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MODERN COMMUNICATIONS SYSTEMS DEVELOPMENT GUIDELINES IN FUNCTION OF AIR TRAFFIC SAFETY INCREASE IN BOSNIA AND HERZEGOVINA

ABSTRACT

The communications requirements in air traffic control are increasing in complexity. From the middle 90s, huge progress in airport infrastructure, especially in air traffic control systems, has been made in Bosnia and Herzegovina in damage rehabilitation, caused by war conflicts, owing, first of all, to the European Union aid that contributed to the re-establishment of regular international air traffic. The current air traffic control system has matured in its functionality. Therefore, the phase of advancement and preparation for the technological improvement is the next logical step. However, before establishing a new communications strategy, the current application trends have to be analyzed in details according to the existing communications environment interfaces. The goal of this work is to find the guidelines of technological development that will result in more efficiency, safety and economic benefit in the near future, but the air traffic safety must not be compromised by economic benefit.

KEY WORDS

air traffic control, communications system, technological development, air traffic safety, economic benefit

1. INTRODUCTION

The communications requirements in air traffic control are increasing in complexity. However, before establishing a new communications strategy, the current application trends have to be analyzed. The trends go beyond the current need for simple connectivity between the national systems. In the future, the distributed systems will be required that provide managed networks to support the distribution of applications and data across national boundaries.

An even closer integration of air and ground systems, with the information exchange through the data-link is adding a new airborne dimension to the requirement.

New concepts such as the gate-to-gate perspective are extending the scope of the communications systems to accommodate ground-based mobile components. This, in turn, is leading to an increase in the need for the transfer of real-time information, as airport, airline operators, approach and en-route systems must now all be seamlessly involved in data exchange.

Likewise, closer integration of mobile and fixed voice communications services is placing increased emphasis on the need for seamless end-to-end voice services across diverse network technologies. These must show demonstrable economic early benefit and provide a clear direction towards the goals to EATMP (European Air Traffic Management Program).

2. CURRENT ATC COMMUNICATIONS SERVICES OVERVIEW IN BOSNIA AND HERZEGOVINA

The EATMP-communications strategy, which is followed in Bosnia and Herzegovina as well, addresses the communications services, subdivided into:

- Voice communications services, providing the end-to-end and broadcast voice capability for air-ground, air-air and ground-ground purposes between ATCs (Air Traffic Control), aircraft, air-

lines, airports and external organizations e. g. army, using terrestrial and/or wireless technology.
- Data communications services, providing end-to--end connectivity (application to application) and broadcast capability for air-ground, air-air, and ground-ground application purposes between ATCs, aircraft, airlines, airports and external organizations e. g. army.

2.1 A/G (Air/Ground) voice communications services

Instantaneous voice communications between pilots and controllers is central to ATC-strategy for the short and medium term. The strategy is, however, to reduce the voice communication workload for the cockpit and the controller. This measure will increase safety because human errors through misinterpretation of voice messages will be reduced. The key requirement is for controllers and pilots to have (virtually) immediate access to voice communication channel when needed for the communication of safety-critical messages between them.

Today, this is achieved primarily by VHF (Very High Frequency) radio between controllers and pilots by use of routine pre-determined channels that are continually monitored in the air and by ground stations. There are, however, problems of congestion and the availability of channels in the VHF-band.

The ATCCs in Bosnia and Herzegovina are still isolated in the sense of VHF communications, so that VHF signal coverage and redundancy are completely limited (Figure 1).

The main part of the national A/G VCS (Voice Communications System) consists of VCS 3020S installed in Sarajevo ATC and VCS 3020X installed in Mostar ATC. The Voice Communications Systems are connected to VHF receivers and transmitters located in the control tower or remote radio sites that are connected with ATCs via radio links (Bukovik – TWR Sarajevo).

For managing the VHF receivers and transmitters the "in-band" signalization is used with the frequency of 2040 Hz.

2.2 G/G (Ground/Ground) voice communications services

In addition to the A/G voice communications as the most important ones, the G/G fixed voice communications system is also used for air traffic coordination between ATCs.

Bosnia and Herzegovina established the G/G voice communications system at four main airports: Sarajevo, Mostar, Banja Luka and Tuzla, three of which are international airports and the fourth one is used for military purposes (Figure 2).

Due to the realization order and equipping the ATCs in the post-war period, various degrees of interconnection are present. The VCS systems are connected into the common European communications system of Eurocontrol via leased lines of local telecoms. Their connection presents continuous and complex harmonization process with the neighbouring FIRs (Flight Information Region), which is termed by permanent upgrade and modernization processes of these systems.

The upper airspace is delegated to Zagreb FIR and Belgrade FIR in operational sense, and the lower

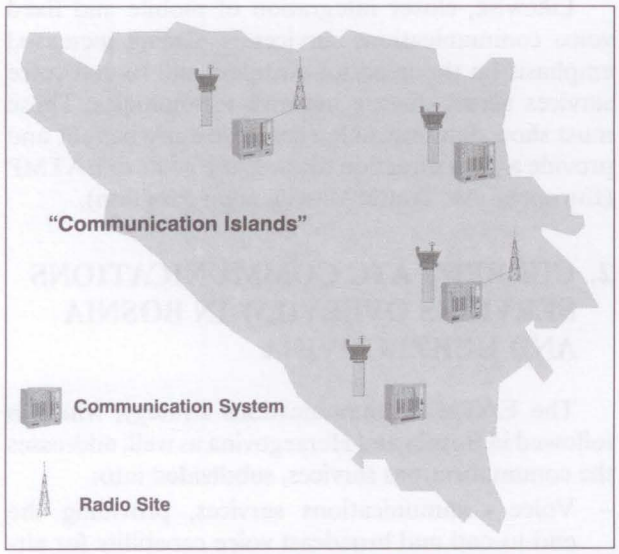

Figure 1 – Current A/G voice communications situation in Bosnia and Herzegovina

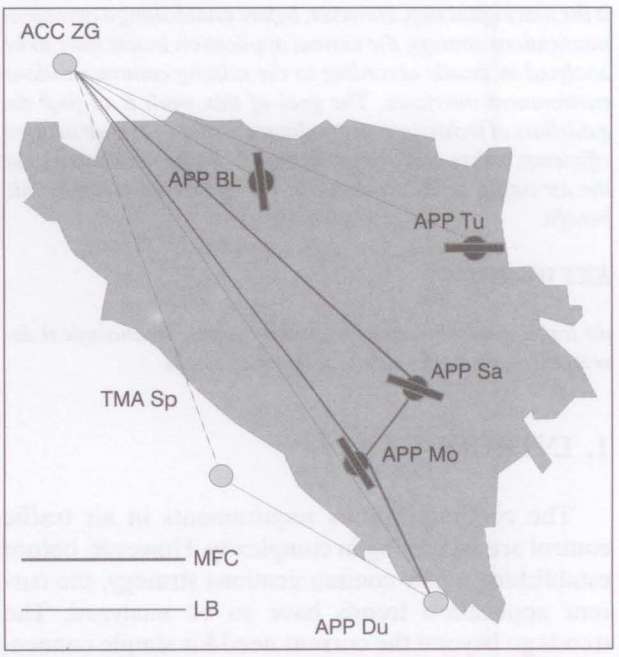

Figure 2 – Current G/G voice communications situation in Bosnia and Herzegovina

airspace is delegated to Zagreb FIR, so the communications part was adapted to that situation as well.

The communications systems use leased capacities for their interconnection, and these are provided by the local telecoms. In international traffic the communications systems are connected to the neighbouring ATCs via the same communications service providers.

The following VCS interfaces and protocols are used in voice communications transmission for aircraft guidance operational purposes in domestic and international air traffic:

- Two-wire LB (Local Battery)
- Four-wire E&M LB
- MFC-R2 (Multi Frequency Coding) Eurocontrol
- PSTN (Public Switched Telephone Network)

The application of these interfaces depends on how each particular ATC centre is equipped and so it presents the limiting factor in global communications in the whole region as well as at the domestic and international level.

In addition to the existing operational ATS-infrastructure new concepts like gate-to-gate or collaborative decision-making will increase the necessity to communicate and interwork with other existing or future networks, and the resolution of the routing and numbering issues.

Access and charging mechanisms have to be studied with regard to future transit traffic requirements (for both, voice and data). In addition, users (aircraft, ground installations at airports) will wish to access the network and will therefore require to be authenticated. Finally, privatized ATCs may wish to charge or recover costs for using the network. The current signalling protocols provide only call-related services and would therefore need to be extended to include security services and charging.

There is an ongoing need to assess whether there are benefits in using shared resources for international operational and administrative voice communications.

2.3 Data communications services

Services to be considered in Bosnia and Herzegovina:

- Radar (TMA radar Sarajevo)
- OLDI (On-line Data Interchange)
- AFTN (Aeronautical Fixed Telecommunication Network)
- CIDIN (Common ICAO Data Interchange Network)
- EAD (European Aeronautical Information Service Database)
- Weather Data: WMO (World Meteorological Organization) and ICAO (information are available via AFTN and local meteo stations)

Bosnia and Herzegovina has currently one radar, located at Sarajevo Airport, which is used for approach air traffic control. The AFTN/CIDIN systems are located in Sarajevo and Banja Luka ATCs and are connected by terminals to other ATCs.

The central part of the EAD system is located in Mostar ATC and is connected by the terminals to other ATCs in the country.

The main feature of all communications systems is the use of the leased lines provided by the telecoms, and each of them is functioning as an autonomous system.

The business objectives for higher levels of automation, better utilization of resources and increased safety levels demand an increased use of data communications services in the future. Data communication between distributed automation components allows better co-ordination, both in air-ground and ground-ground context. Data communications also present a lower cost, but higher integrity alternative to voice communications for not time-critical information exchanges, with less scope for misinterpretation of the message.

In the mid- and long-term, the evolving ATM-concepts, based mainly on optimized capacity management and increased ATC automation will generate requirements for an improved "new generation" data communications service. In addition to the increased need for ATC automation there is a parallel requirement from airlines arising from evolving user needs. Single communication service architecture must be crafted to satisfy all aeronautical data communications needs.

The current ATS data communications infrastructure has been developed in an ad-hoc manner without a consistent architecture and supports many different Legacy applications. The new data communications architecture must allow for the continued operation of the Legacy systems by defining "Legacy adaptation interfaces" between them and the new architecture. New applications will be defined with "standard application" interfaces from the beginning and will gradually replace the Legacy units.

The new data communications service architecture will provide a single vehicle for the operation of Legacy systems, the introduction of new concepts and applications whilst allowing the addition of new technology for ground-ground and air-ground sub-networks via "standard sub-network plugs". The adoption of such a model will protect the investment of ANSP (Air Navigation Service Provider) and airlines by offering data communications service users safe and reliable

data communications services over market leading sub-networks offered by industry.

3. TECHNOLOGIES THAT COULD BRING PROGRESS IN THE NEAR FUTURE

In addition to voice information whose nodes are VCS systems, there is also the data network in Bosnia and Herzegovina (AFTN, EAD) which serves the ATC centres with flight information, NOTAM (Notice to Airman) messages, meteorological data and other data that are important for air traffic safety.

Today's communication systems development in ATC centres in the world increases progressively with the tendency to more complex systems for modern aviation purposes.

Air traffic, as one of the traffic branches, has been expanding over the last few years, that is, the new technology applications are the fastest, that is conditioned by the rapid utilization increase of air traffic in the modern societies.

In that context, the existing systems in Bosnia and Herzegovina have matured in their function, so there is a need for new application technologies.

The voice and data services described earlier require a cost-effective and uniform fixed network. The GGN (Ground/Ground Network) is foreseen as the strategic ground telecommunications infrastructure for voice and data transmission and switching for the aeronautical community. GGN can also support the interconnection of other external networks to support national requirements or identified international requirements (Figure 3).

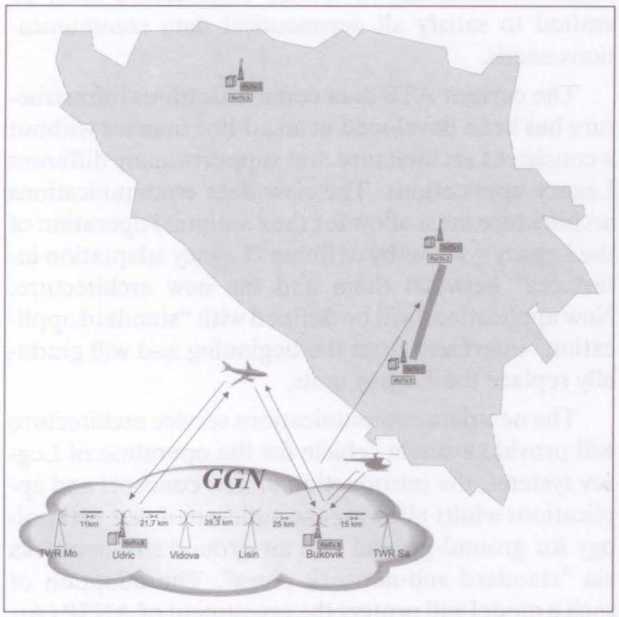

Figure 3 – Future GGN (Ground-Ground Network) between Mostar and Sarajevo ATCs

4. COMMERCIAL COMMUNICATIONS SERVICE PROVIDERS ANALYSIS IN BOSNIA AND HERZEGOVINA

If we take into account everything analyzed by now, we can ask ourselves, who can offer us the required quality of communications service? On the basis of the experience analysis of the domestic telecoms quality, (the entity telecoms and availability statistics for civil aviation purposes), we can conclude the following:

- telecom infrastructure is still very poor for the special users in Bosnia and Herzegovina;
- there are no clearer indications that the situation will change, because modernization moves to users majority, and not to fewer number of special users who require high quality and huge investments in the existing infrastructure;
- the preferred technologies have not been sufficiently tested for air traffic control purposes;
- current resources do not enable highly redundant solutions;
- Quality of Service and the network features are very doubtful;
- high level of operational and physical safety in communications that should be defined by the SLA (Service Level Agreement) with telecoms is not available for air traffic control;
- national strategy is not sufficiently known in the domain of huge investments in the strategic infrastructure of special users.

5. APPLICABLE TECHNICAL SOLUTIONS WITH EARLY BENEFIT AND SAFE LIFE-CYCLE

The solutions and the priority of their solving are the responsibility of the telecoms, that is, the air traffic control service in Bosnia and Herzegovina. In this case the problems and the solutions are being analyzed at the FEDCAD (Federal Civil Aviation Department). It is the ANSP (Air Navigation Service Provider) for Sarajevo, Mostar and Tuzla terminal control area, and as such, it represents the most significant national partner which is directly responsible for the regularity and safety of air traffic in Bosnia and Herzegovina.

Significant efforts have been made for the last few years in order to bring the security component of the most attractive traffic system to the top of the European quality level and so that Bosnia and Herzegovina could become Eurocontrol partner with the same status as other partners.

The priority is to improve the A/G component in the sense of better coverage and voice communications availability in the TMA (Terminal Area) Mostar.

The project is a logical continuation of the tower and approach air traffic control establishment and raising the competence to the wider TMA range that touches Sarajevo, Dubrovnik, Split and Banja Luka. The very frequent EUFOR helicopter flights at lower altitudes in the valleys and hollows impose additional requirements. Being a mountaineous country, Bosnia and Herzegovina, features such a topology that requires more complex and reliable A/G communications technical solutions.

The aim of this work is to review analitically the potentional technical solutions that should give fast improvements and uncompromised air traffic safety increase in Bosnia and Herzegovina.

The investments need to have the cost-benefit analysis that will show the optimal technical solutions with review of the exploatation costs and lifecycle of the technology being used.

This is very important for an ANSP when it is known that the communications technologies are changing rapidly and have short lifecycle. Their selection is the real challenge for civil aviation experts. The world trend is to reduce air traffic service costs for airlines. These projects have direct economic impact on the mentioned trend and require more serious secure, operational, technical and economic analyses.

5.1 VHF radio site selection that should increase A/G communications coverage in Mostar Terminal

The task is complex, because it has to solve several important issues:

- increase of VHF coverage in Mostar TMA;
- the location must have the prospects of future air traffic control infrastructure development in Bosnia and Herzegovina;
- the future radio site infrastructure must have upgrade possibility and be compatible for future internetworking with similar systems;
- the system must comply with the most strict terms, standards and recommendations of such installations in air traffic in Europe and in the world;
- the system realization must be very fast in order to solve the necessities of communications and avoid long-term realization;
- the system must present the basic project and more significant progress towards quality and safety standardization in air traffic in Bosnia and Herzegovina.

5.2 Achievement of high reliability and safety

- the application of the latest technological solutions and secure practice in system design;
- secure-critical system with its quality solution becomes competitive partner in similar communications problems in police, state security and defence requiring similar reliable applications that should be an important factor in the economic benefit analysis;
- high operational availability with emphasized secure component requires adequate solutions checked in practice;
- engagement of experts from this domain with checked references should be the practice in realization.

5.3 Total quality of A/G communications service

- A/G voice-communication design should enable high reliability, availability, regularity and easy maintenance that will be the purpose and the aim, known in secure analysis. The total availability must not be less than 99.9999 % of the time for A/G voice communications.

5.4 Possible applicable solutions on the example of potential location of "Udrič"

- The use of micro location fulfilling the earlier mentioned features. In this case it is the location of Udrič and the spot enabling microwave radio link with Mostar control tower and the Vidova hop on the Čvrsnica mountain and Lisin on the mountain of Prenj in the direction of Sarajevo control tower via Bukovik mountain (Figure 4);

Figure 4 - Radio link connection between Mostar and Sarajevo control tower

- the use of already tested VHF radio aids of well-known world producers with central monitoring and control possibility;
- the radio station object needs to be realized in a modular way (shelter needs to be used because of the fast realization and easy dislocation);
- UPS (Uninterrupting Power Supply) with properly installed earthing must be ensured;
- microwave link must be ensured with the device providing quality voice and data transmission in combination with back-up line;
- all the elements of A/G voice communications in secure chain must have the same availability;

– the radiolocation needs to comply with the operational and physical security.

RECOMMENDATIONS

CONSIDERATION OF NETWORK DESIGN OBJECTIVES

The main objective is to use special designed nodes which could have very high redundant topology to meet the required A/G communication availability (Figure 5).

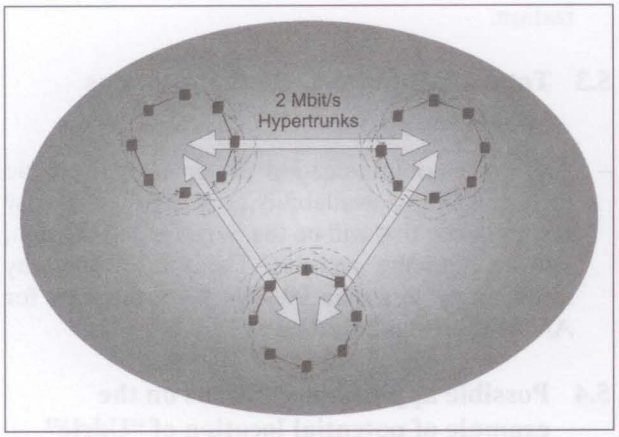

Figure 5 - Super node topology

The problem of predicting and analysing GGN--performance and specifying parameters of GGN--components is a complex design task which seeks to optimise a number of conflicting aspects e. g. topology, throughput, capacity and costs (Figure 6).

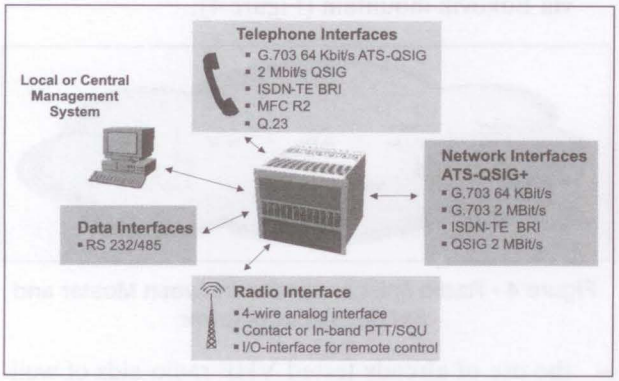

Figure 6 - Network nodes and their connectivity recommendation

Integration of analogue and digital G/G networks and protocols is highly recommended (Figure 7).

GENERAL REMARKS

– it is obvious that the future infrastructure has to be fast and reliable to meet requirements for air traffic communication services;
– step-by-step implementation of infrastructure will be possible, which permits co-existence of the existing and new technology;

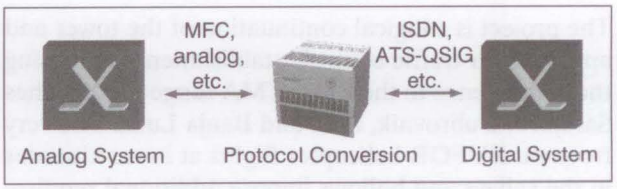

Figure 7 - Communication systems with different protocols can be integrated via Protocol-converter node

– the GGN (Ground-Ground Network) will have high QoS (Quality of Service) and high availability.

MAIN DESIGN GUIDELINES

– to overcome communication problems establish own GGN;
– set up the priority to safety critical issues and solutions with early benefit like A/G coverage and availability;
– wherever possible, COTS (Commercial Off the Shelf) products and services will be incorporated and used, rather than aeronautical industry-specific solutions. However, this may have impacts on the lifecycle because of the higher rate of change of industry standards and products;
– those communication services spanning national boundaries shall conform to international standards. The minimum number of standards should be mandated, in order to minimise implementation costs. Also, the development of aeronautical standards should be kept to the lowest possible.

5. CONCLUSION

It is clear from all the above mentioned that the existing telecommunication service providers in Bosnia and Herzegovina have still very poor infrastructure and technology that cannot serve the special users requirements such as ATCCs (Air Traffic Control Centers).

Therefore, the service that they can offer for the time being is very questionable.

The objective of this work is to see all the facts that will serve that FEDCAD as ANSP (Air Navigation Service Provider) in the Federation of Bosnia and Herzegovina starts the project of establishing its own telecommunication network, that is interconnection of Mostar and Sarajevo ATCCs, that will be independent and will have high degree of reliability, availability and maintainability.

The own telecommunication network (GGN) would serve for integral transmission of all kinds of information (voice, data and video).

The justification of investment in this project is not questionable, especially, if we take into account the fact of how much of financial funds have to be spent

per month or per year for leasing of voice channels from the existing telecommunications service providers.

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SAŽETAK

SMJERNICE RAZVOJA MODERNIH KOMUNIKACIJSKIH SUSTAVA U FUNKCIJI POVEĆANJA SIGURNOSTI ZRAČNOG PROMETA U BOSNI I HERCEGOVINI

Zahtjevi za komunikacijama u centrima kontrole zračnog prometa postaju sve kompleksniji. Od sredine 90-ih godina prošloga stoljeća do danas, u Bosni i Hercegovini su učinjeni veliki iskoraci u saniranju šteta na infrastrukturama zračnih luka, a posebno sustava kontrole letenja, izazvanih ratnim sukobima, zahvaljujući, prije svega, pomoći Europske Unije, što je doprinijelo ponovnoj uspostavi redovitoga međunarodnog zračnog prometa. Sadašnji je sustav kontrole letenja sazrio u svom funkcionalnom dijelu, te stoga, slijedi faza unaprjeđenja sustava i pripreme za sljedeći tehnološki iskorak u razvoju. Međutim, prije uspostave nove strategije razvoja komunikacijskih sustava, trenutni aplikacijski trendovi moraju biti detaljno analizirani prema sučeljima postojećega komunikacijskog okruženja.

Cilj je ovoga rada pronalaženje jasnih smjernica tehnološkoga razvoja, koje će u bliskoj budućnosti pokazati veću efikasnost, sigurnost i ekonomsku isplativost, pri čemu sigurnost zračnog prometa ne smije biti kompromis ekonomske isplativosti.

KLJUČNE RIJEČI

kontrola zračnog prometa, komunikacijski sustav, tehnološki razvoj, sigurnost zračnog prometa, ekonomska isplativost

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