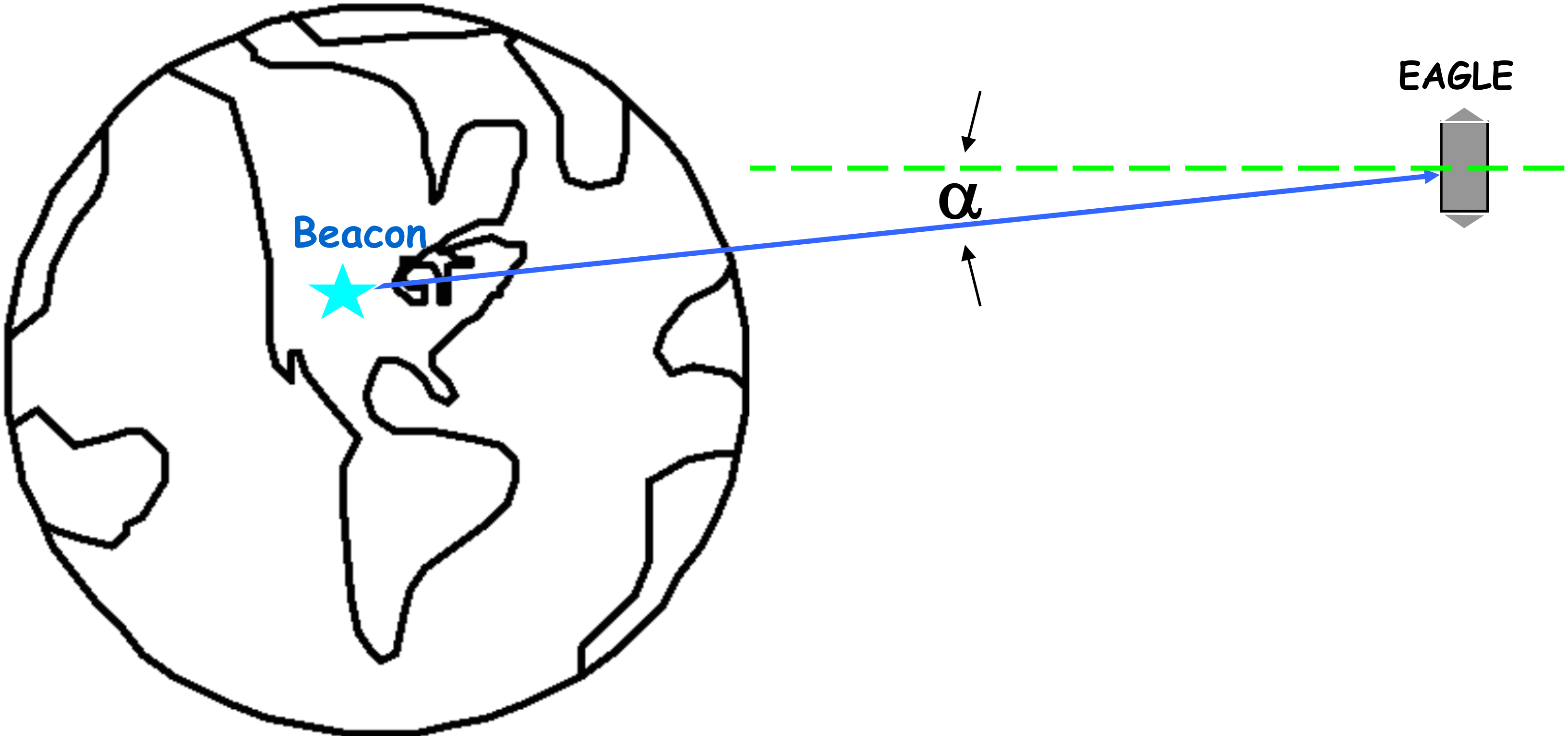


Last year we suggested a Phased Array instead of a Dish Antenna:

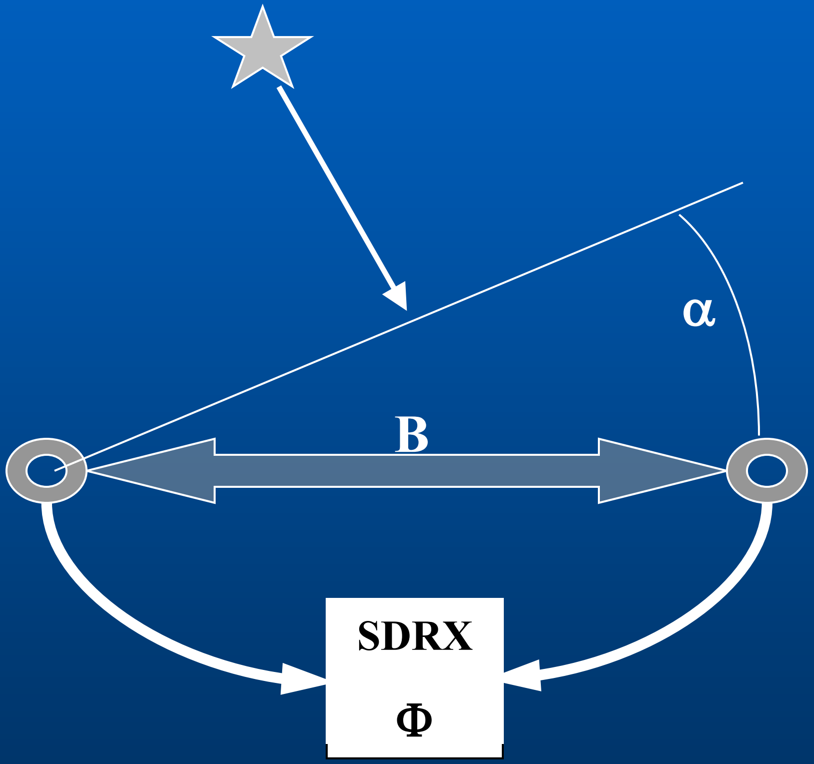


Pointing data from the multi-channel receiver is used to point the transmitter.

Pointing the Antenna

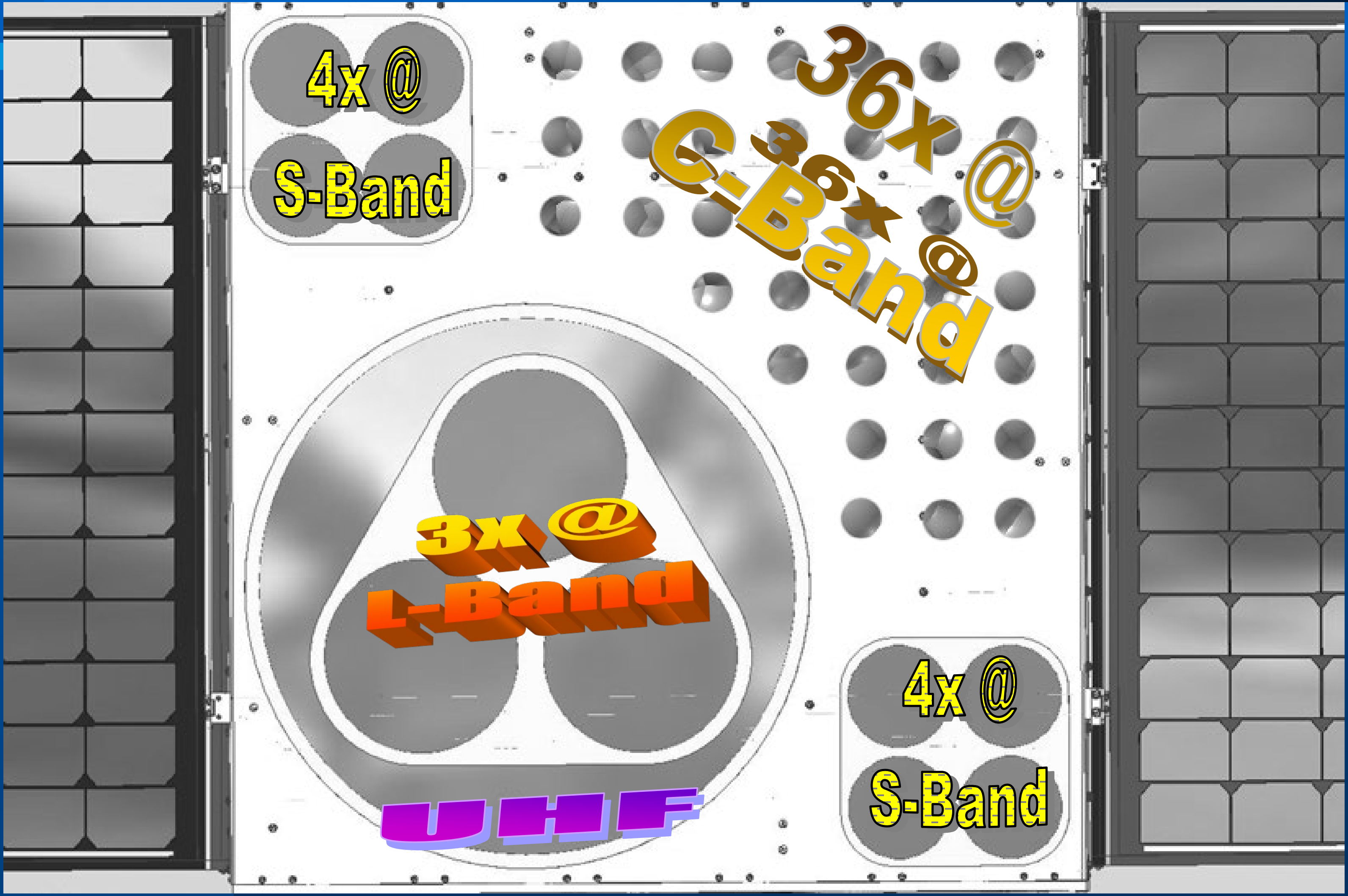


Measuring α with an Interferometer



Interferometer Phase $\Phi = 2\pi B/\lambda \bullet \cos(\alpha)$

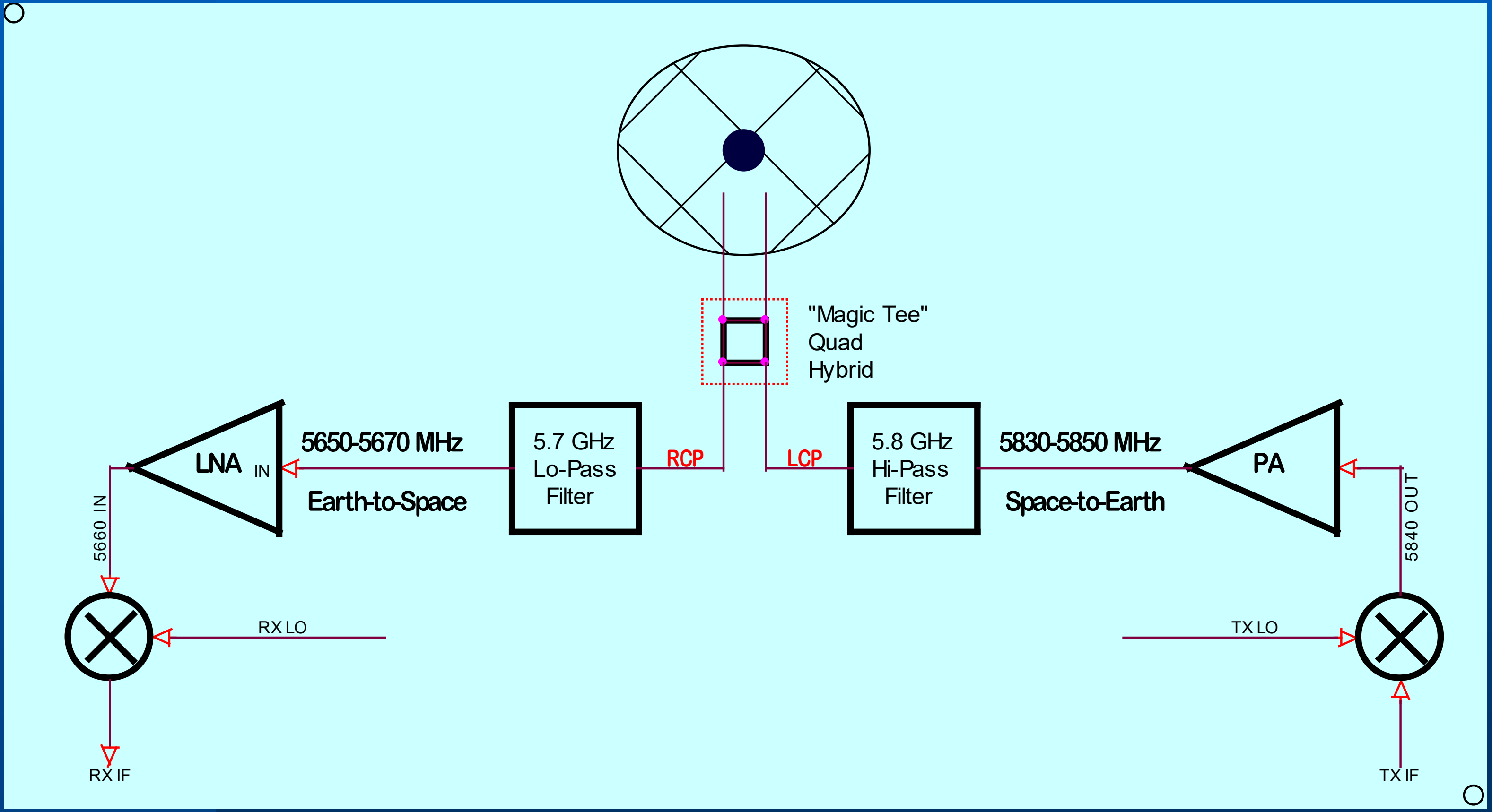
Possible EAGLE Antenna Farm
with CC-Rider Patch Array



36 Patches @ C-Band:

- Gain per patch ~4 dB + Array gain up to ~16 dB
  = ~ 20 dB.
- Beam can be steered ≈ ±45º off axis, even with spinning spacecraft.
- Each patch is active: Diplexer + Filters + LNA + Power Amplifier.
- Failure of a few elements is not fatal.
- Beam could be shaped to match user community.
- The same building blocks could be supplied as a kit for users to build their own stations.

A Small Patch Antenna



Uplink Link Budgets

- **Estimated Noise Environment @ Spacecraft:**

Sky Noise	3 ºK
LNA	40 º K
Antennas and Feedlines	50 º K
802.11a QRM Level	< 57 º K
Transmitter Leakage (est.)	400 º K
Total (est.)	550º K

- **One-way path loss = -196 dB to 40,000 km**
- **User total TX = 30W with +20 dBiC antenna**
- **User's S/N = +12 dB in 100 kHz bandwidth**
- **With FEC, this ⇒ 10-20 user channels supporting many QSOs and roundtables.**

Uplink Limitations

- **Uplink Performance is likely to be limited by three factors:**
  1. **XMTR noise leaking into the RCVR 180 MHz away.**
  2. **The ability to generate significant power on the ground.**
  3. **User antenna gain.**

On the Downlink Side

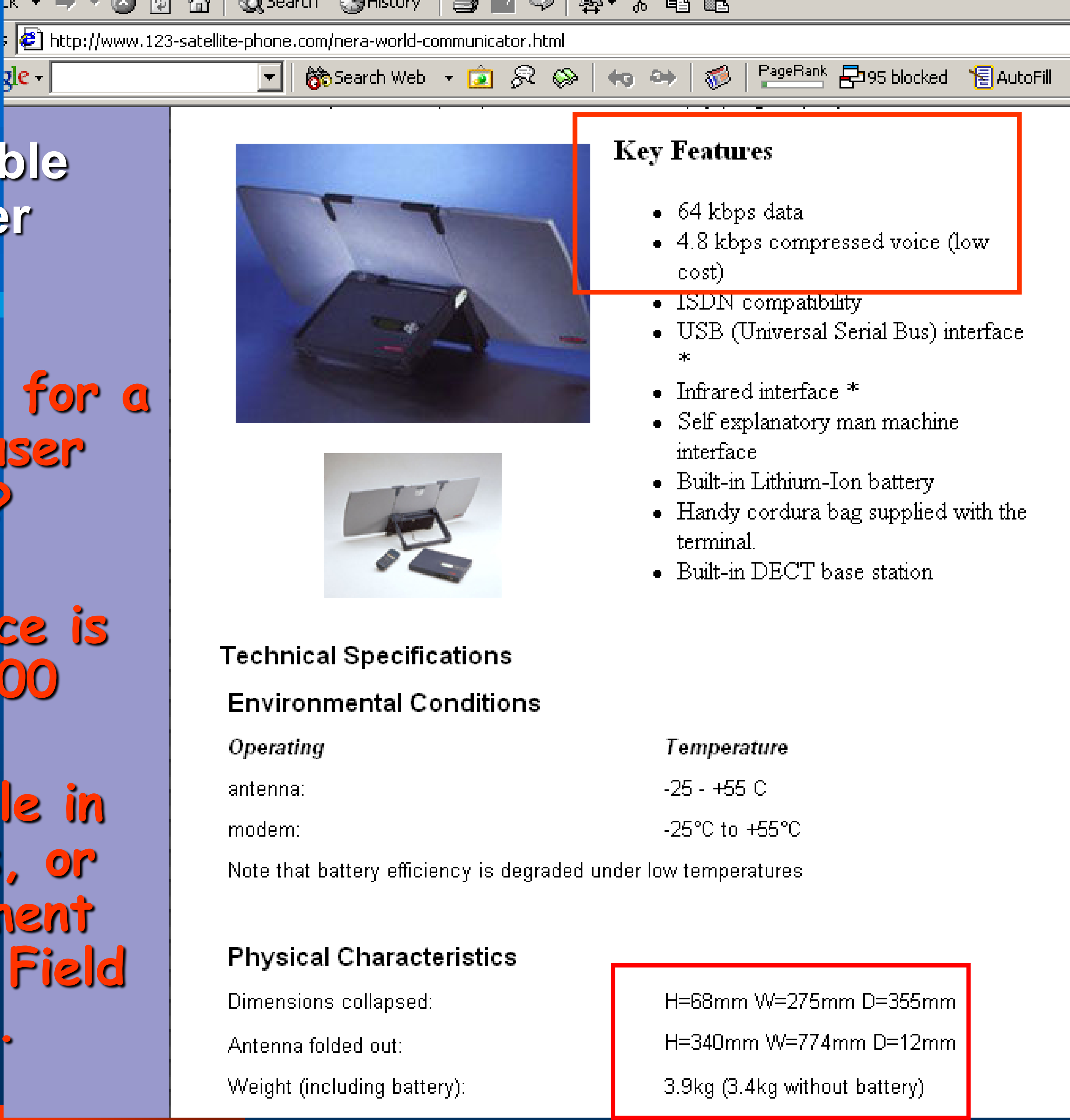
- **Phased array = 20 dBiC gain + ~30 watt Xmtr + 196 dB path loss is likely to be the same as on the uplink.**
- **BUT!! – the system is likely to use time-slotted TDMA, so the user's XMTR generates power only during its own time slot – i.e. it will be a half-duplex system.**
- **Therefore the ~400 ºK XMTR noise will not clobber the receiver and the downlink will be about 10 dB better than the uplink!**

- A typical portable INMARSAT user terminal:

A possible model for a C-C Rider user terminal?

Commercial Price is under $5000

Would be usable in Emergencies, or from apartment balconies, or Field Day, etc.



Key Features

- 64 kbps data
- 4.8 kbps compressed voice (low cost)
- ISDN compatibility
- USB (Universal Serial Bus) interface *
- Infrared interface *
- Self explanatory man machine interface
- Built-in Lithium-Ion battery
- Handy cordura bag supplied with the terminal.
- Built-in DECT base station

Technical Specifications

Environmental Conditions

Operating	*Temperature*
antenna:	-25 - +55 C
modem:	-25°C to +55°C

Note that battery efficiency is degraded under low temperatures

Physical Characteristics

Dimensions collapsed:	H=68mm W=275mm D=355mm
Antenna folded out:	H=340mm W=774mm D=12mm
Weight (including battery):	3.9kg (3.4kg without battery)

Some Remaining Technical Questions

- **Can we really cram a one-watt C-Band PA, patch antenna, circular polarization combiner, bandpass filters and LNA into the 50 mm (~2 inch) space?**
- **What DC-to-RF power efficiency will we able to achieve? How do we get rid of the heat that doesn't make its way into RF energy?**
- **How quiet will the TX be in the RX band? Link performance is critically dependent on this.**
- **How much will these modules weigh? Will they upset the spacecraft's 3-axis moment of inertia that allows the satellite to spin smoothly?**
- **The design of the multi-channel SDRX and SDTX will be challenging! How much computing horsepower is needed? What's the mix between general purpose CPUs vs. DSP CPUs vs. Programmable Gate Arrays?**

Some more issues

- What communication protocols will we use (Time slotted TDMA? CDMA? FDMA? ???)? What is the ratio of Error Correction bits to Data Bits?
- How much does all this weigh? How much power is needed? What temperature range can be tolerated by the hardware?

- AND OF COURSE -- How do raise enough money to fund the development of the payload, the EAGLE satellite and the launch? Can we find (and afford) a suitable launch?

The way for you to become involved is to volunteer.
AMSAT is an Equal Opportunity Exploiter!