Chapter 17

Resource Modeling Method of Decisions in the Management of Standard Operating Procedures for Civil Aviation Flight Crews

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The subject of control decision modeling in this paper is explored from the point of view of individual and group decisions, which can be the normative basis for managing standard operating procedures for civil aviation flight crews. A method of ontological design is proposed. The purpose of the work is to develop a project on the subject of activity and the derivation of basic definitions of ontology and management. The theoretical and practical significance of the work is to establish the normative practical foundations of standardization.

17.1 Introduction

The subject of control decision modeling in this paper is studied from the point of view of individual and group decisions, which can be the normative basis for managing standard operating procedures (SOPs) of civil aviation (CA) flight crews. Decision-making theory is considered a field of study based on "methods of mathematics, statistics, economics, management, and psychology to study the patterns of choosing ways to solve problems and achieve the desired result" [1]. In theory, multi-criteria decision-making problems (MC DMP) are known [2, 3]. The decision paradigm consists of stages: preliminary analysis, structural analysis, uncertainty analysis, utility or value analysis, optimization procedures, and individual or group decisions. The task set is designed to find the optimal solution from the list of alternatives $X_0 = \{xi\}$, $i = 1,n$ by the decision maker (DM), from the position of the best satisfaction of the criteria $R = \{r_j\}$, $j = 1,m$. MC DMP is represented by a tuple (Eq. 17.1):

$$< t, X, R, A, F, G, D >, \tag{17.1}$$

where (t) is the setting of tasks; (X) is the set of feasible alternatives for decisions and actions); (R) is a set of criteria for evaluating the solution of problems; (A) is the set of scales of evaluation criteria; (F) is a mapping of the set of feasible alternatives in the set of criteria-based assessments of their outcomes; (G) - preferences of the decision maker; (D) is a decision rule reflecting preferences.

In corporate management, decision theory is understood as behavior under risk and uncertainty: the adoption and application of rational choice for effective management in the development and implementation of a corporate strategy. Activity in psychological science is defined as "a set of actions aimed at achieving goals", Rubinshtein S.L. (1889-1960) [4]. "Activity is internal (mental) and external (physical) activity generated by needs and aimed at transforming oneself and the surrounding reality. Action (the basic unit of activity analysis) is a process aimed at achieving a goal. The goal is an image of the required future, to achieve which it is required to carry out an action that includes several operations. How operations are performed is determined by the conditions. An operation is a way of performing an action that occurs as a result of adaptation and adaptation", Leontiev A.N. (1903-1979) [5].

17.1.1 The Content of the Problem

Activities in CA are governed by rules regulated by standards - technical specifications adopted by the Council of the International Civil Aviation Organization (ICAO) Standards and Recommended Practices (SARPs) [6, 7, 8, 9, 10, 11]. These standards do not allow multicriteria approaches and analysis of decisions such as MC DMP or the choice of alternatives used in the strategic management of corporations. It is easy to explain this by the example of road traffic, whose participants, from a pedestrian to a vehicle drivers, have choices only within the limits of traffic rules. Rules in such restrictions are established as standard procedures. In aviation, "SOPs are considered to be the basis for the safe conduct of flights" [12]. A deviation from the SOP is considered a description of an erroneous activity. "Errors. An action or inaction by an operational person that leads to deviations from organizational, or the operational person's, intentions or expectations" [11]. "An error is an unintentional deviation from the correct actions, deeds, thoughts; the difference between the expected or measured and the actual value" [13]. "An action, decision, or judgment that produces an unwanted or unintentional result" [14]. "Error. An action or omission by a member of the operating personnel that results in a deviation from the intentions or expectations of the organization or that member of the operating personnel" [6]. All quoted sentences are conceptual descriptions in natural language (NL), but not definitions.

Example

A known analysis by the Flight Safety Foundation (FSF) (1988-1997) identified factors relevant to SOP: "1. Failure to take action, or wrong action. 2. Failure to meet stabilized approach criteria. 3. Poor communication, control, and mutual assistance. 4. Insufficient situational awareness. 5. Inadequate or insufficient understanding of the conditions. 6. Slow or late action. 7. Deliberate deviation from procedures. 8. Errors in the conduct of radio traffic. 9. Incorrect use of automation. Since the listed “factors related to the SOP” have random, semantically unrelated names, and there is no logically justified definition of the SOP [12], then the implementation programs cannot have a comprehensive solution. The problem is that SOP requires the logical development of concepts and the derivation of their definitions, for which the rules for their formulation are developed in logic [15, 16, 17, 18].

17.1.2 Task Statement

The purpose of this work is to develop a method for modeling SOPs based on a logical analysis of activities. The work contains the solution of the following tasks: a) development of a project on the subject of activity and the derivation of basic definitions of ontology and management; b) modeling of activity - decisions, and actions using hybrid means of non-classical logic; c) development of a model and derivation of definitions of nominal and anomalous outcomes of actions. The tasks of this work coincide with the factors identified by the FSF (1, 6, 7, 8). To solve the tasks set, the existing standards and works on logic are studied. The purpose and objectives of the work are aimed at researching and developing the subject of decisions in management to expand the theoretical foundations of standardization.

17.1.3 Method

The resource method of ontological design (MOD) in this work is considered a scientific approach to reducing the uncertainty in the description of complex-structural objects and events [19]. The method contains conditions, rules, and procedures for modeling and establishes the analysis and inference of definitions. The purpose of the method is to establish definitions of concepts used to develop standards. For the solution of the problems of this work, the apparatus of set theory, non-classical logic, and symbolic formalization are used.

17.2 Ontological Project Development of the Subject of Activity

This paper proposes the development of a project for modeling decisions in management at two levels: (1) ontological (categories): resource, event, state, situation, activity space in nominal and abnormal conditions; (2) actological (management): goal, the outcome of an action, result, error (Fig. 17.1).

17.2.1 Ontological Level of Concepts (Categories)

The first level includes:

Definition 17.1. *The Resource R. An elementary resource $r_i \in |R|$ is a material, energy, or information property of an object of any nature, that is observed by measurement or evaluation in states (parameters, indicators). Example. The body has the property of gravity and is observed in states of motion and rest. [19]*

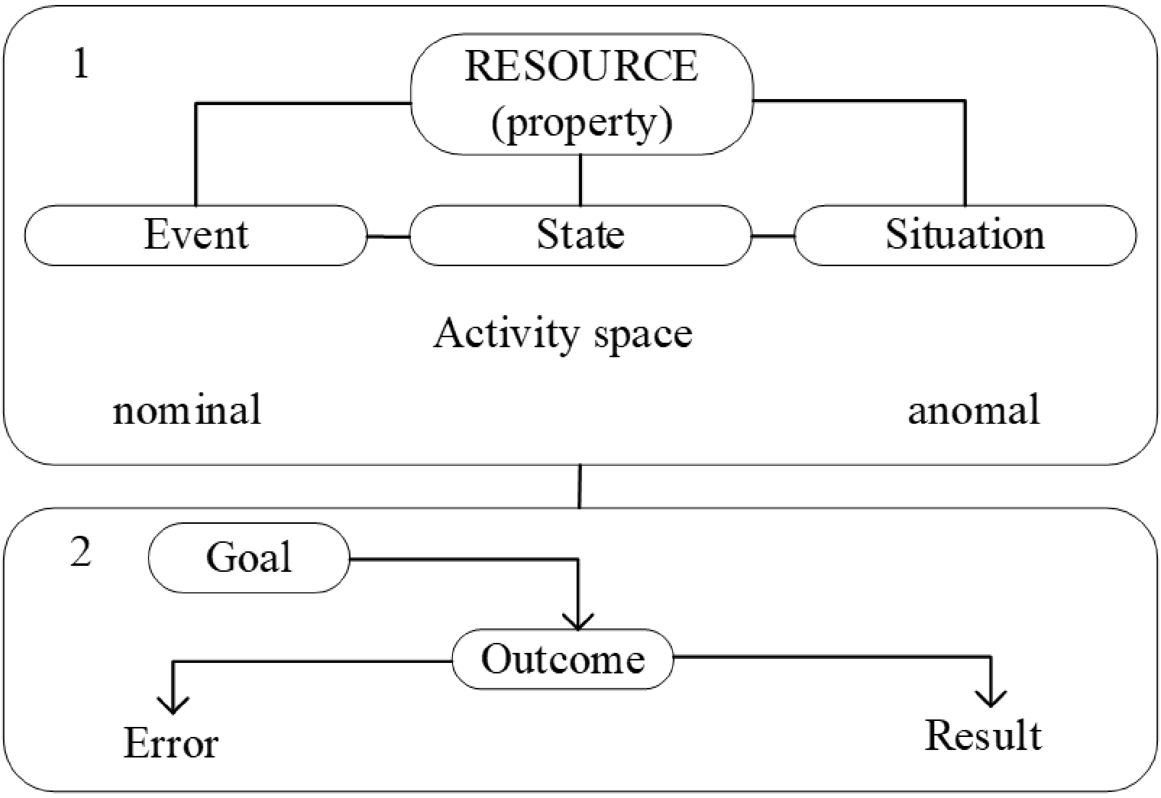

Figure 17.1: Ontological project of the subject of activity.

To understand the concept of a state, definitions of the concepts of state transitions, convolution, and expansion of information about an object are introduced. Let $[O_i]$ to be a term, an observable object.

Definition 17.2. *Transitions in the display spaces of an object are called ascending if they are carried out in the direction of a higher dimension (Eq. 17.2):*

$$O_i : \langle s_i \to s_{i+1}, \ldots, \to s_{i+k} \rangle; s_i \in S, i \in \overline{1,n}, \tag{17.2}$$

where (s_i) is a spatial measure, (n) is the number of object states, and (i) is a feature (name, label, number).

Definition 17.3. *The mappings in ascending transitions are called the sweep of the object description data. Otherwise, the complexity and quality of the information in ascending transitions increase. Example: the moment of separation on takeoff of an aircraft and its transition to motion in three-dimensional space.*

Definition 17.4. *Transitions in the display spaces of an object are called descending if they are carried out in the direction of the lower dimension (Eq. 17.3):*

$$O_i : \langle s_i \to s_{i-1}, \ldots, \to s_{i-k} \rangle, k \in 1, \overline{n-1}, \tag{17.3}$$

where $n-1$ is the number of transitions

Definition 17.5. *The mappings in descending transitions are called the object description data roll-up. Otherwise, the complexity and quality of the information in the downlinks are reduced. Example: the moment of the landing of an aircraft and its transition to movement in two-dimensional space on the run and taxiing.*

Definition 17.6. *Transitions in the display spaces of objects are called symmetrical if they are carried out in any of two directions of one, greater or lesser dimension (Eq. 17.4):*

$$O_i : \langle s_i \leftrightarrow s_{i\pm1}, \ldots, \leftrightarrow s_{i\pm k} \rangle \tag{17.4}$$

Examples: a) on the takeoff run, at the decision speed, the moment the pilot decides to continue or abort the takeoff; b) the moment of decision-making at the decision height (VLOOKUP) on landing or go-around.

Definition 17.7. *An event is a display of changes in the resources of an object ($R \ni r$) at a point in time (τ) in space transitions (Eq. 17.5):*

$$O_i : \langle s_i \leftrightarrow s_{i\pm1}, \ldots, \leftrightarrow s_{i\pm k} \rangle, \tag{17.5}$$

where e_i is the object mapping operator.

An event is a display of any state of the object's resources: information, energy, and matter in time and space. In the cited particular definition, an event is a connection of relations $e_i(t_i, s_i)$ in time: the start of the movement, stop, takeoff, and landing of the aircraft in ascending, descending, symmetrical transitions.

Definition 17.8. *State is a parameter ($i \in Z$) a set of object property parameters in the observed time interval.*

In the standard [13] i. 113-01-10, the time interval is defined as part of the time axis, limited to two instants. In this definition, the concept of a state is defined as a parameter of the correlation of indicators (joint and simultaneous). For example, the speed of a vehicle is measured by two indicators: distance and time.

Definition 17.9. *The situation is resource changes from the present (before the action) state i, to the future (after the action) j state in time are considered in transitions, which are fixed by a set of distinguishing features (Eq. 17.6):*

$$Z \downarrow (Z_i \to Z_j)\tau; z \downarrow (r_i t_i, \ldots, r_j t_j); (\tau, \ni t), (i \in Z), \tag{17.6}$$

where $(r_i t_i \ldots r_j t_j)$ are changes in the resource states of the object, (i) is a sign of the present or initial situation, (j) is a sign of a future or new situation in time $t_i - t_j$.

The Space of Activity Conditions

The task of modeling is presented in terms of actions and outcomes in the space of activity. In this paper, an ontological concept of the space of activity conditions is introduced.

Definition 17.10. *The space in the assigned activity is called the space with **nominal** conditions (Ω_{nom}).*

Definition 17.11. *The space of activity outside the assigned activity is called the space with **anomal** conditions (Ω_{anom}).*

The exit into the space of anomalous conditions can be accidental, forced, inevitable, and deliberate. An accidental exit is possible with a fuzzy formation of the goal, with extreme changes in the conditions of activity. Deliberate exit should be considered as the subject's conscious intentions in terms of freedom and responsibility. This exit is possible when new areas of activity are established, new equipment is tested, and activities are carried out in emergencies and situations, as well as in violations.

Thus, the differences between the ontological concepts of "event", "state" and "situation" are that the event is observed at a moment, the state is observed in a time interval, and the situation is observed in the totality of the attributes of the object's states. An example of the connection of events, states, and transition processes is presented in [20] as an automaton of object reliability. It should be noted that the above definitions are valid for three-dimensional space. If time is considered the fourth measure of space, then definitions and formulas should be corrected.

17.2.2 Actological Level of Concepts (management)

The second level includes:

Definition 17.12. *An action is a purposeful change in the resources of an object in the transition from $Z_i = r_i t_i$ state to $Z_j = r_j t_j$ state (Eq. 17.7):*

$$A : \tau \Leftarrow \{r_i t_i \to r_j t_j\} \tag{17.7}$$

Definition 17.13. *The goal is a quantitative description of the necessity, magnitude, and timeliness of the action, the planned desired state (DZ) of the resource $r_j t_j$, which is formed by the subject, being in the present state (PZ) $r_i t_i$ (Eq. 17.8):*

$$A : \tau \Leftarrow \{(r_i t_i \to r_j t_j) \mid r_i t_i\}; a_i \ni A, t_i \ni \tau \tag{17.8}$$

Definition 17.14. *The outcome of the action is the achieved state $r_j t_j$ according to the condition of the initial state of the subject's resources $r_i t_i$ (Eq. 17.9):*

$$A : \tau \Leftarrow \{r_j t_j \mid r_i t_i\} \tag{17.9}$$

The concept of "outcome of an action" is the attributes of the states of an object, the magnitude of which has not been established. Establishing the value of resources after an action corresponding to the goal requires the introduction of an additional superstructure function.

Observation Function

The superstructure function is called the observation function (measuring, evaluating) the states of the object (Eq. 17.10):

$$A : \tau \Leftarrow \{(x \wedge y) \models f(x \wedge y)\} \mid U_k(n), \tag{17.10}$$

where U_k is a method (procedure) of observing the states of an object, $k(0,1)$ is a distinctive operator for evaluating the goal and outcome of an action; n is the number of different features; $(x \wedge y)$ is a reference pair of subjects of observation, the signs of which are put by the outcome of the action and are called: x - internal reference, if the outcome is assessed by the subject of the action (self-assessment), y - external reference if the outcome is assessed by an external referent (assessment).

So, the description of the goal is the attribution of attributes to those states of resources that will likely be achieved. The result description is the states of the resources that are reached. The observation function, defined as the model, is designed to evaluate outcomes as the degree of compliance with the goal in terms of results or errors in the anomalous or nominal (standard) activity destination space.

Definition 17.15. *The standard operating procedure (SOP) is a set of actions that meet the requirements of the appointment in given nominal conditions Ω_{nom} (Eq. 17.11):*

$$A : \tau \Leftarrow \left\{ S_i \xRightarrow[U_k(n)]{x \wedge y} S_j \right\} \mid \Omega_{nom} \tag{17.11}$$

Thus, a formal ontological and actological structure and derivation of definitions of activity have been developed. The evaluation procedures $(x \wedge y)$ are presented below in the development of a polystructural model of nominal and erroneous outcomes of actions.

17.3 Resource Activity Modeling

17.3.1 Empirical Model Decisions and Actions

The concept of connection between decisions and actions can be described as a mental and verbal enumeration of several behavioral alternatives, which are defined in such a way, that the choice of one of them excludes the choice of all the others. Decisions are comparisons of expected positive and negative results, implementation of each choice, judgment, and conclusion about the preference of one of the choices. Theories of the connection between thinking and the action of mental and physical operations were expressed in the works of Piaget J.W.F. (1896-1980) [21], Hayakawa S.I. (1906 –1992) [22] . Based on a similar concept, the author of this work has developed an empirical model of decisions and actions "from thought to action", which consists of two interconnected and unequal data and information flows (Fig. 17.2).

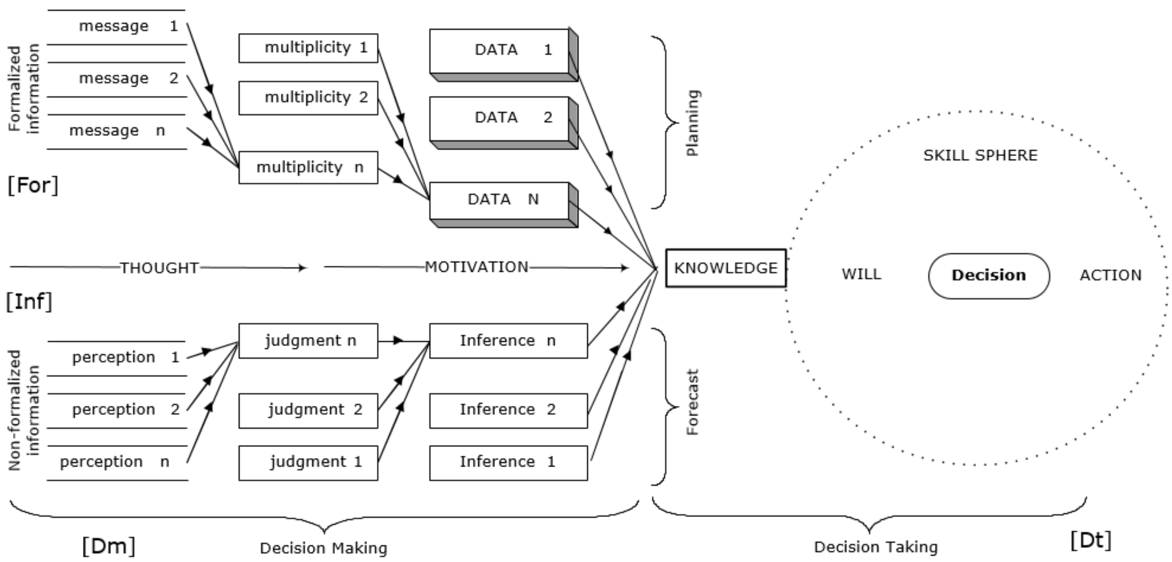

Figure 17.2: Model "from thought to action".

One stream is information identified and inherent in a person, received through the organs of perception of the environment, where analog qualitative information prevails. The other flow is formalized information with a predominance of signed quantitative information. Judgments and conclusions arise, and assumptions and forecasts are made based on analogous right hemispheric information. Based on sign left hemispheric information, data are accumulated and formalized plans are drawn up. Motivation is the root cause of the behavior and the basis for moving information toward a solution. The whole period before the knowledge of WHAT should be done is the stage of decision-making. From motivation, the action begins to be prepared, which is preceded by the last impulse of motivation - the will. Will is an act of decision-making. The decision is a process that precedes action and reflects motivation and will. The content of the model makes it possible to compose the following definitions of decisions.

Definition 17.16. *Decision-making (Dm) is a process that reflects the ability to form knowledge: structure data from sets of messages, choose options for actions and expected consequences, perform an action, or refrain from action, based on perceptions, judgments, and inferences of expected results.*

Definition 17.17. *Decision-taking (Dt) is the process or act of will before action.*

The presented model has important differences from existing descriptions: a two-component composition of information content and a two-stage process of processing information as decisions and actions (Eq. 17.12):

$$\mu \mid \{[\mathrm{Inf}] \wedge [\mathrm{For}] \subset \{[\mathrm{Dm}] \wedge [\mathrm{Dt}]\} \mid :\Leftrightarrow f : D \to A, \tag{17.12}$$

where the elements have attributes and constitute the subject denoted by each of the terms: $\mid D \to A \mid$ is equivalent, by definition, to the power of a fuzzy set of decisions and actions; $[\mathrm{Inf}] \wedge [\mathrm{For}]$ is unformalized and formalized information flows; $[\mathrm{Dm}] \wedge [\mathrm{Dt}]$ is the decision-making process and decision-taking process. The idea of a two-step process is found in the work of Phil Jones: “When we prepare a solution, we (literally) construct this solution: preparing a solution is building a solution. “When we make a decision we (literally) construct that decision: decision making is decision construction. When we take a decision we commit to action: decision taking is decision commitment” [23]. The stated content is realized in activity modeling, in the logical derivation of definitions and terms by the purpose and objectives of this work.

17.3.2 Pseudophysical Modeling of Decisions and Actions

The modeling is called pseudophysical [24], or hybrid because the means of classical logic are not enough to describe it. Hybrid logics are used: fuzzy, temporal, modal, and causal (consequence-causal). The pseudo-physical logic of decisions and actions is illustrated by the following example.

Example (Safety Window)

The concept of "safety window" (SW) [25] is presented in the situation of takeoff and landing and is characterized by the following parameters: the highest workload in terms of importance and the number of operations; the largest share, more than 80% of aviation accidents (AA); height - less than 1000 meters; the shortest time, about 10% of the total flight time (Fig. 17.3).

Situation A. On takeoff run, immediately after liftoff, one of the engines fails. The termination of the takeoff in most cases leads to catastrophes. Decision: continue the takeoff and subsequent approach and landing. Therefore, leaving the SW is the preferred choice of decision.

Situation B. On a straight line, with the landing configuration of the wing and landing gear, one of the engines fires. Go-around in most cases leads to disasters. The crew decides to land. Staying in SW is the preferred decision choice.

Let the space bounded by the runway be identified as a safe space or SW. The logical statement $SW \to [0,1]$ means:

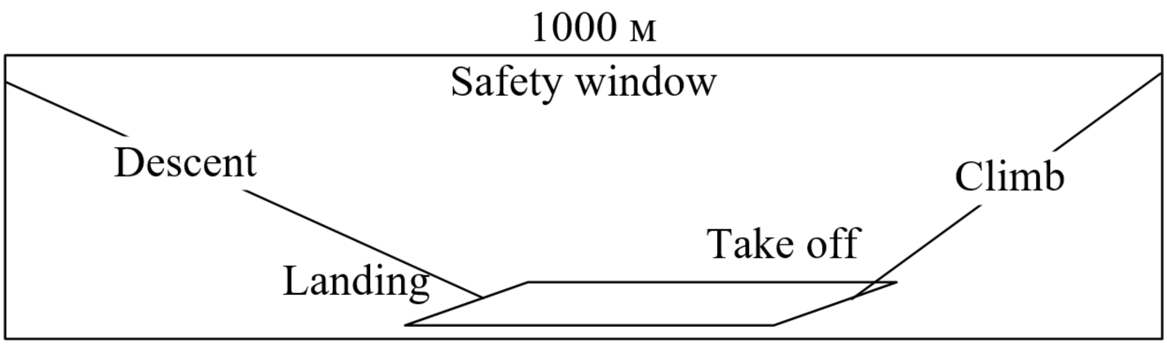

Figure 17.3: "Safety Window".

$SW = 1 \rightarrow$ is the term [safety]; $SW = 0 \rightarrow$ is the term [danger]. Empirically established safety actions:

Situation $A \rightarrow \succ$ "stay in SW"; Situation $B = 0 \rightarrow \succ$ “leave the SW”; where "$\succ$" means "not worse than" ("better than").

Let situation $A = 1$. This means that $A = (SW = 1) \rightarrow A = 1$.

Let situation $B = 1$.This means that $B = (SW = 0) \rightarrow B = 0$.

So, the same SW space seems to be contradictory in the classical logic, since the decisions “leave” or “stay” are fuzzy preferences “$\succ$”, based empirically, which is justified by flight safety practice.

Pseudophysical Model

The task of modeling is presented in terms of actions and outcomes. Fuzzy set of decisions and actions $\mid D \rightarrow A \mid$ is structured: (1) action and necessity of action, (2) magnitude of action and sufficiency of the action magnitude, (3) temporality - time of action and timeliness of action. The concepts of modalities or the predicates "necessity", "sufficiency", and "timeliness" are used in terms of the practical meaning of the SOPs prescribed by the flight operation manuals (FOM) (Table 17.1).

Table 17.1: Pseudophysical model

Decision	Modalities	Predicates		
		nominal space	anomal space	
Action	necessity	required	-	unnecessary
Magnitude	sufficiency	sufficient	insufficient	excessive
Time	timeliness	timely	early	late

The above is explained by the diagram (Fig. 17.4).

The following logical statements and definitions of actions are formalized in the model:

- Action (A), according to the condition of the necessity of the action necessity (N). Nominal action in the space of nominal conditions (Eq. 17.13):

$$A \mid \Omega_{nom} \Leftarrow [A \mid N] \cdot [\tilde{A} \mid \tilde{N}], \tag{17.13}$$

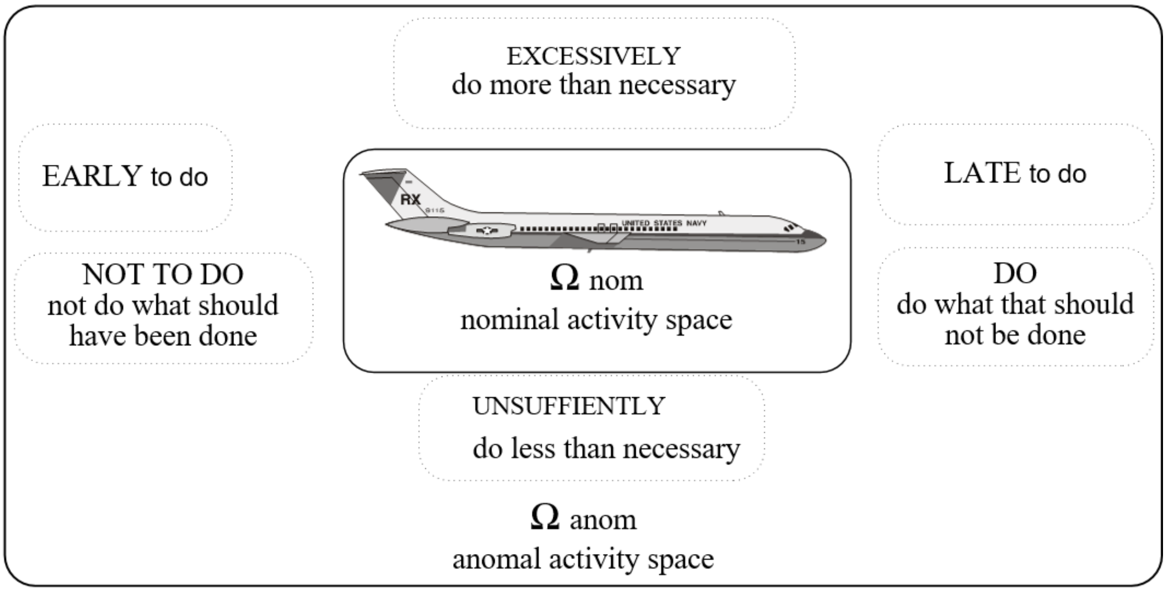

Figure 17.4: "Decision and action model".

where the components have attributes and constitute an object denoted by each of the terms: $[A \mid \tilde{N}]$ is action according to the condition of the need for action and $[\tilde{A} \mid N]$ is inaction according to the condition of the necessity for inaction.

- Anomal (erroneous) action in the space of anomal conditions (Eq. 17.14):

$$A \mid \Omega_{nom} \Leftarrow [A \mid \tilde{N}] \cdot [\tilde{A} \mid N], \tag{17.14}$$

where the components have attributes and constitute an object denoted by each of the terms: $[A \mid \tilde{N}]$ is an action under the condition of the need for inaction and $[\tilde{A} \mid N]$ is inaction under the condition of the need for action.

- Magnitude of action (M), by the condition of sufficiency (S) of the magnitude of the action. The nominal magnitude of action in the space of nominal conditions (Eq. 17.15):

$$M \mid \Omega_{nom} \Leftarrow [M \mid S], \tag{17.15}$$

where the components have features and constitute the subject denoted by each of the terms: $[M \mid S]$ is action according to the condition of the sufficiency of the action magnitude;

- Anomal (erroneous) the magnitude of action in the space of anomalous conditions (Eq. 17.16):

$$M \mid \Omega_{nom} \Leftarrow [\downarrow M > \mid S] \cdot [\downarrow M < \mid S], \tag{17.16}$$

where the components have features and constitute an object denoted by each of the terms: $[\downarrow M >| S]$ is the fact that the magnitude of the action is greater according to the condition of the sufficiency of the magnitude of the action and $[\downarrow M <| S]$ is the fact that the magnitude of the action is less than the condition for the sufficiency of the magnitude of the action.

- Action time (T), temporal characteristic according to the condition of timeliness (Ts) of action. Nominal action time in the space of nominal conditions (Eq. 17.17):

$$T \mid \Omega_{nom} \Leftarrow [T \mid Ts], \tag{17.17}$$

where the components have features and constitute an object denoted by each of the terms: $[T \mid Ts]$ is action time according to the action timeliness condition.

- Anomalous (erroneous) action time in the space of anomalous conditions (Eq. 17.18):

$$T \mid \Omega_{nom} \Leftarrow [\downarrow T >| Ts] \cdot [\downarrow T <| Ts], \tag{17.18}$$

where the components have features and constitute an object denoted by each of the terms: $[\downarrow T >| Ts]$ is the fact that the action time is “late” (greater) by the condition of timeliness of the action and $[\downarrow T <| Ts]$ is the fact that the action time is “early” (less) by the condition of the timeliness of the action.

For further formalization of the decision-making process, the apparatus of hybrid logic is used. The decision space forms two triplexes of calculation elements in the truth scales of a segment of real numbers from 0 to 1 (Eq. 17.19).

$$\Re \Leftarrow \begin{Bmatrix} (A \times M \times T) \rightarrow [0,1] \\ (N \times S \times Ts) \rightarrow [0,1] \end{Bmatrix} \tag{17.19}$$

On each scale with the display of membership functions on the truth scale, the following variables are introduced.

Clear nominal actions (Eq. 17.20):

$$\begin{Bmatrix} \text{"necessary"}\ [A \mid N] \vdash [0,1] \rightarrow [0,1] \\ \text{"unnecessary"}\ [\tilde{A} \mid \tilde{N}] \vdash [0,1] \rightarrow [0,1] \end{Bmatrix} ; A \in [0,1], N \in [0,1] \tag{17.20}$$

Example: $[A \mid N]$ - the action of extending the landing gear before landing the aircraft; $[\tilde{A} \mid \tilde{N}]$ – non-release of the aircraft landing gear in case of an emergency landing on the fuselage; note that this decision becomes pseudological, since the conditions and the pilot’s decision require the "necessity" of such a landing.

Clear anomalous actions (Eq. 17.21):

$$\begin{Bmatrix} \text{"action without necessity"}\ [A \mid \tilde{N}] \vdash [0,1] \rightarrow [0,1] \\ \text{"inaction when necessary"}\ [\tilde{A} \mid N] \vdash [0,1] \rightarrow [0,1] \end{Bmatrix} ; A \in [0,1], N \in [0,1] \tag{17.21}$$

Clear nominal action magnitude (Eq. 17.22):

$$\text{"sufficient"}\ [M \mid S] \vdash [0,1] \to [0,1]; M \in [0,1], S \in [0,1] \tag{17.22}$$

Fuzzy anomal action magnitude (Eq. 17.23):

$$\left\{ \begin{array}{c} \text{"excessive"}\ \mu_{[M>|S]} \vdash [0,1] \to [0,1] \\ \text{"insufficient"}\ \mu_{[M<|S]} \vdash [0,1] \to [0,1] \end{array} \right\}; M \in [0,1], S \in [0,1] \tag{17.23}$$

Example: $\mu_{[M>|S]}$ - the action of excessive flap extension at the stage of descent far before the long-range beacon; $\mu_{[M<|S]}$ - the action of insufficient flaps extension on the straight before landing or before takeoff, which in each case can lead to overrunning the runway (RWY).

Clear nominal action time (Eq. 17.24):

$$\text{"Timely"}\ [T \mid Ts] \vdash [0,1] \to [0,1]; T \in [0,1], Ts \in [0,1] \tag{17.24}$$

Fuzzy anomal action time (Eq. 17.25):

$$\left\{ \begin{array}{c} \text{"late"}\ \mu_{[T>|Ts]} \vdash [0,1] \to [0,1] \\ \text{"early"}\ \mu_{[T<|Ts]} \vdash [0,1] \to [0,1] \end{array} \right\}; T \in [0,1], Ts \in [0,1] \tag{17.25}$$

Detailed definitions and logical descriptions of membership functions are a complete solution to the problem. These functions can form smooth and convex surfaces. An example of the mutual influence of magnitude and timeliness of action illustrates a favorable decision “Timely & sufficiently” (Fig. 17.5).

The height of a point lying on the surface shows the level of "timeliness" and "sufficiency". The most optimal solution should be taken at the highest point of the surface. Another example would be statements of fuzzy anomalous actions “late” and “insufficiently”, “early” and “excessive” with the transition to dangerous flight states. Detailing the scheme can be carried out by further structuring the resource components in the nominal and ordinal scales, as well as by super-imposing experimental data on it.

17.3.3 Polystructural Model of Nominal and Erroneous Outcomes of Actions.

The polystructural model is designed to evaluate outcomes as the degree of compliance with the goal in terms of results or errors using the observation model. Actions are structured in the following way. After the completion of the action and evaluation, establishing the actual correspondence between the goal and the outcome of the action, the outcome can be called the result. The signs of the outcome of the action are put by the operator (k) and the outcomes are called:

Result if $k = 1$:

- **n1.** x-result - self-assessment;
- **n2.** y-result – assessment (Eq. 17.26):

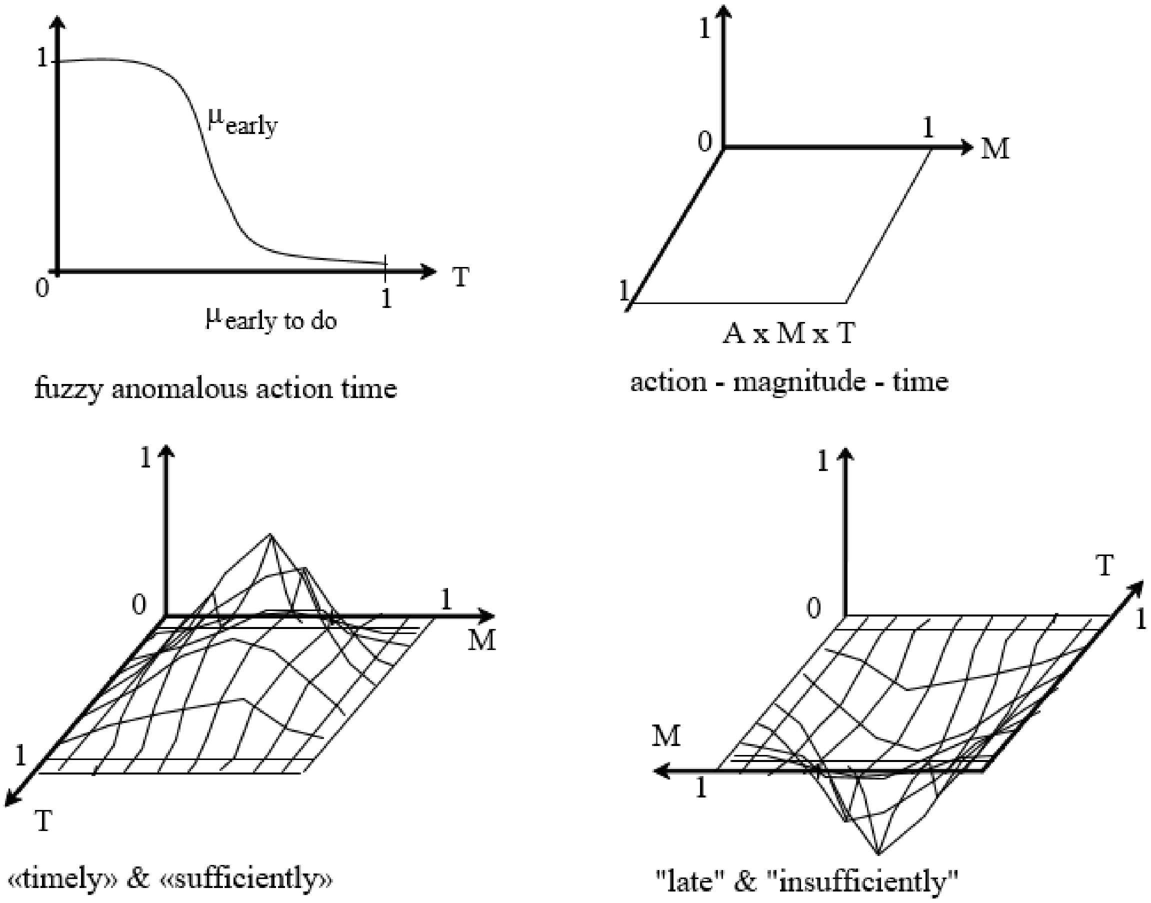

Figure 17.5: Examples of pseudo-logical statements .

$$\exists(A:\tau) \Leftarrow (x \wedge y) \mid \{r_j t_j \mid r_i t_i\}, k=1 \tag{17.26}$$

Error if $k < 1$:

- **n3.** x-error - self-assessment;
- **n4.** y-error - assessment.

The result for $k < 1$ is written (Eq. 17.27):

$$\exists(A:\tau) \Leftarrow (x \wedge y) \mid \{r_j t_j \mid r_i t_i\}, k<1 \tag{17.27}$$

Often, instead of a positive assessment, the subject has an altered understanding of the goal and is not satisfied with the achieved outcome. The subject believes that the outcome could be different, therefore, it is assessed as not congruent to his new resource state. The signs of the outcome of the action under nominal conditions Ω_{nom} are put by the operator, at $k \cong 1$, which becomes fuzzy, and a situation is created that can be written down (Eq. 17.28):

$$\exists(A:\tau) \Leftarrow (x \wedge y) \mid \left(\{r_j t_j \mid r_i t_i\} \cong \{r_i t_i \mid r_j t_j\}\right), k \cong 1 \tag{17.28}$$

Where outcomes are called:

- **n5.** x-error - self-assessment;
- **n6.** y-error is an estimate.

The sign ($\cong$) means a fuzzy identity, which can be a probability measure or a measure of the plausibility of an outcome expressed in weak nominal scales. In the above description, the number of different outcome features reaches six (n1-n6), of which two outcomes are called results, and four outcomes have error features. Thus, outcomes are considered: outcomes called positive outcomes, and errors, called negative outcomes. Positive outcomes are congruent to the goals and meaning of the activity, errors are recognized as not congruent to the goals. The polystructural model of nominal and erroneous outcomes of actions provides an opportunity to draw logical conclusions about the definitions of results and errors. The polystructural model of nominal and erroneous outcomes of actions is to draw logical derivations of the definitions of results and errors.

Definition 17.18. *The result in the nominal conditions of activity is the outcome, which is self-estimated by the subject of the action or evaluated by an external referent as congruent to the resources of the action according to the conditions (n1, n2).*

Definition 17.19. *An error is the outcome of an action that is self-evaluated by the subject of the action or is evaluated by an external referent as not congruent to the resources of the action according to the conditions (n3-n6).*

An extension of the theme of this work is the negative motivation of the subject of activity, called violation.

The Subject of Violation

In the standard [26] a violation is defined as "an intentional failure to perform duties or inaction, the result of which is a departure from established procedures, protocols, norms, and practices". This definition cannot be satisfactory for the following reasons. The complexity of describing the violation lies in the fact that the violation is not only an exit to the conditions of the anomalous space but also the subject of the subject's behavior, including the moral aspect. Behavior can be (a) intentional and (b) unintentional. Intentional behavior can be (+a) with positive motivation and motives. Intentional behavior can be (a) malicious to achieve the goal of causing damage, which is called a crime. Unintentional behavior can lead to outcomes: (+b) positive results and (-b) errors. The outcome of the violation can be self-assessed and be an assessment from the outside (court). The method of observing violations requires additional conditions of observation, the operator for recognizing signs of outcomes $(x \wedge y)$ becomes negative $(\neg k)$ or indefinite.

Definition 17.20. *The outcome of the action is called a violation, for ¬k (Eq. 17.29):*

$$\exists (A:\tau) \Leftarrow (x \wedge y) \mid \left(\{r_j t_j \mid r_i t_i\} \cong \{r_i t_i \mid r_j t_j\} \right), \neg k \tag{17.29}$$

- ***n7.*** *x-violation - self-assessment;*
- ***n8.*** *y-violation - assessment.*

All of the above action outcomes are recorded (Table 17.2) (Eq. 17.30):

$$\forall : (A:\tau) \Leftarrow (x \wedge y) \mid \begin{pmatrix} \{r_j t_j \mid r_i t_i\}, k = 1 \\ \{r_j t_j \mid r_i t_i\}, k < 1 \\ \left(\{r_j t_j \mid r_i t_i\} \cong \{r_i t_i \mid r_j t_j\} \right), k \cong 1 \\ \left(\{r_j t_j \mid r_i t_i\} \cong \{r_i t_i \mid r_j t_j\} \right), \neg k \end{pmatrix} \tag{17.30}$$

Table 17.2: Polystructural model

Outcomes	k	self-assessment	assessment
		x	y
Result	$k = 1$	n1	n2
Error	$k < 1$	n3	n4
Error	$k \cong 1$	n5	n6
Violation	$\neg k$	n7	n8

So, the developed model consists of definitions of the types of outcomes in the classes of results, errors, and violations that correspond to the nominal conditions of activity. Actions leading to destination outcomes have the name of outcomes. Actions leading to undesirable outcomes are called errors. It should be noted that the formulation of the problem may require a more detailed consideration of the options (n5, n6) of the behavior of the reference pair $(x \wedge y)$ of observation in situations of a changed understanding of the goal and outcome of the activity. The subject of violation is a special topic, in this paper, it is shown only to expand the context of the main task of the present study of erroneous activity in nominal and anomalous conditions. The subject of the violation requires the development of an additional model, taking into account the above description of behavior, moral, moral aspects, and legal assessments.

17.4 Conclusion

SOPs in the management of any area normalize actions in the destination space of activities. Regulatory procedures require a preliminary theoretical description, and modeling to derive definitions and terms of the concepts used. Formalization of the content of nominal and erroneous activity allows for setting a standard. The standard is a special function that allows one to distinguish between the outcomes of nominal and anomalous activities, between the subject of the action and the subject (referent) of the assessment, and between outcomes called results and errors. An important component of the polystructural model of nominal and erroneous activity is the establishment of the object of violation and its distinction in the context of the nominal and erroneous activity. The formalized division of error and violation anticipates the prerequisites for establishing the subject's guilt. Modeling in this work shows the irrational nature of management decisions and actions using the example of SARPs in civil aviation, which explains the complexity and lack of definitions of SOPs and the difficulties in forming civil aviation safety programs.

In this work, the development of the project of the subject of activity and the derivation of the basic definitions of ontology and management, the formal definition of the SOP are carried out. The concept of the space of activity conditions is introduced. The significance of the definitions of space is to establish the limits of the nominal activity, decisions, and actions of the SOP and indicate the outcomes - the results and errors. Definitions of the concepts "observation function", and "outcome of action" are introduced, which allow one to formally distinguish between goal, outcome, result, and erroneous action. An empirical model of decisions and actions has been developed and the definitions of decision-making and decision-taking have been substantiated. The pseudo-physical model of decisions, actions, and modalities "necessity", "sufficiency", and "timeliness" reflects the actual complexity of any management procedures. A polystructural model of nominal and erroneous outcomes of actions represents a logical conclusion of definitions of types of outcomes in the classes of results, errors, and violations that correspond to nominal and anomalous conditions of activity. The developed model is considered a new formalized task of research and development of the activities of an individual, social group, or organization. The theoretical and practical significance of the work performed is the creation of a new terminological basis for standardization.

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