LABORATORY AND ON-THE-AIR TRIALS OF AN S-UMTS APPROACH SUPPORTING PACKET ACCESS AND MULTICASTING: THE ESA "ADVANCED TEST BED" PROJECT

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Abstract

This paper describes the *Advanced S-UMTS Test Bed*, shortly *ATB*, a project funded by the European Space Agency (ESA) with the main aim of studying, proposing and assessing solutions in support of packet-access and multicasting, in the context of a wideband system representative of the satellite component (S-UMTS) of 3G mobile networks. After presenting the general aim of *ATB*, this paper illustrates some results of the computer simulations carried out during Phase-1 of the project with the aim to assess the approaches proposed to most efficiently exploit the available Forward-Link (FL) and Reverse-Link (RL) resources, under the expected traffic scenarios. The paper then continues by presenting the implementation activities that are being performed within *ATB* Phase 2, which will lead to the realization of an end-to-end hardware Test Bed to be used for experimenting the packet-access and the multicast mode both in the laboratory and over-the-air, in the context of a wideband satellite mobile services demonstration to the public. The *ATB* Test Bed architecture, main characteristics and trials plan are herein presented.

1 Introduction

The *ATB* project forms part of the ESA mobile satellite wideband services validations & demonstrations, a program intended to foster the development of mobile 3G services via satellite and to attract operators' interest. Such program develops over two main lines, i.e., study & simulation activities intended to identify and assess efficient techniques for 3G services delivery to mobile users, and development of hardware-based Test Beds capable of validating and demonstrating in real time the S-UMTS radio-dependent part, in the laboratory as well as over-the-air. As a matter of fact the *ATB* project and its forerunner *ROBMOD* (an acronym for ESA contract *Robust Modulation and Coding for Personal Satellite Communications Systems*), representing the main milestones of said evolutionary program, both include a study and simulation phase and a Test Bed development phase. The *ROBMOD* project began in a period where the possibility of integrating a satellite infrastructure within the terrestrial UMTS was just starting to be envisioned; at that time both the study and the hardware development efforts were mainly orientated toward the definition of a robust physical layer [1][2][3][4] able to offer customers good-quality circuit-switched via-satellite services. *ROBMOD* has recently concluded with the delivery of a comprehensive hardware Test Bed [5] representative of S-UMTS physical layer offering circuit-switched services and supporting the SW-CDMA transmission standard which had been specified on the grounds of *ROBMOD* study and simulation activities. One of the major challenges that 3G terrestrial mobile systems, e.g., UMTS, are currently facing is represented by the effective support of packet-services (i.e., IP) in the wireless environment. 3GPP Release 5 of the UMTS standard will further improve the packet-switched support of packet-services at physical-layer level, as an evolution of the circuit- and packet-switched support of such services already envisaged in

3GPP Releases 99 and 4. Efficient support of packet-services also represents an important issue with regard to satellite systems, which, in addition to band limitations, also suffer from severe power constraints. Another challenge for UMTS, to be still addressed, is the provision of reliable multicast services, this also being an issue of particular relevance for future mobile satellite systems, whose major strength just relies on their inherent broadcast capability.The *ATB* project was started by ESA in 2001 just to respond to the above needs, in the perspective of keeping the satellite system definition in step with its terrestrial counterpart. *ATB* aims at developing a full set of technical solutions capable of efficiently supporting the packet, broadcast and multicast modes needed for S-UMTS. *ATB* is comprised of two phases, namely Phase 1, already completed and dealing with the technical analysis and trade-offs, and Phase 2, recently started and covering the development of an hardware Test Bed permitting real-time performance assessment of the proposed packet-access and multicast mode approaches, both in the laboratory and over the-air. Public demonstrations are currently planned for the first quarter of year 2003. Similarly to *ROBMOD*, the approach was also taken in *ATB* to base the satellite system solutions as much as possible on those adopted by 3GPP for UMTS, making modifications only when needed to best match the peculiar characteristics of the satellite environment. The *ATB* team comprises *Space Engineering* (Italy) as Prime Contractor, *Alcatel Bell Space* (Belgium), *Alenia Spazio* (Italy), *Ascom* (Switzerland), *RAI* (Italy), *SkySoft* (Portugal) and *Telespazio* (Italy).

2 Packet-Access Solutions

As already mentioned, the general guideline was adopted to derive solutions for the satellite system from those emerging in 3GPP. With regard to the FL, use of a Dedicated CHannel (DCH) or Forward Access CHannel (FACH) would clearly be possible for packet-services support in S-UMTS, but the *ATB* work was mainly focused on adapting the DSCH (Down-Link Shared Channel) already specified in 3GPP Release 99, this potentially being a much more efficient approach also for the satellite environment. As detailed in Sect. 2.1, the need for adapting the terrestrial DSCH approach was mainly driven by the wish of eliminating the use of a dedicated channel in association to the DSCH, such as to improve the system power efficiency and to avoid possible shortages of channelisation codes. With regard to the RL, an adaptation of the Common Packet CHannel (CPCH) specified by 3GPP Release 99 was first investigated, concluding that its possible adaptation to the geostationary (GEO) satellite environment could result in an efficiency reduction due to the satellite links delay. Other solutions were then investigated, namely a spread-Aloha based access, referred in the following as *RASA* (Random Access Spread Aloha), which extends the Random Access CHannel (RACH) approach specified by 3GPP Release 99, and a reservation scheme referred to as *dynamic Rate on Demand* (dRoD). As discussed in Sect. 2.1, both solutions have been retained them being complementary to each other; as a matter of fact the RASA approach was shown to produce a lower delay under light to moderate system load, whilst dRoD performs better under heavy load conditions. In this paper, aiming to provide an overview of the whole *ATB* project, it was only possible to show a subset of the results produced during the study and simulation phase.

2.1 Assessment of Forward-Link Packet-Access

As already mentioned, the FL access adaptation was driven by the wish of eliminating the use of DCH in association to the DSCH. Although only the DPCCH (Dedicated Physical Control Channel), part of the physical DCH, needs to be transmitted continuously for supporting closed-loop power-control operation on the DSCH, this DCH usage would nonetheless represent, in a satellite environment, both a significant power waste and a bottleneck, because of the channelisation codes shortage caused by the use of an associated DCH for each Mobile Station (MS) operating on the DSCH. In the terrestrial environment, a timer is foreseen to release the DCH when the MS is idle for a certain period, the timeout of which may be made short enough to minimize the number of simultaneously active DCHs associated to the DSCH. However, in the satellite environment (particularly the GEO one), a longer timeout should be used to avoid further delaying the DCH set-up before a packet transmission. All these facts have suggested to investigate alternative DSCH operating modes, not relying on associated DCHs for power-control and signaling. In particular, two alternatives were investigated, i.e., one compatible with closed-loop power-control and one requiring a different power-control strategy here termed *open-loop power-control*. This approach envisages that no dedicated resource is used for power-control purposes, but a SSCH (Shared Signaling CHannel) is needed to carry signaling information related to DSCH capacity assignment to MSs. Open-loop power-control operates on SNIR (Signal to Noise plus Interference Ratio) measurement reports from the MS; such measurements are performed on the CPICH (Common PIlot CHannel). In case of an active MS, such measurements can be transmitted with higher periodicity (e.g., 1 s), whilst the periodicity can be decreased after a given inactivity timer expires. The SNIR measurement on the CPICH may be very accurate and unbiased thanks to the availability, on such carrier, of unmodulated symbols (see **Figure 1**, where a comparison with an estimator operating on unknown modulated data is given). However, a bias may anyway result in setting the DSCH (and SSCH) power; moreover, the target SNIR needed for providing the requested Quality of Service (QoS) may only be approximately known. All these factors concur in making an outer power-control loop still desirable, even with such strategy. The proposed approach is that the target MS SNIR used by the GW for calculating the required power is adjusted depending on whether the previous transmission by the GW was successful (see ref. [6]). Alternatively, the DSCH power may be maintained constant and the data rate adapted to the channel conditions. The adapted DSCH may take advantage, for optimal performance, of possible satellite diversity. At this regard it appears useful to support both the conventional satellite diversity (maximal ratio combining) and an alternative Fast Satellite Selection (FSS) mechanism. The two approaches may possibly be simultaneously employed. According to the FSS mechanism, the GW selects the satellite path(s) to be used for actual transmission of the DSCH within the current satellites active set (maintained through standard active set handling signaling), based on its latest information on path quality. At this regard, it shall be observed that a similar mechanism (Fast Cell Selection, FCS) was proposed for enhancing the 3GPP DSCH operation. This mechanism is similar to the one already specified in Release 99 for supporting SSDT (Site Selection Diversity Transmission) in DCH transmission. SSDT is an optional advanced form of FL power-control used in a macro-diversity environment. System simulations of the DSCH efficiency in supporting packet services were also performed, in particular a single-satellite GEO system was simulated. To reduce the simulation time, a single-beam system was considered. Interference from adjacent beams is not dynamically accounted for. However a simple model for interference variation across the beam area has been assumed for system performance evaluation (see [6] for details). **Table 1** summarises the parameters considered in the simulation scenario, in which a vehicular type of MS was assumed. It was considered that at most only half of the beam power is dedicated to the DSCH channel, the remaining part is instead used for circuit-based services (or services anyway carried on physical channels other than the DSCH) and has not been explicitly simulated here. The maximum DSCH information

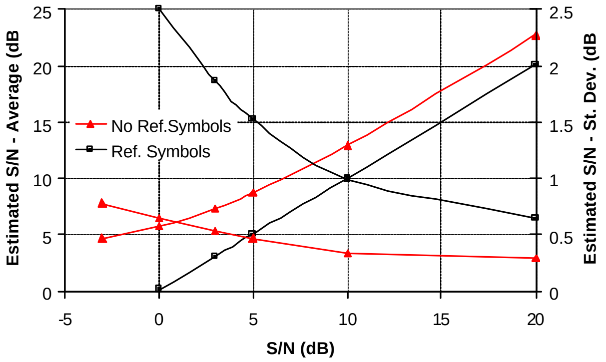
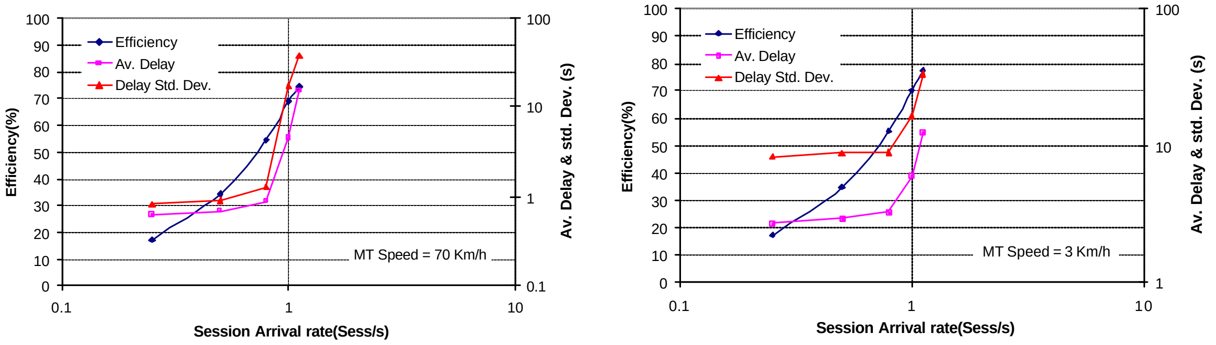


Figure 1 S-curve of SNIR estimators: either based on unmodulated symbols or on x4 phase non-linearity (QPSK modulation). Symbols per frame = 16 (unmodulated) or 160 (modulated)

Traffic Model	ETSI Web Server (10 s read time)
MS peak EIRP	15 dBW
MS G/T	-18 dB/K
no. of simulated satellite beams	1
Satellite Beam Peak Gain	42.7 dBi
Satellite Max Beam RF Power	2 W
Satellite G/T (coverage centre)	15.7 dB/K
Coverage Area (beamwidth)	1 deg @ -2 dB

Table 1 Summary of main simulation parameters

data rate in all simulations shown here was assumed equal to 512 kbit/s corresponding (after channel coding) to a Spreading Factor (SF) of 8. Different combination of data rates can be selected for the same Transmission Time Interval (TTI), ranging from a single packet at the maximum data rate up to N packets, each with SF = N * 8. In our simulations the maximum SF was assumed equal to 128, corresponding to 16 kbit/s information rate. The ETSI Web Server traffic model [7] was used (with respect to ETSI suggested parameters a much short *reading time* of 10 s was used). The implemented scheduler, is very simple; it actually scans the various application queues and selects those from which data will be retrieved for transmission at the next TTI. Criteria for selecting data are, in order of importance, time of permanence in the queue and volume. To maximize channel throughput, MSs having best propagation conditions have to be scheduled first; hence requests should also be sorted against required power per bit. However, such kind of scheduler is not fair as to resources allocation; hence we propose to just check whether propagation conditions are such that required power for the channel becomes excessive; in that case the allocation is postponed. The selected TTI for all the simulations is 10 ms (one frame). If data remains in the queue for more than 4 s. they are discarded. The available MAC segment lengths used in simulations range 20 to 320 bytes. Simulation results are shown in **Figure 2** for a suburban environment and two different MS speeds.



a) ***MS speed:70 km/h.*** ***b) MS speed:3 km/h***

Figure 2 DSCH performance with open-loop power-control. SNIR estim. error std. dev. at MS = 0.5 dB; power-control bias variance = 2 dB). Two-state fading model. Suburban environment

Efficiency of the DSCH is normalized to its maximum capacity, i.e., 512 kbit/s in the simulated case. A two-state channel model has been adopted (Lutz model [8]); in particular attenuation in the shadowed state was assumed to be lognormal, with 8 dB average and 4 dB variance. State transition probability has been computed based on data from ref. [9] and [10]. From **Figure 2** it appears that the achievable throughput is not significantly depending on the MS speed. However the average packet delay is quite significantly impacted, despite the fact that the scheduler is not privileging the MSs which are in good propagation conditions.

2.2 Assessment of Reverse-Link Packet-Access

The 3GPP CPCH has been adapted by Korean TTA for operation in their SAT-CDMA system. The main emphasis in SAT-CDMA is on LEO systems. Hence, a larger access slot size has been considered by TTA with respect to original 3GPP specifications, i.e., 20 ms (2 frames) against 1.333 ms (2 time slots) in 3GPP. Other differences in SAT-CDMA with respect to 3GPP are:

- the lack of any requirements of an associated down-link DPCCH for supporting power-control, but its substitution with a common control physical channel (CPCH CCPCH) shared by all users of the CPCH set;
- the Access Preamble (AP) and Collision Detection (CD) preambles are transmitted in pair (one after the other) in SAT-CDMA to reduce transmission delay.

It shall also be observed that the preamble power ramp-up procedure of 3GPP is maintained, although we expect that, with a sensible choice of parameters, the ramp-up iterations can be minimized to avoid impact on delay. A MS wishing to transmit data has to grab a CPCH by first transmitting an access preamble in one of the access slots. If an acknowledgement (ACK) is received, then this implies the reservation of a CPCH for that MS. The reservation time cannot exceed a number of frames larger than a value *NF_max*, which is set from the Radio Resource Control (RRC) layer. The MS shall release the channel, even if it has more data to transmit, if such number of frames has been exceeded. In such a case the random access procedure to grab a new channel shall restart. Depending on the amount of data to be transmitted, a signature may be chosen for the transmitted access preamble which maps to a CPCH having a given a Transport Format (i.e., a transport block set size, *NF_max*, and TTI), spreading factor (i.e., data rate), scrambling and channelisation codes. It shall be observed that the CPCH approach does not lends itself very well to applications in a GEO environment due the high round-trip delay. This makes it likely not appropriate to use a sufficiently large value for *NF_max* parameter such that, most of the times, we can assume that the MS is able to empty its packet queue with a single CPCH access. As a matter of fact, if this would be true, the GW scheduler would not have full information available for performing its duty. In fact, if the scheduler decides on a new allocation only based on the current interference load, too a conservative strategy would result because, before the new allocation could actually become effective, a significant time interval (in the order of 250 ms) would elapse and some MSs could have spontaneously terminated their packet transmission. To avoid such an inefficiency, one can consider either overbooking or assuming that each allocation lasts a sufficiently short amount of time (i.e., a quite small *NF_max*), such that the probability that the resource is released before actual lease expiration is minimum. The last approach, which has been investigated in detail within *ATB*, however implies that an MS having to transfer a large amount of data would have to perform multiple access requests. By means of a reservation scheme this is actually avoided, because the GW is informed of the real MS needs and can then perform the best possible channel allocation. A drawback of this approach is the longer duration of request packets with respect to the access probes of CPCH. However, this is mitigated by the fact that there is no need to perform multiple access probe transmissions for uploading of very long packets. Moreover, with a reservation scheme, it would be possible to extend the current allocation, if required, by in-band insertion of traffic volume information. For these reasons, the dRoD reservation scheme was selected for use in *ATB* together with RASA [11]. This last access mechanism was in fact shown to produce lower delays when traffic load is not excessive. The combination of dRoD and RASA access may then maximize channel usage as well as minimize channel delay. A strategy based on the traffic volume was implemented at the MS for deciding which mechanism to select for channel access. At higher loading, however, the system reverts to dRoD-only access; the discriminating threshold is however decided at network level and broadcast by the GW to all MSs. System simulations of dRoD and combined dRoD / RASA were performed in the same scenario illustrated in Sect. 2.1 (see also **Table 1** for simulation parameters). Some results are shown in **Figure 3**. The efficiency is normalized to the chip rate, hence an efficiency of 100% would correspond to a throughput of 3.84 Mbit/s. The selection between dRoD and RASA will be based upon the current MS queue size. The GW will broadcast the threshold for deciding the access type, determined upon current system load. Power-control strategy on the RL is similar to that of FL, i.e., open-loop with measurements on the CPICH. However, in the RL, an estimate of the up-link attenuation

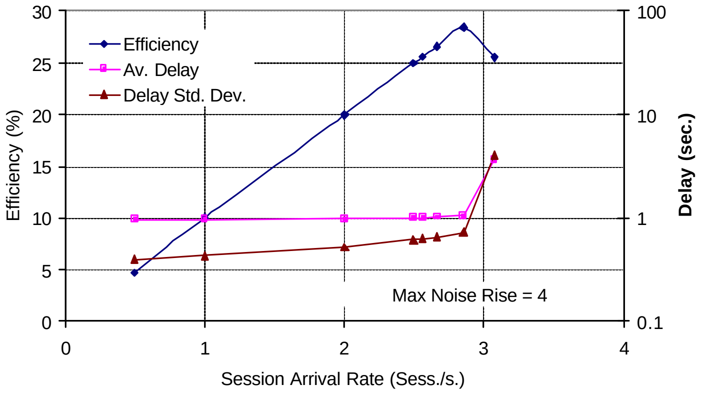


Figure 3 Results for dRoD access in rural environment. SNIR error standard dev. = 0.5 dB, power-control loop bias variance = 4 dB. Two-state channel. MS speed = 70 km/h

is actually required instead of the CPICH SNIR. Assuming up- and down-link attenuation similar (we neglect here the possibility to track multipath fading which is too fast for GEO satellite delay, but we only consider the tracking of longer-term fading), the CPICH measured level can be used to estimate the down- (and hence the up-) link attenuation (CPICH SNIR measurement is not fully appropriate because it does not take into account the orthogonal interference contribution). Large calibration errors may however occur in CPICH level measurements at the MS; this bias (4 dB in **Figure 3**) will however be compensated for by a similar outer power-control loop as the one considered for the FL.

3 Multicasting Mode Definition and Assessment

Multicasting strategies were investigated with particular emphasis on Reliable Multicasting (RM). RM may exploit an Automated Repeat Queuing (ARQ) mechanism, or may be simply provided by a purely Forward Error Correction (FEC) based mechanism. In S-UMTS multicast applications it will be common not to have a feedback channel, either because a receive-only MS is used or because the number of users is so large that the required RL capacity for supporting ARQ would be excessive. In such conditions an RM approach based on FEC only should be considered. In general, a FEC-only approach can fulfil the vast majority of the multicast applications; it would also fit the current 3GPP baseline, which is a non-feedback-based mechanism for multicast delivery [12]. FEC could then be a prime candidate for reliable multicast delivery; in effect, FEC may be the only cost-effective solution for S-UMTS. A large interleaver size is however required to overcome channel outage. This technique was pioneered almost 20 years ago in the ESA PRODAT mobile messaging system. The required interleaver sizing has been investigated in association to RS coding. **Figure 4** shows the resulting codeword error probability in an urban channel [8] versus interleaver size (in codewords) and satellite elevation. The assumed bit rate is 256 kbit/s. For elevation angles above 50 deg. and for the RS(255, 175) code here considered, an interleaver size greater than 10^5 codewords, i.e., 25.5 MBytes, is required to correct all errors, even at speed as low as 3km/hr. The above approach cannot always guarantee error-free transmission; so it is likely to be coupled with a data carousel technique.

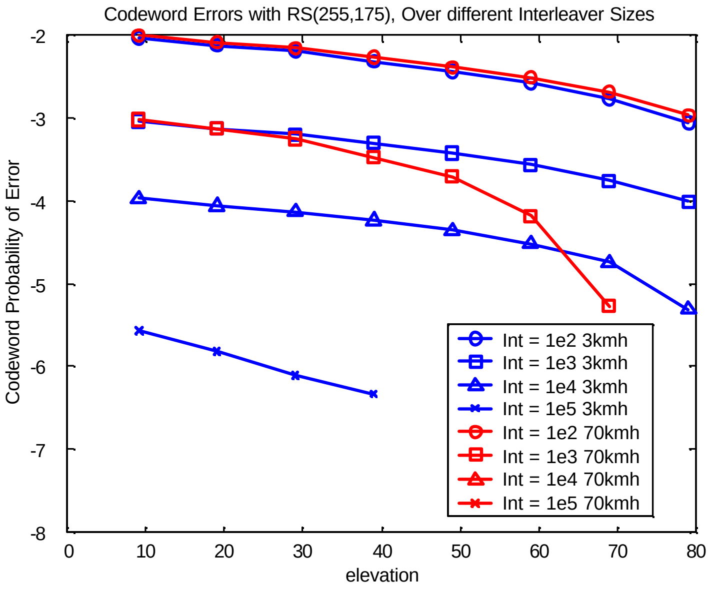


Figure 4 Codeword errors vs. elevation angle for urban channel model

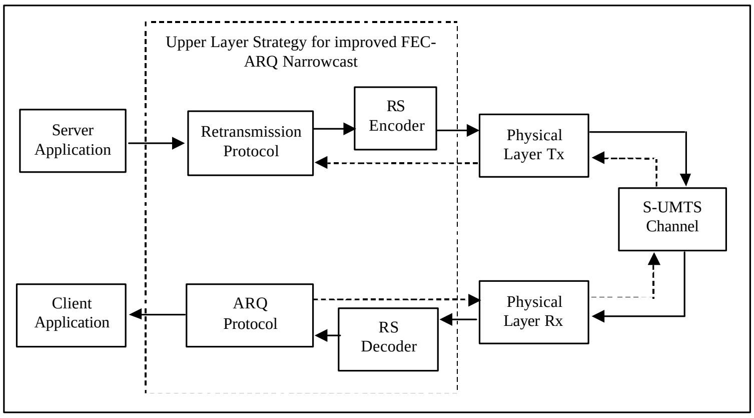


Figure 5 Block diagram for FEC-ARQ narrowcast protocol

Alternatively, for scenarios where the number of users is not excessively great, a narrowcasting technique combining FEC and ARQ may provide full reliability. In this case, each of the addressed receivers sends an non-ACK (NACK) if the number of errors exceeds the FEC capability. The GW filters NACKs in order to decide whether there is a need for retransmission or not. If the need occurs, then the GW retransmits the whole file, according to the scheme shown in **Figure 5**. The MSs therefore combines the results of consecutive transmissions until it correctly receives all the required data. **Figure 6** illustrates the effects of consecutive retransmission process with a data file of 2000 kbytes (before RS encoding). The figure refers to a scenario with a narrowcast group of 100 terminals. Each dot on the graph indicates a lost packet. These results were obtained with reference to a pedestrian MS (MS speed = 3km/h) in urban area; the user data rate was set to 256 kbits/s. From the figure we can clearly see the improvement after each retransmission; after 8 transmissions, all terminals are able to correct the remaining errors and the file is received completely. In the *ATB* Phase-1 study report [6], simulation trade-offs have been performed to select the most appropriate FEC scheme for different propagation environments, bit rates and number of MSs, to optimise file delivery time and RL bandwidth usage for NACKs transmission.

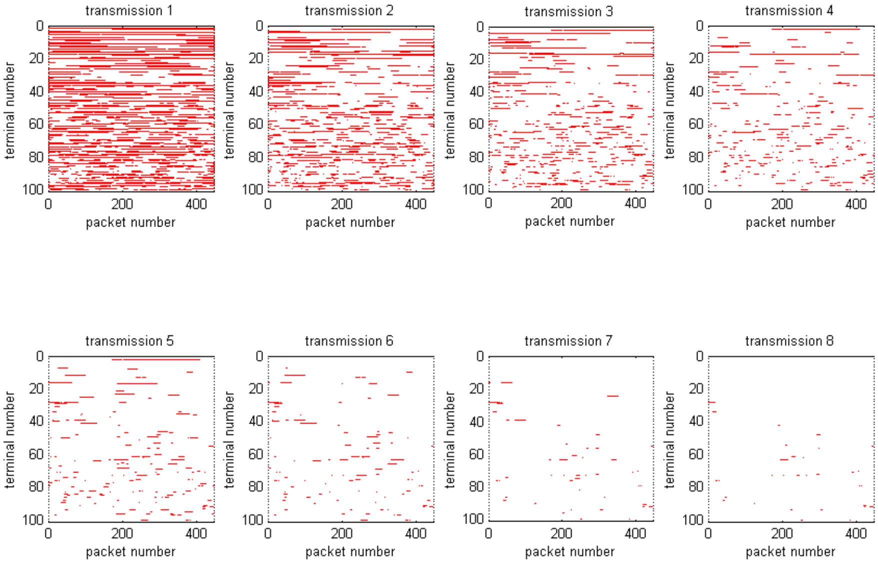


Figure 6 Visualization of an experiment with the NP protocol

4 The *ATB* Test Bed

A major objective of the *ATB* project is that of implementing, within Phase 2, an end-to-end hardware Test Bed incorporating a meaningful set of the packet access and multicast mode solutions studied and assessed during Phase 1. At the time being the Test Bed specification phase has nearly been completed and hardware implementation is about to start. The *ATB* Test Bed is conceived as an upgrade of the *ROBMOD* Test Bed (*RTB*) [5], a comprehensive facility allowing to thoroughly assess, in the laboratory, the performance of a circuit-switched S-

UMTS physical layer, in real time. The new Test Bed has a topology similar to that of the *RTB*, and it then supports a client ↔ server IP-based application over SW-CDMA, modeling a two-way satellite link (GW ↔ MSs), whereby the fixed user (i.e., the server) is connected to the GW and the mobile user (i.e., the client) is attached to the MS. The Test Bed provides a fully-hardware emulation of the modeled system, while use of software-programmable devices provides for good flexibility with regard to air-interface parameters. The set-up offers a faithful emulation of a real operating environment, i.e., multi-satellite diversity and beam-handoff with coherent combining, comprehensive satellite channel simulation (path delay, Doppler, variable link attenuation, user-defined propagation channel, etc.), interference generated by real CDMA codes, control loops (power, frequency), handoff management via ad-hoc signaling channels, adaptive interference suppression on FL (Blind-MOE algorithm), 3GPP-specified Turbo codec, real-time variation of link parameters in accordance with virtually any user-defined constellation (GEO, MEO or LEO). Very comprehensive hardware facilities are available, namely three satellite-emulators permitting to assess dual-diversity advantage + simultaneous satellite- or beam-handoffs, independent emulation of delay, Doppler, link attenuation and propagation channel, seven beams per satellite-emulator (wanted beam + six interfering beams for maximum coverage representation flexibility), three GW SW-CDMA modulators for simultaneously loading three satellites, decorrelated sources for CDMA interference generation, multi-finger demodulators supporting diversity & handoffs. In addition to the legacy *RTB* functions, the *ATB* Test Bed now also offers packet-mode resources management, with multicast support, by the availability of evolved upper-layer protocols. The hardware configuration has also been upgraded to include equipment permitting to validate the operation of the new modes, i.e., a second MS, additional channel simulators, interference generators programmed to emulate packet-access by the other system users, etc. Furthermore the Test Bed is no longer confined to in-laboratory operation, it being designed for integration into an overall trial set-up capable of supporting tests via a real satellite. Such set up is called *SATB* and includes, beyond the *ATB* Test Bed, additional equipment (e.g., converters, RF receive and transmit front-ends, etc.) and facilities (i.e., a mobile van and a GW earth station allowing transmission and reception of signals over the satellite). The *ATB* Test Bed block diagram is shown in **Figure 7**.

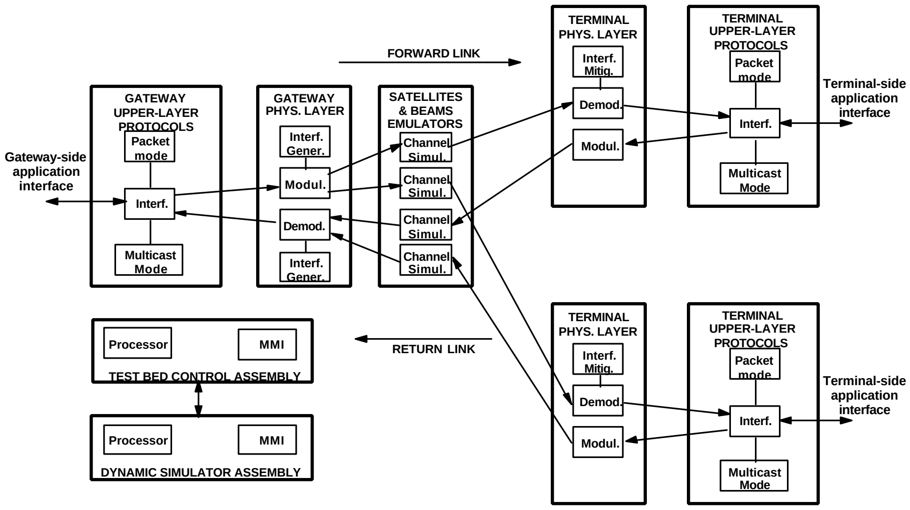


Figure 7 ATB Block Diagram

Available FL channels will be a DSCH with dynamic management and open-loop power-control, a SSCH, FACH and BCCH, all mapped on the primary CCPCH, and the *ROBMOD* DCH. Available RL channels will be a RACH-type channel supporting the RASA strategy, a dRoD channel, and the *ROBMOD* DCH. The operative modes supported by the *ATB* Test Bed are itemized in **Table 2**. The over-the-air bit-rate and spreading are constrained by the available payload (EMS) EIRP and bandwidth.

5 Laboratory and Over-the-air Trials

The overall utilization plan of the *ATB* Test Bed encompasses three trial phases, namely:

- *experiments*: this first phase, in which the ATB Test Bed is used in the so-called <u>stand-alone mode</u>, aims to verify, in the laboratory, the proper operation and the performance of the new packet-access and multicast mode, in conjunction with different satellite constellations and in presence of diversity, handoffs and interference caused by other system users;
- *validations*: this phase, in which the ATB Test Bed is used in the so-called <u>collocated mode</u>, will be performed in the context of an "extended laboratory" also including equipment & facilities for getting access to the satellite and the satellite itself (i.e., the SATB). The validation phase should be regarded as a means to further validate the new operational modes in presence of real via-satellite links;
- *demonstrations*: main aim of this phase, in which the *ATB* Test Bed is used in the so-called <u>detached mode</u>, is to demonstrate to the public the performance of a future S-UMTS system based upon a geostationary satellite, with the aim to increase awareness on S-UMTS and to promote the utilization of satellites as a complement to the terrestrial UMTS infrastructure. Demonstrations will be performed utilizing the *SATB* in conjunction with ad-hoc developed applications, integrating several service components, i.e. InfoEntertainment (as location based Multimedia Infomobility Records, news, weather reports, audio clips), Video-conferencing, Web access, e-mailing, and rely upon the broadcasting, multicasting and unicasting capabilities of the underlying radio system.

Mode	Link	Bit-rate (kbit/s)	Chip-rate (Mchip/s)
Circuit point-to-point (DCH)	FL	*8*	*3.84*
		48	0.48
		128	*3.84*
		384	3.84
	RL	*8*	*3.84*
		16 or 32	0.48
		128	*3.84*
Packet point-to-point (DSCH in the FL, dRoD and RASA in the RL)	FL	48/24	0.48
		384/192	3.84
	RL	8/128	3.84
		16 or 32	0.48

Table 2 ATB Test Bed operative modes

Experiments will be performed at the Space Engineering laboratory in Rome, where the *ATB* Test Bed will be integrated. Validations and demonstrations will initially be performed in northern Italy, around the Lario region, where the GW station owned and operated by Telespazio to support operational services over the EMS payload (aboard Italsat F2 satellite) is located. The experimental setup is shown in **Figure 8**. Two MSs will be used, i.e., a nomadic MS mounted in a mini-rack and a proper mobile MS housed in the ESA-provided technologically-advanced van. The van is equipped with facilities aiming to facilitate trials and increase the amount of collected information, e.g., measurement & recording equipment, a GPS receiver and ancillary sensors permitting remote position monitoring & visualization and data storage together with accurate time & position information, data logging for real-time and off-line analysis of relevant parameters, a wireless interface allowing to detach the MMI from the MS and permitting to demonstrate indoor service extension in the nomadic mode.

6 Conclusions

Both the *ROBMOD* and *ATB* projects witness the feasibility of demonstrating the operation of very complex communications systems in real-time, and are expected to remarkably help in developing the operators' awareness on satellite systems advantages, thus stimulating key players' interest for complementing their UMTS networks by a via-satellite system. Said projects have also significantly contributed in advancing the technical knowledge on S-UMTS, and have led to a set of technical recommendations which are about to be conveyed into the ETSI S-UMTS Working Group in co-ordination with the EC IST project SATIN. Cross-fertilisation between *ATB* and other EC-sponsored activities was already achieved in the past, and more are welcome to occur in the future.

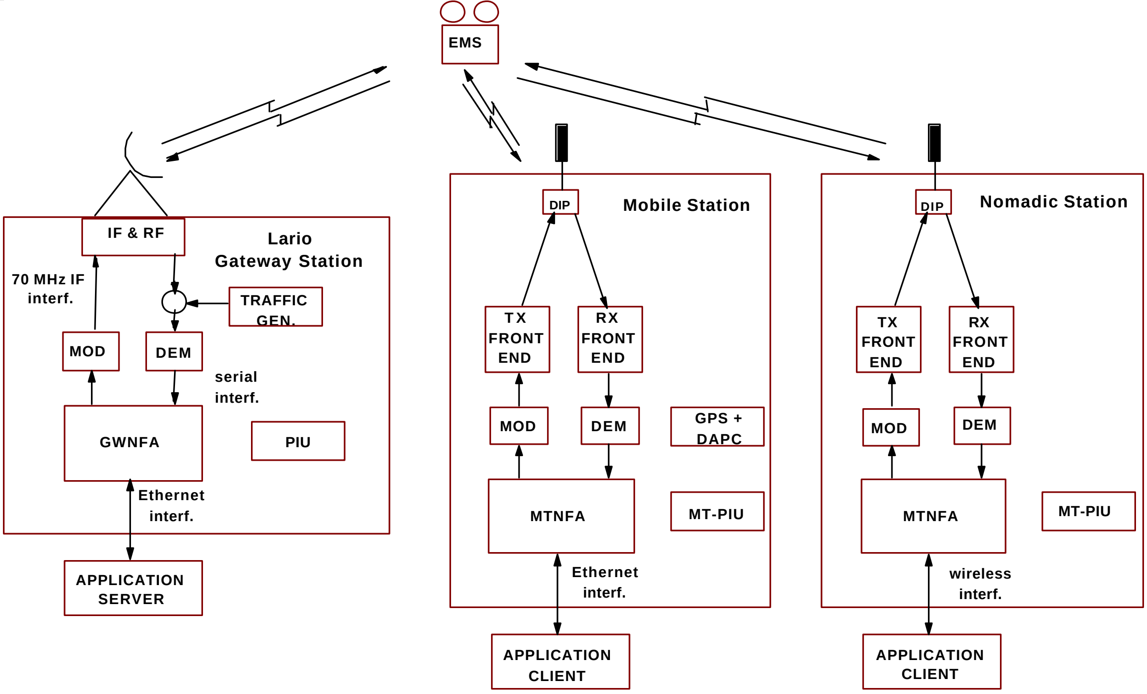


Figure 8 Via-satellite trial set-up

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