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USING OF THE DATA OUTPUT OF THE MODERNIZED PRECISION APPROACH RADAR FOR AIRCRAFT NAVIGATION

INTRODUCTION

The demands of the common navigation are well protected during the En-route by the standard navigational means and systems at the presents, if needs by the Standard Positioning Service (SPS) of the Global Positioning System (GPS). It is impossible to provide the accepted requirements of the International Civil Aviation Organization (ICAO) and the plan of the European Organization for the Safety of Air Navigation Operations (EUROCONTROL) in connection of the creating conditions for the Free Routes and for the Reduced Vertical Separation Minimum (RVSM) by these standard means for the future.
The demands for the accuracy of the navigation during the Aproach are much higher then for the navigation during the En-Route and they are guaranteed by the navigation systems Instrument Landing System (ILS) and Precision Approach Radar (PAR) — for the Precise Approach. These Systems have got high demands to the installation of the land — based subsystem and they are very expensive at the present.
It is impossible to provide the requirements of the navigation by means of the common systems in the case of emergency, for example in the case of the forced landing at the alternate airport, the navigation of the Search and Rescue (SAR), under the severe weather conditions, if need by the air-to ground attack. It is impossible to fulfill such high demands for the precise navigation, neither with the application of the Precise Positioning Service (PPS). It is suitable to applicate the technology of the differential GPS for the providing of these demands. This problem is solved within the bounds of the project named a NAVIS (Navigation Information System) in the conditions of the Czech Air Force. The part and parcel of the NAVIS is the DGPS too.

CONCEPTION OF THE MNI SYSTEM

It is important to look for the new sources of the navigation information for other increasing of the reliability and accuracy of the control of the aircraft during the Approach.

There are several alternatives, one of them is the transfer of the data output of the modernized Precision Approach Radar RP-5M on the board, its data processing and indication for the cross track deviation display. The Multinavigation System might be realized by the application of the data navigation PAR together with the output informations ILS and the DGPS, if needed by the other sources of the navigation information (DME, RALT, Encorder). This Multinavigation System makes the choise 1 of 3 systems by the guidance of the aircraft during the Approach: ILS, DGPS, PAR or their optimal processing, with the application of the Kalmann‘s filtr.
Then it will be possible to realize the Approach by means of up to 3 independent systems — ILS, PAR with the data output and the DGPS at the Air Force base. The realizing of the 2 independent mobile systems — PAR with the data output and the DGPS, which is based on the using of the mobile reference station will be able to have an application at the unpermanent airport.
The output signals all of these 3 Systems might be indicated to the aircrew by the same way on the original ILS indicator. This solution make the realization of the manoeuvre possible by the same way, without regard to the source of the information, by means of the same procedure of the Approach. It will ll make the training of the aircrew easier and it will reduce the demands for the activity of the Air Trafic Control. See the Concept of the MNI Processing and Display on Fig. 1. The MNI System consists of the subsystem DGPS, the source PAR data, the PAR transfer data subsystem, the Data Acqusition Unit and the Control Unit.

DGPS Subsystem

The navigation DGPS Subsystem is determined to the providing of the precision navigation of the advanced aircraft of the Czech Air Force in the En-Route and the precision Approach phases of flight. This System follows the international requirements for the Differential Corrections (DC) and the error control coding. The reliability of the Differential Correction Transfer and the universality of the application of the DGPS Subsystem for the various types of the aircraft is guaranteed by the DC transfer in the 3 independent channels (VHF/UHF, HF /VHF, LF) and by the simultaneous receiving of the DC on from 2 up to 3 channels. The precise navigation information is integrated into the airborne navigation system of the various types of the aircraft. The integrity of the system is guaranteed by its ground monitoring.
The experimental screening of the function of the DGPS System was made in the laboratory conditions at the Military Academy in Brno. The Reference Station and the DC trasmitter were placed in the distance of approx. 200 m from the DC receiver and from the other parts of the airborne segment of the DGPS

navigation system. The verification of the accuracy of the DGPS Subsystem in the static conditions was made on the geodetic point No./fig. 0070 in Brno and the final experimental screening in the dynamic conditions was made on the L-410 FG airplane in the area of the Pardubice Air Force Base in November 1999 and additionally during the flight experiment in October 2000 on the MI-17 SOR helicopter at the Caslav Air Force base.

PAR data source

The PAR data source presents the of the RP-5M Precise Approach Radar, which detected the target‘s position in 2 surfaces — azimuth and elevation. The meassuring data are processing and evaluating as a deviations of the aircraft owing to the Final Approach Segment and after the filtration they are displayed on the indicator.
It is possible to use the evaluating deviations from the final approach segment together with the data refer to the adjusted Final Approach Segment as the data for the transfer for the airborne aircraft. The positions of the target data are transmitted and at the same time it is possible to transmitt the single formalized commands too. These data is necessary to transform into the conventional format of the user message to make possible their processing on aircraft. The given data are transforming twice a second on board by the actual elevation and the azimuth of target position. The „alpha“ mode will make possible the identification of the individual targets during the Approach.
The conventional format of the user message of the PAR data consists of 12 Bytes. The first 3 words form the header of the message, what follows is a message of 8 words of of the PAR data + one-time commands and the message is finished by the check word. The one-time commands are transfered on board with the aim of the making the TOWER – aircrew communication during the Approach and the Landing more effective. The one-time commands must be a nature of the simple orders. The file of the commands should be made by the Air Trafic Cpontrol operators. Analogously is defined the phraseology of the voise communication in the single flight phase. The code combination will be added to particular one-time commands to make possible their transfer and indication on board on conventional format of user message. The requisite bit range for the creating of the one-time commands file will be reserved.

PAR data transfer subsystem

PAR data transfer subsystem is realized in the VHF band (frequency range 138–144 MHz). It consists of the ground and the airborne segment. The round segment has got the PAR data integrator and the DGPS DC integrator on the

RS 232 interface. The RS 232 interface makes the PAR data input and the DGPS DC input into the transmission chanel possible. For the transfer the PAR data file is prefered during the service of the demands. The PAR dara are comming on the input in the according user binary format of the message. The constant lenght of the message is 96 bits. The following Cyclic Redundancy Code (CRC) ensures the reformating of the message into the user format RTCA and the code providing of the CRC transfer. The transmitter modem will transfer the binary signal into the audiosignal with the application of the Mode 1 modulation, which modulates the communication VHF transmitter.
The airborne segment consists of the communication receiver, a modem and the CRC decoder.
The modem provides the convert of the audiosignal Mode 1 to the binary signal. The CRC decoder provides evaluation of error control coding and reformating of PAR messages from RTCA format into original user format.
The channel output consists of the PAR data in the conventional user format for the Data Acqusition Unit and the separation of the DC of the DGPS for the GPS receiver. The separator is equiped with the RS 232 interface.

Data Acqusition Unit

The Data Acqusition Unit (DAU) is determined to the concentrating and to the preliminary data processing from the individual sources of the multinavigation information. It reads the PAR data, the position of the DGPS, the deviations of the LOC and the GS, the distance of the DME and the altitude of the RALT and the Encoder data for the next processing. The data proceeds from the DAU into the Control Unit, they are stored in the definited files there. The DAU is the separated functional unit with its own microprocessor, which is monitoring every navigation senzors. The DAU processes the data of these senzors and it refers the data to the superior computer in the consistent form. It consists of the single units, the setting and the programmed properties of the units may differenciate by the use navigation. It is coincident interface for the connection with the superior computer, the unit of the D/A convertor, the discrete output and input unit, the Gray code decoder, the half-duplex serial interface for the communication with the GPS receiver, the PAR data receiver and the navigation system for all of the variant.

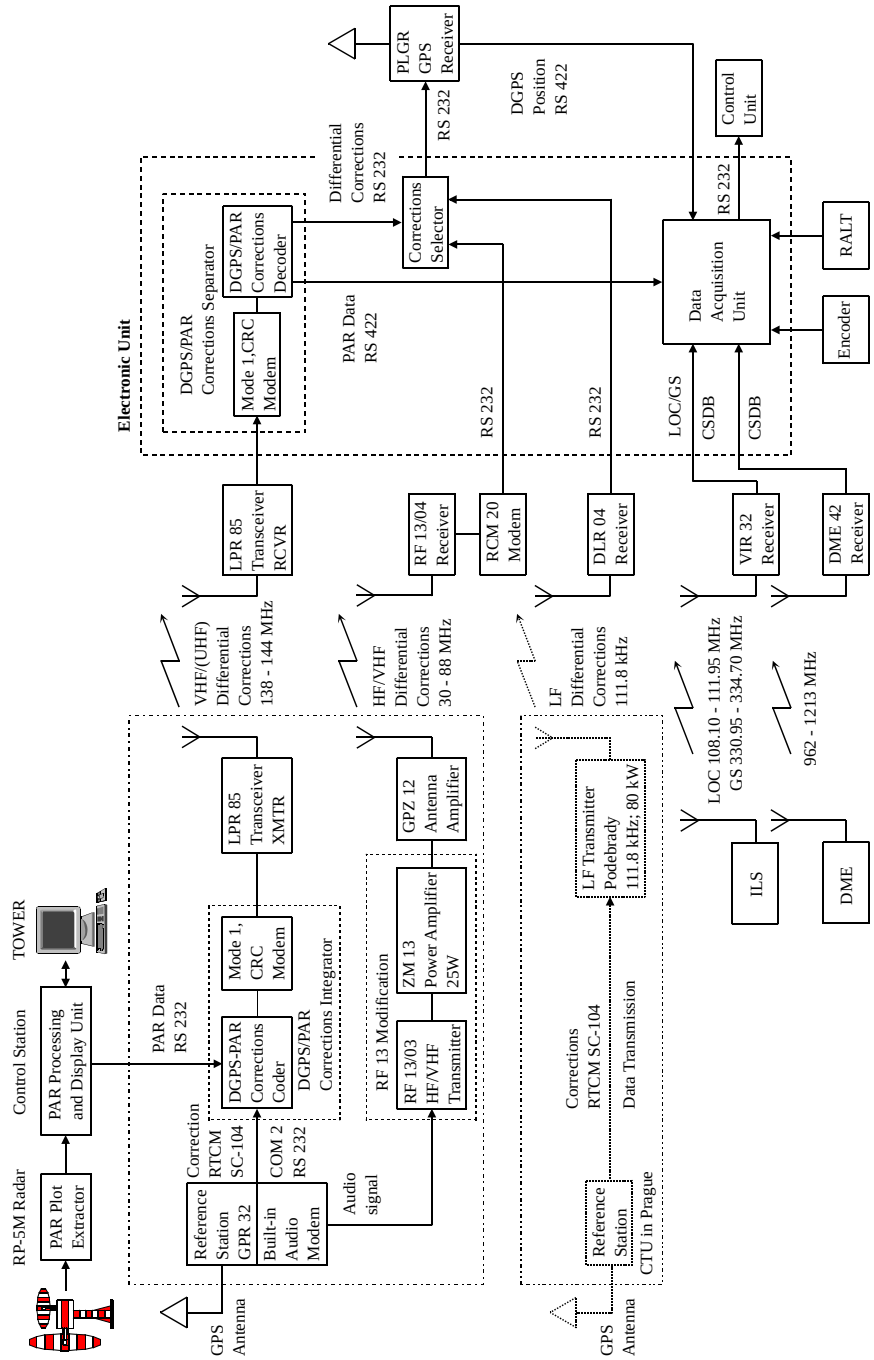

Fig. 1. Concept of Multinavigation Information MNI Processing and Display System

The Control Unit

The Control Unit served for the Data Acqusition and for the controle of the DC Unit during the flight tests. It stored the data from all senzors, they has been connected with the Control Unit by means of the half-duplex parallel interface in the EPP mode. Only data are transfered, the transfer of the add resses is not used. The main demand for the operation system of the Control Unit is its stability, the simple periphery service and for this phase of the project is important variety of the easy available means for the production of the software. The UNIX operation system and its freeware version LINUX for the trial project has been selected for these reasons. The UNIX operation system, should be also reccomended for the final solution of the Approach system in the version for the work in the real time — QNX. The QNX operation system is aplicated in the aviation by now, among others it is used in the navigation system for helicopters. The using of the device programme language, which is assigned to the RT devices, will be the next possibility.

ACHIEVED RESULTS

The aim of the flight test of the system was to ensure the storage of the ILS, PAR, DGPS data and the other auxiliary navigation informations during the Approach and the Landing. At the same time they made the appreciating of the interface function chanel of the PAR data and the data preprocessing by the DAU. The stored data files then made their ensuring processing and evaluating of the accounting of the individual sources of the multinavigation information possible. The aircraft position with regard to the approach segment in the Approach was simmultaneosly monitored by the Radio Telemetry Theodolite System (RTT). The controle of the descent has been planed primary only in some of the specific points. It has been possible to receive and store the data files about the whole descent thanks to the possibility to fix the complete set of the RTT. The data files are supplied with the data in UTC time. The reference data file for the evaluating of the other archivated files has been received by this way. The airborne radionavigation equipment of the applied aircraft made the IFR guidance for the Approach possible. This is why every descent maneouvres where practised by the ILS. The utilization of the data navigation from the PAR files and the DGPS files for the guidance of the aircraft descent in the Approach was appreciated on the basis of the comparation of the evaluating deviations from the Final Approach Segment. The deviations from the final Approach segment are defined by the ILS System. The measured target positions from the separated sources of the navigation information has been received

in the different time moments, and with the differrent (for the individual systems constant) delay, it is why it was necessary to ensure their synchronization. It is mentioned the example of the comparison of the elevation and the azimuth deviations of the PAR systrem and the DGPS system from the Final Approach Segment in the dependence upon the distance from the touchdown on the Fig.2. The offset of the course of the deviations in the distance between the PAR system and the DGPS system is made by the different definition of the touchdown for the individual systems.

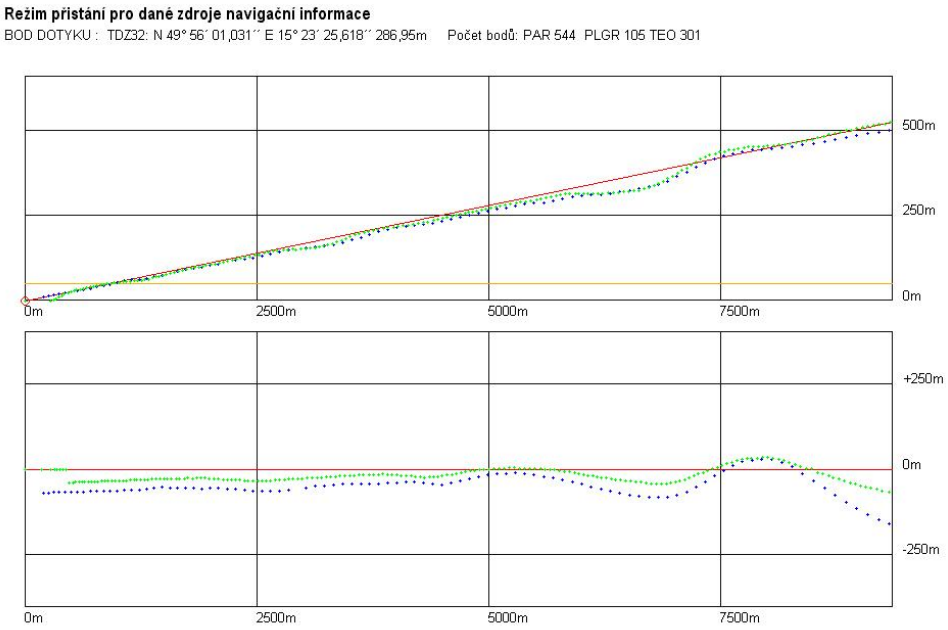

Fig. 2. The course of deviations of the PAR system and the DGPS system in the dependence upon the distance

CONCLUSION

The results of the research task indicated the possibility to applicate the probing parts of the segment especially during the precise Aproach. The results of the first phase of the research proved the possibility of the using of the DGPS system for the navigation in the En-Route and also in the Precise Approach. The results of the second part proved the possibility to use the PAR data for the precise Approach too.

We can see the possibility to arising the multinavigation system thanks to the using of the results of the first and the second phase. The MN system presents the comprehensive complex of the acquisition, the processing and the navigation informations. The comprehensive complex of the acqusition is used above all during the Precise Approach. It attends to the objective increasing of the safety of this flight phase because of the information above. This system should significantly increase the redundance of the navigation information and it could save the delete (filtration) of the navigation informations. Then it could improve the continuosness and improve the reability of the flight safety, especially in the critical phase of the Precise Approach. These improvements of the navigation parametrs of the navigation system should be displayed especially during the landing at the alternate airdrome. The aim of the next phase of the research of the MNI system is the working model of the construction Acqusition Data Unit, the processing and the display of the deviation of the aircraft from the descent trajectory, the distance to the touchdown and the terrain altitude in the phase of the precise Approach in the pilot‘s point of view. It is able to realize the indication by the help of the edict for the standard analogue indicators or by the way of the syntetic display on the multifunctional display.
The ILS and the DGPS systems provide the navigation in the real time and their common indication was verified experimentaly. The information of the PAR system shows the explicit time hysterezion, which manifests during synchronization by the distance and this is why its using needs the assigning of the aircraft position by means of the deviation its vector speed. This integration of the presented sources assumes first of all the providing of the standards for their selection, and then their processing by the method of the Kalmann‘s filtration for the optimal assigning of the aircraft deviations from the ordered FAS. The assigning of the distance to the touchdown and the altitude, which is resolving from the touchdown of the waiting increasing of the flight safet, demands an analogous way of the data processing as by the basic navigation informations. The informations about the distance to the touchdown and about the altitude are the complementary navigation informations.

REFERENCES

[1] ANDRLE Milos, NAIDER Jiri, SUSEN Jaroslav, VOSECKY Slavomir, ZELINKA Jaroslav: Final report of research project ICAO/NAVIS/DGPS. Air Force and Defence Technical Institute Prague, 1999. (in Czech).

[2] ANDRLE Milos, NAIDER Jiri, JERABEK Jaroslav, VOSECKY Slavomir, ZELINKA Jaroslav: Final report of research project NAVIS/2000, Volume 1. Air Force and Defence Technical Institute Prague, 2000. (in Czech).

[3] Partial research reports of project NAVIS/2000. Air Force and Defence Technical Institute Prague, 2000. (in Czech).