Proceedings

9th Ka and Broadband Communications Conference

November 5-7, 2003 - Island of Ischia, Italy

Organized by:

IIC - Istituto Internazionale delle Comunicazioni, Genoa, Italy

Under the auspices of:

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Ka band User Terminals for DVB IP and DVB RCS Commercial Services

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ABSTRACT

After about three decades of studies and experimental or preoperative systems the utilization of Ka band is entering the commercial phase in Europe with the launch and the start of service operated by the two biggest satellite operators, Eutelsat and Astra and with the support of ESA for all technological aspects. The development of commercial services in the Ka band is becoming the solution for the next future either for DVB IP or DVB RCS networks.

To ease market penetration a key issue is represented by the availability of low cost, high performance terminal, competitive with those at present commercially available for Ku band communication.

To reach this goal the Italian Ministry for the Productive Activities has funded a R&D and Industrial Program for the Ka User Terminal mass production, leaded by Aersat with the support of University of Rome "Tor Vergata,,, Department of Electronics Engineering.

The paper aims both at presenting the Program activities and at describing the technological characteristics of the Ka band user terminal to be developed in this framework (using innovative technologies and methodologies).

1 INTRODUCTION

After many years dedicated to preliminary studies [1], measurements campaigns [2], governmental operative missions [3] and experimental systems [4], the technology for Ka band satellite communication is considered sufficiently mature to convince European commercial satellite operators to deploy capacity at that frequency, with the purpose to complement Ku band. In fact, to support the same kind of services traditionally offered at Ku band, Eutelsat offers Ka band capacity with Hot Bird 6 [5], alternatively usable either in transparent option or with the SkyPlex system [6], and Astra launched the 1H satellite with Ka band capacity on board, to support the ARCS system [7], which uses the Ku band for the forward link. Moreover, these operators, planning to greatly increase the availability of Ka band capacity in the next few years, are developing additional satellites to be deployed soon.

In this scenario, market penetration can be critical if the user terminal is not competitive with a typical Ku band terminal both in terms of performance and cost. To reach this aim, Aersat, supported by University of Rome "Tor Vergata,, has started a R&D and Industrial Program funded by the Ministry for Productive Activities.

The key issue for R&D and Industrial Program (M€ 7.5 total funding) is represented by the development of very efficient and low cost Ka User Terminal (target cost € 1.500 or less for mass production) composed of three main units: Antenna Dish with Ka feed, Ka Transceiver and Satellite Modem. This Program will be developed in two phases:

- R&D Phase which will last 30 months starting from June 2003;
- Industrial Phase which will start 3 years after the beginning of the R&D Phase (June 2006) in the factory located in Lamezia Terme (South of Italy).

2 Development Key Issues and Program Planning

The key issues for a multi-standard Ka Terminal development are:

- Cost Reduction;
- Flexibility of operation with transparent and regenerative satellites;
- Compatibility with existing standards, DVB RCS [8] or CDMA;
- Multi-functionality with star and mesh networks depending on the selected technology (DVB RCS or CDMA) and satellite (transparent or regenerative);
- Multi-service operation with IP standard.

2.1 Research and Development Activities

The Research and Development activities will last 30 months and will be coordinated by Aersat. These activities will be essentially constituted by the following items:

- Feasibility Study and Market Research on Ka SMT and MMIC technologies
- Ka NCC Network Specifications (satellite simulator)
- Ka User Terminal RF Head Specifications
- Ka User Terminal Service and Application Specifications
- Transceiver Tx and Rx Design

- ➤ Antenna and Transceiver industrial prototype realization
- ➤ *Transceiver Tx and Rx Test Validation*

All the above Research and Development activities will terminate with the successful completion of the Test Trials which will involve the Hub NCC Ka Station in Lamezia Terme and some terminals located at the Aersat offices in Rome and Lamezia Terme.

2.2 Approach for the Research and Development

The assessed approach to develop the Ka User Terminal is to split the R&D into two main phases:

1. Research Phase: carried out in collaboration with the University of Rome "Tor Vergata,, its related Telecommunication Research Centres with reference to: a) the definition of the Ka SMT and MMIC technologies; b) the implementation of a satellite system simulator; c) the NCC Network Specifications and traffic balance policy; d) the definition of the test strategies for the equipment;
2. Development Phase: carried out utilizing all possible synergies from other Italian companies[1] working in this field with cooperation related to: i) the design of the Ka antenna and Ka transceiver (University); ii) equipment assembly and integration test (AIT) of the first prototypes; iii) satellite test bed implementation (University); iv) network test with the different satellite modems to be used (DVB RCS or CDMA) on transparent and regenerative satellites.

3 Technological Key Aspects vs Cost Reduction

The Ka typical antenna diameter will be 65 cm and 90 cm, depending on the transmitted bit rate. The antenna will be industrialized in composite materials in order to reduce the cost up to € 100 for mass production; as concerns the Ka feed, plastic materials with metallization will be employed in order to keep the same electromagnetic features and to reduce the production cost to € 50.

As concerns the Ka Transceiver (including Up and Down Converters, SSPA and LNB) with power stages of 1 and 2 W, the technological innovation consists in utilizing SMT (Surface Mount Technology) technology making large use of MMIC (microwave monolithic integrated circuit) instead of traditional FET technology. The MMIC are devices based on Gallium Arsenide (GA) o Silicon Germanium (SiGe) semi conductors which provide integral

[1] Alenia Spazio, Antech, Telespazio, etc

blocks of the transmitting or receiving chains (oscillators, PLL, Up converter-mixer, LNA, medium and high power amplifier etc.). These SMD (Surface Mount Devices) shall be mounted on new generation sub-layer materials compatible with millimetric wave operation. The objective is to industrialize Ka Tx and Rx units whose cost shall not exceed € 800 depending on the power stage of 1 or 2 W.

As far as the satellite modem is concerned, the existing DVB RCS technology reflects the state of the art and optimizations can be based only on process innovations and risk technologies for large utilization. The objective is to industrialize satellite modems whose cost does not exceed € 500 for large production.

4 KA USER TERMINAL DESCRIPTION

The Ka Terminal block diagram and interface are shown in Figure 1.

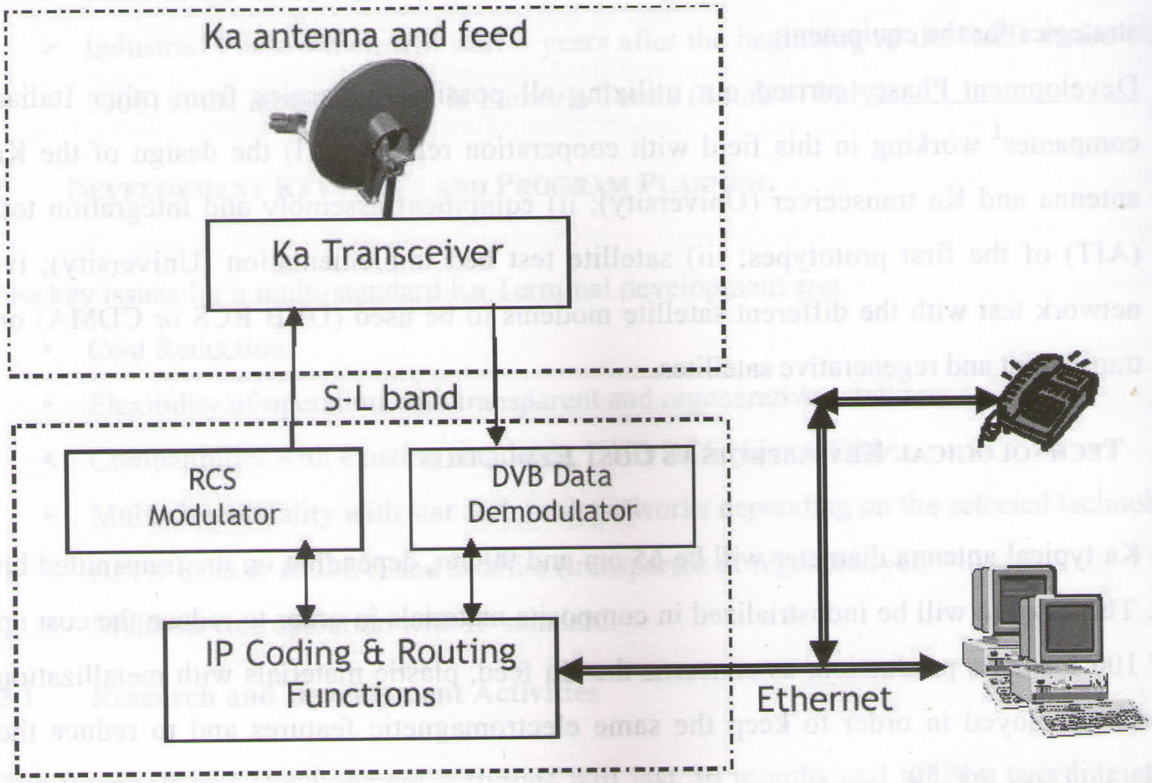

Figure 1 Ka Terminal Block Diagram

The main tasks concerning the development of the Ka User Terminal, object of this R&D and Industrial Program, are summarized in Table 1.

Ka Antenna for User Terminal (UT)	– Optics Development Study for 65 cm and 90 cm – Technology Assessment with Fiberglass material and prototype test results
Ka Feed	– Feasibility Study utilizing Plastic materials – Technology assessment and prototype test results
Ka RF Front End	– Ka RF Transceiver Development study for a power stage of 1, 2 and 4 W – Technology assessment with the adoption of SMT (Surface Mount Technology) and large use of MMIC (microwave monolithic integrated circuit) technologies – Prototype Test Results
DVB RCS Baseband & Modem Development	– MF TDMA DAMA for transmission up to 4 Mbit/s – DVB IP for reception up to 45 Mbit/s – MPEG4 Codec Built-in – Turbo Coding DVB RCS compliant – QPSK Modulation – IPSec Features – IP QoS – TCP PEP – Adaptive coding – Adaptive modulation
DVB RCS Network NCC Development	– Bandwidth on demand (BOD) Management – CIR Allocation – Network monitoring – Gateway functions

Table 1: Ka User Terminal Characteristics

4.1 Ka RF Section (Outdoor) Technological Features and Characteristics

The Ka Antenna and Feed preliminary specifications are summarized in Table 2.

Parameter	Value
❖ Diameter	65-90 cm
❖ Polarization	Linear
❖ Frequency	19.7 - 20.2 GHz (Reception) 29.5 - 30.0 GHz (Transmission)
❖ Antenna Gain (65 cm dish)	RX: 40,3 dBi min. (@ 19.7 GHz) TX: 43.8 dBi min. (@ 29.5 GHz)
❖ XPD on axis	35 dB min.
❖ XPD within main lobe	20 dB min.
❖ Manual Antenna adjustment	AZ: ± 15° EL: 0° ÷ 50°
❖ Feed Performances	TX Insertion Loss ≤ 0.3 dB TX Return Loss ≥ 21.0 dB RX Insertion Loss ≤ 0.3 dB RX Return Loss ≥ 20.0 dB

Table 2: Ka Antenna and Feed Characteristics

The Ka Transceiver preliminary specifications are summarized in Table 3.

Tx Section		Rx Section	
Frequency	29.5 to 30 GHz	Frequency	19.7 to 20.2 GHz
Input frequency range	950 MHz to 1450 MHz	Output frequency range	950 MHz to 1450 MHz
Transmitter power	1 W or 2 W	Gain	50 dB min
Small signal gain	60 dB min	Noise Figure	2.5 dB max
Reference PLL input	10 MHz 0 dBm nominal	PLL input reference	10 MHz (or internal stability ≤ 10^{-8})
Power supply	24V DC, 2.5A max	Phase noise	- 75 dBc @ 10 kHz
Output connection	Waveguide	Input connection	Waveguide
Input connection	F (or N)	Output connection	F (or N)
Spectral inversion	No		

Table 3: Ka Transceiver Characteristics

4.2 Satellite Modem (Indoor) Main Features

The R&D program is mainly focused on the RF component. Nevertheless, some activity concerning optimization and integration of the modem will be performed. The technological features of the satellite modem are well assessed, being commercially available in different versions for TDMA and CDMA, as shown in Table 4. The Ka RF Section shall be compatible with the commercial modems available on the gross market.

MF TDMA Modem	CDMA Modem
TDMA access	CDMA access
Transmission Rate: 128 kbit/s up to 4 Mbit/s	Transmission Rate: 128 kbit/s up to 512 kbit/s
Reception (DVB IP) up to 45 Mbit/s	Dynamic code distribution CDMA (mesh mode) or DVB IP (star mode) reception
Turbo Coding DVB RCS compliant	Turbo Coding
QPSK Modulation	QPSK Modulation
IPSec	IPSec
IP QoS	IP QoS
TCP PEP	TCP PEP

Table 4: Modem characteristics

4.3 Operational Achievements

Link calculations have been carried out to size the antenna and SSPA stage (to be developed) with the objective to provide a typical Tx data rate of 384 kbit/s (the received bit rate could be up to 45 Mbit/s). Availability figure of 99,7 % have been obtained in case of rainfall with additional attenuation of 8-9 dBs.

These link calculations justify the assumptions done for the proposed solution: 65 cm or 90 cm dish with 1 W or 2 W for the power stage depending on the transmitted bit rate and the access technology (see Table 5).

Parameter	Main characteristics for Tx bit rate 128/256 kbit/s	Main characteristics for Tx bit rate 128/256 kbit/s	Main characteristics for Tx bit rate 384 kbit/s
Antenna diameter	65 cm	90 cm	90 cm
SSPA Amplifier	1 W	2 W	2 W
Modulator (RC)	MF TDMA	CDMA	MF TDMA
Demodulator (FC)	DVB IP	DVB IP	DVB IP
BER	10^{-7}	10^{-7}	10^{-7}
Availability	99.7%	99.7%	99.7%
Payload	Transparent	Transparent	Transparent
Network Topology	Star	Star/Mesh	Star

Table 5: User Terminal Sizing

5 Conclusions

The satellite operators are increasing bandwidth availability introducing the use of Ka band for commercial services. In addition to the already available transponders new satellites will be launched soon to allow a wider use of Ka frequency band for DVB IP and DVB RCS services.

The paper addressed the presentation of a R&D program aimed at the development of an user terminal with cost and performance comparable with those working at Ku band, currently commercially available. The program structure has been detailed and the target technical specification of the terminal have been presented.

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