1. Introduction

By definition, operation is a set of conscious activities that lead to a desired result. Therefore, scientific research should provide fundamentals for efficiency of such activities. Content of such approach is finalized in continuous progress of ideas, concepts, methods, procedures and tools as well as diagnoses and predictions. Though, the progress, similar to any other area of human activities, encounters a number of obstacles. Despite the fact that technical progress, including progress in operation and maintenance techniques, is virtually unlimited, rates of such progress subject to variations and have their upper limits, although still unknown. Various factors that restrict rates of technical progress are identified, not to mention the following:

- human factors with restricted ability to perceive and adopt new ideas,
- research methods that are considered as adaptable to the areas of operation knowledge and maintenance practice,
- affordability of offered solutions limited by economic incapability of structures and organizations that deal with operation of OT.

Knowledge related to technical operation is generally dedicated to performance of typical assignments that are referred to as operation tasks.

Operation task is a set of activities with a defined objective or a set of objectives. The task is performed in a defined space and time (space-time continuum of operations).

Operation tasks are subdivided into classes, series, groups, etc. Subdivision criterion results from specific features of the OT and its scope of dedication (assignment). Knowledge of operation and maintenance processes assists in successful completion of assigned tasks. It serves as the basis to set up the system of methods – procedures – tools (MPT) for execution of operation tasks. The tasks represent sequences of sophisticated actions that make up together operation events within a single operation task.

Service and replenishment operations represent simple actions with only a limited set of MPT’s. Diagnostic and maintenance actions and more complex, hence they are supported by relevant text and graphic documents (usually computer-aided documentation systems).

Each task should have strictly defined criteria for its correct execution with particular stress to crucial phases and components. Such an approach makes it possible to take maximum possible advantage of potential benefits inherent to any piece of technical equipment, e.g. an aircraft (SP), including its operation potential and operation energy [4].

2. Operation potential and operation energy of aircrafts

Operation potential \( \text{Pe} \) shall be understood as the enabling resource of an aircraft to carry out a defined number of flights. The potential is attributable to every aircraft and is released during performance of flights (operation).

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1 Such a definition of \( \text{Pe} \) complies with the meaning of the word “potential” as it is common in the referenced literature. Potential is: a) “an overall resource of power, production capability [or operation ability, as here used – J.L.] that is inherent to something”, b) a field represented by a function (a scalar of a vector one). That field is defined by differentiation, hence the potential [is – J.L.] determined only by a defined accuracy [4] c) e.g. “thermodynamic potential that make it possible to determine the work that is performed by the system during a specific process”. The cited content
Operation energy \((Ee)\) shall be meant as “something” that can be obtained from an aircraft during its operation. The energy has been accumulated during the manufacturing process and can be replenished (refilled) in various refurbishment and revamping processes.\(^2\)

Every aircraft undergoes various phases and operation states during its operation lifetime (Table 1).

The term of aircraft status has several meanings. The system of aircraft operation has its initial status \((S_{in})\), associated with the initial value of operation potential \((Pe_i)\) and final status \((S_{fin})\) characterized by its final operation potential \((Pe_f)\). The difference of operation potentials equals to the useful value of operation energy:

\[
Ee = (Pe_f - Pe_i) \cdot \beta
\]  
(1)

where: \(\beta\) – numerical parameter that stands for the unit value of energy \(Ee\) per a unit of potential \(Pe\).

The obtained value of operation energy \((Ee)\) can be defined for a single flight (single operation cycle of an aircraft) or for multiple flights of for the entire lifetime (all the flights) of an aircraft.

The term of operation energy is transformed into the term of achieved economic benefit in accordance to the formula:

\[
K_e = \alpha \cdot Ee
\]  
(2)

where: \(K_e\) – unconditional economic benefit that is used for civil aviation or relative economic benefit used for military aviation,

\(Ee\) – operation energy that can be released during the aircraft lifetime, \(\alpha\) – coefficient that stands for the rate of economic benefit per a single unit of operation energy.

For operation of aircrafts that make up the entire fleet of an avionic transport system (LST) that consists of \(N\) types of aircrafts and each type comprises \(M\) units can be expressed by the total operation energy \(Ee_j\) inherent to the system:

\[
E_{e_j} = \sum_{i=1}^{N} \sum_{j=1}^{M} Ee_j
\]  
(3)

Formal characteristics of the system operating condition can be noted with use of: the value of operation potential \(Pe\), the value of operation potential variation rate \(\varphi\), where:

\[
\varphi = \frac{dPe}{dt}
\]  
(4)

The values of \(Pe\) and \(\varphi\) can be positive, negative or zero.

Table 2 presents an example for classification of selected operation states in various operation phases. In accordance to the foregoing rule, the terms of maintenance, overhaul or revamping, etc. potentials can be introduced.

3. Administration and control of an aircraft fleet

Control, management and administration\(^3\) of an operation system (SE) refers to the organizational structure of the system as the anthropotechnical system, while in other aspect as the technique of application of this system (its operation and

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\(^2\) The term \(Ee\) jest complies with the meaning of the word “energy” as it is common in referenced literature. \([4]\). Energy is) “penchant and ability to act in intense manner – the value that reflects the system ability to carry out a specific work”, b) “the scalar physical parameter that conforms to the strict law of conservation and is used for quantitative description of various processes and types of interactions, c) “the universal physical value that us suitable for description of all the kinds of processes and interactions that occur in nature”.

\(^3\) Control – is understood as tracing the direction or evoking positive alterations, Management – is giving guidelines, instructions, directives or indications to be carried out in order to achieve desired alterations, Administration – is the process of acting, chiefly in the sphere of personnel administration.

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<table>
<thead>
<tr>
<th>Phase name</th>
<th>Phase symbol</th>
<th>Aircraft</th>
<th>Subsystem name SE</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft operation</td>
<td>Uz</td>
<td>Initial status (S_{in}) Final status (S_{fin})</td>
<td>Aircraft operation</td>
<td>PEUz</td>
</tr>
<tr>
<td>Aircraft maintenance</td>
<td>Ut</td>
<td>Initial status (S_{in}) Final status (S_{fin})</td>
<td>Maintenance of aircraft operability status (the aircraft is permanently ready to perform its tasks )</td>
<td>PEUt</td>
</tr>
</tbody>
</table>

Tab. 2. Example for description of operation statuses

<table>
<thead>
<tr>
<th>(\varphi)</th>
<th>(Pe)</th>
<th>Situation 1</th>
<th>Situation 2</th>
<th>Situation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\varphi = 0)</td>
<td>downtime waiting</td>
<td>(Ee = 0)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>(\varphi &gt; 0)</td>
<td>-</td>
<td>-</td>
<td>overhaul, resource extension</td>
<td>(Ee = 0)</td>
</tr>
<tr>
<td>(\varphi &lt; 0)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>flight</td>
</tr>
</tbody>
</table>

that is assigned to the term “potential” exhibits and reflects, to the best possible extent, the phenomena that occur during the operation process. Useful value can be obtained from an aircraft, that value can be defined as the operation energy. It is portent to pay attention to the phrase “with a defined accuracy” that is achievable for description of the field of operation potential, and, consequently, resulting effects of that potential, such as reliability, safety and readiness. Measures and values that describe these phenomena can be deterministic figures solely for the first approximation thereof. Actually, we have to deal with probabilistic and undeterminable processes and the measured value can be defined only with the maximum achievable accuracy.

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Control, management and administration is most frequently considered, i.e. described and modelled, in the categories of a process [1-8]. As result of such processes a desired effect is achieved, whose extent depends on the realization of the program, e.g. controlling as an extorting action.

Appropriate management of a fleet of aircrafts operated within a common system depends of efficient course of operation, exhausting and reliable information on operation and disastrous phenomena and events. Management refers to the spheres of technology, economy and social relations. By means of so called management engineering it solves problems that may arise along the borderlines of these zones [5].

The management process deals with events that happen in time moments and have defined duration (shorter or longer), therefore it is a process. As time passes, the information that serves for decision-making can become out of date at the moment when the actions caused by the specific decision are to be put in practice. This is connected with the term of operation time relativity [4].

Operation management of a single aircraft consists in organization of its use in accordance to the adopted operation strategy (by its resource, technical condition, age, reliability, etc.) until the aircraft lifetime is expired (flight hours or calendar age). Full (exact) records on the aircraft operation, its overhauls and revamps should be kept and retained.

Operation of aircrafts in accordance to conventional strategies (resource, technical condition and others) is well known and put in common practice. It is governed by relevant regulations and employs appropriate on-board and land-based diagnostic methods and tools for prediction of technical condition of the equipment.

But a new strategy for operation management of aircrafts by age thereof has recently appeared [9]. The need to develop such a strategy has arisen due to premature so called calendar ageing. It refers to such aircrafts that have not completed their operation resource, counted as hours of flights, but have reached their calendar lifetime. This strategy, being more economical, needs to develop new methods, procedures and tools.

Efficient management of aircraft fleet should be based on optimal organization, well-defined interactions supervision of operation and assessment of results caused by various decisions in accordance to the adopted criterion of operational target.

The next component of efficient management is working out decisions of various nature and related to actions, operations and strategies.

By assumption, every decision should be correct, effective and preferably optimal one.

Among various decision-making models [2, 6] the probabilistic approach is the most popular. The model is described by the formula:

$$E(y) = \int P(x,a)f_a(a)da$$

where: $E(y)$ – expected value (EV) for the $y$ variable, $f_a(a)$ – function of probability density of the for the $a$ parameter

The expected value (2) should be minimized with respect to $x$ and the result is the most advantageous in terms of the average value, i.e. for a specific number of working cycles it gives the lowest average value of $y$.

It is assumed that the operation system is controllable. Thus, it must be composed of a control unit and a controlled module. The controlled module transforms matter or energy. The control system is used for information processing.

Controlling (management, administration) operation system is embedded into the cycle of planning and monitoring of activities by means of information circulation, which is nowadays achieved with aid of computer systems (Fig. 1).

The operation control process (for every operation system) represents a sequence of states and operation activities between the stated that make up a chain of events during the time when an aircraft is used in an avionic transport system (LST). It is the process that should guarantee:

- reasonable operation of aircrafts in accordance with the intended use thereof,
- maintaining aircrafts in full readiness to perform their functions and assigned tasks, to enable faultless operation thereof for the defined scope of operation tasks, with account of the existing resources, restrictions and disturbances under defined conditions and time.

![Fig. 1. Activities within the aircraft operation system](image)
The set of control operations $DS$ can be symbolically expressed in the following form:

$$DS = \{D, G, P, P_r, R_0, DZ\}$$

(6)

The set incorporates the following components:

- diagnostic operations $D(t)$ as verification of a hypothesis that is moved at the moment of $t$ about the system condition at the moment of $t$;
- genesis operations $G(t)$ as verification of a hypothesis that is moved at the moment of $t$ about the system condition at the moment of $t_{i-1}$;
- prediction $P(t)$ as verification of a hypothesis that is moved at the moment of $t$ about the system condition at the moment of $t_{i+1}$;
- prophylactics $P_r(t)$ as the activity that is carried out at the moment of $t$ in order to prevent the system against the undesired predictable state at the moment of $t_{i+1}$;
- revamping $R_0(t)$ as the activity that restores the state of the system as it was before the moment of $t$;
- replenishment activities $DZ$.

The most troublesome parts in the control process are the following: selection of a suitable model of the actual process and selection of diagnostic signals [3]. These problems must be solved individually, each time when detailed specification of the operated system is to be carried out.

4. References


