Availability of Radio Relay Systems of the TELEKOM Srbija Network

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Abstract

The Annual Plan of the Yugoslav PTT Community for 1997 also included the analysis of availability of radio relay systems of the Telekom Srbija network. This analysis was based on data concerning the number of failures of radio relay systems in the course of the last year. The paper explains the term of availability and gives a short analysis of the network and of the report for 1997.

Introduction

Telekom Srbija, being a fixed and mobile operator, offers a wide range of services. From the subscriber's point of view, technical aspect of signal transfer - cable or radio, type of modulation, type of exchange, etc. are of no importance. Good quality of service at any moment is what is essential for a subscriber. In order to inspect functionality and quality of the telecommunications system, operator carries out availability analysis of the whole network as well as of subsystems of network i.e. of the corresponding interval of time in which a subscriber gets particular service and the operator makes profit.

In the Telekom Srbija telecommunications network, radio relay systems are of great importance. The whole length of the radio relay hops is 5946.52 kms (4253.7 kms being analog and 1692.88 kms digital). Figures 1 and 2 show participation of analog and digital RR systems: it can be seen that only small percent of analog systems (3.6%) is on the short haul level and 61% of them is on the long haul level.

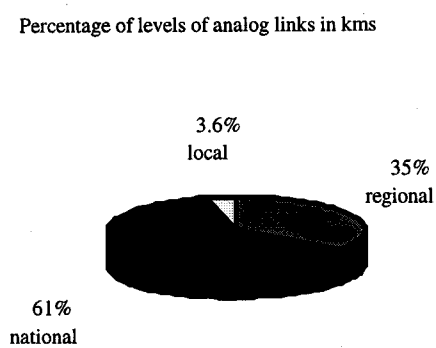

Figure 1

The situation with digital systems is almost equal: 23% of connections are on the short haul level, 42% medium and 35% on the long haul level. This difference is due to growing use of digital mini-links of lower capacity (2Mbit/s and 8Mbit/s) on medium and short haul level. Such links are used in Telekom Srbija network because of their easy and quick installation, good quality and relatively low price.

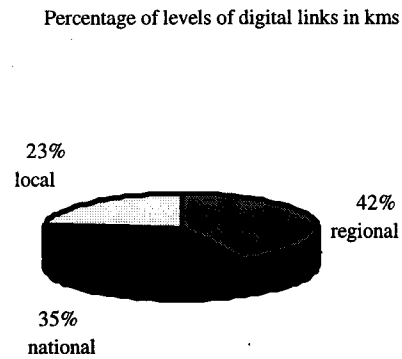

Figure 2

1. Availability as a Term

Availability is defined in CCITT Recommendation G.821 as follows:

A period of unavailable time begins when the bit error ratio (BER) in each second is worse than $1x10^{-3}$ in a period of ten consecutive seconds. These ten seconds are considered to be unavailable time. The period of available time terminates when the BER in each second is better than $1x10^{-3}$ in a period of ten consecutive seconds. These ten second are considered to be available time.

Causes of unavailability can be due to equipment failure or propagation disorder. Basic reasons for propagation disorder are multipath fading and fading due to rain. Multipath fading is typical for radio relay systems operating at frequencies lower than 10 GHz. RR systems operating over 10 GHz are sensitive to climatic conditions (especially rainfall). Thus, in temperate climates (in Europe, for example), 11 GHz frequency band is used for long haul transmission, whereas in tropical climates it is only used for short haul applications.

The reliability of modern digital radio relay equipment is comparable to other types of transmission equipment. Reliability of equipment is usually expressed as a mean-time between failures (MTBF). Some manufacturers of modern digital radio relay equipment claim MTBFs of the order of 100,000 hours for an unprotected terminal or one-way repeater. Reliability also depends on the duration of the interruptions that occur at each failure. Duration of this interruption is normally described as the Mean

Time Between Restore (MTBR). Interval failure time is calculated from the beginning of the failure until the moment of the traffic restore. (Recommendation on radio relay systems maintenance U.3. „Zbirka propisa iz oblasti RR-2 sistema", published by ZJPTT, Belgrade, 1986).

Total unavailability of a system is defined as:

$$\text{Equipment unavailability} = \left(100 - \frac{\text{MTBF}}{\text{MTBF} + \text{MTBR}} \times 100\right)\%$$

The availability objective in Telekom Srbija network is given concerning the hypothetical length of 2,500 kms and its value is 99.5%. For RR systems of shorter lengths, availability is calculated by formula (100–0.5×L/2500) %, where L is length in kilometers.

2. Analysis of the Failure Report and RR Systems Availability

Recommendation for radio-relay systems maintenance U.3. („Zbirka propisa iz oblasti RR-2 sistema", published by ZJPTT, Belgrade 1986), item 9. – Failure Records (paragraph 9.5.) proposes formulas to define failures and classify them in the Book of Failures.

Analysis of data regularly delivered by each responsible regional branch to the Network Division helps to determine quality of transmission performance, the most frequent causes of failures, as well as further steps to be taken in order to reduce number of failures.

The following categories are being considered:

- Capacity of a RR system (number of telephone channels)
- Modulation type (analog/digital)
- Type of failure (longer then 1 minute)
- Number of failures
- Total failure time interval
- Time interval of failures per 100 kms and average failure time interval per 100 kms
- Time interval of particular failure in relation to the total failure time interval in percents and
- Availability of RR systems for 1997 that did or did not fulfill CYPTT objectives.

Table 1 represents all failures of the RR systems. Causes of failures are divided into several categories:

- RR unit with modem and secondary alignment
- Switching
- Antenna and waveguide
- Power supply
- Propagation
- Human factor
- Planned failure
- Damage

As the analysis example, we have observed digital RR equipment of high capacity (140 Mbit/s i.e. 1920 th. ch.) and analog equipment of low capacity (120 th. ch.).

Table 1. shows that digital equipment usually suffers from propagation failures, while planned failures and power supplies are on the second place. Equipment failures never happened, which can be explained by the fact that modern equipment have spare channels as a protection. On the other hand, it can be seen that with the old analog equipment (mostly without protection), there were no failures due to propagation, but only due to malfunction of RR equipment and power units.

Parameter of number of failures per RR link is very useful for comparing qualities of RR links. This parameter is the worst in analog systems of low capacity (24 and 60 th. ch.); the best is in digital systems of capacity 480 th. ch. (1.15h per RR link). Considering the number of equipment failures (excluding propagation, planned failures and human factor), we can see that the parameter was best with digital systems of capacity 30 and 1920 th. ch. (0.2 per RR link).

It is important to note that only in one case the cause of failure was human factor. Comparing failure time interval of RR systems on national, regional and local level (Figures 3a, 3b and 3c), it is obvious that digital systems are better.

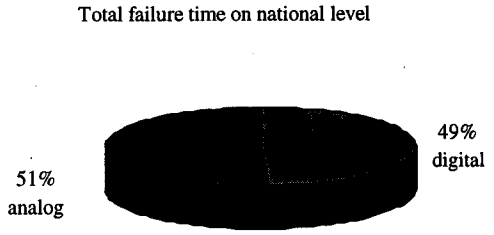

Figure 3(a)

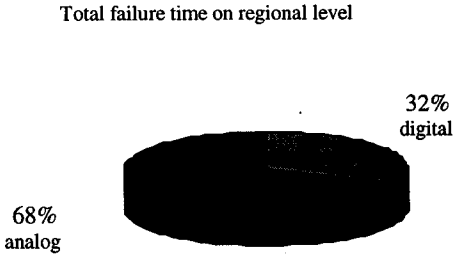

Figure 3(b)

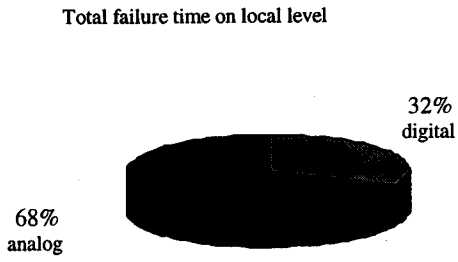

Figure 3(c)

Digital RR systems are characterized by very small percent of failures in national and regional RR links, which is welcome considering the international traffic priority (Figure 4).

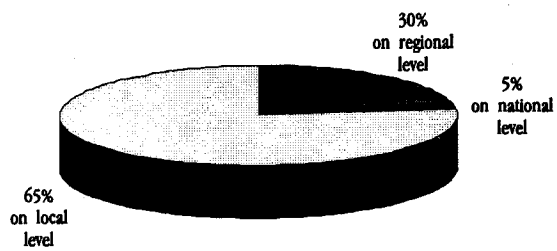

Figure 4

Finally, Table 1. shows that in 1997 were:

-51 failures of 137h duration in RR equipment with modem and power unit,
- 6 failures of 3.54h duration in protection switching,
-13 failures of 22.4h duration in antennas and wavequide,
-76 failures of 218h duration in power supply,
-71 failure of 72.5h duration due to propagation conditions,
- 1 failure of 0.5h duration caused by human factor,
-10 planned failures of 8.27h duration,
- 3 failures of 41h duration caused by damages.

The total amounts to 231 failures in the duration of 503.3h. Availability is calculated based on the failure time interval:

Failures of more than one minute duration are taken into consideration.

Failure time interval per kilometer of link (TK) is calculated (total failure duration time/lenght of RR link).

Availability is calculated on a year's level (365×24h=8760h).

Availability per 100 kms is:
((8760-Tk×100)/8760)×100%;
Availability per 2,500 kms is:
((8760-Tk×2500)/8760)×100%

AVAILABILITY OF TELEKOM SRBIJA RR SYSTEMS IN 1997				
Capacity of RR link	A/D	Availability per 100 kms	Availability per 2500 kms	Per-centage of RR links that fulfill CYPTT objec-tives
1920	D	99.98	99.5	100%
1800	A	99.97	99.3	84%
960	A	99.96	99.1	86%
480	D	99.96	98.9	88%
300	A	99.78	94.6	62%
120	A	99.86	96.4	62,5%
120	D	99.83	95.5	65%
60	A	99.58	89.5	75%
30	D	99.29	82.3	75%
24	A	99.37	84.3	50%

RR systems on the national level generally fulfill objectives of availability for RR links, while availability of low capacity RR links should be increased. One solution is digitalization of RR links on the local level. RR links of higher capacity mainly fulfill CYPTT objectives. Digital RR systems of 1920 th. ch. capacity fall into the only category that fully satisfy the CYPTT objectives. RR systems of lower capacity fulfill CYPTT objectives in a small percent, so their availability has to be increased. However, it should be noted that, if links of lower capacity were assigned classes 3 or 4 (according to CCIR Recommendation number 1052), percentage of availability would be higher.

3. Conclusion

The most frequent causes of failures are:

- Power supply (34%),
- RR equipment with modem and power unit (27%),
- Propagation (14%).

Total failure time interval is 503.3h, which means 0.052h or 3.16 min per kilometer (note that average expected failure time interval for optical systems is 10 min per km) (Ref. „Master Plan for Republic of Srpska" - OTE 1996).

Availability in 1997 compared with that in 1996 is much better. Total duration of failures is reduced from 843.3h to 503.3h. Particularly, failure due to equipment disorder has dropped from 409h to 137h. Failure time interval due to human factor and

planned failures are both minimized, which indicates good organization and skill of maintenance personnel.

It has to be noted that number of digital RR links has increased by 10%, which also improved availability of the system as a whole. This fact is leading us to the conclusion that faster renovation of RR links is necessary.

Table T.1. 1997

NUMBER OF FAILURES AND FAILURE TIME PER CAPACITY

A/D	Capa-city of RR link	Num-ber of RR links	Length of RR links (kms)	Number of failures/failure time (hrs)																	
				RR unit with modem and secondary alignment		Switching		Antenna and waveguide		Power supply		Propa-gation		Human factor		Planned failure		Damage		Total	
D	1920	5	622.57	0	0	0	0	0	0	1	0.93	17	7.08	0	0	2	3.63	0	0	20	11.64
A	1800	25	1895.5	16	9.81	3	1.7	10	2.25	19	28.6	6	1.67	0	0	0	0	0	0	54	44.01
A	960	23	1035.7	3	7.75	2	0.34	0	0	10	24.4	1	0.36	0	0	1	0.33	0	0	17	33.22
D	480	8	233.66	1	0.66	0	0	0	0	1	1.8	3	3.74	0	0	1	1.5	1	1.5	7	9.2
A	300	27	731.97	13	29.6	1	1.5	2	18.4	12	82.2	5	6.67	0	0	0	0	0	0	33	138.4
A	120	16	444.64	5	12.5	0	0	1	1.75	7	18.7	0	0	0	0	4	0.81	1	22	18	55.74
D	120	29	792.6	7	24.5	0	0	0	0	7	18.2	38	52.8	1	0.5	2	2	1	17.5	56	115.5
A	60	4	68.64	2	11.3	0	0	0	0	3	14	1	0.22	0	0	0	0	0	0	6	25.47
D	30	5	43.97	1	27.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	27.33
A	24	3	77.3	3	13.7	0	0	0	0	16	28.9	0	0	0	0	0	0	0	0	19	42.58
	Σ	145	5947	51	137	6	3.54	13	22.4	76	218	71	72.5	1	0.5	10	8.27	3	41	231	503