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FACTORS AFFECTING THE DESIGN OF INSTRUMENT FLIGHT PROCEDURES

Summary: The article highlights factors, which might affect the design of instrument flight procedures. Ishikawa diagram is used to distribute individual factors into classes, as are People, Methods, Regulations, Tools, Data and Environment.

CZYNNIKI WPŁYWAJĄCE NA PROJEKTOWANIE PROCEDUR LOTU WEDŁUG PRZYRZĄDÓW

Steszczenie: Artykuł przedstawia czynniki, które mogą wpływać na projektowanie procedur lotu według przyrządów. Schemat Ishikawy został użyty do rozdzielenia poszczególnych czynników na klasy, takie jak: Ludzie, Metody, Przepisy, Narzędzia, Dane oraz Środowisko.

1. INTRODUCTION

Instrument flight procedures based on area navigation relies on series of declared points in space and it is not always clear, what radio navigation aids are used to determine the position of the aircraft. The Performance Based Navigation concept is based on navigation performance of aircraft, so it is becoming the responsibility of aircrew to use navigation means suitable to intended portion of flight.

Furthermore, with the introduction of area navigation, traditional risk mitigation element – physical presence of signal of ground based navigation system in space is not more effective. Reliance of area navigation on data is fundamental. Due to this reliance, any change to an instrument approach procedure has to be reviewed with skilled personnel and proper tools.

2. FACTORS AFFECTING THE DESIGN

Considering the Instrument procedure design as a process with its inputs and outputs, an impact of any input on the final product might by evaluated. All inputs are interpreted as effect of People, Methods, Regulations, Tools, Data and Environment. Such classification facilitates the identification of potential sources of the product deficiencies.

2.1. People

Generally, there are no obligatory requirements for formal certification of Instrument procedure designer. It is a good practice to require appropriate professional background; usually former experience as a pilot or as an air traffic controller is a pre-requisite to attend Instrument procedure designer training course. This might, of course, affect designer's professional feeling. Former pilots have better understanding of workload distribution in different phases of flight, whilst the air traffic controllers have better understanding of organisation of air traffic flow.

The Instrument Procedure Designer is the most important – but not the only – person, on whom the quality of a procedure depends. The Client, who initiates the design, should be familiar with operational environment and should be competent to prepare a comprehensive list of requirements. The Charting expert has to arrange all data on the chart respecting the safety relevance of various information and limitations and assures good readability of chart in-flight. The Procedure Validation specialist should be familiar with all applicable standards and should be capable of identifying and evaluating all potential risks of the procedure and providing valuable input to subsequent flight inspection. The Flight Inspection Pilot should understand the construction principles of procedures protection areas and keep in mind not only behavior of flight inspection aircraft, but capabilities of all aircraft categories. The Flight Inspector should have a thorough knowledge of procedure design principles as well as flight inspection practices.

2.2. Regulations

Three levels of regulation of instrument procedure design may be recognized: international, regional and national. International level represents ICAO Doc 8168 Volume II [1], the basic guidance material for procedure designers. It has a lower status than ICAO SARPs have, but it is very well accepted worldwide. Regional level represents, for example, Eurocontrol Guidance Material for the Design of Terminal Procedures for Area Navigation [2], the boundary between regional and national level represent TERPS - U.S. Standard for Terminal Instrument Procedures [3] or Australian Manual of Standards Applicable to Instrument Flight Procedure Design [4]. At national level there are Aviation Acts of individual States, standards and directives of national aviation authorities. The procedure has to be in compliance with all applicable regulations at airport concerned, so the flight inspector must be aware of regulations that are applicable to the procedure.

2.3. Methods

In general, it is not possible to inspect the procedure designer office from inside. However, the quality of internal processes affect designed procedure significantly. A procedure design is a sequential process – in case it is necessary to go back to a previous step, all succeeding activities have to be performed again. The designer may be enticed to reuse some parts of his/her previous work, but it may lead to unwanted effects such as incorrect location of waypoints, deformation of protected areas, omitting relevant obstacles, inadequate lengths of segments, exceeding gradients and many other defects of the procedure.

Interpretation and application of regulations depends primarily on the quality of designer training. The designer, of course, does all the best what he/she believe it is, but the opinion of validation specialist or flight inspector may be different (but not necessary correct…). It is important to distinguish, what is an attribute of the designer's creativity and what is a lack of compliance with regulations.

It is usually not possible to make the design in real 3D world. The designer has to set up a coordinate system, which is the most appropriate for airport location for the purpose of the design.

Such system is called Designer Work Space, in which the entire design is done. Only some important geodesic calculations are performed outside of this Work Space using precise formulas.

2.4. Environment

The designer has to deal with a number of environment related restrictions, such as airspace availability, noise restrictions, areas with sensitive fauna and potentially dangerous areas. It has to be clear, what must fall into available airspace: entire protection area, primary area only or nominal track only.

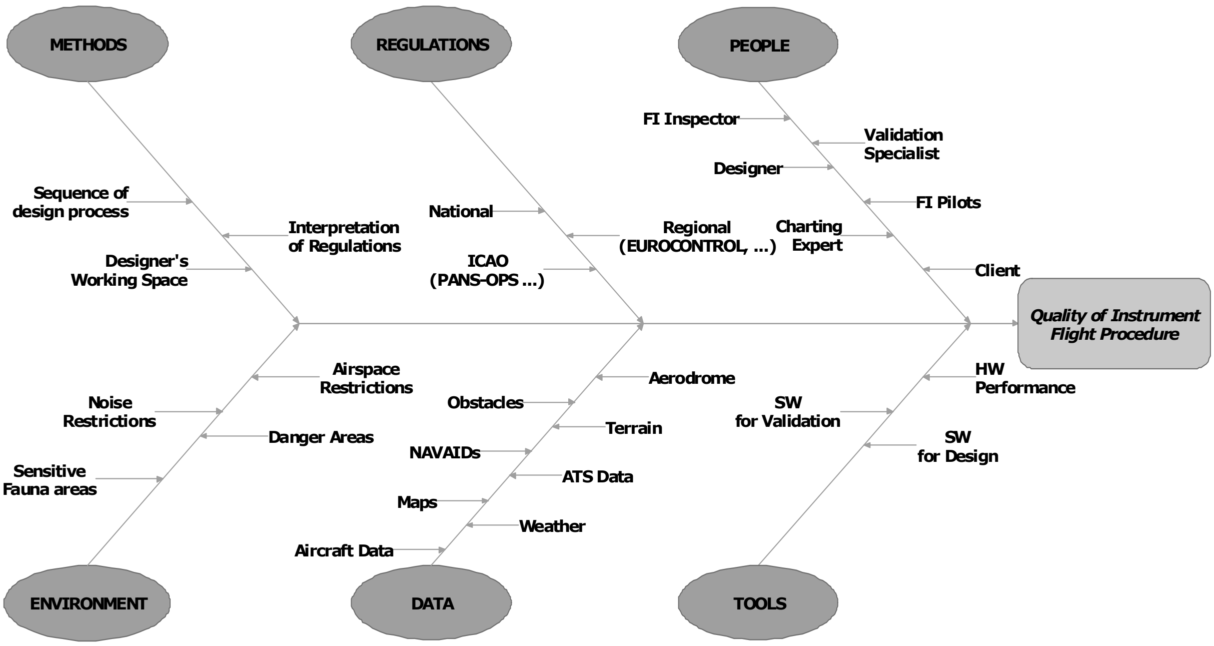

Fig. 1. Ishikawa Diagram of the Instrument Procedure Design
Rys. 1. Schemat Ishikawa Narzędzia Procedury Projektowania

2.5. Data

Quality and completeness of data have the most critical impact on the safety of procedure. It is typical, that data comes from different sources and it is designer's task to transform them into common platform of the Designer Work Space.

Aircraft data, such as aircraft category, wing span, distance between path of the GP antenna and the lowest part of wheels, Minimum Equipment List are factors affecting procedures. In some cases, for example where non-standard missed approach or departure gradient is required or in case of airspeed or altitude restrictions consultations with operators should take place. It is the role of validation to verify, whether such consultations were done.

Relevant Aerodrome Data are: horizontal position and elevation of runway ends, runway thresholds, Departure End of Runway (DER), Aerodrome Reference Point. These data are usually declared as WGS-84 data; in reality they were directly surveyed or transformed to some realization of International Terrestrial Reference System (ITRS) – European Terrestrial Reference System 89 (ETRS-89) for instance.

NAVAIDs Database should include horizontal position, elevation, frequency, identification, Designated Operational Coverage, DME offset, GP angle, ILS Reference Datum Height (RDH). There are usually no problems with the quality of NAVAIDs Data. However, it shall be assured, that navigation systems performance is sufficient to support the procedure. Especially, initial phases of departure procedures are important from this point of view.

Data, such as fixes/waypoints, which are required to be used in the procedure, interfaces with other procedures, procedure altitudes and other ATS related data should be judged in the earliest phases of the design work.

Obstacles data might be obtained from various sources of different accuracy, completeness and reliability. While completeness of obstacle data is critical, uncertainty of position can be taken into account by virtual increasing of obstacle dimensions. It is important to consider the effectiveness of obstacle control policy to be sure that all obstacles were included. The height of trees, other vegetation and possible uncontrolled structures should be evaluated and incorporated into obstacle data.

3D terrain data are useful to visualize the procedure and it helps the designer to optimize placement of the procedure into surrounding terrain. The information, whether mountainous terrain criteria – increasing of MOC – shall be applied or not, is also derived from terrain data.

Historical records of temperature and wind speed can be used instead of standard values. In some cases, standard values are not conservative enough; for example in equatorial areas the International Standard Atmosphere +15°C figure, but higher, should not be used. Special situation represent procedures based on radar vectoring, where cold weather corrections have to be accommodated into minimum vectoring altitudes.

Maps or satellite images are used in the procedure design to digitize terrain contours, spot heights, or to provide background graphic. Maps are available in electronic form or in paper form. Paper maps have to be scanned before using in the design. Regardless of the fact, whether the map is electronic or scanned, it has to be transformed into the Designer Work Space. This transformation brings risks of transformation error, which can be interpreted as an error of translation, rotation, zoom or a combination of the above.

2.6. Tools

Nowadays, an age of drawing board and tracing paper is irrevocably away. A number of software tools with different degree of automation for procedure designers are available on the market. Generally, more automation in the software raises more prudence in the use of it. A manner of validation of such functionalities should be in place – as a minimum, inside the designer's office. It is extremely important to keep control over the design and not fully rely on automation.

A performance of hardware might have an influence not only on the time of work, but on the design quality. If the hardware is not able to work with large obstacle databases, detailed maps and 3D models in reasonable timeframes, the designer is forced to apply some kind of data filtering, which could potentially lead to exclusion of safety relevant element from the design.

Obviously, it is not possible to simulate behavior of all aircrafts in all weather conditions in one flight inspection flight. Suitable simulations tools are very useful for validation of procedures. A lot of problems might be discovered using simulation software, because a broad range of combination of aircraft, wind and temperature can be tested.

3. CONCLUSIONS

With no doubt, the instrument procedure design plays a significant role in the safety of aircraft operations. Huge amount of safety sensitive work lies on the shoulders of one person – the instrument procedure designer.

Validation and flight inspection of flight procedures represent a barrier, which mitigates risks associated with the instrument procedures design. Effectiveness of such risk mitigation strongly depends on skills of validation specialists and flight inspectors.

To identify critical aspect of the design, it is necessary to understand not only applicable regulations, but also apprehend processes inside the designer office.

This article has been worked out within the project VEGA 1/0274/08 – Theoretical research on enhancement of safety and quality in civil aviation.

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Received 22.02.2008; accepted in revised form 16.10.2008