Eugeniusz Piechoczek, Jan Kaźmierczak
Silesian University of Technology

EVALUATION OF APPLICATION OF ALTERNATIVE TECHNICAL MEASURES IN PROVIDING SELECTED AIR SERVICES

Abstract: The paper presents general assumptions and preliminary concept of the studies on theoretical and practical aspects of providing selected services with alternative technical means. The study focused on the areas of aircraft application in building and utilising linear objects. The study purpose was based on an analysis of process-focused approach towards air services. The specificity of the assumptions in the selected areas was illustrated on the basis of examples of completed undertakings. Additionally, the article contains a list of examined factors influencing the adaptation of Unmanned Aircraft Systems as components of the model of conversion of services that could have an impact on decision-making in terms of applications of alternative air platforms.

Keywords: service provision effectiveness, aviation, Unmanned Aircraft Services

1. INTRODUCTION

Market expectations, related both to manufacture processes and - it might be that first and foremost - to service provision processes, are aimed at meeting certain key demands, which are concerned with the course of the very processes as well as their final results. Those demands may be universal, orbit around the completion of manufacture and perimmanufacture processes or be directly connected with a product or a service. Among the universal demands as regards the contemporary perception of product and service provision, particular attention is paid to quality, and productivity is especially significant according to the perception of production. Similar categories may be applied to the demand of effectiveness, which is essential for contemporary perception of service provision [1].

The point of departure for the previous and this study is the thesis stating that one of the way of improving the effectiveness of providing services might be to apply technical means which are alternative to those used currently in those services. In the described study purpose, proving the legitimacy of the above assumption is planned for the practical area of providing such services, which essentially require the application of aircraft (air platforms). That purpose has been presented in more detail later on in this article. The next chapters include the study results obtained so far and the authors' reflection, which will constitute the basis for the studies.
Chapter 2 describes the group of air services selected for investigation. In Chapter 3, an attempt has been made to present an outline of methodological assumptions, which will be used to fulfil the study purpose, i.e. production of a model which allows for the evaluation of usability of air services as alternative technical solutions (with elements of comparative analysis).

2. STUDY PURPOSE DESCRIPTION

The practical study area was a group of air services which may be rendered by means of both manned aircraft and unmanned aircraft. The study result has been assumed to be a model supporting all of the tasks related to the conversion of services provided by manned aircraft to unmanned aircraft. Particularly, such a model should allow for making quantity evaluations, which will in turn allow for the assessment of effectiveness of the examined and proposed changes to be implemented in service provision (both technical and non-technical), as well as give the possibility to support a variant, parallel analysis of various solutions. What is also considered is to "equip" the prepared model with IT tools supporting the completion of tasks based on it.

Therefore, the preparation and verification of the model supporting comparative evaluation of selected services provided with alternative technical means should lead to the compilation of a tool (a set of tools) that will be tested in the area of supporting decision-making connected with using an alternative platform in air services. It is assumed that the confirmation of usability and effectiveness of such tools in a selected, practical area of service provision should translate into their usability in a wider range of cases.

The expected outcome is service innovation that gives reduction of costs and maintenance of quality and safety standards at the same time. That studies have been commenced in such an area results from the following circumstances:

- there is a tendency that unmanned aircraft will be taking an increasing part in the market of air services in the next 10 years,
- the development directions of unmanned aircraft as defined by the European Commission promote research and optimisation of the processes related to air operations of those air platforms,
- the users that have been using manned aircraft so far expect an offer for unmanned platforms; therefore, they need supporting tools,
- the availability of unmanned platforms on the market will lead to them being used commonly and the lack of legal solutions hinders their application in enterprises dealing with strategic infrastructure use,
- lack of criteria (including legal regulations) as regards unmanned aircraft application poses a threat for the strategic infrastructure,
- lack of a similar model on the market and in the literature of the subject justifies its creation.

It has been especially assumed that service provision may be seen as a particular process type, which crucially influences the set of methods and tools to be used in the said study...
purpose. Next part of the article details specific conditions of air service provision, indicating the influence of those conditions on the prepared model. The current status of studies on the model of air service conversion is defined by the list of the areas where unmanned aircraft can be used on the one hand, and on the other by the evaluation of the used (described in the available sources) practical solutions with determination of the basic evaluation criteria as regards the individual processes. Such a model may be useful in various aspects.

In particular, the model of reorientation of air platform use in service provision may make the decision-making process at lower tiers easier. The adaptation of unmanned aircraft to the air services rendered with air platforms should include the following components, which have an influence on the safety of the process: operator (their experience in unmanned aircraft operation), preparation of the operator for the type of the task carried out (training), preparation of the operator for the type of the task carried out (experience), unmanned aircraft type (airplane, multirotor or aerostat), weather-related limitations of unmanned aircraft (wind strength, meteorological phenomena), weather-related limitations for the task type (precipitation, icing), technological limitations for the task type (minimal altitude, task conditions, air temperature, humidity), time limitations of the flight, time allocated for the task, level of legal liability insurance, used equipment - origin/permission for use (form of certification), whether the product has been registered, whether the used device has a limited operation area, the distance between the airline and site of unmanned aircraft operation, task type (inspection, measurement, emergency situations), requirements for the task type, deadline for carrying out the task (fixed or flexible), route (VLOS, BVLOS), whether the route crosses limited zones (CTR, MATZ, P, D, R, etc.), unmanned aircraft control boundaries, whether the route has its course above human settlements or facilities that are particularly sensitive (power stations, gas compression stations, etc.), whether the operator possesses a certificate for the type of task carried out, whether the operator has performed risk analysis, etc. The rocketing technological progress of unmanned aircraft does not influence the proposed model of changes.

2.1. DESCRIPTION OF SELECTED AIR SERVICES

For the purposes of the study, a part of the critical infrastructure (power lines, gas pipelines and oil pipelines) was chosen as the base since this is an area where air services are commonly provided. The linear objects are over 14 thousand km of highest voltage lines (400 and 200 kV), over 30 thousand km of 110 kV lines, thousands of kilometres of medium-voltage lines and about 10 thousand km of industrial gas pipelines (without the transit gas pipeline) and PERN oil pipelines.

2.1.1. Power lines

The technical and technological progress in power supply has become one of the basic factors that initiate the process of seeking and implementing new solutions for maintaining
the proper condition of power lines. In turn, this influences the quality of services provided to the recipients of electrical power. Furthermore, striving for modernisations incorporates the financial aspect as well - it decreases energy losses and operation and repair expenses [2,3]. The standard operation actions are based on inspections and visual examinations. Periodical visual examination of the lines include the general land route of the line, evaluation of the condition of chains, insulators along with accessories, cables (Fig. 1), spacers, dampers, pylon structure gratings, evaluation of rust, assessment of the sections at risk (important intersections, areas at risk of mining damage, passage routes of birds, etc.) and location of residential and commercial facilities on the route of the line. The said examination is performed on a scheduled or emergency basis.

The operational processes are complemented by diagnostic activity such as thermovisual measurements and measurements of the corona effect. Thermography (thermal mapping of the surface of the examined object; Fig 2.) is a modern method allowing for the identification of places where electrical device components overheat during loading. The thermovisual measurements make it possible to determine the places where the temperature of cables is increased. Such actions prevent power cuts and sometimes even damage to property. Burning-off of the bridge on the 15 KV line running over a parking lot in the city of Bytom started a fire of the cars parked below.

![Fig. 1. Broken lightning protection bridge](image)

*Source: PSE Południe sp. z o.o.*
Measuring the corona effect is one of the effective and diagnostic methods taking advantage of the corona discharge. High voltage between the line cables and the ground leads to the formation of the so-called partial discharge on the surface of the cable: those are electrical spark jumps which do not become full discharge (gas ionisation around the conductor). This phenomenon, known as the corona effect, results in energy losses, noise, radioelectric disturbances, release of small amounts of ozone and nitrogen oxides. The devices tracing the corona effect in ultraviolet can detect damage to live conductors (fraying, cracking, etc.), loose connections (untightened spacers, loose connections with an insulator, incorrectly clipped cable ends, etc.) and damage to insulators. The indispensable support tool for operation services is the Geographic Information System (GIS). Based on orthophotomaps and digital land models, it allows for the management of linear objects and gather operational data and it provides a wide access to information on linear objects. The modern technologies of managing linear objects and diagnostics technologies can be widely used thanks to device installation in air platforms. They constitute a useful working tool for power line operation services, which reduces costs of power transmission and distribution.

2.1.2. Gas and oil pipelines

Another equally significant elements of the critical infrastructure are gas pipelines and oil pipelines. Preservation of safety in the protection zone, the condition of infrastructure (shut off and relieve valve systems, dehydrators, cathodic protection stations and gas stations) and leaktightness status are the main responsibilities of the system operators. Monitoring with a helicopter is a programme support of the operation services.
2.1.3. Power line construction support

Involvement of air platforms in the critical infrastructure operation does not consist solely in patrol flights. Power line construction enterprises need the support of air platforms as well. The construction of power lines carried out in forests requires the employment of air platforms due to limited possibilities offered by ground equipment. The support is grounded in pulling a pilot (initial) cord (Fig. 4) between the so-called over-the-forest poles, which cord makes it possible to pull the working cable through the route of the power line without the necessity to fell trees.

Fig. 3. Untight spot in the transmission gas pipeline
*Source*: own study.

Fig. 4. Pulling an initial cord on a 400 kV line
*Source*: own study.
2.2. APPLICATION PERSPECTIVES FOR UNMANNED PLATFORMS IN GAS AND POWER ENGINEERING

The technological potential lying dormant in unmanned air platforms gives new possibilities for economic growth and competitiveness increase in various industries. The application of new technologies in this scope is also limited in terms of technology and law. Despite the barriers existing so far, refinement of unmanned platform technology aims to make their application widespread as the service costs may be up to 10 times lower compared to some manned platform applications. Will the safety of this new technology be equal to that required in the case of manned aircraft?

The potential transfer from the traditional air services to unmanned platforms should include more than merely technical aspects. A good example illustrating this demand is the need for considering not only the decision-makers', but also the users' reception of such conversion as well as - in a broader view - the public opinion on the issue (it may be treated as the "passive user" of the introduced innovative method and technology). The use of unmanned aircraft includes other, non-technical aspects of the investigated service conversion as well.

In the formal view, RPAS (remotely piloted aircraft system) are aircraft, so they have to meet all requirements as regards aviation safety. The ICAO standards prohibit unmanned craft from flying unless the competent state authorities issue a special, individual permission thereto [7]. According to the ERSG action plan, "the technologies which require further development and approval are control, including the assignment of frequencies and managing it; anti-collision technologies, protection against physical, electronic and cyber attacks; transparent and harmonised emergency procedures, decision-making ability ensuring standard and predictable behaviour in all flight stages and the issues of the human factor, such as pilotage" [8]. RPASs are becoming reality and they will soon be available for commercial trading in the entire Europe. The RPAS market is a great opportunity to support creating jobs and a source of innovation and economic growth in the next years.

The market, however, involves new challenges related to safety, protection and respect for civil rights. Those challenges are to be solved before it is possible to use RPASs on a broad scale in the civil environment. The shortage of harmonised European provisions and certified technologies constitutes the chief obstacle for opening the RPAS market and integrating RPASs in the non-allocated airspace in Europe [9]).

2.2.1. General directions of unmanned aircraft application in the operation of linear critical infrastructure

The protection of the critical infrastructure consists in monitoring and diagnostics of the linear object and its protection zone. The tendency of the Polish unmanned craft operators is to try to eliminate manned platforms. This seems inappropriate, as confirmed by Douglas Nelms [5]. Activity should be concentrated on the integration of unmanned aircraft and manned aircraft services. Unmanned aircraft. At present, unmanned aircraft should complement the traditional aviation services with a tendency towards conversion.
For instance, an unmanned aircraft cannot be currently used to extinguish fire, but it can fulfill a task of evaluating the site of that fire and identifying the embers following the extinguishing action. For linear object operation services, unmanned craft can carry out tasks e.g. at the branches of power lines, leaving the main lines to be operated on with the traditional means. It does not close the way for service conversion. The niche areas should be filled, e.g. unmanned aircraft application. The pilot of manned aircraft with experience in aviation services are - according to Larry Welk from WELK's AVIATION - a priceless support in training the operators of unmanned aircraft used in specialist aviation services. Filming the area with unmanned aircraft is different from power line patrolling or agricultural aviation service (spraying) [5]. The transposition requires legal and technological instruments. The provisions on unmanned aircraft operation set forth that the operator guarantee that every flying model or unmanned aircraft at their disposal be used without posing threat for human beings, property or other users of the airspace; they fly taking into account meteorological conditions and information on limited air traffic; they fly in a manner ensuring safe distance from human beings and property, in the case of a malfunction or loss of control of a flying model or unmanned aircraft. The operator is liable for the decision to make a flight and for its correctness [10]. The authors of this paper made preparations for the project on the instrument to evaluate the application of alternative technical measures in providing selected air services. The project has a character of a technical innovation, i.e. it is a combination of process innovation with service innovation. The process innovation consists in the adoption of new or significantly improved production methods. The service innovation, in turn, is a service which offers the consumer a new benefit or value [6].

2.2.2. Selected experience in the application of unmanned platforms in Poland and their social reception

The issues of studies on the manners of evaluating the influence of innovative technologies and products on a widely understood social environment has already been quite widespread in the available publications connected with the notion/term of "Technology Assessment" (TA) [4]. It has to be underscored here that this study area has not been well "equipped" so far (homogeneous methodology and used means and solutions). It seems that the development of studies in this respect requires basing on specific examples, such as the issues related to the unmanned aircraft application defined above in this article.

National attempts at applying unmanned platforms have been made for instance in power and gas engineering. Many constructors, operators and producers talk about unlimited possibilities of their products, which can be used to patrol power lines and gas pipelines and guarantee support in building power lines. The present scope of application has rather been of research and development character than of universal one due to a range of technical and legal limitations. The length of the flight, meteorological conditions, visual range and airspace availability are selected problems, which - despite an attractive price of the service - do not make it widely popular. Other difficulties might be the manoeuvre capabilities of the operator, who has to operate the unmanned aircraft and the video camera at the same time, or the radio range. The technical problems are being gradually solved. The terms and conditions of the operator's legal liability insurance, terms
of trainings and certification requirements have already been defined legally. Nevertheless, the process of creating and implementing the necessary technical and legal changes is under way.

3. OUTLINE OF METHODOLOGICAL ASSUMPTIONS FOR THE MODEL OF USABILITY EVALUATION OF ALTERNATIVE TECHNICAL SOLUTIONS IN SERVICE PROVISION PROCESSES

The general aim of the study purpose presented in this paper, i.e. preparation of a model for usability evaluation of alternative technical means/solutions in service provision processes, may be presented in the list of the following specific aims:

1. description (visualisation) of the service provision process,
2. description (visualisation) of comprehensive and partial outcome resulting from the implementation of an alternative service provision scenario,
3. selection of methods and tools for a multifaceted and quantity analysis of the examined solutions,
4. selection of methods and tools for picking the optimal solution as regards the assumed criteria.

At the current, preliminary stage of studies, it is justifiable to assume that the completion of the above aims may involve the methods and tools borrowed from other application areas. In line with this premise it has been assumed that for the fulfilment of the above-defined partial aims, first and foremost the following will be assessed:

- For aim 1: usability of the process mapping method (Fig. 5).
- For aim 2: usability of the value stream mapping method (VSM) (Fig. 6).
- For aim 3: usability of the index analysis method.

It has to be added that at the current stage of study plan development it has been assumed that the element combining the above means and solutions in the built model will be the so-called "scenario approach", used e.g. in studies on technical means operation processes [13]. In particular, it has been assumed that each created, alternative scenario for the provision of a selected service/s will be provided with the map of the process, connected with an adequate value stream map. Such an approach will make it possible to introduce changes in the service process in stages and to carry out partial effectiveness analysis for successive steps.

It seems that at this stage of the study it is impossible to make the final decision on how to fulfil the tasks involved in aim 4. It may be initially assumed that it is necessary to check both the traditional optimisation methods and other methods and tools allowing for comparative value analysis. In particular, what is here analysed are the possibilities of applying scenario analysis methods and tools borrowed from the area of the so-called pattern recognition. The results of those studies will be presented in next publications by the authors.
Fig. 5. Example of a process map (acc. to [11])

Fig. 6. Example of a value stream map (VSM) (acc. to [12])
4. CONCLUSION

The tendency towards widespread application of unmanned aircraft requires adequate instruments supporting the decision-making process in the recipients of the service, which take into consideration the technological progress in this respect. At the current stage, it is advisable to develop complementing the services rendered by means of the traditional methods with unmanned aircraft. Synergy may be achieved in effectiveness and efficiency. The innovation process consists in a range of actions required for going from the conceptualisation phase to the phase of releasing new products and services on the market. Employment of quality improving tools in individual phases of the innovation process may effectively support the development of new products or services [6]. If the purpose of the study, concerning the preparation of a practical solution for a specific service area, and the services provided with aircraft are such a specific area, is fulfilled, a significant study task will surely become the perspective of spreading the usability of the created model over other categories of services [1].

Additionally, taking into consideration the specificity of air services, the authors strive to make an attempt at including in the model being created a "non-technical" element, i.e. the criterion of social recognition of innovative forms and means of providing services, which may well and truly be considered such an element [13].

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**OCENA PROCESU ZASTOSOWANIA ALTERNATYWNYCH ŚRODKÓW TECHNICZNYCH DLA ŚWIADCZENIA WYBRANYCH USŁUG LOTNICZYCH**

**Streszczenie:** W artykule przedstawiono ogólne uwarunkowania oraz wstępną koncepcję badań nad teoretycznymi i praktycznymi aspektami procesów świadczenia wybranych usług z wykorzystaniem alternatywnych środków technicznych. Do celów badawczych wybrano obszary zastosowania statków powietrznych w budowie i eksploatacji obiektów liniowych. Zamierzenie badawcze oparto na analizie ujęcia procesowego usług lotniczych. Przedstawiono specyfikę uwarunkowań w wybranych obszarach opierając ją na przykładach zrealizowanych przedsięwzięć. Artykuł zawiera również wykaz badanych czynników wpływających na adaptację BSP, jako elementów modelu konwersji usług mogących wpływać na proces podejmowania decyzji zastosowania alternatywnych platform lotniczych.

**Słowa kluczowe:** efektywność świadczenia usług, lotnictwo, bezpilotowce