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Integrated Radio Communication Systems based on IT

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Abstract. *Paper deals with complex solutions of radio communication systems for special application especially in air traffic control ATC and integrated rescue systems IRS area. Basic customer demands for such applications are briefly described and discussed from point of view of multi band antenna systems and SW transceivers. The architecture design of an ATC and an IRS system is demonstrated including remote monitoring and control RMC system. High contribution of IT is demonstrated to solve the problem of the mobile communication system infrastructure with connectivity based on standard interfaces*

Keywords

Radio communication systems, Air traffic control (ATC), Search and rescue (SAR), Remote monitoring and control (RMC), Information technology (IT) applications

1. Application Area

Modern radio communication devices and their parts and options are the basic components to built up an integrated complex system usable in air traffic control (ATC) or search and rescue (SAR) applications. In these cases the basic application demands are:

- capability of voice and data communication in different frequency bands,
- voice and data communication with ground vehicles, aircrafts and helicopters, work team members, the operators and cooperating staff,
- bidirectional data transfer and connectivity based on standard interfaces and protocols,
- remote monitoring and control of all system parts and subsystems,
- open architecture and flexibility to reconfigure the devices and system as a whole dependent on real situation and working conditions,
- capability to work under hard environment condition, robustness and stability,
- high reliability.

As we can demonstrate on the practical examples system designer has to solve also a quite important problem of system integration of very complicated complex of different specialized devices from a variety of producers and distributors. Such today devices and systems are characterized by intensive implementation of information technology HW/SW including digital processing algorithms and procedures as guarantee of fulfilling the system function variability and adaptability to customer demands.

In this article we would like to roughly describe some design possibilities how to solve the problem of system integration and technology monitoring using IT oriented solutions.

2. ATC system design

A mobile ATC system under discussion provides transportation, build-up, and operation of radio communication, radio navigation, landing lights and support systems for air controllers to enable secure GAG communication and landing of helicopters on temporary landing zones. Discussion is about an autonomous system independent of any support except the long distance sea or air transportation. Land surface transportation is provided by trucks.

It is necessary to take in account three basic demands when a mobile ATC system has to be designed with adequate architecture to fulfill the basic application parameters:

- mobility (system has to allow transportation and built up a heliport/helipad in a operation work area),
- functionality (system can be used for radio landing navigation of helicopters),
- complexity (system consists of all technologies needed to built up a heliport - communication, navigation, lightening and power system including all necessary cabling).

The ATC communication system has to provide: (a) ground to air radio communication between control tower operator and helicopter pilots in the checked area covering frequency bands AM/FM/SSB2-30MHz, AM/FM30-88MHz, AM/FM100-150MHz, AM/FM 220-400MHz, (b) ground to ground radio communication between cooperating stands and navigation requires frequency band AM/FM(SSB)2-30MHz with min.100W, (c) ground to ground link and digital data connection.

A manpack radio station for ground to air communication has to be included in ATC system covering frequency bands AM/FM2-30MHz, AM/FM30-88MHz, AM/FM100-150MHz, AM/FM 220-400MHz with min AM modulation power 10W. The satellite voice communication and data transfer subsystem has to guarantee cooperation with host system.. A multiband receiver covering frequency range AM/FM1,5-512MHz has to be used for monitoring radios and rescue system.. Ground to ground communication will be covered by handheld radio station working in 30-150MHz frequency band wit output power >2W.

2.1 A Mobile Heliport System (MHS) Design

MHS design has to reflect all the basic requirements so we can divide the system into two main parts – fix mounted control tower technologies (CTT) used for ground-to-ground (GAG) communication and navigation including operators places and supporting complementary technologies (SCT) to fulfill all the operational requirement of heliport as stated by International Civil Aviation Organisation (ICAO) or military standards. So the MHS consists of mobile ATC tower (MT) for CCT, technology support shelter (TSS) for SCT and Diesel-electric power generator (DA) as basic independent power source of MHS power system. Mechanically MT and TSS are realized as ISO containers transportable on tracks – see fig.1.

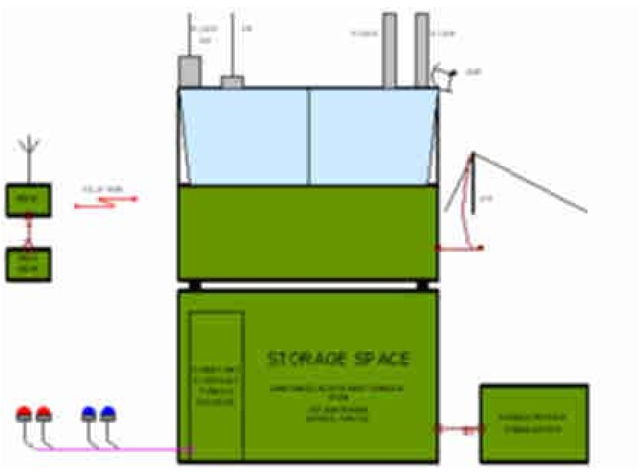

Fig. 1. Two ISO container MHS concept

The MT shelter has two practically identical workplaces for ATC operators and is equipped with communication and information technology. Devices are placed in the rack below, behinds and at the back of the operator workplaces. Most of the information and control elements are presented at the touch screen displays. Each workplace consists of one display for the Voice Communication System (VCS) and second for the remote monitoring and control system (RMC). Some other equipment panels, like meteo system or guard receivers are singular. Controllers have 360° view through sloped bulletproof windows. The windows are covered at the time of the transport by steel panels. The shelter is equipped by air condition and military air filtering system.

The technology itself can be divided into four separate parts: RCS - radio communication system, LLS – landing lights system, NDB – non directional beacon, PSS – power supply system.

The TSS shelter is assigned for storage and transportation of LLS including the constant current source system, NDB, antennas and antenna masts, cables, auxiliary systems and materials, etc. Shelter may be optionally air conditioned and to provide the working place for system serviceman. TSS is variable and may be modified according to the requirements.

The RCS contains manpack radio (not shown) in VHF/UHF range, satellite communication spectrum monitoring receiver with direction finding (DF) functions, guard receiver scanning 121,5MHz and 243MHz landing area, crew communication (1 mobile, n x handheld radios), voice control switch, dual digital sound recorders, remote and monitoring control station RMC, voice and data multiplexer as line communication gateway. The RCS architecture is demonstrated by fig.2.

The PSS consists of 24 VDC power supply system with battery backup and Diesel power generator. A 24VDC power supply system covers requirements of all electronic equipment. Power supply system is intelligent, modular, processor controlled supply with optimal battery charging. Battery capacity is 115 A/h, sufficient for app. 1 hour for standard use of equipment (Tx/Rx/Stdby = 1/1/8).Other DC voltages are covered by DC/DC converters. The 44 kVA Diesel power generator was selected as base for an automated power generating system which fully covers power requirements of all electric load mounted in MT and TSS containers including landing lights system. Power generator is built in separate small container transported by the truck with technology support shelter.

The LLS is assigned to visual identification of landing area of MHS, visual aid for the end phase of helicopter approach to landing area and for landing in normal, night and heavy meteorological conditions, visual marking of obstacles and other dangerous object and areas at the vicinity of MHS landing zone. LLS provides necessary conditions for the operation of the helicopters days and nights. It consists of the components for the marking the relevant areas and landing aids for the end phase of visual landing. The system may serve minimally to four helicopters within the ATP-49(D) requirements, optionally ATP-4(C) standards requirements.

The NDB as navigational aid is optional part of the MHS. For specific customer a beacon with transmitting frequency band 155 kHz to 1200 kHz was selected. This beacon has doubled RF amplifier, UPS for uninterruptable operation, internal monitoring and control of the parameters, RS-232 interface for remote monitoring and control. MHS modification of NDB is installed into air conditioned TSS shelter, an independent diesel power generator supplying NDB was used.

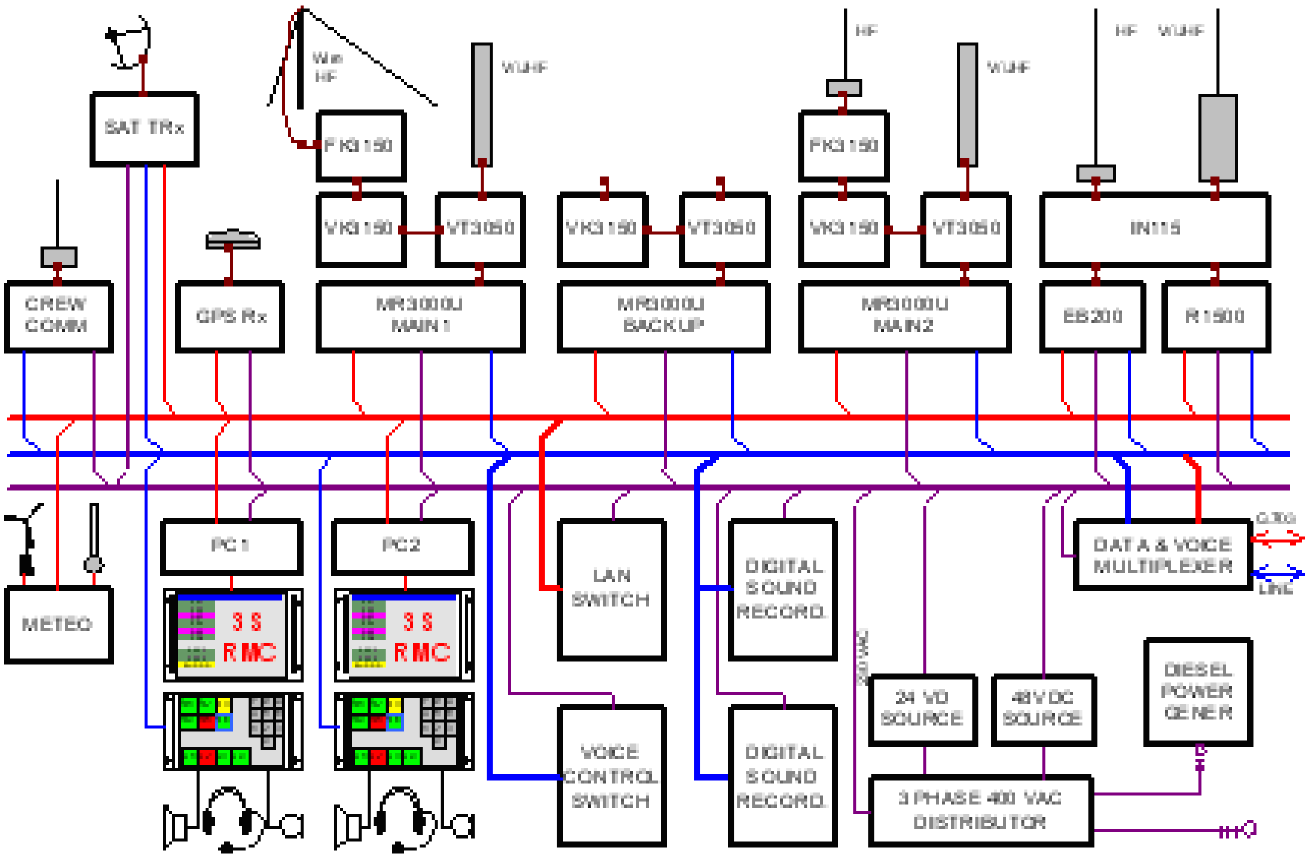

Fig. 2. The RCS of HMS architecture

2.2 The RCS architecture

The RCS architecture design accepted high level functionality and interoperability in the ATC application area. The basic concept stems from IT possibilities and digital system based devices with standard interfaces and protocols. From this point of view a member of a new family of high-performance digital radios covering the HF and VHF/FM bands in single unit was selected. Such a device can operate in different high-speed data modes under variety of communication protocols. The SW configurable and reprogrammable radio is integrated to network. System architecture can be seen on block diagram – see fig.2.

The SW transceiver used in MHS architecture design has multiband capability from 1,5MHz to 512MHz with complementary external components, multivaweform capability, high data rate up to 72kb/s for data and video. The RCS concept based on this type of radio eliminates the need to use different types of devices to cover all frequency bands used in ATC. The only individual device is adequate antenna to cover required communication band. A reliability model was used to increase the MTBF of the RCS with two radios in operation and one in standby mode.

The voice communication system with fully digital system architecture was used for both ground to air and ground to ground communication. The VCS provides comprehensive functionality and flexibility and full digital networking capabilities in accordance with the ATS-QSIG standard.

Data and voice multiplexer combines multiservice access, copper and fiber based transmission, multiplexing/cross-connecting within a single high performance versatile network element. The access capability ranges from voice, data and high speed access services to fast LAN interconnection.

LAN switch wit industrial networking capability was used with redundant fast Ethernet ring capability and short recovery time.

2.3 The RCS monitoring and control

The MHS technology is continuously monitored and controlled by remote monitoring and control system RMC presenting the ATC operators and technical staff actual and precise information about all of the MHS parts and subsystems. The RMC provides continuous check of communication of each radio site and radio configured in system network, allows remotely modify set up parameters of any radio in the net, monitoring and control of selected device (continuous/time scheduled/on event/on error) such transmitters/receivers, ground to air communication radios, AC and DC lines, battery backup system, Diesel power generator, communication lines between an airbase ATC, voice and data multiplexer, voice control system, voice recording system. Very important role of RMC is to monitor the MHS runway and approach lights system. All of the information is saved, continuous recording of status and events is archived to a database. Sorting, filtering, calculation of data records in database is possible. The operator presentation of the information is in text or graphical form.

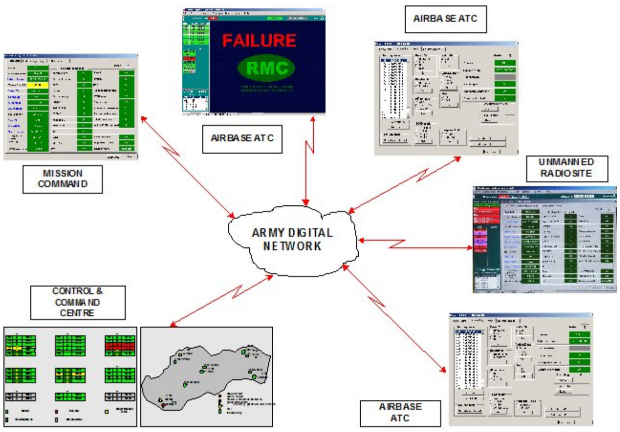

Fig. 3. The RMC data presentation

Variety of the RMC interfaces is typical for today IT device so the MHS system architecture as a whole is open and can be modified, reconfigured or changed in accordance with operational experience and conditions.

3. The SAR system design

As we will see system integration and design of a mobile communication system for SAR is very similar to ATC one. SAR also provides transportation and operation of radio communication technology necessary to support search and rescue operation in unknown terrain and area in case of an aircraft accident. As the ATC also the SAR system has to be maximally autonomous with high level of :

- mobility (system has to allow communication during transportation to final operation work area, where it is used as a transient commander centre),
- functionality (system provides communication centre and rescue team coordination in the frequency interval 100-500MHz),
- complexity (system consists of all technologies needed to built up a small communication centre - communication, lightening and power system including all necessary cabling and support parts).

We can demonstrate the same design principles of SAR system as it was in ATC application case.

3.1 The RCS architecture for SAR

Basically a mobile SAR system functionality has to be oriented to communication and cooperation among rescue operation commander and members of ground and air rescue search teams. It is necessary to built up on site communication infrastructure needed for cooperation of commander with airbase controlling rescue helicopters and airplanes, terrain search squad leaders, police forces, fire brigades, medical teams and other involved persons.

The SAR system RCS has to provide:

- ground-air-ground radio communication,
- medium to long distance ground-ground radio communication,
- radio communication to squad leaders,
- retransmission between different radio communication systems ,
- radiolocation of emergency transmitters,
- coordination of support forces/teams,
- illumination of the event place,
- day/night, rough terrain and meteorological conditions availability.

The RCS has to provide ground – air – ground radio communication between the rescue commander and rescue/search team inclusive helicopter/aircraft pilots and their control tower operators. The RCS has to cover frequency bands 1,5-30MHz, 30-108MHz, 100-149,975MHz, 225-399,75MHz and 400-500MHz. To increase reliability of the system two sets of basic SW digital transceiver were used. Simplex, duplex, retranslation and data connection is possible. System architecture can be seen on block diagram – see fig.3.

Complementary devices as handheld radio stations and a portable radio are also important parts of the RCS infrastructure opened out at standpoint. Whole the system is built in a terrain class personal vehicle with three persons as the crew.

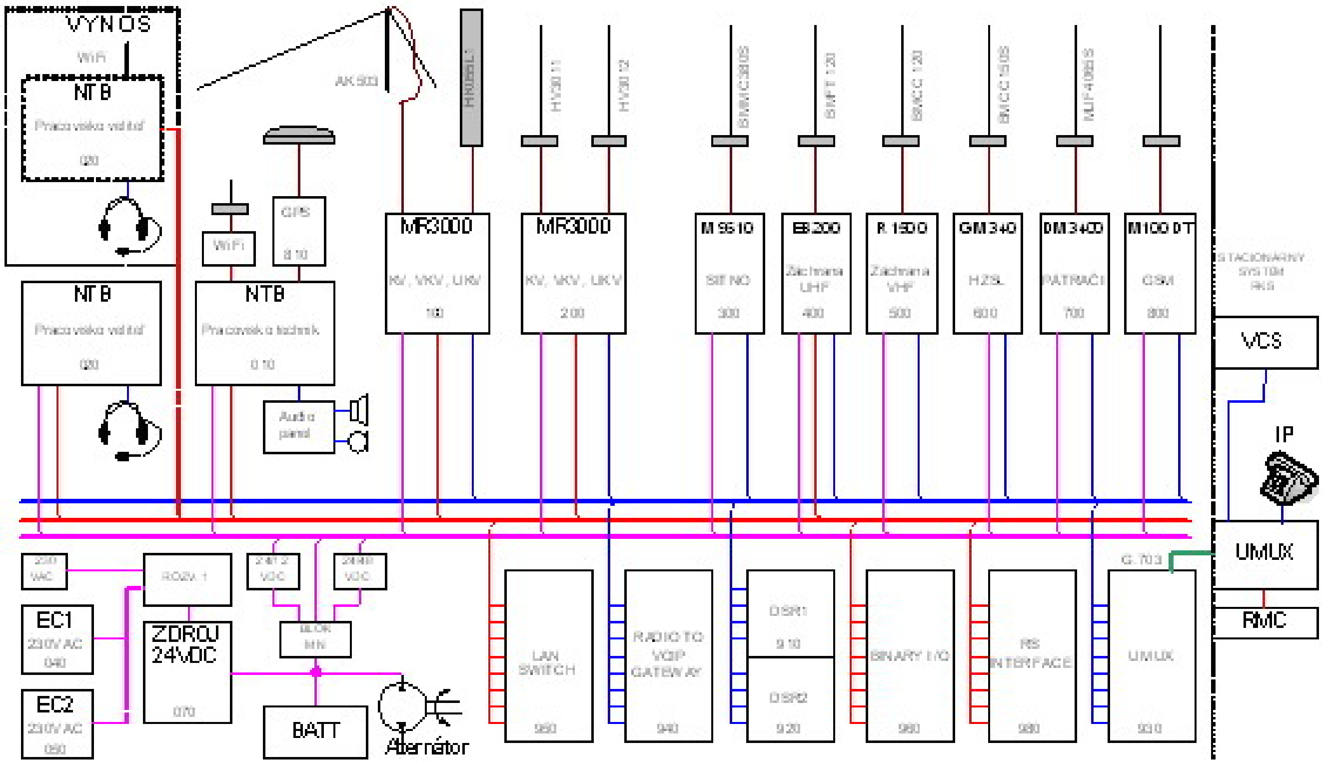

Fig. 4. The RCS architecture of SAR system

The SAR system technology itself can be divided into four parts: RCS - radio communication system, PSS – power supply system, SCD – supporting and complementary devices and IT – information technologies.

The RCS consists of two SW transceiver used in MHS architecture with multiband capability from 1,5MHz to 512MHz with properly selected antennas in accordance with frequency band covering, high data rate up to 72kb/s for data and video. As we have said in previous chapter the RCS concept based on this type of radio eliminates the need of different types of devices, simplifies service and increases MTBF of the application system. The reliability model is based on two identical transceivers in operation.

A radio to VOIP gateway compatible with most PBX and IP gateways, independent of a specific network operator, full compatible with different types of mobile telephony network (CDMA, GSM, GPRS, UMTS,etc.) was used in described solution. The equipment itself is processing both incoming and outgoing calls on up to 30 channels at the same time in bi-directional communication mode. The gateway can be configured using RMC station connected to the equipment via LAN port allowing to configure various types routes from the E1 trunks to the wireless networks and VoIP gateways.

The PSS consists of 24 VDC modular power supply system with battery backup covering all requirements of built in vehicle electronic equipments. Power supply system is fully processor controlled inclusive optimal backup battery charging. Main power connection is via electric distribution unit to public supply network or a 4kVA portable power generator as a part of on board SCD. This wattage is adequate to keep all the vehicle communication technology devices in work.

Very important part of SCD is a floodlight system used for illumination of the event place. It must be powered by another 4 kVA portable power generator and cannot be connected to the same power system as communication technology.

4. Conclusions

On two ATC and SAR design examples we have demonstrated possibility to realize very complicated complex systems utilizing IT based devices and systems. Especially in air traffic control ATC and search and rescue SAR application area the system integrator/designer has to fulfill wide variety of application demands. Today IT with digital data and information processing,, with open architecture and sophisticated radio communication transceiver concepts can solve practically any problem in the area.

On the other side we can summarize that without complex monitoring system there is no chance to collect properly all system information by human person. The situation is much more important in the decision making process in crisis situations where some control actions can be done by the system itself.

Very important role has the reliability model design as a tool how to predict bottleneck of technology in real practice.

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