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KRATKO ILI PRETHODNO SAOPŠTENJE / SHORT OR PRELIMINARY REPORT

OPTIMIZATION OF THE TELECOMMUNICATIONS NETWORK BETWEEN TWO AIR TRAFFIC CONTROL CENTERS USING MICROWAVE LINKS

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Abstract: *Microwave line of sight transmission is one of several transmission media in modern commutation. An important part of microwave network is to account for these conditions and provide technical corrections. Currently, the Telecommunication Network (TN) between the two area air traffic control centers in BHANSA is based on leased lines from the "Consortium", which consists of three telecom operators in Bosnia and Herzegovina. In this way, the quality of services provided through such a network depends on the availability of such a network. The disadvantages of this solution are the high cost of leasing telecommunication lines, the lack of end-to-end supervision of the entire network by BHANSA staff, the dependence of service maintenance and any request for future capacity increase requires the procurement of new services from the telecom operator, which implies new costs. The aim of the work is to offer a transport network solution that will be based on microwave links (MW) with high output power (HP) and a long range, which reduces the number of jumps in the network and in a protective configuration, with sufficient capacity to meet the current and future needs of BHANSA.*

Keywords: *Microwave link, Communications Regulatory Agenncy, Cost-benefit.*

JEL classification: *M2, O2, Y5*

INTRODUCTION

Telecommunications transmission facilities are the physical means of communicating large amounts of information over distance (Musaab Ali Abdelrahim, January

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2019). Two area air traffic control centers in BHANSA called ATCU I and ATCU II are connected with the largest number of leased lines. Leased lines are used to transmit data for services such as G/G, A/G, DPS, METEO, OLDI, AMHS, radars, etc. Taking into account the schedule of locations to be connected, the most optimal option for implementing own MW links is shown in Figure 1 (Atom, 2018). The frequency bands proposed by the Communications Regulatory Agency (RAK) are: 6 GHz (so-called 6L) in "rural areas" and so-called "Long-haul" connections and 13 GHz in "urban areas".

Figure 1. The optimal option for implementing MW links

Source: (Author's and coupedecheveux2015)

The services of traditional digital lines from this Offer are provided according to the prices from the Price list as indicated in the table below (BHTELECOM, 2020).

Table 1. Overview of the price list for leased lines

1.	Iznajmljena linija s kraja na kraj				
1.1.	Pristupna taksa, jednokratno po priključnoj tački			Cijena (KM)	
1.1.1.	64 kb/s			360,00	
1.1.2.	128 kb/s			450,00	
1.1.3.	256 kb/s			540,00	
1.1.4.	512 kb/s			720,00	
1.1.5.	1 Mb/s			1.035,00	
1.1.6.	2 Mb/s			1.350,00	
1.1.7.	34 Mb/s			4.050,00	
1.1.8.	155 Mb/s			5.670,00	
1.1.9.	622 Mb/s			Na upit	
1.2.	Mjesečna naknada	Cijena (KM)			
	Brzina	Lokalna	Međumjesna M1	Međumjesna M2	Međumjesna M3
1.2.1.	64 kb/s	135,00	261,00	396,00	477,00
1.2.2.	128 kb/s	180,00	432,00	585,00	720,00
1.2.3.	256 kb/s	234,00	612,00	810,00	1.080,00
1.2.4.	512 kb/s	357,00	846,00	1.170,00	1.575,00
1.2.5.	1 Mb/s	517,00	1.053,00	1.980,00	2.700,00
1.2.6.	2 Mb/s	702,00	1.476,00	3.168,00	4.005,00
1.2.7.	34 Mb/s	3.933,00	5.729,00	8.218,00	10.991,00
1.2.8.	155 Mb/s	6.618,00	10.636,00	20.761,00	31.863,00
1.2.9.	622 Mb/s	Na upit	Na upit	Na upit	Na upit

Source: (BHTELECOM, 06/2020.)

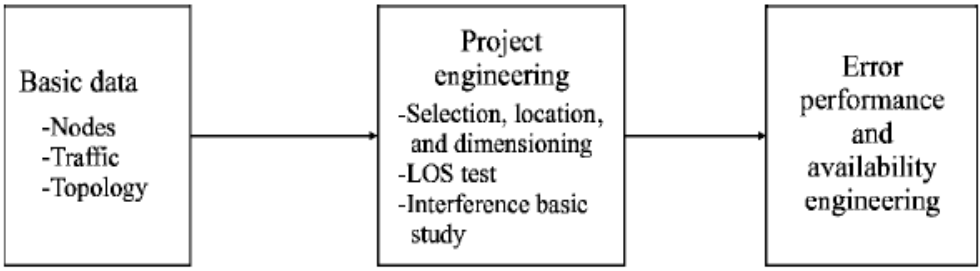
BHANSA has a signed SLA contract with telecom operators regarding leased lines (BHTELCOM&BHANSA, 2020).

SOLUTION PROPOSAL AND NETWORK IMPLEMENTATION - CONNECTING ATCU I AND ATCU II

This solution envisages the connection of the ATCU I and ATCU II sites via the VHF/radar site Jahorina and the Vlašić site, which is owned by BHRT (Radio and Television of Bosnia and Herzegovina). This implies the implementation of three MW hops: ATCU I - Jahorina, Jahorina - Vlašić and Vlašić - ATCU II.

The design and planning of a microwave line of sight LOS link is usually a complex task that involves diverse interrelated aspects. Obviously, all the mentioned engineering tasks: path engineering, link performance engineering, the design of an adequate frequency plan, and the choice of equipment of the link will be closely interrelated. Figure 2. provides a simplified diagram that illustrates the design flowin the planning process of a microwave LOS link (PABLO ANGUEIRA, 2012).

Figure 2. Planning process diagram

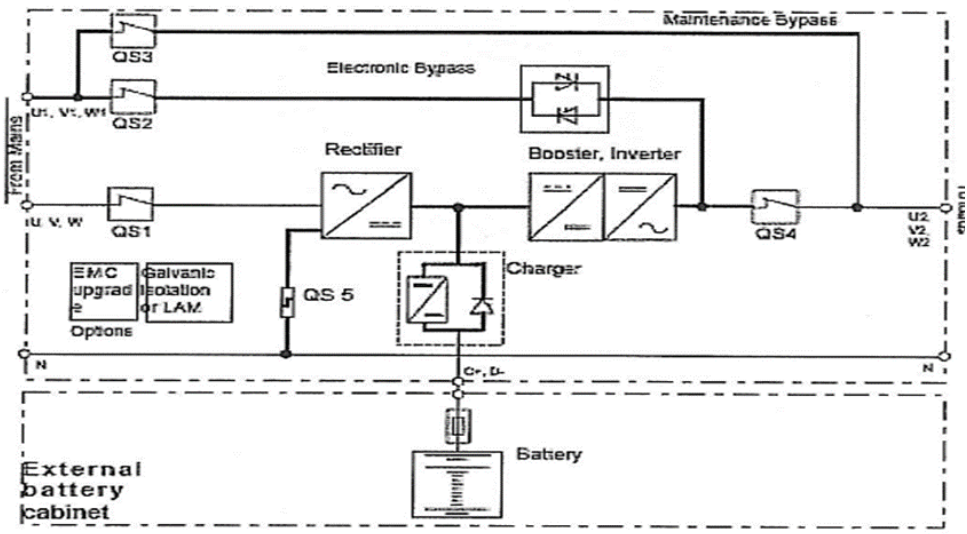


Source: (Pablo Angueira, Juan Antonio Romo, 2012.)

It is planned that the annual availability of operational services in the MW chain ATCU I - ATCU II will be at least as much as the current availability of telecom lines between the mentioned locations (99.99%), and it is desirable to be even higher. With this availability and that of protected connections, which continue to be provided by telecom operators, the total annual availability of services transmitted via the said connections would be at least equal to the current service availability, with great financial savings and complete network monitoring by BHANSA.

Uninterruptible Power Supply or UPS (Uninterruptible Power Supply) are electronic devices designed to overcome various problems that sensitive consumers connected to the electrical distribution network may have, whether it is various impulse disturbances, short-term and long-term overvoltages or undervoltages, or complete loss of network voltage. The diagram for the UPS is given in Figure 3.

Figure 3. Block diagram of an uninterruptible power supply device



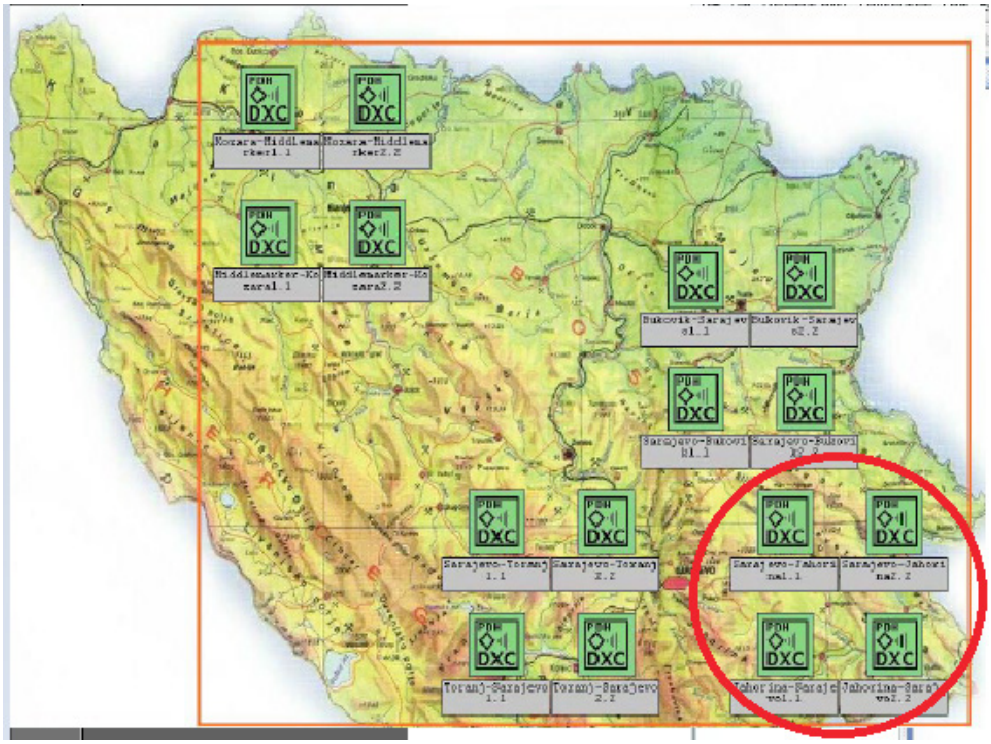
Source: (BHANSA)

Hop ATCU I – Jahorina

RAK's recommendation is to keep 13 GHz for this hop. At this hop, BHANSA already has a microwave link at 13 GHz, which would be replaced with a new one. The current Mini-Link would be used for spare parts after replacement. By replacing the existing links on this hop with new devices, about €21,500.00 would be saved.

The configuration at the ATCU I location would be the so-called "Split", where the radio unit would be installed next to the antenna, and the "indoor part" in a rack in the technical room, while an "All-indoor" variant should be foreseen in Jahorina, where all electronic circuits would be located inside the building, and the antenna on the object. Only one antenna would be installed at all locations, and it would be double polarized, so that two radio modules of the MW device could be connected to it. Instead of the existing ones that have been around for over 10 years, new antennas need to be provided for this hop. The monitoring of the existing MW links at the Jahorina location is shown in Figure 4. (CNS.UPU.055, 2022).

Figure 4. Existing link monitoring



Source: (Author's & BHANSA)

Supervision of technical systems implies constant monitoring of the proper functioning of all parts of the technical system with the aim of ensuring its operational usability, and is a part of maintenance (CNS.PROC.003, 2022).

Hop Jahorina – Vlašić

At the Jahora location, the antenna would be mounted on the existing building. At both locations, envisage an "All-indoor" variant, where only the antennas would be exposed to harsh weather conditions, and the electronic parts would be located inside the facility. The building and the pillar on Vlašić are owned by BHRT. Also, rectifiers and batteries with an autonomy of eight hours should be foreseen. High performance (HP) antennas should be provided at all locations.

According to information from the RAK, there is a lack of frequency channels in the frequency ranges that are intended for "long-haul" connections, so that the same frequency will be used for the intended configurations, but each radio will be on a different polarization. This is achieved on the so-called XPIC option, which should be predicted. Band 6L with a channel width of 40 MHz is planned for this hop (about 96 km). This also avoids double payment of frequencies to RAK for spectrum use.

Hop Vlašić – ATCU II

The length of this hop is about 76 km. The same as for the Jahorina - Vlašić hop, for this route it is necessary to provide a frequency range of 6L with a channel width of 40 MHz. The equipment on Vlašić for this hop will be identical to the Jahorina-Vlašić ("All-indoor") hop. The antennas would be installed on a pole owned by BHRT. At the ATCU II location, envisage a "Split" version of the MW device. The antenna with ODU (outdoor) radio units would be mounted on the ATCU II facility, while the so-called "indoor" part installed in the technical hall inside the building.

A more detailed overview of the needs for the mentioned locations can be found in the table below.

Table 2. Location Needs Overview

Location name	Mounting variant	Antenna diameter	Carrier required	A ladder is required	The length of the cable or waveguide	Dehydrator required	EE needs
ATCU I	Split	1,2 m Jahorina	NO	NO	25 m (RF cable)	NO	NO
Jahorina	All indoor	1,8 m ATCU I	YES	YES	2 x 30 m waveguide	YES	Rectifier and batteries
	All indoor	1,8 m Vlašić	YES		2 x 30 m waveguide		
Vlašić	All indoor	2,4 m Jahorina	YES	NO	2 x 45 m waveguide	YES	Rectifier and batteries
	All indoor	2,4 m ATCU II	YES		2 x 45 m waveguide	YES	
ATCU II	Split	1,8 m Vlašić	YES	YES	20 m (RF cable)	NO	NO

Source: (Author's)

Based on past experience in maintaining MW links, the equipment manufacturer has committed itself to the SLA contract to deliver spare parts in a timely manner (BHTELCOM&BHANSA, 2020).

COST-BENEFIT ANALYSIS

In order to make a CB analysis, it is necessary to compare the costs of renting lines that BHANSA currently pays to the "Consortium", which could be saved by implementing the MW network, then the costs that will arise from the implementation and those that will be generated on an annual basis. The detailed calculation for this is quite large so only the final figures will be given.

The process of implementing new or improving existing aviation technical systems is carried out with the aim of replacing devices/systems whose resources have expired, replacing or improving devices/systems whose operational availability is not at the required technological level, achieving set safety goals, expanding the capacity of existing systems, applying new functionalities, services and possibilities that the existing equipment does not support in accordance with development plans at the European and national level, development plans within BHANSA, as well as the requirements of system users (CNS.PROC.002, 2022).

Initial costs for implementation

In order to achieve long-term savings, an initial investment is required, which includes the acquisition of MW equipment, its installation, testing, commissioning and integration. In addition to microwave equipment, it is necessary to acquire power supply equipment. After the completed preliminary analysis of needs by location and market research, it was established that the total initial (one-time) costs would amount to €282,000.00.

These costs include at least the following:

- MW devices in configuration and characteristics
- Needs by location
- System for centralized monitoring with a server in ATCU I and a client on location in ATCU II
- Construction works by location
- Staff training
- Installation of equipment
- Integration into the existing network
- Project of the performance status
- Set of necessary spare parts

It is also necessary to take into account the costs (RAK) which is responsible for issuing the frequency spectrum.

If the projected benefits outweigh the costs, you could argue that the decision is a good one to make. If, on the other hand, the costs outweigh the benefits, then a company may want to rethink the decision or project. Once those individual costs are identified, it's equally important to understand the possible benefits of the proposed decision or project. Some of those benefits include (Stobierski, 2019):

- Direct: Increased revenue and sales generated from a new product
- Indirect: Increased customer interest in your business or brand
- Intangible: Improved employee morale
- Competitive: Being a first-mover within an industry or vertical

Cost - benefit analysis for ATCU I - ATCU II

The construction of the MW chain on the route ATCU I - ATCU II would create the conditions for transferring part of the leased lines to this chain. The construction of such a MW network also brings some new costs such as:

- Lease of infrastructure at the Vlašić location (installation of equipment in buildings and antenna on a pole)
- Costs of electricity consumption
- Price of using RF spectrum (payment to RAK for frequency licenses)
- Maintenance contract with equipment supplier (first year free of charge)

By implementing our own MW network, the savings on an annual level that would be achieved by transferring a part of the operational network would roughly amount to €234,200.00. The total new costs in this variant amount to about €16,900.00 on an annual basis. This primarily includes infrastructure rental costs, frequency spectrum rental costs, and electricity consumption by location.

By comparing the above-mentioned savings from switching to the MW network and the newly incurred costs, it can be concluded that the implementation would result in savings of around €217,300.00 on an annual basis, not counting the initial costs of purchasing the equipment that were previously mentioned.

The table below shows the costs and savings over a five-year period for ATCU I - ATCU II.

Table 3. Cost and savings ratio for ATCU I and ATCU II locations

Ordinal	Years	Year I	Year II	Year III	Year IV	Year V
1.	Initial investment in the network (€)	282.000,00	-	-	-	-
2.	Infrastructure rental costs (€)	12.885,00	12.885,00	12.885,00	12.885,00	12.885,00
3.	Electricity consumption (€)	2.086,00	2.086,00	2.086,00	2.086,00	2.086,00
4.	Frequency spectrum costs (€)	1.840,00	1.840,00	1.840,00	1.840,00	1.840,00
5.	MW chain maintenance (€)	-	-	-	-	-
6.	Total costs without maintenance (€)	298.811,00	16.811,00	16.811,00	16.811,00	16.811,00
7.	Savings on line rental (€)	234.020,00	234.020,00	234.020,00	234.020,00	234.020,00
8.	Difference: Savings-Costs	-64.791,00	217.209,00	217.209,00	217.209,00	217.209,00

Source: (Author's)

From the table above, it is evident that the initial investment for the construction of the network, as well as the annual costs, would pay off in about a year and a half. In addition to the above-mentioned costs, it is necessary to keep in mind the network maintenance costs, which will appear after the end of the first year from the signing of the contract (item 5 in the table).

Based on past experience in maintaining MW links, the equipment manufacturer has committed itself to the SLA contract to deliver spare parts in a timely manner (ABB, 2022).

POSSIBLE PROBLEMS

This method of communication intended for the exchange of messages via a data transmission link is also prescribed by the State Ordinance (BHDCA, 2018). Like every implementation, this one also has the so-called "Pros" and "Cons". All the positive aspects have been mentioned in the previous part of the work (especially the increase in availability and reliability with the acquisition of supervision over a part of the network over which until now BHANSA had no supervision, as well as significant financial savings on an annual basis).

It is necessary to appoint personnel who will carry out the tasks established by the rulebook and assign them appropriate powers (Sl.glasnik BiH, 2020).

The required quality of services, including the required availability of requested services, will be defined in service level protocols (SLA) between aviation services and their service users in BHANSA and other ANSPs. These documents will be in accordance with international standards and practices in the field of civil aviation, which satisfy the users of BHANSA services (BHANSA & CNS.PROC.009, 2022).

Some of the negative aspects of performance are listed below:

- Potential problem with the placement of equipment at one of the locations,
- Difficult maintenance due to difficult access to certain locations located at dominant elevations,
- The network is relatively complex, but due to the terrain configuration in the country, a complete solution cannot be achieved with a smaller number of hops than the proposed solution.

In the case of the need to purchase additional spare parts and materials, the competent staff for aviation technology prepares a request for the purchase of spare parts (CNS.PROC.003, 2022).

CONCLUSION

The overall goal of this research is to offer a better optimization of the telecommunications network between two air traffic control centers. This optimization would be based on the implementation of MW links between the two centers. The paper shows the relationship between the costs related to the leased lines and the savings that would occur with the implementation of the MW network. It can be seen that the implementation of the MW network would be profitable in a year and a half, and in each subsequent period it would bring net savings compared to the leased telecom lines by the consortium of telecom operators. Regardless of some negative sides, it turns out that there are many more positive sides such as increased protection for services, increased network capacities, increased network availability and great financial savings.

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