Ministry of Education and Science of Ukraine
National Aviation University

TRANSPORT VEHICLES OPERATION PART III: ELEMENTARY OPTIMAL SUPPLY SPEED

SELF-STUDY METHOD GUIDE

Part III

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

Kyiv 2023

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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 III : Elementary Optimal Supply Speed** : Self-Study Method Guide . Part III / compiler: A. V. Goncharenko. – K. : NAU, 2023. – 53 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** and **II:**

[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."

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 third part, **PART III,** 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 III** 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 [1-275], 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 [24-275] 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 third part, **PART III,** 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], their combinations, optimization of supply links: [275], reliability objective measures allowing assessing the improvements of the A/C functional system M/T process considered in references [138-140].

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 [1-275]. 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.**

SUPPLY SPEED OPTIMIZATION PROBLEM

The principal theoretical provisions can be found out in the references [1-23] and other literature sources and informational resources. Especially [56, 69].

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

This prototype problem can also be easily found at study- (text-) books even in the school textbooks of the final (last) forms.

An hourly cost of transportation consists of the two following components: the one that does not depend upon the speed of the transportation; and the other one that depends upon (proportional to) the speed raised to a certain power. Find the optimal speed of transportation that minimizes the flight (trip, voyage) cost.

Similarly to the previous problem, one can construct the objective function of the flight cost, i.e.

$$\$_h(v) = \$_{h_1} + \$_{h_2}(v), \tag{2.1}$$

where $\$_h(v)$ is the hourly cost of transportation as a function of the speed of transportation: v ; $\$_{h_1}$ and $\$_{h_2}(v)$ are the corresponding components of $\$_h(v)$.

Then, the flight total cost at a constant speed will make up

$$\$_f(v) = \$_h(v)T_f, \tag{2.2}$$

where T_f is the flight duration (time).

The flight duration at the constant flight speed can be expressed as follows:

$$T_f = \frac{D_f}{v}, \tag{2.3}$$

where D_f is the flight range (distance).

That also means that the flight duration: (2.3) is also a function of the constant speed of flight, i.e.

$$T_f(v). \tag{2.4}$$

Taking the (2.1)-(2.4) equations and expressions into account, (2.2) can be written down as

$$\$_f(v) = \left[\$_{h_1} + \$_{h_2}(v)\right]\frac{D_f}{v}. \tag{2.5}$$

The component of $\$_{h_2}(v)$ have the view of

$$\$_{h_2}(v) = kv^n, \tag{2.6}$$

where k is a coefficient of proportionality; n is a power index.

Considering k and n constant and independent upon v, the proportionality coefficient of k as well as the power index of n can be determined at some given (fixed) flight speed: v and the simplest assumptions. Those parameters also can be assessed as the statistical data estimations, presupposed, found out from a certain series of the especially (specifically) conducted experimentations etc.

Anyway, now, the relationships of (2.1)-(2.6) will give following:

$$\$_f(v) = \left(\$_{h_1} + kv^n\right)\frac{D_f}{v}. \tag{2.7}$$

Now, the problem described with the relations of (2.1)-(2.7) can be solved either by calculations (using some presumed data for the values of the parameters entering the objective function of (2.5) or its components

of (2.3) and (2.6) in correspondence) or graphically or by drawing the scheme in scales and calculating again etc.

2. Optimal supply speed

The most precious, although, is the analytical solution since it allows analytical analyzing the obtained results with respect to the parameters values variations (changes).

Thus, the optimal flight speed for the minimal flight cost will be found from the extremum existence necessary conditions, i.e., likewise above in the previous problem, Part II: (1.5).

Taking the first derivative of (2.7) with respect to the flight speed: v one can obtain

$$\frac{d\$_f(v)}{dv} = nkv^{n-1}\frac{D_f}{v} - \left(\$_{h_1} + kv^n\right)\frac{D_f}{v^2}. \tag{2.8}$$

Equalizing equation (2.8) to zero yields

$$nkv^n - \left(\$_{h_1} + kv^n\right) = 0. \tag{2.9}$$

Then

$$v_{\text{opt}} = \sqrt[n]{\frac{\$_{h_1}}{k(n-1)}}. \tag{2.10}$$

From (2.10) one can analyze the optimal solution. It depends upon three parameters. Their values are up to the students.

3. Computer simulations

The illustration to the graphical representation based upon the Mathcad calculation platform is shown in Fig. 2.1.

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

The students are supposed to set the correspondence.

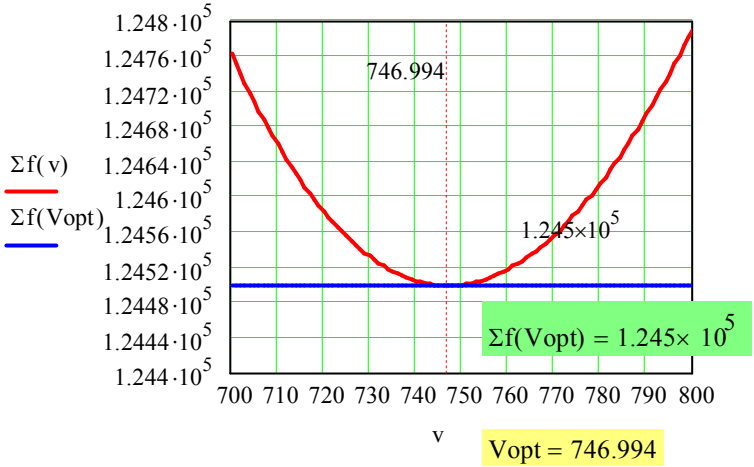

Fig. 2.1 – Optimal solution

Considering (2.1)-(2.10) as

$$\$_f\left(v,\$_{h_1}\right)=\left(\$_{h_1}+kv^n\right)\frac{D_f}{v}. \qquad (2.11)$$

From (2.11) one can obtain the results shown in Fig. 2.2.

According with Fig. 2.2 the optimal solution drifts as a significant parameter of $\$_{h_1}$ varies.

It is proposed to find the optimal values for the parameter of $\$_{h_1}$ possible variations.

4. Variation of a significant parameter

According with Fig. 2.2 the optimal solution drifts.
Based upon (2.10)

$$\$_{h_1}(v)_{\text{opt}} = kv^n(n-1). \qquad (2.12)$$

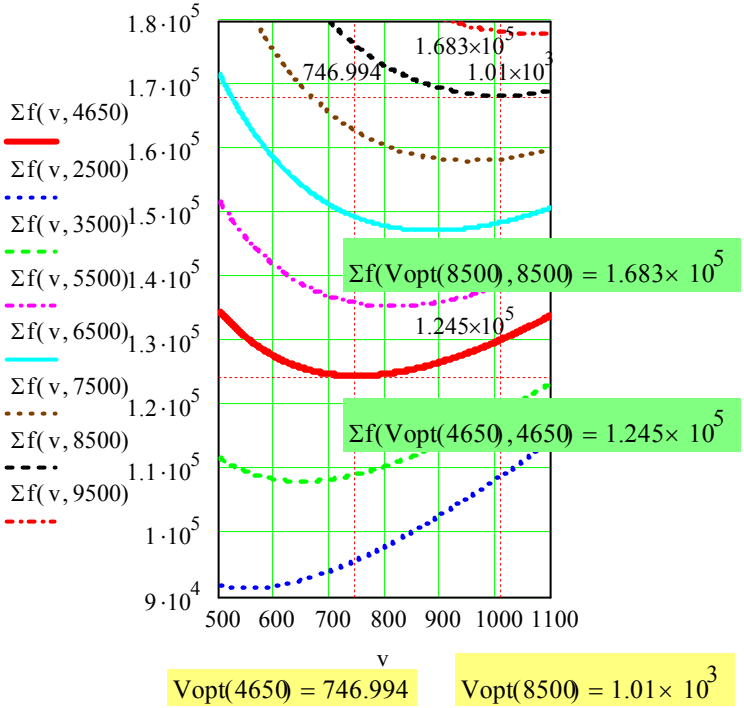

Fig. 2.2 – Optimal solutions

5. Optimal curves plotting

Calculations by (2.12) are illustrated in Fig. 2.3.

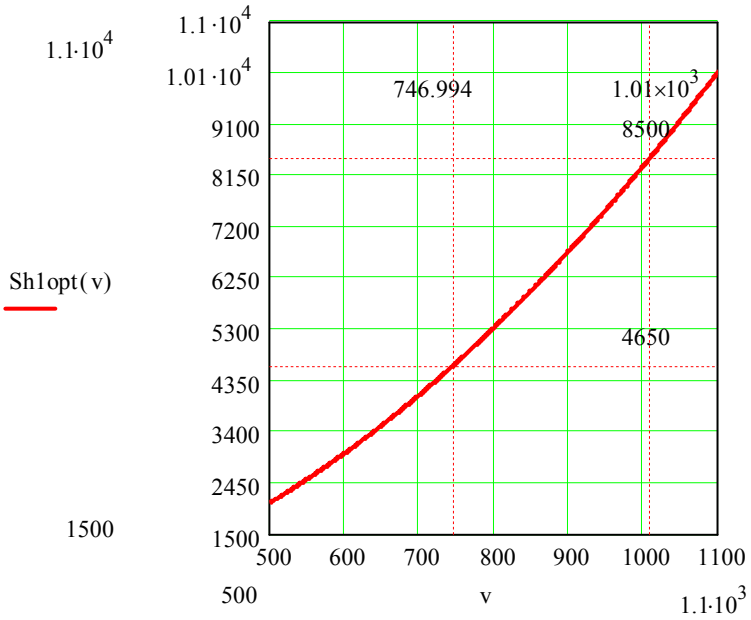

Fig. 2.3 – Optimal constant hourly cost

From Fig. 2.3 it is seen the dependence of the optimal constant hourly cost of $\$_{h_1}(v)_{\text{opt}}$ upon v, the unacceptable speeds being excluded (rejected, ignored).

Then, applying (2.1)-(2.12), one can plot the dependence of the minimal flight costs upon the only independent variable of v:

$$\$_{f_{\min}}\left[v,\$_{h_1}(v)_{\text{opt}}\right]=\left[\$_{h_1}(v)_{\text{opt}}+kv^n\right]\frac{D_f}{v}. \qquad (2.13)$$

The curve by the equation of (2.13) that goes through the optimal points is shown in Fig. 2.4.

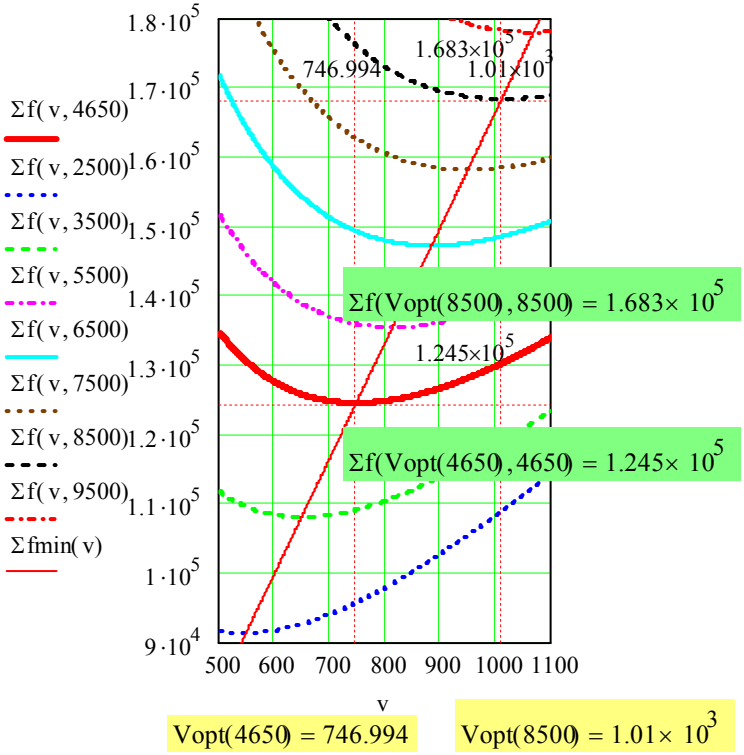

Fig. 2.4 – Optimal solutions

Analyzing Fig. 2.3 and Fig. 2.4 it is possible to point graphically what minimal flight cost: $\$_{f_{\min}}\left[v,\$_{h_1}(v)_{\text{opt}}\right]$ corresponds to what optimal flight speed of v and at what optimal constant hourly cost: $\$_{h_1}(v)_{\text{opt}}$ at other unchangeable conditions. Thus, these three parameters are relating in an optimal combination.

The approach (2.1)-(2.13) allows researching the influence of other parameters.

There are some developments of the problem; in trajectories, distances, speeds, random (stochastic, probability) values, optimization, cost and other economical issues, dynamics, 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 [1-275].

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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Частина ІІІ

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