Ministry of Education and Science of Ukraine
National Aviation University

TRANSPORT VEHICLES OPERATION PART IX: MATHEMATICAL LOGICS APPLICATIONS

SELF-STUDY METHOD GUIDE

Part IX

For the Students of the
Field of Study 27 “Transport”
Specialty 275 “Transport Technologies”

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Містять декілька рекомендацій для самостійної роботи щодо застосування знань отриманих при проходженні дисципліни «Експлуатація транспортних засобів», що є необхідним для виконання робіт індивідуального завдання, підготовки до складання заключних видів контролю.

Для студентів 2-го курсу галузі знань 27 «Транспорт», спеціальності 275 «Транспортні технології (на авіаційному транспорті)».

А992 **Transport Vehicles Operation. Part IX : Mathematical Logics Applications** : Self-Study Method Guide . Part IX / compiler: A. V. Goncharenko. – K. : NAU, 2023. – 56 p.

The **METHOD GUIDE** contains a few recommendations on the Self-Study in regards with the application of the knowledge acquired at the study of the Academic Subject “Transport Vehicles Operation” carrying out, which is indispensable to complete the works of the individual task, get ready for passing the final kinds of the check.

Designed for the 2nd year students of the Field of Study 27 “Transport”, Specialty 275 “Transport Technologies (by Air Transport)”.

CONTENTS

INTRODUCTION

This **METHOD GUIDE ON THE SELF-STUDY** (SS) is contemplated as an ideological continuation of **PART I-VIII:**

[263]: **"Transport** Vehicles Operation. Part I : Number of Transport Vehicles : Self-Study Method Guide . Part I . Number of Transport Vehicles . Optimal Choice Dilemma / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2022. – 48 p. https://er.nau.edu.ua/handle/NAU/56234, Method_Guide.pdf."

[275]: **"Transport** Vehicles Operation. Part II: Elementary Supply Chain Optimization : Self-Study Method Guide . Part II / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2023. – 53 p. https://er.nau.edu.ua/handle/NAU/62062, II_TVO_SSG.pdf."

[276]: **"Transport** Vehicles Operation. Part III : Elementary Optimal Supply Speed : Self-Study Method Guide . Part III / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2023. – 53 p. https://er.nau.edu.ua/handle/NAU/62139, III_TVO_SSG.pdf."

[277]: **"Transport** Vehicles Operation. Part IV : Optimal Number of Transport Vehicles : Self-Study Method Guide . Part IV / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2023. – 57 p. https://er.nau.edu.ua/handle/NAU/62141, IV_TVO_SSG.pdf."

[278]: **"Transport** Vehicles Operation. Part V: The Simplest Problem of the Probability of a Choice : Self-Study Method Guide . Part V / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2023. – 54 p. https://er.nau.edu.ua/handle/NAU/62159, V_TVO_SSG.pdf."

[279]: **"Transport** Vehicles Operation. Part VI : The Simplest System Reliability : Self-Study Method Guide . Part VI / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2023. – 55 p. https://er.nau.edu.ua/handle/NAU/62201, VI_TVO_SSG.pdf."

[280]: **"Transport** Vehicles Operation. Part VII : The Simplest Random Process : Self-Study Method Guide . Part VII / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2023. – 61 p. https://er.nau.edu.ua/handle/NAU/62243, VII_TVO_SSG.pdf."

[281]: **"Transport** Vehicles Operation. Part VIII : Subjective Preferences Optimality : Self-Study Method Guide . Part VIII / compiler: A. V. Goncharenko. – K. : NAU, Electronic Repository. – 2023. – 64 p. https://er.nau.edu.ua/handle/NAU/62320, VIII_TVO_SSG.pdf."

in response to the needs of our students in more detailed elaborations concerning the **TRANSPORT VEHICLES OPERATION** (TVO) tasks stated, set, or given for the students' independent work on this **ACADEMIC SUBJECT** for the specified **CALCULATION AND GRAPHIC PAPER** (CGP), possibly used in their further educational works, such as their **TERM PAPERING** (TP), **COURSE PROJECTING** (CP), further **GRADUATION PAPERS** or even **PH.D. STUDIES.** The whole material is

split into portions. Each portion is intended to cover a fraction of the probable applications aimed at the **TRANSPORT TECHNOLOGIES** (TT) (by **AIR TRANSPORT** (AT)), particularly dealing with the **TRANSPORTATION ORGANIZATION AND MANAGEMENT ON TRANSPORT** (TOMT) for AT. It means AT management in operation possibly including some **AIRCRAFT** (A/C) technical operation issues in regards with the **AERONAUTICAL ENGINEERING** (AE) **MAINTENANCE** (M/T), as for example, in aviation business.

The presented in the ninth part, **PART IX,** of the **METHOD GUIDE ON THE** SS assignments are dedicated, and a special attention is drawn here, to the general aspects of the SS work for the TVO practical works, individual task, final kinds of the check, future students' prospective research and scientific publications as well as conference reports and presentations.

The scientific component of the SS work is very important. That is why, specifically, the objectives of the **PART IX** material are to help students cope with the challenging problems relating to the studied **ACADEMIC SUBJECT** of TVO on the AT management in operation, for instance, A/C technical operation in regards with the aeronautical engineering M/T as well as the **AIRCRAFT AIRWORTHINESS** support measures.

The set of the considered issues is based upon the **RECOMMENDED LITERATURE SOURCES** (the list is presented, but not limited to it). The **LIST OF LITERATURE** at the end of the **METHOD GUIDE** is basic (major) and compiled partially not only in the alphabetic order, but mainly with respect to the matter of supposed (assumed) importance.

The **REFERENCES LIST** is selected, set in the order [1-281], does not pretend for completeness, but instead it is aimed at developing the students' abilities of thinking and to analyze, contemplate in the specified directory rather than their abilities to know and memorize. However, these are very significant too. Actually, in the contemporary informative boom world, the needed or required data can be easily retrieved from the internet, found in multiple references, guidance materials [1-23], studies, dictionaries, comprehensive books, publications and scientific papers like [24-281] amongst those monographs [9, 90, 108, 121, 198, 201, 206] etc. The **METHOD GUIDE** is designed for the 2nd year students (**BACHELOR'S DEGREE** contenders) in the Field of Study: 27 "Transport", Specialty: 275

"Transport technologies (by air transport)", Specialization: 05 "Air Transportation Management". The considered studied academic subject of TVO finalizes the previous education in the Field of Study: 27 "Transport", Specialty: 275 "Transport technologies (by air transport)", (**BACHELOR'S DEGREE** contenders); plus of the 1st year students (**BACHELOR'S DEGREE** contenders) in the Field of Study: 27 "Transport", Specialty: 275 "Transport technologies (by air transport)", Specialization: 05 "Air Transportation Management". There are a lot of the planned academic subjects in the **BACHELOR'S** and **MASTER'S DEGREE CURRICULA (CURRICULUMS)** related to the considered studied academic subject of TVO.

This very special ninth part, **PART IX,** of the studied academic subject of TVO is aimed at the **MATHEMATICAL SETTING OF THE PROBLEMS** considered in the CGP on TVO, with the possibilities of the further development to education work, such as, course projects, even up to the graduation papers, **BACHELOR'S** and **MASTER'S DEGREE GRADUATION WORK,** or even Ph.D. studies. Therefore it is strongly suggested for the students to agree their own envisaged course projects, **BACHELOR'S** and **MASTER'S DEGREE GRADUATION WORK THEMES** and prospective research areas with their **SUPERVISORS**.

The scientific portion of the students' SS work might prolong the initiated at the preceding stages of the **BACHELOR'S DEGREE** contending study. It includes the **students' SS research results publication in scientific journals and scientific conferences proceedings**. In the prospect such kinds of the students' activity may lead to a successful defense of the **GRADUATION WORK** or a successful passing the **FINAL STATE EXAMINATION;** as well that may lead to a successful passing of the **UNIVERSITY PH.D.'S DEGREE PROGRAM ENTRANCE EXAMINATION.** The other benefit of the research results publication may be, for example, in the detailed solutions for obtaining the optimal distributions of transportation means: [263, 277], their combinations, optimization of the supply chain links: [275], and supply speeds: [276], probability of a choice: [278], the simplest system's reliability: [279], reliability objective measures: [280], allowing assessing the improvements of the A/C functional system M/T process considered in references [138-140], subjective preferences distributions optimality: [281].

Herewith it is proposed to continue the search for the detailed solutions for the examples considered in the references of:

[194]: **"Goncharenko A. V.** Multi-optional hybridization for UAV maintenance purposes / A. V. Goncharenko // 2019 IEEE 5th International Conference "Actual Problems of Unmanned Aerial Vehicles Developments (APUAVD)" Proceedings. – October, 22-24, 2019, Kyiv, Ukraine. – 2019. – pp. 48-51.**"**

[182]: **"Goncharenko A. V.** Relative Pseudo-Entropy Functions and Variation Model Theoretically Adjusted to an Activity Splitting / A. V. Goncharenko // 2019 9th International Conference on Advanced Computer Information Technologies (ACIT'2019). – June 5-7, 2019. – Ceske Budejovice, Czech Republic, 2019. – pp. 52-55.**"**

[71]: **"Goncharenko A. V.** Measures for estimating transport vessels operators' subjective preferences uncertainty / A. V. Goncharenko // Scientific Bulletin of Kherson State Maritime Academy. – 2012. – № 1(6). – pp. 59-69.**"**

Completion of CGP is an independent / individual student's work of a creativeness.

The essential sections of the student's report of the CGP completion are:

Introduction;

Literature survey;

Theoretical background;

Major dependencies;

Statistical data;

Student's own contribution;

Derivations;

Findings;

Calculations;

Plotting diagrams;

Analysis;

Discussion;

Conclusion;

References;

Other necessary parts (significant results).

The time required for CGP completion is about 10 academic hours.

The length of the report for the about 10 academic hours completion work is up to 5 pages.

For the **PANDEMIC QUARANTINE PERIOD,** especially **MARTIAL LAW,** it possibly might have the corrections in the **ORDER** of the SS on TVO carrying out.

The general control for the SS on TVO performance is realized (amongst others) through the corresponding **GOOGLE CLASS ROOM.**

Thus, dear students, get down to this challenge to demonstrate your own creativity!

GENERAL PROVISIONS

The principal theoretical provisions can be found out in references [1-23].

1. Planned hours

According to the **TRAINING PROGRAM** on the **ACADEMIC SUBJECT** of the considered TVO and depending upon the particular academic hours specified for the training and study, the entire **SUBJECT** may contain up to many hours.

According with the **TIME TABLE, PROGRAM,** and **CURRICULUM,** regularly approved by the **UNIVERSITY RECTOR'S ORDER,** it figures out like following:

17-19 (optionally 18) weeks of the **SEMESTER WORK,** including some days for the **MODULE TESTS** or the **CGP DEFENSE,** final **GRADED TEST CHECK.**

Thus, it all usually makes a **SEMESTER** weeks **PERIOD.**

Regularly, there might be **2 SHIFTS** that are planned for the **STUDENTS.**

Namely:
The **1ST SHIFT** starts at 8:00;
The **2ND SHIFT** starts at 15:20.

For the **SOPHOMORIC STUDENTS** it is usually the **1ST SHIFT;** and for the not large groups it is just **COMMON LABORATORY CLASSES**, without dividing the groups into **HALVES (SUBGROUPS).**

Therefore, duration is 2 (4) academic hours a week for each **STUDENT** of a group on the day of the **LECTURE DELIVERY** and **LABORATORY CLASS CONDUCTION.** Totally it makes up to 30-40 academic hours of **AUDITORIUM WORK** for the entire considered studied academic subject of TVO. Then, it is plus about up to two thirds

of SS (up to 100 academic hours) including up to 30 academic hours for CGP. As whole it may have variations.

As a rule, the information on the **TIME TABLE, PROGRAM,** and **CURRICULUM,** and **TOPICS** are provided at the **AIR TRANSPORTATION MANAGEMENT DEPARTMENT** on the **INFORMATION BOARD (DESK)**; as well as, it can be displaced at the corresponding **GOOGLE CLASS ROOM** and/or the **DEPARTMENT WEBSITE (PAGE), UNIVERSITY REPOSITORY PAGE** etc.

For the **PANDEMIC QUARANTINE PERIOD,** especially **MARTIAL LAW,** the general control for the CGP performance is possible (amongst others) through the corresponding **GOOGLE CLASS ROOM.**

2. Subject content

This step is very important too.

The mentioned above 18 (16) weeks of the Semester study **STUDENTS' WORK** (accordingly with the **TIME TABLE)** are, or might be, subdivided into **COMMON AND INDIVIDUAL TOPICS**:

1.1. Organizational meeting. Instruction on labour protection and fire safety.
1.2. Common aspects of the General Approaches.
1.3. Individual Tasks relations to the chosen research areas.
1.4. Correspondence with the Final Work theme.
1.5. Appropriate methods of the research.
1.6. Mathematical Apparatus for the objectives.
1.7. Mathematical formulation of the conceptual provisions.
1.8. Experimentations.
1.9. Statistical Data processing.
1.10. Analysis of the obtained preliminary results.
1.11. Choice of the corrective methods and ideas.
1.12. Analysis of the use of the corrected methods research results.
1.13. Implementation into the Final Work.
1.14. Prospects of the research results application.
1.15. Publication of the research results.

These **TOPICS** might also be provided at the **AIR TRANSPORTATION MANAGEMENT DEPARTMENT** on the **INFORMATION BOARD (DESK)**; as well as, they can be displaced at the corresponding **GOOGLE CLASS ROOM** and/or **UNIVERSITY REPOSITORY PAGE.**

There is one major document that the student must prepare: CGP **REPORT**. The **REPORT** of the CGP is discussed at the corresponding following **SECTIONS** of this SS **METHOD GUIDE.**

After this **PROGRAM** on CGP completion, and having done and submitted the own **REPORT,** every **STUDENT (AUTHOR)** is supposed attempting to pass the

DEFENSE AND GRADED TEST

The ***DEFENSE*** is going to be discussed further on in this SS **METHOD GUIDE.**

And the best way of the CGP completion is the **SCIENTIFIC PUBLICATION,** which also will be instructed down here in the presented SS **METHOD GUIDE.**

Theoretical material for the CGP tasks is based upon references [1-281]. The idea is traced from the comparatively newest (latest) books [4, 5, 9, 13-17], **NATIONAL PROVISIONS** for aviation business in compliance with the **IATA, EASA,** continental, normative documents, and **ICAO** requirements like in [14]. Some convenient aspects of the subject learning are in the TOMT for AT, TT (by AT), **DIRECTIVES ON TECHNICAL OPERATION,** A/C and AE M/T, referred to in [14].

For the **PANDEMIC QUARANTINE PERIOD,** especially **MARTIAL LAW,** the general control for the CGP performance is possible (amongst others) through the corresponding **GOOGLE CLASS ROOM.**

AIR TRANSPORTATION TECHNOLOGIES LOGICS PROBLEMS

The principal theoretical provisions can be found out in the references [1-23] and other literature sources and informational resources. Especially in [7, 14, 60].

The directions of the CGP work and their completion are reflected in the series of problems offered to be considered, set, and solved.

1. Basic theoretical provisions

Mathematical logics is a powerful tool for solving certain specific air transportation technologies problems.

In order to solve such problems there is a need to remind the basics of the mathematical logics.

A word statement (utterance, expression, affirmation, declaration etc.) for which there is a sense to say whether it is *Correct* (*True, Truth*) or *False* (*Wrong*) is deemed (understood, thought, believed, considered, estimated, supposed, judged, reckoned with as etc.) to be an *assertion*.

Therefore, a word combination as an affirmative sentence (it should be in the form of an affirmative sentence or a clause, an assertion, a statement etc.) of the type of: *"It is hard to study at the National Aviation University."* from the point of view of mathematical logics is not an assertion, because there is not any sense to say about that affirmative sentence whether it is true or false, since there might be someone for whom it is hard, though for someone else it might be not. Also, it will not be an assertion, for instance, a question of the kind of: *"What time is it now?"* Since it is a question but not an affirmative sentence by its grammatical form, thus, there is no sense to say that it is an assertion (affirmative statement) at all. That is, an estimation of the question whether it is *True* or *False* is denunciated being taken as a granted.

Statements (assertions) are denoted (indicated, signified, symbolized, designated) with capital letters (characters) (A, B, …) similarly to the sets and events (cases, occurrence) although, it might be done in some other way.

Some theorems of the algebra of logics:

1. A sum (summation) of assertions (statements). It is a logical operation of *"or"*; disjunction.

This is an assertion of C which is understood as a sum of assertions of A and B. C is correct in case if at least one of the assertions of A and B is a true assertion, i.e.

$$A + B = C = True\ . \tag{8.1}$$

In other words, the logical equation of (8.1), an elementary "predicate", is truth if:

Either a)

$$A = True\ , \tag{8.2}$$

Or b)

$$B = True\ , \tag{8.3}$$

Or c)

$$A = True\ \ and\ \ B = True\ \ together. \tag{8.4}$$

2. A product (multiplication) of assertions (statements). It is a logical operation of *"and"*; conjunction.

This is an assertion of C which is understood as a product of the assertions of A and B. C is correct just in the case if both of the assertions of A and B are the true assertions, i.e.

$$A \cdot B = C = True\ . \tag{8.5}$$

In other words, the logical equation of (8.5), an elementary "predicate", is truth only if:

$$A = True\ \ and\ \ B = True\ \ together. \tag{8.6}$$

3. Associativity of a disjunction (sum):

$$A + \left(B + C\right) = \left(A + B\right) + C\ . \tag{8.7}$$

4. Associativity of a conjunction (product):

$$A \cdot (B \cdot C) = (A \cdot B) \cdot C . \tag{8.8}$$

5. Distributivity of a conjunction with respect to a disjunction:

$$A(B + C) = AB + AC . \tag{8.9}$$

6. Distributivity of a disjunction with respect to a conjunction:

$$A + BC = (A + B)(A + C). \tag{8.10}$$

7. Negation (denial) of a disjunction (sum) (De Morgan rule):

$$\overline{A + B} = \overline{A}\,\overline{B} , \tag{8.11}$$

where $\overline{A}$ is the negation (denial) of A: it reads: "not A". The sign of negation (denial): "$\bar{\bullet}$", is used.

8. Negation (denial) of a conjunction (product) (De Morgan rule):

$$\overline{AB} = \overline{A} + \overline{B} . \tag{8.12}$$

9. Negation of a negation (a rule of a double denial cancellation):

$$\overline{\overline{A}} = A . \tag{8.13}$$

10. Implication

An assertion, in which A is a condition (affirmative, presupposition) leads to the consequence of (results in) B, which is a result (conclusion), is called an implication. It is denoted (indicated, signified, symbolized, designated) as

$$A \Rightarrow B . \tag{8.14}$$

It is read: *"If A then B."*. The implication of $A \Rightarrow B$, (8.14), is a wrong assertion only in the case when A is true and B is false. That is, the falseness

(wrongness) of A makes the implication of $A \Rightarrow B$, (8.14), be true assertion independently upon B. An implication is developed accordingly to the rule of

$$A \Rightarrow B = \overline{A} + B . \tag{8.15}$$

Once again it must be emphasized herewith that the operators and designations represented above, (8.1)-(8.15) deal with the mathematical logics objects (assertions, statements, implications, logical operators etc.) rather than the quantitative mathematics measures and their mathematical operators as in the "quantitative mathematics" ("quantitative algebra", "algebra of quantities").

2. Examples on the air transportation technologies logics problems

Below, it is proposed a few examples that may relate to making decisions at conducting investigations or analyses (scrutiny) whereas the air transportation technologies or air transport vehicles operations are realized.

Example 1. Prototypic problem with the necessary theoretical explanations see in [7, Chapter II, § 1, pp. 30-37; 14, p. 490; 60, pp. 36-38].

There carried out, for instance, an air cargo delivery by some (uncertain, unknown) type of aircraft of the airline named: *"Brumcashirma"*, to some (uncertain) airport of delivery ("destination"). However, unfortunately, the unclearness in such air transportation technologies and air transport vehicles operations makes a serious impact upon the reputation losses of the *"Brumcashirma"* airline involving the grave influential decrease in demand for the transportation services providing. In order to institute an inquiry into the circumstances of such an incident in the best possible way the responsible person, *Paintoak* by name, received the following preliminary information from his/her three subordinates (minor/assistant inspectors). They reported where to and by what type of aircraft the air cargo had been delivered.

The first subordinate, named *Halambuta*, reported that the incident of the unclear air cargo delivery (in the sense of the airport of destination and the aircraft type either) had occurred in the Amsterdam airport and that air transportation task had been performed (carried out) by a Boeing aircraft.

The second minor inspector, *Tumberson*, said that the air cargo had been delivered by the Airbus type aircraft to the Frankfurt am Main airport.

At last the third assistant inspector, *Aucticus*, reported: the Copenhagen airport, but the incident does not have anything in common with the aircraft of the Airbus type.

The author has witnessed such analogous (similar) event when one colleague arrived to participate in a Conference and his luggage had been delivered to some other unknown "destination". The colleague, who experienced the "mishap", had been waiting for a few days (actually for the all time long of the Conference), at the venue, up to the final day of the Conference closing.

This example of the real situation proves that the problem stated above is not just a paradox or an exclusively made up (invented) virtual story.

Anyway, turning back to the problem of the mathematical logics, it is very useful to implement the listed theorems of the algebra of logics.

So, those three inspectors, perhaps, willing to entangle their Chief Paintoak or hide the truth, or on some other unknown reasons, each of them cheated Paintoak, i.e. telling him/her correctly either the airport of delivery (the airport of the "destination", the place, the one part of their reports, where that happened, the airport where the cargo has been delivered to) or the second part of their reports: by what type of the aircraft the cargo has been delivered (the air transport vehicle type by means of which that incident occurred).

Actually, in the formalisms of algebra of logics all those three inspectors, in their opinions, reported the following:

$$Ap_i \cdot At_i = False_i = \overline{True_i} , \tag{8.16}$$

where Ap_i is the airport of the "destination", the airport where the cargo has been delivered to, reported by the "i"th subordinate collaborator to the Chief responsible person, *Paintoak* by name; At_i is the aircraft type engaged to the delivery, also claimed by each of the minor inspectors.

Since each of the assistant inspectors said the "semi-truth" ("half-a-true"), the product of those elementary assertions, in accordance with the theorem # 2 of the algebra of logics, (8.5), is the false statement (assertion). It is because in the harmony with the assertion product truthfulness both elementary must be true. The mathematical logics operator "and" is important here.

However, the Chief Paintoak is and has to discover by what and where to the cargo delivery really happened in order to appoint a proper investigation commission. Moreover, knowing the laws of the mathematical logics (being equipped, armed, with the power of the knowledge), and having learned surely that each of her/his co-workers factually told her/him the "semi-truth", the clever Chief Paintoak converted all the three false statements (assertions) into the true ones, i.e.

$$Ap_i + At_i = True_i . \tag{8.17}$$

The correctness of the expressions of the (8.17) style comes out based upon the theorem # 1, (8.1), of the algebra of logics. At least one of the sums

members must be true. The mathematical logics operator "or" is significant in such context. And that actually is so; one of the components (elementary assertions) of each of the three reports is a true assertion.

The investigation follows the next procedure.

The preliminary information consists of such three notifications:

1. The cargo is delivered by Boeing aircraft to Amsterdam.
2. The cargo is delivered by Airbus aircraft to Frankfurt am Main.
3. The cargo is delivered to Copenhagen but not by Airbus aircraft.

It is proposed to depict the elementary assertions of the ## 1-3 reports (statements) as: B is for the Boeing type aircraft; A is for the Airbus type aircraft; A_m is for the Amsterdam airport; F is for the Frankfurt am Main airport; and, C_o is for the Copenhagen airport. It is logical to denote $\overline{A}$ as for the aircraft of the not Airbus type.

Thus, knowing the conditions revealed above and laws of mathematical logics Paintoak does not have to go to the incident site. As each of the minor inspectors deceived Paintoak only a half, truthfully saying either the airport where the air cargo has been delivered to or the second part of their reports, (8.16), then it means that by the algebra logics theorem for summation, (8.1), each of them (minor inspectors) reported the true (correct) statement, (8.17). Namely:

Halambuta: "Amsterdam, Boeing", the true specific is either airport of "Amsterdam", statement: A_m, or the aircraft type: "Boeing", statement: B, i.e.

$$A_m + B = True_H . \tag{8.18}$$

Thus Halambuta's transformed statement, (8.17) or (8.18): "Amsterdam or Boeing", is the true statement. Whereas, he/she tried to deceive saying lye, (8.16): "Amsterdam and Boeing", i.e.

$$A_m \cdot B = Wrong_H . \tag{8.19}$$

In an analogous way, Tumberson: "Frankfurt am Main, Airbus".

$$F + A = True_T , \qquad F \cdot A = Wrong_T . \tag{8.20}$$

Aucticus: “Copenhagen, not Airbus”.

$$C_o + \overline{A} = True_A, \qquad C_o \cdot \overline{A} = Wrong_A. \tag{8.21}$$

This means, that accordingly to the multiplication theorem, the product of the correct statements of (8.18), (8.20), and (8.21) is also the true statement, i.e.

$$True_H \cdot True_T \cdot True_A = \left(A_m + B\right) \cdot \left(F + A\right) \cdot \left(C_o + \overline{A}\right) = True. \tag{8.22}$$

Opening parentheses in (8.22) one can have

$$\begin{aligned} &A_m\left(F + A\right) \cdot \left(C_o + \overline{A}\right) + B\left(F + A\right) \cdot \left(C_o + \overline{A}\right) = \\ &= \left(A_m F + A_m A + BF + BA\right) \cdot \left(C_o + \overline{A}\right) = \\ &= A_m F C_o + A_m A C_o + BF C_o + BA C_o + \\ &+ A_m F\overline{A} + A_m A\overline{A} + BF\overline{A} + BA\overline{A} = True. \end{aligned} \tag{8.23}$$

Here, in (8.23), at least one of the eight members must be true. The only one member $BF\overline{A}$ does not have any logical contradictions. That means it is true. The rest is the fake assertions. Thus, the “incident” of the uncertain air cargo delivery (air transportation technology failure or imperfect air transport vehicles operation) is now resolved, that occurred in the Frankfurt am Main airport and that, now clear, air cargo delivery was made by the Boeing type aircraft.

Thus, the truth has been successfully found, though each minor inspector lied: (8.19) and the second equations of (8.20) and (8.21).

It is possible to solve the given problem by graphical means. It is necessary to represent the “and” operator like the sequential connection of the assertions (“elements” of the air transportation technologies or air transport vehicles operations); whereas the “or” logical operator is like the parallel one. The motion (passage) is realized only through correct assertions.

The presented Example 1 of (8.16)-(8.23) can be prolonged and developed, for instance, like follows.

Example 2. [7, Chapter II, §§ 1-4, pp. 30-57; 14, p. 490; 60, p. 39].

In conditions of the previous example Chief Paintoak has learnt:

1. If the first subordinate, named Halambuta plotted to cheat the Chief, then the second minor inspector, Tumberson is also guilty in that lying.

2. But it is not true, that if the third, Aucticus, has done this, then the second minor inspector, Tumberson is also to be blamed of it.

Chief Paintoak wants to find out who tried to deceive him/her.

In such problem setting, in terms of the mathematical logics, there are two implications.

One more example is the next.

Example 3. [7, pp. 30-57; 14, p. 490; 60, pp. 40, 41].

At an investigation of an accident relevant with an air transportation technology or an air transport vehicles operation, the Head of the investigation commission received three reports from his/her three inspectors:

1. Inspector Johnson: "If the 2nd pilot was drunk, then either the 1st pilot (captain) made the accident or the 2nd is saying the lye".

2. Inspector Krause: "Either the 1st pilot is guilty or the 2nd pilot was not drunk (was sober) and the accident occurred after the midnight".

3. Inspector Sydorchuk: "If this happened after the midnight, then either the 1st pilot did the accident or the 2nd pilot lies".

The Head has the undoubtedly proven reasons (basis) to trust the inspectors absolutely; also he/she knows that the 2nd pilot never lies when he/she is sober. The Head should find out (reveal) who of the pilots is guilty and to be blamed of the accident.

In order to solve the problem, there is a need to consider separate elementary statements.

From (8.1)-(8.23) one can analyze some more and more complicated logical statements helping making optimal decisions and finding best solutions. It depends upon some parameters. Their values are up to the students.

The magnitudes of the values have a certain conventional (some conditional) measurement units (dimensions).

The students are supposed to set the correspondence.

The approach (8.1)-(8.23) allows researching the influence of some important parameters.

There are some developments of the problems; in the air transportation technologies qualities and their number, the number of the “good” and “bad” aircraft, different aircraft fleets varying in the aircraft numbers, aircraft types, trajectories, distances, speeds, other random (stochastic, probability) values, cost and other economical issues, dynamics, elements of optimization subject to additional conditions or constraints and so on.

It is possible to plot three-dimensional surfaces and graphically find solutions upon them.

REPORT PREPARATION

The CGP stages are aimed at the effective CGP time management and results estimation control in the field of TOMT for AT, TT (by AT), A/C and AE M/T.

The best way is when it leads to the **SCIENTIFIC FORMALIZATION** of the **RESEARCHED MATTER.** For this purpose the **SCIENTIFIC PUBLICATIONS** suit the best.

The CGP **REPORT** is usually prepared in accordance with the **REPORT TEMPLATE.** As a rule it is provided at the corresponding **GOOGLE CLASS ROOM** and/or **UNIVERSITY REPOSITORY PAGE.**

The **REPORT** must contain the materials connected with CGP, especially with the **REPORT SECTIONS** characteristic, **INTRODUCTION, IMPORTANCE, TOPICS** etc.

The CGP work completion **REPORT** reflects the student's own achievements in acquiring the practical knowledge and skills of work in the **SCIENTIFIC FORMALIZATION** of the **RESEARCHED ISSUES.** For this purpose the **SCIENTIFIC PUBLICATIONS** suit the best.

The **REPORT** must contain the materials connected with CGP, especially with the researched object characteristic, student's own achievements etc.

The **REPORT** must be **SIGNED** (amongst the others) by the **AUTHOR (STUDENT),** with pointing the **NAMES** and **POSITIONS;** also **DATED.**

The **AUTHOR (STUDENT);** should characterize generally the topic; and He/She should emphasize the strong and weak points of the CGP work.

Finally, the **AUTHOR (STUDENT)** should evaluate the CGP work with the own reasonable and own rational **GENERAL ESTIMATION.**

After the CGP work completion (all is **SIGNED, DATED, AND SO ON**) it **(**CGP **REPORT)** must be, along with the CGP author's own **SCIENTIFIC PUBLICATIONS** (if there are any **RELEVANT**), submitted to the **DEPARTMENT COMMISSION** for the **DEFENSE**.

DEFENSE

The principal theoretical provisions can be found out in the references [1-23].

The **DEFENSE** of the CGP **REPORT,** along with the CGP **RELEVANT SCIENTIFIC PUBLICATIONS** (if there are any) on the CGP works completion takes place in the **AIR TRANSPORTATION MANAGEMENT DEPARTMENT COMMISSION** on the corresponding CGP.

The process of the **DEFENSE** is held at the specified period of time.

The **AIR TRANSPORTATION MANAGEMENT DEPARTMENT COMMISSION** on the corresponding CGP is to put the contending **STUDENT** the **FINAL ESTIMATION MARK.**

PUBLICATIONS

The principal theoretical provisions can be found out in the lecture notes of the students who have been attended the lectures, completed practical and laboratory works, finished course projects and homework etc., have some scientific inclinations and in the references [1-281].

For nowadays, it is incredibly important for the students to take part in some scientific activity. Results of such deeds as scientific research must be duly presented to the scientific community. The most popular forms of such presentation are the publications in:

1. Scientific Journals
2. Proceedings of the Scientific Conferences

In any case it is up to the students what and how to do, but relevant **PUBLICATIONS** will definitely help enter the **NEXT STAGE OF EDUCATION** and defend **EDUCATIONAL GRADUATION** and **SCIENTIFIC QUALIFICATION WORKS,** theses, dissertations etc.

Generally speaking the move toward the **PUBLICATIONS** actions may be reduced to a few indispensable steps. Perhaps, the first and apparently the most important is the choice of the scientific supervisor. It has to relate with the general theme of the research and the contender preferences. After finding such field of the creative potential application, it is reasonable to distinguish the specific direction, formulate the problem, propose the solution, and demonstrate verification of the approach and scientific findings.

All the students' findings, including made at the CGP, may be implemented into further students' achievements.

For nowadays the most valuable **PUBLICATIONS** are those indexed in the **SCOPUS** and **WEB OF SCIENCE SCIENTIFIC DATABASES.**

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Навчальне видання

ЕКСПЛУАТАЦІЯ ТРАНСПОРТНИХ ЗАСОБІВ

Частина IX

ЗАСТОСУВАННЯ МАТЕМАТИЧНОЇ ЛОГІКИ

Методичні рекомендації
до виконання самостійної роботи
для студентів 2-го курсу галузі знань 27 «Транспорт»,
спеціальності 275 «Транспортні технології
(на авіаційному транспорті)»,
спеціалізації 05 «Організація авіаційних перевезень».

(Англійською мовою)

Укладач ГОНЧАРЕНКО Андрій Вікторович

В авторській редакції

Технічний редактор *А. І. Лавринович*
Комп'ютерна верстка *Н. С. Ахроменко*

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Свідоцтво про внесення до Державного реєстру ДК № 977 від 05.07.2002