Fixed Service in 23 and 38 GHz Bands Network Applications and European Standardisation Overview

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Introduction

The increasing demand for communication in Europe and all over the world has dramatically changed the scenario of radio-relay applications and market in the last 10 years.

The typical applications of Fixed links, for trunk and regional connections among switching centres of the public network operators, was quickly changed, first by requirement of Private networks for digital telephony and data transmission in medium-large business companies and soon after by the initial deregulation, in some countries, of fixed network operators and then by the advent of second operators of mobile networks, which requires quick deployment infrastructure for connecting a large number of GSM Base Stations.

In particular most of the above new applications are required in an urban and sub-urban areas, where connections are relatively short but a large number of them may be envisaged.

The frequency bands 23 and 38 GHz has been the natural choice for these applications.

These bands are allocated by ITU (International Telecommunication Union) and by the ERC (European Radiocommunication Committee) of CEPT (the European Conference of Postal and Telecommunications Administrations) to Fixed Service (FS), in co-primary sharing with other services.

In this document a brief discussion about the propagation related performance characteristics in both frequency bands is reported; moreover the reader will find a description of the various phases of ETSI (European Telecommunication Standardisation Institute) and ERC standardisation and regulatory issues since 1990, which led to the present published Standards EN 300 197 v1.2.1 [1] and EN 300 198 v1.2.1 [2], harmonised in CEPT Countries.

Propagation Characteristics and Outage Prediction for the 23 and 38 GHz Frequency Bands

The applications and the microwaves technology in these bands, are characterised by physical electromagnetic factors:

- relatively high rain induced attenuation
- relatively low transmit power available from solid state power devices.
- relatively high antenna gains
- relatively small size and simple design, possible in these frequency ranges, that is attractive for the production of relatively low cost equipments if compared to those required in the conventional high capacity trunk oriented frequency bands (i.e. up to 11 GHz).

These characteristics highly match to the typical urban environment, characterised by short hops, crowded interference scenario and requirement for low ambient impact of equipments and antennas.

The availability parameter is the major concern were high rain intensity rate is expected; ITU-R had long since studied the rain induced attenuation and many recommendations has been made.

In particular ITU-R Recommendation P.530 [3] contains all the reference to predict the rain-induced attenuation behaviour for the various climate zones into which the world has been divided.

In a second ITU-R Recommendation F.1102 [4] the relationship between rain intensity rate, hop length and link budget in order to predicted the link outage has been made explicit.

In F.1102 [4] no universal hop length versus frequency characteristic can be constructed, however the following parameters contribute to the availability objectives on hop length:

- Free Space Specific Attenuation:
  $\mathcal{A}_0$ [dB/km]
  frequency dependent, is derived from ITU-R Recommendation P.525 [5]
- O_2 and H_2O Gaseous Absorption Attenuation :
  $\mathcal{A}_a$ [dB/km]
  frequency dependent in the relevant frequency ranges, reported in ITU-R Recommendation P.676 [6], derived from the older CCIR Report 719 [7]
- Antenna Isotropic Gain :
  Gi [dB]
  it is a constant depending on geometrical size of antennas, with no theoretical upper bound, but practically limited, to allow feasible boresigth alignment, by field operability of the 3 dB main beam angle width (normally not narrower than 1°).This leads to a practical upper limit of G ≅ 45 dB.
- Transmit Power :
  P_T [dBm]

related to the available technology for RF carrier generation/amplification and to the linearity requirement of the modulation format.

- BER Threshold :

  P_{Th} [dBm]

  relative to the relevant BER* at which the availability objective is defined. This parameter is related to the receiver Noise Figure, the transmitted Bit-rate and the Carrier-to-Noise ratio performance of the modulation format.

- Rain Attenuation for the time-percentage objective :

  $R_{l\%}$ [dB]

  estimated on the basis of rain-rate intensity for the required unavailability time percentage, through the method reported in ITU-R Recommendation P.530 [3], derived from older CCIR Report 721 [8], using statistics for rain zones obtained from ITU-R Recommendation P.837 [9].

  Figure 1 shows the general rain climate zones for Europe and Table 1 gives the relative rain rates as reported by P.837; more detailed national subdivision should be found from the relevant National weather or radiocommunication authorities.

The above parameters may be subdivided into two blocks [note 1]:

- A fixed, implementation depending, constant "Hop Gain" (HG):

$$HG\ [dB] = 2Gi + |P_{Th}| + P_T$$

- A rain-rate/frequency depending for a given time percentage objective, "Hop Attenuation" ($HA_{l\%}$) over the length l [km] of the hop as foreseen by ITU-R Recommendation P.530 [3]:

$$HA_{l\%}\ [dB] = R_{l\%} + (\mathcal{A}_0 + \mathcal{A}_a) \cdot l$$

Using the above approach, graphics like those reported in Fig. 2, 3 and 4 (computed as an example for the climatic zones E, G and K on the most unfavourable polarisation H) may be derived, from which the maximum hop length, for the given implementation, frequency band, climatic zone and unavailability time-percentage objective (%U), may be obtained.

Note 1 : In general, Radio Systems above 17Ghz are supplied with integral antennas or very short antenna connections, in these assumptions feeder losses are neglected; in case of feeder connections between equipment and antenna, the feeder losses will decrease the Hop Gain (HG)

Earliest Application of Fixed Radio Links in 23 and 38 GHz Bands: Business Leased Lines and Private Fixed Networks

Market requirement for digital leased lines at data rate N x 2 Mbit/s and 34 Mbit/s for medium large business locations commenced around 1990.

At that time, the public network operators were the only actors on the telecommunications service providers scenario and the European standardisation body for FS, the STC-TM4, had been just moved from the responsibility of CEPT (an organisation among European P&T Administrations only), to the more customer and market-oriented, newly established, ETSI (a wider organisation among Administrations, Network Operators, Service Providers and Manufacturers).

It were also present the first signs of the radical changing scenario which today impacts the fixed Radio market: British Telecom had been privatised and a second fixed network operator (Mercury) had been allowed in UK.

At that time the Fibre Optic network was not yet widely implemented, therefore the „Radio solution" was the natural choice for quick deployment of wide band digital connections for leased lines and private networks (for which Mercury was the largest example)

Initial ETSI Standardisation - ETS 300 197 and ETS 300 198

Following the market requirement, the recently established ETSI STC TM4 opened, in 1990, two of its firsts Work Items DE/TM-4001 and DE/TM-4003 which led, through the various phase of drafting and approval by Public Enquiry (PE) by the National Standards Organisations (NSO) to the first issue, in 1994, of ETS 300 197 [10] and ETS 300 198 [11] in the 38 and 23 GHz, respectively.

Due to the relatively new, market demand for Europe, the technical characteristics, reported in these ETSs, were a collection of a wide variety of systems already available, at that times, on the world market with system capacities ranging from 2 Mbit/s up to 140 Mbit/s. They were designed with far different technologies, ranging from the simplest FSK modulation to the more complex QPSK.

This resulted in large difference in the basic characteristics of spectral efficiency (e.g. from 0.3 to 1.3 bits/Hz), system gains (e.g. large difference in Signal-to-Noise error performance and Noise-Figure) and frequency stability (e.g. up to 50 p.p.m.).

Notwithstanding these not homogeneous characteristics, the standard was considered to be successful and many countries started to utilise links with equipments based on these ETSs.

The CEPT/ERC Harmonisation of the Channel Arrangements

In the meantime the CEPT recognised that in European countries many different frequency channel arrangements were in use, in particular for 23 GHz; this re-

quired the equipments to cover a large difference in Duplex Frequency.
From technology point of view, this results in different characteristics required to the radio-frequency design (e.g. to duplexer filters and local oscillator design).
These differences burdened the cost and flexibility of equipments which could not benefit of larger production volumes.
Therefore CEPT, after long debate in ERC WG FM, reached an agreement in order to recommend harmonised Radio frequency channel arrangements, to which, in due time, all CEPT countries should conform.
ERC Recommendation T/R12-01 [12] was approved in 1991 and T/R13-02 [13] in 1993 for the bands 38 and 23 GHz, respectively.
These recommendations provide different options of Radio frequency channels bandwidths, from 3.5 to 140 MHz, for accommodating the various transmission capacities foreseen by ETSI standards.
All the channels are obtained by aggregation of multiples of a basic 3.5 MHz channel raster, with a unique Duplex Frequency of 1008 MHz for 23 GHz band and 1232 MHz for 38 GHz band.
In this scenario, the basis for a new generation of mass-production, commercial equipments were established.

Increasing Demands for Fixed Links:

The Mobile Networks Infrastructure

In the last years, the advent of mobile communications and the liberalisation for the GSM network operators, opened a new phase for the Fixed Service in these bands.
The second and third operators, in order not to depend too much on the incumbent network operator for the transport infrastructure, took the decision to implement their own network to connect base stations, with point-to-point Radio links, mainly in urban areas and in 23 and 38 GHz bands.
The necessity of deployment of large number of links in very short time, created difficulties in frequency planning that could hardly be realised with the required precision and timely actions.
Therefore the market of these new operators rewarded flexibility in Radio equipments and in particular frequency agility and remote power control, were considered of great help in their network.

The ERC Decisions :

–CEPT Harmonisation of ETS 300 197 and ETS 300 198

–Mutual Recognition of Conformity Assessment Procedures

The ERC recognised that, for harmonised fixed and mobile radio services to be introduced successfully throughout Europe, manufacturers and operators must be given the confidence to make the necessary investment in the development and procurement of new systems. Commitment by CEPT Administrations to implement ERC Decisions will provide a clear indication that equipments, conforming to approval regulations based on an ETS, subject of the Decision, will have the benefit of a Europe-wide market.
Due to the relatively large market for equipments under ETS 300 197 and ETS 300 198, the ERC decided that they were worth to become harmonised standards and benefit of the withdrawal any conflicting national standards and of any forthcoming simplified regulatory procedures for type approval.
ERC Decisions provide the necessary mechanism for CEPT Administrations to commit themselves to implement, within their national regimes, the ETS, subject of the Decision, and withdraw any conflicting national standard.
Consequently, in co-operation with ETSI, the ERC developed two ERC Decisions, ERC/DEC(96)/08 [14] and ERC/DEC(96)/09 [15] for the two ETSs 300 197 and 198, respectively.
ETSI issued in early 1997, an amended version of ETSs 300 197 (Amendment 2) [16] and 300 198 (Amendment 1) [17] for cross-referencing the ERC Decisions and open for harmonisation of these standards.
In addition, in the continuous search for facilitating this incumbent market which would give benefit to all European community, CEPT considered also harmonising the procedure for placing equipments in operation from the point of view of the Regulatory Bodies.
Traditionally, CEPT Administrations have in principle required radio equipment to be type approved to a relevant (national) technical standard. Economies of scale and harmonisation made it in the interest of the manufacturers to produce radio equipment for the largest possible markets, with a minimum of cost and effort.
CEPT Administrations therefore promoted the harmonisation of technical standards as far as possible, harmonising and simplifying type approval procedures, supporting mutual acceptance, among Regulatory Bodies, of the results of type testing.
As a first step ERC WG-RR produced in 1994 the CEPT/ERC Recommendation 01-06 [18] on the procedure for mutual recognition and more recently an ERC

Decision ERC/DEC(97)10 [19] on the same argument has been adopted by ERC.

Under these decision, the state members adopting it should recognise the type test and type approval, issued by another state member, of Radio equipments designed under harmonised standards requirements.

These countries should drop any additional national procedure and this would quicken the introduction of Radio systems in CEPT countries as soon as they have shown conformity.

Second Generation Equipments and the New Release of ETSI Standards - EN 300 197 and EN 300 198

As described before, the market requirements and the available technology for equipments in 23 and 38 GHz is considerably changed since the production of the first stable draft of the standards by ETSI TM4 around 1992.

New generation of equipment has been introduced on the market offering modern features such as:

- more robust and complex modulation formats (e.g. OQPSK and CPM/TFM) or more efficient multistate or coded formats (e.g. QAM, BCM and TCM)
- low noise RF preamplifier
- forward error correction (FEC)
- frequency agility and RF synthesisers
- higher frequency stability
- remote transmit power control (RTPC)
- adaptive transmit power control (ATPC)
- multi-rate operation
- more options for SDH transport
- standardised antenna performances

These characteristics, led ETSI members participating to ETSI TM4 to open in 1996 a revision work-item for the two ETSs.

In particular the multi-rate operation, where multiple bit-rates may be synthesised on the same system through software pre-setting, requires that the spectrum masks for the various rates are of parametric type (i.e. the same shape scaled only in frequency).

SDH operation was also enhanced introducing the medium capacity rates STM-0 (subSTM-1) and also provision for the forthcoming low capacity rates for transport of NxVC12 (subSTM-0), today in final standardisation phase in ITU-T SG15.

Introduction of multistate formats for the highest rates (STM-0 and STM-1) reduced in practice the bandwidth requirement to a maximum of 56 MHz.

WG TM4 had also recently produced ETS 300 833 [20] standardising the antenna characteristics that are also considered essential for frequency co-ordination; reference to this standard was also required.

ETSI TM4 approved the new version of the standard by the end of 1997; ETSI had in the mean time changed the types of deliverables, ETSs no longer are produced and in their place ENs (Europ_ische Normung) have been introduced.

Meanwhile ERC in close contact with ETSI was producing new ERC Decisions related to the new version of the two standards.

Therefore, after the approval of the new versions of the standards, become, in early 1998, EN 300 197 v1.2.1. [1] and EN 300 198 v1.2.1.[2], new ERC Decisions, for these ENs, ERC/DEC(98)08 [21] and ERC/DEC(98)09 [22] have been developed in parallel, approved and published nearly at the same time.

The Future and the New EC Directive RE&TTE

Nowadays the market demand is in continuous evolution, the European Community, besides for the mobile networks, has liberalised competition also for the fixed networks; these fact would require even more Radio systems to be deployed in next years.

The ERO (European Radiocommunication Office of ERC) has recently published an ERO Report [23] on the expected market, applications and regulatory aspects for Fixed Radio in the next years.

From this report, derived from the analysis of opinions freely offered by European Administrations, Network Operators, Service Providers and Manufacturers, it may be seen that the frequency bands 23 and 38 GHz are far from being saturated and a large number of new links are expected to be required by new Network Operators.

In particular, it is reported the importance of a careful and „smart" frequency co-ordination in order not to waste spectrum efficiency because of interference among different Operators; it is therefore required that expertise on frequency planning, traditionally residing within the „old Public PTTs", is rapidly acquired by the Administration departments specially devoted to this task for co-ordination among the different Operators sharing the same frequency band.

It is also underlined the requirement for new systems options which may offer, in the most crowded network areas, higher spectrum efficiency (e.g. using multistate modulation formats) also for the smaller channel bandwidths (i.e. 3.5 to 14 MHz) .

The European Manufacturer accepted the challenge and ETSI WG TM4 has opened other two new revision WI on ENs 300 197 and 198 in order to extend the standardisation to more multistate modulation options; therefore a new release of these ENs is already in progress.

These new releases, as for the past ones, while introducing the new higher efficiency options, would maintain standardisation requirements for the present systems. All these options balancing system complexity and cost with the network requirements, will offer the market all the choices for the best satisfaction of final customers.

As additional change on the telecommunication scenario, the European Commission considered that the present procedures, for type testing and approval of Radio systems, are still too complex in the interest of a timely and cost effective introduction of new systems when the demand from the market raise.

Therefore a new draft Directive RE&TTE (Radio equipment and Telecommunication Terminals) has been prepared and is expected to be approved by the European Parliament in early 1999.

This new directive will aim to replace the present regulations of type test and approval by the regulatory bodies, with a supplier declaration which automatically gives „presumption of conformity" to a harmonised standard.

The only pre-requisite from regulatory point of view should be that, in the case of radio equipment using frequency bands, the use of which is not harmonized through the European Community (such are the 23 and 38 GHz), the supplier responsible for placing the equipment on the market shall notify the national authority, responsible in the relevant Member State for spectrum management, of the intention to place such equipment on its national market.

Regulatory Bodies would change their role from the present type approval responsibility to that of surveillance of the market to avoid equipments to deviate from the spirit of the directive and causing harmful interference to other ones in the same network.

Conclusions

It has been shown that the two frequency bands in subject, 23 and 38 GHz, are among the best examples of how equipment standardisation and regulatory procedures should operate and improve in close relationship with the market requirements, that are in continuous evolutions.

This will eventually end in the best satisfaction, in terms of services availabilty, quality and cost for the final customer, the European Citizen.

The Author

After the degree in Electronics Engineering at University Politecnico of Milan, joined GTE Telecomunicazioni SpA, in 1972, where he covered, with increasing responsibilities, various positions in the development of microwave components and Digital PDH and SDH Radio System design. While GTE Telecomunicazioni migrated into Siemens Telecomunicazioni and then into present Italtel spa, he maintained its responsibilities in the R&D sector.

Presently he is in charge of medium and high capacity microwave system integration and of co-ordination in international standardisation activity for Fixed Radio Systems.

Since mid 1997 he is Chairman of ETSI WG TM4 (Fixed Radio Systems).

He is also active member in ITU-R SG 1-TG1/5 (Spectrum Management/Unwanted emissions), ITU-R SG 9 (Fixed Systems), ETSI TC ERM (EMC and Radio Matters) and ETSI TC TM (Transmission and Multiplexing).

References

[1] ETSI EN 300 197 v1.2.1 (2/1998): Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Parameters for radio relay systems for the transmission of digital signals and analogue video signals operating at 38 GHz

[2] ETSI EN 300 198 v1.2.1 (2/1998): Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Parameters for radio relay systems for the transmission of digital signals and analogue video signals operating at 23 GHz

[3] ITU-R Recommendation P 530 Propagation data and prediction methods required for the design of terrestrial line-of-sight systems

[4] ITU-R Recommendation F.1102 : Characteristics of radio-relay systems operating in frequency bands above about 17 GHz

[5] ITU-R Recommendation P.525 Calculation of free space attenuation

[6] ITU-R Recommendation P.676 Attenuation by atmospheric gases

[7] CCIR Rep.719 : Attenuation by atmospheric gases

[8] CCIR Report 721 Attenuation and scattering by precipitations and other atmosphere particles.

[9] ITU-R Recommendation P.837 : Characteristics of precipitation for propagation modeling.

[10] ETSI ETS 300 197 (3/1994)+ Amendment A1(5/1995): Transmission and Multiplexing (TM); Parameters for radio relay systems for the transmission of digital signals and analogue video signals operating at 38 GHz

[11] ETSI ETS 300 198 (4/1994) Transmission and Multiplexing (TM); Parameters for radio relay systems for the transmission of digital signals and analogue video signals operating at 23 GHz

[12] ERC Recommendation T/R12-01 (Helsinki 1991) Harmonised radio frequency channel arrangements for analogue and digital terrestrial fixed systems operating in the band 37 GHz-39.5 GHz

[13] ERC Recommendation T/R13-02 (Montreaux 1993) „Preferred channel arrangements for Fixed Service in the range 22.0 - 29.5 GHz"

[14] ERC Decision, ERC/DEC(96)/08 (11/96) on the adoption of approval regulations for equipment to be used for radio relay systems operating in the fixed service for the transmission of digital signals and analogue video signals operating between 37 GHz and 39.5 GHz, based on the European Telecommunications Standard (ETS) 300 197

[15] ERC Decision, ERC/DEC(96)/09 (11/96) on the adoption of approval regulations for equipment to be used for radio relay systems operating in the fixed service for the transmission of digital signals and analogue video signals operating between 21.2 GHz and 23.6 GHz based on the European Telecommunications Standard (ETS) 300 198

[16] ETSI ETS 300 197 Amendment A2 (3/1997)

[17] ETSI ETS 300 198 Amendment A1 (3/1997)

[18] CEPT/ERC/RECOMMENDATION 01-06 E (Brussels 1994) „Procedure for mutual recognition of type testing and type approval for radio equipment „

[19] ERC Decision, ERC/DEC (97)/10 (6/97) on the mutual recognition of conformity assessment procedures including marking of radio equipment and radio terminal equipment

[20] ETSI ETS 300 833 : Transmission and Multiplexing(TM); Digital Radio Relay Systems (DRRS); Antennas used in point-to-point DRRS operating in the frequency band 3 to 60 GHz

[21] ERC Decision, ERC/DEC (98)/08 (3/98) on the adoption of approval regulations for equipment to be used for radio relay systems operating in the fixed service for the transmission of digital signals and analogue video signals operating between 37 GHz and 39.5 GHz, based on the European Standard (Telecommunications series) EN 300 197 V1.2.1

[22] ERC Decision, ERC/DEC (98)/09 (3/98) on the adoption of approval regulations for equipment to be used for radio relay systems operating in the fixed service for the transmission of digital signals and analogue video signals operating between 21.2 GHz and 23.6 GHz, based on the European Standard (Telecommunications series) EN 300 198 V1.2.1

[23] ERO Report : Fixed Service trends post-1998 (5/1998)

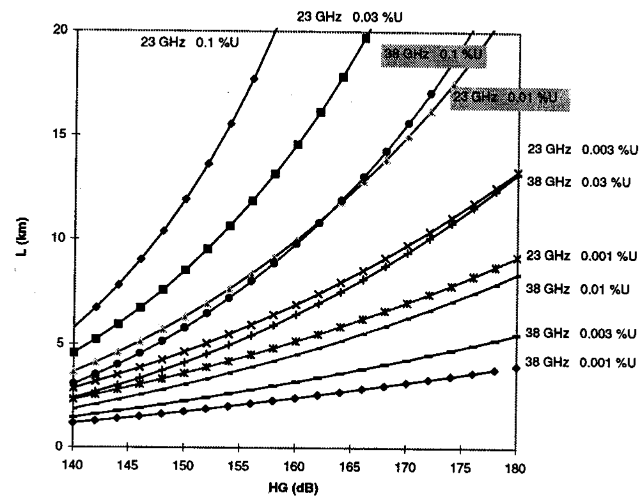

Fig. 2 Critical hop length vs hop gain
(Rain zone E - H polarisation worst case)

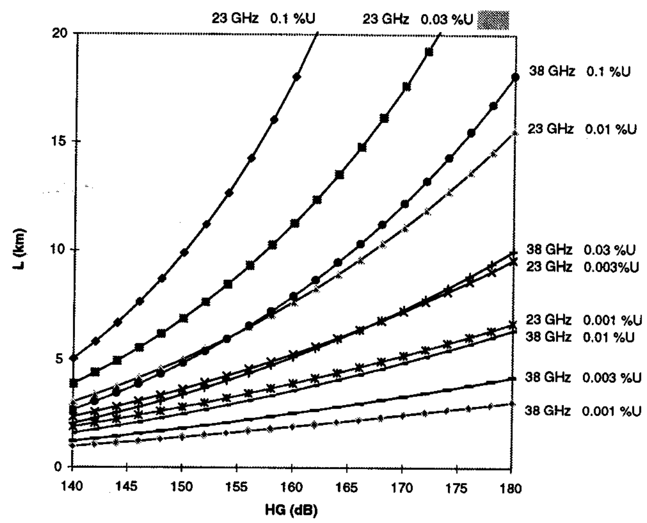

Fig. 3 Critical hop length vs hop gain
(Rain zone G - H polarisation worst case)

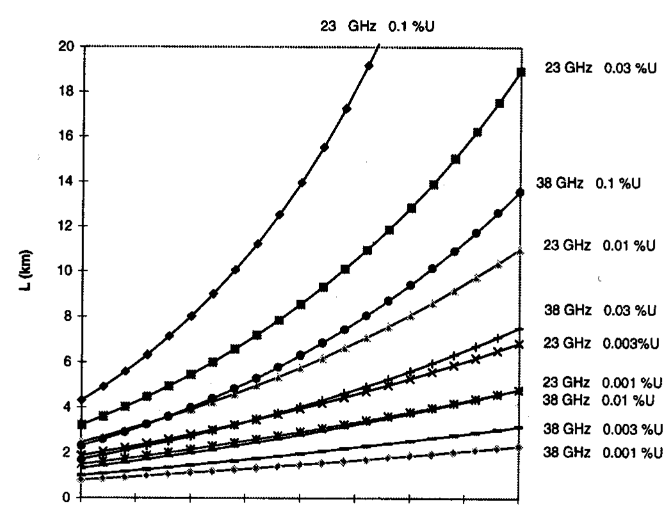

Fig. 4 Critical hop length vs hop gaim
(Rain zone K - H polarisation worst case)

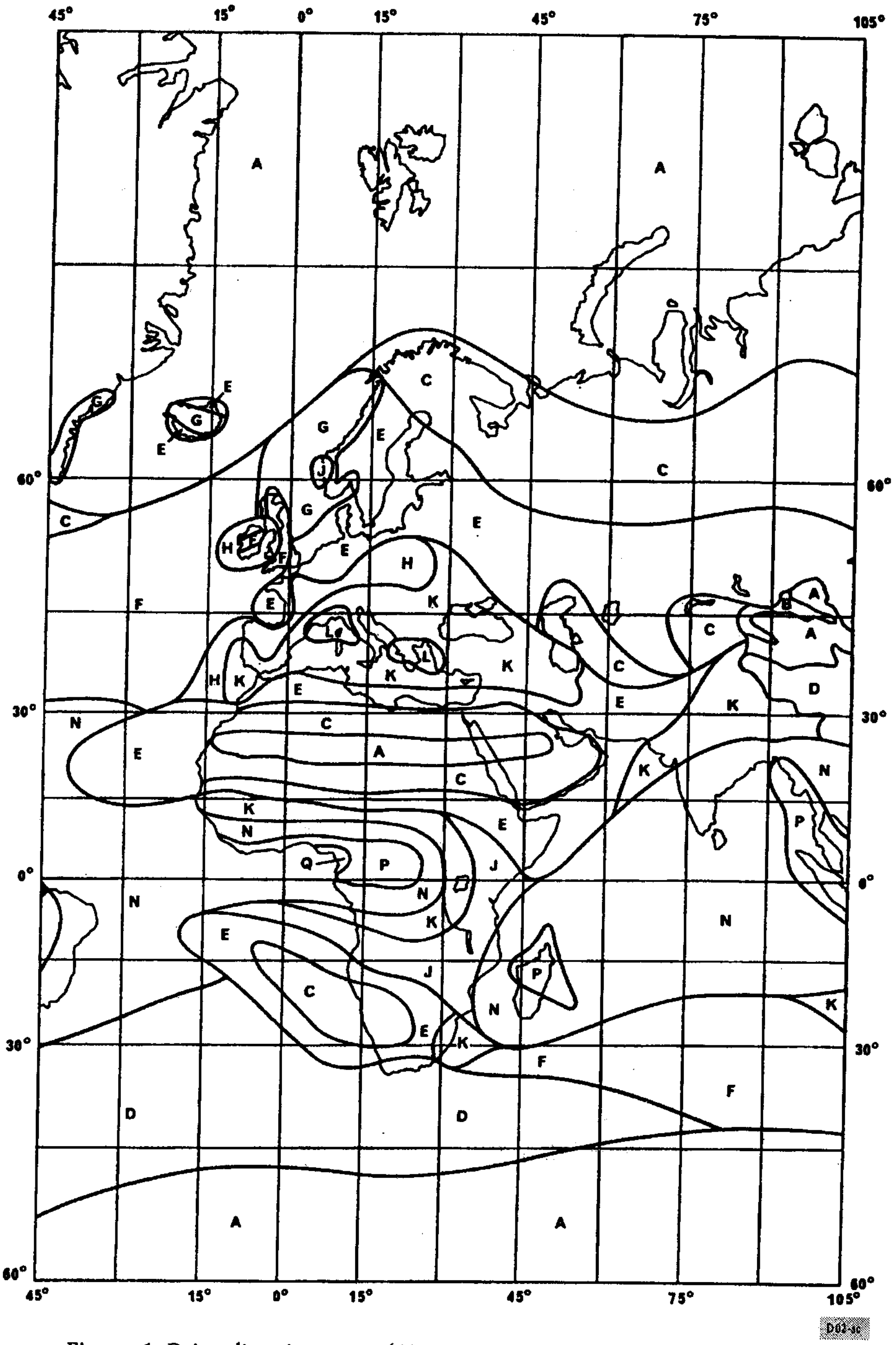

Figure 1 Rain climatic zones (ITU-R P.837-1; Reference to Table 1)

TABLE 1
Rain climatic zones Rain zones
Rainfall intensity exceeded (mm/h) (ITU-R P.837-1; Reference to Figure. 1)

Percentage of time (%)	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
1.0	<0.1	0.5	0.7	2.1	0.6	1.7	3	2	8	1.5	2	4	5	12	24
0.3	0.8	2	2.8	4.5	2.4	4.5	7	4	13	4.2	7	11	15	34	49
0.1	2	3	5	8	6	8	12	10	20	12	15	22	35	65	72
0.03	5	6	9	13	12	15	20	18	28	23	33	40	65	105	96
0.01	8	12	15	19	22	28	30	32	35	42	60	63	95	145	115
0.003	14	21	26	29	41	54	45	55	45	70	105	95	140	200	142
0.001	22	32	42	42	70	78	65	83	55	100	150	120	180	250	170