

A satellite-style map of South America is visible in the background, showing the continent's outline and some internal details like coastlines and major cities. The map is rendered in shades of blue and white against a dark background.

Wireless Technologies in Mérida, Venezuela

Abdus Salam ICTP

Emerging Radio Technologies for ICT:

Projects that have worked

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Ermanno Pietrosevoli

Latin American Networking School

www.eslared.org.ve

Universidad de los Andes

Mérida- Venezuela

ermanno@ula.ve

Agenda

- Motivation
- Wireless Computer Networks
- Broadband Licensed Wireless Venezuela
- Unlicensed 2.4 GHz Networks in Mérida: RedUla and Fundacite
- Point to Point 5.8 GHz
- Mesh Networks

Motivation

- The university buildings at Universidad de los Andes are dispersed all over the town
- In 1991, ULA had 40000 students, a computer center, but no network
- Strong need to improve the communications both inside the university and to the outside world
- The only fiber optic deployed in the country was in a few basic industries

Background

- Very limited resources, both financial and human
- 700 km by mountain road to the capital
- Telephone communication out of Mérida by terrestrial analog microwave only
- Low teledensity, no cell phones

Background

- Faced with the need to deploy a computer network, we concluded that despite our big technical hurdles the main obstacle was the lack of trained people
- Established a pilot computer network with two LANs connected by modems
- Started training a group of enthusiastic students in Unix, TCP/IP, and basic networking techniques
- Realized that we did not have the means to provide advanced training

Background

- The International Centre for Theoretical Physics in Trieste organized in 1990 the First International School on Computer Networks, which was attended by a member of our group
- Upon his return Prof. Luis Nunez suggested that we did something similar in our institution, counting on the fact that the need of training in the whole region would help us getting outside resources

Background

- We decided that I would dedicate my upcoming Sabbatical Leave to prepare the Latin American Networking School, Escuela Latinoamericana de Redes, EsLaRed'92
- The time I was going to spend at Bellcore in New Jersey was cut short to make room for a stint at SuraNet in College Park, Maryland, working with Dr. Glenn Ricart and then moving to the ICTP to work on the preparation of the Second Computer Networks School, held in 1992

Background

- With this experience, and the contacts acquired we organized EsLaRed'92 during 3 weeks in November 1992
- 45 participants from 10 countries were trained in hands-on techniques in computer networks by 15 Instructors from Europe and the Americas
- The Organization of American States provided the seminal financial support through Saul Hahn's Red Hemisférica Universitaria, which prompted several other institutions to chip-in.

Background

- The infrastructure prepared for EsLaRed'92 left us with an improved network, connected to the Internet by an UUCP phone call made daily to Caracas, and a group of well trained people
- The participants suggested that we made EsLaRed a biannual event, with Mérida as the permanent venue, thanks to its favorable environment
- One of the techniques covered in our lab sessions was wireless data transmission, of paramount importance in places with low teledensity and difficult terrain

Wireless Computer Networks

- Packet Radio in HF, VHF and UHF
 - Low speed (up to 56 kbps),
 - Good range (up to 400 km)
- Spread Spectrum transmission in the ISM bands (915, 2400 and 5800 MHz)
 - Speed up to 54 Mbps
 - Ranges of up to 65 km

Wireless Computer Networks

The university network, RedUla, made good use of these technologies and in 1995 during a visit to ICTP I proposed this solution to the communication needs of the university of ILE-IFE in Nigeria. The Computer Center LAN there was thus connected by 915 MHz Spread Spectrum links to the Physical Sciences building and the Technology building

Evolution

- We were not able to held EsLaRed in 1994, but we managed to organize it in 1995, 1997, 1999, 2001 and 2003
- Our training efforts where recognized by the Internet Society, that had been holding training workshops in English since 1992, later augmented with a French version

Latin American Training Workshop

- ISOC sponsored WALC'98 in Rio de Janeiro, with local support provided by the Universidade Federal de Rio, where the Spanish and Portuguese training was organized by EsLaRed
- WALC'99 merged with EsLaRed'99 in Mérida
- WALC'2000 was held at Universidad Autónoma in Mexico City
- WALC'2001 merged with EsLaRed'2001 in Mérida



Latin American Training Workshop

- WALC'2002 was held in Santo Domingo, Dominican Republic
- WALC'2003 merged with 6th EsLaRed in Mérida from October 20 to 24
- On January 2004 the UNESCO-ULA-Cisco computer networking chair was inaugurated with EsLaRed in charge of training activities

RedUla

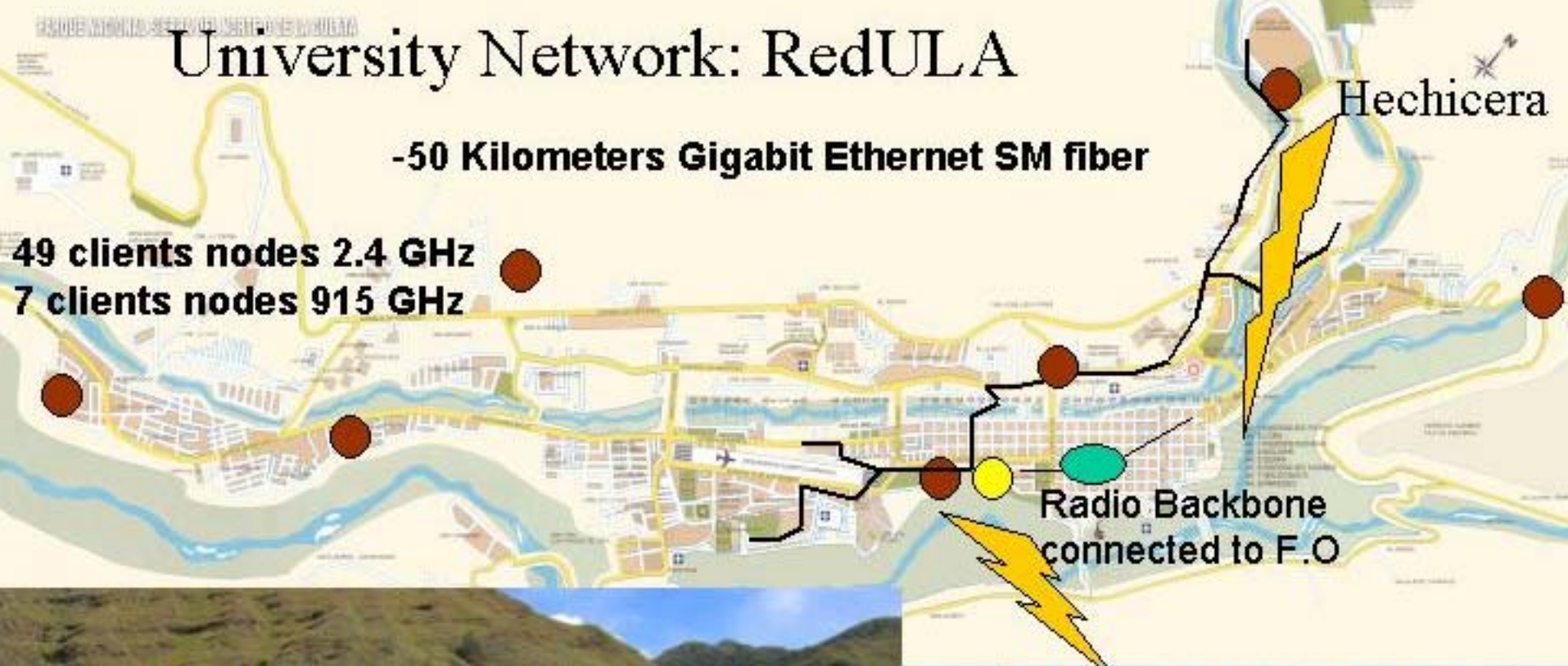
Meanwhile, the momentum gathered by the training activities helped securing resources for our university network that led us to:

- Establishing the first Fiber Optic links with multimode fiber in 1992
- Installing a Satellite connection to the Internet
- Building the first monomode Fiber WAN that spans our city with a 100 Mbps TDM
- Deploying the first ATM network in an academic institution in Venezuela
- Installing Gigabit Ethernet over 50 km of SM fiber

University Network: RedULA

-50 Kilometers Gigabit Ethernet SM fiber

49 clients nodes 2.4 GHz
7 clients nodes 915 MHz



Hechicera

Radio Backbone
connected to F.O

Hechicera



Redula, Base Station La Aguada



RETIEM

- Our efforts to wire the city were joined by Fundacite Mérida, a government organization that provided support for a wireless network to span the state of Mérida
- The first links used packet radio techniques at 19.2 kbps, but the advent of the web made mandatory the quest for faster technologies
- We thus deployed a spread spectrum network at 2.4 GHz, installing a base station in a 3450 m mountain overlooking the city and surrounding

RETIEM

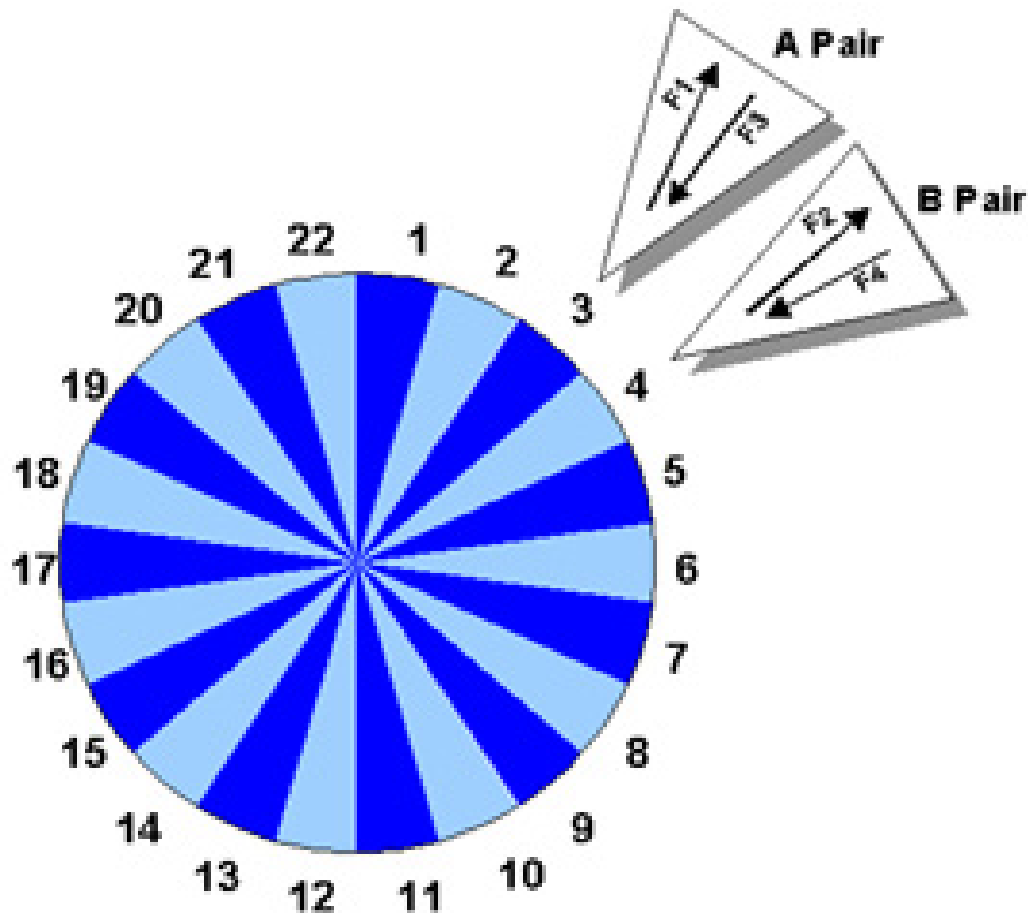
While looking at the alternatives for building a robust wireless backbone, in July 1997 I visited a small startup, Spike Technologies, that had an experimental broadband network in Nashua, New Hampshire. By using MMDS frequencies, they were able to provide full duplex 10 Mps on a pair of 6 MHz wide channels. But the real innovation was a special patented base station multiselector antenna that allows for up to 24 sectors with only 3 frequencies pairs. A deal was arranged to install a base station in Mérida and a 90 km broadband backbone to reach the town of Tovar

Broadband Delivery System

- Sectored antenna
- Frequency Reusability
- Long Range, 50 km
- High Throughput, 10 Mbit/s, Full Duplex
- Upgradable
- Standards based

Broadband Delivery System

THE SECTORED APPROACH



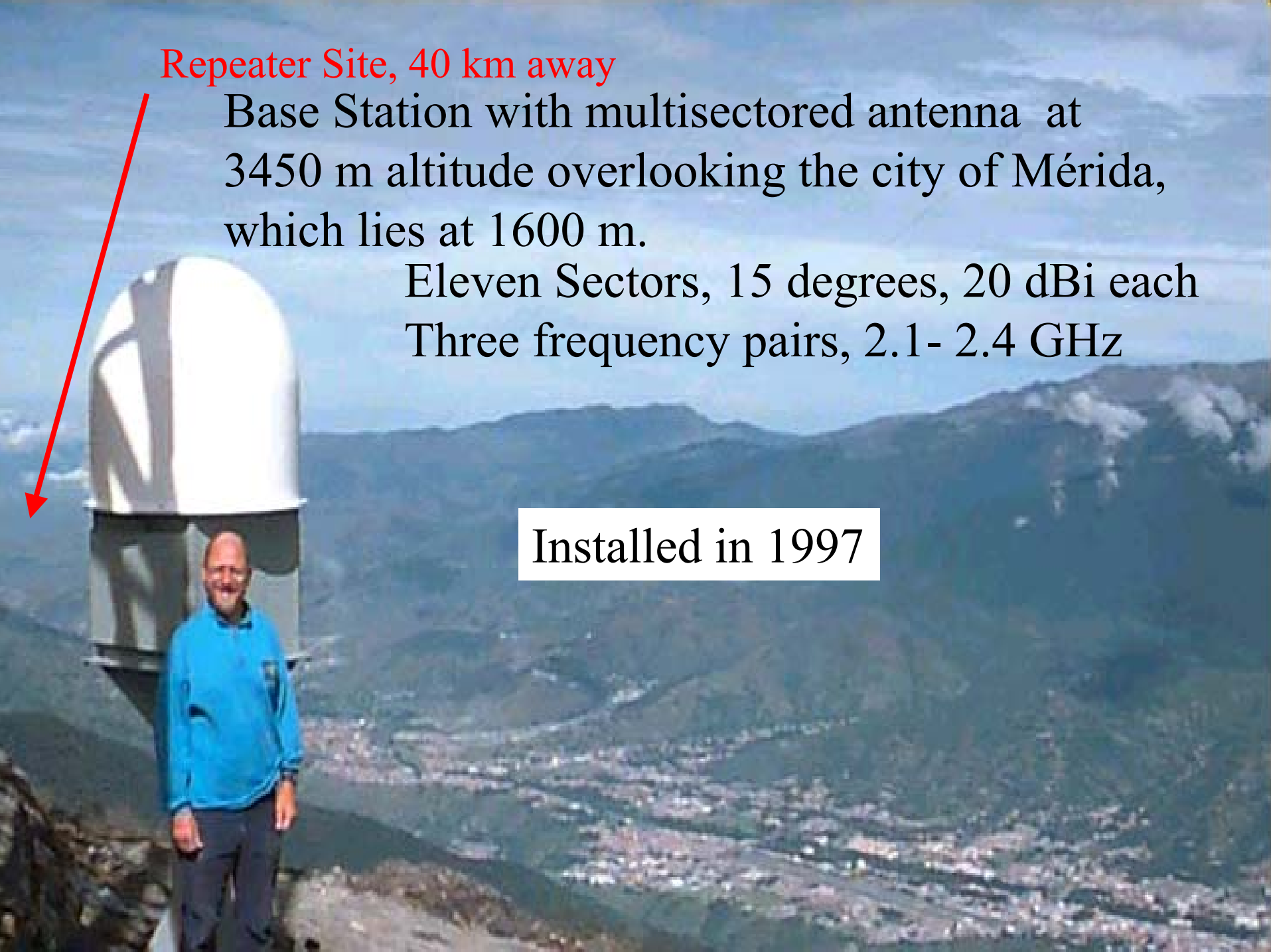
- PRIZM BDS utilizes a patented, sectored single aperture that allows spectral reuse of two channel pairs
- Spectral efficiency of this model results in a ratio of 11:1

Repeater Site, 40 km away

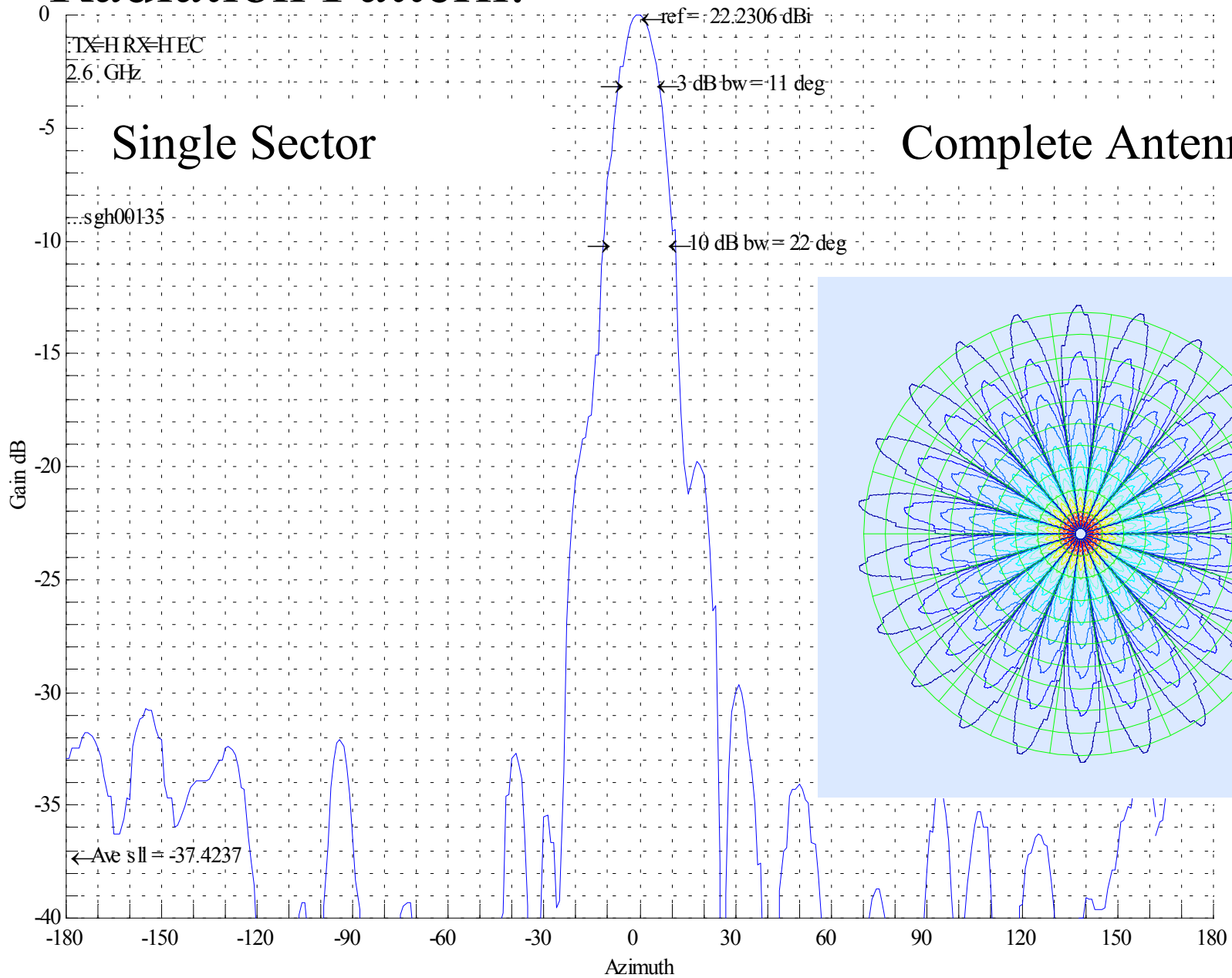
Base Station with multisector antenna at 3450 m altitude overlooking the city of Mérida, which lies at 1600 m.

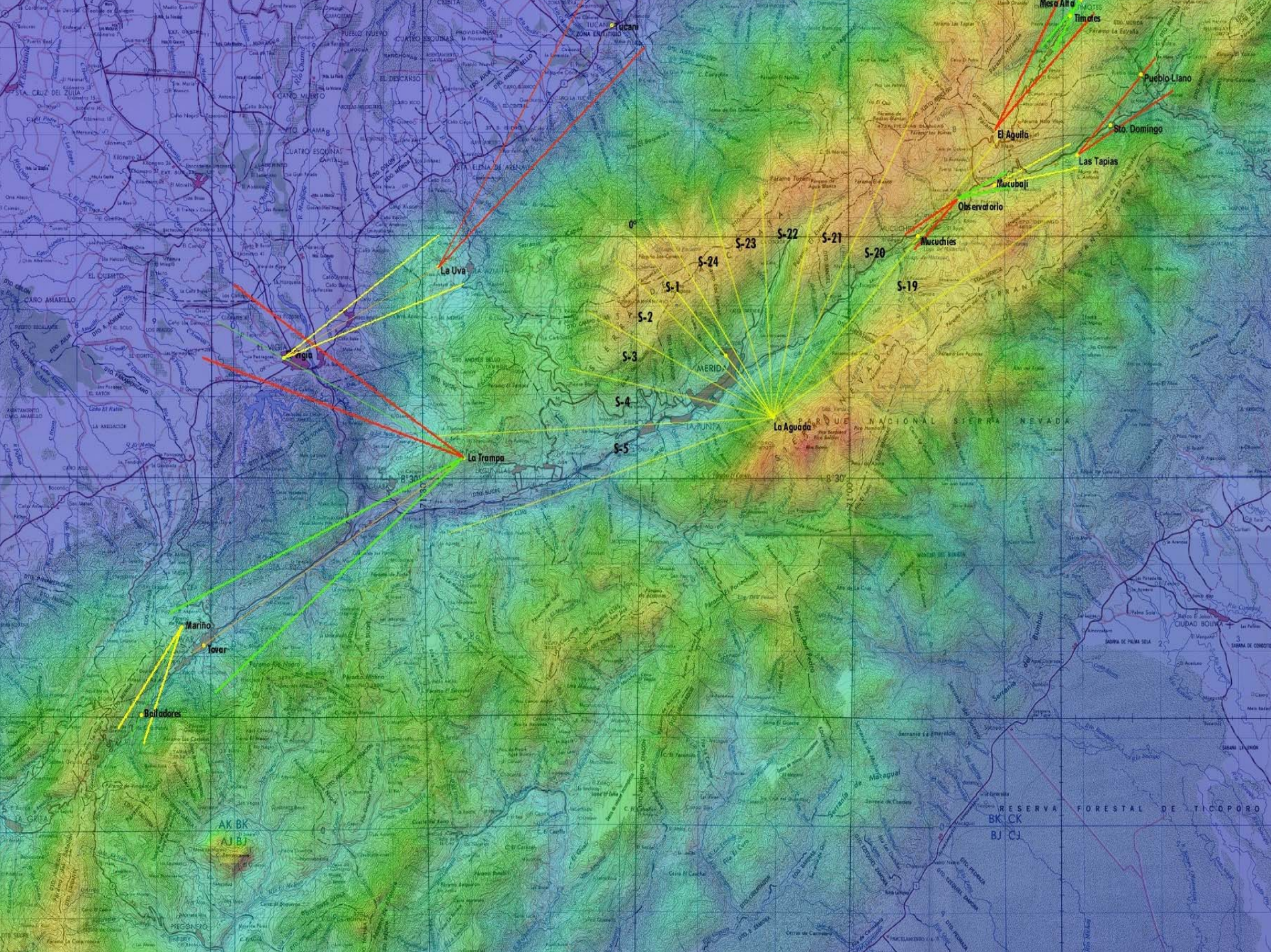
Eleven Sectors, 15 degrees, 20 dBi each
Three frequency pairs, 2.1- 2.4 GHz

Installed in 1997

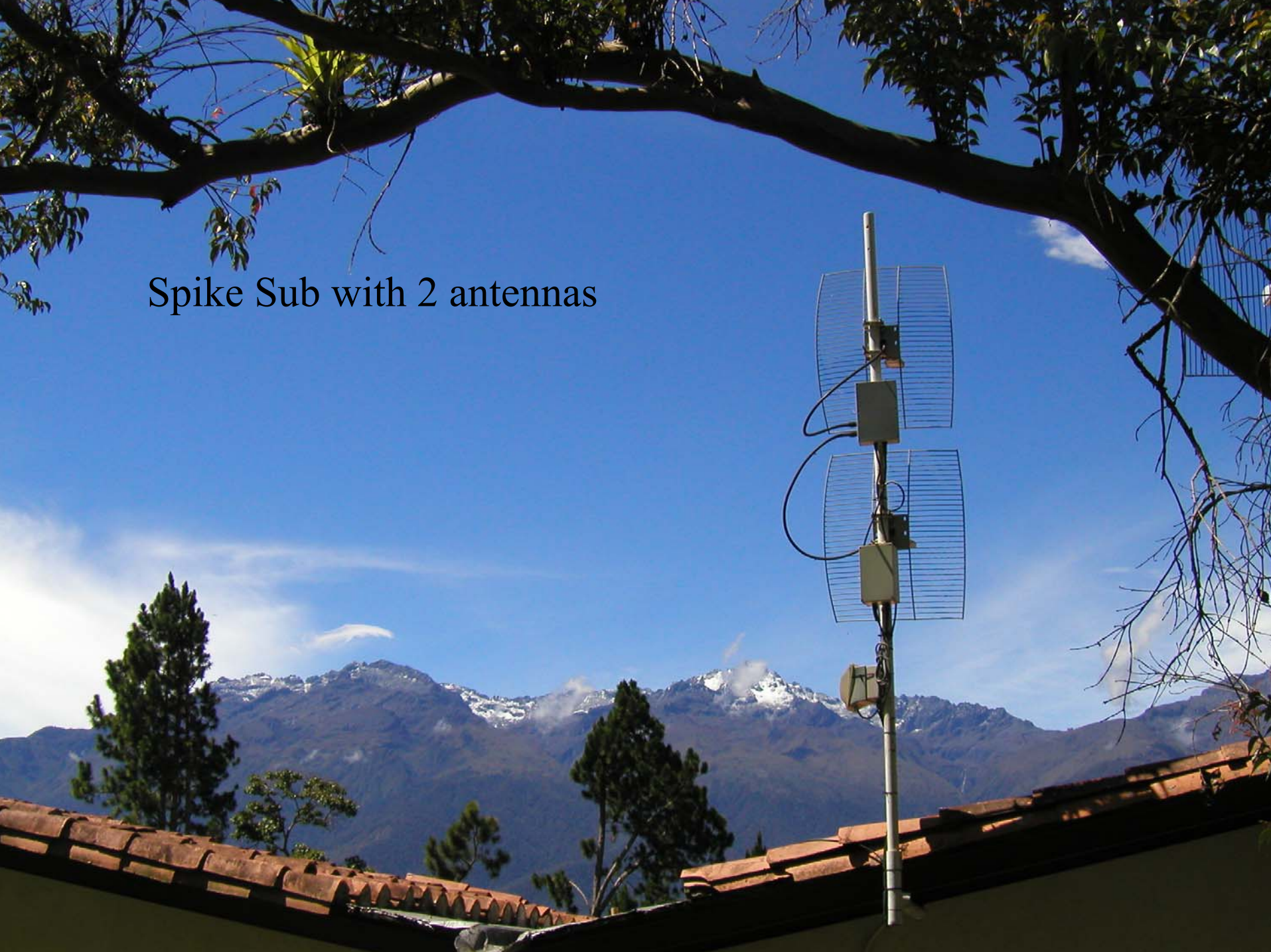


Radiation Pattern: File # 1139 8/25/99





Spike Sub with 2 antennas

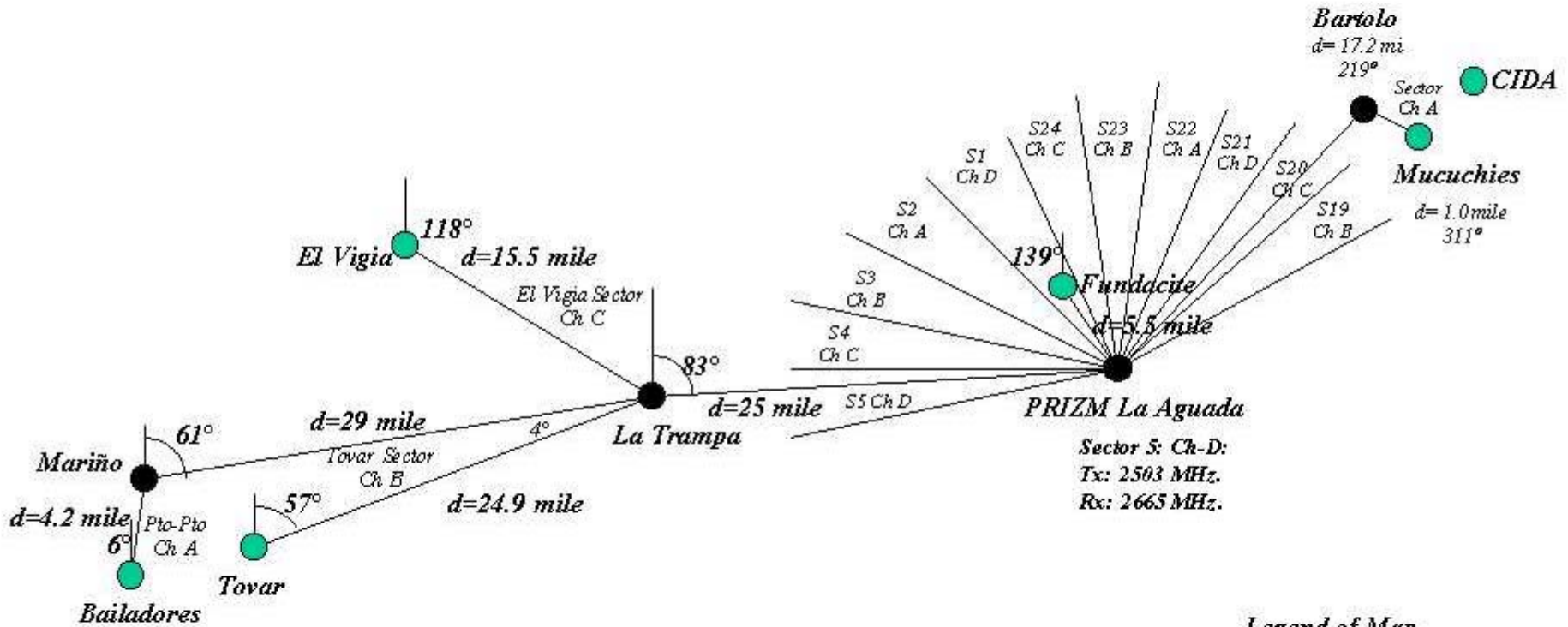


Active REPEATER

- Due to the rugged topography, repetitions points where required to serve neighboring villages
- We found a suitable repetition point at 40 km from the base station, that allowed the extension of the coverage to further 41 km



Frequency Plan





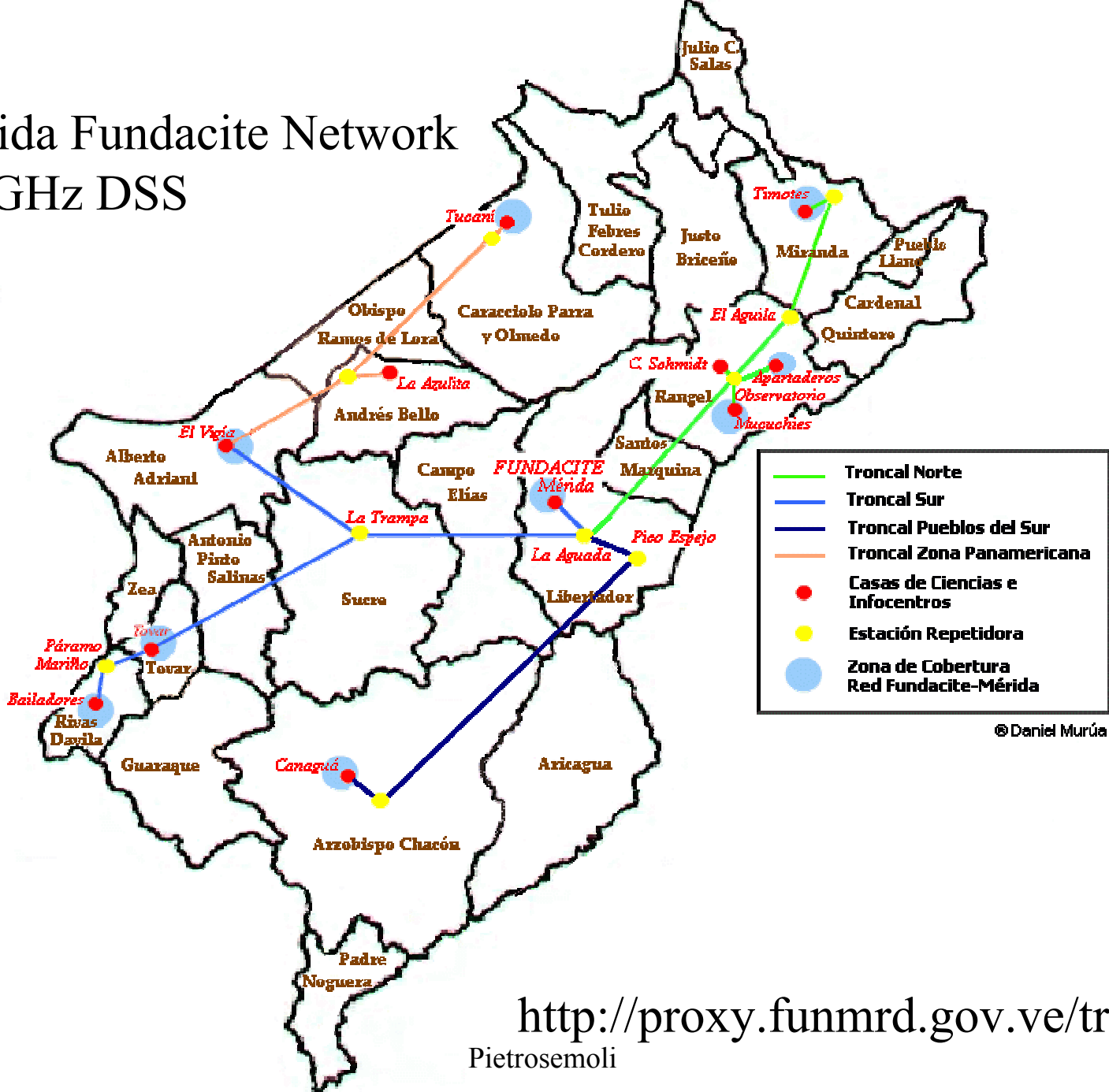
RETIEM

- Currently 150 remote stations provide broadband connectivity to schools, health centers, libraries, community centers and government institutions

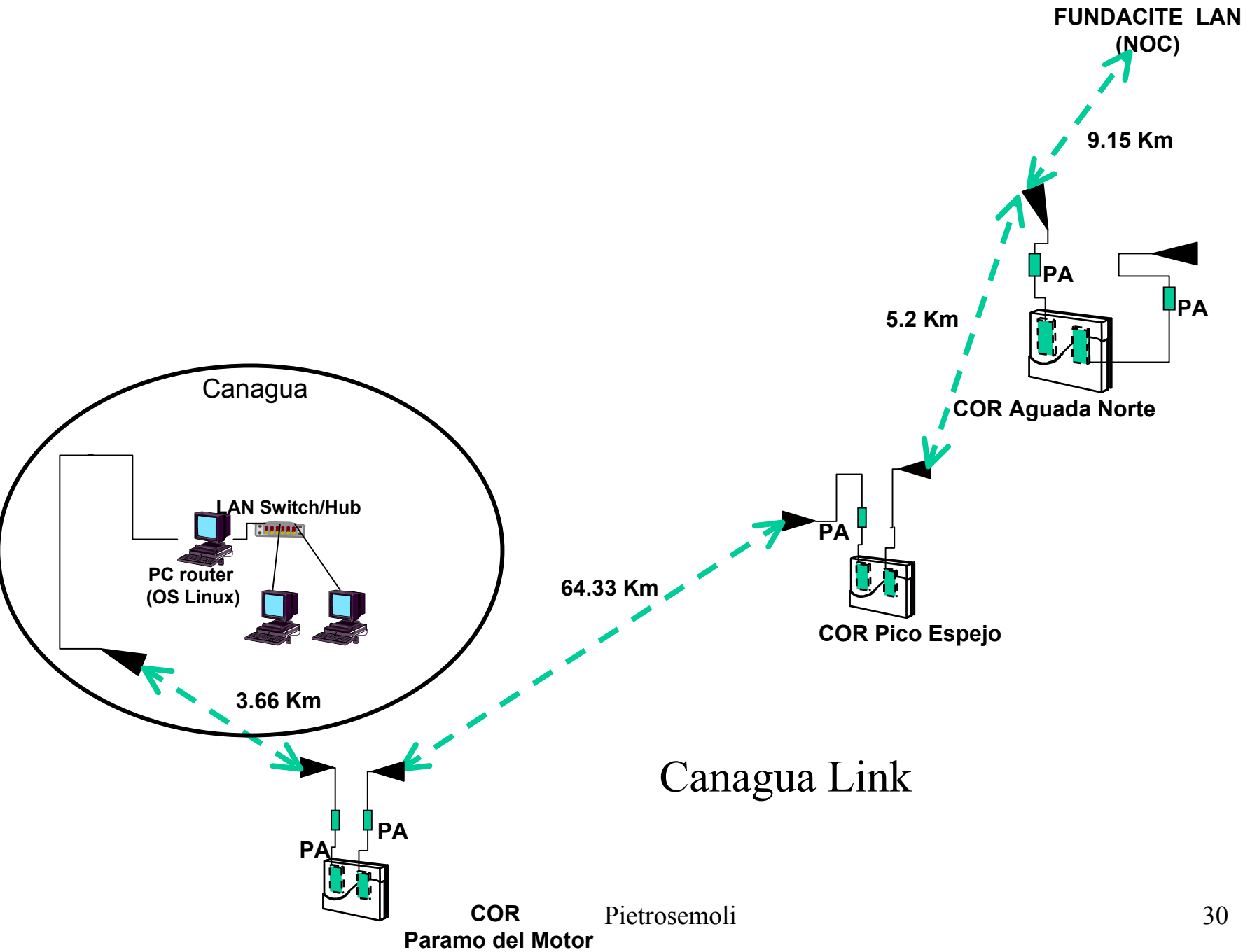
Supercomm '98 Atlanta Georgia, USA

During this event, **RETIEM** was awarded the best network prize in the category of **Remote Access**, while **Third Rail Technologies**, a **Spike Technologies** subsidiary that uses the same technology got the **Local Access** prize.

Merida Fundacite Network 2.4 GHz DSS

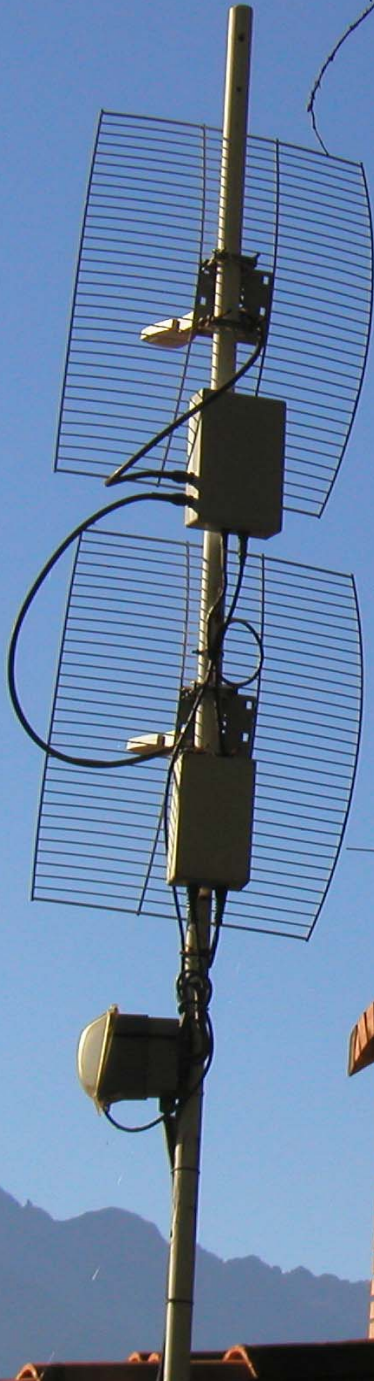


<http://proxy.funmrd.gov.ve/trafico/>
Pietrosemoli



Wireless Roof

Spike

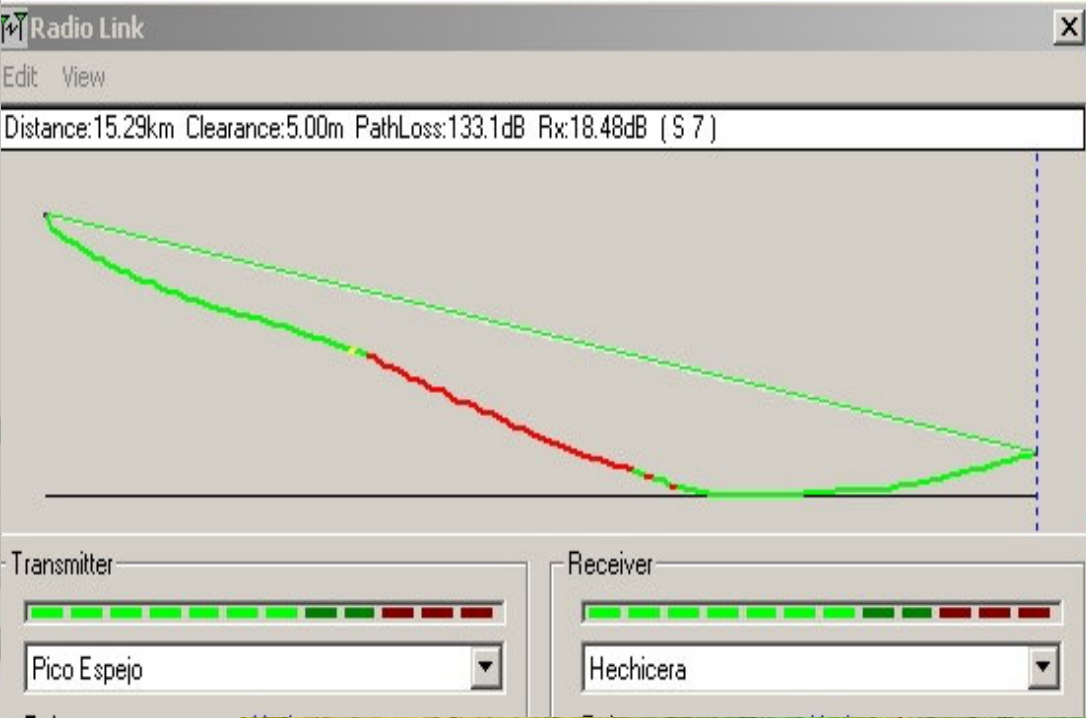


RedUla



Fdcte DSSS





**Mérida Atmospheric
Research Station (MARS)**
Joint Venezuelan-German
project:
5.8 GHz, 16 km link
Pico Espejo. 4765 m
to Hechicera 1800 m



A webcam is at Pico Espejo pointed towards Pico Bolivar (5000 m altitude) and can be seen at:

<http://www-imk.fzk.de/imk2/mira/home.html>

with the details of this research project



Mesh Networks

To alleviate the interference problems and the requirement that every subscriber has a LOS with the base station, we are deploying a pilot with Mesh technology using public domain software developed by LocustWorld and Wi-Fi cards on PCs



Conclusions

- We succeeded in turning the region lack of trained personnel into an opportunity
- By focusing on manageable projects within the framework of a long term plan we were able to overcome budget limitations
- Team work was essential to accomplish our goals, and helped securing international support

urls

www.third-rail.net

www.isoc.org

www.eslared.org.ve

www.ula.ve

www-imk.fzk.de/imk2/mira/home.html

www.ictp.trieste.it