Master Thesis Guidelines in Applied Physics

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The textbook is devised for students of applied physics and electrical engineering. It provides a rigorous analysis of guidelines, as well as practical advice for thesis writing.

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Contents

Preface

Applied Physics is an innovative interdisciplinary field that involves nanotechnologies, advanced materials, advanced instrumentation, photonics, biotechnology, and advanced manufacturing. Students pursuing a degree in applied physics are immersed in the cultures of physics, engineering, and technology to meet the relentlessly accelerating demands of a technologically demanding society, industry, and academia. Applied physics thrives on solid collaboration and innovation among academic and research institutions, the industry and the use of state-of-the-art converging core technologies. Students pursuing a degree in applied physics should invest on building instrumental knowledge in this highly interdisciplinary field. At the same time, they need to engage in leading-edge research where the practical applications of these fundamental concepts and the effectiveness of leveraging existing technologies or introducing novel creative technologies can be explored as a step to advance further knowledge in the field and introduce new solutions to critical societal and industrial challenges and problems. Post-graduate work can enhance students' knowledge by exposing them to a wide repertoire of theoretical frameworks and revolutionary studies undertaken in the field. The thesis can guide students in applying this newly constructed knowledge to explore its potential applications to solve real life problems and propose new cutting-edge solutions to instrumental societal problems. Drawing on its strong interdisciplinary orientation and in close collaboration with their academic advisor, students should apply the techniques and training that they have gained in the field in order to branch out in new directions of research that are deeply embedded in the multidisciplinary nature of applied physics.

To guide students in understanding some of the underlying complex processes involved in composing a thesis, this book provides a synoptic view of the general requirements, as well as the guidelines and procedures that students need to follow to plan, design, and conduct research. The book introduces the rules, policies, and general requirements for composing a master thesis. Further, the book is designed to guide students in pursuing state-of-the art thesis research that is grounded in innovative techniques, the multidisciplinary nature of applied physics, and the theoretical and practical principles of the field. It aims to introduce students to the importance of engaging in scholastic inquiry by critically examining the current body of research, undertaking new innovative approaches to research, and generating high quality results that can be presented in their master thesis work.

In addition to the guidelines explicated in this book, students must adhere to the policies, rules, and regulations of their academic institution, the code of conduct, and academic and research integrity policies. In close collaboration with their academic advisor, students must fulfil all departmental requirements and follow all university binding policies, guidelines, and regulations for the completion of their thesis work. Students should also consult very closely with the post-graduate program chair and post-graduate administrator to meet all graduate college regulations and policies. All students need to be in good standing and demonstrate satisfactory academic progress before the completion of their thesis work.

Chapter 1: Introduction to Graduate Research and Research Requirements in Applied Physics

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1.1. Requirements for the structure of the thesis

The requirements for the structure of the master's thesis prepared at the Belarusian Universities are determined by the Regulations on the organization of the final certification while mastering the content of higher education educational programs of the second stage at the Belarusian Universities, approved by the order of Rector of each Belarusian University. At Belarusian State University, the content of higher education educational programs of the second stage was approved by the order of the BSU Rector No. 48-OD of 07.02.2014.

The structure of the master's thesis should include a computational and explanatory note and a graphic part, such as drawings, graphs, diagrams, tables, figures and other illustrative material that clearly represents the work performed and the results obtained.

The explanatory note includes:

- title page with the topic of the thesis
- table of contents
- a list of symbols, terms, and abbreviations (if necessary)
- general characteristics of the work
- introduction
- the main part, divided into chapters (sections)
- a conclusion
- reference to the literature used in the study
- graphic material (in the case of an electronic presentation)
- a set of design, technological, software, and other documents (if necessary)
- applications and appendices (if necessary).

Following the decision of the issuing department, the graphical part can be presented on the defense of the master's thesis in the form of an electronic presentation with the printing of paper handouts for the members of the State Examination Commission (SEC).

The presence of an electronic presentation does not exclude the need to include graphic material, namely drawings, graphs, charts, diagrams, tables, figures, and other illustrative material in a paper-explanatory note on paper.

1.2. Title of the thesis

The title of the work should exactly correspond to its content, be as brief as possible, and free of abbreviations. In the title, it is desirable to outline the field of research conducted, bearing in mind the main goal of the work. By formulating the title of the dissertation work, students will be able to determine the subject of research through the object, highlighting the studied aspects of the object.

The object of research sets the area in which the studies described in the dissertation work were carried out.

The subject of the research concretizes the direction, in which the student has received new scientific knowledge about the object of research. The object of the study may include the "tool" of new knowledge obtained about the object of research by the master's student that possesses significant signs of novelty. The object and subject of the research correlate as general and particular. In other words, the subject of research is a "certain part" of the object chosen by the author of the study.

For example, in the thesis "Hopping electrical conductivity of germanium single crystals irradiated with neutrons", the object of investigation is a germanium single crystal, whereas the subject is hopping electrical conductivity.

1.3. Table of contents

The table of contents is given at the beginning of the thesis. It allows students to evaluate immediately its overall structure and creates the first impression of the reader about the work. The clearly worked out structure of the dissertation with a detailed division into sections and subsections, which reflects the logic of research, makes it easier for the reader to understand the essence of the scientific work.

The table of contents includes the names of the structural elements of the dissertation, the names of all sections, subsections, and the paragraphs indicating the page numbers on which the beginning of the material of the relevant parts of the work is placed. If the item does not have a name, it should not be included in the table of contents.

1.4. List of symbols and terms

If the work uses specific terminology, and abbreviations and notations are also used, their list should be presented as a separate page before the introduction. In addition, their decoding is given in the text at the first mention. This allows the reader to save time while working on the text of the dissertation.

As a rule, the list of definitions begins with the words: "In the thesis, the following terms are used with the corresponding definitions: ...". The definitions are arranged in separate paragraphs, one by one, in sequence, according to the order in which they are used in the work.

Abbreviations and notations are listed in the page after the definitions in order of mention in the text. The notation is placed after the abbreviations. The abbreviation is mentioned on the left of the page (designation) and its detailed decoding is mentioned on the right of the page.

1.5. Section "General characteristics of work"

"General characteristics of work" includes a list of keywords, as well as information on the characteristics and the structure of the master's thesis.

The list of keywords usually consists of 5-10 words (or phrases) in the nominative case, marked with a comma, comma in a line in capital letters. The list of keywords should best reflect the content of the work and provide an opportunity for information retrieval. Competently make a list of key words since, when placing a thesis in open access, the keywords will enable interested readers to quickly and easily locate it. This implies that in the future with an appropriate level of research done by the master's student, there is a possibility to cite and increase the impact of the work undertaken in the thesis.

In the text of the "General Characteristics of Work", in concise form, the author should cast:

- the object and subject of the research
- the main goal of the work
- the research methods
- the results obtained and a description of their novelty
- the degree of application or recommendations for using the results.

Information on the structure of the master's thesis is devoted to a brief enumeration of its elements. In addition, a brief explanation of the logic of the construction of the thesis work is possible. The following is the full amount of work in the pages; the volume occupied by illustrations, tables, annexes (indicating their number); the number of bibliographic sources used, which may also include the student's own publications.

When expanding, one should use the syntactic constructions inherent in the language of scientific documents and avoid complex grammatical terms. It is necessary to use the standardized terminology to avoid uncommon terms and symbols.

1.6. Thesis introduction

The main task of the introduction of the master's thesis is to prepare the reader on what will follow in the main text. For this purpose, based on scientific publications, an overall assessment of the current state of the scientific and technical problem is provided, a range of unresolved issues is singled out, and the relevance of the work is justified.

The relevance (currentness) of the research is one of the main criteria for its evaluation and that means that the tasks set in the work require an early decision for the practice or the relevant branch of science.

In the introduction it is necessary to show the following: the tasks or problems to which the work is devoted; the proffered solution of these problems to promote the development of

science and technology and the need for further scientific research and / or production in the field.

The final stage of the introduction is the formulation of a single (main) goal of the work. The goal can be divided into several tasks, a consistent solution of which is necessary to achieve it.

1.7. Main part of the thesis

The main part of the thesis is divided into relevant chapters. Chapters can consist of sections and subsections. The separation of the main material of the master's thesis into chapters (sections) and the structuring by sub-sections (paragraphs, etc.) is determined by the master's student. The selection of chapters, sections, subsections, and their sequence should be logically justified.

As a rule, the main part of the work contains:

- a section with an analysis of the current state of the scientific problem in which
  - known results are given (with obligatory reference to the source of information) and their completeness is estimated
  - unexplored aspects of the problem are identified
  - the choice of the research direction is justified
- a methodological section, where
  - the main known (experimental and / or theoretical) research methods are described
  - the choice of own research method is justified
  - a description of the equipment used by the author and the technique of performing the experiment (with enough details to allow replication of the experiment) is provided
  - samples of materials and structures are described, as well as methods for their preparation
- A section, which contains the results of studies
- A section containing an analysis and generalization of the results, comparing them with the known results, the promotion and support of hypotheses, and constructing the physical and mathematical models of the studied phenomena and processes.

The separation of text by chapter, sections, and subsections is performed by the author in accordance with the above recommendations and the internal logic of the study. Each part of the text should have a specific purpose being the basis for the subsequent part. The style and nature of the presentation of materials must be subordinated to the purpose of the work.

In analyzing the state of the scientific problem, one should concentrate on the object of research, and avoid the discussion of nonessential and minor details not directly related to the topic of the thesis work. The main attention should be paid to unresolved issues. This is the basis for the subsequent description of new results obtained personally by the author.

In describing the basic methods of research, their essence is revealed, and also theoretical justification is given and algorithms for solving problems are described. Theoretical work includes known and proposed methods of calculation, and their comparative estimates. In the experimental master's thesis, the principles of operation and characteristics of the equipment used and estimates of measurement errors are given.

In the section of the master's student own research, it is necessary to state the actual material such as mathematical calculations with finite formulas and the results of numerical calculations and experiments, which serves as a basis for the subsequent analysis and formulation of scientific conclusions. The text of the work and the form of the presentation of the results, such as tables and graphs, should ensure the unambiguity and objectivity of information transfer. The fundamental requirement for the experimental (theoretical) results of the work is their reliability.

The reliability of the experimental work is achieved by:

- repetition of experiments and verification of the results
- access to data obtained at similar facilities by different scientists independently of each other
- use of complementary experimental techniques.

The reliability of the theoretical work is confirmed by:

- internal logical consistency
- agreement with fundamental physical laws
- compliance with experimental data
- possibility to describe known phenomena
- the ability to predict new phenomena and facts.

An obligatory element of the analysis of the experimental (theoretical) results is the exposure of their novelty. For this goal, the author compares his/her results with the known data of domestic and foreign scientists.

Scientific novelty consists of solving a scientific problem that extends the existing boundaries of knowledge in a particular branch of science. It is possible to isolate the following novelty elements that can be represented in the work:

- a new research object, such as a problem that has been posed and considered for the first time
- new formulation of known problems or tasks; for example, assumptions are removed, new conditions are accepted
- a new method for solving a known problem
- a new application of a known solution or method
- new results of the theory and / or experiments and their consequences
- new or improved criteria, indicators for describing and/or evaluating the research subject
- development of devices and methods at the level of inventions and utility models.

To outline and analyze the results, it is necessary to strictly observe one of the laws of logic - the law of a sufficient basis: In order for every thought to become authentic, it should be substantiated by other thoughts, the truth of which needs to be proven or be self-evident.

The analysis of the results should be accompanied by an assessment of their scientific and practical significance.

New results have scientific significance if they:

- supplement the picture of empirical facts about the object of research
- allow to generalize known data
- explain known empirical facts for the first time (or at a higher level)
- challenge or overcome existing disagreements in understanding a process or a phenomenon
- allow the development of an existing model (theory for more important results)
- represent a model (a theory for more important results) that fills a gap in the system of scientific knowledge about the object of research.

The practical significance of the results of the work is represented in

- positive effects from direct use in production
- recommendations to improve the accuracy of measurements, research methods, production technology
- knowledge that is useful for the educational process of the secondary or higher school.

As a rule, scientifically significant results that have a greater generality are more significant than other types of results. Therefore, the final stage in the discussion of research should be the generalization of individual facts and the construction on their basis of models, and the promotion and testing of hypotheses that explain known (predicting new) states, processes, and phenomena.

Each chapter of the thesis should be concluded with brief conclusions that sum up the results of the steps of the study.

At the end of the main part, the student should evaluate the achievement of the goal and completeness of the solution of the tasks. If it is necessary to conduct additional studies, students should provide the relevant arguments in the thesis.

1.8. Conclusion section

In the conclusion section, it is necessary to summarize the main results of the study and provide the conclusions made on their basis. Conclusions should be made in the form of 3-4 states, each of which is an independent scientific statement.

1.9. References

The list of literature should contain information about the sources used in composing the thesis. The author is required to provide the references to all literary sources from which materials, individual results or ideas are borrowed. Based on copyright laws and norms of scientific ethics, such references are mandatory. In addition, they allow the reader to locate publications and verify the reliability of the information presented in the work. If the same material is reprinted more than once, then the last edition should be referenced. The earlier edition can be referenced only in cases where the necessary material was not included in subsequent editions.

1.10. Graphic material

Graphic material (illustrations, photographs, drawings, sketches, charts, diagrams, maps, etc.) and tables serve to visualize the characteristics of research objects in the thesis, theoretical and (or) experimental data, and revealed regularities. Students should not present the same results in the form of an illustration and a table.

Graphic material can be placed both in the text itself (which refers to the main material and is necessary for the convenience of information perception), and can be rendered in separate applications, which can be achieved through the use of auxiliary material.

The Appendices include any supporting materials necessary for the completeness of the thesis work, but for one reason or another they were not included in the main text. The appendices can be:

- copies of documents confirming the scientific or practical application of research results or recommendations for their use
- intermediate mathematical proofs, formulas and calculations, estimates of measurement errors
- tables of auxiliary digital data
- block diagrams of experimental installations or computer simulation code
- drawings of the developed equipment and technological routes
- source code for computer programs with comments or screens for the user interface.

Illustrations should be made using computer graphics. The graphs must clear and points and curves should be visible. If the aim is to guide readers in obtaining the data from the graph, then students should apply a grid. If the main objective of the graph is to show the general nature of any dependence, then students should plot the graph without a grid. The graph does not need to be overloaded with dots (symbols), curves, and inscriptions. It is necessary to use digital or alphabetic designations and to transfer all explanations to the signature or the text. The use of special symbols, such as circles, triangles, and line segments in the caption of the drawings is not recommended for aesthetic or technical reasons; however, this may create additional problems in the layout of the thesis. Students should label these elements with the numbers in the figure.

Chapter 2: Selection of Innovative Research Topics

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2.1. Introduction

Students should collaborate closely with faculty members and research teams in order to become acquainted with global research trends, initiatives, and actions undertaken to tackle critical societal challenges. Students should also pay particular attention to how researchers leverage leading-edge technologies, particularly nanotechnology, industrial biotechnology, and other advanced novel technologies in their effort to propose innovative societal and industrial solutions to emerging challenges. Students should also become acquainted with current European research initiatives, key actions, policy efforts, industrial exploitations of advanced technologies, and societal benefits and challenges. Exploring the synergies between advanced innovative technologies, academic research, industrial demands, and societal impact, students can develop a conceptual understanding of the research directions in the field and identify possible areas where they could contribute to the field.

Before formulating their final research idea for their thesis work, students should contemplate that the selection of an innovative research topic should enact opportunities for:

- Identifying an empirically important research topic that is relevant and innovative, and has the potential to address key research and societal needs and make substantial contributions to the field
- Undertaking an original investigation of an empirically, societally, and industrially significant research topic
- Drawing, expanding on and contributing to the current body of knowledge and research in the field
- Striving to maintain a solid interdisciplinary orientation
- Leveraging existing or emerging advanced technologies to generate cutting-edge research findings and applications that open new possibilities to overcome societal challenges
- Exploiting the potential of generating findings that can be turned into marketable products or applications that meet important societal, industrial, and research needs.

Selecting a thesis topic from the wide interdisciplinary branches of applied physics in which students have a special interest can be demanding. To guide students with this process, this chapter provides an overview of four main research areas in the field:

- Advanced materials
- Nanoelectronics
- Nanotechnologies
- Photonics

2.2. Advanced Materials

The development of modern and very diverse industries in the Republic of Belarus is associated with enterprises and companies of very different orientations, such as electronics, optics, chemistry, agriculture, and construction. At the same time, the lack of sufficient energy sources and minerals and other resources in Belarus requires the development and implementation of special energy- and resource-saving technologies, which promote efficiency in use of available energy, material, and human resources. The implementation of such an approach is inextricably linked with the need for modernization, development, and production of new materials based on the modern synthesis of technologies and modification of their properties. This will reduce the cost of energy and material resources for the development of products, increase in the period of their operation, and the efficiency of use. Thus, the preparation of highly qualified specialists at the master's level in the field of creating new modern materials is imperative for the improvement of the economy of the Republic of Belarus.

1. Current state of research in this field. Reasoning from the existing state of industrial development of Belarus and the current world trends in the field of modern materials science, carbon nanostructured materials (including nanocomposites based on them), polymer nanomaterials, nanostructured systems for power engineering, ultradispersed powders, etc. are the most popular types of materials for the above mentioned industries. The results of recent years, obtained in the leading world scientific centers, indicate availability of development of new materials, modification of their properties, study and application of such materials, which can provide a significant increase in the performance characteristics of products based on them.

The analysis of the state-of-art and new trends in the development of nanoindustrial objects allow us to conclude that the synthesis of carbon-based nanomaterials is one of the most promising areas of modern materials science in "Functional nanomaterials". Among the carbon forms of nanomaterials, the fullerenes and fullerene-like systems have been the most studied systems in the field during the last decades. Of great interest is also the research on nanotubes (single- and multi-walled) and their compositions with polymers which can be used in microwave and terahertz electronics, and can increase the strength and thermal conductivity. One of the most interesting and widely researched nanostructured forms of carbon is graphene in the form of single-layer and bilayer systems, as well as in the form of their compositions with nanoparticles and layers, such as magnetic and semiconductor. Similar systems are prospective for manufacturing various kinds of sensors and detectors of gases, magnetic field, and temperature, which can create memory environments and other applications. All these amazing properties of graphene are due to the unique nature of its band structure and charge carriers, which behave like relativistic particles.

One of the varieties of semiconductor materials are organic (molecular) semiconductors - a wide class of substances, which are of the type of connection to molecular compounds and have appreciable electrical conductivity. These include, for example, molecular crystals, organic dyes, molecular complexes with charge transfer, biological substances (chlorophyll, betta-carotene), ion radical salts, and polymers. Work in this area is stimulated by successes in the synthesis of organic materials with specified, well-reproducible parameters, in particular

polymers, because of their variety, manufacturability, and a relatively low cost. Organic nanomaterials have been widely used in recent years to solve a number of fundamental and applied problems of modern electrical engineering. For example, intensive research is being performed to create new types of conductive, dielectric and semiconductor materials that create opportunities for the development of molecular electronics. Experiments indicate that special methods of synthesis and subsequent modification, such as a combination of ion implantation methods and special heat treatments, allow the conductivity of some types of polymers or their near-surface layers to vary in a wide range from values corresponding to dielectrics (below 10-10 Sim/cm) or metals (above 1 Sim/cm). The awarding of the Nobel Prize in Chemistry in 2000 for the discovery and creation of conducting polymers proves the importance of the development of this field of research.

An important role in modern materials science is played by the development of nanomaterials for power engineering. For example, nanomaterials are beginning to be widely used to convert solar energy into electrical energy in solar cells of the third generation. In particular, it has been shown that semiconductor materials have a number of advantages in the nanostructured state as collectors (harvesters) of light. For example, a change in the size of nanoparticles can affect the region of light absorption, and the effect of multiple exciton generation allows one to overcome the limit of Shockley-Kwesser efficiency. In addition, it is possible to use surface plasmon resonance to enhance optical absorption in solar cells. Among other nanomaterials for power engineering, it is possible to mention nanomaterials for generation, transformation, and storage of energy; special nanodispersed materials with the most effective energy release and energy absorption, including pulsed; nanomaterials and nanocomposites for efficient storage and combustion of hydrogen; and materials for alternative energy sources, including fuel cells, hydrogen accumulators, electrochemical current sources, thermoelectric current sources, and supercapacitors.

2. Use of innovative technologies in the field under investigation. Nanoindustry refers to the most knowledge-intensive high-tech areas with a high level of intellectual value. This is due, first of all, to the use of sophisticated innovative technologies for the production of nanomaterials and products (goods) based on them. The uniqueness of the direction "Functional nanomaterials" is that it can be claimed by various social strata and professional groups. Further, it can stimulate the development of human capital and the economic potential of the state, and promote the integration and effective use of highly skilled professionals. That is why in all industrialized countries, national programs in the field of nanotechnology are not only oriented to the scientific or military spheres, but are also viewed as a factor in the socio-economic development of a country.

3. Use of theoretical and practical principles of modern applied physics. The effective use of the functional materials described above is based on modern scientifically-grounded ideas about the structure of matter and processes that occur both in synthesis and as a result of various external impacts, the theoretical basis of which is laid in the physics of functional nanomaterials. The study of such materials and the writing of master's theses in this direction provide training with the aim to create specialists for research and design and technological activities in the field of physical materials science and non-destructive testing of materials.

At this stage of the wider use of functional nanomaterials at the product development stage, specialists with the qualification of a master's degree or a scientific degree are most in demand. Based on qualification requirements and professional competencies, specialists who focus on interdisciplinary research in the field of nanoscale effects and systems, especially in the field of materials science, are especially in demand.

The necessary level of training required for research and organization of work of companies that produce nanotechnology products can be provided on the basis of university-level physical education. Such education forms a specialist's worldview, a methodology for solving the emerging diverse problems, and the ability to conduct a comprehensive analysis and predict the development of events. This, in particular, requires closer training links between production companies specializing in the manufacturing of high-tech nanotechnology products with the physics faculties of modern universities in Belarus.

4. Expected concrete applied or fundamental results. Carbon-based nanomaterials and their compositions have a number of unique properties due to the ordered structure of their nanofragments: good electrical conductivity and adsorption properties, ability to cold emission of electrons and accumulation of gases, diamagnetic characteristics, chemical and thermal stability, and high strength in combination with high values of elastic deformation. Such materials can be successfully used as structural modifiers of materials, hydrogen accumulators, elements of radio electronics, additives in lubricants, varnishes and paints, highly effective adsorbents, and gas-distributing layers of fuel elements. The use of carbon nanostructures in fine chemical synthesis, biology and medicine is widely discussed. Such properties of graphene as high mobility of electrons, minimum thickness of the order of one atom, and low specific resistivity open up prospects for the creation of various biological and chemical sensors, as well as various versions of thin films that can be used in photovoltaic devices for the conversion of solar energy or in touch screens. The special behavior of the spin in graphene can lead to the creation of new spintronic devices, and due to the high thermal conductivity property, graphene can serve as a heat sink in modern integrated circuits in which heating is a serious problem.

The use of polymers in electronics will give impetus to the formation of a whole set of new functional elements. Doped polymers are currently used as various antistatic coatings, electromagnetic screens, and in lithographic processes, such as conducting wires in silicon ICs. In electrochemically doped polymers, the process of doping can be controlled by external voltage, which is used to create light batteries. Undoped polymers have semiconductor properties and can be injected with charge carriers from electrodes. A fully polymeric (and hence flexible) field-effect transistor has already been created; however, due to the low carrier mobility (0.01-0.5 cm2/V·s), it has a limited range of operating frequencies (up to 100 kHz). Completely polymer integrated circuits that in some cases allow the replacement (for example, in coded electronic locks) of silicon chips are developed. New applications include polymer LEDs, solar batteries, and displays.

One of the key areas in the use of nanotechnologies in the energy sector will be the creation of new generation batteries. The main research in this area today is focused on solving problems of increasing the density of the energy flows, reducing the duration of the battery charging cycle, reducing their overall dimensions and weight, and improving safety and stability. The

strategic goal is to develop high-capacity batteries that will allow for the mileage of electric vehicles for long distances, and can also guarantee more economical operation of renewable energy sources, such as solar panels and windmills, by accumulating excess energy. No less promising areas of application of nanotechnology in power engineering are the creation of supercapacitors with high electrical capacity; luminescent nanocomposites for new generation white light sources; high-efficiency subminiature sources and power storage devices; and high-saving light sources.

2.3. Nanoelectronics

1. Current state of research in this field. After the Nobel prize was awarded for the discovery of the quantum Hall effect (1985) and giant magnetoresistive effect (2007), the investigations in the field of electronic states and processes in low-dimensional systems with magnetic ordering became one of the most "hot" points in solid state physics. On the one hand, it deals with unique physical properties of low-dimensional systems which are absent in three-dimensional solids, while, on the other hand, there is a big potential for its quick and effective incorporation in industry.

2. Use of innovative technologies in the field under investigation. To produce solid state systems with low-dimensional and spin-dependent electron states and processes, all kinds of modern technologies are used including physics-chemical methods of deposition, molecular-beam epitaxy, and ion beam modification of solids. At the present, it is very difficult to make classification and to determine the most perspective technological processes for solving concrete tasks dealing with fabricating such systems based on insulators, semiconductors, and metals and using their electrical, magnetic, galvanomagnetic and optic properties. Every concrete case needs complex analysis, which takes into consideration a lot of factors. A final decision has to be made in accordance with local opportunities. Without a doubt, the development of new knowledge during scientific research strongly influences the development of new technological processes in solid state electronics, leading to positive results in science and industry.

3. Use of theoretical and practical principles of modern applied physics. The production of modern materials and structures of nanoelectronics and spintronics starts with deep analysis of the theoretical background of quantizing electrons energy spectrum in low-dimensional systems and formation of low-dimensional structures with magnetic ordering, as well as spin-dependent electron transport. The next step is to study and model technological processes fabrication of such systems, with early predicted properties. Finally, fabricated nanostructured materials and structures have to be examined regarding their electrophysical characteristics. This knowledge will influence the results of theoretical modelling and optimization technological processes of their fabrication. This may be a subject of an advanced master thesis or a Ph.D. dissertation.

4. Expected concrete applied or fundamental results. Concrete applied or fundamental results will be obtained through a thesis and their novelty will be determined with respect to common

knowledge in various areas of scientific knowledge such as optics, electricity, magnetism, and mechanical properties of solids.

2.4. Nanotechnologies

Considering the importance of nanotechnology for sustainable economic growth in the Republic of Belarus at the current stage, the Belarusian scientists developed the "Concept for the development and adaptation of Nanotechnologies and Nanomaterials in the Republic of Belarus". In addition to assessing the global trends in the development of the nanotechnology industry and characterizing the state of scientific research and industrial developments in the field of nanomaterials and nanotechnologies in our country, it emphasizes the importance of systemic training of scientific and engineering personnel for the successful development of industry.

In connection with the need to modernize existing and create new high-tech industries, there is a growing need for highly qualified engineers, researchers, designers, and managers with a high level of knowledge in the field of nanomaterials and nanotechnologies, which are well versed in current trends in their development. Of particular importance in this case is the training of specialists at the second stage of higher education, at which both the deepening of fundamental and the perfection of highly specialized knowledge of future masters in the field chosen can contribute to the successful development of the industry.

1. Current state of research in this field. Nanotechnologies are one of the leading modern technologies that are used in various fields of science and technology, as well as in various industrial fields such as electronics, engineering, medicine, and agriculture.

In electronics, the improvement of technological methods for the creation of integrated circuits (IC) leads to the possibility of creating individual elements with dimensions less than 10 nm. As a result, there is an increase in the number of active elements placed per unit area. Further development of electronics will be based on increasing the speed and informational capacity of the ICs and reducing power consumption, not through simple proportional miniaturization of elements, but as a result of the use of quantum phenomena. Thus, the switching time of transistors and the principle of operation which is based on the resonance tunneling effect, ranges from tenths to several picoseconds.

The creation of biological, chemical, and gas sensors based on nanomaterials makes it possible to increase their sensitivity due to the developed nanostructured surface. Similar to various high-sensitivity sensors (pressure, temperature, acceleration, and angular velocities), micro- and nanoelectromechanical systems are used that combine micro- or nanoelectronic components created by the methods of traditional electronic technology, with mechanical elements obtained with the help of microprocessing.

The use of nanostructured materials created by nanotechnological methods in engineering and construction is caused by a significant change in the mechanical properties, such as hardness,

strength, ductility, and elasticity, with a decrease in the size of the structural elements of which they consist. The strength and hardness of nanocrystalline metallic alloys increase approximately 5-fold as the grain size decreases to nanometer dimensions. This allows the increase in the service life of machine parts. Nanostructured hard alloys are also used to create cutting tools with increased abrasion resistance.

Technologies for the epitaxial growth of semiconductor layers and quantum dot arrays are used to create lasers and light-emitting diodes emitting in the near infrared range of the electromagnetic spectrum, as well as photodetectors for the mid-infrared wavelength range.

2. Use of innovative technologies in the field under investigation. Nanotechnology refers to advanced modern technologies, which allow the creation of high-tech innovative products with high added cost. Therefore, it is assumed that the need for specialists in the field of nanomaterials and nanotechnologies with a master's degree will constantly increase. At the same time, the demands for knowledge development and expertise gained in the field will also increase as new methods and approaches are introduced to create nanotechnological products.

Specialists in the field of nanotechnology should have a high level of fundamental training in the field of physics, chemistry, mathematics, biology, and knowledge of the fundamentals of physical and chemical processes at the atomic-molecular level. Therefore, the direction "Functional nanomaterials" for training specialists in the Republic of Belarus for work in research centers and industrial enterprises of nanotechnological profile is becoming especially relevant.

3. Use of theoretical and practical principles of modern applied physics. Successful mastering of the curriculum in the direction of "Functional nanomaterials" assumes that the undergraduates acquire fundamental theoretical knowledge in the field of materials science, physics of low-dimensional systems, as well as gain practical skills in modern research equipment, mastering modern methods used to characterize various nanomaterials such as electronic and atomic force microscopy, Raman spectroscopy, impedance spectroscopy, and X-ray diffraction analysis.

Practical experience acquired by modern analytical equipment undergraduates can be obtained not only in their educational institutions, but also in cooperation with Belarusian companies specializing in the development of such equipment. In addition, it is very important to master the methods of modeling the physical processes and phenomena on which nanotechnologies are based, as well as methods for carrying out quantum chemical calculations of various low-dimensional systems.

When composing master's theses for the purpose of mastering the methods of nanomaterials, students should cooperate with universities, research centers, and manufacturing companies of the Republic of Belarus that possess the required technological equipment, such as magnetron and ion-beam sputtering systems, molecular beam epitaxy devices, and systems for the synthesis of carbon nanostructures.

4. Expected concrete applied or fundamental results. It is assumed that undergraduates studying in the direction of "Functional nanomaterials" will compose research papers on actual contemporary topics while working on their master's thesis. The development of methods for

creating nanocomposites (including those filled with carbon nanomaterials) can be used in the production of building materials, lithium ion batteries, and electrostatic and electromagnetic screens, as well as materials for the aerospace industry.

It is expected that the future advancements in nanotechnology will allow creating "one-electron" and "one-photon" devices that control the transfer of single electrons and the propagation of single quanta of light. This will significantly reduce power consumption in such devices. In general, the improvement of nanotechnology methods in electronics and photonics will help increase the productivity of computing circuits, will enhance their information capacity, and will create cost-effective solid-state lighting devices, optical filters and receivers of visible, microwave, and terahertz frequency bands.

In addition, master's theses on the development of wear resistant, high-strength, anti-corrosion coatings using ion-assisted plasma synthesis are relevant for the industry of the Republic of Belarus. Thin film production technologies can also be used to create magnetic field sensors, ultra-high-density information recording media, and hydrophobic and oleophobic coatings.

2.5. Photonics

Photonics is a field of science and engineering associated with light radiation (photons) used in optical and optoelectronic elements and systems. Photonics covers the principles of design, operation, and implementation of the devices, where optical signals of the ultraviolet, visible, and infrared regions (terahertz range including) are generated, transformed, propagated, and detected. At present, all the latest information technologies are based on the principles of photonics. Photonics that has occurred at the junction of laser physics, optics, and quantum radio physics is oriented to solving the problems of the classical electronics when using optical radiation (photons) instead of the electric current (electrons). Photonics is called the electronics of the XXI century.

The development of photonics in the Republic of Belarus is based on such classical courses of scientific research as laser physics and nonlinear optics successfully realized since the beginning of the 1960s due to the advent of lasers. Now photonics is recognized as one of the research trends of high priority. Due to this, training in the field of photonics at master's level is an important task undertaken by Belarusian Universities.

1. Current state of research in this field. Photonics involves the materials, devices, techniques, and technologies which are intended for transmission, recording, processing, mapping, and storing of information on the basis of material carriers – photons. Presently, the principal problem of photonics is miniaturization and integration of optical elements and devices, the creation of multipurpose optical materials and systems, the conversion of analog devices to the digital ones, and the development of new-generation computer techniques. Photonics is perceived a field that embraces laser physics, nonlinear optics, optical holography, fiber optics, integrated optics, and optoelectronics. Other-related fields, such as optoinformatics and optical data processing are also becoming more and more important.

In modern laser systems, the radiation frequency doubles and cascaded multipliers for the third, fourth, and higher harmonics are now widely used. The parametric optical generators operating on the basis of the principles of nonlinear optics are created. High-power laser systems are impossible without the elements of adaptive optics using the wavefront conjugation effect. At the junction of waveguide optics and laser physics, a new trend has been developed that is associated with the design of high-power fiber lasers. Due to the nonlinear and optical methods in spectroscopy, the potentialities of spectroscopic studies in material science have been greatly improved.

Most extensively used in different fields of science and technology are holographic systems for recording, storage, and processing of information; holographic interferometry, diffraction optical elements; holographic technologies for the protection of documents and securities. Holographic principles are used to solve the problems of adaptive optics including systems for the formation of light fields with the desired spatial structure.

Modern communication systems are based on fiber-optical devices enabling telephone communication and Internet services. Waveguide systems are effectively used in science, engineering, and medicine. For example, high-power beams of laser radiation are implemented for laser welding and cutting, in laser surgery and cosmetology.

Studies in the field of optical data processing are also in progress. Apart from the classical analog techniques based on Fourier transforms of images, optical bistable elements have been created to offer digital processing of optical signals. With the development of such systems, optical processors have been designed. The optical frequency range offers a wider transmission band and enables an extremely fast response compared to the radio-frequency bandwidth.

Quantum optics, as a combination of quantum field theory and physical optics, is developing at a great pace; we can name studies of squeezed states in a light field; atomic coherence; development of a laser without the population inversion, of nanosized laser systems and even single-atomic lasers.

In nanophotonics, special attention is given to the processes of propagation, transformation, and generation of optical radiation by the nanostructures; to the development of nanostructured optical devices from lasers to biochips. These studies involve the nanostructured optical fibers, light-emitting diodes based on heterostructures, and photonic crystals enabling the control of light beams at a microlevel.

2. Use of innovative technologies in the field under investigation. Continuously developing photonics necessitates the use of innovative technologies and advanced technologies from other fields. The photonic devices have found application in all spheres of our everyday life including optical communications, visualization, data processing and storage, energy-saving technologies for illumination equipment and material processing, biophotonics, and laser medicine. The creation of new systems for data processing and communication requires the creation of innovative materials and technologies. Nanophotonics embracing photonics and nanotechnologies is associated with the architecture development and with the production technologies of nanostructured devices for the generation, amplification, modulation, transmission, and detection of electromagnetic radiation. Besides, nanophotonics is effective in studies of physical phenomena determining the operation of nanostructured devices, which are

proceeding when photons are interacting with the nanosized objects. The developments in this field are of great importance for the dynamically progressing integrated optics. At the same time, the innovative approaches to the interactions between light and materials are influencing the latest technologies in laser material processing, laser medicine, and superhigh-resolution microscopy. The development of innovative methods for the light beam transformation makes it possible to design advanced devices for diagnostics of different media and objects, for communication, and data storage. Considering significant advances in the development of electronic computer systems, it seems logical to study more closely the possibilities of designing the electronic-optical computer with the balance of its electronic and optical parts dependent on the problem at hand – such an approach will contribute to optimal realization of the advantages inherent in both parts. A significant role of the innovative technologies in the field of photonics may be demonstrated by examination of the data for the world market, where the share of photonic technologies comes to several dozens of billion dollars a year, and is still growing.

3. Use of theoretical and practical principles of modern applied physics. As any other research field, photonics is in need of highly qualified professionals capable of working in the related fields. Material studies and the development of new approaches for the creation of photonic devices are impossible without competent people who have adequate knowledge in the field of material structure, interaction between electromagnetic radiation and material, characteristics of electromagnetic radiation, and quantum effects. Training of professionals in the field of photonics, apart from the courses of general physics, necessitates profound knowledge in spectroscopy, material science, optics of condensed media and nanostructures, quantum mechanics, nonlinear optics, laser physics, laser-material interactions, optical data processing, and some other instrumental areas depending on the specialization. High quality raining in experimental work is of paramount importance for the specialists engaged in the development of innovative technologies and manufacturing of photonic devices.

4. Expected concrete applied or fundamental results. The specific applied and fundamental findings in the process of writing master's thesis in the field of photonics are determined by the selected research problem. The fundamental problems which may be selected by students for the master's degree are associated with theoretical and experimental studies of the interactions of quantum and coherent light fields with atomic and molecular systems, and also with studies of photonic crystals and metamaterials. Besides, students can study different effects arising as light beams propagating within nonlinear media or the features of the light beam transformations on multiwave interactions. The applied research activities are aimed at the development of the control systems for laser beams on the basis of holographic and waveguide elements; at designing of nano- and micro-structured elements for transformations of the phase and polarization characteristics of light beams; and at the development of materials offering much promise for the creation of advanced nanophotonic devices and diagnostic systems for optical elements using the holographic interferometry method. Ultimately, of considerable promise are studies in biophotonics and laser medicine.

2.6. Conclusion

Whether composing a thesis on advanced materials, nanoelectronics, nanotechnologies, or photonics, it is imperative to develop a solid understanding of the relentlessly accelerating social and industrial changes, developments, and newly emerging needs and develop the skills and competences to compete not only in the Belarusian labor market but also in the greater global labor market. Innovation, knowledge, and expertise need to be developed and the selection of a novel research topic can guide students in exploring the trajectories of knowledge, innovation, and research in their effort to engage in scholastic and ground-breaking research work. Through their thesis work, students should strive for creativity and state-of-the-art research and innovation that transcend the trajectories of existing knowledge and provide novel solutions to existing problems and challenges.

Chapter 3: Exploring Recent Developments in the Field (Information Search)

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3.1. Scientific information sources

In this chapter, students will learn in a very applicable way to recognize the decent scientific information sources and they will be introduced to the phenomenon “Open Access”. Decent scientific information sources can be identified both by their form and their content.

3.1.1. Form

- Reliable profile of the author

The author has proven his/her level of competence about the subject he/she is working on. The author is very often associated with an academic institution. His/her academic title and/or research group are frequently mentioned in his/her work and publications.

- References to other sources

A scientific text usually includes precise references to other scientific sources, either by footnotes or by a list at the end of the text.

- Language use

The vocabulary and the writing style are often more complex. The text, which is often composed in English, is designed for readers with a scientific background.

3.1.2. Content

- Correct

Everything has been proven. Logical arguments are given and/or all relevant data are taken into account.

- Verifiable

There is a clear description of the followed methodology and a precise listing of the consulted sources.

- Independent

The information is neither influenced by emotional considerations nor is dictated by religious, nationalistic, commercial, or other interests.

- Reliable

The content has been carefully verified by colleague-researchers before publication (peer reviewed).

- Up-to-date

Scientific journals contain publications with the latest developments within a particular discipline.

The "Open Access (OA)" movement started at the beginning of the 21st century as a new, quick way to make research results accessible on the internet, resulting in a worldwide stimulation of knowledge and sharing of research findings. The aim is to have the same quality as obtained with the traditional commercial publications, without the scientists having to pay for consultation.

According to the general principles of "Open Access", the author allows everybody to read, download, copy, and disseminate a particular text without any service fee or limitation. Furthermore, the OA-movement stimulates the authors to set aside the traditional concept of copyright, whereby the content of a paper shared with other scholars may not be changed. At the same time, scholars offer their publications as base material upon which other scholars can enhance their knowledge and build their research framework. However, it is imperative to acknowledge the original authors for their contribution to the field.

At the beginning, the focus within the OA-movement was primarily placed on the scientific journals, but more recently, the number of books and databases have grown significantly. Further trends are the OA-data, such as the research data which have been served as a basis for the publications, and the Open Educational Resources, such as educational material which is accessible on the internet.

3.2. Types of scientific information sources

In this section, students will be introduced to the different types of scientific information sources, so that they can make well-informed choices while browsing for scientifically-sound information for their thesis work.

3.2.1. Primary, secondary and tertiary sources

During the scientific communication process, three different types of sources arise:

- *Primary source*

A primary source is an original object or document that contains first-hand information. It includes a publication in which the researcher conveys his/her research findings for the first time.

- *Secondary source*

A secondary source builds further on the information of a primary source. By synthesis, combination, interpretation, comment, and discussion about the original matter, new information missing in the primary source, can be identified.

- *Tertiary source*

A tertiary source is a publication giving an overview of the secondary sources. Well-known examples are the encyclopaedias.

3.2.2 Types of information sources

On the basis of the form of the information source, eight different types of sources can be distinguished:

- *Reference works*

A reference work contains a whole series of short contributions about a word/ person/concept, alphabetically arranged by lemma or keyword.

- *Catalogues*

A catalogue contains a description of books, journals and audiovisual materials, including their location; for example, the precise location of a printed copy or the direct link to the electronic version.

- *Databases*

A database contains the bibliographic reference (bibliographic database) and in some cases the electronic version of scientific publications, for example, journal articles (full-text database). A citation database contains not only the bibliographic reference but also the reference list of the article.

- *Scientific books*

A scientific book usually contains a synthesis of the scientific findings previously published in scientific journals. In some cases, there is a printed version, as well as an electronic version of a book (e-book).

- *Journals*

Journals are periodically published (weekly, monthly, quarterly, yearly) and contain short, specific studies about topics within a specific discipline. They are more up-to-date than books. Every volume of a journal has a sequence number. A volume may include one or more issues. It is important to know that the pagination continues in a volume, even when there are two or more issues.

- *Proceedings of conferences*

Proceedings are the collection of academic papers published in the context of an academic conference. They are usually distributed as printed volumes or in electronic form either before the conference opens or after it closes. Proceedings include the contributions made by researchers at the conference. They are the written record of the work that is presented to fellow researchers. In sciences, the quality of publications in conference proceedings is usually not as high as that of international scientific journals.

- *Other information sources*

Other information sources are theses, PhD dissertations, newspaper archives, and statistical sources.

3.3. Scientific information sources for students

Students should:

- Use online reference works when searching for basic information about their subject.
- Use online sources when searching texts, images, compositions, objects, and inscriptions.
- Initially use the central search interface of their academic institution when searching for scientific publications on their subject.
- Use relevant catalogues to obtain books, journals, and proceedings of conferences.
- Use databases to find articles and reviews and use search engines to find websites.

3.4. First information search

To start an information search, there are two ways that are usually applied:

3.4.1. Exploratory information search

On the basis of relevant keywords occurring in a student's research question(s), he/she needs to formulate appropriate search terms that can be subsequently used in future information searches. Such search terms are:

- synonyms
- morphological variants
- variants in spelling
- related terms
- narrower terms
- broader terms.

It is important to locate as many relevant publications and other sources as possible with as few search terms. Therefore, general terms are not appropriate/effective keywords. Turning keywords into full search terms can be best achieved by first searching basic information in reference works.

An exploratory information search is characterized by indirect searching. When students find a relevant information source, they need to search for other relevant publications on the basis of this first information source by consulting its reference list and footnotes. When using scientific databases and scientific search engines, students can consult the links to related publications given by these sources.

3.4.2. Direct information search

In a direct information search, students can start from one or more references mentioned in the assignment to search for specific sources. Searching for a reference included in a reference list of a relevant publication is an example of a direct information search (see section 3.4.1).

Please note that information search is not a linear but a circular process. Gradually, students will have to modify their search strategy, to change or to refine their search terms, and even to choose a new search direction.

3.5. Combination of search terms

To find specific information about a subject, students have to combine different search terms in a meaningful manner. For this purpose, several techniques are available.

3.5.1. Boolean operators

- AND: for information containing both search terms;
- OR: for information containing at least one of both search terms;
- NOT: for information containing the first but not the second search term.

3.5.2. Truncation characters

- * (asterisk): a substitution of one or more characters; students can use this truncation character only at the back of a root;
- ? (question mark): a substitution of one character; students can use this truncation character at the back of a word and even in the middle of a word, at least in some databases.

3.5.3. Exact word combination

If students only want those search results that contain the specified search terms in the identical sequence, they have to place their search terms between double quotation marks (“).

3.5.4. To specify search fields

By using the “advanced search”, it is often possible to search in different search fields at the same time. This means that students can, for example, request a specific title of a particular author.

3.5.5. Proximity operators

- NEAR: is used when the word order is not important;

- ADJ: is used when the search terms appear in the search result in a specific sequence;
- SAME: is used when the words appear in the same sentence or paragraph, or in the same bibliographic field.

The practical use of the techniques mentioned above, may differ depending on the setting in which students look for information. Therefore, students should always remember to check in which way the combination options are supported, consulting the "help function" before they start working with a search engine or a scientific database.

3.6. Finding items in the information sources

3.6.1. Items in WorldCat

"WorldCat" (https://www.worldcat.org) is the largest bibliographic database in the world that makes the information sources accessible in different languages. More than 50, 000 libraries of more than 90 countries work together to develop one common online catalogue.

Users can search for all possible library materials and find their exact location:

- physical items (books, CDs and DVDs),
- digital materials (images, documents, audiobooks),
- electronic files (citations of articles with a link to the full-text).

The availability of open access opened materials depends on the conditions stipulated by the respective libraries.

3.6.2. Items in bibliographic and full-text databases

Databases offer students the references of scientific publications. To obtain the scientific publication itself, students can choose one of the four following scenarios:

- Scenario 1: along the found bibliographic reference, identify a link to an electronic version, either in the database itself (as a 'PDF' document), or in another database (via "LibriLinks");
- Scenario 2: if there is no electronic version, students can find a printed version of the article via "LibriLinks";
- Scenario 3: if there is no "LibriLinks -function", students have to locate an electronic or a printed version of the article via the central search interface of their academic institution;
- Scenario 4: if there is no electronic or printed version available in their academic institution, students have to collaborate with their library services in order to request the article to be sent to their institution.

3.6.3. Items in citation databases

In a citation database (citation index), students can check which articles (or authors) are cited in more recent publications concerning a specific subject.

3.6.4. Items in scientific search engines

There are some search engines which specialize in the indexing of scientific publications. “Google Scholar” and “Google Books” are certainly worthwhile as a starting point or as a supplement of the bibliographic catalogues and databases described above.

3.7. Management of newly-collected information

Students can save their references online by using specialized software. All they need is an internet connection. By doing so, students can have all items of a bibliographic reference. As a consequence, they will not have to visit the library on the very last day to search for any missing items, such as page numbers and place of publication. Some examples of bibliographic software are

- Endnote
- Mendeley
- Zotero

More and more databases offer a personalized environment that allows students not only to save and export their found references but also to define a set of alerts for brand new publications. There are three types of alerts:

- TOC-alert: for new volumes of the journal;
- search-alert: for new records complying with any search action previously entered;
- citation-alert: for new citations of a publication, that is to say new publications which cite a publication a student has already marked.

3.8. Evaluation of the usefulness and reliability information?

The usefulness of the collected information depends on the extent in which it gives a relevant answer to a student's research question(s) and/or the key to solving the problem. The reliability of a publication depends on a range of internal and external criteria. The more criteria are fulfilled, the more reliable a publication tends to be.

3.8.1. Internal criteria

- Structure of the publication: a reliable publication includes a bibliography, a footnote system, an introduction, an abstract, and a conclusion;
- Content of the publication: a reliable publication contains relevant arguments, verifiable data, and an objective language use;
- Age of the publication: recent publications are often up-to-date and therefore reliable. The reliability of an older publication depends on the intensity with which the subject was studied and possibly on the timing-related character of the subject;
- Profile of the author: an author builds his/her reliability from a qualified education, an executive function and/or his/her affiliation with a scientific academic or research institution.

3.8.2. External criteria

- Reviews before publication: editorial committees or colleagues/researchers familiar with the subject ('peer reviewers') evaluate the submitted publication before it is published in a scientific journal;
- Reviews after publication: reviews in scientific journals and citations in other scientific publications can help students evaluate the reliability of a publication.

Students can evaluate the reliability of a web page, using some of the following criteria:

- identify the author
- examine how up-to-date the information is
- evaluate the content
- control the maintenance of the website.

3.9. Citations and references to published work

If students prepare a master's thesis, they participate in and contribute to the scientific network. Therefore, students have to indicate their position compared to others who have published about the same subject. Students can do this by referring to their information searches.

Plagiarism is taking over other scholarly work, either as an identical copy or in slightly altered shape and without making the required references. Students do not need to mention the information source if it is a generally accepted statement or if they introduce novel ideas, statements and interpretations.

Students need to cite their information sources by bibliographic references, i.e., brief enumerations of basic data needed to:

- identify the consulted source accurately;
- allow their readership to search and consult the original source itself.

There are many ways to draw up the bibliographic references. The most important rules to be followed here, are the following:

- use one uniform style per assignment and apply this style consistently in every reference;
- make sure that enough bibliographic data are provided, so that readers can obtain complete and clear references, regardless of the style which students use in their thesis.

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Chapter 4: Composing a Literature Review Section

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4.1. Literature review

A carefully synthesized literature review does not simply introduce the major research findings in the field but rather offers a critical and thought-provoking examination on the topic under investigation, its theoretical and methodological underpinnings, and research outcomes. Through their literature review, students should demonstrate an in-depth knowledge and understanding of the work already undertaken in the field and offer a critical appraisal of the findings. The literature review section should also identify drawbacks, limitations, and gaps in the field. However, students should strive to provide an objective, meaningful, and balanced examination of each study, method or treatment applied, and its research outcomes. As indicated in Fig. 4.1 below, by providing a thorough and critical examination of the most relevant, scientifically-sound and high impact research undertaken in the field of applied physics, Kaminstein (2017) invites students to offer:

(i) A focused, well-informed, and insightful perspective on the most significant scientific advancements in the area in order to enhance the readers' understanding on the particular topic of applied physics examined in the thesis;
(ii) A systematic and critical discussion on the previous studies, quantitative characterizations, experimental methods, and key research outcomes to support the arguments made;
(iii) A cogent and meaningful discussion on possible research overlaps, contradictory outcomes, and gaps in the field.

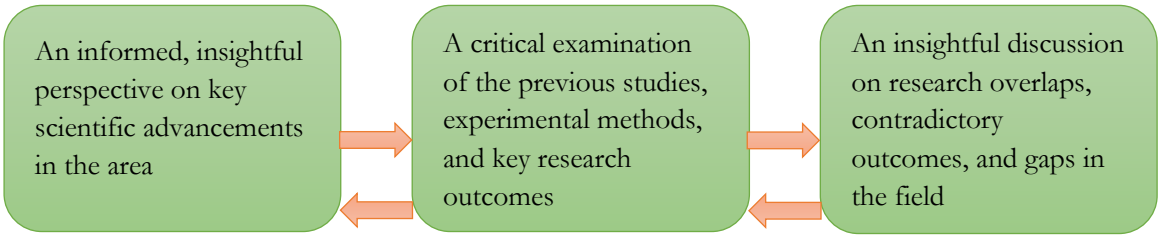

Figure 4.1. Kaminstein's proffered steps for an effective literature review

To follow the three steps identified by Kaminstein (2017), students should first begin by conducting a preliminary investigation of the existing literature in the field.

A preliminary examination of the literature

The rich and diverse repertoire of research studies and scientific publications in the field often cause students to struggle in finding, selecting, and evaluating the most relevant resources that can guide them in the synthesis of their literature review. Once a student has formulated an idea for a thesis topic in close collaboration with an academic advisor, it is critical to embark on a quest to identify relevant, compelling, and state-of-the-art papers that have significantly contributed to the field. In the initial research, students could begin by searching keywords,

identifying relevant publications in high impact journals, research papers, letters, or conference proceedings in the field. Students should then read carefully the abstract of these published works to get an overview of the research undertaken in the field, large scale projects, current trends and advancements, future research directions, and challenges in the field. After looking at the abstract of a range of papers, students should select some of the most relevant articles and read them very closely to get a better understanding in the particular area they are examining. Key authors with high level of expertise and research experience in the field should be identified and their published work should also be examined more closely. In their initial research, students could be guided by some of the following questions:

- What type of research work has already been undertaken in the field?
- What are some of the research outcomes of the research work undertaken in the field?
- What is the importance of these research outcomes in the field?
- What are some of the current research trends in the field?
- What are some of the recent advancements in the field?
- What are some of the limitations, drawbacks, and gaps of these research studies?
- What are some of the emerging and proposed future directions for research?
- Which elements of this line of research can help students narrow down the focus of their research and turn it into a more manageable topic?

Becoming acquainted with key research articles and high impact publications in the field can help students start thinking more critically about their topic, identify possible ways to narrow down the focus of their work, and turn it into a more feasible and manageable project that can be completed within the indicated time-frame. While it is important to deliver a focused literature review, students should also frame the literature review in such a way in order to expand its impact in the field. For example, students can address some of the underlying implications for other fields and appeal to a multidisciplinary audience. Most importantly, students should structure their literature review section to support the need for further research in this field and should strive to use this gap in the literature as a guide in setting the research questions in their thesis.

(i) An informed, insightful perspective on key scientific advancements in the area

After selecting and examining very carefully the existing research and scientific developments in the field, students should present the material in a new and interesting way to shed new light on the previous research outcomes. The aim is not to simply present the scientific advancements in the field, but rather to provide a new well-informed, in-depth, and insightful examination of the findings and advances in the field that will shed new light to the previously generated hypotheses, experimental methods used, research outcomes generated, and wider implications discussed in previous studies. Through their literature review, students should strive to enhance the understanding of a multidisciplinary audience in that particular area.

A well-informed, thought-provoking literature review also serves the broader scope of the research discussed in students' theses: To support the research questions raised, experimental methods used and outcomes of the research undertaken. The key is to devise a set of research

questions that build on previously undertaken research and outcomes and explicitly address the goals and scope of this new research. Previous study designs, experimental methods and outcomes can guide students in developing their research questions. The research questions should be feasible, meaningful, clear, focused, and manageable. Clear, focused, and thought-provoking research questions that expand on the theoretical and experimental trajectories discussed in the literature can guide students in making critical decisions about the experimental methods and subsequently the data collected and research outcomes. Students should seek the guidance and support of their academic advisor in order to devise solid research questions and avoid undertaking a broad or ambitious research study that is neither feasible nor can be completed in a timely manner.

(ii) A critical investigation of the previous studies, experimental methods, and key research outcomes

A critical discussion on the previous studies undertaken in the field should include common trends and themes generated by these studies, experimental methods applied, key research outcomes, some of the implications of the outcomes of these studies, and a thought-provoking discussion on how these themes and trends relate to the new research undertaken in this thesis. What should drive students' critical examination of previous research carried out and published in the field are the following questions:

- What are some of the common trends or themes identified in previous studies?
- How are these trends and themes related to the topic under investigation in this study?
- What are some of the key outcomes of previous studies in the field?
- What are some of the experimental methods or treatments applied in these previous studies?
- What are some of the strengths and limitations of the experimental methods or treatments applied in these previous studies?
- Which assumptions, methods, treatments, or outcomes can be challenged and examined from a different angle?
- What are some of the areas that deserve further investigation?

Multiple other questions could also be raised during a critical review of the studies already conducted in the field in order to guide students in planning and composing their literature review section. Students should examine these studies critically and devise cogent, clear and logical arguments to support their claims. Students should provide evidence from these studies or other relevant studies and supporting arguments and propose new paths to research and innovation.

(iii) An insightful discussion on research overlaps, contradictory outcomes, and gaps in the field

Students should rigorously, systematically, and objectively review studies undertaken in the field in order to identify any overlaps and inconsistencies in the methods used or experimental treatments applied, theoretical bases driving the studies, contradictory outcomes generated, and

emerging gaps in the field. This step is demanding but critical in guiding each student's study. It calls for a thorough, systematic, and well-thought examination and understanding of the theoretical frameworks and scientific methods used, treatments and mathematical models applied, analysis and presentation of research findings. Students should devise cogent, logically structured arguments to support their claims and justify the need, potential benefits, and contributions of their study to this widely expanding interdisciplinary field. Students should stir away from personal opinions. Instead, students should shift their attention to the gaps and limitation of previous studies, and attempt to present a new perspective that has not been examined yet. Students could be driven by the following set of questions:

- What are the major trends, methods or treatments applied in the field? In what ways do they differ, overlap, or contradict the ones used in previous studies?
- In what ways are the research outcomes conflicting or contradictory?
- What are some of the limitations and possible gaps in these research studies?
- How can the study proposed in this thesis help address or overcome some of these possible gaps in the field?
- Which other methods or experimental treatments could fit the topic being investigated in the study and generate more insightful findings?
- In what ways does the study undertaken in this thesis offer a new perspective on a topic that has not been previously examined?
- In what ways will this new perspective contribute to the field?

4.2. Organizing the literature review

A logically-structured literature review should be organized around scientific topics, research themes, experimental methods, or treatments applied. It needs to be systematic, coherent, focused, and consistent. The research themes, topics, or methodological approaches addressed in the literature review should be directly related to the kind of research work undertaken in the thesis. Students should begin with an introductory section, followed by the main body, and finally by the conclusive arguments.

Introductory section

The introductory section needs to offer a specific and clear overview of the way the literature review will be organized. There are multiple ways to organize the literature review section. If the literature review will be organized based on research themes, topics, experimental methods used, or treatments applied, it should be clearly indicated in the introductory section.

- An introduction: introduces the topics, themes, experimental methods, or treatments examined in the literature review
- A main body: offers a logically-organized structure of the studies examined in the literature review. The main body could be organized around different research themes, topics, or methodologies.
- Conclusive arguments: draw some conclusive remarks from the literature, discuss their implications, and the direction of future discussion in the area.

The main body

Organizing the main body of the literature review can present a major challenge since it is a complex and time-consuming process. After a systematic and thorough examination of the literature, students should devise a clear organizational framework. Students could map and classify the studies under specific research themes, topics, or experimental methods. The use of headings, subheadings, diagrams, or other visual materials could assist in conveying more clearly the organizational structure of the thesis.

(i) Research themes or topics

If the thesis is organized around specific research themes or topics, then students could devise their literature review based on the development, progression, or advancements in the area. For instance, if the focus of the literature review is on the enhancement of vehicle-to-vehicle communication systems using new technologies such as novel optical wireless communication systems (OWC), then the studies undertaken on the use of the relevant technologies to enhance vehicle-to-vehicle communication systems should be reviewed. Particular emphasis could be placed on the developments and advancements made in the specific areas of optical wireless communication (OWC), such as light emitting diode LED-based systems, which will be examined in the thesis.

(ii) Experimental methods used or treatments applied

In case the focus of the literature review is placed on the experimental methods or treatments applied by other researchers in their work, students should set a clear goal for following this organizational structure. For example, students might attempt to identify any overlaps or contradictions in the methods used or to discuss if the experimental methods applied could guide the type of research undertaken and the results generated. Students should be well immersed in the experimental methods used or treatments applied. Scholarly debates on these methods over the years could help inform students' arguments on the research overlaps, contradictions, or outcomes generated. Students should also try to be objective when discussing the experimental methods used or treatments applied.

4.3. Beginning the writing process

Composing a literature review can be a complex multifaceted process since students need to synthesize all the relevant articles in a coherent, cohesive, and systematic way. A well written literature review is clearly organized, includes relevant articles, reviews certain major critically achievements and outcomes in the field, identifies possible gaps, and introduces new perspectives and critical discussions that expand the conversation and offer new possibilities and directions for new inquiries and research in the field. A critical discussion should also include relevant evidence to support all claims made. For example, students could deliver effectively an argument by referring to the original sources and could use quotes to support or challenge that argument. Short memorable quotes or quotes summarizing major findings from a study could help highlight a particular point. In most cases, quotes should be followed by a constructive in-depth discussion that contributes further to the conversation and establishes a direct link with students' thesis work. Students should avoid extensive use of quotes. Instead, they should offer an in-depth discussion on some of the major achievements or research directions in the field. When paraphrasing other scholarly work or findings, students should strive to deliver each author's claims or findings succinctly and accurately. Whether using direct quotes from a source or paraphrasing a source, students should abide by the rules and guidelines of the formatting style adopted by their department in order to format, cite, and make references to the sources used in their work.

Even though the use of direct quotes and paraphrasing are important strategies in delivering cogent arguments, particular emphasis should be given to students' contribution to the field. Through the use of their own voice, students should share their views and critical perspectives on the topic examined in their literature review section. To achieve this goal, students need to be well informed about a particular topic and relevant research undertaken in the field.

While synthesizing their literature review, students should also formulate effective organizational strategies that will guide them in the topic development. The information should be logically and clearly arranged to deliver coherently and succinctly the intended message. The abstract should briefly discuss the purpose and importance of the literature review. Background information that can guide readers in understanding the order, context, and other critical constructs provided in the abstract. The literature review should also be organized in major sections and subsections. Use of titles, subtitles, sections, subsections, tables, diagrams, and other visual aids could help in logically organizing the literature review sections and delivering effectively the major points to the readers. Subsections could also contribute to identifying and discussing methodologies and experimental treatments used and to helping learners understand these critical components of the literature review. Subsections could also assist in the logical flow of the literature review by linking together and contrasting the different methodologies, experimental treatments, and outcomes. Subsections should be organized in different paragraphs, succinctly delivering at the beginning of each sentence the major points to the reader, identifying drawbacks in the studies, and discussing possible emerging implications in the field.

Conclusive remarks should summarize the main research outcomes, briefly discuss commonalities or contradictions between studies undertaken, methodologies, and experimental treatments in the field. This final section could also be used to justify the need for the study undertaken in the thesis.

Before submitting their literature review section to their academic advisor, students should read it very thoroughly, rewrite or rework the different parts, eliminate any complex technical jargon, clarify ideas, methodological issues, and devise more cogent arguments. Feedback from more experienced peers could also guide students in enhancing the quality of their work. Finally, after receiving their academic advisor's feedback, students need to revise further their literature review section in order to enhance its quality.

4.4. References

All sources used should be directly cited, paraphrased, referred to in the literature review section and the reference section using the proper formatting style. Students should consult with their academic advisor and department about the required formatting style.

References

Kaminstein, D. (2017). Writing a literature review for an applied master's degree. *Organizational Dynamics Working Papers, 23*, 1-13.

http://repository.upenn.edu/od_working_papers/23

Chapter 5: Type of Research Undertaken and Research Methodology

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5.1. The importance of discussing the type of research undertaken

The discourse used in the research methodology section will also be determined by the nature and the type of study undertaken. For example, research can be classified into different categories, including basic and applied research. Although the distinction between basic and applied research is increasingly becoming more complicated and unclear, it can essentially affect the discussion in the research methodology section.

5.1.1 Basic Research

Basic research is also known as fundamental or theoretical research. Basic research is undertaken to examine certain fundamental principles and natural phenomena that can lead to new scientific knowledge and valuable insights to scientific phenomena. Basic research can enrich the current body of knowledge by shedding new light on complex scientific problems and phenomena and by generating scientific conclusions that can ignite the spark for designing new interventions. Basic research does not generate new scientific practical breakthroughs or novel practical interventions and outcomes but rather provides a path to developing a new outlook on scientific phenomena. However, basic research should not be undermined in any way since the outcomes of basic research studies can galvanize applied scientists' interest in devising and/or implementing later on novel methodological approaches or interventions to solve a practical problem and generate new innovative outcomes. For example, Nobel Prize Winner Howard Robert Horvitz, an MIT professor of biology, candidly admitted that his curiosity drove him to engage in basic research and then to pursue more rigorously research studies where he examined the genetic regulation of cell death.

Fundamental research can also be driven by a quest to enhance an existing theoretical framework or an experimental approach. In other cases, a new theory or a novel matter maybe also be introduced. For instance, a novel method could be proposed for delivering biopolymeric agents to target sites in the human body and create a highly personalized treatment for cancer.

5.1.2 Applied Research

Applied research, on the other hand, can build on the newly acquired knowledge generated through basic research to develop and apply in praxis new practical applications. Applied research often aims to address and provide specific solutions to questions raised by fundamental research and deliver high impact results that serve the broader needs of both society and industry. In many cases, researchers in the field are simply compelled by scientific curiosity or driven by a passion and commitment to solve a societal, technological, or industrial problem. Applied research can lead to the development of novel technological solutions and products, help overcome practical constraints, and improve the quality and efficiency of products. In some cases, a specific theory might be examined by applying methods or techniques to collect and analyse data in an attempt to solve practical societal, technological, or industrial problems. Applied research is usually undertaken by academic institutions, the industry, or even governments striving to study phenomena, practical problems, and propose viable novel

solutions or introduce new products that will drive societal, technological, and industrial development and innovation.

There is an enduring and deeply-rooted debate on the importance and advantages of basic and applied research, with some scholars, researchers, and policy makers promoting strong and sustainable research programs that focus on applied research as a path to generating novel solutions. Many scholars, however, tend to agree that both basic and fundamental research studies are imperative since they both contribute to the scientific study, fundamental understandings and advancements in the field.

5.1.3 Qualitative and Quantitative Research

A research study can be qualitative, quantitative, or even a mixed method where a combination of qualitative and quantitative measures of analysis can be applied to collect and analyze the data. The measures of analysis used in each study will be determined by the goals and objectives of the study. Quantitative studies usually involve: (a) the identification of a particular problem, (b) the development of a hypothesis, and (c) testing of a hypothesis using experiments to collect and examine a set of data. Quantitative measures of data collection and analytical tools are often based on what scholars believe to be more "objective" procedures that can generate findings through statistical analyses. Statistics focus on examining the structure of the collected data. Statistics can include the design and use of instruments for data collection, such as surveys and experiments. It can involve simple percentages and frequencies calculations, or more complex multivariate analyses and experimental manipulations. That is, it can include both descriptive or inferential statistical methods of analysis. Quantitative research has the following qualities:

- It involves numerical, non-descriptive data, and relies on statistical measures of analysis or numbers
- It often examines variables that identify common features which can be quantified, assigned frequency values, or categorized under a set of categories
- It often involves categorization schemes or values which are usually determined prior to data collection
- It presents the outcomes in tables, graphs, and figures
- It presents conclusive outcomes
- It often relies on standardized procedures that are intended to capture the objective reality and can be used across research studies
- It strives to generate facts and outcomes that can be generalized beyond that study and context

Qualitative research, on the other hand, centers on examining qualitative phenomena and developing an in-depth understanding beyond the inferential or descriptive statistical measures of analyses and their outcomes. Qualitative research is not so rigidly predetermined or based on specific preconceived hypotheses as quantitative research. It rather emerges based on the observed phenomena. For example, the identification of a new infectious agent or an interview can be a part of a qualitative study. The focus is not on a variety of data or on large numbers of closely studied phenomena. Qualitative research has the following qualities:

- It does not involve numerical data but rather a small sample size
- It is rather emergent, descriptive, and does not rely on preconceived hypotheses or standardized procedures
- It provides interpretive analyses since it is driven by subjective opinions, decisions, and interpretations of a particular set of data
- In some cases, the outcomes are presented through tables and figures but graphs are rarely used
- The results can contribute to the field but cannot be generalized beyond that particular study or context

There are other types of research, such as exploratory research, comparative research, and action research. If there is limited knowledge on a particular phenomenon, exploratory research can provide a thorough investigation of that phenomenon through a limited number of cases that could potentially generate some crucial answers or findings. Comparative research is built on the notion that careful comparisons between different phenomena, methods, or techniques can guide researchers in identifying potential similarities and differences between these phenomena, methods, or techniques being compared. Action research, on the other hand, is often conducted to enhance knowledge or to improve a situation, overcome a problem, and introduce further actions in society.

5.2. The importance of discussing the research methodology and research methods

The research methodology and research methods applied in a research study need to be discussed. Research methodology is a critical component in each research study since it determines experiment design, data collection and analysis procedures, and research outcomes. Whether focusing on plasma physics and fusion energy or solid-state physics, students should develop and/or apply the most suitable methodology in their study that can effectively address a scientific problem and generate quality scientific outcomes. In many cases, the same scientific problem may be addressed using different research methodological approaches. Before composing their research methodology part, students need to familiarize themselves with a critical distinction between a research methodology and research methods. A research methodology refers to the systematic analysis of the procedures used to study a particular scientific problem. It provides a rigorous path to examine how a particular study is conducted methodologically. To be more precise, it describes and explains thoroughly the different techniques, instruments, and methods utilized to describe and explain the data and generate the required outcome. Research methods, on the other hand, refer to the methods, procedures, and instruments used to carry out a research study. Research methods may include qualitative and quantitative measures, such as statistical approaches, numerical schemes, and algorithms. Research methods guide researchers in conducting scientific experiments, collecting data, and providing solutions to scientific problems.

The research methodology section of the thesis should be concise, accurate, and specific. It should provide a rigorous and precise discussion that can guide an interdisciplinary audience in understanding the research problem at hand, the underlying reasons for applying this research methodology to address the specific research problem, the research methods used to collect the data, and their role in the outcomes of the study. The validity, reliability, and accuracy of the study will be determined by the research methodology applied in the study.

5.3. The importance of discussing the underlying reasons for selecting a research methodology

Students should discuss the underlying reasons that have led to select a particular research method and how the design of a systematic research methodology or a novel approach in the implementation of existing research methods can guide them in addressing the research problem they are examining in their work. After collaborating closely with their academic advisor in order to design or modify a research methodology, students need to discuss the specific ways in which this research methodology will be suitable for addressing this research problem. Students should discuss efficiently and accurately the measuring techniques, numerical simulations, algorithms, or any other technique, method, or approach applied in their research study. For example, in investigating light-emitting diodes (LEDs) and organic light-emitting diodes (OLEDs) multiple optical simulation methods are often used to enhance their performance and examine their design, such as photonic crystal (PC) gratings and patterned substrates. However, if a mixed-simulation methodology were used in a novel approach to overcome some of the limitations of electromagnetic (EM) wave-based tools and ray-based tools, then the mixed-simulation methodology would need to be introduced and described in detail. This novel research methodology, the simulation tools, such as FullWAVE™ and the required numerical techniques used to enhance and optimize the performance of LEDs and OLEDs need to be discussed in detail in the thesis. Any advantages emerging from implementing the various mixed simulation methods would also need to be highlighted in the study. The research methodology of the thesis should be designed to address the following questions:

- What is the purpose of the research study?
- What is the intended goal of the research study?
- What is the research problem examined in the study?
- What kind of methods were used to collect the data?
- What kind of instruments, methods, statistical approaches, or experimental techniques were used to analyse the data?
- Why were these particular instruments, methods, statistical approaches, or experimental techniques used to analyse the data?
- How did these instruments, methods, statistical approaches, or measuring techniques contribute to meet the purpose of the study?

- How did these instruments, methods, or experimental techniques contribute to the outcomes of the study?

Such fundamental questions should galvanize both the design and/or modification of existing research methods and the composing process on the thesis since they can provide the underlying basis for devising the research methodology of the thesis. Similarly, in determining research methods, statistical approaches, numerical simulations, or measuring techniques that will be applied in the thesis, students need to contemplate and address the following set of questions in their thesis in order to describe the rationale for selecting or designing the specific research method in their work:

- Why is the selected method, measuring technique, or numerical analysis simulation applied the most appropriate one to address the research problem?
- What is the degree of accuracy, reliability, and validity of the research method?

Students need to be informed about newly updated experimental methods, algorithms, or other measuring techniques that have been recently introduced in the field. They need to avoid conducting a research study and presenting research outcomes that are based on outdated methods, techniques, or instruments. The specific features of the method applied in the research study need to be discussed in detail. Any complex computer algorithms applied to create models need to be carefully explained and discussed in the study. Above all, computer algorithms need to be carefully tested, verified, and validated in order to avoid or identify any potential mistakes. Similarly, the statistical data analysis tools and techniques need to be discussed in detail and any quantitative analysis software used to examine and interpret the data needs to be introduced. In addition, the underlying reasons that have led to the selection of that particular statistical data analysis software need to be thoroughly explained. Any advanced complex statistical techniques formulated or applied to address the research questions need to be introduced and discussed thoroughly. The number and type of data collected and included in the study, the correlation coefficients for variables that formed part of the research study, and other relevant information need to be discussed in detail and graphically demonstrated. All graphs and tables need to be introduced and discussed thoroughly in the actual text, while detailed explanations should also be provided on the outcomes of the statistical measures used.

In a similar vein, if students attempt to introduce a newly developed method of analysis or even a new theoretical framework, the scientific rationale needs to be provided. The advantages and disadvantages of this newly introduced method or new theoretical basis of the study need to be addressed. In some cases, the new method or theoretical framework need to be compared and contrasted with other related methods or theoretical frameworks applied in other studies. Other processes or new interpretations should also be explicitly addressed and explained very thoroughly. Students should always remember to indicate in their thesis how the research study is supported and informed by the theoretical bases, the research methodology and research methods, all hypotheses made, analyses, and outcomes of the study.

5.4. Conclusive remarks

The type of research conducted, the research methodology, and research methods used are instrumental components in each study and play a decisive role in generating the outcomes of the research study. A careful consideration of all these critical elements of a research study is imperative in selecting and analysing the data, and generating the findings of the study. Students need to familiarize themselves with previous studies, their methodological underpinnings, and their outcomes, and solicit the assistance of their advisor before applying a particular methodology in their research work. The scope, aim, goal, and nature of the study should determine the type of methodology and research methods that could be applied in the study. With the guidance and support of their academic advisor, they could use, develop, or introduce a new methodological approach to analyse their findings. However, students should also familiarize themselves with the limitations and drawbacks of the proffered research methods and their role in generating a particular set of outcomes.

Chapter 6: Presentation and Discussion of Findings

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6.1. Introduction

In presenting and analyzing the research findings of an innovative and often multidisciplinary research project that students have undertaken under the close supervision of an academic advisor or as part of a larger collaborative research team, students first need to develop an outline that can guide them in briefly recapping and organizing their research findings. Then, during the discussion of their findings, students need to provide a detailed and thorough description of their research findings, their original contributions to the scientific research community, and concrete benefits to society, industry, and technology. The intended goal is to present in detail the research findings in order to offer an in-depth examination of the subject under investigation and generate new insights that can significantly contribute to the developing and multidisciplinary field of applied physics. The objective of the presentation of the research findings is to effectively, concisely, and precisely articulate the research outcomes in order to actively contribute to and advance further the current body of knowledge and engage in a scholastic inquiry that will generate novel outcomes and perspectives. In presenting their research findings, students need to contemplate certain important elements which are discussed in more detail in the following sections of this chapter.

6.2. Create an outline of the most important outcomes of the study

Before engaging in the complex process of presenting the research outcomes of the study, students need to examine more closely all the data collected and identify the most central and instrumental advances of the study. A well-developed outline could be presented as a figure where the main outcomes of the study could be summarized, organized, and conveyed in a coherent and cohesive way. This approach could guide students in developing a framework of analysis where the results, complex outcomes, implications, course of action, and limitations of the research study could be presented with clarity in the logical sequence that they emerged. A synoptic synthesis of the results through a figure could also assist students in articulating their findings more effectively and devising more cogent arguments while analysing and discussing their research findings.

6.3. Highlight personal contributions to the research study

If students form a part of a large collaborative research team, they should place particular emphasis on presenting their personal contributions to the research study and the novelty of their research findings. Discussions on research findings, newly devised concepts, applications, and newly designed, built, or integrated technologies by other research team members could be briefly addressed to clarify students' research contributions and highlight the significance of

their work. Students should discuss their contributions in a coherent and compelling manner that will render their engagement in cross-cutting edge research and offer new insights to the field. Similarly, students, who draw on experimental, theoretical, or computational approaches in their thesis work, should strive to minimize the discussion to the relevant components that they are investigating in their thesis work and discuss how their research findings are supported by, expanding further, or challenging such approaches.

6.4. Convey the novelty, originality, and importance of the research findings

The thesis work should convey novel research findings and describe clearly their importance in the development of a deeper understanding and the advancement of the field. Students need to provide substantial, useful, and meaningful information on the research study, its context, and its findings and offer a detailed discussion on how the results will inform the development or improvement of technologies, applications, and other cross-cutting edge issues in the field. The research findings should not be incrementally presented without an explicit discussion on their importance, state-of-the-art developments, and their contribution to the field. The aim should be to inform the audience about the novelty of the research study and the unique scientific value of the research findings. The research results could also be compared to other research studies as a path to present the findings, their contributions, their novelty, and their importance to the field.

6.5. Draw an explicit and direct link to the research questions

In presenting and analysing the research findings, students should draw an explicit and direct link between the research questions and research findings. The research study should have been initially motivated by a compelling set of research questions which aim to enhance understanding, promote the development and functionality of technologies, methods, and devices, and/or undertake an investigation of other experimental, theoretical, or computational approaches in applied physics. Consequently, the research outcomes should directly address the initial set of questions and produce results that could generate a more profound understanding of the subject under investigation. The research findings should also highlight the importance of addressing this set of questions, their importance in relation to the research findings, and any emerging social or technological implications.

6.6. Provide a comprehensive and precise description of the research findings

Reporting the research findings calls for a clear, comprehensive, and cogent description of the novel results in a timely manner. A constructive, thought-provoking, and accurate presentation of the research findings forms an integral part of the students' capacity to engage in research activity, generate novel outcomes or propose substantial advancements on existing knowledge or research, and propose new venues for research and innovation. Using a clear and concise writing style, students need to communicate effectively the importance of their study's outcomes to all the interested stakeholders. Students engaged in a high impact research study in applied physics should interpret and analyse the data by providing particular emphasis on the newly generated data. They should also address the subject under investigation, their unique contribution to the emerging field of applied physics, and their role in providing a greater understanding on critical phenomena in the field and society.

Students should not simply report the data but rather provide a compelling discussion on their findings by offering productive insights that convey the importance of the findings and their contribution to the field, and open a new venue for engaging in academic inquiry. The discussion should begin by providing an intuitive, succinct, and precise introduction, placing the outcomes of the study in a particular context and introducing them effectively. In addition, the discussion should highlight the development and integration of new tools, applications, and materials, or the use of conventional or advanced methods and novel techniques and applications in the study. That means providing a significant interpretation and analysis that highlights the novel contributions of the study in comparison to previous findings, physical interpretations, methods, concepts, functions, procedures, or applications. For example, students embarking on a quest to enhance computer-mediated design tools to support the existing optical tools should discuss the limitations emerging from traditionally shifting the attention to the simulations of the materials and integrated circuits, and explicitly indicate the specific ways their thesis could contribute to overcoming this limitation. Consequently, solid knowledge of past research undertaken in this area and related research findings is critical. This knowledge can also guide students in creating a sharp comparison and contrast with previous findings in order to address the new dimensions and new scientific outcomes of their study, and address the implications of the findings.

An equally critical element in describing the research findings is the need to limit the discussion and analysis to the most important findings generated in the study. Students should provide a rigorous but precise analysis of the results that have been generated in their work. The most accurate and constructive discussions are carefully designed to offer precise and thought-provoking descriptions on high quality and novel research findings generated in the study and avoid lengthy, verbose discussions that tackle other-related issues, emerging challenges, or innovative approaches that are not directly linked to the study or its aims and objectives. Access to myriad sources of information, approaches, and innovative research projects and initiatives can be overwhelming. In close collaboration with their advisor, students should devote their

attention to the most crucial research findings and discuss their importance and contribution to the field.

Moreover, students need to provide substantial evidence that is informed by the data, the design of the study, and is supported by the experimental or theoretical outcomes of the study. Clear and systematic conclusive arguments need to be drawn from well-supported empirical findings or from a clearly defined body of evidence. Well-structured theses are evidence-based and focus primarily on key conclusive arguments without making any casual inferences or unsubstantiated claims.

Further, it is vitally important to use language succinctly and provide an accurate and precise synthesis or description of the research results that have been generated by the study. Students should avoid using complex jargon or terminology that may implicitly generate casual conclusions and deductive reasoning that may cause confusion or raise additional questions about the validity of the study. Students should refrain from using colloquial language, imprecise expressions, or vague terminology that may cause confusion, uncertainty, or even generate a new set of questions about the outcomes of the study. Missing terms may also generate incoherence and confusion. Whether describing results emerging from new material synthesis, offering a novel technological solution, or proposing new process monitoring-techniques, concrete solutions, or innovative products, students should strive to use terminology entrenched in the scientific discourse of the field. Students should also aim to provide a balance between the positive outcomes, the implications, and the limitations of the study.

6.7. Address the limitations of the research study

Using the appropriate tone and discourse strategies, students should also address the limitations of their study. Every study is subject to several limitations that are often beyond the student's or researcher's control. Students should first carefully contemplate and identify possible limitations that may have had an impact on the design, methodological considerations, and outcomes of the study. Limitations may emerge due to the framing and purpose of the research questions, literature review, methodological considerations, simulations, or interpretations of the results. Students should refrain from addressing the limitations of their study at the beginning of presenting the data analysis and from discussing further the outcomes of the study. Further, students should neither simply list nor exaggerate the limitations of the study. Instead they need to candidly and openly address these structural limitations, so they can then discuss their significance and demonstrate their in-depth knowledge on the subject-matter under investigation, the studies previously undertaken in the field, the methodological design of the study, and the newly generated outcomes.

At the same time, by drawing on these limitations, students can devise cogent arguments to support their choices, methodological considerations, and outcomes of the study. Finally, students should also identify possible innovative ways to overcome these limitations by proposing future studies.

6.8. Use effective tables and figures

Tables and figures can form an effective strategy in providing a synoptic schematic representational depiction of the research findings and in drawing attention to the most important outcomes of the study. Using the indicated software, such as Word or LaTeX, students can present visually complex research outcomes, identify critical relationships, and offer concise and precise statistical analyses. Students may use tables to offer statistical analyses of the dataset and provide an effective visual description of the outcomes of the study. Using effective and appropriate statistical techniques and procedures, students should interpret the results and discuss the standards of error analysis. Explicit reference should be made to each table in the text and a thorough discussion of the research findings displayed in each table should be provided. However, students should not simply summarize or repeat the findings presented in the table in their text. Rather, they should highlight the significance of these findings and provide the rationale for their significance in the text.

Similarly, figures can deliver visually, concisely, and precisely the data, often demonstrating comparisons, identifying changes over a period of time, and reporting the outcomes of the study. Simple schematic representations of the findings can be used to convey central ideas and concepts, and identify important relationships over a period of time. Students should include a clear, feasible, and justifiable number of items in each axis and maintain consistency and clarity throughout their work. Each axis should be labelled and students should include the corresponding units wherever it is necessary. Students should also plot a legend describing the different curves. In case different sets of data with no direct relationship are presented, students need to explicitly state that in their work. All units of measurement presented in each figure need to be verified. The measurement errors and their statistical treatment should also be reported in the figures. Repeated or multiple measures of analysis are subject to error. Students need to number and label their figures, tables, and equations, and offer a more detailed and concrete description to each one of them in their text. However, students should refrain from providing detailed descriptions in the figure; they should rather focus on presenting clearly and precisely the items that have been deemed significant to be presented in figures. Some items could also be highlighted in the figures to draw attention to their importance.

The description should not be a synoptic view of the data but rather a thorough and insightful discussion on the importance of the newly generated outcomes and a description of the underlying importance of the outcomes. Students need to use a white background to present the items and avoid distracting colours or other decorative effects. The presentation of the research findings must be legible, clear, and accurate. All tables, figures, and graphs should be formatted to adhere to the requirements, policies, and procedures promoted by the department and academic institution.

6.9. Provide mathematical equations

Mathematical equations can be complex and may include many variables and parameters. Mathematical equations that include multiple and complex symbols, functions, units, variables, and parameters need to be defined and discussed as soon as they are introduced in the thesis. To ensure that all mathematical equations adhere to departmental policies and formatting requirements, students need to consult with their department and academic advisor. However, mathematical equations usually appear in italics on a separate line in the text. In most cases, mathematical equations are centered or indented. In the case of long and complex equations, students need to split, align, and present them in several lines. Students need to follow the indicated format, including punctuation. All equations on which an explicit reference was made in the text need to be numbered. In case where no explicit reference was made in the text to certain short equations, they could be presented in the running text. Long equations, on the other hand, with no explicit reference, need to be presented in a following line without being numbered.

6.10. Use symbols and units of measurement

Mathematical symbols and units could be used to present the outcomes of a series of experiments, measurements, or simulations. Even though specific guidelines and format requirements may be offered by each academic institution, students could use the Microsoft Equation Editor, the Math-type add-on, or LaTex to present any experiments, measurements, or simulations conducted in the study. Students should also use the International System of Units also known as Le Système International d' Unités (SI) to present the basic units of measurement, the supplementary units, and the multiple derived units which are generated from a combination of two or more fundamental or derived units. For more detailed information, students should consult with their academic advisor or rely on the guidelines on the use of symbols and units of measurements provided by their academic institution.

6.11. Conclusion

Presenting and analyzing the research outcomes of a research study can be a multicomplex and demanding task. However, engaging in this process can form a critical step in understanding the complexities and contradictions emerging from participation in research studies and generating and reporting novel research findings. Students need to familiarize themselves with a set of strategies that can guide them in organizing and conveying their research outcomes in a constructive and effective way. Careful planning and organization, visual depictions, and a wide repertoire of other effective strategies can assist students in synthesizing and

communicating effectively their research outcomes. The aim is to implement effective techniques and approaches in order to share and highlight the important contributions of a research study in the field and its broader impact on the field, the industry, and society. Students should strive to integrate these strategies in order to present succinct and compelling arguments that are grounded on the empirically collected data, effective statistical analyses or other treatments used, and conclusive findings provided.

Chapter 7: Project Management

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7.1. Introduction

The planning of master's thesis is generally described in the internal rules of universities, but in case of industrial nature of the master task, and in case of development of a market oriented product, the general project management paradigm should be adapted and used for each case. The scientific supervisor of the master's thesis with the agreement of student and in cooperation with the industrial partner (if any), develops and supervises the planning of the project, and the quality of deliverables by agreed milestones.

A student is not obliged to use the entire methodology of project management for developing the final thesis, but the main general tools only. The project management should be understood as flexible methodology, which collects the best practices and particular case studies, and it allows to achieve valuable results of the project in minimal tame and defined quality level. The usage of project management approach is absolutely necessary, in cases where the results of the master's thesis will be used in the industry.

The project managers must understand the nature of master research, and flexibly adopt number of tools and approaches to efficiently manage a project. The project management approach, in general, is challenging. Therefore, it is absolutely necessary to understand the basic principles in order to flexibly use it during the research project.

The project management approach is useful, because projects are similar and have common characteristics: Projects have a number of challenges within the scope, defined budget, and schedule. The projects also differ according to the research area. The different approaches and understanding of project can lead to inefficient management of a project. The projects require application of project management tools, because of their complexity, and time constraints within defined budget frames. The industrial systems, and processes reengineer projects that are very different from the small and purely research project. Within this chapter, the authors provide a project management technique and present the different project management approaches used in practice.

7.2. Phases of project management

The way from idea till the product may differs, and in project management it is calling critical path, however there are predefined project stages, which are relevant to almost all projects. The project management is based on the decomposition of large size task in the smaller components - phases. The traditional approach in project management is based on ideal of operational research, and it consist of six phases:

1. Initiation phase
2. Definition phase
3. Design phase
4. Development phase

5. Implementation phase
6. Follow-up phase

7.2.1. Initiation phase

The initiation phase is the first phase and the starting step of the project. In this stage, the idea of the project must be defined in formal project management terms. The initiation phase may differ in structure because the idea could be self-generated or be predefined (bottom up and top down approaches). The main idea of the initiation phase is to present the project concept. The project structure must be established, the parties and resources that will be dedicated should be explicitly stated, as well as whether the project has assigned sufficient recourses for project implementation.

The initiation phase often starts with the preparation of the project description document, which contains main project information, and it is a formalized description of the project according to the project management approach. It includes the project scope, activities, time and financial planning. According to Baars (2006), questions to be answered in the initiation phase include the following:

- Why this project?
- Is it feasible?
- Who are possible partners in this project?
- What should the results be?
- What are the boundaries of this project (what is outside the scope of the project)?

In the initiation stage, the project partners must be assigned, experts with special qualification must be invited if needed, and the laboratory resources must be planned accordingly. The project planning is closely related to the nature and expectations of the project, consisting of three main possibilities:

- A research and development project
- A project that will deliver a prototype or ‘proof of concept’
- A project that will deliver a working product.

The choice for a particular type of project largely determines its results. The project, which is targeted to the prototype development, delivers all of the functionalities of an application, and it could be tested in the laboratory only. The project may not have a target to test it on wider user group in contradiction to the project that delivers a market product that must include the development of all supportive processes, like delivery, customer care, promotion, maintenance etc. (Baars 2006).

The assignment of experts, technicians, laboratory equipment, and industrial support must be done very carefully as the avoidance of planning mistakes almost guarantees a positive project completion.

7.2.2. Definition phase

In the initiation phase, the project plan must be developed and approved; for example, during the meeting with industrial partners (kick off meeting) after the acceptance of the project plan, the project approaches the second stage which is the definition phase. The target of this stage is to ensure that all requirements and specifications are clear for the developers, and are universally understood in the same way. The requirements for the project result should be specified as clearly as possible. Therefore, an early stage definition of processes is an important step in this stage. Wijnen (2004) distinguishes several categories of project requirements that can serve as a memory aid:

- Preconditions
- Functional requirements
- Operational requirements
- Design limitations

Preconditions refer to the project context and the issues, which are important for the project management. The conditions could be related to legal bases, working-conditions, national regulations, and requirements. These preconditions cannot be influenced by the project, but they could seriously impact the project.

Functional requirements must be quantified precisely enough.

Operational requirements refer to the achievement of the use of the project result. The *design limitations* refer to the requirements that involve the actual implementation of the project.

The result of the definition phase and the actual number of requirements are defined and presented as a list of formalized requirements. The results must be achievable by the time of the presentation of the project, and the conflicting requirements (if any) must be reviewed and reformulated. The final acceptance from the project participants (including the industry) must be received during this phase. The approval of the definition of these requirements means that the design phase can begin. At the close of the definition phase, most of the agreements between the customer and the project team have been established. The list of requirements specifies the guidelines that the project must adhere to. The project team is evaluated according to this list. The end of the definition phase, is a midterm phase, therefore, the project user can add no new requirements (Baars, 2006).

7.2.3. Design phase

The list of prototype/technical/functional and other requirements that is already developed in the definition phase will be later developed in the actual phase. The aim of the design phase is to present one or more designs of a developed product which are aimed to be developed as the project result. At it is already formulated in the project scope, the products of the design can be early stage prototypes, screeches, schemas, etc. The student, guided by project scientific supervisor and industrial partner will make choice according to the available designs in order to choose the most suitable design that will be produced in the project. The future design has been chosen in definition phase and from this stage cannot be changed (Baars 2006).

When the implementation phase begins and the project is being finalized, it is too late to redesign its results, taking into account that the budget is probably almost exhausted.

7.2.4. Development phase

The development phase is that phase of the project when everything will be arranged in order to implement the project. The personnel and experts are assigned, the resources and activities are planned, and the responsibilities are correctly assigned. The development phase is the last phase before the implementation stage; therefore, this is the last stage of the project implementation planning.

The development stage is not so important for a small project and could be implemented together with another stage. The most important aspect during this stage is that all implementation activities are sufficiently planned for all size projects.

7.2.5. Implementation phase

The project is finally shaped in the implementation phase. The implementation stage is the most critical for the achievement of the project result. The execution of this phase must be carefully planned according to the expected project deliverables; the time and resource planning is very important at this stage, too. This phase involves the construction of the actual project result. The implementation phase is the phase in which all activities are realized, and it is important to maintain the momentum.

The results of this stage should be evaluated against the initial requirements for the design and functional requirements. In the time period, when this phase is complete, all the requirements must be carefully analysed against the result of the phase.

The risk management plan and procedures are equally very important at this stage. All the deviations from the initial design and functional requirements must be sufficiently proven in the project description documentation, and most likely approved by stakeholders during the project meeting. The deviation from requirements is a potential source of conflict, particularly if an industrial partner has ordered the specific project result. In this case the formal agreement, which is signed during the project initiation phase, must be taken into account. If there is no such agreement for a master's thesis it is enough to merely describe the steps of the development and the achievements in sufficient detail.

Usually the requirements for the product development cannot be changed during the project, and especially after the definition phase. The product design should be fixed after the project design stage. The chancing of design at that phase should be seriously discussed and sufficiently justified, as soon as possible. The design or requirement adjustments should be well documented, in order to avoid later discussions.

7.2.6. Follow-up phase

Although this phase is very important, it is often skipped if it is not included in the written formal contract with the industrial partner. This phase is dedicated to making sufficient quality assurance activities.

The main challenge during this phase is the end of the project, because the closing conditions may fail to be described. The project closing conditions must be clearly described in the agreement, and only in this case it become an obligation for the student and the university. In all other cases, the project is closed, when the scientific advisor approves the quality of the results.

It is sometimes unclearly documented whether the project result is to be a prototype or a market oriented working product. In case of the master's thesis it is a purely student and supervisor decision, but in industry- oriented projects the industrial partner may expect to receive a market product, while the project team is just working on building a prototype. Such situations may appear during this phase if there is a problem with initial documentation.

For a more detailed description of the model and the tasks for the above mentioned six phases, see Wijnen (2004) and Baars (2006).

7.3. Managing a project

The basic project management intention could be defined in such notions:

1. Team

A project team, which consists of a group of qualified specialists, has a defined task and contributes invaluably to the achievement of the project results. The project group is usually comprised of people who have different backgrounds and competences, and each of them contributes their knowledge and expertise to the project.

2. Goal

A project result (main deliverable) is the end product after a project has been completed.

3. Limited resources

The additional constraints of time and money that are assigned for the project are always limited. The pressure of money and time constraints are a very important factor in the project implementation. During a master project, the laboratory availability could be also seriously limited.

4. Uncertainty (risk)

The uncertainty in the project could cause delays in the project realisation plan and other important difficulties in the project realisation. Although the uncertainty cannot be predicted, in good project realisation practise, a risk mitigation plan/action list is always required.

The project managers have to take care about the project implementation progress, and in particular such parameters as:

- Time
- Money
- Quality
- Organization
- Information

These parameters are also known as ‘control factors’ and are described further below. These factors are main issues for the planning, control, and monitoring of the project.

7.3.1. Time

The time management must be done in accordance with the task progress, achievement of milestones, and deliverables. The time control is usually visualized by Gantt chart.

Time in project plans:

- Definition of the activities by project stages
- Estimation of activity duration
- Determination of activity implementation sequences and orders, the settlement of priorities, and identification of critical path
- Control of human expertise and resource (in particular laboratories) allocation according to the project tasks
- Ordering activities over time
- Setting milestones and control of most important deadlines.

Time in progress monitoring:

- Control of project progress
- Control of project deadlines
- Adjust schedule according to the actual progress.

Time in project reporting:

- Present the progress in actual timeline
- To explain delays or faster progress in the project.

The development of project time line is based on responsibilities settled up in the work-breakdown structure (WBS). The WBS is based on the decomposition of the project tasks. The preparation of project schedule requires information about project tasks, the critical activities, planning of human resources, and laboratory space for the project. The example of time planning is presented as bar chart or Gantt chart (see Fig. 7.1.).

ABC Technologies: Manufacturing division								
Welding and machining Certification update				Quarter 3			Quarter 4	
ID	Test name	Start/finish	Days	July	August	September	October	November
1	Welding-GT-AL-01	7/1-7/30	21					
2	Welding-GT-AL-01	8/1-8/31	23					
3	Welding-GT-AL-01	9/1-9/30	22					
4	Machining-QT-01	8/11-9/21	30					
5	Machining-QT-01	9/22-10/31	35					
6	Machining-QT-01	10/6-11/10	26					

Figure 7.1. An example of a simple Gantt chart

7.3.2. Money

The budget management is one of main tasks in the project. In case of industry–academia collaboration, the financial management is very simple, but if the master's thesis is contributing to a more global task, the financial management must be performed by professionals.

Budget planning:

- The payment planning over the time, including staff costs and procurements
- Estimation of the time consumption by project activities for each project implementer
- Assign budgets to the execution of the tasks
- Determination of laboratory and costs of resources.

Budget progress monitoring

- Monitor cash flow
- Make a control of original cost and estimate actual project costs
- Adjust budget
- Inform project team and stakeholders (industrial partners) concerning budget adjustments (if applicable).

Reporting of the budget matters:

- Organise the financial reporting and support of actual financial statements
- Analyse financial reporting results and inform project team.

The cost of the task is consisted of the cost of subtasks as they had been performed. In Fig. 7.2, an example of subtasks costs is depicted.

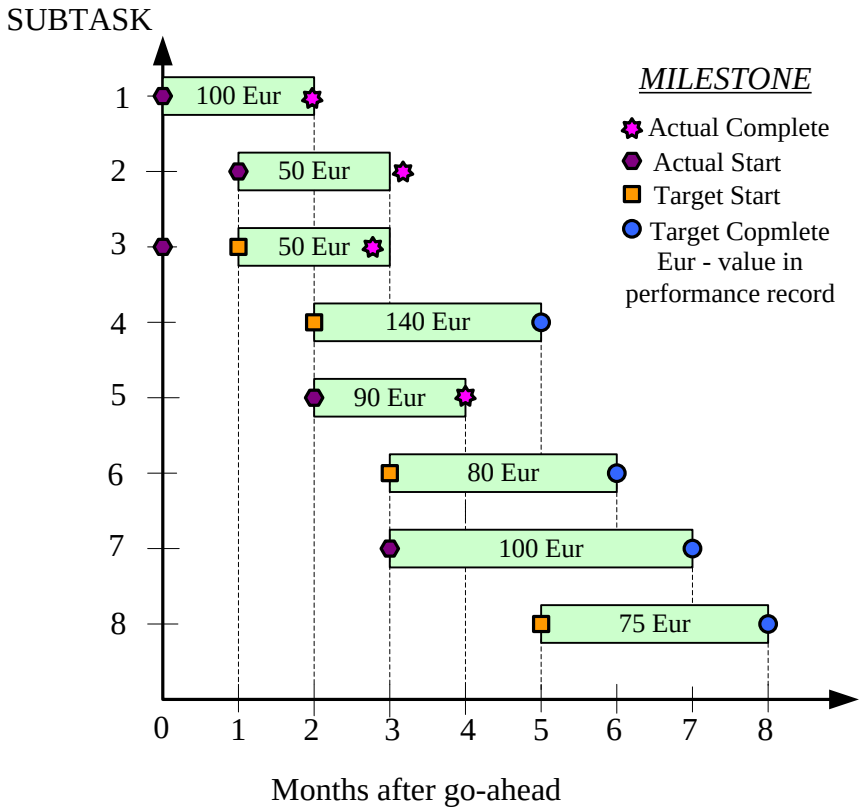

Figure 7.2. An example of subtasks costs (Kerzner 2009)

7.3.3. Quality

The project result must conform to defined quality requirements. This also applies to the beta prototype and industrial product. For project management it is important that the quality requirements are defined, agreed, and approved in written form. The clear quality requirements should be evaluated at the end of the implementation phase. The progress evaluation in comparison with the initial idea should be provided. The certification requirements for each step should be clearly defined, as below:

Quality control of the project planning:

- Define the quality of deliverables and the intermediate products (this activity must be done during the definition phase).
- Define the quality of different activities in the project with special attention to testing issues, and production of prototype.

Quality monitoring during the project execution:

- Evaluate the prototype in the development progress
- Assure that all quality requirements are included in the project planning.

Quality assessment in the project reports:

- The reporting must contain quality description for the products, services, and processes.
- Explain any discrepancies with initial planning.

The project developing technique is required to complete the project in the sufficient quality level. As a rule, a perfect result within the project time is not reachable.

7.3.4. Organisation

The team management is one of the main tasks in project management approach. When a master's thesis is developed in cooperation with an industry, the good atmosphere and collaborative relationship spirit are the best possible achievements in team management. The team management precisely defines the area of responsibility for project implementers. In broader terms, it also includes motivational techniques, communication skills, leadership styles, and working culture in order to achieve a goal within a group of people. Finding a goal is a main task, which can unite and sustain a team throughout the duration of the project. It will help to achieve a level of self-motivation enough to keep project team in a good motivation level.

The assessment of organisational issues in project plans consists of the following steps:

- Create the team
- Assign responsibilities
- Clearly assign the tasks to the project team experts
- Make sure that needed personnel and experts are available and officially assigned for the project.

Progress monitoring within the organization:

- Develop guidelines for the team
- Try to manage human aspects; use all your soft skills in order to maintain creative and positive atmosphere in the project team
- Contact people according to their responsibilities, and mediate between the project implementers, if needed.

7.3.5. Information

According to the main project management approach, the project manager must spend 60% of his/ her time just to inform all involved parties in the project development. The information about the project should be available, and project implementers must be informed about the place of its availability, use the standard instruments for industrial projects, and choose from commonly used tools (e.g., Dropbox, Google Drive, Wi-Ki, etc.).

Information for industry-oriented project:

- Define information flow in the frame of project, the seatrain information, and especially reporting information
- Define the information which is important and must be recorded, distributed, and stored in related folders
- Define the information tools, if any.

Progress information definition and track record:

- Ensure that meeting presentations are stored and available to the partners
- Ensure that the information is provided to the right person in time
- Ensure that legal requirements as well as other agreements are relevantly adhered to.

Information in project reporting:

- The relevant information must be sufficiently addressed in the project reporting.

A number of information exchanging forms within a project:

- Issue list
- Action-and-decision list
- Risk log
- Meeting report

The information regarding project progress must be stored in the available-for-all-participants media. The project reporting must be done in such detailed way that it could be reproducible, if needed, by another person; in particular, it is important to document all decisions in written form. The non-documented oral decisions may cause misunderstandings in the project.

7.3.6. Roles within a project

There are predefined and specific roles in the projects:

1. Project team

The project members are the implementers of the project—those who really make the activities and contribute to the project. Team members should come from different areas of interest, so that they have different areas of expertise. Team members can be internal (university representatives), external (from project industrial partners, customers, users, or temporary personnel) or both.

2. Project leader

The project leader is the person who is personally responsible for the project implementation; depending on the case it could be a scientific supervisor, an industrial partner, or a student himself. Depending on the project background, one who directs the project team and carries out the project result is the project leader. This role in the project could be delegated to the student, but it is obvious that for an industrial research project external experts and even formal managers could be involved.

3. Project manager

A project manager role is extremely important but may vary depending on the project nature. In the industrial matrix project organization, the project manager is usually responsible for several projects. The actual area of project manager responsibilities must be clearly described for all involved project implementers. The student or his supervisor could be also project manager at the same time.

4. Programme manager

The programme manager is the person who is responsible for a number of projects within a similar area, or a long-term development programme. In industrial cases, the project leader and project manager report to the programme manager; the programme manager could also be involved as industrial partner representative.

5. Customer

The customer (e.g., industrial partner, government institution, local authority) is the person who is interested in the project result. Customers could be actively involved in the project (especially in case of small industrial projects), or may participate only in the dedicated project meetings. The relations with customers must be specified in the industry-university agreement at the beginning of the project.

6. Users

The users are the group of people who will use the results of the project; for example, engineers who will use the final market product which is developed and prototyped in the project. In the definition phase, the design phase, and in the testing of the project result, it is important to involve representatives of the user group (if it is relevant).

7. Project partner

The project partner is a third party (company, enterprises, NGO, etc.) which may be involved in the project. In case that the project partner or partners are taking part in the research or using the results, it is important to define their roles at the beginning of the project. The certification bodies, NEGOs, and associations may often be a part of the project steering committee, which is responsible for the sustainable usage and future development of market product: customers' requirements, developing market placement requirements, testing, dissemination of results, etc.

8. Client/customer/sponsor

The financial supporter of the project could be a third part as in European research projects, but it could be also a representative of Industrial Corporation of even small enterprise. In many cases it is European/Governmental/ State or university level financing, but in many cases, this is directly the industrial representative (industrial partner). This part - client must be sufficiently involved and informed about project progress. It is important to invite him in the mid phase reporting cycle (Baars 2006).

7.4. Project reporting

The decision-making must be organised at critical points along a project (see Fig. 7.3.); these decision points are discussed during a formal meeting at the end of each project phase, and they are related with defining the current status of the project and writing an intermediate report. The project meetings are usually organised at project reporting points and at decision points, where

project leaders should consult clients regarding project progress and take decisions about the project. At these points, “go or kill” decisions must be made. In reality, it is very important to understand project progress and to take any corrective actions, if needed.

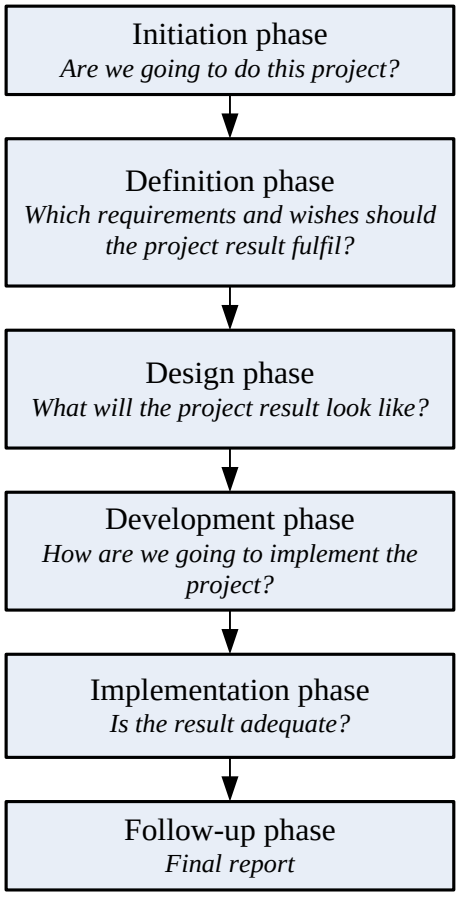

Figure 7.3. Five important decision points in a project

The project implementation in the project-oriented organisations is often presented in the following manner: A project WBS is prepared, a project time schedule is initially written, and the initial control procedures are described in the project planning documents. A schedule (Time) is specified, and a budget (Money) is agreed upon, a team is assigned (Organisation), project deliverables are described (Quality), and the tools for information reporting are determined (Information). If during a project time the project leader is just updating the budget and time related information but makes no real control and notification of the related partner, it may end in a situation in which at the end of the project cost are higher, or there is not enough time to execute the project; those are serious deviations from the originally expected project execution. The project may run till the end but this situation could seriously affect initial expectation in terms of budget, time, or quality.

7.5. Project risks

The risks must be properly evaluated, and sufficient risk mitigation strategy must be developed. It is also important to develop a decision-making procedure for the risk mitigation, in case of a non-expected situation. In risk mitigation the most important factor is time in identification of potential risk and the evaluation of the potential impact of the risk. For industrial projects, it is important to create a risk mitigation plan, which must be agreed on with clients.

Identifying the sources of risk by category is another method for exploring potential risk on a project. Some examples of categories for potential risks include the following (Schmitz 2012):

- Technology risk
- Financial risk
- Time-planning
- Customer's expectations
- Political risk
- Environmental
- Human management risk.

7.5.1 Risk Evaluation

For the industry-oriented projects, professional risk evaluation should be conducted, the risk mitigation actions should be defined, and the decision making procedure should be developed. The certain risk events are more frequently accrued than others, and they may significantly impact costs of a risk. The risk evaluation is one of the most important steps in the management process (see Fig. 7.4), and equally important for small and big projects.

The risk evaluation is usually a task for several project experts; therefore, it is often carried out during the workshops. The risk evaluation is often based on financial factors. One should be aware of which financial, time, or quality issues will accrue, and if certain risks will take place. The risk impact is evaluated as high, medium, or low. The risk mitigation actions may address both factors: likelihoods and impacts.

7.5.2. Risk Mitigation

The risk mitigation plan is developed after evaluation of the risk. The project management technique foresees such mitigation actions:

- avoidance of the risk
- sharing of the risk
- reduction of the risk
- transfer of the risk

The students must pay attention and try to properly address the risk mitigation actions in the project. The decision making process should be generally discussed, and written in the industry-university agreement. The sufficient information of the parties involved in the project will be

helpful for finding the best solution in the mitigation case. The risk mitigation plan includes the risk mitigation measures according to each identified risk and the preliminary planned actions that the project management team will take to reduce or eliminate the risk (Schmitz 2012).

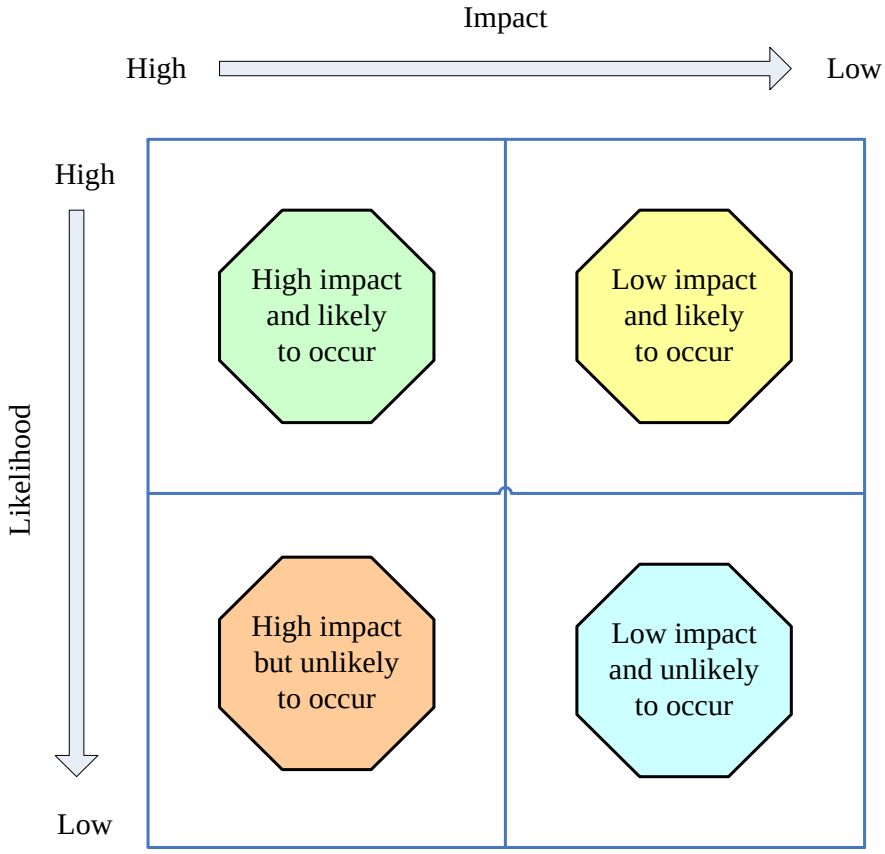

Figure 7.4. Risk and Impact

7.6. The work breakdown structure for planning

In the stage of project planning, the Work Breakdown Structure (WBS) should be developed. The logical decomposition of the project activities and assignment of the responsibilities are identified in the project WBS. The aim of this stage is to identify stand-alone and sufficiently small project activities. When identification of activities is done, the project leader, in agreement with the project team, has to create an initial project plan. A team has to agree on activity durations, create a schedule, estimate activity costs, create a project budget, and assign responsibilities. The WBS and the Gantt chart are minimum required plans for the kick off meeting of the project. WBS is a visualised roadmap of responsibilities. In case a third party is involved in the project execution, apart from master's students and a scientific supervisor, the WBS is essential.

There are several reasons why the (WBS) (see Fig. 7.5.) is essential for a project:

- The WBS is a good graphical representation of task assignment for the responsible implementers.
- At the beginning of the project planning, the real job amount could be under- or overestimated; the WBS clarifies the real amount of work to be done.
- The WBS provides a logical structure for the responsibilities and assigned resources for the particular task and envisages the estimated duration and costs.
- The WBS provides an excellent source for examining the risks associated with the project.

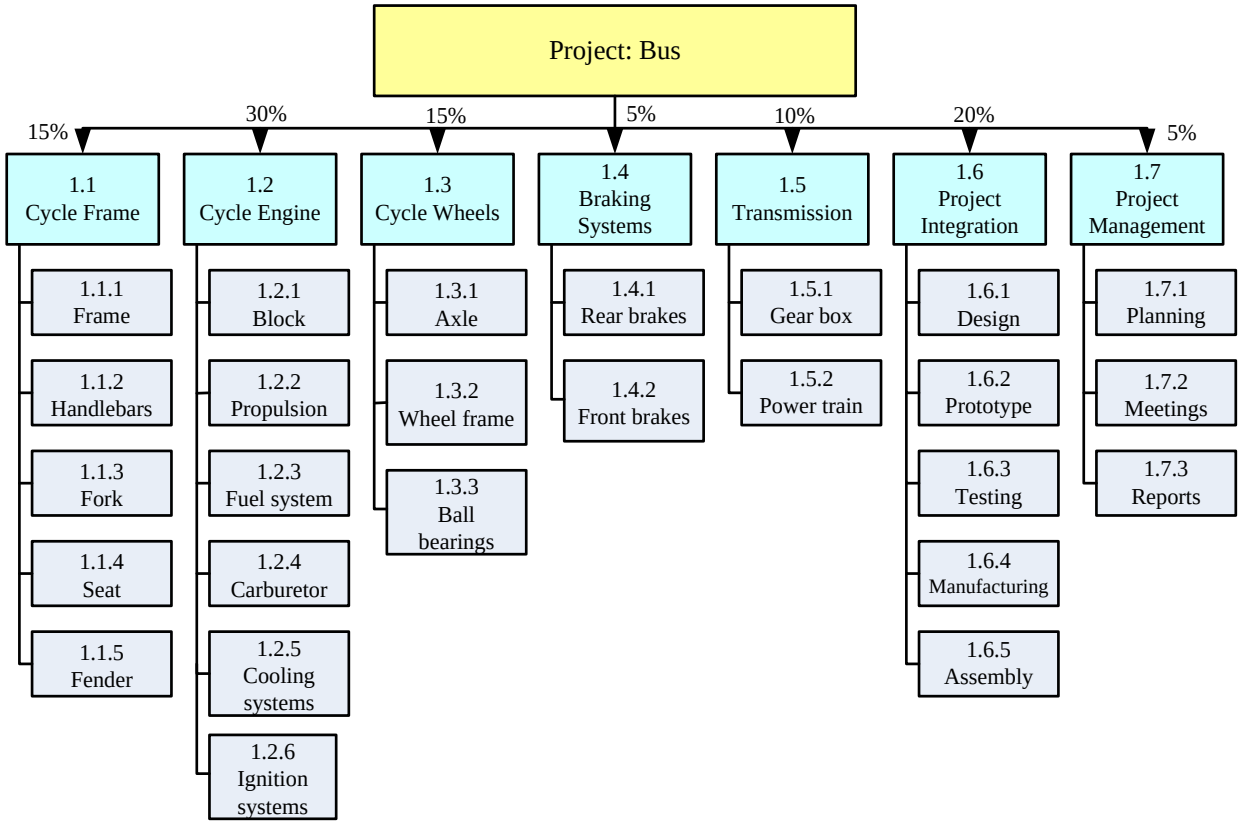

Figure 7.5. Work breakdown structure (WBS)

For each of these activities, a project team needs to clarify dimensions. The dimensions should be used as input for planning the activities of the project:

- Time: the estimation of active/working time duration.
- Cost: the estimation of at least human costs, the costs of materials, resources, and laboratory equipment.
- Scope: the definition of the project results, methodology, and included activities.
- Responsibility: the definition of the personal responsibility for the implementation of the project deliverables.
- Resources: the definition of the suppliers, testing and in-house available materials.
- Quality: the definition of the future activities and its quality.

- Relationship to other activities: the definition of the critical path of the project, and to building sequence of project activities according to the particular task.

7.6.1. Preparing a Project Timeline: A Seven-Step Process

For better understanding of the next text some basic definitions are explained in Table 7.1.

Table 7.1. Project Management Definitions

Critical	The event or result which must be achieved in the lifespan of the project; this deliverable is very important for the achievement of the final results.
Critical path	The critical path is the sequence of activities from the beginning until the end of the project, which assures the earliest completion of the project.
Duration	Usually used for determination of project activity duration, it is the time from the beginning of the activity until its completion.
Events	The events corresponding to the beginning and end of the project activities.
Milestone	Milestones are time points when seatrain activity must be done at defined progress. Project progress evaluation is based on the control of achievement of milestones.
Forward pass/backward pass	The analysis of the execution of the activities; the activities with no float are referred to as critical activities.
Network	Networks are also called “arrow diagrams.” It is a graphical interpretation of interdependence between activities.
Parallel activities	Activities that can be implemented in the same time spot.

There are many ways to create a project schedule. The practical seven-step approach is presented below:

Step 1. The schedule is based on the time planning of activities from the WBS. The level of decomposition depends on the task complexity. The general decomposition level must be detailed enough to a level where the progress could be tracked and controlled. The definition of each activity has to be prepared in sufficient detail and be agreed among all project participants and stakeholders.

Step 2. Development of the Network Diagram. Create a logical diagram that includes project activities. The ordering of activities and outline of any interdependencies should be clarified according to two questions:

- What is the optimal sequence of the tasks and which tasks should use results of previous tasks?
- Which tasks can be performed in parallel?

Step 3. Estimate Preliminary Activity Durations. Imagine, if the time and budget of the project were not, which sequence of activities would be optimal. Try to find examples of best practice for your schedule.

Step 4. Mark Specific Calendar Dates and Times. In the project management, the specific dates are also called milestones. During those days, the deliverables must be met. The network diagram can now be used for the estimation of activity durations, and the project timeline should be planned accordingly. The first estimation of the project completion date will represent the earliest possible completion date.

Step 5. The limitations of the resource availability, experts' timeline, and other internal and external constraints will impact the realistic duration of the activities. It is important to take into account the actual commitment of all involved experts and the resource availability planning commitments and begin assessing their availability, considering the actual schedule, described in Step 4. All limitations must be taken into account and the final version of the plan must be created. The complexity of the plan and external concerns may rise several iterations of the redesigning. (Step 6).

Step 6. Make sure that all External Constraints are identified, and use external expertise, if available, in order to make sure that all constraints are properly handled/addressed? in the planning. Occasionally, the external constraints cannot be properly addressed in the planning because often the project leader is not available, so the planning should be done with approximation, and, if needed, re-planned in iterations.

Step 7. After proper addressing of all the constraints, the baseline control schedule should be defined.

7.6.2. Creating a Network Diagram

The scheduling and the WBS activities must be organized in a logical sequence and network diagrams could be created for this purpose. In case of an industry-academia cooperation project, the University holds, as a rule, only a small part of a Network Diagram (ND) of industrial activities. The scheduling is done taking into account all specified activities. The next step in planning is related to network diagram creation.

Examining of the WBS should be carried out for identifying activities aiming to schedule, track, and control. The relations between activities could be identified in different ways; for example, construction of a certain sequence, a chart (using the WBS), or a wall chart (see an example of a network diagram at Fig. 7.6.).

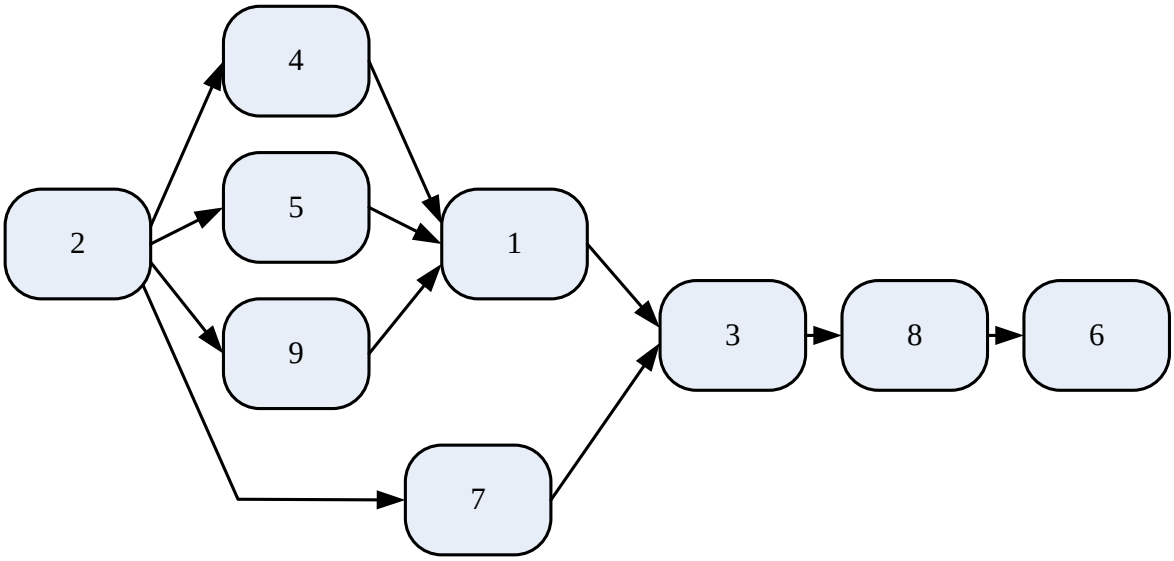

Figure 7.6. An example of a network diagram

7.6.3. Calculating the Critical Path

The shortest sequence of activity, which must be realized in order to reach final results, is called critical path. The critical path is the shortest way from the beginning until the end of the project, taking into account logical sequences of activities and availability of resources.

Although the critical path is obvious in the schedule depicted in Fig. 7.7, it is also evident that the complexity of the project seriously impacts the complexity of planning. The sequence of the activities in the developed critical path should be analysed and optimized, if needed in both directions of the schedule—a forward pass and a backward pass. The forward pass is planned based on earliest starting day, but the backward pass calculates the latest term, when activities can start and finish. The simple network diagram used for the composition of critical path is illustrated in Figure 7.7.

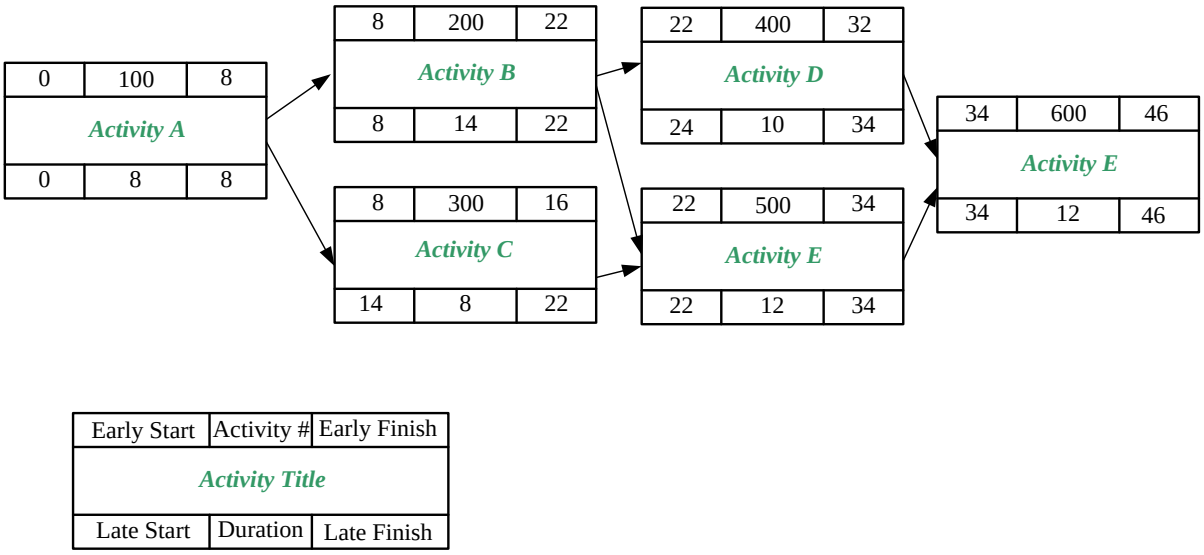

Figure 7.7. Calculation of forward and backward passes

7.6.4. Estimating time, costs, and resources

One of the most important dimensions of project planning is the estimation of cash flow. The financial management of the project is a very important part of project management for industry-oriented projects. This stage involves creating a budget: defining the costs for all project activities, defining cash flow in the timescale, and identifying the overall project expenditure. The costs could be divided according to the timeline and the basic accounting rules should be taken into account during the planning.

A project direct cost is related to the project costs itself, for example: staff costs (including social security) costs, materials, travel and accommodation, supplies and equipment, and other direct costs.

A project indirect cost corresponds to additional and related expenses, for example: laboratory costs, supporting the facilities, general services, and administration costs. It may include the following:

- *Facilities*: The usage of laboratory equipment is often not free to use, and the equipment and materials which may be needed have to be clearly identified.
- *General and Administrative*: This category of management costs is related to support services, such as accounting and financial support, auditing and administrative costs, and the costs of university facilities.

Figure 7.8. illustrates the WBS with respective project costs; the same idea may be used for time planning in the form of Gantt chart.

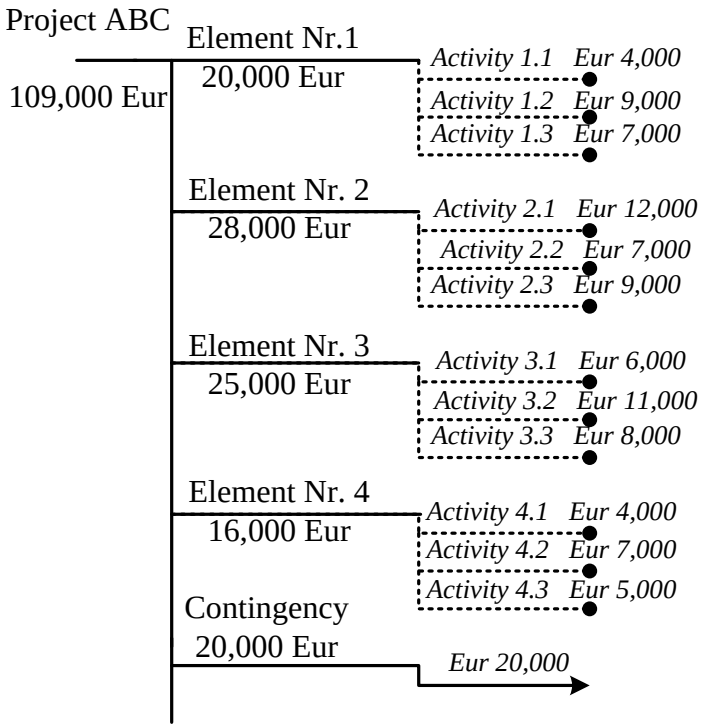

Figure 7.8. The project WBS with project costs

7.7. Project control and evaluation

In the project control organisation all planned activities must be defined, and the actual completion date must be specified. To perform internal quality assessment, the project team should keep in mind:

1. The clear definition of the project tasks and related deliverables, as well as the formulated project scope with strictly defined project area of activities.
2. The related staff plan and staff assignment procedures.
3. Adequate resources and related expertise.
4. The proper quality and progress control mechanisms.
5. The decision-making procedures in order to manage any unexpected events or mitigate the project risks.

7.7.1. Characteristics of a Project Control System

The industrial partner could use their own project control system; the control methods must be defined according to the organizations involved in the project. Generally, the project control system must involve quality control in all project stages. The project budget and schedule are crucial issues, directly related to the quality of deliverables.

Project Review Meetings

The project starts with a kick-off meeting, where the project leader assures that the project team are informed about the status and deliverables of the project. In the later stages of the project, each project official stage ends up with a project review meeting, which forms an efficient communication channel between the project manager, the stakeholders, and the project executive committee. In case of direct industry-academia cooperation the review meeting usually ends up with industry acceptance of the project activities and quality of deliverables. In case of failure of ideas, costs, team, or technical perspectives, the meeting ends up with end of development. If the performance of the project in not good progress, certain improvements might be presented and accepted during the review meeting. During a review meeting the project leader should present such reviews:

1. Status reviews
2. Process reviews
3. Design reviews

A project leader has to present a complete project status for a certain time period, including status and process reviews. Design reviews are appropriate only if a project team designs a market-oriented solution; for the prototyping stage design this is less important.

Project Evaluation

The project evaluation activities are related to the project nature. The project progress and status of the work should be performed in terms of ensuring that the deliverables comply to the industry requirements at the end of the project. The evaluation is related to the quality and quantity of the project deliverables, and its correspondence to the initial requirements.

The evaluation process is usually based on the intermediate delivery acceptance in defined milestones and acceptance of the final delivery, as well as checking the track record about management decisions of the whole project.

7.8. Managing the project team

7.8.1. Team Building and Conflicts

Team building is a very important challenge, especially in case of an industry-university collaboration. The definition and mutual recognition of the project goals is essential for the motivation of the team and for maintaining an amiable working atmosphere during the project. Team building is significant in case of collaboration with industrial matrix organizations, with number of management structures in the decision-making hierarchy of industrial partner, and less important in case of SMEs.

Promoting Teamwork through Planning

The sharing of responsibility in the team could be done during the process of planning: the project team must be sufficiently informed, and even involved in the project planning, if needed. There are cases when industrial leaders often plan the projects by themselves.

The planning is always based on some information, but the risk factors must be properly addressed during the project planning and estimations. All assignments must be properly documented, at least on the Gantt charts or WBS level.

Clarifying the Team's Mission, Goals, and Objectives

The project manager must carry out the information activities, the efficient management structure of the project, including drawbacks in communication that may raise serious difficulties for the implementation of the project.

Team Issues

The team building methodology is based on four basic issues. These are *goals, roles and responsibilities, procedures,* and *relationships*. The role of each team must be clearly defined, and generally presented toe all the project team members at least during the first project meeting

(kick-off). The clarification of individual contribution by all of the team members assures smooth project running. It is essential for project leaders to establish creative working atmosphere in the teams, and the staff assignment and team building activities are the main tools for assuring high level of team creativity.

7.8.2. Working out Procedures

The industry-oriented research work must be done effectively, and improvement of work processes is a very important issue for the project leader. The production and implementation of products or solutions may raise implementation questions, which are related to changes in industrial partner daily operations. It is also called as a process re-engineering, aiming for the analysis and improvement of work processes in order to make the organization more efficient.

The difficulties which teams meet while working on the project, could be related to loss of project focus as the individuals involved tend to forget about the common idea of the project and focus instead on individual tasks only. However, the project leader must assure the sufficient progress and achievement of the project targets. The basic production, promoting, customer care and pricing questions should be revised and elaborated during the project. The team, from time to time, should evaluate its processes and see whether it could use better approaches. It is better to have a regular team meeting for resolving such issues.

7.8.3. Developing Commitment to a Team

Special attention must be paid to the team members which will be assigned to a project. The assignment is based on a simple decision: only the best available experts are assigned. March and Simon (1993), presented five rules for developing commitment to a team or organisation:

1. Team members should interact frequently so that they gain a sense of team spirit.
2. Individual needs should be met through participation in the team.
3. Team members have to know why the project is important.
4. All members have to share the goals of the team; “one bad apple spoils the barrel”.
5. Competition within the team should be reduced to a minimum. Competition and cooperation are opposites.

The team management for the geographically distributed teams may follow the videoconferencing practice, try to organize frequent information exchange through teleconferencing, videoconferencing, social media, “clouds”, etc.

7.8.4. Constraints in the Coordination of Projects

The reasonable grouping of the projects may structure and clarify administrative issues and give some advantage and simplification in the coordination of multiple projects. Several factors must be analysed in that case:

Money: justification of financial sustainability of the projects.

Organisation: using structuring and mutual agreements practice in order to prioritise industry-academia projects and clarify the essential interconnections between the projects.

Quality: agree on the project end conditions: whether the goals of a project are corresponding to the strategy of the partners.

Information: develop reporting procedures in order to organize sufficient information flow between the project teams.

Time: specify how many experts and developers' efforts and time is needed in this period to achieve at a relevant distribution of tasks.

At the beginning of the project activities and at the milestones of each project phase a project manager should complete a report regarding factors for the next period of the project.

Money

The program manager is responsible for properly addressing the evaluation of financial matters by assigned experts This involves the following issues:

- Is the project sufficiently financed in the separate phases, is the cash flow adequate?
- To identify financial risks of the project and develop sufficient action plan for financial risk mitigation, if relevant.
- Does the proposed solution bring revenue to the project customer; does the developed technology allow to get planned financial benefits?

The attraction of extra researchers to the seatrain project and by increasing the project budget, the scope of project could be increased, therefore, the agreements with the industry must be accordingly documented. The industrial personnel could be allocated to different individuals, if it is better for the company in this extra period. Additional industrial personnel could be hired in the duration of the project and also could be released in case that a project is postponed or even cancelled.

Time

Consolidating the time line for the same company projects in the relevant period provides an indication of the workload for that period.

The industrial partner may have a target to increase industrial productivity, and it may lead to insufficient planning, for example the personnel could be often assigned to too many projects. It can cause serious delays in the research-oriented projects. According to Goldratt (2002), the fact that organizations often assign personnel to many projects simultaneously is one of the most important reasons that projects take (much) too long. In such cases, projects with initial duration of few months often last for more than two years. Therefore, the personal workload should not be taken too ambitiously, and real workload on the personnel during a certain period must be thoroughly evaluated.

Time registration

The finances and time capacity should be analysed by the project leader at the beginning of every new project, and the project planning process should assure preformation of the control

procedures described above. The regular follow-up activities must be done by the project leader during the project duration, and the project budget must be appropriately adjusted.

A time-tracking procedure:

- The working time-registration practice should be defined and used throughout the entire project.
- The time-registration system must be accessible; it is better to have it as web-based application.
- The project leader and client have to be able to check time reports.
- The allocated and used time must be sufficiently identified into the time-registration system.

Time-registration systems must be flexible and allow to make adjustments according to the time deviation in the work packages during the entitle project.

7.9. Environment of Projects

7.9.1. Organisational structures

In his work, Wijnen (2004), distinguished three structures of project management with regard to the large size industrial company:

- Consultation or coordinating structure;
- Matrix structure;
- Pure project structure.

The *consultation or coordination structure* is a sufficient structure for the simple industry-academia projects. In this case, a project team usually consists of project leader only. The project leader has certain privileges and obligations. The project leader personally performs or closely controls research work and is responsible for the management of the project. The project team is not officially under project leader supervision from an organizational supervision point of view, so in case of any grievances, the project leader may either ask for help informally or arrange it through their direct structural managers.

The matrix structure refers to the widely applied structure for project oriented organizations. In this case, the organization structure is arranged in such a way that the project team staff work officially in the project teams, but at the same time the staff keep their positions in the organization (part-time). In the matrix organizations it is common practice to assign people to multiple projects simultaneously. Figure 7.9. shows projects matrix model organization. The main feature is that the project teams have two supervisors at the same time: the project leader and the department head.

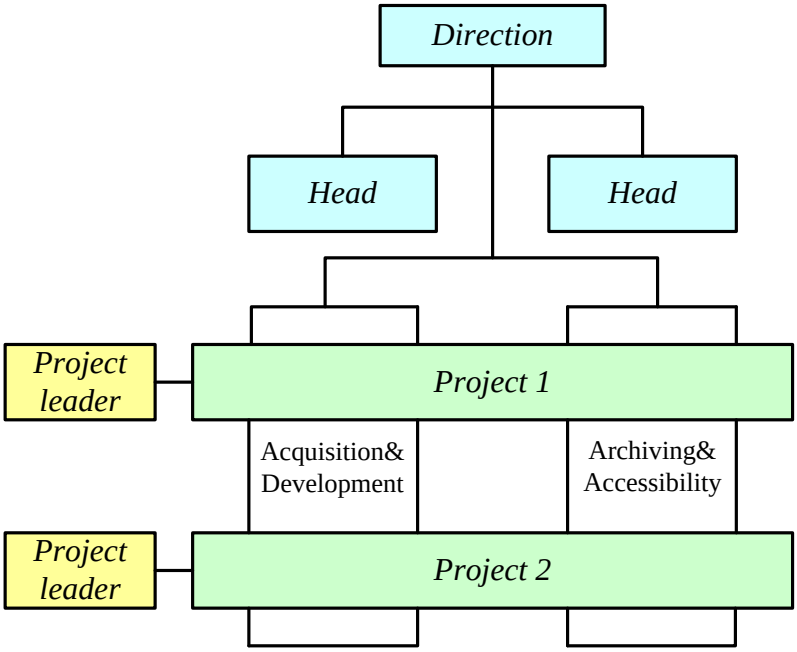

Figure 7.9. Project organisation according to the matrix model

In the pure *project oriented industrial company structure*, the employment is based on the projects, the project staff have no permanent contract, but work under contract for the defined project period. This form is the most relevant for large, heavy projects (for example in the building and construction of a certain object). The project team is largely autonomous and has only the project leader as a supervisor. This structure, however, has disadvantages, such as the administration flexibility, staff attraction, the contracting process is time consuming, and the motivation of employees is not so high as employees are taken away from their original work for long periods.

7.9.2. Project Management for Public Governance

The research projects under public governance are not easy to manage because of decision making complexity. Project managers should adapt management structures according to the environment in which the project is conducted, therefore they must define in which way the decisions are taken depending on the nature of the project. The project management approach depends utterly on the environment: pure research, the world of the business, and the world of the public governance.

In the business making case, profit maximisation and stability are very important. In the public governance and state organisations, the knowledge of management structures and loyalty is very important, even if a governor's opinion differs from that of the group on a number of points. The project leader has to take care of external factors as these projects often involve at least some element of politics.

Implementing a project in a public governance environment is not easy due to the different culture of officials who work in the ministries and municipalities. The crucial notion of project

management “time” is usually not deemed important. The officials are ready to dispute several meetings about a particular word of sentence in the text of meeting minutes, because they recognize project team meetings as routine “document confirmation meetings”. The project manager has to have patience, spare time, and good knowledge of legislation.

7.10. Advanced project management techniques - Agile

7.10.1. Agile Project Management Principles

The Agile Project Management is a relatively new method which has been introduced recently for project management. It is one of the newest project management strategies that is mainly applied to project management in software development. The application of Agile technique for the students’ final projects is not so popular, but in certain universities this practice could be used for innovation-based research.

Under the term Agile, a number of relevant approaches are understood; this term is used for identifying a number of models used for agile development, for example, Scrum. The agile project management is a relatively new specialized area in project management. The Agile technique is based on continuous improvement, scope flexibility, team input, and on delivering essential quality products. The agile techniques adhere to the *Agile Manifesto* and the *twelve Agile Principles*, which focus on people, communications, the product, and flexibility (Layton 2012). Named manifesto can be used as a guide to implement agile methodologies in the research projects (Agile Manifesto 2001). The twelve Agile Principles are formulated in order to underline the concepts that project teams should follow in the execution of agile projects.

1. The highest priority is to reduce delivery time for customer, and continuous delivery of valuable software.
2. The changing requirements are welcomed, even at late stages of the project. Agile processes increase the chance for the customer's market benefit.
3. Let customer use software even at earlier stage, and improve working software frequently, from several weeks to a number of months, with a target to the shorter timescale.
4. The industrial partner–customer must be involved in the development process on daily basis. Customers and developers must work together.
5. Create the project around motivated personalities. Support them with an appropriate environment.
6. The information exchange in face-to-face conversation is the most efficient and effective method of conveying information within the project team.
7. Working software is essential and it is the most important progress indicator.
8. Agile processes assure sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity—the limit of the amount of work to be done—is essential.

11. The best architectures, requirements, and designs come from self-organizing teams.
12. During the certain intervals, the team reflects on effectiveness matters, then tunes and adjusts its behaviour accordingly.

The Agile Roadmap to Value is a general view of an agile development. The defined steps of the Roadmap to Value are described below and are depicted in Fig. 7.10.

- In Stage 1, the software holder identifies the *product vision.* The product vision includes a definition of an existing product, the way will be used in the company or support the strategy of the organization, and a description of the product user group. During the development of longer projects, the product vision should be revised at least once a year.
- In Stage 2, a *product roadmap* should be produced by the product owner. The high- level requirements should be recorded in the product roadmap and the time slot for the development of these requirements should be indicated. The formalization of product requirements and following sequencing of them should be performed in order to create a sufficient product roadmap. This product roadmap should be revised at least twice a year for longer projects.
- In Stage 3, the *release plan should be created by* the product owner. The prepared plan identifies a high-level timetable for the working software introduction. In the agile projects the many releases of the software are foreseen, the most crucial features for the customer will be implemented in the earlier releases, and the number of releases is not limited comprising three to five iterations. The planning at the beginning of each release is considered essential.
- Stage 4, the beginning of the sprints, is targeted at the beginning of the product development. The product owner, the master, and the development team make planning for sprints, also called iterations. This planning, also called *Sprint planning* sessions, takes place at the launching of each sprint. At this stage, the scrum team has to agree on the requirements for upcoming iterations.
- In Stage 5, the *daily meetings* should be organized during each sprint, and the development team has to plan it in advance. The duration of those meeting should last 15 minutes only and it is sufficient to discuss the job done in previous day, plan for the current day and set future targets.
- In Stage 6, the *sprint review* should be organized within the developer's team. In the sprint review, the working product created during the sprint should be presented to the product stakeholder, at the end of every sprint.

In Stage 7, the *sprint retrospective* should be taken by the developer's team. During sprint retrospective the team evaluates through discussion the implementation of the finalized sprint and agrees on the plans for improvements in the next sprint period. Like the sprint review, the sprint retrospective should be organised at the end of every sprint.

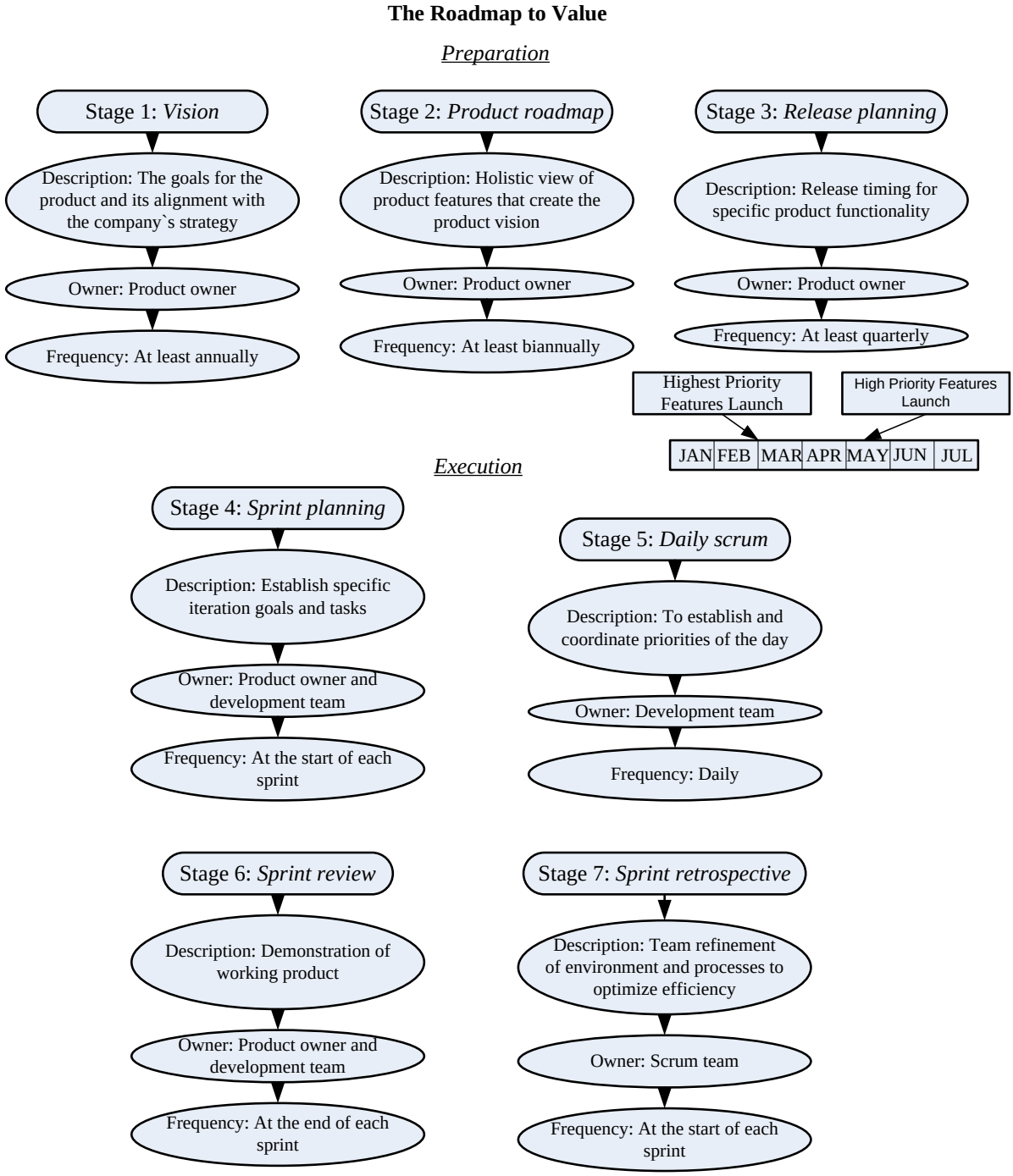

Figure 7.10. The Agile Roadmap to Value (adopted from Layton, 2012)

Agile project teams include the following five roles:

- ***Development team*:** The product development team develops the new product. The relevant staff competences for such team most usually are: programming, testing, and designing. Product developers are working on a day-to-day basis on this development.
- ***Product owner*:** is responsible for information flow between the customer, the stakeholders, and the development team. The definition of the product according to the

customer's needs and priorities is an essential task for the product owner. The daily responsibilities of the product owner are related to the clarification of requirements to the development team on daily bases. The product owner is also often called a *customer representative.*

- ***Scrum master or** project facilitator* is the person who supports the development team, by clarifying the roadblocks to the organizational issues and organizing the agile process in a consistent way.
- ***Stakeholders:*** It is a person, a group of persons, or organizations, which support the project and are interested in the results. The stakeholders are not responsible for the product, but they specify certain input and their impact on the outcome of the project.
- ***Agile mentor*:** The experienced agile projects implementer shares agile approach practice with the team of developers.

Agile Project Management Artefacts

It is obvious that project progress should be measurable. Agile project teams usually use six main *artefacts, or deliverables,* in order to evaluate products progress, as listed here:

- ***Product vision statement*:** The defined position for dedicated product in the strategies of the organisation. The vision statement must clearly describe the product development goals.
- ***Product backlog*:** The prioritized complete list of project feature, which are in the scope of the project.
- ***Product roadmap*:** It is the high-level product development roadmap, a view of the product requirements, with indication for time frame, as needed for the requirements development.
- ***Release plan*:** A high-level planning timetable of the working product release development.
- ***Sprint backlog*:** The goal, user cases, and tasks associated with the current sprint.
- ***Increment*:** The defined functionality of working product at the end of each sprint.

Agile Project Management Events

There are seven stages in the Agile product development projects approach, and they have to be organised in the following form of events:

- ***Project planning:*** The creation of a product vision statement and a product roadmap is an aim of the initial planning stage. The project planning could be performed usually in a single day.
- ***Release planning*:** It is a project step, during which planning of product features for the next set to release and identification of the product launch date should be agreed in this stage.
- ***Sprint:*** The development stage. It is one development cycle in scrum. A good planning practice advice is to keep the same length of sprints throughout the project.

- ***Sprint planning*:** A meeting at the beginning of each sprint where the scrum team commits to a sprint goal.
- ***Daily scrum*:** A short daily meeting in a sprint. The team members inform each other about results of work from the previous day, plan for the actual day, and briefly discuss future plans.
- ***Sprint review*:** It is a meeting which is planned at the end of each sprint. During this meeting, the product owner should be informed about the development progress. the functionality of the working product is also demonstrated by the product developers.
- ***Sprint retrospective*:** It is a methodological feedback planned at the end of each sprint, where the scrum team discusses successes and failures during the sprint.

7.10.2. Agile versus traditional project management

Let us compare Agile Project Management with traditional project management to show how the approaches differ. Traditional project management as Waterfall model is depicted in Fig. 7.11, while Agile project management model is depicted in Fig. 7.16. Table 7.3 provides a comparison between traditional and Agile project management.

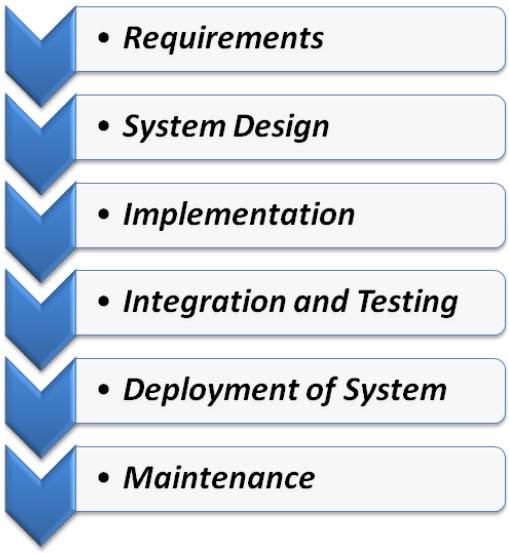

Figure 7.11. Project management traditional Waterfall model (the figure is from Sharma, 2016)

Ultimately, traditional project management is often best in a stable environment, where a defined deliverable is needed for a fixed budget. Agile is often best where the end-product is uncertain, or where the environment is changing fast. How to choose between traditional and Agile?

Traditional	Agile
• Change is very expensive	• Change happens frequently
• Well-defined requirements	• Requirements not well-defined
• Project is familiar territory	• New technology or project domain

• Customer is difficult to communicate with	• Customer is not sure of what is desired

Table 7.3. Comparison of traditional and Agile project management

Agile Project Management	Traditional Project Management
Teams are self-directed and are free to accomplish deliverables as they choose, as long as they follow agreed rules.	Teams are typically tightly controlled by a project manager. They work to detailed schedules agreed at the outset.
Project requirements are developed within the process as needs and uses emerge. This could mean that the final outcome is different from the one envisaged at the outset.	Project requirements are identified before the project begins. This can sometimes lead to "scope creep," because stakeholders often ask for more than they need, "just in case."
User testing and customer feedback happen constantly. It is easy to learn from mistakes, implement feedback, and evolve deliverables. However, the constant testing needed for this is labour-intensive, and it can be difficult to manage if users are not engaged.	User testing and customer feedback take place towards the end of the project, when everything has been designed and implemented. This can mean that problems can emerge after the release, sometimes leading to expensive fixes and even public recalls.
Teams constantly assess the scope and direction of their product or project. This means that they can change direction at any time in the process to make sure that their product will meet changing needs. Because of this, however, it can be difficult to write a business case at the outset, because the final outcome is not fully known.	Teams work on a final product that can be delivered some time—often months or years—after the project begins. Sometimes, the end product or project is no longer relevant, because business or customer needs have changed.

Apart from traditional Waterfall projects (see Fig. 7.11.), Agile projects are broken down into small, consistent time intervals. These intervals are referred to as sprints. They can be as short as a few days and generally take no longer than 3–4 weeks.

The team typically works for 1–3 week on sprints depending on the extent of the overall project. During a sprint there is a dedicated team that includes designers, developers, and business people working together. Before each sprint, there is a sprint planning meeting (often combined with the sprint review meeting). This meeting determines what the goals are for that sprint. Based on the team's velocity, a set of features are pulled from the top of the backlog. During

the sprint no features are added, and the sprint goals do not change. The only exception to this is the case when the team finishes a sprint early. Client communication is generally limited to the daily stand-up results, but some firms allow for an open dialog via a chatroom (see Fig. 7.12.).

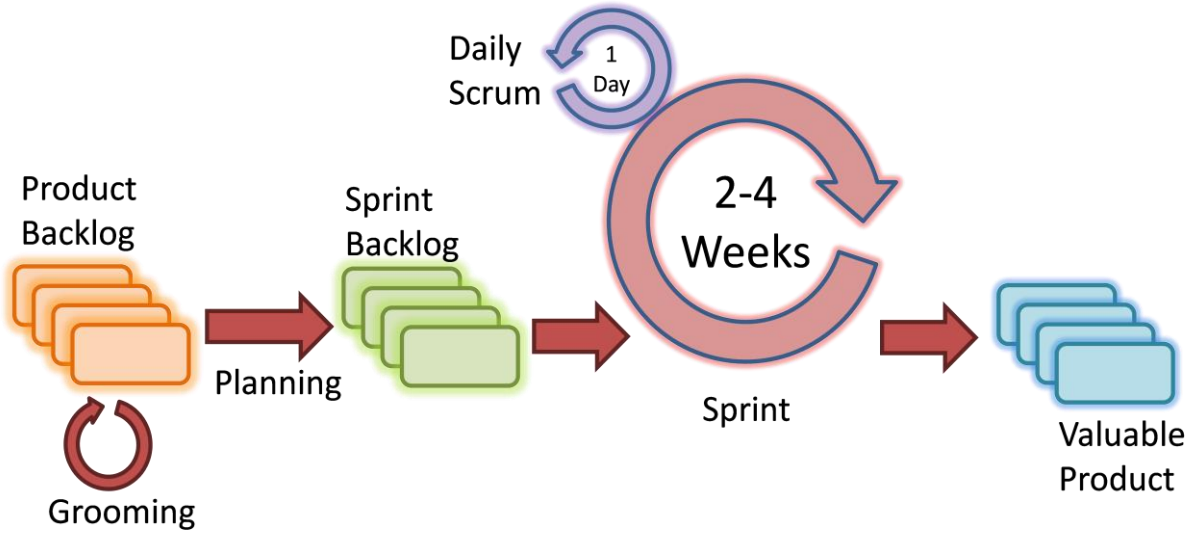

Figure 7.12. Agile project management process model (the figure is from Smith, 2011)

Scope of Agile Project Management

In an agile project, the entire team is responsible for managing the team; it is not just the project manager's responsibility. When it comes to processes and procedures, common sense is used over written policies. This makes sure that there is no delay is management decision making and therefore things can progress faster.

In addition to being a manager, the individuals responsible for the agile project management should also demonstrate the leadership and skills in motivating others. This helps retaining the spirit among the team members and gets the team to follow discipline.

The agile project manager is not the 'boss' of the software development team. Rather, he or she facilitates and coordinates the activities and resources required for quality and speedy software development.

Responsibilities of an Agile Project Manager

The responsibilities of an agile project management function are given below. From one project to another, these responsibilities can slightly change and are interpreted differently.

- Responsible for maintaining the agile values and practices in the project team.
- The agile project manager removes impediments as the core function of the role.
- Helps the project team members to turn the requirements backlog into working software functionality.

- Facilitates and encourages effective and open communication within the team.
- Responsible for holding agile meetings to discuss the short-term plans and formulates plans to overcome obstacles.
- Enhances the tool and practices used in the development process.
- The agile project manager is the chief motivator of the team and plays the role of a mentor for the team members as well.

Agile Project Management does not:

- Manage the software development team
- Overrule the informed decisions taken by the team members
- Direct team members to perform tasks or routines
- Drive the team to achieve specific milestones or deliveries
- Assign tasks to the team members
- Make decisions on behalf of the team
- Become involved in technical decision making or deriving the product strategy.

7.10.3. Conclusion

In agile projects, it is everyone's responsibility (developers, quality assurance engineers, designers, etc.) to manage the project to achieve the objectives of the project. In addition to that, the agile project manager plays a key role in the agile team in order to provide the resources, keep the team motivated, remove blocking issues, and resolve impediments as early as possible. In this sense, an agile project manager is a mentor and a protector of an agile team, rather than a manager.

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Chapter 8: Thesis Presentation

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8.1. Introduction

The success of a thesis presentation does not only depend on the content of a student's presentation during the defense but also on the way of communicating the message. In this chapter, students will learn how to prepare and structure an oral presentation. Furthermore, some communication techniques and tools are added, as well as a number of tips for an effective PowerPoint presentation. Some techniques are more general and apply to all presentations, while other techniques focus on the thesis presentation.

8.2. Preparation of an oral presentation

A successful presentation starts with a good preparation. Hereby, students always have to keep in mind three basic questions:

- Who is the audience (target group)?
- Which goals do students want to achieve (objective)?
- How can students optimize their message so that it will suit the target group and the objective (message)?

8.2.1. Target group

The identification of the target group offers multiple benefits in making your ideas/results resonate with the audience and being confident that the performance will have the desired impact on the audience. Knowing the target group offers multiple benefits. First of all, it improves the efficiency of the message because students can adapt multiple elements during their presentation including the degree of difficulty, the content, and the form. Furthermore, the probability to reach a positive effect with the intended message increases. Finally, students will be able to better connect to the audience. Students should visualize their target group by asking the following questions:

- Is the audience internal or external?
- What does the audience know about the subject?
- What are the expectations?
- Which interests does the audience have?
- Which content level can the audience handle?
- To what extent does the audience welcome the subject of this presentation?
- Which other characteristics (e.g., educational level) are important?

8.2.2. Objective

What do students want to achieve through their presentation? In other words, at what point will they be satisfied with the result? Students should try to formulate the objectives of their

outcomes as accurately as possible. Students should contemplate what they expect the audience to remember and take away with them after their presentation.

8.2.3. Message

After visualizing the target group and the objectives, students will be able to adapt their message accordingly. What will be the key message? To answer this important question, students should follow some of the principles outlined below:

- KISS principle ('Keep It Simple, Stupid'): students should limit the information to the topics which are relevant to the audience. They should focus on the core of their message. Students should keep it simple by translating the research results in 'human language'. Simplicity also applies to the form and the style. Students should not distract the audience from the content of their message by using distracting elements in their presentations.
- Communicate clearly and avoid doubt about the content of their message. Students should always be consistent with their vocabulary and style. For example, they should always use the same term to refer to the same concept. Since the audience needs repetition and confirmation, students should apply the 'TTT formula' ('Tell them what you are to tell; then tell them and finally tell them what you told them').
- Empathize with the audience. Students should think about what kind of information they want to deliver to the target audience and adjust their language and style according to their target audience's needs. Students should provide examples which could be easily understood by the target audience.

8.3. Structure of an oral presentation

A good presentation has a clear structure. It helps the audience if students inform them at the beginning what they can expect and how the presentation will be built up. Students could achieve this goal if they plan the speech into smaller components, thus tackling one area at a time. As already mentioned above, repetitions and summaries are necessary. The audience needs redundancy, i.e., repetition of the message using other words. The most obvious structure is the 'head-body-tail' structure.

8.3.1. Head of an oral presentation

The head includes a table of contents and an introduction to the topic. Here, students have the opportunity for an exciting opening! As Aristotle argues, 'well begun is half done'. Those who start with an attractive opening, are more likely to engage and maintain the interest of the target audience. Subsequently, students should present the problem definition of their master thesis by formulating the research questions briefly and concisely.

8.3.2. Body of an oral presentation

The body contains the actual message which is the core of the presentation. Students should underpin their point of view using cogent arguments. Students can use the table of contents presented in the head (see section 8.3.1.) as the common thread throughout their presentation. Each time students start a new section, they should project the table of contents again, highlighting this new section. In this way, the audience could easily follow the line of the students' presentation.

8.3.3. Tail of an oral presentation

In the tail, students should summarize the research results of their master thesis and reach a well-considered and precise final conclusion. Furthermore, students can add some future perspectives and possible further directions of research.

A good closing argument is very important. The final points delivered during a presentation could be well memorized by the target audience even after the ending of the presentation. Students should keep their conclusions short; the audience has already listened for a while, so their level of concentration is more likely to drop at the end of the presentation.

8.4. Communication techniques

Students should use several communication techniques to ask and grab the attention of the target audience. Some of these techniques are described in more detail below.

8.4.1. Body language

Students are not only communicating with words. Their facial expressions, movements, and gestures could also communicate the intended message. With body language, students could convey more effectively the intended message. But, body language could also undermine the message if students unintentionally convey, both verbally and non-verbally, different or contradictory messages. In the latter case, people could rely on the non-verbal signals and less on what they actually try to convey.

Students should move on the stage in a relaxed manner and should use gestures (hands and feet in a manner of speaking) to reinforce their intended message. With an open and relaxed body position, students should express their engagement with the audience. It is important to avoid crossed arms. Students should use a pointer instead of their hands to draw attention to a part of the projected slide.

Finally, students should be dressed and act professionally during their presentation. Following the appropriate dressing code could also show respect to the audience and more precisely to the committee members.

8.4.2. Eye contact

Students should strive to make a good eye contact with all the audience and not only with the chairman. Students should not simply focus on their personal notes. If students attempt to make eye contact, they are more likely to express their interest in the audience and appear more self-confident. If students do not make eye contact, it could be perceived as fear or insincerity.

8.4.3. Voice

Students' voice is the mirror of their soul. The audience could determine by a student's voice if he or she is tense. A good and firm voice could begin with one's breathing. A student's breathing, in turn, could begin with a good body position. During their thesis presentation, students should:

- Stay or sit firmly with both feet on the ground.
- Relax their shoulders.
- Keep their head upright.
- Breath with their abdomen. Abdominal breathing could ensure a maximum filling of the lungs with a minimal effort. The larger the inhalation, the larger the exhalation, and the fuller their vocal sound.
- Create variation of pitch. Those who use a different pitch or intonation could hold the attention of the audience. A low voice is more pleasant than a high voice.
- Control their voice volume. If students speak loudly from time to time, they could attract the audience's attention. The audience will be more likely to get annoyed or intimidated by loud speakers.

8.5. Communication tools

People focus on the ears of the speakers for 20% of the time, but more attention is paid to the eyes of the speaker, 80% of the time. Therefore, students should let the people in the target audience see what they are trying to convey during their presentation! Students should use objects to deliver their points. For example, they could show photographs, figures, or slides. If possible, students should illustrate their speech through actions.

But above all, students should make use of communication tools which clarify things quickly. Today, the most widely used tool is a PC combined with an LCD-projector. This is quite suitable for a presentation to a larger group (about 50 people). Using the PowerPoint software (see section 8.6), students could deliver an effective presentation.

Benefits:

- With a visual presentation, students should hold the line of their speech.
- The presentation provides a basis to the audience and personal notes to the speaker.
- Students could provide handouts of their PowerPoint presentation.

Risks:

- In many cases, a visually effective presentation is obtained at the expense of the content. Flowing images, falling letters, and multi-coloured presentations could distract the target audience and fail to deliver the actual message of the thesis.
- A presentation with an LCD-projector requires some technical knowledge and preparation ahead of time, so students should set and test the LCD-projector prior to their presentation.
- In many cases, students tend to overload slides with information.

8.6. Tips and tricks for a PowerPoint presentation

Many speakers use the PowerPoint software to visually support their presentation. This is usually anticipated by the target audience. Although students could have endless possibilities to design splashing and colourful slides, such as swirling movements and popping sounds, students should use it consciously and constructively to deliver the intended message. Students should:

- Use the right template of their academic institution.
- Design clear and readable slides which can be easily visible at the back of the room. Therefore, students should use a font style which is not too small or difficult to read. Students should avoid rounded fonts, such as 'Times Roman'. There is a difference in readability between a text on a computer screen and a text projected on a screen in a room.
- Not use more than 1 to 2 different fonts. The use of a variety of fonts could distract the audience. To highlight some terms, students should use layout possibilities, such as text size, bold, and italic.
- Overemphasize contrasts without using bright colours. If a slideshow is projected on a screen, colours and contrasts could fade away. Further, students should create enough contrast between the text and the background.
- Limit themselves to one background style. Several backgrounds could be distracting.
- Choose the right colour combinations and should ensure that the content can be easily read. Students should choose a light and uniform background and dark letters. Examples of wrong colour combinations are:
    - black letters, red background,
    - white letters, yellow background,
    - purple letters, blue background,
    - red letters, purple background.

  Students should also consider colour blindness. A color-blind person could see little or no difference between red and green.

- Students should use a maximum of three colours per slide.

- Students should not overload each slide with excessive and often unnecessary information. Students should make sure that every line consists of a maximum of 6 words. Students should limit themselves to a maximum of 8 lines per slide. Students should use keywords and should avoid articles, verbs, or sentences on their slides. Students should keep it short and should provide further explanations during their presentation. The attention of the audience will drop if all and often unnecessary details are provided during the presentation. During a presentation, the focus should be placed on listening rather than reading.
- The slides should not distract the attention of the audience from the speaker. The slides should support a students' speech. Therefore, students should strategically avoid using any content or material that can be distracting.
- Students should avoid the use of animation effects, such as textlines and figures sparklingly scattered in a presentation. Nothing can irritate the audience more than distracting animation effects. Furthermore, those effects make a file unnecessarily large and consequently slow down the presentation.
- Students should not use sounds. Similar to the animation effects, sound effects which highlight the change of a slide could also cause irritation.
- Students should not use too many slides since that might speed up the slide presentation as the presentation advances. In general, students should adopt the rule of thumb that one slide should be visible during at least one minute.
- Edit copied illustrations. Students should not copy blindly the photos, drawings, and graphs from the web or the articles. Many of these illustrations are not intended for use in a presentation. When copying blindly, the audience could only view unclear legends, lines, and/or numbers. If it is not possible to edit properly an illustration, then it would be better to omit it.
- Students should not have many slides in their presentation since the figures or photographs could appear very slowly or students would have to wait for a very long time until the file downloads from the internet. Here are some preventing tips:
    - Students should scan graphic material using a resolution of at most 75-100 dpi. They should choose a higher resolution only if if they need more details.
    - Students should compress the TIF(F) files by saving them as JPG or GIF files. This is readily accomplished by means of an image processing program such as Photoshop and Paint ShopPro. Students should use a JPG format in case of (color) photographs and a GIF format in case of black-and-white photographs.
    - Students should edit their scans before they use them. Resizing, cropping, or recolouring images could easily be done using any image processing program. Students should save the final result and use this image in their PowerPoint presentation.
    - After completing their presentation, students should let the PowerPoint software itself compress all figures again to reduce the size of their ppt file. If students add new figures afterwards, they should repeat this action. Note: by compressing, some information will be lost. This is not a problem in case of

screen use and projection. However, students should save the original image on their PC.
    - Students should limit their animation effects.
- Students should number their pages. During the defense of their master thesis, a member of the committee can refer to a page number when asking a question. This is quite useful.
- Last but not least! Students should save their PowerPoint presentation and have several backups, such as a USB-stick, a Hard Disk, and the cloud using a network connection.

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Chapter 9: Introducing New Offers to the Market

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9.1. Introduction

Rapid economic and market turnover determine the development of business opportunities and more effective ways for introducing new products to the market or enhancing existing ones. The development of new products, goods and services for the market is a challenge, especially where new technologies are required in order to yieldpositive economic effects. The introduction of new offers to the market is related to idea generation, idea development through project management, new offer introduction and management of product life cycle. The introduction of new ideas to the market, using a project management approach, facilitates more efficient outcomes, effective ways to enhance speed and meet quality targets, and time and resource planning to facilitate task implementation. By definition, any business formation may require setting goals and reaching them, so that the result satisfies both the goods and service to customers (Rankis I, Kunicina N., 2006, Kunicina N., 2006). The new market products could be developed for new or existing markets. The Ansoff Matrix (Fig. 9.1) is a strategic planning tool that provides a framework to help executives, senior managers, and marketers devise strategies for future growth. It is named after a Russian-American, Igor Ansoff, who came up with the concept (Matrix, 1957). It was first published in the Harvard Business Review in 1957, in an article titled "Strategies for Diversification." It has given generations of marketers and business leaders a quick and simple way to think about the risks of growth. Sometimes called the Product/Market Expansion Grid, the Matrix shows four strategies that can be used to expand a business. It also helps analyze the risks associated with each one. The most essential feature is that each time there is a movement to a new quadrant (horizontally or vertically) the risk increases.

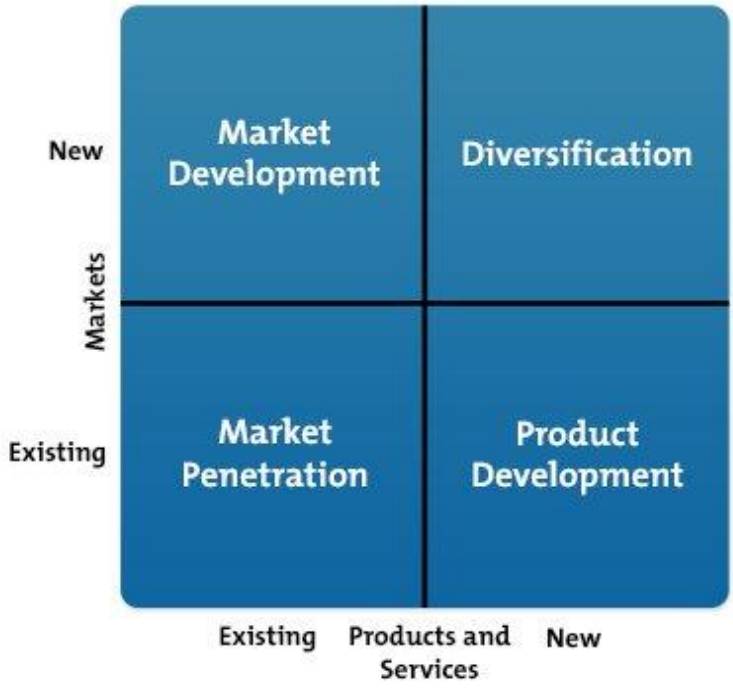

Figure 9.1. The Ansoff Matrix (Matrix, 1957)

There are only four possibilities in developing market ideas. Market penetration focuses on sailing existing products in the existing market. Product development describes the introduction of a new product into an existing market. Market development is a strategic step that provides means new markets for an existing product, and diversification; it deals with the introduction of a new product into a new market. The topics of market thesis are usually related to product development or market development and form an exception to diversification.

Pure scientific research is usually related to diversification; this research should be conducted at the PhD level. Technology development, which may derive from scientific research, is an innovation path from basic research to market the product, as shown in Fig. 9.2. Applied research deals with product development, which could reach the market in the medium term period. Pure scientific research can bring results to market in the long term. The engineering tasks are mostly related to applied research, while fundamental scientific research is mainly related to the development or synthesis of new basic principles in physics, chemistry, and so on.

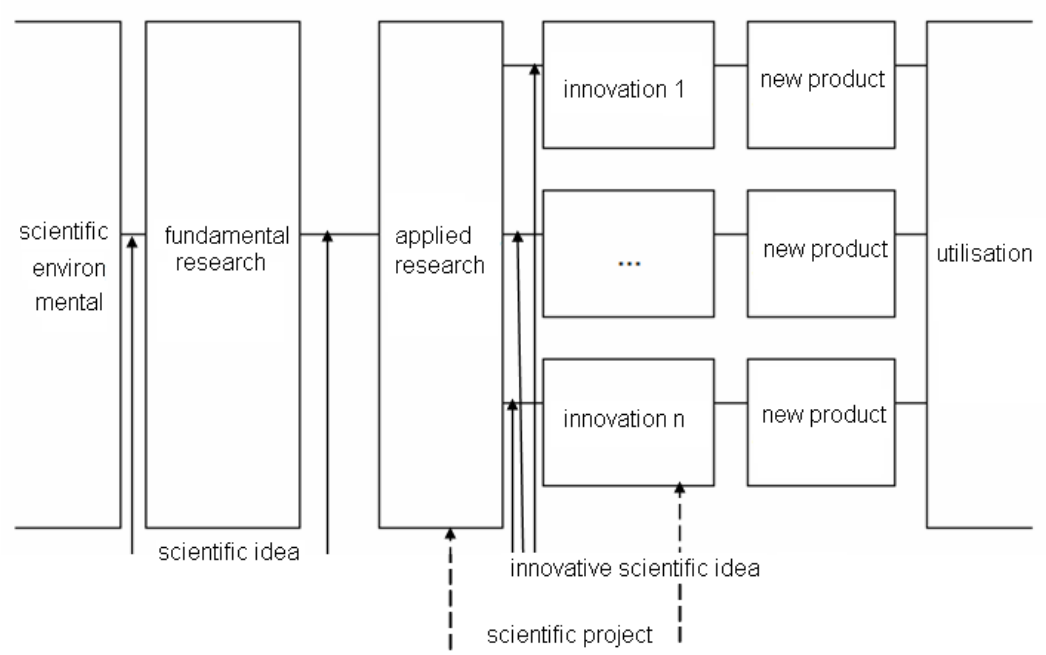

Figure 9.2. Project path from basic research to market the product

Over the last 10 to 15 years, the term "innovation" has steadily become an established practice. Innovation is a very broad concept which includes both scientific research and financial and market organization, as well as other measures. In this chapter, the focus will be placed on innovation related to new technologies and products which result from the establishment of new scientific methods - that is, scientific projects and their management. New technologies and products that emerge from scientific projects are considered to be the so-called applied research.

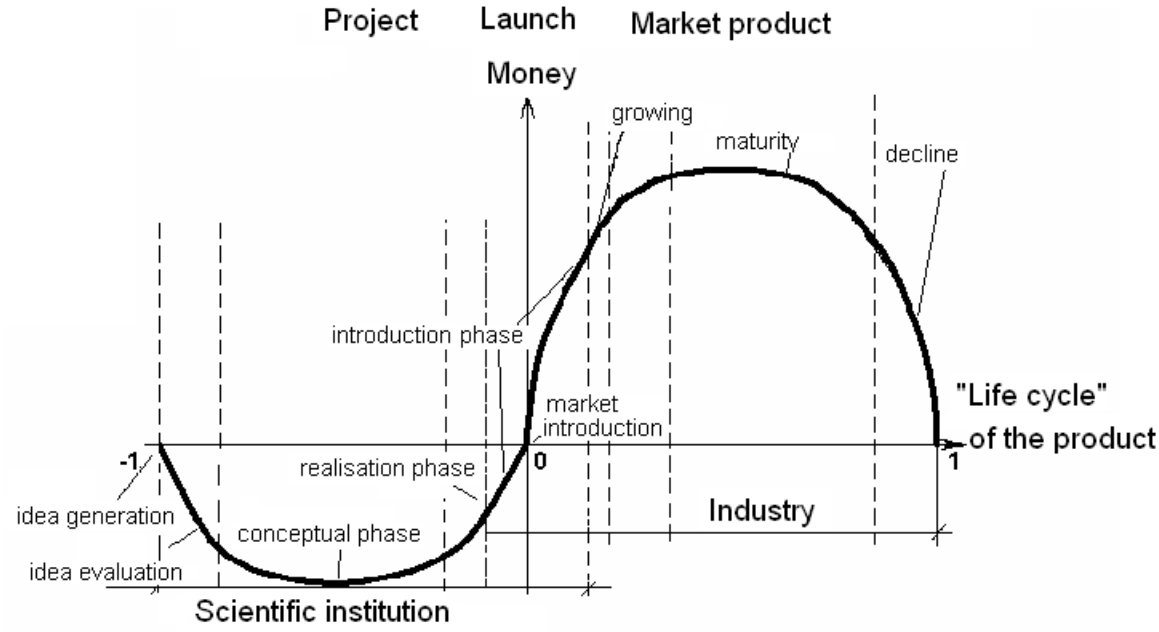

Figure 9.3. A successful scientific research development cycle from the start of the project to the end product of commercial use

The development of an idea from the very beginning until it reaches the market, as well as the scope of project management and marketing, is shown in Fig. 9.3. The actions and money flow during the period from idea generation to the end of a product lifecycle are also illustrated in the figure. During the development stage, scientific- and market-oriented projects are often made in collaboration with scientific and industrial partner teams. The idea development is usually implemented using a project approach, and it could be generally divided into the following phases: idea generation, idea evaluation, conception, realization, and implementation. In scientific research projects, the additional research phase should be taken in account.

For an industrial application, the new market product should be introduced in cooperation with scientific research organizations and enterprises. This cooperation, the production, and implementation phase involve representatives of both the scientific research institutions and industrial companies.

The general principles of innovation management, which are discussed by Trott (1998), are classified by the original A. Pearson map – where product and technology development during phase 4 map the job sequence and separate stages of uncertain representation (Fig. 9.4.).

As it is illustrated in Fig. 9.4, during the first stage of research, there is considerable uncertainty about both the process itself and its outcome. The research phase of the start-up is based on the idea of new product opportunities. The research project is being carried out during scientific feasibility studies, during which information is collected on one's opinion on a new product, process or service development, modification and improvement of the technical feasibility, and financial effectiveness.

The second phase is the development of engineering, during which the research results are implemented in pilot products and technologies are developed for the new product, process, service, or the original sample, including prototyping. It should also be noted that at this stage there is a high level of uncertainty about the process, because the research was realized with simplified models. However, the clarity of the outcome is high, because it has been identified during the research process.

The third stage involves the use of engineering measures that is, established industrial technology or products that can be promoted to the technical information material. There is no longer a level of uncertainty about the process at this stage; however, there is still a high level of uncertainty in the creation of a product or technology that can benefit a wide range of applications. The uncertainty refers to whether the product will be accepted by the consumer after perceiving its new and advanced features. The final stage is the market and the technological possibilities of the development stage, during which there is a small level of uncertainty in both the process and the outcome.

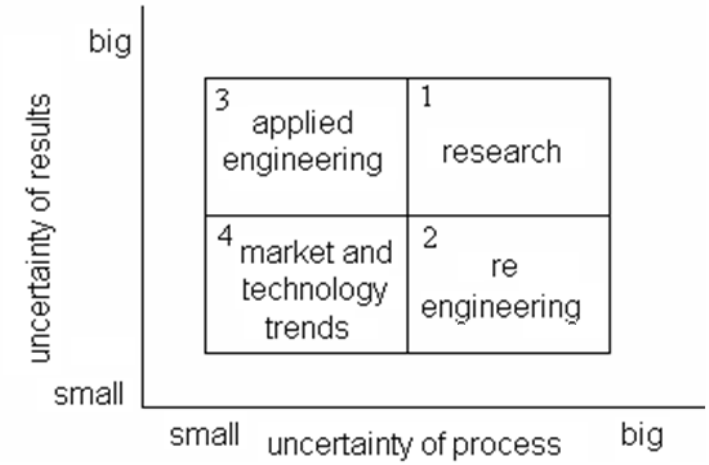

Figure 9.4. Technologies and products in innovative process steps and the uncertainty characteristics

A research project carried out during a master thesis is carried out in circumstances where there is considerable uncertainty about the process. That is, there is a big hit risk from the very beginning of the research project. As an organizational method, project management has arisen from the need to plan, manage, and control a variety of interrelated activities in the course of the project. Project management is also up to date with scientific projects. Management is responsible for project failure. As a result, to reduce the level of risk in the master's thesis and research project execution, students need to ensure the successful execution of the research work. Students should ensure the effective implementation of Phase 1, possible case 2, and another phase of successful realization. This chapter presents the scientific project for the leaders of both the required range of activities of the project and their successful implementation and the individual stages of the project characteristics, and those where further work is needed to facilitate the research project and its effective enforcement. The outcome of the research

project is a new patented solution, which could be implemented in the market, while its value is defined on open market conditions.

9.2. Technology development

Technology analysis ties together customer needs and technology opportunities. It presents the tradeoffs between customer needs and technology opportunities. The technology analysis (Fig. 9.4.) action map shows the main steps emerging from the analysis of available technology on the market until customers' needs are met. It also helps to figure out the optimal offer needed to market a new product development methodology, and to uptake risk mitigation plans, including technology risks.

Table 9.1. The technology analysis action map

Technology development trend	Reliability Capacity User interface Design	Easy to use Maintenance is cheap and convenient	Functionality: e.g., electromechanics	Cover; Software; Hardware	Thermo physics Precision mechanics Electronics
Market	**Customer utility**	**Performance**	**Components**	**Subsystems**	**Technology**
Customer					**Technology**

The market offers are usually grouped in the related product groups, which may include either several offers, based on the same technology, or may satisfy the same customers' needs. However, they may be packed as different market products and may be priced or branded differently.

A platform is a technical entity which enables the provision of a set of products for same or different customer needs. Intelligent networks are an example of platforms in electrical engineering. These platforms can promote products or functionality of products, which are based on some other platform. A product or an offer can be based on several platforms, which can enable different functionalities, such as different access technologies, a network protocol, or a content protocol.

The main Product Strategy definition process steps are presented in Fig. 9.5.

Idea • New offer idea brainstorming and evaluation • Product Master Plan (PMP) draft	
Kick-off • Approve approach and schedule • Approve Development Teams • Approve work plan	
Platform definition • Identify existing platforms • Platform Team	**Product line definition** • Identify existing product lines • Product Line Team
Platform summary	**Product line summary**
To New Offers Board	

Figure 9.5. Product Strategy definition process

The new product must be defined in the context of the market needs, so it should not only include the product or service itself, but also all the related processes, which should be arranged according to the corresponding market. With the high completion on the open market, companies have to constantly develop new products and services to strengthen their market position and win new markets with innovative ideas which link marketing and engineering approaches (see Fig. 9.6) (Livotov, 2013).

Today it is not enough to satisfy customers' need. Customers want to be 'excited'. Only those companies that meet these high consumer demands and expectations will be able to keep their customers in the long run. The so-called 'excitement elements' and new product features can be accurately and quickly predicted with the help of the evolution patterns of technical systems as the most important TRIZ component; TRIZ is a Russian acronym used to refer to "Theory of Inventive Problem Solving". The conventional and modern methods of market research are effectively assisted by TRIZ in the analysis of future market requirements. As a further development of the QFD method (Quality Function Deployment), the real but often hidden expectations of the customers can be determined and the most effective product features can be defined. Having completed this phase, the TRIZ tools can now help to implement the required features into the new technical solutions and innovative products. Such a systematic link of marketing and TRIZ know-how can lead to a unique market position.

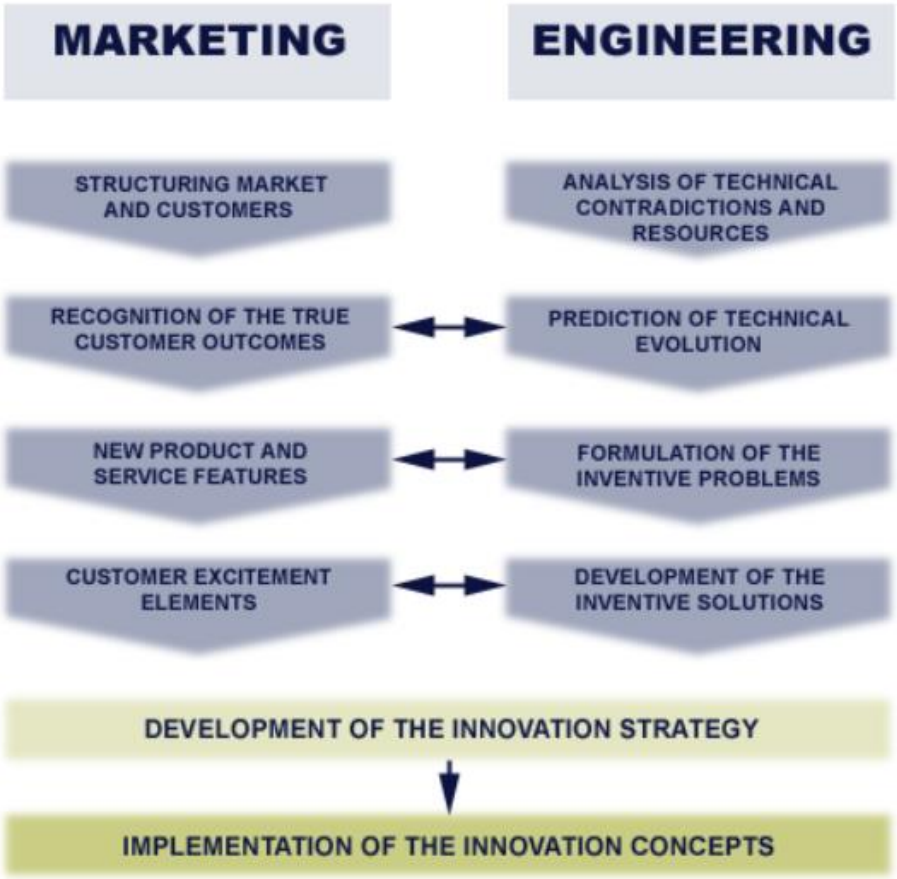

Figure 9.6. Linking Marketing and Engineering (from Livotov, 2013)

The analysis of several thousand patents led to the conclusion that inventive tasks and technical contradictions from all kinds of industrial branches could be solved by a limited number of basic principles (techniques). Modern TRIZ contains 40 basic Inventive Principles. Here are some examples:

11. Principle of the "safety cushion in advance" (preventative measure).
18. Principle of the utilization of mechanical vibration.
22. Principle of the conversion of harmful influences into beneficial ones.
27. Principle of disposability (use of cheap short-livings objects).
28. Replacement of the mechanical system.
35. Transformation of the physical and chemical properties.

The analysis of more complex tasks revealed that they could only be solved by the simultaneous use of several such principles, along with various physical effects. Such a particularly effective combination of principles and effects forms the system of Standard solutions of inventive tasks.

TRIZ Standards are general laws for the synthesis and transformation of technical systems (TS). They are based on the patterns of the evolution of TS. Some of the Standards directly represent the practical application of these laws. The modern system of Standards leads to structured and

highly systematic working methods and can be used further to analyse the technical evolution of the systems and products. It consists of 76 Standards, which are classified into 5 classes and 18 groups:

Class 1: Synthesis and transformation of the technical systems.

Class 2: Enhancement of efficiency of the technical systems.

Class 3: Stages of evolution of the technical systems.

Class 4: Measurement and detection in technical systems.

Class 5: Assistance in the application of the Standards.

The Standards operate with abstract models of technical systems, which are easy to build using the so-called substance-field analysis. Each technical system can be described in terms of available substances, fields, and their interaction. “Substances” are objects or parts of the system, regardless of their degree of complexity. The term “field” is not limited to the four classical physical fields such as the electromagnetic field, the gravitational field and the fields of strong and weak nuclear interaction. In TRIZ, the term “field” also includes all other forms of “technical” fields, such as the field of temperature, the field of centrifugal force, the pressure field, the acoustic field, and the field of odours.

From a business point of view, any enterprise has strategic planning in order to set priorities in company development, which are formalized as an organizational management activity. Strategic planning is a formal approach which allows the establishment of priorities, the arrangement of adequate resources, the conduction of an operation analysis as basis of optimisation process, and the establishment of strong contacts with employees and stakeholders in order to achieve a strong level of synergy in company. Effective strategic planning is needed to ensure formalization of action in all company structures. To develop a formal list to any of the structures of a company's division, an action plan is needed to make progress and to be successful on market. The strategic planning document is a document used to communicate with the organization, the goals of the organization, the actions needed to achieve those goals, and all the other critical elements developed during the planning stage. Strategic management is the list of activities undertaken in order to coordinate and maximize benefits from existing infrastructure resources and actions with mission, as well as the vision and strategy adopted by an organization. Strategic management activities transform the development plan into a system that provides strategic performance feedback to decision making and enables the plan to evolve and grow as requirements and other circumstances change. Strategy execution is synonymous with strategy management and amounts to the systematic implementation of a strategy. Some examples of outcomes from strategic planning of business development are illustrated in Fig. 9.7.

The companies striving to introduce a new product into an existing market are the main target group for such business and technological ideas. The mutual recognition of market needs – that is, the need to meet the technology and product development of a new generation of engineers in the universities is the basis for the successful development of technology-driven companies. During the master’s thesis, students are encouraged to pursue or engage in similar case studies

in their research and establish a strong cooperation with other partners that will help them continue this line of research work during their PhD studies.

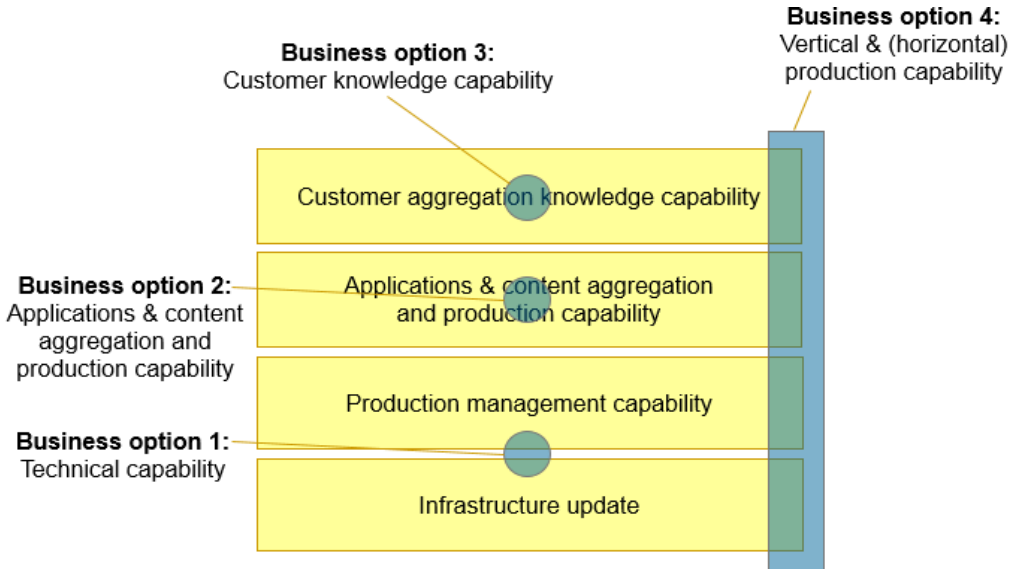

Figure 9.7. The analysis of business opportunities

The technology development plan should be matched with the existing products of companies, which may also require a solid understanding of the current business model (e.g., spin off/ regular product/ special branding). The Product-Line Extension / Positioning Map (Fig. 9.8.) is an effective tool for the planning of product lines, which may result in an attempt to enlarge the existing company market.

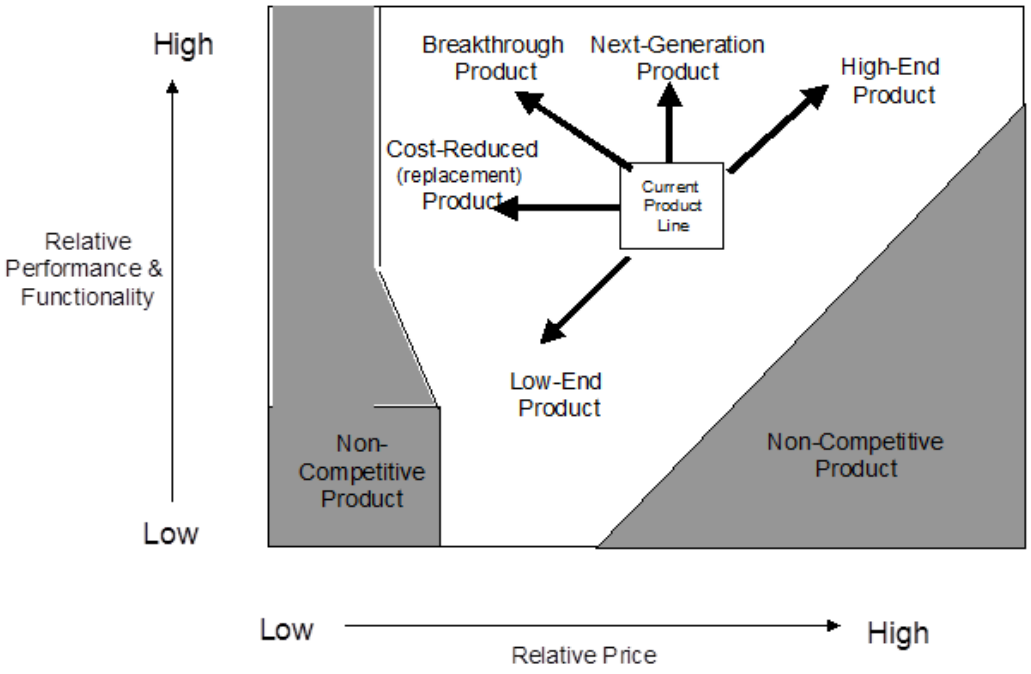

Figure 9.8. Product-Line Extension / Positioning Map

A low-end product is characterized by reduced functionality and low costs policy, and the relative pricing discounts instead of lower functionality. Typically, these products focus on price sensitive segments; however, they could also co-exist with other offers and high price offers. There are cost-reduced products, which may be the "last season" offers, or re-designed products intended to take advantage of improved technology. Typically, this is a planned product price strategy. Breakthrough products usually replace old technology products; that is, this process refers to the transfer of new technology.

The mutual understanding of a technology development timeline, functionality, and potential market can form the basis for the successful cooperation between research institutions and commercial enterprises. The typical master's thesis development process requires cooperation with industrial partner for the development of new technology ideas for business companies. The stage of development of the technological solutions for the market is formalized. The stages of idea development from scratch to the market product is called Technology readiness levels (TRL) (Horizon 2020), where a topic description refers to:

> TRL, the following definitions apply, unless otherwise specified:
>
> TRL 1 – basic principles observed
>
> TRL 2 – technology concept formulated
>
> TRL 3 – experimental proof of concept
>
> TRL 4 – technology validated in lab
>
> TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
>
> TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
>
> TRL 7 – system prototype demonstration in operational environment
>
> TRL 8 – system complete and qualified
>
> TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

The TRL classification is a rather easy descriptive classification, which facilitates a mutual understanding of technology development. It also promotes the evaluation of the required resources, as well as time and investments, in order to develop market ready products.

As an example of new product development for an existing market let us discuss a case study (Noviks, 2016) where the target of this particular research is the development of the "apnea" breathe controller. Apnea Syndrome is a pause in breathing, which is common in premature infants. Currently there are available several ready-made technical solutions on the market that help solve this problem. However, such solutions are expensive and complex. Within the framework of engineering work, a technical solution can be planned in order to facilitate the

maintenance of the vital functions of a child during an attack, without the need for medical personnel to be present.

The main objective of development is the ability to use the device to assess a child's breathing rate effectively, whether the child is in a hospital or at home. This solution will reduce the time premature children spend in the hospital and may lead to an early discharge from the hospital. Often, the good physical condition of a child after birth may allow his/her discharge from the hospital; however, apnea attack can prevent this. The device will help solve this problem, and parents will be able to go home with their child earlier than the current time spent in a hospital after birth. This process can help save some of the funds allocated for the keeping and caring for premature infants in the hospital. A research study has already been conducted in this area, and the prototype was successfully tested in a hospital in Riga, Latvia.

Figure 9.9. Testing of the “apnea” breathe controller

The idea comes from Dr. Varpa from Children’s Hospital Neonatology Department in Riga. The idea was explored further in Arturs Noviks' thesis. At the end of this research study, the first prototype (see Fig. 9.9) was developed and tested.

Firstly, the device requirements were formulated. The physiological characteristics of prematurely born children were also discussed, as well their overall physical condition and the need for detention in the hospital at different stages. It revives the postpartum period and, being in the centre of neonatology, it observes the most common treatment options and children's physiological condition in order to promote the development of a user-friendly device.

Secondly, it was devoted to the study of different devices that provide vital functions of prematurely-born children, their characteristics and typical signs of prematurity, as well as emerging problems at different stages of development.

Thirdly, the offered respiratory diagnostic algorithm was described. It explained the choice of technical solutions and described the study of the data obtained from the records of breathing and heartbeat of newborn children at Riga Children's Clinical University Hospital. At the end of the research study, the developed solution was described at TRL 3 level. After this very first concept testing, questions about the development of the device for the market emerged.

The development of a commercial product should be achieved through a commercial product development project (PMBOK, 2013), while at the same time several emerging constraints should be taken into consideration. . For example, consider a case where both parts of a sensor and detector have to be compatible with medical hygiene requirements. The high percentage of device reliability should be proven. Further, in order to be compatible with Five Nines, which may commonly mean "99.999%", it may require high availability of services, when the downtime is less than 5.26 minutes per year.

The Fine Nine principle could be implemented by taking in account the Mean Time Between Failures (MTBF). MTBF is the predicted elapsed time between the inherent failures of a system during operation. MTBF can be calculated as the arithmetic mean (average) time between the failures of a system. The term is used in both plant and equipment maintenance contexts. The MTBF is typically part of a model that assumes the failed system is immediately repaired (mean time to repair, or MTTR), as a part of a renewal process. This is in contrast to the mean time of failure (MTTF), which measures average time to failures with the modelling assumption that the failed system is not repaired (infinite repair time). Several technological improvements must be carried out by Beta prototype (Melendez, 2017) until a device becomes commercial. For example, consider the need for an alarm transfer when the device fails to transmit the required set of data. There should be a sensor that determines whether there is a sufficiently adequate or contact surface, in principle, at a minimum temperature or capacitive sensor ring. It is also necessary to examine and provide a solution for repairing the sensor or stethoscope - changeable silicone rings – and identify specific ways of repairing the sensor, for example, by using medical-off patches with elastic bands. If commercialization is not followed by the order of at least 300 units (sets with sensors and diagnostic equipment to the end user price category ~ 400-500 euro), an analysis of pricing should be done.

The Business Model Canvas (Osterwalder 2013) reflects systematically on a business model, so one can freely map each of its elements to the real business components. That also means that one does not have to define or enter all of these components. The following list and questions will help one brainstorm the precise idea for his/her next business model innovation (see Fig. 9.10).

1. Key partners
    i. Who are the key partners/suppliers?
    ii. What are the motivations for the partnerships?
2. Key activities

i. What key activities does the value proposition require?
ii. What activities are the most important elements in distribution channels, customer relationships, and revenue stream?

3. Value proposition
    i. What core value does one deliver to the customer?
    ii. Which customer needs to be satisfied?
4. Customer relationships
    i. What kind of relationships do the target customers expect to be established?
    ii. How can that be integrated into a business in terms of cost and format?
5. Customer segment
    i. For which classes are these values created?
    ii. Who are the most important customers?
6. Key resources
    i. What key resources does the value proposition require?
    ii. Which resources are the most important in distribution channels, customer relationships, and revenue stream?
7. Distribution channels
    i. Through which channels can the customers be reached?
    ii. Which channels work the best? How much do they cost? How can they be integrated into a business and its customers' routines?
8. Cost structure
    i. Which are the highest costs in a business?
    ii. Which key resources/ activities are the most expensive?
9. Revenue stream
    i. For what value are these customers willing to pay?
    ii. What and how much have they recently paid? How would they prefer to pay?
    iii. How much does every revenue stream contribute to the overall revenues?

The Project management (PMBOK, 2013) methodology contributes to the development of commercial products. The idea could be developed in two basic ways, either step-by-step or in a cyclic way.

The development of a market-oriented product could be done using different idea development models. The most common idea development model is the Waterfall model (Kruchten, Obbink, and Stafford, 2006) (Fig. 9.11.). The Waterfall model facilitates the distinction of different project stages, and provides step-by-step activities, from idea inception to the delivery of a market ready product.

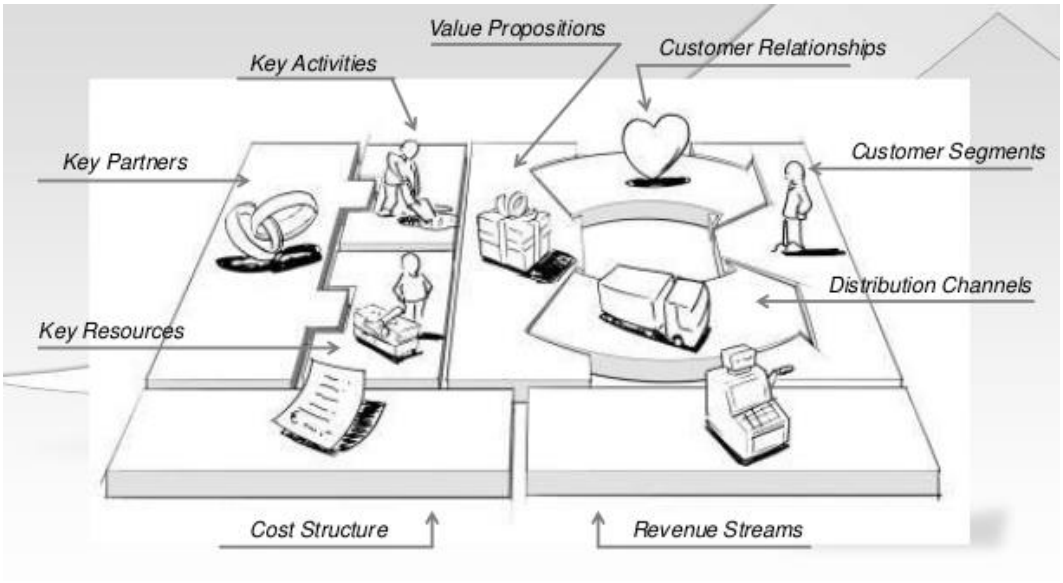

Figure 9.10. Business Modelling Canvas (from Osterwalder 2013)

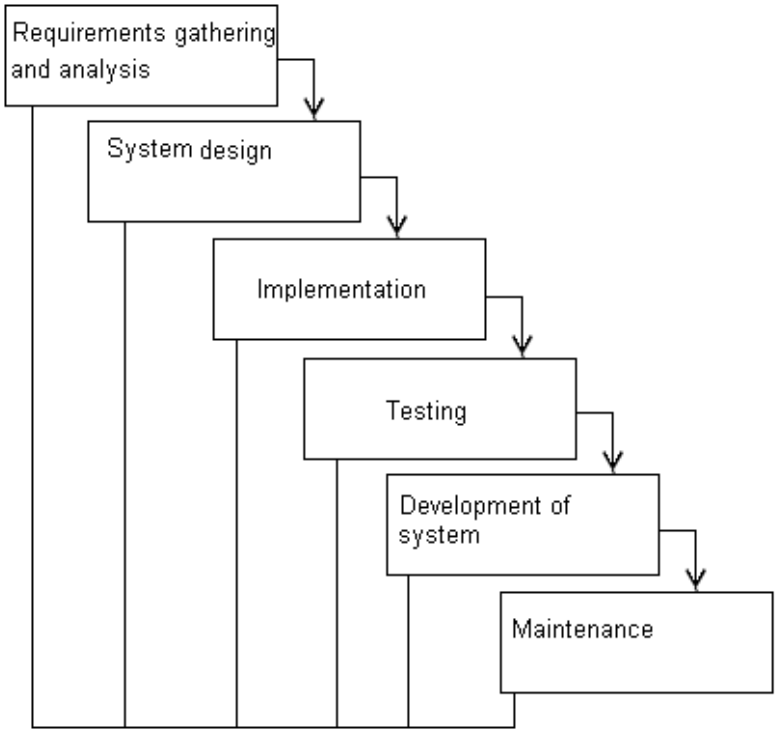

Figure 9.11. Waterfall model

The Waterfall model (Royce, 1970) consists of a sequenced set of stages including analysis of the requirements, testing, integration, and introduction of a product into the market. The waterfall model is well-suited for classical project development stages (see Fig. 9.12): idea development, conception, and implementation.

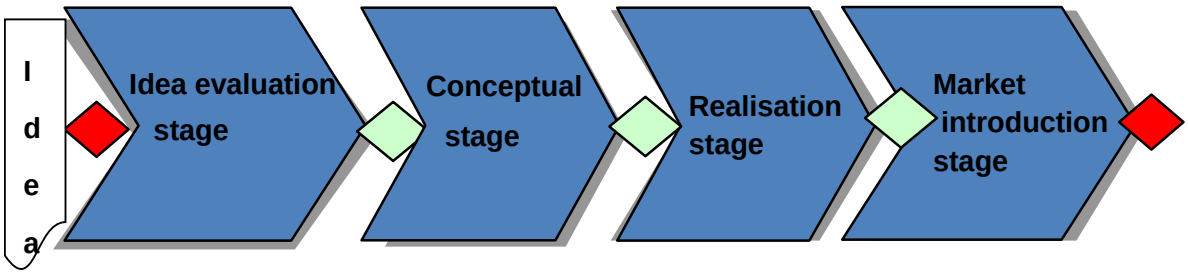

Figure 9.12. Product development

The Waterfall model does not allow the return to the previous stages and foresees that all assumptions made during previous stages were precise.

The spiral model (Fig. 9.13) (Boehm 1988) promotes research on high risk factors by also taking into account that the research could be unsuccessful.

This model was initially formulated for software development, but is also suitable for scientific developments, and in cases where different prototypes are being developed while the market product is configured.

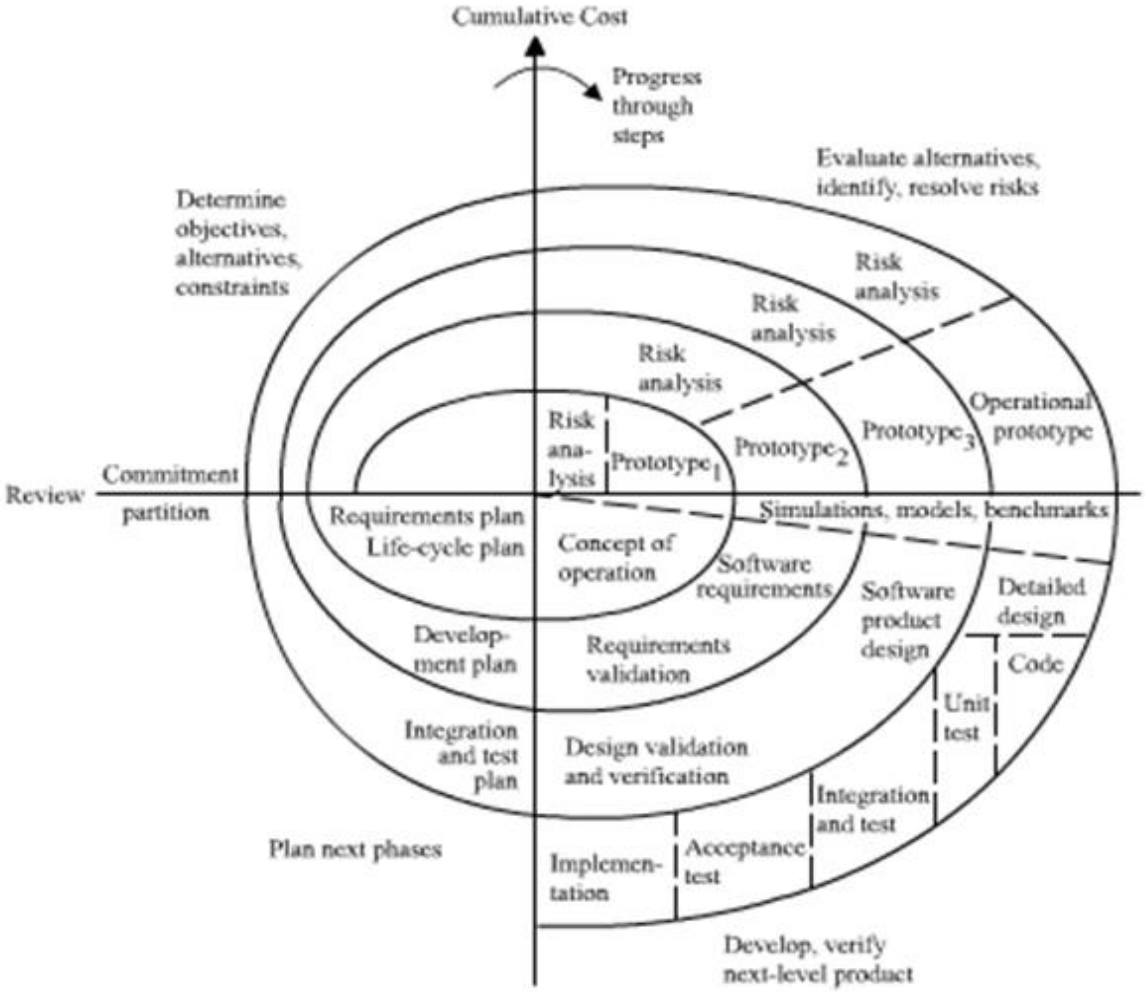

Figure 9.13. Spiral model

The interactive model foresees a parallel execution of activities by performing a continuous analysis of the results and making corrections on the previous phase. In addition, during each stage of development, the project is carried out using the same principles: "*plan-do-check-act cycle"* (please refer to the Interactive Approach principle which is illustrated in Fig. 9.14).

A serious risk mitigation study is necessary at the initial stage. Furthermore, continuous testing facilitates the implementation of an interactive control for the entire project.

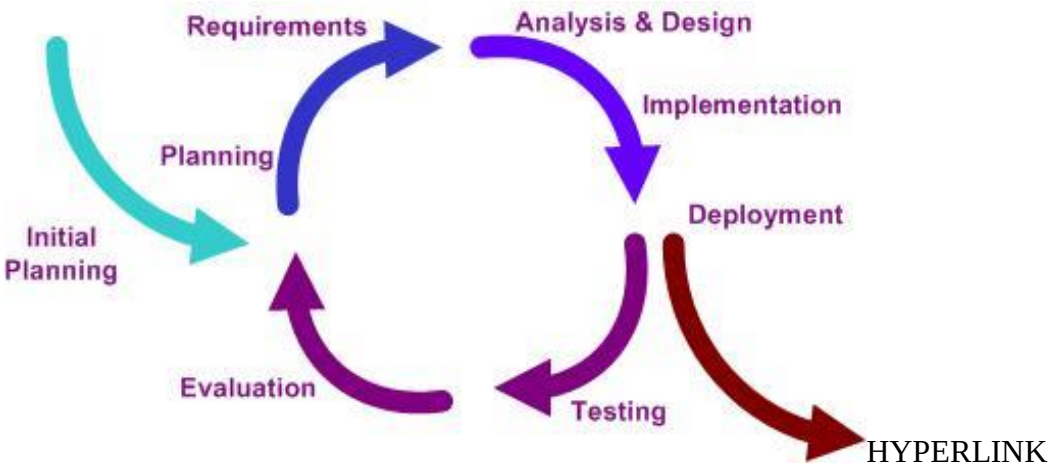

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Figure 9.14. Interactive Approach (accessed from upload.wikimedia.org/wikipedia/commons/a/ac/Iterative_development_model_V2.jpg)

New Approach Notified and Designated Organisations (Nando) Information System

Bringing new offers to the market often requires adherence to European Union and national regulations, policies, and laws. The EU expertise is harmonized, and several EU market access instruments are available for developers.

According to Nando Information System launched by the European Commission,

> Notification is an act whereby a Member State informs the Commission and the other Member States that a body, which fulfils the relevant requirements, has been designated to carry out conformity assessment according to a directive. The notification of Notified Bodies and their withdrawal are the responsibility of notifying the Member State.
>
> The Member States, EFTA countries (EEA members) and other countries with which the EC has concluded Mutual Recognition Agreements (MRAs) and Protocols to the Europe Agreements on Conformity Assessment and Acceptance of Industrial Products (PECAs) have designated Notified Bodies, established per directive. Lists of Notified Bodies can be searched on the NANDO web site (see Fig. 9.15.). The lists include the identification number of each notified body, as well as the tasks for which it has been notified, and are subject to regular update.

NB: The lists of notified bodies are given for information only and are valid at the date indicated. Information is made available as provided by the designating authorities of the Member States.

Any comments concerning the information contained in the lists should be addressed by the notified bodies themselves directly to the relevant competent authorities in the Member States which are responsible for the designation of the bodies (Growth: Internal market, industry, entrepreneurship and SMEs, par. 1-4).

Figure 9.15. NANDO database

9.3. Commercialization and intellectual property

The World Intellectual Property Organization (WIPO) has adopted the following motto: “The human mind is the source of all works of art and inventions”. The human minds are providing novel ideas for technical progress in order to make life easier, comfortable, and effective. The responsibility of the government is to take care of works of art and inventions”. Materialized human mental activities, such as intellectual property, is protected by each two legal spheres: copyright and other-related rights, and industrial property rights (Baltvilka M. and Greivulis J., 2006.).

It is vital for students to become acquainted with some of the elementary aspects of IP, so that they can fully benefit from it, regardless of the career path they eventually pursue. Students and academic institutions should be aware, too, of how they can utilize the incomparable wealth of technical and commercial information available in IP documentation. They should also understand the need for academic institutions to convert their research into IP rights, to manage

their IP portfolios, and to engage in technology transfer to industrial partners for value creation and the benefit of society as a whole (Intellectual Property Teaching Kit).

Each of these areas is regulated and supervised by a different legislation and responsible institutions.

Copyright refers to intellectual property laws intended to protect an author's original work (literary, scientific, technical, musical, and artistic). Copyright laws protect the technical books, brochures, drawings, published scientific research results, and descriptions of inventions. However, these right laws protect only the form of expression, not the idea itself. The author is protected from unauthorized publication or imitation, but not against the practical use of these ideas.

Industrial property, such as invention patents, trademarks, utility models, and industrial designs are protected by registered rights of mental activity results.

A special form of intellectual property protection could include integrated circuit topographies and plant varieties.

With industrial property, the different forms of authorship protection could be related to each other, such as patents, trademarks, and unfair competition protection.

The Paris Convention (Convention, 1983) defines unfair competition as follows:

(1) The countries of the Union are bound to assure to nationals of such countries effective protection against unfair competition.
(2) Any act of competition contrary to honest practices in industrial or commercial matters constitutes an act of unfair competition.
(3) The following in particular shall be prohibited:

> (i) all acts of such a nature as to create confusion by any means whatever with the establishment, the goods, or the industrial or commercial activities, of a competitor;
> (ii) false allegations in the course of trade of such a nature as to discredit the establishment, the goods, or the industrial or commercial activities, of a competitor;
> (iii) indications or allegations the use of which in the course of trade is liable to mislead the public as to the nature, the manufacturing process, the characteristics, the suitability for their purpose, or the quantity, of the goods (Article 1: Establishment of the Union; Scope of Industrial Property).

The concept of unfair competition is largely due to the economic and socio-political conditions in each country.

Types of Intellectual Property

Intellectual property types are defined in the Convention of establishing the World Intellectual Property Organization (WIPO, the World Intellectual Property Organization), which was adopted in 1967. WIPO has 183 Member States, including Latvia which joined WIPO in 1992. Article 2 of the Convention states that intellectual property shall include rights relating to:

- literary, artistic, and scientific works
- performing artists, sound recordings, radio, and television broadcasting
- inventions
- scientific discoveries
- design (industrial) samples
- trademarks and service marks, company names, commercial signs
- protection against unfair competition
- all other rights are attributable to intellectual activities in the production, science, literature and art.

Intellectual property is divided into two categories. Unregistered rights are copyright and other-related rights, such as trade secrets, and protection against unfair competition. Registered right, on the other hand, refer to patents, trademarks, industrial designs (they can also be a non-registered), topographies of semiconductor products (integrated chip), and new varieties of plants.

Each of these categories is regulated and protected by a set of laws and rules. This division includes rather general terms, as both industrial and 'artistic' properties are quite diverse. In addition, there are cases where industrial property objects are protected by copyright laws.

Copyright

Copyright laws protect scientific, artistic and literary work, such as monographs, poetry, paintings, and musical compositions. Literary work could refer to any kind of information, including scientific information, which constitutes authorship. An author is required to adhere to copyright laws, and this is also acknowledged in the author's intellectual performance where originality is required only in the content (or ideas) developed and/or published.

There are examples of well-known literary and artistic work where the basic content was not changed, and the story and main idea remained the same. For example, consider the Bible stories which have been used by many authors. Copyright laws protect the work as a whole and as a content presentation. The author's right to his/her own creative work results does not require any registration or special documentation.

An important moment in the work of expression is the publication and reproduction. Disclosure means that the work is made available to others. That is, it refers to the communication of the work to all interested stakeholders. However, the publication of copyright laws differs from concept disclosure in other intellectual property areas. Patent case disclosure is usually used to refer to an invention that is intended to be communicated to all interested stakeholders.

The author's right to publish the work also provides the right to determine some of the conditions for the use of the work, i.e. to determine or prohibit the reproduction and distribution of the work.

9.3.1. The copyright concept of authorship, co-authorship, and collective copyrights

Co-authorship refers to cases where an author's individual contribution to the work could not be fenced off as an independent work as in cases where two authors collectively compose a book. In some cases, where each author's contribution cannot be identified or eliminated, then this work could also be considered as co-authored. Collective copyright does not exclude each author whose work is used in the work or his/her individual contribution to the collective work.

An author can request protection against copyright infringement. Each author also has the right to use his/her works in any form, and to receive remuneration for permission to use the work. Use of a work is the disclosure, reproduction, distribution, rental or public lending, as well as the translation and dramatization of that particular work. If the work does not belong to a particular author, then he/she must obtain the original author's permission. In some cases, it is possible to use an author's work without his/her consent and compensation, if it is used for informational, educational, and research purposes. Similarly, no consent might be needed if the work is reproduced for the hearing and visually impaired, for library and archive needs, and for judicial proceedings. In case where there is a need to make reference to important information from a specific published work, then the original author needs to be acknowledged and credited for his/her work.

Industrial property

The concept of industrial property may be used to refer to the right to disclose the technical creative work results. The industrial property or objects, in the traditional sense, can be considered as invention and utility models, while trade and external product-type design solutions can be considered as design samples.

In addition, industrial property may be added to the trade and service marks, as well as the trade names of origin. The results from the unit's intellectual activity are not so important and decisive, but can promote this product or service and can protect the consumer from the different types of Forgery and Counterfeiting and illegal entry. These rights of ownership are guaranteed by the owners. They are produced only when an object is registered in a special state institution and has received the required proof protection - patent or registration certificate.

The invention is a new technical or technological solution. The applicant could be either a company or a person who meets the requirements specified in the appropriate documents in their national patent office. A patent for an invention may be obtained, if it meets the conditions (criteria) that are defined by each national patent legislation. Protection for the invention to the patent indicates that the holder has the exclusive rights to this invention for a? statutorily defined period of time.

Intellectual property and innovation

A competitive economy requires innovation, which is a knowledge-based economic engine that can contribute not only to the country's competitiveness, but also to its well-being.

Technical innovation can refer to the scientific and technological development of the final stage, which may be completed with the invention or other intellectual property.

An important use of the invention is a determining factor in the development of science and technology, because it is both informative and material. The use of such inventions in new technologies and materials can have a powerful technical and economic effect. Inventions can be the basis or the beginning of new technical ideas.

This is particularly true in the case of large inventions addressing cross-sectoral issues. However, not all inventions can be used as subject to rapid technical and technological development pace. Some inventions may not be materialized or put into production as new solutions may be already introduced to the market.

Therefore, any decisions to proceed with the production must be made by taking into account some of these predicted factors.

Licence

The license is entitled to some compensation in case some industrial property objects are used. The seller (licensor) can license contracts on industrial property rights that can be used to the extent specified in the particular contract. Licensing is also a path to technology transfer. License can refer to any type of intellectual property, such as patents, trademarks, design, know-how, and copyright laws.

A potential licensee and licensor search can successfully use patent information systems, special Internet addresses for the licensing of technology, the general technical literature, publications, data banks, exhibitions, and fairs materials.

Some licensing terms that are also used:

Patent license refers to a contract for the transfer of rights to use industrial project objects, which is also protected by a patent.

License-free refers to the know-how transfer of practical use.

Abandonment of the patent refers to the complete transfer to the purchaser (licensee).

An exclusive license is a monopoly transfer to the licensee in order to use the license object specified in the contract amount.

A simple license is expected to transfer the rights of use; it does not exclude third party rights. The seller still reserves the right to produce and sell products and to issue a simple license at the next license. The agreement may also include other restrictive conditions.

To effectively use the innovation, it is appropriate to:

- strengthen the intellectual property rights;
- analyse and identify the objects of intellectual property, which are the most effective forms of commercialization;
- commercialize a product in order to maximize the use of the contractual relationship.

In addition to the patents and know-how licenses, separate trademark licenses may be granted. The licensee has the right to know the number of the licensees in a particular territory that have been issued licenses. The know-how provision may be included in the documentation, which is separate from the license agreement. It may also be included in the contract.

International agreements

A number of intellectual property rights are regulated by international treaties and conventions. Here are some examples:

1. The World Trade Organization agreement on intellectual property rights in relation to trade (TRIPS Agreement).
2. The Paris Convention for the Protection of Industrial Property.
3 Convention establishing the World Intellectual Property Organization Establishment (WIPO).
4. The Madrid Agreement Concerning the International Registration of Marks.
5. The Nice Agreement concerning the goods and services to the international classification of the Registration of Marks.
6. The Hague Agreement concerning the international registration of designs – the Geneva Act.
7. The Patent Cooperation Treaty (PCT).
8. The Budapest Treaty on the Deposit of Microorganisms for the international recognition of patent procedures.
9. The International Convention for the Protection of New Varieties of Plants.
10. The agreement between the Latvian Republic and the European Patent Organisation.

WIPO is actually carried out all over the world of intellectual activity associations and the secretariat of the organization. Since 1974, WIPO became a specialized intergovernmental organisation, which is responsible for the implementation of appropriate measures in accordance with its statute and activities in order to operate all agreements on intellectual property, and to facilitate technology transfer to developing countries.

WIPO includes a number of international associations. They have set up their tasks and budget. At the same time, they have coordinated the efforts of WIPO on intellectual property as a whole. Within an association, WIPO operates on the basis of agreements which can be divided into three groups:

- contracts, which provide international protection (the Paris and Bern agreements, the Madrid Agreement concerning misleading and false origin of goods, the provision of information, and the Rome Convention for the protection of the interests of performers);
- agreements that promote international protection (the Patent Cooperation Treaty, the Madrid Agreement on the registration of trademarks, and the Budapest Treaty on the deposit of microorganisms);
- treaties governing international classifications (e.g., the Strasbourg Agreement on Patent Classification the Nice agreement for trade and service marks, and the Locarno Agreement Establishing an International Classification for Industrial Designs).

The main features of WIPO include:

- registration activities;
- promotion of cooperation in intellectual property management;
- material activities, which promotes the expansion of the participation and cooperation of countries in the field of intellectual property, as well as the agreement renewal and adjustment.

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Chapter 10: E-Marketing

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10.1. Introduction

As we enter the third millennium, we see the move of the global society to an Internet-based society. Computers and the Internet have changed the world, technologies, communication among people, and the way of doing business.

The Internet and different electronic commerce tools totally changed the way of doing business, the business processes, and marketing; in the last thirty years there have been many more innovations in business processes than in the last few centuries.

We are experiencing a relentlessly accelerating expansion of the electronic environment. At the same time, it is very important not to lose orientation in various possibilities and options, to understand one's own personal and business needs, and to choose the most useful and suitable methods and tools for communication and business development in electronic environments in order to establish an effective communication with the target audience. In this chapter, we describe the most popular and useful Internet media and tools used for marketing and Public Relations in digital environments. Particular attention is placed on the most popular methods used in the Internet marketing in order to promote companies, products, services, and personalities.

10.2. Effectiveness of Internet media and electronic environment

An electronic environment (e-environment) has several benefits compared to a real business environment. One of its most important benefits is the **fast growing audience**. In the beginning of 2017, there were 3.478 billion Internet users worldwide (50% of the entire world population). The biggest social medium, Facebook, had 1.71 billion active accounts, but in total, it was estimated that there were 2.7 billion active social media accounts worldwide. Two hundred million people are registered on Twitter, and 200 million more professionals are on LinkedIn. All those people are easily accessible in electronic environments. In the last six years, the world population has increased by 1.17% per year, while Internet users have increased by 11.6% per year.

There are a wide range of opportunities for **non-stop business,** 24 hours per day, 7 days per week. Consequently, it saves a lot of human resources during the year, and there is an unlimited possibility to provide information to the potential audience, even if one is not in his/her working place. It provides a feeling of **availability.**

An e-environment provides an opportunity to directly reach a great number of people from **a target group** in a **wide and diverse geographic area** in a rather short time period. As a result, it saves human and financial resources. In many cases, it is possible to provide existing and potential customers with **information in textual, image, audio, video form,** or altogether. Inexpensive organization of **two-way communication** between companies and customer groups offers an important benefit not only for public relations but also for customer service.

Effective/Efficient communication helps build good relations with customers by providing lower prices (due to the **reduced cost**), along with a variety and high quality of products/ services and channels of distribution. An equally important goal for a business is to reach the **selected focus group.** Several Internet marketing tools provide the possibility to select target groups according to specific features (see Table 10.1).

The Internet and IT technologies globalize business processes and improve information distribution of services and goods, thus reducing the gap between big cities and rural areas in information supply and customer service.

Table 10.1. The consumer decision process and supporting communications

	→	→	→	→	→
Marketing Communication Channels	**Awareness**	**Search**	**Evaluation of Alternatives**	**Purchase**	**Customer Loyalty**
Offline Communications	Mass media TV Radio Social networks Printed mass media	Catalogues Print ads Mass media Sales people Product raters Store visits Social networks	Reference groups Opinion leaders Mass media Product raters Store visits Social networks	Promotions Direct mails Mass media Print media	Warranties Services calls Parts and repair Consumer groups Social networks
Online Communications	Targeted banner ads Interstitials Targeted event promotions Social networks	Search engines Site visits Targeted e-mails Social networks	Search engines Online catalogues Site visits Products reviews User evaluations Social networks	Online promotions Lotteries Discounts Targeted e-mails Flash sales	Communities of consumption Newsletters Customer e-mail Online updates Social networks

As indicated in Table 10.2, it is possible to conclude that an e-environment has both tangible and intangible benefits. Tangible benefits include increased sales from new and existing customers and new markets, sales and promotion cost reductions from reduced time in customer

service, online ads, reduced printing and distribution costs of marketing communication, and reduced costs emerging from direct customer communication.

Intangible benefits include corporate image communication, brand enhancement, more rapid and responsive marketing communication and PR, faster and more effective market research and notification of changes in the market.

Table 10.2. The main benefits of e-environment

Benefit	**Short description**
24/7/365	Global network works all the time without breaks. Information posted at a particular time can be read at a reader's convenience and availability of a business environment.
Fast growing global audience	The potential audience increases very fast and can reach customers in any part of the planet; one also needs to consider the ubiquity of an e-environment.
Selected target groups	Internet tools provide an opportunity to select special target groups by defined specification, personalization and customization of information targeting specific customer groups.
Immediate reaction and two-way multi-channel communication	Technologies and different communication tools provide an opportunity to get information quickly and react immediately, and to utilize its rich content.
Profitability	All of the previous components can give access to safe human and financial resources, can reduce transportation and communication expenses, and can increase profitability.

10.3. Internet media and marketing communication tools

The Internet environment includes a wide variety of different types of media and tools.

Portal is a term, which is also synonymous to *gateway*, used for a World Wide Web site that is or is intended to be a major starting site for users when they get connected to the Web or when they attempt to visit it as an anchor site. The main difference between portals and other type of the Internet sites is that a portal provides a variety and different information levels for a wide range of users (see Fig. 10.1). Some major general portals include Yahoo, Excite, Netscape, Lycos, CNET, Microsoft Network, and America Online's AOL.com. Portals attract users with different services like a mailbox, news, news feeds, a search engine or information search in the portal, and information on different subjects. They usually include several vortals.

Advertisements and other commercial information have become an integral part of portals. There are several portals and many different vortals or niche content (vertical) portals in each country.

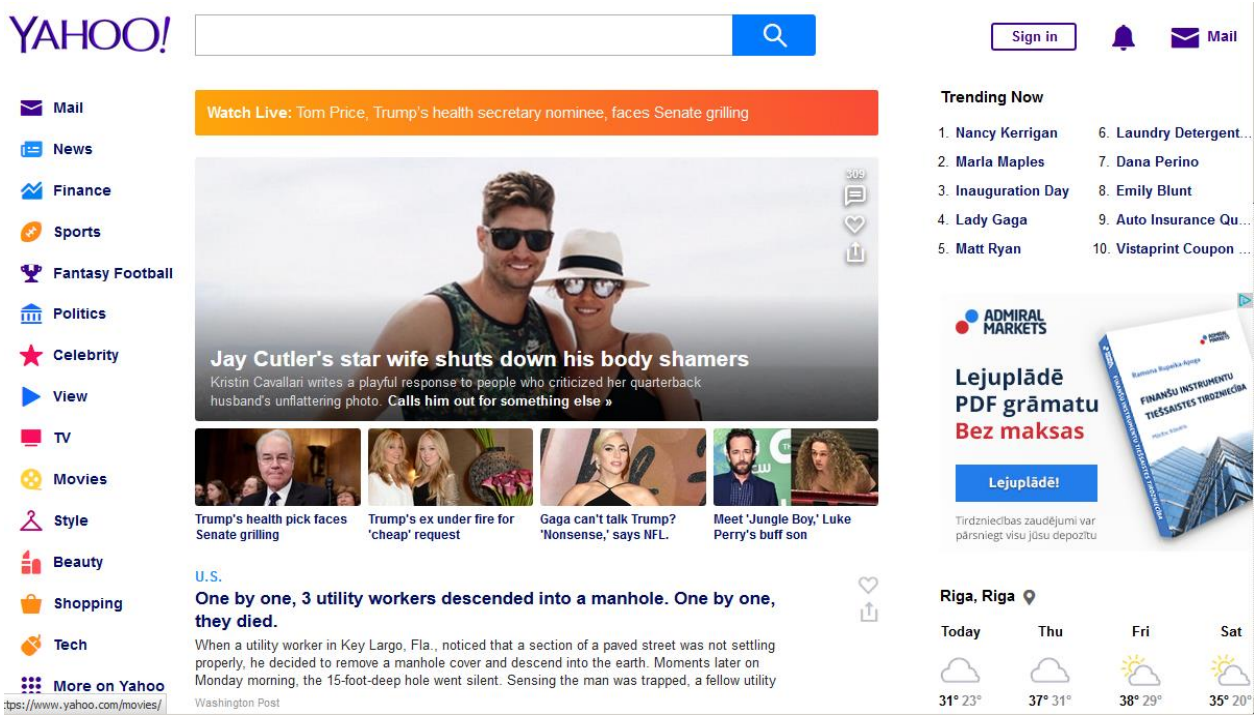

Figure 10.1. Portal services

In Internet marketing, a portal is usually used in cases when it is necessary to reach a wide range of users.

Vortal or a vertical portal, on the other hand, is an interactive information source with information on the selected subject for a wide range of users or information for selected groups of users (see Fig. 10.2.). Examples of niche portals include Garden.com (for gardeners), Fool.com (for investors), and SearchNetworking.com (for network administrators). Vortals are mostly targeted at specific user groups.

Search engines are special software systems that search different types of information (data bases, documents, pictures, and all types of files) in WWW by using keywords. The most popular search engines in the world are google.com, yahoo.com, and bing.com.

Domain names are used to identify one or a group of IP addresses. It is a unique identification; for example, consider the domain name riga.lv which represents approximately a dozen of IP addresses in the Riga City Council network. Domain names are used in URLs to identify particular web pages. For example, in the URL *http://www.grodno.by/grodno/history.html*,the domain name is *grodno.by* which describes Grodno city using the domain name of Belarus. Each domain name has a suffix that indicates which top level domain it belongs to. There are only a limited number of such domains. For example:

- **gov** - government bodies
- **edu** - educational institutions
- **org** - organizations (mostly non-profit)
- **mil** – military organization
- **com** - commercial business
- **net** - network organizations
- **lv** – Latvia (country identification)
- **net**- technologic enterprise

As the Internet is a fast growing environment, a domain name is becoming a more and more limited resource. For this reason, it is possible to register domains in some other popular languages, for example, in Russian, Arabic, and Chinese. The domain itself can be an excellent marketing tool that can be used to promote a company's brand, a popular product name, a place, or a series of other-related characteristics. When choosing a domain name, it is important to be aware of the meaning of this name in other popular languages. A domain name needs to be easily used in an information search. For this reason, companies sometimes even use expressions as a domain name. For example, visitlatvia.lv or whattodoinweekend.tv

Figure 10.2. Vortal services

Blog is a regularly updated website or web page, typically run by an individual or a small group; it usually includes informal or conversational-style content. A blog can be created in the textual form, in video or audio files, by using pictures or some other methods of expression. There are special platforms where individuals or companies can host their blogs.

Microblog is a type of a blog that lets users publish short text updates. Bloggers can usually use a number of services for the updates including instant messaging, e-mail, or specially built microblog platforms. These posts are called micro posts. Some social media also use a microblogging feature in profiles. Microblogs may include text messaging, instant messaging, e-mail, and digital audio or video.

Social media/ network is a type of Internet service that allows individuals or companies to create a public or a semi-public profile, within a bounded system which comprises a list of other users with whom they share a connection and hosted information. The nature and nomenclature of these connections is not homogeneous. Social media sites are free of charge; in some instances, a fee for some additional services may be charged. The most popular social media is Facebook which is used by individuals and companies; the most popular professional social network is LinkedIn which brings together business world professionals.

Home page is the initial page of a site on the World Wide Web. The web site is a connected group of pages on the World Wide Web which is regarded as a single entity. It is usually maintained by one person or an organization and is devoted to a single topic or several closely related topics. For the creation of a web page, it is possible to use ICT professionals or to build a web page using ready templates such as: www.sites.google.com; www.smallbusiness.yahoo.com, and www.godaddy.com. The main task of a web page/site is to provide as much information as possible in an easily accessible way to all existing and potential customers.

Banner advertising is a rectangular graphic display that stretches across the top or bottom of a website or down the right or left sidebar. The former type of banner advertisement is called a leaderboard, while the latter is called a skyscraper. Banner ads are image-based rather than text-based and are a popular form of website advertising. The purpose of banner advertising is to promote a brand and/or to get visitors from the host website to go to the advertiser's website. Different types of banners are popular. It is a traditional Internet marketing method which has been used from the beginning of WWW.

Mail is not just a communication service between two or several parts, but a useful Internet marketing tool for sending messages from one individual to another via telecommunications links between computers or terminals using dedicated software. Communication by email is almost instantaneous.

10.4. Internet marketing methods

Internet marketing, also called online marketing or digital marketing, is the process of promoting a company, a brand, a product, or a service over the Internet. Its broad scope includes email marketing, social media marketing, affiliate marketing, electronic customer relationship management, and any promotional activities that are performed via wireless media (see Fig. 10.3). Internet marketing could also be perceived as a step to achieving marketing objectives by applying digital technologies. However, e-marketing focuses on the importance to detail in order to use the internet and digital media to promote products, services, or brands. It also combines the technical and creative aspects of the WWW such as advertising, designing, development, and sales. Moreover, Internet marketing deals with the creation and placement of information throughout the various stages of the customer engagement cycle.

Figure 10.3. Different types of Internet marketing

Search Engine Marketing **(SEM)** is a marketing method which helps promote a website, attract visitors who can eventually become customers, increase visibility of a brand online, and implement an e-marketing strategy. It is one of the most effective Internet marketing methods that can provide prospective customers with the necessary information. This Internet marketing form involves the promotion of websites by increasing their visibility in search engine results pages through paid advertising. SEM may incorporate search engine optimization (SEO), which adjusts or rewrites website content and site architecture in order to achieve a higher ranking in search engine page results and enhance pay per click (PPC) listing. This method increases the number of website visitors and facilitates the promotion of a brand, a product, or a service of a company, thus increasing sales. SEO is a crucial part of a successful e-marketing strategy, because a visually-attractive and functional website is not enough in such a highly competitive

global Internet market. A company is not able to compete with its rivals without the well-designed optimization of a website. SEO is a long-term process, with complicated algorithms, that cannot give any guarantees. In this process, it is important to understand the needs of the company's audience and what they search for. If SEO is done correctly, a SEM campaign will be successful, and the popularity of a company or products will increase significantly. SEM includes the following activities: planning, creating, optimizing, promoting, and engaging with content on topics that customers and target audience care about. The quality of the website content is crucial.

Another effective Internet marketing method is **Pay Per Click (PPC)**. PPC is a model which offers a higher level the visibility of a company's website in different search engines and social media than its competitors.

By using this method, it is possible to reach a new target audience and have better control of the website and its position. In cases that this method is selected, advertisements need to be interesting, exciting, and useful to the selected targeted audience.

E-mail marketing is a method used to promote a company, a product, or a service using e-mail to communicate information directly to a potential or existing customer. There are several ways to organize e-mail campaigns: to do everything by one's own resources, partly by one's own resources, or to fully outsource this service. There are several global companies, such as www.iContact.com, www.MadMimi.com and other local companies, like www.Mailingen.lv, that offer a full range of services for e-mail marketing campaigns: a platform, the necessary data base, and design and textual solutions. The most crucial aspect of e-mail marketing is the provision of correct and updated data bases related to legislation on the Consumers Protection Laws of a host country, which are intended to regulate spams.

E-mail marketing generates approximately double return on investment among all other considerable marketing channels, such as banners or directory advertising campaigns. Regular mail campaigns or mailing lists offer customers the opportunity to subscribe in order to receive information and regular updates on a particular topic. It helps a company keep its prospective or existing customers interested in the offers of the company on products or services. This method allows interaction between a customer and the company until the customer unsubscribes from this service. Companies require the email owner's permission in order to include them in mailing lists. After the permission has been received, it is important to determine how often the company will send messages. As customers voluntarily subscribe for promotional e-mails, the chances of their responding to the offers are higher. The best way is to use e-mail marketing for advertising new offers, discounts, product launches, or sharing brand-related information.

The most popular e-mail marketing options are:

- Regular newsletters. Preferably with customer's confirmation of frequency, not more often than once a week or once a month.
- Related to events. An e-mail is sent only when a company has news about its activity, such as launching of a new service or product or a new offer, which can take place every 3 to 6 months.

- Sequence of e-mails. Special software sends a reminder to the customer, often after subscriptions for products with a trial period.

It is **very important** to follow a few important points for a successful e-mail campaign:

- Frequency or time when e-mail is sent. A company can determine which time is the most appropriate to launch an e-mail campaign. There should be specifically defined periods between messages.
- Subject line. This information is the first information that a customer views, and it determines whether a recipient will open the message. The subject line should contain a strong message that will engage the client.
- Headline of an e-mail which determines if the customer will move to the subject line.
- E-mail length. Different messages need different approaches. A promotion and sales letter should be short, while a newsletter could be long.
- Logo of the brand that is necessary and important to be on the first page. It usually appears at the top on the left side of the document or e-mail.

Further, e-mail marketing expenses are rather low, but generating a lot of spam can overwhelm consumers with often unnecessary information that is not always desired and useful. Marketers have experienced high success rate through this medium, especially with the link provided within an e-mail to access the offer. However, there is also a general agreement that e-mail marketing is not an effective strategy for attracting new customers.

10.4.1. Banner Marketing

Banner advertisements have been around since 1994. Different types of ads influence people every second when they browse through different websites or mobile applications. There are several types of banners. The advantages of each type is described in more detail below.

Static Banners

Known as the simplest type of banner, static banners contain very simple graphic and texts. Many websites and blogs prefer this type of banner due to its simplicity. Different design improvements make these simple marketing tools very effective. The image and text chosen should not just be attractive but also meaningful. The goal is for the banner to be simple and not distracting; it should attract the attention of web users.

Advantages of a static banner:

- it is cost effective,
- it is simple, therefore it does not scream,
- it is the most traditional type of banner,
- CTR (Click-through rate) is higher compared to other types of banners.

Flash Banners

This type of banner is animated and uses flash technology. It employs animation, which makes it more realistic and interactive. Due to the use of SWF (small web format) into the web pages,

it is possible to use sound and special effects. One of their disadvantages is that flash banners are not friendly to mobile applications.

Advantages of a flash banner:

- It receives a high click-through rate (CTR). Click-through rate is the ratio of users who click on a specific link compared to the number of total users who view a page, an e-mail, or an advertisement.
- It is attractive because of the use of special effects.
- It is easy to explain anything with a flash.
- The use of sound attracts attention quickly.
- It invites viewers to engage.

Animated GIF Banners

GIF file format banners refer to one of the most powerful graphic design units. Though it is considered a rather traditional way of advertising, there are multiple reasons for still using it so extensively.

GIF banners have small file format and load into web pages quickly and easily. This type of banner can also be as interactive as a flash banner. It is mobile and friendly to smart devices. As they were introduced a long ago, GIF banners can be created by almost anyone. This means that it is relatively cheap to make. There is no need to pay for website designers or programmers. It is friendly to mobile telephones and other devices.

Advantages of animated GIF Banners:

- Multiple frames can be used.
- They are supported by all kinds of devices.
- They have the capacity to increase CTR.
- They do not need a plug-in to view.
- They are helpful when it comes to describing complicated services or products.

Pop-Up Ads

Pop-ups could be shortly described as advertising messages which open automatically in a new window. Pop-ups get high attention (positive or negative) because they are unavoidable and their appearance disturbs users' navigation. This is the only advertisement that cannot be ignored. Pop-ups can vary in size and in time used for page opening. They are usually activated by a simple click. It is possible to disregard the message and content of such advertisement but not to ignore its appearance.

The method of banner marketing is an old one, but is still the most commonly used on the internet. By clicking on a banner, a user is redirected to the website of the company, special offers on products, or special applications inviting him/her to order some goods or services. Sometimes users watch a banner in order to obtain information or to download files. A banner can be a keyword banner. That is, it can be used for narrowing the target audience or market

segment and can appear if a related word is required in the search engine and random banners; they appear randomly regardless users' actions. Personalized banners are used when an advertiser has some information on a user and thus it can be customized.

The host is paid for the banner advertisement through one of the following three methods: cost per impression (payment for every website a visitor views an ad), cost per click (payment for every website a visitor clicks on the ad and visits the advertiser's website), or cost per action (payment for every website a visitor clicks on the ad, visits the advertiser's website and completes a task, such as filling out a form or making a purchase).

Banner marketing is one of the most expensive Internet marketing methods. Banners require a high cost if a big campaign is planned; a high cost of banner swapping is required (exchanging of banners between partner companies). A small amount of information could be placed on a banner; therefore, it should be short, attractive, and informative. Since most users are accustomed to this kind of ads, the popularity of banner ads has been declining over past years, especially if there are long messages in banners which require the users' time and attention; however, users seek for immediate results and information. This also contributes to the low effectiveness of banners. Nevertheless, banner marketing is still in intensive use and generates income and profitability to advertisers (Bayan, R., 2001).

"Interactive marketing," on the other hand, contrasts traditional advertising, which is impersonal and one-way mass communication, and facilitates direct interaction between a company and customers. At the moment, some initiatives are undertaken to make an advertising message more personalized by addressing a small audience instead of a large mass audience. The Internet is the best place for this strategy.

If an advertisement includes the precise information about a product at a moment when customers are not sure about what exactly they want, or they have just a rather broad idea, it can have a positive impact on a customer's desire to purchase a product or a service. In this case, a brand will advise customers about what they need and what is valuable.

10.4.2. Content Marketing

Content marketing enacts opportunities for the long-term development of a reliable relationship between the target audience and the company. In this era, when users search for information online, content marketing is especially important. Information has to be clearly explained, easily understood, and it is important to use a lot of graphic elements. Infographics are helpful in creating the appropriate and valuable content.

Content marketing has several channels:

- **News articles** promote a company, goods, or services by presenting important information on production or marketing. People like to search for news they can easily read and try to recall something new and innovative.
- **Analytics articles** usually present information about companies, products, or services by analyzing certain market niches, certain special subjects, or historical developments

and provide certain special brands as examples. This type is usually used for image improvement, for comparison with competitors, or for criticizing competitors.

- **Case study articles** usually present examples of market research or projects as a positive or a negative experience for some parts of certain industries. It is usually used for brand development and company recognition.
- **Blogs** can be used as a permanent direct communication channel with a target customer group in order to indirectly promote products or services. This method is popular in several industries like fashion, beauty, technologies, the food industry and some others, where informative content is interlinked with the commercial one (see Fig. 10.4).
- **Microblogs** can be easily created and organized but are time-consuming. If one decides to use the microblog option in order to organize followers, he/she has to be creative in order to keep the target group's attention in the long-term. The messages need to be trustworthy.

Context marketing expenses depend on several factors. Does one take the initiative to prepare the article or does one rely on outsourcing? Is the blog integrated in the web page or is it on a separate platform? Does one use his/her own domain or not? There are several options, but it is still one of the most inexpensive ways to directly target the intended audience, especially if one chooses to use a blog or a microblog.

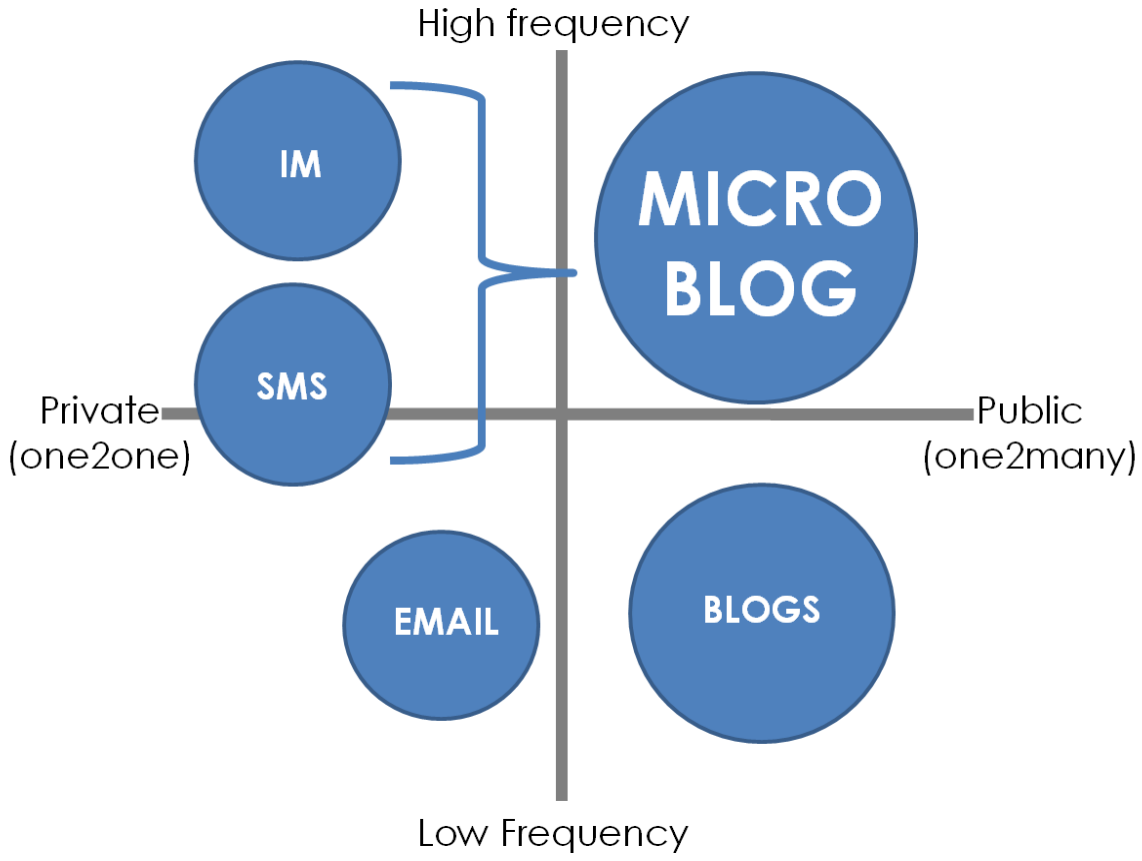

Figure 10.4. Positioning of communication channels

Companies can use public blogs to establish communication channels with the target audience. That is, companies can send messages directly to customers. However, in contrast to text messages and e-mail campaigns, the target audience can choose to read these messages and are more likely to be interested in the subject. Instead of blogs, microblogs are frequency used and the potential audience is ready to receive meaningful messages.
Blogs help contact target audiences. They enable a company to reach people who have a real interest in their content. Moreover, conversations with those who are interested in a brand, product, and industry help establish a level of trust and strong relationships with customers. As a result, blogging is considered to be a powerful marketing channel. Many companies have already started using blogs as a rather inexpensive marketing and advertising tool because it facilitates precise targeting, the establishment of credibility and close relations with customers, making advertisements appear unobtrusive and hardly distinguishable. It is a powerful public relation method.

10.4.3. Branding Marketing

A company's brand represents its market identity — who they are, what they do, what kind of quality they provide, their reputation for trustworthiness, and other-related information. Consequently, brand marketing is important to nearly every business; marketing influences the decisions of a variety of customers including both end consumers and businesses. It is the most effective way for developing repeated business, as a customer's perception of a brand is primarily informed by previous experiences. For customers, the brand of the company represents instant knowledge of that company. Companies work to enhance their reputation and improve customers' awareness. Setting goals for brand marketing involves identifying what the company desires to be known for, and then developing a consistent message across multiple advertising channels. E-environment is widely used for branding marketing using all possible channels to increase awareness about companies, products, and services.

Branding in social media often involves the use of blogs, microblogs, video streaming, and comments in communication sites. Commercials, incentive shares, games, lotteries, and different "virus marketing" activities (distribution of information via mail or social media profiles used for sharing information on each user) are used in portals and vortals. A brand can be successfully promoted using a combination of all three methods and results can be monitored (see Table 10.3).

Domains can be used as a brand name and can be promoted by using three different activities: through the use of banners, social media, and e-mails in order to communicate with the target audience. Any domain name which is chosen by using the correct strategy can work as a perfect brand name and can contribute to building the image, products, or services of the company.

Table 10.3 Brand promotion advantages and disadvantages in social media

Role in enterprise	Advantage	Disadvantage
Own media – a home page, a blog, a profile in social media, a microblog		
A long-term relationship with the target audience	• control • low costs • longevity • flexibility • audience accumulation	• low trust of audience • company resources are required
Paid media – banner ads, content marketing, sponsorship		
Changing from basic (writing own media) to catalytic (organizing paid media)	• control • dimension • easy accessibility • immediate reaction • scalability	• high refusal percentage • low trust of audience • audience does not accept all offers
Earned media – users become a channel (suggestions, "effect of virus", rumours)		
Result of good quality activities in own and paid media	• high trust of audience • important role in majority scale	• no control • can be a negative reaction • not measurable

10.4.4. Social Media Marketing

A new way of communication between people has developed in the last 20 years, offering another possibility for marketing through social networks. Relationships are also built on similar interests or views, and users have the option to socialize without leaving their home. In the context of Internet marketing, social media could be described as the connection between brands and consumers. They offer a personal channel for user-centred networking and social interaction. A new phenomenon called **social commerce** has emerged that supports social interaction through the use of online forums, communities, ratings, reviews, and personal recommendations to promote companies, products, or services.

Social media marketing is available to all organizations, from large multinational corporations to small firms, non-profit organizations, and governmental institutions. It is relatively low cost and can reach clients directly. At the same time, it can be challenging for a company to develop a strategy for **Social Media Marketing (SMM)** because there is a wide range of social media, and it is rather difficult to understand where the target audience is and what messages they require. It is also important to consider that people use a wide range of social media (which also have very different audiences). Inaccurate targeting can become a failure, so it is important to be aware of both online and offline audiences and their differences. Recent research results show that 60% of all new small companies do not register their own domain name and do not develop a web page. Instead, they successfully organize communication and online marketing with the target audience by using several social media and microblogs.

There are several reasons that customers turn to social media: The combination of information, communication, and entertainment t make social media attractive. Customers have begun to realize that they can influence companies and this motivates them to take part in the co-creation of new products, services, and a brand itself. There is an interrelation between social media and users' attitude to shopping online and Internet advertising. If users consider it possible, useful, and simple to make a purchase in the social network, there is a chance that they will do it both in a social network and an online shop. Another factor influencing the desire to purchase a product is the level of trust, which needs to be provided by the social media.

Potential customers are encouraged by their friends and the social network itself to make a purchase via the social media website. The trust and perceived usefulness influence each other. It is this perceived usefulness that mostly affects one's intention to buy.

Most of the companies consider that it is of major importance to achieve some of the basic aims of traditional marketing, such as direct sales, a big market share and a reduction of expenses. SMM helps achieve all these goals by enacting opportunities to reach customers' needs and establish close connections. Social media help companies understand the preferences and needs of their clients, based on their comments. These comments also offer a path to view the customers' opinion on goods or services. Customers are actively changing business by taking part in marketing and contributing to the creation of a brand. If at the beginning the Internet was a source of information, now it has become a tool for influence. Now a company is required to have a strong presence in social networks like Facebook, Instagram, microblog, and Twitter. The size of a company does not matter, even though it is often perceived as one system with separate parts. Besides having a strong online presence, few companies understand how it could be done effectively, what indicators to consider, and how to measure them. Key performance indicators such as fans, friends, and comments to business outcomes like network growth, engagement, and sales measurement are essential for effective brand social media participation.

Facebook is the most famous and popular social medium that not only facilitates the establishment of relationships with people from all over the world and promotes socialization, but also plays a crucial role in the promotion of business and the generation of traffic. Companies, especially small and medium with limited expenses for marketing activities, can organize successful campaigns and achieve business goals by using social media. The most important goal that companies can achieve is visibility (see Fig. 10.5). Two other benefits that are not less important but give more tangible results to companies are the reduction of marketing expenses and the improvement of sales activities (Gudele, I. and Rivza, B. 2016).

Social Media Optimization (SMO) is an excellent tool of digital marketing related to SMM. It facilitates the generation of traffic and buzz to the website of the company using YouTube, Facebook, Pinterest, LinkedIn and many other Web 2.0 technologies.

Social media are becoming an environment for viral advertising and viral marketing since digital marketers are transforming social media from channels for interpersonal communication into a channel where a vendor communicates with a client.

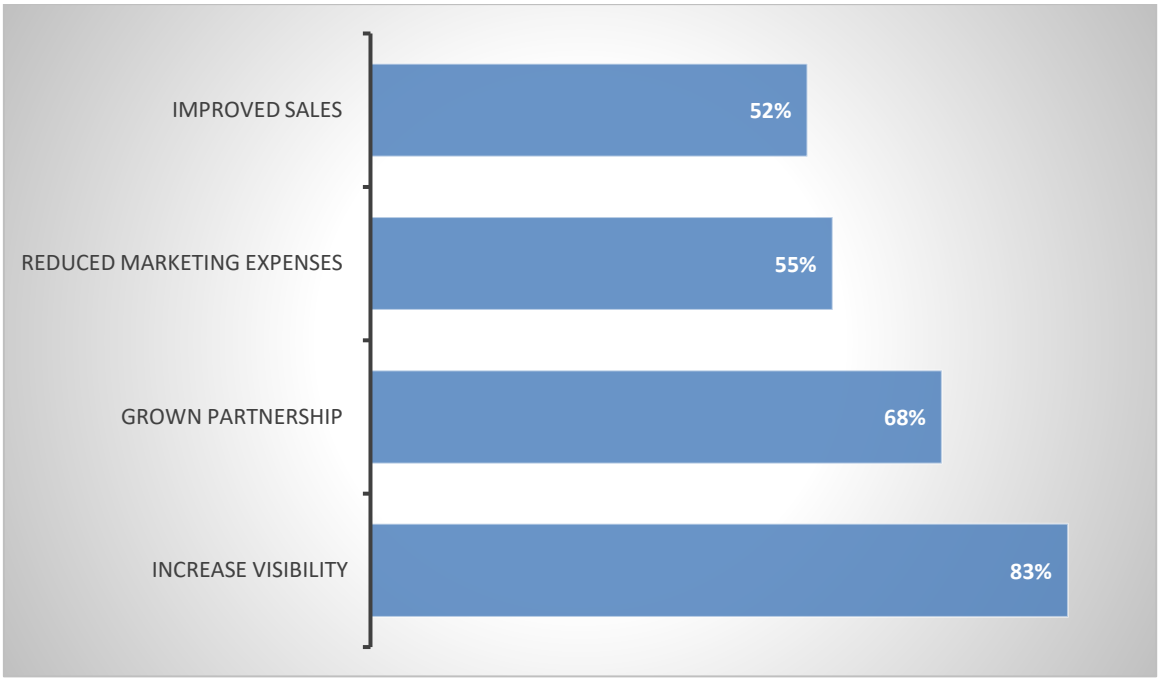

Figure 10.5. Benefits of usage of social media for small and medium companies

On social media, people discuss and comment, suggest and recommend products and brands, and in many cases these conversations unfold among strangers and can be noticed by hundreds and even thousands of people. Word-of-mouth (WOM or e-WOM) plays a great role in social media. Viral marketing helps spread a message with the help and cooperation of the customers; this is also known as a seeding strategy. The key here is to get a positive result of a viral campaign which can be achieved by using more "seeds" (initial customers) at the beginning of a project. These initial customers need to be chosen accurately on the basis of the goals of the campaign. These customers will share this message with their friends, colleagues, partners, and other interested stakeholders. Customers are significantly influenced by emotions when they share information on the web. Viral marketing has more benefits than traditional advertising: the cost is lower, credibility is much higher, diffusion goes faster and, most importantly, it facilitates the use of precise targeting.

A social media environment is changing constantly, so the following steps should be taken into account for successful performance:

- choose social media carefully according to the target audience
- keep social media activities aligned with each other to avoid any confusion and the circulation of contradicting information in different sources
- consider both digital and traditional marketing tools since customers do not perceive them as two different categories
- social media is all about interaction, so being active (messaging, sharing) and up-to-date on social media is key since information becomes outdated quickly
- maintain the customers' interest and share information based on what users want to see, read, or hear

- be honest since it is easy to verify whether the information provided is real or not.

Social media are a new model in advertising, which facilitates the establishment of close contacts and interactions with the consumers; almost 20% of all online advertising includes advertising in social media. It uses banners, a common online advertising form. However, the goal should be to target messages in the most precise way according to the users' profiles which usually includes important data on their age, sex, geographic location, and personal interests. It not only helps attract new customers but also to keep in touch with the old ones and significantly impact sales and PR. Considering that people spend more and more time on social media and advertisements on social media are cheap, it seems to be the perfect place for advertising where information about a product could be posted by both brand and customers, reposted, discussed, and shared.

Table 10.4. Main results of different Internet marketing methods

Channel	**Purpose**
Search engine marketing (SEM)	Increase visibility in search engine result pages through paid advertising or paid inclusion.
Search engine optimization (SEO)	Increase visibility in search engine result pages through modifications to one's web site or direct efforts to get others to link to one's site.
Display and rich media advertising	Attract users' attention and clicks with image-based video, online audio, widget, in-game or animated online advertisements.
E-mail methods	Attract new visitors through opt-in e-mail advertising (but no spam), encourage repeated purchases, and increase engagement among existing customers; develop leads from other channels.
Affiliate and partner marketing	Provide financial incentives to others to perform certain transactions on one's behalf or drive traffic to one's site in exchange for a commission on completed sales, branding, or other non-monetary rewards.
Directory marketing	Increase visibility in niche directories, local search engines, price comparison engines, booking engines, and other vertical-specified directories and aggregators.
Social media	Publish content and solicit user-generated content via blog, tweets, feeds, profile pages, contests, managed communities, and other social media platforms.

On the one hand, it offers a chance for precise targeting; on the other hand, questions are raised about customers' privacy since social network advertisements use the personal data provided on the users' profiles to reach their goal and users find this intrusive.

Advertising in social networks does not necessarily have a negative influence on the users; however, users come across these advertisements and brand recognition is higher than in other

media. Some possible reasons for this higher level of brand recognition in social media is that users are engaged in communication actions, such as friends and their news, and shared pictures. They are also fascinated by exciting information and, as a result, advertising is not likely to attract attention (Curran, K., Graham, S. and Temple, C., 2011). This does not mean that advertising space in social media is not active or feasible. The use of the method e-WoM gives more results than simple advertisements in Internet media. Any of the used Internet marketing methods can positively influence the development of a company, but the use of several or a combination of methods can have a bigger effect on the customers. As a result, it is necessary to choose the right methods for each case (see Table 10.4).

10.5. Target groups and customer behavior

Personalization is key in Internet marketing. Technology facilitates the collection of different sets of data on visitors, online navigation history, request for search, previous purchases, and other-related information. This provides unique opportunities for studying customers' behaviour online. As a result, it facilitates perfect targeting and customization. Online advertisements should have a strong and attractive message and blinking, or animated graphics added in order to promote action and generate the required results.

An electronic environment has the capacity to classify all global auditory of Internet users into different segments and find customer groups for products and services of companies using a set of criteria. We can select potential customer groups by:

- gender—males and females can have different interests and reactions to the same occasion or information;
- age—different experiences influence decisions and reactions to the same offers;
- level of income—it can strongly influence our choice in the kind of goods and services that we purchase;
- geographical area—it is important to determine in advance the geographical location for which these goods are intended since that can influence the logistic;
- used language—customer prefer their communication with the seller in their native language;
- social groups like students, senior citizens, young parents influence our interests and needs;
- professional experiences influencing the preference of some groups;
- interests and hobbies, religious, national and other affiliations to different groups influence people's cultural behaviour and preference to certain groups of products.

The behavior of any of these groups and reaction to marketing activities can vary. For this reason, it is important to understand who the potential customers are and anticipate their behavior and reaction to different offers in digital environments. It is impossible to achieve the same reaction to a marketing activity in different customer groups. For example, males and females can have a different reaction to the same action, while youngster and senior citizens

can react differently to the same picture or a representative of a different nation. Religions can also generate different responses on the same message (Odden L., 2012).

There are certain products and services that are the same for all customers in the global Internet market. However, there are several specific products that are intended for specific target groups. Therefore, it is very important to understand the target customers since this will essentially determine the kind of marketing methods and media that need to be used in order to grab the attention of the target customers.

There are five steps involved in making a decision to purchase a product: understanding the need, conducting research on a product (looking for product information), comparing possible alternative products, making a decision to purchase a product, and undertaking post-purchase actions (evaluation and loyalty). This process in general is the same for both traditional and online markets. Figure 10.6 illustrates how a combination of tools of traditional and web communications can influence the customer's decision to buy at every step of the decision-making process.

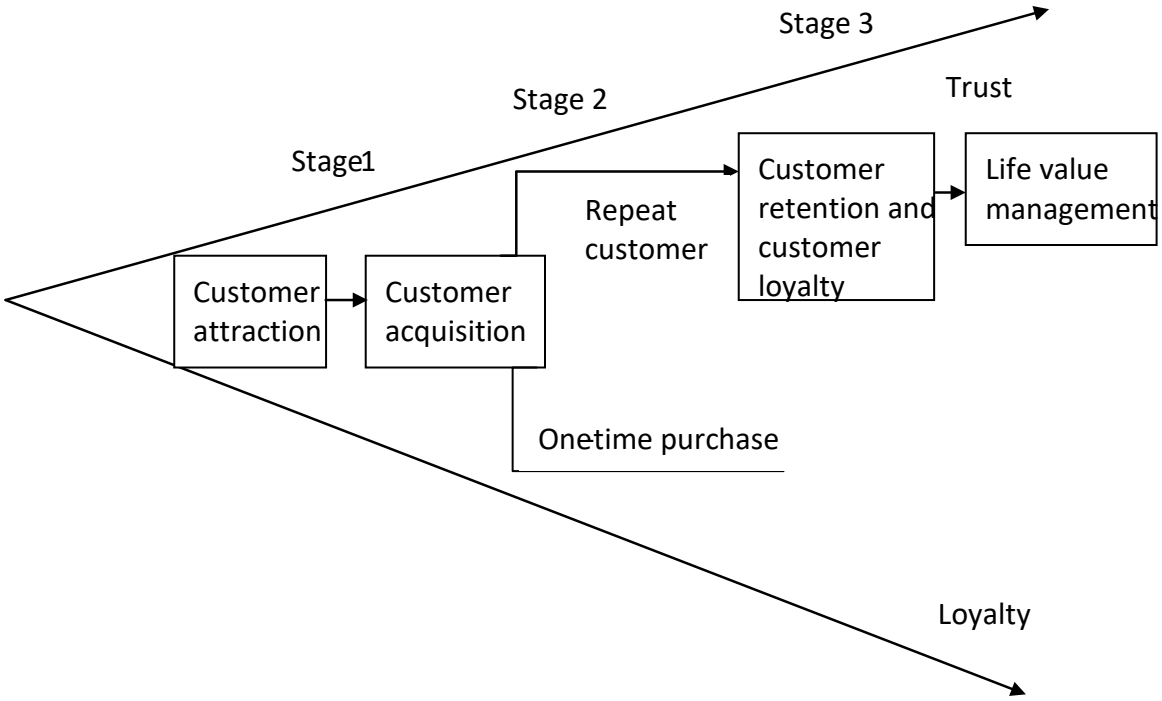

Figure 10.6. Customer relationship management model

To stay competitive, companies that have online operations need to establish e-loyalty. One of the difficulties emerging with purchasing online is that it is not possible to overview and test a product physically. This is the reason why customers' trust is perceived a key factor for online shopping and Internet marketing in general. The customer's level of satisfaction is considered to be key in e-loyalty. Without customer loyalty, even the best-designed e-business model can soon fall apart. E-loyalty is very important for companies and the Internet can help establish strong and sustainable connections and relations with customers, if used properly. A high level

of customer loyalty, the pleasure of shopping, and the feeling of control cannot accurately determine whether a customer will return or make a purchase. An online customer has higher expectations and is more demanding than a traditional shopper. That might be caused by the limited number of information presented, which may cause customers to strive to control this situation. As a result, client satisfaction is key. It is important to identify the best and most effective way of communication with the target customers. It is possible to attract customers by involving them in the process of new product design, content, marketing strategy and, thus, providing them with more control. It is even more important to point that mistakes should be avoided in online environments since they will be noted by thousands of people (Kaufmann H., 2015).

However, e-trust is not only determined by perfect service. In contrast to traditional shopping, buying online carries more risks and uncertainties. Web stores are unknown and are potentially dangerous because of emerging security problems. Customers cannot totally control online transactions and payment processes and often have to assume that online security is good enough to prevent fraud. They also develop a level trust for the retailer, so they proceed with the purchase.

Companies have to put a lot of effort in order to create customer trust in electronic environments. E-trust, as a means that facilitates the establishment of close relations with clients, obtains more personal information and thus customizable products and services. The result is deeper trust and stronger loyalty. Some of the factors that determine the e-trust of consumers are warranty regulations, credit card data protection policies, conditions for returning a product, possibility for making a credit payment, quality of customer service, and usability of a website. Loyal customers often attract new customers using word of mouth and this increases the revenue of the company. More and more companies strive to make the referral process easier by making it automatic and by sending e-mails and notifications to customers' friends, colleagues, and relatives. The cost for this process is not high but generates higher profits.

There are four main stages in establishing effective relations with customers:

1. Attracting ordinary users and visitors to the website. Here, brands play a central role by influencing the customers' behavior and opinion about the company.
2. Gaining customers' trust by using a unique value proposition at the acquisition stage. This is the most important part of the online marketing strategy. The marketer should predict how many clients are likely to visit the website and how many are likely to make a purchase.
3. Turning a one-time buyer into a loyal client by establishing mutual trust.
4. The last stage requires maintaining this mutual trust and keeping the customer loyal. This stage is a long-term strategy. Long-lasting relationships and loyalty enable companies to get cross-sells, keep their customers, and have lower service costs. Here it is important to note that it can be up to six times more expensive to attract new customers than to keep the loyal ones.

10.6. Internet marketing strategy and communication plans

Before one starts investing money on integral digital marketing processes and paid advertisements, it is necessary to analyze and understand the marketplace. It is crucial to understand customer demographics or their attitudes and beliefs on the specific industry and product. One has to also consider the market trends and get abreast with the current competition in his/her specific segment worldwide. By understanding the company strengths, weaknesses and opportunities, it is possible to deliver high-quality products to the customers.

To organize a successful Internet marketing campaign, it is necessary to analyze the current market situation and the competitor activities, and to prepare a strategic marketing plan. As demonstrated in Fig. 10.7., there are eight main stages for a strategic marketing campaign.

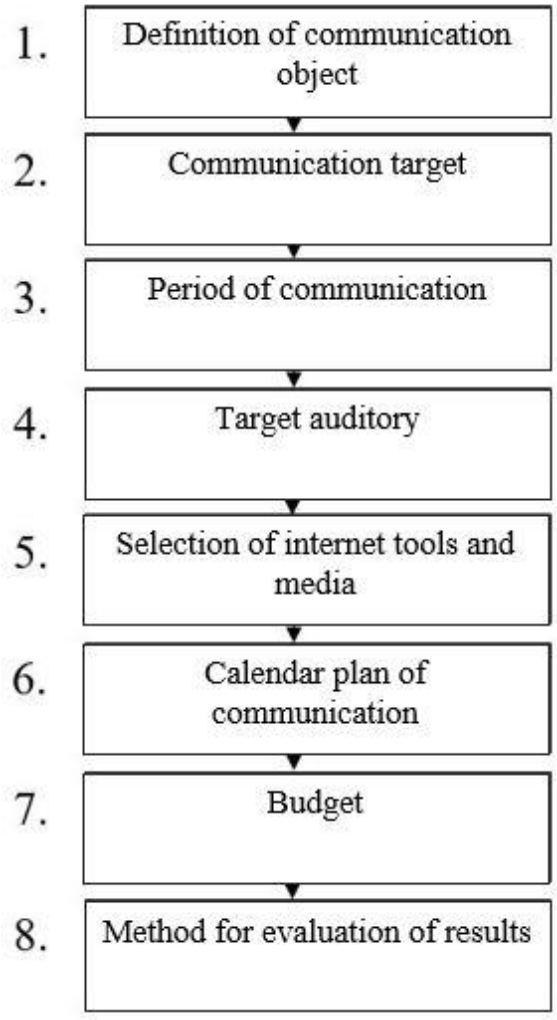

Figure 10.7. Stages of Internet marketing strategy development

In the first stage, it is necessary to clearly define the object (project, product or service) of marketing communication. It is important to strategically avoid linking different targets of the company together and trying to achieve everything in one campaign. It is crucial to send a clear message to the potential customer target group.

There are several possibilities for an object of communication:

- A company—if we are looking to introduce a new company name or to enhance the recognition of an existing company.
- A product, a service, or a brand name—to promote new or existing products in order to increase sale or introduce a new brand in the market.
- A person—the representative of a company or a personality looking for popularity.
- Events or projects—a set of well-thought activities that need to attract the attention of society.

With a clear definition, we describe our communication object and highlight the most significant property attributes and characteristics of a communication target.

In the second stage, it is necessary to define one or several targets for the campaign: what one would like to achieve through this communication. It can be the promotion of a brand, the increase in the number of customers or enhancement of a company's recognition, the promotion of a new product or service, or any other target. In some campaigns, it is possible to combine two or several targets.

Communication targets can be:

- The introduction of a new product, a service, a company, a person, an event, or a project;
- An increase in the level of awareness or popularity;
- An increase in sales, revenue, or profit (financial indicators);
- The dissemination of information.

The definition of the marketing communication plan time period is important for the preparation of the budget and planning of human resources involved in the campaign, in order to plan the timeframe for the activities. Like in any project, there needs to be a starting date and an end date. Based on the marketing communication target, it is necessary to select a time period during which it will be organized, and all planned activities and time units will be carried out.

The fluctuating global market situation can be influenced by several conditions. Changes in the current economic situation, the activities of competitors, and some other reasons may influence the communication object. For this reason, it is not necessary to choose a long communication period and one needs to avoid planning activities that will take longer than 6 to 7 months. It is more appropriate to review the planned activities and to prepare a new communication plan. In some cases, it might be necessary to organize a longer communication period. A shorter communication period facilitates the planning of additional activities, human resources, and reduces the budget of the communication plan.

The definition of the target audience depends on the object and the target of the marketing communication campaign. Each target audience may have different Internet habits and may use different media and tools. A target audience can be selected by geographic region, level of income, other social parameters, or other-related factors. Communication may target a specific audience or several audiences depending on the communication object specification. That is, the nature of the product or service could determine the target group of the message. It is

necessary to describe precisely the target audiences—who they are, what habits and behavior they have online, what kind of Internet media they like, and which Internet tools they use.

The most important stage of the marketing communication plan is the selection of the most effective and useful Internet tools and marketing methods in order to reach the target audience. Internet tools can have a different effect on different audiences and this is determined by their behavior in the digital environment. Any Internet tool can be used at a different frequency rate in a defined time period in order to attract the attention of the target audience.

After the definition of Internet marketing tools and methods and the frequency of use for any group of the target audience, it is necessary to prepare a calendar plan for all activities in that time period. This can be achieved through different ways. For example, it can be achieved through the use of a simple table reflecting on the used tools or methods in the indicated timeline and frequency of use of each tool. A calendar plan for communication can be drawn in several ways. For example, it can be a list of chosen activities and dates of actions, a table with time periods and activities (see Table 10.7), or a special software could be used to plan all the project activities.

Table 10.7. An example of a marketing communication calendar plan

Activity	1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks
Mail to partners	x					
Information in social media		x		x		x
Advertisement banners in portals			x	x	x	x
Affiliate marketing	x	x	x	x	x	x
Articles in special vortals		x			x	
Articles in blogs	x		x			x
Information in web page	x	x	x	x	x	x
SEO	x	x	x	x	x	x

A timetable with activities can help plan and organize all the indicated activities, follow-up on them, and plan human and financial resources for the implementation of communication activities. An important part of any marketing communication plan is the budget. The budget reflects on all the activities related to the necessary achievements. A digital environment offers the possibility of organizing marketing activities in a low cost and effective way, thus, directly reaching the target audience. Even if multiple activities, materials, and information are prepared by a company, its cost could be based on a fixed amount. It is important to prepare a budget for

each activity in order to estimate the total cost of the campaign, the cost of each separate activity, and the cost of using different Internet marketing tools. Any tool or communication method has a particular cost. They can be outsourcing costs, personal costs, or cost of service. The marketing communication campaign cost has to be set based on the communication target and achieve the planned results without defalcation of human, administrative, and financial resources.

Measurement of success

Before starting any marketing communication campaign, it is necessary to find out the right methods for evaluating the results. There are several ways to evaluate the results and the success of any marketing communication campaign. Some results are visible immediately after or even during a campaign. However, some targets need additional time after all the activities have been completed. Some of the methods for evaluating the results are:

- financial (revenue or profit during a defined period);
- awareness of a company, a brand, or a product (sociological studies or questionnaires, information from social media);
- customer data base;
- number of sales and other-related factors.

Factors for successful adoption

The following actions will drive the e-commerce of a brand in a constantly changing business environment where technology is becoming more and more complicated and the competition is becoming more and more fierce:

- efficient and effective business transactions
- conduct business anytime, anywhere in a convenient way
- share information quickly and on time
- customize products and services
- use rich media in advertisement, entertainment, and social networks
- receive experts' and another users' advice quickly
- collaborate in different ways, both internally and externally
- increase productivity and performance, reduce costs, compress time
- find information about competitors quickly

The trust and confidence of a customer is essential for a successful e-marketing activity. Building trust online requires a lot of time and effort. It requires a clear trust model that should generate the right balance between security, usability, and costs. In Internet marketing campaigns, performance is measured by the number of returned customers or attention received from potential customer groups, so companies should shift their attention from a product to a customer by implementing the so-called customer-centric approach (Laudon K., Traver C., 2010).

- Brands should demonstrate that they ideally understand their customers and should strive to tailor their products for this particular set of customers. Customers should be assured that they are important to the company and the brand will pay attention to them and their preferences.
- Brands should enhance their interactions with customers and promise to pay more attention to them, their opinion, and needs. They should also determine if the customers are loyal to the brand. Thus, brands can become more valuable to their customers.

To build and maintain a long-lasting relation with customers, companies should take the following steps:

- Help customers express and share their opinion freely, thus understanding what should be improved and delivering these messages to R&D or the customer service department
- Demonstrate that each customer's opinion was heard, and appropriate actions were taken
- View the whole lifecycle of a client's experience with the website, simplify the process of purchasing products, and constantly monitor, manage, and improve offerings.

The key step to the successful implementation of e-commerce is the devotion of attention and resources in order to follow, analyse, and improve online marketing or web analytics.

Another important factor that needs to be considered in the adoption of e-commerce is the establishment of an appropriate payment system and mechanisms because the appearance of numerous online payment systems instead of the use of cash influenced the growth of e-commerce. The security of payment systems is an inevitable part of e-commerce.

The correct assessment of risks and their further elimination before starting the implementation of e-commerce can also determine whether the adoption will be successful.

Besides internal actions and improvements of a brand, it should be noted that the business performance of a company is based not only on what the company does, but also on what its competitors do. In this case, a company should not simply analyse its performance according to its own metrics, plans, and goals. It should also pay attention to the business environment that can sometimes influence the performance of the brand in unpredictable ways. The pressure can be financial, changes in the market, trade agreements, labor costs, societal (ethical issues, political changes, and social responsibilities), or technological (new innovations and the role of technologies). Considering that the environment is very competitive and is changing rapidly, traditional ways of responding to these challenges may not be effective and solutions may need to be modified or created anew.

Along with a well-designed e-marketing strategy and implementation actions, particular attention should also be placed on the website since it is the tool used for both sales and the presentation of the brand. The development of a website needs a “systematic approach”. It is not sufficient to be simply familiar with technology. It is important to understand the infrastructure, the business and the social processes as well. That means that the website should be accessible and available to all users even in cases where users have some disabilities, or they use a different web browser for accessing the website. A set of guidelines on this issue are provided by governmental and non-governmental organizations and may even be related to legislation.

Good optimization of a website and its structure can have an impact on its general performance, thus, facilitating easy navigation and helping search engines to find and indicate the content. It is a matter of compromise in the search for a solution on the design that will suit both users and search engines.

There are a few factors that can contribute to the successful performance of a website:

- Functionality—a page that directs to the products quickly
- Informational—easy to find links on the page on necessary information
- Simple and clear navigation
- "Redundant navigation"—alternative navigation to the same content
- Compatibility with the mostly used browsers
- Clear and understandable text

The process of adoption

Before starting the process of adopting Internet marketing, a company should make a plan by taking into account the following questions:

- What will be the stages of implementation (scheduling)?
- How much will the implementation and further developing cost (budgeting)?
- What resources will be required and how will they be obtained (resources)?
- How will the structure of the company be modified (organization)?
- How will the implementation be supported technically (technologies)?

To launch a pilot project, it is necessary to create a team with clearly defined duties and roles needs. It should also be headed by a leader. The adoption of e-commerce usually requires a serious investment. However, before this investment is made, it is better to identify any emerging problems while testing a pilot project and make the necessary adjustments and improvements. The distribution of resources should be based on the needs and capacities of every project. Implementation can also consider outsourcing for getting professional advice, trying to adopt new technology, and protecting internal network (Farhoomand, A. and Lovelock, P., 2001).

The structure of a company does not require any changes during the first stage of Internet marketing implementation which usually involves the construction of a website for promoting the products of a brand. Often the company begins to require reorganization which may include the adoption of the new structure of the company and new or modified working practices. However, this process and questions on its necessity in general depend on the size of a company. Thus, for small and medium companies, it may not be reasonable to make a separate department for Internet marketing. It may be sufficient just to hire a few people who will concentrate on the Internet marketing implementation. In some companies, it can be a one-person responsibility, even a general manager task. Big companies may require an entire department and significant organizational changes.

10.7. Performance Marketing

Internet marketing requires constant evaluation and analysis of its effectiveness. According to web analytics, this step is crucial for the successful implementation of marketing strategies. Internet marketing also measures different data, like Internet traffic, transactions, usability, and data about users. This activity helps develop a better understanding on the customers, their preferences, and behavior. Web analytics is the assessment of a variety of data, including web traffic, web-based transactions, web server performance, studies in usability, user-submitted information (i.e. surveys), and related sources in order to help create a general understanding of the visitor experience online. In the traditional mass media web, such variables cannot be measured so effectively. At the same time, it is possible to measure the exact impact of an advertising campaign on the Internet, and its success and results during the timescale. In the last 7 years a new type of Internet marketing has been developed and launched: performance marketing. This method focuses more on the results of the performance of the marketing strategy by analyzing all the available data on these marketing activities and customer reaction, and recommending further steps for activities.

Performance-based marketing is a method of interactive advertising which is not paid using a pre-set price, but rather with the use of a variable price that depends on the performance of the ad. For example, the cost of an ad might be based upon how often it is viewed on a particular webpage, how often it is actually clicked, how often it actually generates a lead, or how often it results in a sale.

10.7.1. Key benefits of Performance Marketing

Transparency

Performance marketing programs provide measurable, verifiable results on the outcome a program and/or a campaign. Further, a performance-marketing program may provide measurable results by channel, tactic, click, or impression.

Performance marketing aligns the incentives of advertiser and publisher. An advertiser is inclined to invest in programs with positive returns. Publishers make more money when consumers complete the desired objective of the campaign.

Not all performance actions are considered equal. The closer the performance action is to a transaction, the more accountable the outcome is. However, actions across the full continuum of the customer experience are crucial in driving consumers into the sales funnel.

Pay-For-Performance

Not only does the advertiser have the ability to measure the connection between the advertising and the intended action and to optimize the campaign on that basis, but also has the option to pay when that performance action occurs.

This includes traditional search marketing, e-mail marketing, and other marketing methods (see Fig. 10.8.). Pay-For-Performance can reduce the advertiser's risk as the desired outcome is more closely aligned with the payment trigger.

Figure 10.8. provides a framework for contemplating how various channels relate to a transaction. How close a performance action is to a transaction will vary from company to company, and in some cases, it may not even be a performance action.

For example, one company may consider pre-roll video views as a pure branding tool, while another may link pre-roll views to transactions by using an attribution model that creates an effective performance link. A key element in defining a performance action is the need for the action to be measurable and the purchasing campaign to be optimized on that basis. Those actions can influence a consumer to purchase a product.

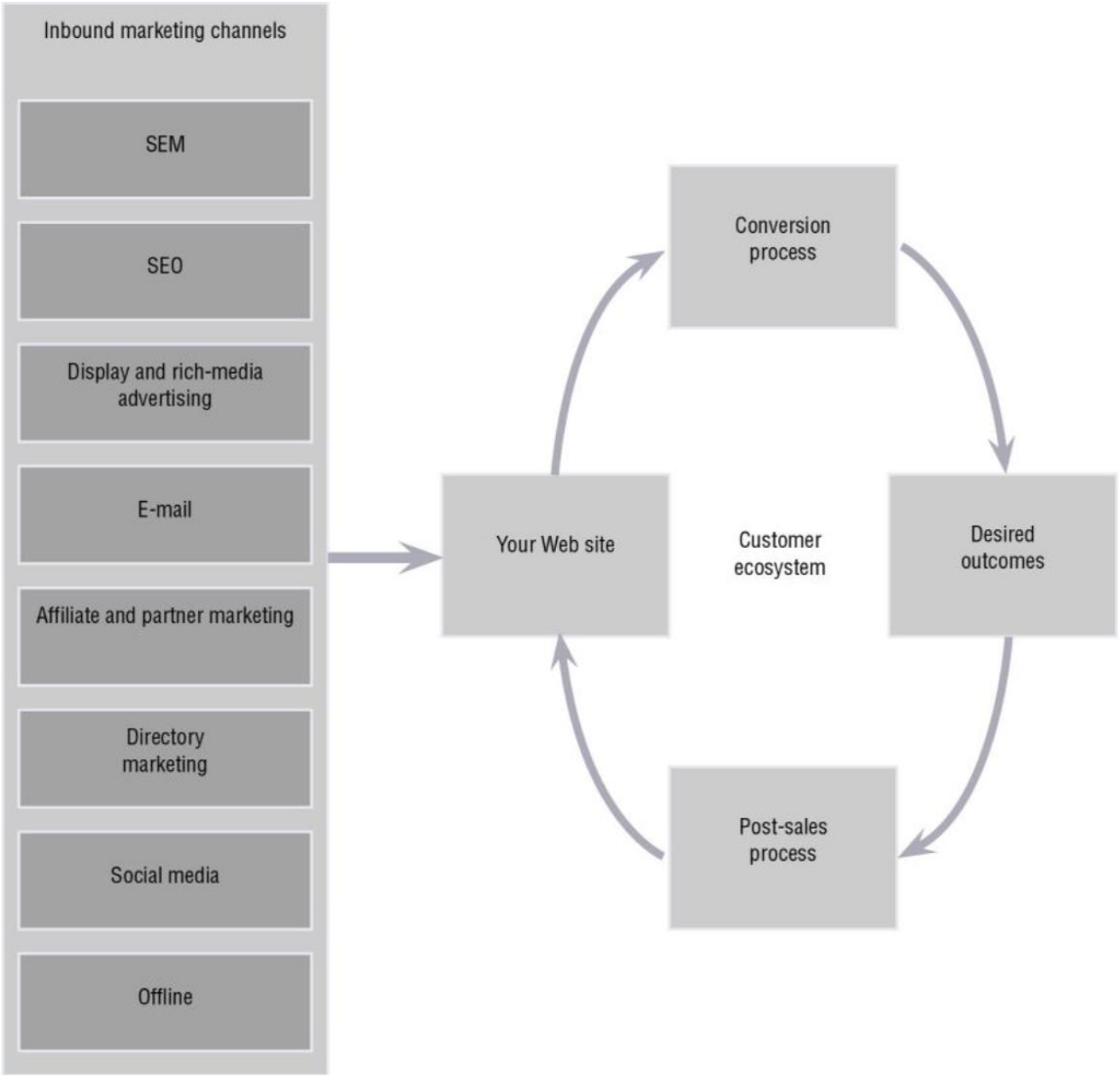

Figure 10.8. The life cycle of Performance Marketing activities

Value of Actions

Technology has expanded so rapidly that the market has gained a greater access to the reporting of outcomes that are not necessarily direct conversions. As such, performance marketing is able to drive even more outcomes through cross-device measurements.

Real-Time or Near Real-Time Optimization

Real-time bidding (RTB) has been a part of search engine marketing for a decade, and is growing quickly in display advertising. Along with real-time bidding, real-time or near real-time optimization was introduced, where advertising platforms use performance data post-impression or post-click to improve the return of a campaign. In this way, RTB has evolved from not just an efficient way for buyers and sellers to agree on the price of an impression, but also as a way to use data and insights from the results of these campaigns to enable a feedback loop of continuous performance improvement. It is expected that real-time performance optimization will move in lockstep with RTB over the next few years.

Web advertising offers precise information on its effectiveness. A measurement usually includes the following elements: how often the website is used and its specific parts, information about visitors and customers, location, time of visit and time spent on the website, and the products that users clicked on. This process facilitates a better understanding on which elements are attractive on a website, which elements do not work, which content needs to be modified, and whether the visitor was new or a returning customer. At the same time, advertising online has a number of limitations: no precise standards for measurement, difficulties with measuring the market, and the audience may not be as big as the audience reached using traditional media. Sometimes after big marketing campaigns, implementers may reach the conclusion that the intended targets have not been reached and the money was spent without generating reliable results. For this reason, it is very important to use methods that can easily measure the outcomes of the campaign and offer the possibility to monitor all the processes of these marketing activities (see Fig. 10.9). In some stages, it is necessary to restart a campaign by undertaking some changes and making some improvements.

Access to various data of the customers raises concerns about privacy, how data are kept and researched. Traditional media used to collect some data; however, only the Internet facilitates the collection of such detailed information. Online advertising can also be less effective and can be perceived negatively by customers who are concerned with their privacy. The number of people expressing these concerns is increasing. Companies have a right to collect customer data and use them for advertising. However, gaining more control on how this information is used could help reduce consumers' concerns. The more users know about how these ads are targeted, the more discomfort they feel about highly personalized advertising (Chaffey D., 2009).

The life cycle of Performance Marketing activities offers several possibilities for monitoring and improving the actions for communication with existing and potential customer groups, and is key for the implementation of successful digital marketing. However, this process requires regular reviews of marketing activities and evaluations of new activities and methods.

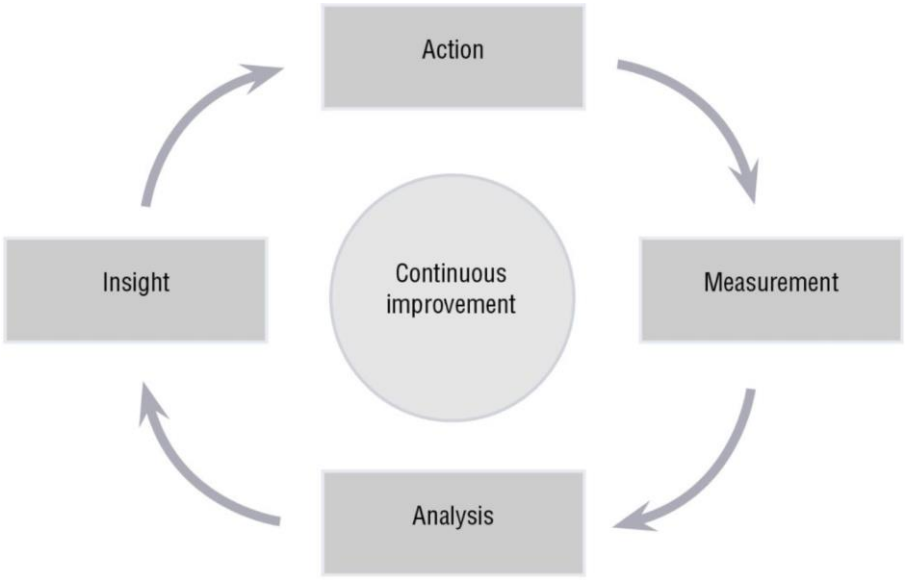

Figure 10.9. The process of monitoring marketing activities in a digital environment

10.8. Conclusion

This chapter described different Internet media, electronic tools, and methods for marketing activities in electronic environments. It provided examples of media, explained the differences between them, and offered recommendations on how to use different Internet media to communicate with the target audience. The chapter also analysed the advantages and drawbacks of different Internet marketing tools and offered methods for establishing more efficient communication channels with existing and potential customers in order to promote products or services in a digital environment. It provided a methodology for preparing a marketing communication strategy and for planning communication in a digital environment by using different Internet marketing methods. This material can help develop a better understanding on the use of tools and methods for communication with each target audience.

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Chapter 11: Prime Cost of a Project

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11.1. Introduction

It is often believed that the prime cost of a commodity is the same as the price, but this is not always the case. There is a difference between the price and the prime cost. Therefore, it is important to understand this distinction.

The price is an expression of the value of a good or a service (hereinafter – goods) in terms of money or the amount of money that a consumer is able or wants to spend to obtain a unit of a good and sellers are able and ready to sell a unit of a good. It is important to determine the price so that it would not be too high or too low. If the price is too high, it can scare away potential buyers, but if the price is too low, it can cause negative demand, for example, doubts about the quality of the product. A low price can also cause losses to the seller, when for example the income cannot compensate an effort and raw materials used to produce a good.

Several factors can influence the price, for example, market demand, the level of competition, and market saturation. Therefore, before determining the price, it is necessary to examine the environment and conditions of a company (in the text a company is understood as any organization).

When determining the price of a good one must consider inflation forecast, solvency, economic development, etc. A demand for similar goods needs to be analysed, as well. In order to forecast the supply and demand relationship in the future, it is important to analyse not only the present situation, but also predict the economic situation, lifestyle changes, and other ambient factors. Pricing policy of the goods must be aligned with the business strategy of the company. The strategy is a long-term plan or a program where the objective, stages, and mechanism for achieving this objective are defined. If the objective of the company in a given period is the survival, the price level will be quite low. Similarly, if the objective of the company is to gain new markets, then the price level will be lower than that of its competitors. However, if the objective is to make products perceived as a luxury item, the price will be set higher in order to maintain such an impression. When determining the pricing, an important factor can be the analysis of the product life cycle. If the company wants to quickly recover the invested funds during the stage of introducing the product in the market, the price will be reasonably high. However, if the company wants to seek market power quickly, the price will be set lower at first. The pricing policy will also be affected by the fact whether the product is an industrial product or commodity. When determining the price for an industrial product, such factors as a sales volume, transportation, payment options, etc. have to be taken into account.

The price is affected by the changes of price of complementary goods and substitute goods. Complementary goods are goods whose use is interrelated. For example, a tennis racket and a tennis ball, or cars and car tyres. If the price of one good changes, it will affect its demand and consequently the price and demand of the complementary good. Substitute goods are goods that satisfy the same needs of the consumers and can be used to replace one another. For example, butter and margarine, or oranges and tangerines. If the price of one good goes up, the consumers can choose to buy the other one, therefore, the sales of the other good rises, thus, forcing the price of the original product to go down. Whether the good is considered a luxury, it also affects the price. The luxury goods are goods which are not necessary daily, but tend to make life more

pleasant for the consumer. Luxury goods can be, for example, jewellery and hand watches with high added value, such as precious stones. The price of these goods is determined according to different criteria than the price of such commodities as bread, clothes, etc. which are consumed daily and bought more often and regularly.

When determining the pricing, one of the factors can be the prime cost. Prime cost is a cost of producing a unit of a single commodity. Prime cost is calculated when planning the budget of a company, controlling the business results, evaluating the finished product and work-in-progress inventories, determining selling price, etc.

If the price of a good is determined purely based on cost, the price is based on prime cost plus profit margin or mark-up determined by the company. Therefore, the prime cost can be taken into account when determining the price of a good, but the prime cost cannot be the final price, except when the company decides to sell their product at a price equal to or below the prime cost without adding any mark-up. Companies can choose such pricing scenario when, for example, the storage of goods can cause even greater losses than selling them at a price equal to or below the prime cost. Another reason for lowering the price would be an urgent need to remove the goods from the warehouse, attract new clients, or gain market share.

Such pricing policy when the price is determined based on the costs is most frequently used by organizations which operate in monopoly and oligopoly markets. Monopoly is a market situation where there is one producer whose product does not have a close substitute. A pure monopoly is possible only when the product does not have a substitute in the market or there are no similar products regarding the properties of use. The entry of new sellers is prevented or highly restricted in monopoly. Monopolists keep the price higher than in perfect competition conditions. Perfect competition is a market structure in which all companies sell an identical product, they cannot control the market price of their product, all companies have a relatively small market share, customers have complete information about the product being sold, and the prices charged by each company and the industry is characterized by freedom of entry and exit. Oligopoly is a market situation where there are only a few sellers. Also the entry of new sellers is prevented or highly restricted for several reasons. For example, because of limited resources, large investments, or legislative restrictions.

Price and prime cost are related, because when determining the pricing, one of the factors can also be the prime cost. Costs are also very important in project initiating and implementation because there are always costs during the implementation of the project.

11.2. Project costs

Project financial management is part of the project management, which can significantly affect the results of the project. It includes budgeting, forecasting cash flow, control, and analysis of the project. The objective of the financial management is to ensure the implementation of the project and receive the planned or approved funding. The most important element of the project

financial management is the determination of the project costs and cost control process during the project lifecycle.

The project costs are determined and planned during the initiation phase of the project. The planning of the project is a process where the information which allows to carry out several tasks simultaneously and which provides the most effective time for their implementation is identified. The basic stages of the project which end with a specific achievable or intermediate outcome must be determined at the beginning of the planning. Project financial planning involves resource allocation and expenditure planning, as well as planning of tasks, personnel, time, quality, control, and reporting.

The realization of the project is related to resources – the use of equipment, inventory, materials, information, etc. Therefore, the resources have to be planned. A developed plan of resources enables the optimum use of company resources, the project group has an instant access to necessary resources, and the plan helps to draw up the budget of the project. When planning the necessary resources for the project one has to determine the required amount, type, and placement of resources, as well as the start and end dates of resources.

A plan of expenses and revenue is created. Expenses are necessary funds to realize the project, but revenue is the amount of money received by a company over a period of time. A cash flow plan is created using the plan of expenses and revenues. The plan of expenses and revenues is necessary for the sponsor of the project to ensure timely funding, for the management of the company to control and take decisions, for the project manager to ensure surveillance and control and, finally, to achieve the result of the project. If the project is complex, the project budget controller can be dedicated, but mostly it is the project manager who controls the budget. If resources are not secured and committed, then the project does not start at all.

11.3. Determination of project prime cost

It may seem easy to determine the total prime cost. Necessary data can be found in financial statements and financial programming documents of previous years. However, it is not so easy from an economic perspective because there are several important things taken into account in financial calculations. One important thing that requires close attention is direct and indirect costs, as well as allocation of indirect costs to direct costs.

In order to calculate and determine the prime cost, the funds (hereinafter – projects) need to be divided into direct and indirect projects. Direct projects are projects whose costs are 100% related to the specific project. Indirect projects are projects where prime cost is allocated and added to direct project costs as indirect costs, arising from allocated total indirect project costs.

There are many different project execution costs or funds necessary for the project which are eligible to the specific project (eligible project costs). The input costs necessary for the realization of the project can be divided into two groups – direct eligible costs and indirect eligible costs of the project.

Direct eligible costs of the project are costs which are directly connected to the implementation of the project activities and are considered necessary to reach project results and this connection is clearly understandable and demonstrable. For example, the costs (salaries) of the personnel who will carry out the project includes all personnel related costs, transportation costs during the project, and the purchase of necessary equipment if it is needed for the project. Also, the costs of information and publicity measures are included in direct project costs.

Indirect eligible costs of the project are eligible costs which are not directly connected to the project results, but support and ensure appropriate conditions for the implementation of the project activities and for reaching project results. These costs are, for example, administrative costs necessary for day-to-day activities that ensure the function of the company and which are not directly related to the realization of a specific project, such as renting of premises and costs of equipment, utilities and communications services, management and support service costs (for example, legal and accounting services), and depreciation of assets.

11.4. Basic principles of cost allocation according to the cost method

There are several ways to allocate costs between different projects. One of them is cost allocation according to the cost method.

Expense data are used to calculate the prime cost. In order to use cost allocation to calculate the direct cost of the project, classification features of the project are used. Each organization establishes its own classification according to the characteristics that the projects will be classified. Cost allocation is carried out based on these principles.

Using basic principles of cost allocation according to the cost method, for the calculation of total prime cost all funds can be considered as projects which can be classified into:

1. Direct project (D);
2. Total allocated costs (IAT);
3. Costs excluded from the calculations (IN).

Direct project (D) is a revenue-generating project whose full costs are attributable only to the specific project. There is no need to allocate these funds because they are fully included in the prime cost of the project.

Indirect/allocated/total project cost (IAT) or total allocated cost is a project mainly implemented by administrative units and related to the whole structure or a part of it and also may not be a revenue-generating project which requires the calculation of prime cost. IAT classification is usually applied to funds and projects of centralized administration whose costs, using an allocation key scenario, are allocated between all of them or a part of direct projects according to a characteristic which characterizes a specific group of projects. In bigger organizations, it is possible to divide the joint structure into units or departments. Then the expenses can be classified into allocated costs of a unit or indirect/allocated/unit (IAU). These expenses are not attributable to the whole structure, but to the specific unit. Such project costs, which are

attributable only to a specific unit, using an allocation key scenario, are allocated in the unit not in the whole structure.

Indirect/non-allocated project (IN) or expenses not included in the prime cost calculations do not affect the prime cost of other projects, therefore, these funds are not allocated to direct projects. For this reason, it is inefficient to determine the prime cost of indirect/non-allocated projects. Such projects can be, for example, principal of the loan without interest from a bank, but such projects are not very common.

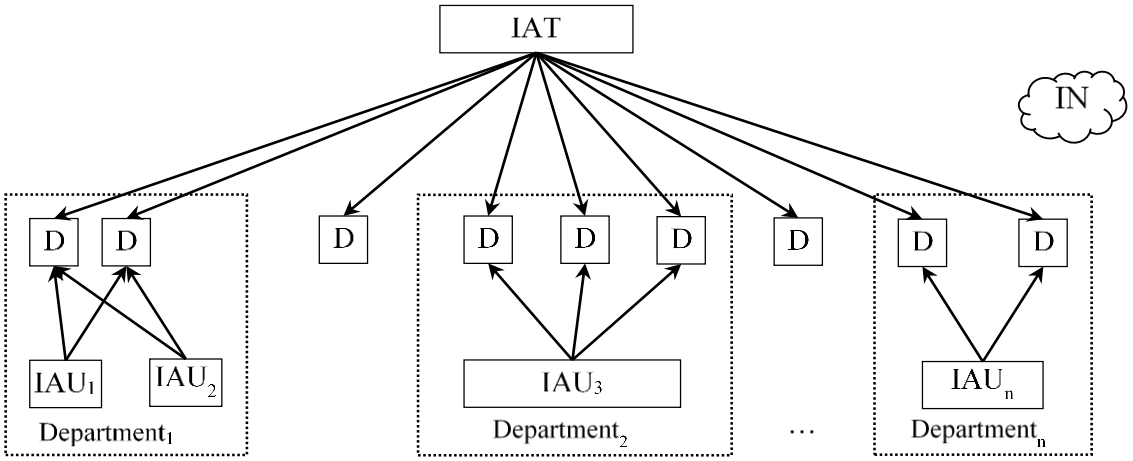

Figure 11.1. Basic principles of cost allocation

The basic principles of cost allocation are provided in Fig. 11.1. It is given that allocated costs (IAT) are allocated to all of them or a part of direct projects (D) regardless of whether this direct project is a project of a specific department or the direct project of the whole structure. However, allocated costs of the units (IAU) are allocated only to direct projects which are in the specific department. These funds are not allocated to the projects of another department or the direct projects of the whole structure. The expenses that are not included in the calculations (IN) are not allocated to any direct projects and they do not affect the prime cost of the direct projects.

11.5. Types of allocation keys

All costs, incurred as a result of economic activities and realization of stand-alone projects, are attributed to a specific project, which, in turn, can be a direct or indirect project. In the case of a direct project, the costs are added to the specific project. In the case of an indirect project, an allocation key scenario of the project concerned is applied to the division. As a result, these costs are allocated and proportionally added to the direct projects as indirect costs of the project.

Indirect costs between direct projects can be allocated in several ways. One of them is allocating costs proportionally to the costs to all or a part of the direct projects, which are subjected to a specific indirect project. Indirect costs can also be allocated proportionally to the costs with a specific characteristic to all the direct projects corresponding to this characteristic(s) and subjected to a specific indirect project, as well as according to different types of allocation key scenarios which are manually entered, for example, proportionally to the costs to a few specific projects or manually entered coefficients.

Each type of key has two types—a private and a public key. The public key is for general allocation scenarios which can be applied to the majority of IAT projects. The private key is for specific allocation scenarios. The scenario is custom made for each IAT project. Only the types of keys—cost or manual proportion are uniformly defined.

Allocation key scenarios are a combination of the type and dimension of the key. There are two functions AND and OR which combine dimensions and criteria. With the function AND the dimensions are combined in criteria and in this case all conditions need to be fulfilled. With the function OR several criteria are combined and in this case one of the criteria needs to be fulfilled, not all of them.

In the process of forming key scenarios one needs to follow the order of disjunction (OR) operations because it affects the use of allocation coefficient. In cases when one direct project corresponds to several coefficient application cases of one allocation key scenario, the first eligible coefficient will be used because for each direct project, in the case of applying one allocation key scenario, the part of indirect cost of the project is applicable only once.

In cases when an indirect project can be applied to a specific direct project or a group of direct projects, another more suitable allocation key scenario from the offers of defined public keys is used or, if necessary, a new allocation key scenario is defined. Allocation mechanism can be applied hereafter to several projects or it can be made only for a specific project to which it is defined.

As a result of the use of allocation keys, the costs in management accounting for the calculation of prime cost of direct projects, which are eligible to indirect projects according to financial accounting data, are allocated and added proportionally to the direct projects as indirect costs of the project.

11.6. Project funding

All resources are divided into four groups—natural resources, capital resources, labor resources and entrepreneurial resources. Natural resources include forests, minerals, air, water, etc. Labour resources are all employees who contribute to the economic activity of the organization with their knowledge and work. Entrepreneurial resources are necessary for conducting entrepreneurship or commercial activity. Capital resources are already previously produced instruments, equipment, factory buildings, means of transport, warehouses, etc., to produce

goods and deliver them to the consumer. The financial resources of a company are capital resources. Financial resources can solve the lack of other resources in the company. If a company has sufficient financial resources, it may acquire the necessary resources it lacked before and avoid shutdown.

Financial resources help to achieve the objective of a project; therefore, funding is needed to successfully realize projects. Project funding is all activities necessary to ensure a project has financial resources. It is a process of obtaining and using financial resources.

The amount of the necessary funding depends on the objective of the project, its scale, planned events, and other planned activities. Funding should be managed under strict conditions in order to control the use of funds and ensure that financial resources for the project are spent transparently, responsibly, and effectively. There are several types of project funding.

Co-financing is the financial resources necessary for the success of the project. It is a certain part of eligible costs of the project. Before the project submission the amount of eligible costs should be carefully considered, as well as the source of co-financing. The project manager is responsible for timely co-financing.

The project co-financing should be planned by calculating the monthly or another time period cash flow according to the project objectives and deliverables indicating the amount of co-financing and months when it will be provided.

Additional co-financing is necessary financial resources in the project to cover the costs of the project that are not reimbursed by the project sponsor. These are ineligible costs of the project, for example, bank charges for bank transactions.

The moment when the project sponsor has not yet made the payment to the project promoter, but the implementation of the project needs funding for further action and it should not stop or there is a need to start the implementation of the project faster than funding is received, one should look for ways and opportunities how to attract pre-financing. Pre-financing is financial resources necessary for successful implementation of the project when the project sponsor has not made an advance payment or current payment to the project promoter.

The initial amount of pre-financing of the project, granting, and repayment periods are planned by preparing a cash flow of the project. Cash flow is prepared across a range of timescales depending on the objectives and tasks of the project. It can be daily, monthly, quarterly, etc. cash flow. Pre-financing for the projects most often is taken from the funds of the organization or bank credits. When the payment of project funding is received, pre-financing, if not covered by the organization itself, is returned to the sponsor.

11.7. Financial plan of the project

In order to plan the amount of necessary funding and its use, a financial plan is needed. There are such documents as cash flow of the project, cost plan, income plan, and other necessary

documents. It is much easier to negotiate with partners, investors, other people involved in the project, and financing entities using indicators of financial plan.

When preparing a financial plan, it is necessary to evaluate the amount of funding to realize the project—the value of resources required in terms or money. It shows how many resources in terms of money and a period of time are necessary to ensure the implementation of the project, as well as what the expected results of the project are.

There are some significant recommendations for a financial plan. Firstly, it is important for the given information to be objective and real. Secondly, there should be more than one scenario of the financial plan i.e., carry out two financial calculations—optimistic and pessimistic. Thirdly, the financial plan needs to be periodically reviewed and, if necessary, corrected. The reason for this can be changes in prices, technologies, market situation, legislative changes, etc. These changes can influence the prime cost of the project. The time period, according to which the plan indicators are determined, depends on the objective of the project.

One of the parts of the financial plan is cash flow forecast which is prepared in order to calculate the necessary amount of funding, deadlines, and breakdown per sources of funding. Cash flow needs to be as accurate as possible. It is essential to plan the cash flow because as soon as the project is implemented there is a risk of having serious financial problems, if all expenses and the time when they occur are not taken into account or revenue and deadlines are overestimated. In properly drawn up cash flow, necessary financial resources for a particular month are clearly seen, which would ensure the expenses that will occur within the project.

When drawing up cash flow, it should be taken into account that the cash flow balance at the end of the period cannot be negative. If there is negative balance during drawing up the timing of the cash flow, then it is necessary to plan a short-term loan or another way of getting the funding that would cover the negative balance and repayment of the loan if the loan was taken. If the negative balance is small, then it is advised to carefully consider cash revenue and expenditure deadlines in case it is possible to reduce the cash deficit by changing the deadlines.

A bigger or smaller funding is necessary to create projects; therefore, calculation of cost price of the project is an important stage in the development of the project and it needs as much attention as other project development stages. By calculating the prime cost and working out the financial plan of the project, the project team gets an idea of the necessary funding and plans their activities so that the project would be successfully implemented.

Chapter 12: Evaluating the Development of Students' Key Competences during their Master's Thesis

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12.1. Introduction

Through the master's thesis, the student independently develops his/her analytical and problem solving capability at an academic level. The final objective is to evaluate the development of these key competences in a transparent way, taking into account the quality assurance of the assessment. Therefore, a multidimensional approach, using a carefully selected combination of different evaluation tools, and different assessors at different times, is adopted (Associatie KULeuven, 2005).

12.2. Evaluation criteria

In general, the student delivers a thesis that reflects the critical reflection and the research attitude of the student. In concrete terms, the evaluation of the master's thesis is based on the following categories of evaluation criteria (Burman, M. et al.), (Lauwers, A., 2007):

- Research
- Written reporting
- Oral presentation
- Working method.

12.2.1. Research

In the section of the research, several aspects are evaluated:

- Problem definition: The student is able to formulate correctly the subject of his/her master's thesis and to translate it into a series of technical requirements and/or scientific research questions. He critically relates it to the existing scientific and technological knowledge. He makes several proposals for a solution.
- Information processing: The student is able to collect information and, subsequently, to select, to synthesize, and to interpret the relevant information.
- Research methodology: The student can apply the current research approach of his scientific-technological discipline.
- Interpretation of own results: The student is able to interpret his/her research results in an honest, balanced, and scientifically accurate way.
- Final conclusions: The student can formulate well-considered and correct final conclusions.

12.2.2. Written reporting

Concerning the written final report, the following aspects are evaluated:

- Content: The content is correct and complete.
- Structure: The text has a systematic coherence and a logical structure.
- Writing style: The student has a clear and concise writing style. His/Her text is easily accessible and readable.
- Language use: The student uses a correct language and does not make any mistakes in grammar, spelling, or punctuation.
- Layout: The report contains a correct table of contents. All chapters and paragraphs are numbered. The layout is uniform and well-structured/designed? .
- Tables, graphs, figures, and (scheme) drawings: All tables, graphs, figures and (scheme) drawings have a name and a number according to the standards. In the text, the student consequently refers to those numbers.
- Acknowledgement of the sources: The report includes a complete bibliography according to the instructions.

12.2.3. Oral presentation

The oral presentation is evaluated on the basis of the following criteria:

- Introduction: The presentation starts with a table of contents. Subsequently, the student outlined the context of the subject, together with the problem definition.
- Structure of the message: The message is clearly and logically structured. The student does not mention any unnecessary details.
- PowerPoint presentation: The PowerPoint slides are well worked-out and adequately support the presentation.
- Body language and clothing: The student has an appropriate body language and wears clothing according to the dress code.
- Language use: The student communicates in short and comprehensible sentences and pays attention to the intonation of his voice.
- Time use: The student keeps strictly to the speaking time allocated to him.
- Defense of the dissertation: The student uses material from his master’s thesis to support his clear and quite quick answers to the questions of the jury. He is able to prove himself being strong with regard to content. He is well informed of the most recent developments in his scientific-technological discipline. He also can indicate the direction of the new developments.

12.2.4. Working method

Concerning the working method, the following aspects are evaluated:

- Commitment: The student works with a sense of responsibility, commitment and motivation. He has the perseverance to solve any emerging problems.
- Planning: The student ensures a clear planning of the steps needed to deliver the objectives, including timing. He tackles the problems methodically.
- Autonomy: The student is able to reason and to work autonomously during the elaboration of his master's thesis.
- Teamwork: The student actively reacts to the ideas and the criticism of his teammates while respecting them. He follows the agreements previously made rigorously.

12.3. Multidimensional approach

To evaluate the key competences, developed during the master thesis, a multidimensional approach is applied (Van de Walle, B., 2009). This means that a carefully selected combination of different evaluation tools and different assessors is used at different times to check to what extent the student:

- has an understanding of the underlying theoretical framework
- possesses the adequate skills to perform the necessary actions
- is able to reflect on and to steer his own development.

One can, therefore, conclude that the knowledge as well as the application of knowledge and skills/ attitudes are the purpose of the measurement. The assessors use an instrumentation with which they can observe, record, interpret, and assess the attitude of the student within an authentic and profession-specific context. Furthermore, not only the learning product but also the learning process is evaluated. Here, providing constructive feedback is a major focus.

During the master's thesis, three moments of evaluation are planned:

- A first evaluation after the initial phase
- A mid-term evaluation
- The final evaluation.

12.3.1. First evaluation

An evaluation with a formative character, takes place after the initial phase. During a feedback session, the internal coach examines two aspects of the section of research: problem definition and information processing.

If the student underperforms, the necessary remedial measures are taken in consultation with the student involved, the internal coach, and the external coach. These remedial measures are noted in the logbook of the student.

12.3.2. Mid-term evaluation

A mid-term evaluation with both a formative and a summative character, investigates the progress of the student, concerning the following aspects of the master's thesis:

- Research methodology
- Interpretation of own results
- Working method.

Both the internal and the external coaches are involved in this mid-term evaluation.

12.3.3. Final evaluation

The final evaluation is strictly summative. Here, the written final report, the oral presentation, and the defense of the dissertation are assessed. A jury of external experts and teachers is present at the oral presentation and the defense. They evaluate the student on the basis of the evaluation criteria mentioned above.

12.4. Quality Assurance

The multidimensional evaluation system ensures the educational quality of the evaluation. The main objective is to strive for a transparent, valid, and reliable assessment (Van de Walle, B., 2009).

12.4.1. Transparency of the evaluation

The assessors include the evaluation criteria and the evaluation system in the study guide, intended for the students, in a clear and accessible way. This study guide is handed over to the students at the start of their master's thesis. It is also available in the digital learning platform.

During the master's thesis, the internal coach informs the student additionally and regularly about:

- The learning objectives to be acquired
- The evaluation method
- The degree of complexity
- The manner of posing questions by the jury
- The exam administration.

12.4.2. Validity of the evaluation

In order to obtain a valid evaluation system, the assessors take into account the following quality standards when developing the various examinations:

- The complexity of the master's thesis is sufficiently high
- All learning objectives are equally verified using balanced examinations
- The questions are relevant and form a representative sample of the complete assignment of the master's thesis
- The required thinking processes are analogous to those that experts are using to solve problems
- The whole of the several part-assignments allows the complete assessment of the key competences very well
- The content of the master's thesis is sufficiently measured.

Concerning the formative feedback, the assessors should also meet some quality standards. This feedback should be:

- Focusing on the achievements of the student and not on his personality
- Related to the needs of the student
- Sufficient and specific
- At the right moment (when it is still relevant)
- Congruent with the objective of the assignment
- Constructive for the further learning process.

12.4.3. Reliability of the evaluation

In order to increase the reliability of the evaluation, the assessors follow some important aspects of the assessment:

- Reliability of item (clear and unambiguous questions)
- Specificity (correct answers are only possible after studying the master's thesis)
- Ability of differentiation (distinction between good and bad answers is possible)
- Congruence with the students' level (not too difficult or too easy questions)
- Application of clear evaluation criteria.

As for the evaluation of the oral presentation and the defense, a separate procedure is conceived. Prior to the oral presentation and the defense, supporting documents are delivered to the external experts of the jury. Consequently, those experts are properly informed about the evaluation system. Afterwards, the evaluation method of the jury is based on 'negotiation'. Through dialogue, a consensus between the several assessors is obtained concerning the key competences of the student. Here, information from multiple perspectives contributes to a better decision.

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Annex: Formal Requirements in Belarus for Master's Theses

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A.1. General requirements

The requirements on the rules for the preparation of the master's thesis in Belarusian universities are determined by the Regulations on the organization of the final certification while mastering the content of higher educational programs of the second (II) stage at every university, approved by the order of Rector (for example, the order of the BSU Rector № 48-OD of 07.02.2014 [1]). Below, some brief excerpts from this Regulation are presented.

The master's thesis is printed on one side of a sheet of white A4 paper (210x297 mm). It is allowed to submit tables and illustrations on A3 sheets (297x420 mm).

The thesis is typed using the text editor Word. It is recommended to use Times New Roman type fonts with the size of 14 points. The number of characters per line should be 60-70, the line spacing should be 18 points, the number of text lines on the page around 39-40. In the case of inserting a formula into the string, an increase in the line spacing is allowed.

The following sizes of fields of the pages are established: upper and lower - 20 mm, left - 30 mm, right - 10 mm.

The font should be straight, light, clear, black, the same throughout the volume of the thesis. It is allowed to use computer capabilities to focus attention on definitions, terms, theorems, important features, applying different types of font: italic, bold, italic bold, framing, discharging, underscoring, and more.

A.2. Requirements for the design of headings [2], [3]

Headings of the structural parts of the dissertation "Table of Contents", "List of Symbols", "General Characteristics of Work", "Introduction", "Chapters", "Conclusion", "Bibliographic List (References)", "Supplement" and “Appendices” are printed in capital letters in the middle of lines, using boldface with a size of 1-2 points more than the font in the main text.

Sections headings in Chapters are printed in lower case letters (except for the first upper case) with a paragraph indentation in bold type with a size 1-2 points larger than in the main text.

Headings of subsections are printed with a paragraph indent lowercase (except the first capital) in bold type with the font size of the main text.

At the end of the headings of Chapters, sections and subsections do not put a period. If the header consists of two or more sentences, they are separated by a period (dots).

The distance between the heading (except for the title of the item) and the text should be 2-3 lines. If there is no text between the two headers, then the distance between them is set to 1.5-2 lines spacing. The distance between the title and the text after which the heading follows may be greater than the distance between the title and the text to which it refers.

Each structural part of the dissertation should begin with a new page.

A.3. Numbering requirements [2], [3]

The numbering of pages is given in Arabic numerals. The first page of the thesis is the title page, which is included in the overall numbering of the dissertation pages. On the title page, the page number is not set, on the subsequent pages the number is placed in the center of the bottom of the page without a period at the end.

The numbering of Chapters, sections, subsections, paragraphs, figures, tables, formulas, equations is given by Arabic numerals without the "№" sign.

The Chapter number is placed after the word "Chapter". The Sections, "Table of Contents", "List of Symbols", "General Characteristics of Work", "Introduction", "Conclusion", "List of used literature", and "Supplement" do not have numbers.

Paragraphs (sections) are numbered within each Chapter. The paragraph number (section) consists of the Chapter number and the sequence number of the section, separated by a period, for example: "2.3".

Subsections are numbered within each section. The subdivision number consists of sequence numbers of the chapter, section, subsection, separated by dots, for example: "1.3.2".

The title of the chapter is printed from the new line following the Chapter number. Headings of sections and subsections are presented after their numbers through a space. At the end of the numbering of Chapters, sections, subsections, and also their headings, the period is not placed.

The number of the illustration (table) should consist of the Chapter number and the sequence number of the illustration (table, figure, chart, etc.) separated by a period. For example: "Figure 1.2" (the second figure of the first Chapter), "Table 2.5" (the fifth table of the second Chapter). If only one illustration (table) is given in the Chapters of the dissertation, they are numbered consecutively within the dissertation as a whole, for example: "Figure 1", "Table 3".

Formulas and equations in the Master's thesis (if there are more than one) are numbered within the Chapter. The number of the formula (equation) consists of the Chapter number and the ordinal number of the formula (equation) in the Chapter, separated by a period. The numbers of the formulas (equations) are written in parentheses at the right margin of the sheet at the level of the formula (equations), for example: "(3.1)" is the first formula of the third chapter.

It is advisable to number information sources as they are mentioned in the text of the thesis. It is possible to number the sources placed on the "List of used literature" in alphabetical order.

A.4. General requirements for the design of graphs, illustrations and other graphic material [2], [3]

Illustrations should be performed using computer technology or ink or paste black on white opaque paper. The quality of the illustrations should ensure that they can be copied clearly.

Illustrations and tables should be placed in the thesis directly on the page with the text after the paragraph in which they are mentioned for the first time, or separately on the next page. They should be arranged so that it is convenient to examine them without turning the page. If it is required to turn the page, it is preferable to turn it clockwise. Illustrations and tables, which are located on separate pages of the thesis are included in the overall page numbering. If their sizes are larger than the A4 size, they are placed on an A3 size sheet and counted as one page.

Illustrations and tables are denoted by the words "Figure" and "Table" respectively, and are numbered consecutively within each Chapter. All tables and illustrations should be referenced in the text of the thesis. The words “drawing”, “sketch”, “table” in the signatures to the drawing, table and references to them are not reduced.

Illustrations, as a rule, have the name and explanatory data (the drawing text), located on the center of the page. Explanatory data is placed under the illustration, and on the next line - the word "Figure", the number and name of the illustration, separating the dash with the number from the name. A period is not placed at the end of numbering and names of illustrations. Do not carry words in the name of the picture. The word "Figure", its number and the name of the illustration are printed in bold type, and the word "Figure", its number, as well as its explanatory data, is reduced by 1-2 points in the font size.

A.5. Requirements for the design of tables [2], [3]

The digital material of the Master's thesis is made out in the form of tables. Each table should have a short title, which consists of the word "Table", its sequence number and name separated from the number by a dash. The title should be placed above the table on the left, without a paragraph indentation.

When you create tables, you must follow the following rules:

- It is allowed to apply a font in the table for 1-2 points less than in the text of the Master's thesis
- Do not include the "Number in order" column in the table. If it is necessary to number the indicators included in the table, the serial numbers are indicated in the side table immediately before their name.
- A table with a large number of rows can be moved to the next page. When you transfer a part of a table to another page, its title is indicated once over the first part, and the word "Continuation" is written to the left of the other parts. If there are several tables in the thesis, then after the word "Continuation" indicate the number of the table, for example: "Continuation of Table 1.2".
- A table with a large number of graphs can be divided into parts and placed one part under another within a single page, repeating in each part of the table the outset. The title of the table is placed only above the first part of the table, and above the others write "Continuation of the table" or "End of the table" with indication of its number.

- A table with a small number of graphs can be divided into parts and placed one part next to another on one page, separating them from each other by a double line and repeating the head of the table in each part. With a large head size, it is allowed not to repeat it in the second and subsequent parts, replacing it with the corresponding numbers of the graphs. The graphs are numbered with Arabic numerals.
- If the text repeating in different rows of the table graph consists of one word, it can be replaced with quotes after the first writing. If from two or more words, then it is replaced by the words "The same" at the first repetition, and then - by quotation marks. Put quotes instead of repeated numbers, marks, signs, mathematical, physical and chemical symbols is not allowed. If digital or other data in any row of the table does not lead, then a dash is placed in it.
- The headings of graphs and lines should be written with a capital letter in the singular, and the subheadings of the graph should be lowercase if they constitute one sentence with a header, and with capital if they have an independent meaning. It is allowed to number the columns with Arabic numerals, if it is necessary to give references to them in the text of the thesis.
- The headings of the graphs, as a rule, are written parallel to the rows of the table. If necessary, it is allowed to place the graph headings in parallel with the columns of the table.
- The head of the table is separated by a line from the rest of the table. The left, right and bottom of the table is also bounded by lines. Horizontal and vertical lines delineating the rows and columns of the table may not be carried out (if it does not hinder the table reading.
- It is not allowed to separate the headings and subheadings of the outset and the graph with diagonal lines
- In case of interruption of the table and transfer of its part to the next page at the end of the first part of the table, the lower limit is not carried out

A.6. Requirements for writing formulas

To designate physical and mathematical quantities, including indices, only Latin (italic) and Greek (straight) letters should be used. Vector values are indicated by bold straight Latin or Greek letters. Formulas should preferably be written in such a way that they are not "high-rise". To do this, use $\exp(x)$ instead of e^x, as well as the image of the fractions through a slash and clearly place the brackets so that you can easily distinguish the numerator from the denominator.

Mathematical formulas are included in the sentence as its full-fledged element, with all the rules of syntax and punctuation preserved. Non-independent and / or small formulas are placed inside the lines of text. Long, important and all numbered formulas are placed in the center of a single

line. The formula is assigned a number in the event that the author subsequently refers to it. The numbers of the formulas are written in parentheses in the extreme right position on the line. If the formula does not fit in one line, it must be moved after the equal signs, plus, minus, multiplication or division.

Explanation of the meaning of symbols and numerical coefficients should be given under the formula, if it was selected in a separate line, or immediately after the formula, if it was located in the text of the paragraph. Explanations are given in the same sequence as they are given in the formula. The first line of explanation begins with the words "where" without a colon.

References in the text to the formula give its number in parentheses.

A.7. Requirements for the design of references to information sources

References to the source of information are given by indicating its ordinal number in square brackets according to the list placed in the structural element "List of used literature".

A.8. Requirements for the design of a bibliographic description of information sources in the «List of used literature»

Bibliographic description of information is carried out in accordance with GOST (State standards of Belarus) [4].

A.9. Requirements for presentation of applications

The section "Supplement" is made at the end of the manuscript or in the form of a separate part, placing them in the order of appearance of references in the text of the Master's thesis. It is not allowed to include materials in the application that are not referenced in the text.

Each Supplement should begin with a new sheet with the word “SUPPLEMENT” or “APPENDIX” printed in uppercase in the upper right corner. The application should have a meaningful title, which is placed from a new line in the center of the sheet with a capital letter.

Appendices are denoted by capital letters, starting with A, for example: "APPENDIX A", "APPENDIX B ", "APPENDIX C". It is allowed to denote applications with letters of the Russian or Latin alphabet.

The text of each Supplement, if necessary, can be divided into sections and subsections, which are numbered within each application, with the letter corresponding to the application designation preceded by the section number (sub-section) (for example: A1.2 - the second subsection of the first section of Appendix A). Also, illustrations, tables, formulas and equations are numbered in the application.

A.10. Requirements for the designation of physical quantities measurement units

Physical quantities are indicated only by Latin (italic) or Greek (direct) letters. The units of measurement of physical quantities are designated exclusively by straight letters.

It is allowed to use either international or Russian designations of units. Simultaneous application of both types of symbols is not allowed. In the designations of units, the point as a sign of reduction is not put.

For SI units that do not have special names, it is necessary to use notation containing the minimum number of SI units with special names and basic units with possibly lower exponents.

Example:

Right	Wrong
A / kg	Cl / (kg·s)
Ω·m	$(m^3 \cdot kg) / (s^3 \cdot A^2)$

The notation of units of measure is placed on one line after a space after the numerical values of the values.

Example:

Right	Wrong
10 A	10A
80 %	80%
30 °C	30°C; 30° C

An exception:

Right	Wrong
30°	30 °

The transfer of the notation to the next line is undesirable.

The designations of the units entering the work are separated from each other by the multiplication symbol in the form of a point on the middle line.

Example:

Right	Wrong
N·m	Nm
$A \cdot m^2$	Am^2

In the notation of the ratio of units of physical quantities measurement, only one trait (oblique or horizontal) should be used as the division sign. It is allowed to use the notation of units as a product of the designations of units raised to the power.

Example:

m/s; $Wt \cdot m^{-2}$; cm^{-2}/ (V· s)

When specifying a derived unit consisting of two or more units, it is forbidden to combine designations and names.

If a number of numerical values is given in the text, then the unit designation is indicated only after the last digit.

Example:

4,2; 5,7; 6,9; 8,4 W.

Example:

4.2; 5.7; 6.9; 8.4 W.

When specifying the interval of numerical values of a physical quantity, its measurement unit is indicated only after the last number.

Example:

from 10 to 20 Sm; from 2 to 8 mV; from 100 to 400 pF.

However, when specifying limit deviations, it is necessary to enclose numerical values with the maximum deviation in parentheses and designate the units to be placed after the parentheses.

Example:

(10 ± 1) cm; (124 ± 3) mg; (18.5 ± 0.2) A; (0.17 ± 0.04) μV.

Preference is given to the use of SI units, decimal multiples and lobes from them. The multipliers and attachments for the formation of decimal multiples and lobes of SI are given in Table A.1.

Table A.1 — Multipliers and prefixes for the formation of decimal multiple and lobed units and their names

Factor	Console	Designation of the console	
		International	Russian
10^{18}	Exa	E	Э
10^{15}	Peta	P	П
10^{12}	Tera	T	Т
10^{9}	Giga	G	Г
10^{6}	Mega	M	М
10^{3}	Kilo	k	к
10^{2}	Hecto	h	г
10^{1}	Deck	da	да
10^{-1}	Deci	d	д
10^{-2}	Centi	c	с
10^{-3}	Milli	m	м
10^{-6}	Micro	μ	мк
10^{-9}	Nano	n	н
10^{-12}	Pico	p	п
10^{-15}	Femto	f	ф
10^{-18}	Atto	a	а

Example:

Millisimens, mSm.

The choice of a decimal multiple or unit SI unit is dictated primarily by the convenience of its application. It is recommended that multiples and units be selected in such a way that the numerical values are in the range from 0.1 to 1000.

Example:

0.4 pF; 5 μA; 12 nCl; 140 kV.

In addition to SI units, units of values estimated by conventional scales (for example, Rockwell and Vickers hardness scales), relative and logarithmic units (for example, promille, bel, decibel), as well as carat, atomic mass unit, minute, hour, eV and some others in accordance with GOST 8.417-81 [5]. In exceptional cases, the use of units of CGS and CGSM systems is allowed.

References

[1] OCBO 1-31 81 02-2012. Higher education. The second step (Master). Specialty 1-31 81 02 – Photonics. Degree master of physics. — 24.08.2012. — Mn.: Ministry of Education of the Republic of Belarus, 2012. — 16 p. (Educational standard of higher education).

[2] OCBO 1-31 81 03-2012. Higher education. The second step (Master). Specialty 1-31 81 03 – Functional nanomaterials. Degree master of physics. — Introduction.24.08.2012. — Mn.: Ministry of Education of the Republic of Belarus, 2012. — 16 p. (Educational standard of higher education).

[3] Regulations on the organization of final certification while mastering the content of educational programs of higher education of the second II stage in the Belarusian State University. Approved by the order of the Rector of the BSU No. 48-OD of 07.02.2014. — Mn.: BSU, 2014. — 42 p.

[4] GOST 7.1–84. Bibliographic record Bibliographic description. General requirements and rules of compilation. — In exchange for GOST 7.1-84; Enter. 01.07.2004. — M.: Publishing Standards, 2004. — 166 pp.

[5] Units of physical quantities: Sat. Standard-techn. Documents. — Moscow: Publishing Standards, 1987. — 176 p.

[6] GOST 7.32-2001. Report on research work. Structure and rules of registration. — In exchange for GOST 7.32-91; Enter. 01/01/2003. — Mn.: BelGISS, 2002. — 16 p.