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Operation process of training aircraft Diamond DA 20-C1

Keywords

reliability, dependability, aircraft, Diamond DA 20-C

Abstract

The method of the stochastic Markov process used for the analysis of operation of a training aircraft – Diamond DA 20-C has been presented in the article. This was performed by analysing the transitional processes of the exploitation process and determining the probability of technical objects staying in particular exploitation states. Markov stochastic processes have been used as a model to determine the readiness of aircraft – Diamond DA 20-C for specific tasks. In order to find out the readiness of the explored aircraft, the probability of being in one of the investigated states has been determined. The analysed states included: standby, pre-flight service, flight, interstate service, after-flight service and hangar service. Selected and described methods, tools and methodologies as well as their application are the basic set of knowledge for the analysis and assessment of the safety condition of training aircraft.

1. Introduction

At the turn of the years, aviation is gaining in popularity, the number of passengers of well-known airlines is increasing and the network of connections is constantly growing. At the same time, it is the safest means of transport. However, in order to achieve this, it is necessary to ensure an adequate level of flight safety. Security is an area that requires constant attention and implementation of changes aimed at eliminating further emerging threats (Shappell & Wiegmann, 2003).

This chapter investigates the operational process of an aircraft belonging to the light category. This was achieved by analysing the transitional processes of the exploitation process and determining the probability of technical objects staying in particular exploitation states. The analysis of the transition processes of the operation allows the aircraft to be in a state of readiness and avoids stagnation in hangar services (Konieczny, 1975; Pszczółkowski, 2020).

The method of the stochastic Markov process used for the analysis of operation of an aircraft Diamond DA 20-C has been presented in the article (Callus, 2003).

1.1. Object of research – Diamond DA20-C

The Diamond DA20 is a two-seater aircraft designed and manufactured by the Austrian company Hoffmann Flugzeugbau, founded in 1981. At the end of the 1980s, due to changes in own-

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ership, the company changed its name to Diamond Aircraft. On the basis of the Diamond HK36 Dimona aircraft, work began on the first DV20 Katana aircraft. The prototype flight took place in 1991 while the first presentation and certification of the aircraft took place in 1993. The production of this aircraft started in Austria in 1993 under the name DV20, nevertheless in the following year, in order to meet the requirements of the North American market, the production started also in Canada under the name DA20. The aircraft achieved great success on the international market and gained considerable popularity, so that it gained many improved and much more developed variants. By the end of 2010, around 1,000 aircrafts were produced. Moreover, on its basis Diamond Aircraft decided to produce the four-seater Diamond DA40 Diamond Star (Ayyub, 2011).

The great request for a *single engine training aircraft* has prompted the re-visitation of the creation of the Diamond DA20-C1 fueled by a 125HP Continental IO- 240 motor and furnished with new best-in-class G500TXi Avionics. The DA20-C1 has been endorsed by Transport Canada as per the Canadian Airworthiness Manual (AWM) Chapter 523-VLA., Type Certificate No. A-191. Continental IO 240, normally suctioned, 4 chambers, 4 phase engines, is fused which is fuel infused, evenly restricted, air-cooled. This plane is named an extremely light plane endorsed for Visual Meteorological Conditions just, in non-icing conditions. All aerobatic moves, aside from deliberate turning which is allowed with flaps UP just, are denied. The most extreme passable speed for all working modes is 164KIAS. The airplane is furnished with elevation remunerating fuel framework. Flights are admissible as per visual flight rules.

The Diamond DA 20-C1 is a two-seater tourist aircraft, designed for flight training as an alternative to the most frequently used Cessna aircraft in aviation schools. The recommendation for this aircraft is that it was selected as a basic training aircraft by the US Airforce Academy. This aircraft is manufactured in Canada by the Diamond Aircraft subsidiary in London, Ontario.

Description and characteristics of selected dimensions:

- wingspan: 10.87 m,
- maximum length: 7.17 m,
- maximum height: 2.19 m,
- chassis spacing: 1.9 m,
- fixed pitch propeller diameter: 1.75 m,
- wing area: 11.6 m^2 (ULC, 1997).

2. Calculation methodology

2.1. Markov chains

Among analytical methods based on the analysis of random processes, also called state space methods, the most frequently used are the methods of the Markov chains and processes, and recently the semi-Markov processes. They are based on the assumption that the tested object of random process fulfilling the property of the Markov process (Dys, 2008).

The random process is called the Markov process, when for any finite sequence of moments and any real numbers there is an equality (Dąbrowska, 2020):

$$P[X(t_n) < x_n \mid X(t_{n-1}) = x_{n-1},\ldots,X(t_1) = x_1]$$

$$= P[X(t_n) < x_n \mid X(t_{n-1}) = x_{n-1}] \qquad (1)$$

This relationship means that the conditional probability distribution of a random variable $X(t_n)$ depends solely on the probability distribution of one of the random variables $X(t_{n-1})$. Properties of the Markov process at the moment of t_n do not depend on the values that the process assumed at moments t_1, t_2, ..., t_{n-2}. The Markov process is therefore fully characterized by the conditional distribution (MIL-STD-882D, 2000):

$$F(s,t,x,y) = P\left[X(t) < x \mid X(s) = y\right], s < t \qquad (2)$$

or the total distribution of random *vector* $(X(s), X(t))$ with initial distribution $F(s, y) = P[X(s)<y]$. In the analysis of Markov's processes, a function called the probability of transition is essential, which is defined for any moment t, state s and for any number of real y and any Borel set **B**, in the following way:

$$P(s,t,\mathrm{B},y) = P\left[X(t) \in \mathbf{B} \mid X(s) = y\right] \qquad (3)$$

In the case of the Markov process, the probability distributions of time in the states must be exponential. The exception is the calculation of asymptotic reliability indicates. In some cases it is also possible to transform the state space in such a way that non-explanatory probability distributions will be replaced by a sequence of exponential distributions (Leski et al., 2009).

2.2. Smoluchowski-Chapman-Kolmogorov equation

In practical applications, especially in reliability considerations, the most important part is performed by Markov's point processes defined on the range $T = <t_0, \infty)$ with the state space $S = 0, 1, 2; \ldots$. The realizations of the Markov point process are functions of fixed intervals and their graphs are stair line.

For a point process Markov probability of transition (Grabski, 2015):

$$p_{ij}(s,t) = P[X(t) = j \mid X(s) = i], \tag{4}$$

$$t \geq s, \;\; i, j = 0,1,2,...$$

satisfy the relationships:

$$p_{ij}(s,t) = \sum_{k=0}^{\infty} p_{ik}(s,t_1) p_{kj}(t_1,t), (s < t_1 < t) \tag{5}$$

known as Smoluchowski-Chapman-Kolmogorov equation. Moreover, for each i ($i = 0, 1, 2; \ldots$) there is an equation (Grabski & Jaźwiński, 2009):

$$\sum_{j=0}^{\infty} p_{ij}(s,t) = 1. \tag{6}$$

Introducing functions $\lambda_{ij}(t)$ known as process transition intensities or transition rates:

$$\lambda_{ij}(t) = \lim_{\Delta t \to 0} \frac{1}{\Delta t} p_{ij}(t, t + \Delta t), \tag{7}$$

$$i, j = 0,1,2,..., \;\; i \neq j,$$

the system of differential equations with variable coefficients is obtained (Niemiro, 2013):

$$\forall i \in S : \frac{dP_i(t)}{dt} = \lambda_{ij}(t) P_i(t) + \sum_{\substack{j \in S \\ j \neq i}} \lambda_{ij}(t) P_j(t)$$

$$\lambda_{ij}(t) = -\sum_{\substack{j \in S \\ j \neq i}} \lambda_{ij}(t) P_j(t) \tag{8}$$

where:
$P_i(t)$ – the unconditional probability of the process remaining at time t at state i,
$\lambda_{ij}(t)$ – the transition rate of the process at t from state i to state j.
When the Markov process is homogeneous, the transition rate is independent of the time $\lambda_{ij}(t) = \lambda_{ij}$ = const., $i \neq j$ and a system of differential equations with constant coefficients is obtained:

$$\forall i \in S : \frac{dd_i(t)}{dt} = \lambda_{ii} d_i(t) + \sum_{\substack{j \in S \\ i \neq j}} \lambda_{ji} d_j(t) \tag{9}$$

where:
$d_i(t)$ – the unconditional probability of the process being in the state i at moment t, $d_i(t) = P\{X_t = i\}$ for $i \in S$, $t \in T$, for which knowledge of initial probabilities for which knowledge of initial probabilities $P_i(0)$, $i \in S$ is needed.
The above system can be written in vector form, as:

$$\frac{d}{dt} \mathbf{D}(t) = \mathbf{\Lambda}^T \mathbf{D}(t) \tag{10}$$

where:
$\mathbf{D}(t) = [d_1(t), d_2(t), \ldots, P_m(t)]_{m \times 1}$ – column vector of probabilities of process presence in particular states,

$$\mathbf{\Lambda} = \begin{bmatrix} -\sum_{j=2}^{m} \lambda_{1j} & \lambda_{12} & \cdots & \lambda_{1m} \\ \lambda_{21} & -\sum_{\substack{j=1 \\ j \neq 2}}^{m} \lambda_{2j} & \cdots & \lambda_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \lambda_{m1} & \lambda_{m2} & \cdots & -\sum_{j=1}^{m-1} \lambda_{mj} \end{bmatrix}$$

– transition rate matrix,
m – number of sets S (number of process states).
The elements of the $\mathbf{\Lambda} = [\lambda_{ij}]$, $i, j \in S$ transition rate matrix the following probabilistic interpreta-

tion may be given:

$$\lambda_{ij} \cdot \Delta t + o(\Delta t) = p_{ij}(\Delta t) \tag{11}$$

$$1 - \lambda_i \cdot \Delta t + o(\Delta t) = p_{ii}(\Delta t) \tag{12}$$

where $\frac{o(\Delta t)}{\Delta t} \xrightarrow[\Delta t \to 0]{} 0$.

The expected value of the random variable T_{ij} can be interpreted as the average time of stay in the state S_i before the state S_j. From equation (11) the estimator of parameter λ from the sample can be calculated from the formula (Paska, 2005):

$$\hat{\lambda}_{ij} = \frac{1}{E[T_i]} \cdot \hat{p}_{ij} = \frac{n_i}{\sum_{k=1}^{N} t_i^{(k)}} \frac{n_{ij}}{n_i} \tag{13}$$

$$\hat{p}_{ij} = \frac{n_{ij}}{n_i} \tag{14}$$

where:
n_{ij} – number of transitions from the state S_i to the state S_j,
n_i – number of outputs from the S_i state,
$t_i^{(k)}$ – time of the object being in the S_i state for observation number k from the sample.

2.3. Markov process stationary distribution

In many practical applications, only the asymptotic probability values, i.e. $D(t)$ values at $t \to \infty$, are relevant. If these values are assumed to exist, i.e. the process is ergodic, the differential equations are transformed into algebraic equations. Therefore, for processes with a finite number of states and a non-zero transition intensity matrix, there are stationary (boundary) distribution of states (Plucińska & Pluciński, 2015):

$$\lim_{t \to \infty} \mathbf{D}(t) = \mathbf{\Pi} \tag{15}$$

For continuous time, linear equations are solved from the stationary probabilities p_i^*:

$$\mathbf{0} = \mathbf{\Lambda}^T \mathbf{\Pi}^T \tag{16}$$

where $\mathbf{\Pi} = [p_1^*, p_2^*, \ldots, p_r^*]_{1 \times m}$ – stationary distribution (or invariant measure) vector (Kowalenko et al., 1989).

2.4. Embedded Markov chain

At the same time as a given Markov process, the corresponding Markov chain can be considered, called the embedded Markov chain, with the same phase space S and the moments of testing occurring at the moments of state change by the process.
If the Markov process is taken into account only at those moments upon which the state of the system changes, then the probability matrix of chain transitions between individual operating states is $\mathbf{P} = [p_{ij}]$, where:

$$p_{ij} = -\frac{\lambda_{ij}}{\lambda_{ii}} \tag{17}$$

with λ_{ij} being the intensity of the Markov process.
The elements of the **P** matrix should be treated as the probability that a certain transition to state j will occur at the moment of the immediate state change, exit of the process from state i.
The most important characteristics of the chain are its unconditional distributions. The unconditional distribution of the Markov chain at moment n can be described as a vector (Taylor & Karlin, 1998):

$$\mathbf{D}_n = \left[d_{n1}, d_{n2}, \ldots, d_{nm}\right]_{1 \times m} \tag{18}$$

where:

$$d_{nj} = P\{X_n = j\} \quad \forall j \in S : d_{nj} \geq 0 \quad \wedge \quad \sum_{j=1}^{m} d_{nj} = 1.$$

Using the formula for total probability, it is possible to obtain:

$$P\{X_{n+1} = j\} = \sum_{i=1}^{m} P\{X_n = i\} P\{X_{n+1} = j \mid X_n = i;\}$$

$$d_{n+1,j} = \sum_{i=1}^{m} d_{n,i}\, p_{ij} \tag{19}$$

which in the matrix notation leads to the following relationship between the unconditional distributions of the variables X_n and X_{n+1} (Ocaña-

Rilola, 2002):

$$\mathbf{D}_{n+1} = \mathbf{D}_n \mathbf{P} \tag{20}$$

The stationary distribution of the finite, homogeneous Markov chain with the transition matrix **P** is the boundary $\lim_{n\to\infty} \mathbf{D}_n = \mathbf{\Pi}_c$. It is a vector that

$$\forall i \in S : p_i^* \geq 0 \quad \wedge \quad \sum_{i=1}^{r} p_i^* = 1$$

and (Decewicz, 2011):

$$\mathbf{\Pi}_c \mathbf{P} = \mathbf{\Pi}_c . \tag{21}$$

The stationary distribution is the only non-zero solution (Cappe et al., 2005):

$$\left(\mathbf{P}^T - \mathbf{I}\right)\mathbf{\Pi}_c^T = \mathbf{0} . \tag{22}$$

3. Operational state model

The operation process is the transition of aircraft from one operating state to another. The transition from state to state of the aircraft under operation can be illustrated, by a direct graph or as a zero-one matrix (Rabiner, 1989).
An aircraft may be in one of the states in the operation process:

- S_1 – standby state,
- S_2 – pre-flight service state,
- S_3 – flight state,
- S_4 – interstate service state,
- S_5 – after-flight service state,
- S_6 – hangar service state.

The states S_1, S_2, S_3 and S_4 are classified as readiness states.

3.1. Standby state

The operating state in which the aircraft is airworthy and completely available for the flight task.

3.2. Pre-flight service state

The operating state during which pre-flight service is carried out. There are two types of pre-flight service: pre-flight inspection and thru-flight inspection. Pre-flight inspection is performed immediately prior to the first take-off (flight) of the aircraft from its base on a certain day, and is valid for 24 hours. Pre-flight inspection is performed prior to each flight from the base, except for the first flight on that day. Pre-flight service shall be performed on an aircraft that is airworthy and all periodic services, recommendations, bulletins, etc. have been completed on it.

3.3. Flight state

The performance of an aeronautical task is the flight state whereby the aircraft performs the scheduled flight. There are performed such flights as flights with passengers on board, training, technical, etc. For the aircraft to be in this condition, it must be airworthy, and pre-flight service must be performed immediately before the flight. After the completion of the flight task, there is an after-flight service on the aircraft.

3.4. Interstate service state

The intermittent service is the operating state, when periodic service is carried out, the level of which depends on the operating period (e.g. ACheck) or the number of flight hours (e.g. 2CCheck).
Depending on the scope of the periodic service, after its completion:

- the aircraft may be ready for the flight task,
- the aircraft can be directed to make a bulletin, recommendations, etc.,
- a failure may be detected, resulting in a diagnosis or repair,
- the aircraft may be referred for technical verification for a flight.

3.5. After-flight service state

The operating status during which service is performed after the last flight of the day if the aircraft lands at home base. After the post-flight service:

- the aircraft may be ready for the flight task,
- the aircraft may be directed to periodic service or to the performance of a bulletin, recommendations, etc.
- a detected failure may be resulting in a diagnosis or repair.

3.6. Hangar service state

The operating state, when diagnostic technical activities, such as the identification and analysis of failures or eventual repair, are performed on the aircraft. The performance of these operations depends on the technical condition of the aircraft, and the transition to this state may occur whenever the aircraft is maintained. Depending on the scope of technical activities performed during diagnostics and repair, it may be necessary to re-evaluate the technical condition of the aircraft.

4. Exploitation elements

Nowadays, an aircraft structure must be designed in accordance with the assumed flight parameters, flight performance, but also in accordance with the operating principles. The concept of exploitation of an aircraft, plane, glider or helicopter covers a very wide range of issues related to its use, maintenance, supply of spare parts and consumables (fuel, lubricants), repairs, storage and disposal. According to maintenance, repair, operational and diagnostic susceptibility, measures are determined which define the susceptibility of an aircraft. Such vulnerabilities are determined, among others, on the basis of the following theories: flight safety, readiness and reliability.

The essential elements of exploitation are the use of the aircraft, the maintenance of the aircraft and the operational investigation of the aircraft. Maintenance concerns not only the technical object itself, which in aviation is the aircraft, but also takes into account the influence of the environment in which the technical objects are exploited, as well as the humans in the aircraft operational subsystem.

The maintenance process of technical objects, including aircraft, is influenced by:

- type, category, class, age of aircraft,
- environment,
- operations to maintain the aircraft in readiness,

the conditions under which the flight is performed.

Aviation is a transport industry where safety is more important than anywhere else, so a lot of emphasis is given to information flow. Pilots need to be in effective contact with mechanics and avionics (who carry out work in the aircraft maintenance subsystem). Smooth transmission of information about the behaviour of the aircraft in the air, its failures, difficulties in piloting, variances from the accepted standards, is necessary to maintain safety at the appropriate level required. Environmental conditions often require unsteady states which deviate from the accepted aircraft construction load standards. Aircraft maintenance stations, with appropriately qualified personnel and a basic set of equipment, are needed for direct pre-flight and post-flight maintenance. This enables the aircraft to be maintained in a constant state of readiness for flight and ensures an adequate level of safety and reliability.

5. Analysis of readiness for Diamond DA 20-C1 aircraft to perform training task

The operational process is the transition of aircraft from one operational state to another. At the same time it is a set of events that occur inside the operational state when the aircraft is in this state, and it is a set of physical and chemical events occurring in the aircraft itself, which are independent of human actions. They are partly influenced, e.g. by lubrication to reduce friction, proper maintenance to delay the development and destructive effects of corrosion (Hlinka, 2007).

In addition, it is possible that an aircraft could be simultaneously in two or more operational states, for example: a resupply process would take place in parallel with an aircraft maintenance process.

The possibility of transition between different states of an exploited aircraft can be represented, for example, by a directed graph or in the form of a zero-one matrix (Ross, 1996). In this chapter, the model of operating states will be visualised in the form of a graph.

Graphs can illustrate the structure and relationships of states. An aircraft or an exploitation system, as mentioned earlier, may simultaneously be in several different exploitation states. The vertices of the graph represent the operational states, and the arrows mark possible transitions between states (Kowalski, 2005).

Data for the analysis was collected during exploration process. On the basis of the collected data, the exploitation graph presented in Figure 1 was developed.

The number of flights performed at intervals assumed are presented in Table 1.

Table 1. Number of flights performed at intervals assumed

Aircraft type	Day	Week	Month	Year
DA 20-C1	4	27	108	1148

The average residence time of the aircraft in each state are presented in Table 2.

Table 2. Average residence time of aircraft in each state

No.	State	Time
1	Standby	6 h
2	Pre-flight service	55 min
3	Flight	90 min
4	Interstate service	22 min
5	After-flight service	35 min
6	Hangar service	8–24 h

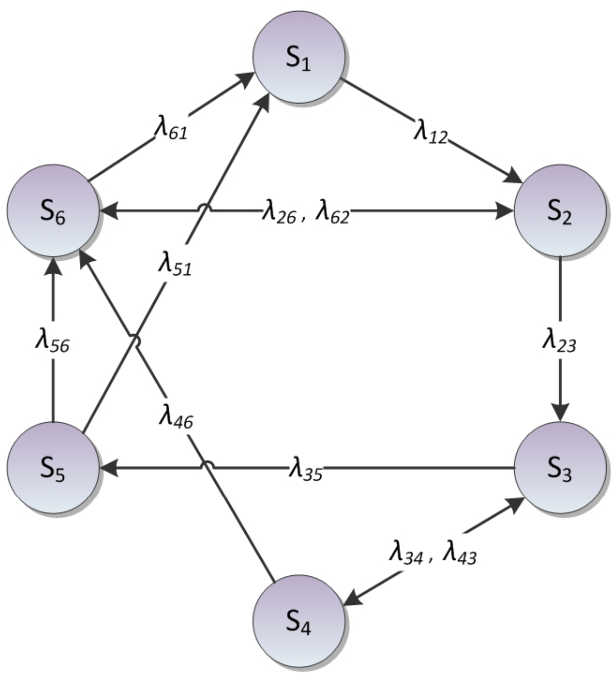

Figure 1. Directed graph of operating states of Diamond DA 20-C1 aircraft.

The system shown in Figure 1 can be described by a system of differential equations:

$$\frac{dP_1(t)}{dt} = -(\lambda_{12} + \lambda_{16})P_1(t) + \lambda_{51}P_5(t) + \lambda_{61}P_6(t)$$

$$\frac{dP_2(t)}{dt} = -(\lambda_{23} + \lambda_{26})P_2(t) + \lambda_{12}P_1(t)$$

$$\frac{dP_3(t)}{dt} = -(\lambda_{34} + \lambda_{35})P_3(t) + \lambda_{23}P_2(t) + \lambda_{43}P_4(t)$$

$$\frac{dP_4(t)}{dt} = -(\lambda_{43} + \lambda_{46})P_4(t) + \lambda_{34}P_3(t)$$

$$\frac{dP_5(t)}{dt} = -(\lambda_{51} + \lambda_{56})P_5(t) + \lambda_{35}P_3(t)$$

$$\frac{dP_6(t)}{dt} = -\lambda_{61}P_6(t) + \lambda_{16}P_1(t) + \lambda_{26}P_2(t)$$

$$+ \lambda_{46}P_4(t) + \lambda_{56}P_5(t) \quad (23)$$

where:
$P_1(t)$ – the probability that the system is in a standby state;
$P_2(t)$ – the probability that the system is in a pre-flight service state;
$P_3(t)$ – the probability that the system is in a flight state;
$P_4(t)$ – the probability that the system is in a interstate service state;
$P_5(t)$ – the probability that the system is in an after-flight service state;
$P_6(t)$ – the probability that the system is in a hangar service state.
These probabilities can be determined using the program Wolfram Mathematica (Koźniewska & Włodarczyk, 1978).
Table 3 presents the data related to the probability of transitions between particular exploitation states.

Table 3. Probability of transition between individual operating states of Diamond DA 20-C1

p_{ij}	S_1	S_2	S_3	S_4	S_5	S_6
S_1	0	0.982	0	0	0	0.018
S_2	0	0	0.394	0.602	0	0
S_3	0	0	0	0.989	0	0
S_4	0	0	0	0	1	0
S_5	0.263	0.732	0	0	0	0.005
S_6	0.282	0.718	0	0	0	0

Table 4 summarizes the transition rates between particular operating states for the real exploitation process.
Probability graphs P were generated from the time t in a year perspective. At the initial stage, the tested technical object may be in one of the

Table 4. Transition rates between individual operating states of Diamond DA 20-C1

λ_{ij}	S_1	S_2	S_3	S_4	S_5	S_6
S_1	-0.075	0.074	0	0	0	0.001
S_2	0	-0.346	0.137	0.209	0	0
S_3	0	0	-1.823	1.823	0	0
S_4	0	0	0	-0.212	0.212	0
S_5	0.143	0.399	0	0	-0.545	0.003
S_6	0.358	0.910	0	0	0	-1.468

assumed operational states. The probability of staying in a given state as a function of time has been calculated.
The stationary distribution $\mathbf{\Pi}_c$ of the finite, homogeneous Markov chain was as follows:

$$\mathbf{\Pi}_c = \begin{bmatrix} 0.0726; 0.2731; 0.1073; \\ 0.2708; 0.2708; 0.0049 \end{bmatrix}_{1\times 6}$$

The stationary distribution $\mathbf{\Pi}$ of the process was as follows:

$$\mathbf{\Pi} = \begin{bmatrix} 0.2676; 0.2190; 0.0165; \\ 0.3574; 0.1390; 0.0005 \end{bmatrix}_{1\times 6}$$

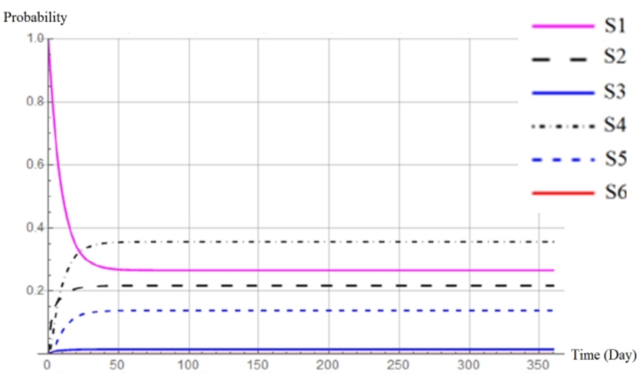

Figure 2. Probabilities of being in one of analysed operating states as a function of time, assuming that the initial state was the standby state for Diamond DA 20-C1.

Figure 2 shows the probabilities of being in one of the analysed operating states as a function of time, assuming that the initial state was the standby state. On this basis (Mattrand et al., 2011). Analysis of Fatigue Crack Growth under Random Load Sequences Derived from Military In-flight Load, it can be seen that the probability of an aircraft remaining in a standby state at the initial phase is 100% and decreases over time. After about 30 days, this probability reaches a constant level called the limit probability, which is approximately 24%. The probability of an aircraft being in between-flight service state increases until an estimated 30 days and has since remained stable at approximately 38%. Probabilities for states with lower values are shown in Figure 3.

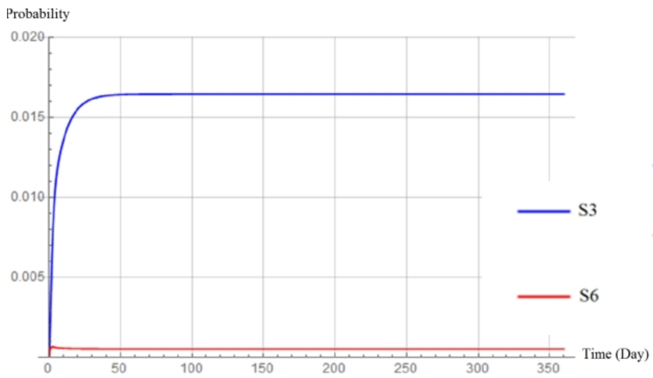

Figure 3. Probabilities of being in one of analysed operating states as a function of time, assuming that the initial state was the standby state for Diamond DA 20-C1 – enlarged drawing.

The probability of the aircraft being in flight condition is approximately 1.5% and the probability of the aircraft being in hangar service state is negligible. The aircraft is likely to be in the state of maintenance before flight at 21% and the aircraft is likely to be in the state of maintenance after flight at 16%.
For the process under study and the initial distribution $\mathbf{D}_0 = [1, 0, 0, 0, 0, 0]_{1\times 6}$, by calculating successive powers of the $\mathbf{P}$ matrix, the calculated d_n values can be shown in Figure 4

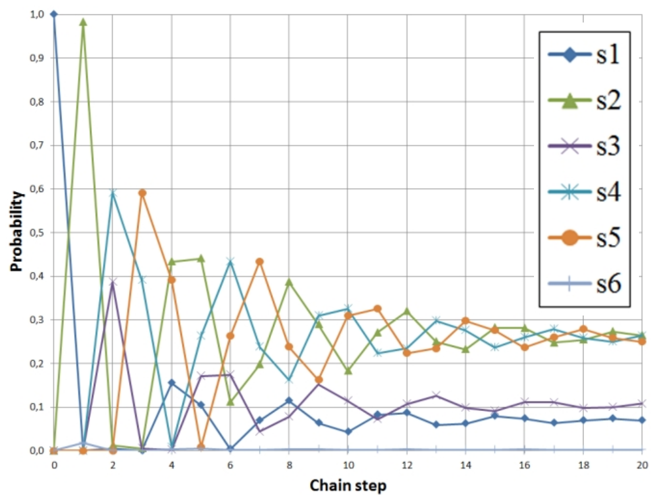

Figure 4. Probabilities of state observation as a function of chain step.

6. Conclusion

The Markov's processes, while satisfying appropriate assumptions, allow to determine the probability in which the analysed technical object is standing. Concluding on the basis of the performed analysis of probabilities of staying of the studied technical objects in one of the exploitation states, approximate values of probabilities of staying of the aircraft of type Diamond DA-20 in the assumed exploitation states were determined. After about 30 days, the probabilities shown in the figures reach constant levels called limit probabilities. It has been assumed that hangar service operations are performed regularly in accordance with the guidelines described by the manufacturer in the operating instructions. The probability for both aircrafts of being in a hangar service state is negligible. The probability of being in a state of flight result from the more expensive operation of the Diamond aircraft, which is mainly used for night flights. In addition, it is assumed that operations are carried out correctly by appropriately trained personnel. It can be concluded that Diamond aircrafts rarely fail.

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