

# An Introduction to the Management of Complex Software Projects



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By

Veljko Milutinović, Filip Đorđević,  
Miloš Kotlar and Jakob Salom

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## PREFACE

A couple of years ago, a former student donated a significant amount of money to the faculty of our alma mater. The amount would today be equivalent to a total of one million dollars. This happened on the donor's 80th birthday, when he looked back on his life, and decided to give some money to Stanford and Belgrade universities.

After that event, the dean of the School of Electrical Engineering (at that time), who later became the rector of the entire university, together with a few other people, including one of the co-authors of this book, met to discuss what could be done on the part of the faculty to increase the probability of an event like this one happening again. The conclusion of the discussion was to form a course that would teach the students, above everything else, the skills that are crucially important in the period after graduation.

The course was first offered to students with a major in Software Engineering and Computer Engineering at the School of Electrical Engineering of the University of Belgrade and the School of Mathematics of the University of Belgrade. When the entire university heard about this course, several other schools of the same university decided to make it elective or even mandatory in their postgraduate studies; in some cases, it was even the only mandatory course of master studies. The schools that adopted the course include the School of Civil Engineering and the School of Physical Chemistry, while the same course in a reduced format was adopted by the School of Business Administration, and the School of Urban Architecture. Some of them decided that the class should include twelve hours a week dedicated to homework, with all homework assignments being mandatory. In other schools, only four homework assignments were mandatory, so the selected topics were covered both by homework and at the exam, while the remaining topics were covered only at the exam.

After the chapter that presents the teaching content for each week of the course, the authors have added chapters dedicated to special topics of importance for the success of new graduates, with special emphasis on computing.



# TEACHING THE BASICS

VELJKO MILUTINOVIĆ

The material that follows are summaries of weekly lectures of the course<sup>1</sup>.

## **Week 1: Introductory Overview 1**

Leading a project is a holistic activity, which means that before starting the project, it is important to first ensure the resources, i.e., the money needed to support the project financially, and the knowledge needed to manage the crucial activities of the project. It is important to control the entire logistics of the project successfully, and not only the narrow professional part of it. That is why the lectures of the first weeks of this book cover the topic of applying for resources. This part is tuned to small and medium-sized companies, universities, research institutes, or similar; they can be either private or government-owned. The major grant-giving system in Europe started with the Framework Programme (FP, now called H2020 - Horizon 2020) mechanism, while in the United States of America, the agency most supportive of science is called the National Science Foundation (NSF).

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<sup>1</sup> Disclaimer: The text of Chapter #1 had been generated from the recording of the lectures of Professor Veljko Milutinovic. To make his lectures more interesting to students, often times it was necessary to use colloquial words, which were not changed later, for the reason of authenticity. Also, to make the concepts easier for students to comprehend during the lecture, often times the concepts were presented in a way which is not exactly correct in the narrowest sense, with the assumption that the students will later be able to acquire the absolutely correct information from the accompanying textbooks written by Professor Milutinovic. Again, for authenticity reasons, these statements from lectures were intentionally not been polished later for this book, so that the students could learn through associations related to lectures that they had attended.

It does not matter whether a proposal is to be written for H2020 or NSF, the essence remains the same, which is to demonstrate the awareness of a problem's best current solution and what its flaws are, from the viewpoint of the research investor. The proposed research idea should be better than the best existing one. In addition, it is also useful to provide explanations on what will be done to demonstrate the superiority of the idea and how the idea can be commercialized. So, the first part of the course is dedicated to the management part of a project, in the broadest sense of that word.

The second part provides details about MBA studies in the United States, with a review of what European variations look like. This part also explains how to get accepted at one of the most prestigious universities in the world, such as Purdue or Indiana University, through their entrance exams, where the most challenging part of the exam is the analytical part.

Parts 3 and 4 explain how to assemble a strategic plan for the entire duration of the project, and also for day-to-day work. The CMMI (Capability Maturity Model Integration) process could be used for this first plan, while agile methodologies for short-term planning are suitable for the second plan. The CMMI is a DARPA project. DARPA (Defence Advanced Research Projects Agency) is an American agency for financing scientific research. This agency gets its assets from the military budget, while expert civilians control the money flow. Expert civilians are, most of the time, chairpeople of leading US companies such as Google, Oracle, Microsoft, and IBM, and presidents of leading universities like MIT, Stanford, Harvard, or U.C. Berkeley. What is also important to underline about DARPA is that more than 95% of DARPA projects end up as relative failures. However, on the other hand, those 5% of successes do change the world. For instance, the Internet arose from the project named ARPANET. Later on, RISC processors, C-MOS technology, Moses technology, and so on, were all the outcomes of DARPA projects.

The H2020 program from Brussels and the NSF agency program from Washington expect a prototype of the proposed idea to be built. Both agencies hope that the idea will be commercialized later. The end result could be the prototype of a future product, the prototype of a future service, or a prototype of whatever it is that the idea is about. This is the reason why researchers should think in terms of developing prototypes.

Part 5 presents methodologies for writing business plans when asking for money from potential investors.

There are two types of such investments: venture capital and business angels. Both types are presented through methodologies that are typical for the American market. The reality of that market will sooner or later arrive in European countries, as well. The market is the strongest industrial force in today's world. However, there are agencies in the USA, financed from the state budget, which are involved in helping small or medium-sized businesses to become more effective when writing business plans. Those agencies are SBA (Small Business Administration) and PTO (Patent and Trademark Office), and this book is based on their methodologies. The patenting issues are covered in part 6.

Part 7 sheds light on writing survey papers and the methodologies for doing that work properly. Besides survey papers, this book also introduces methodologies for writing (in part 8). For a given problem, not all existing solutions but only the best one from the open literature are elaborated; the research paper should criticize it positively, along with an idea on how to make it better or with a presentation of a better solution. Within that elaboration, it is to be shown how much the proposed solution is better and under what conditions.

When the project is finished, it can be useful to create a website for marketing the sales of a product or service. Such a website needs an appropriate marketing campaign, which is why parts 9 and 10 cover the following two topics: designing a website for the sale of the project, or its product or service, and preparing a marketing campaign according to the methodology of Mind Genomics. Mind Genomics is a new method, whose author Howard Moskowitz received the award Sigma Xi, which is like a Nobel Prize for marketing.

There are two main approaches to marketing: broadband and narrowband or targeted marketing. Broadband marketing means that everyone receives the same message via billboards, tram prints, television, radio, etc. Targeted marketing, on the other hand, means that everyone receives a different message. Companies all around the world that are in the modern targeted marketing business, do two things that are not considered as proper. The first thing is that to enter the system, a customer has to fill in some forms, which is a waste of time. The second issue is that customers are most probably tracked afterwards. So, in the first case, it is a time leak, and in the second case, it is a privacy leak.

Mind Genomics, on the other hand, has neither of the two drawbacks. It simply waits for a customer at the welcome web page of the business and offers him/her a value exchange. It asks the customer to click three times to answer three triple-choice questions, and in return, it gives the customer a benefit such as a small discount or a small present. When the customer clicks three times, it is quite enough for the system to determine the customer's mindset and based on that, the system offers the customer something that this specific mindset rarely refuses to buy. No forms need to be filled out and no one tracks the customer after this purchase. From the scientific side, there is a lot of sophisticated mathematics and logistic programming being used, as the researcher who came up with this methodology has a major in both experimental psychology and advanced mathematics.

At this stage of commercially oriented research, all production is finished, the commercialization process is running, and lots of data of importance for the overall project has been gathered. Parts 11 and 12 present two subjects related to this stage of work: data mining and branding. Data mining means the discovery of hidden knowledge out of big databases that are used on the Internet. In the context of project management, after describing the general approach, the text focuses on four algorithms and mentions 32 others that are widely used for data mining. Another important element of project success is the methods that could be used to brand the project and or its related products or services, which is all discussed in part 12.

Parts 13, 14, 15, and 16 focus on efficiency, effectiveness, inventiveness, and creativity. To be effective means to choose the best possible way towards a goal, in conditions where more paths lead to the goal. In the final part, we focus on the induction of creativity.

This book could be useful for courses that are sometimes called "lifetime management".

When students finish their bachelor studies, they are over 20 years old. Some students find their place in the industry, while others enrol in postgraduate studies. Those who choose to work in the industry should know how to write a successful proposal. The same is important for students going for a PhD in the United States since professors expect PhD students to write proposals aligned with the requirements of the NSF or other agencies.

One can pursue both these careers until the age of 40 when new generations arrive. Since those new generations are more comfortable with new technologies than the previous generation, this is the time when one should strive for a higher place in the hierarchy, to run away from the technological details.

Which place would be the best then? Those would be management or ownership of a company, or climbing the corporate ladder. For the first goal, one needs to know how to write business plans, and for the second one, it is important to have an MBA degree. Both approaches are well described in this book. Another possible scenario is that at some point in life, a former student, now director or professor, gathers enough knowledge to choose one of the following paths: to become a wise university professor, or to become an effective industrial investor.

This book presents the topic of project management in the widest sense, in the most sophisticated environment, starting with efforts to ensure the funding and knowledge needed for a project, all the way until the end of the process, when the results of the project are successfully commercialized and used for the general mission that the project aimed to accomplish.

There are two important activities that have to be accomplished before the project starts. Number one, as indicated above, is to ensure funding, and number two, as also indicated above, is to acquire the knowledge needed for the management of the project in the broadest sense.

Regarding the funding, this book covers two typical mechanisms: Horizon 2020 for Europe and NSF for the USA.

On the other hand, one needs the following mechanisms to acquire the knowledge needed to run the project in the broadest sense: the essence of MBA studies with a number of case study examples for a specific MBA program and PhD studies and their essence. In the context of these major topics, this book also covers the methods that students could apply in order to get admitted to the best schools in the USA and different countries in Europe. The most sophisticated part of the entrance exam required to enter a major graduate college is the analytical essay, which is a part of the Graduate Records Examinations (GRE) or the Graduate Management Admission Test (GMAT).

It has been assumed that with the knowledge of how to ensure funding and with the knowledge of how to run a project in the widest sense, the funding can be obtained and the management process needs to start. The next two topics of the book are related to the planning of project activities. Using the DARPA CMMI methodology, this book explains how to do long-term strategic planning.

This book also presents the essence of agile planning methodologies, which enables fine-grain planning in short-term intervals like one week, or one month, and then coarse-grain planning for the time to follow. Directions have been also provided for the ambiguous planning in the weeks and months later on, with the general framework related to the previously mentioned strategic planning using CMMI.

Once the project is over, the next step in holistic project management is to start a company and protect the name and the product/service/whatever of that company.

This book therefore also covers the topic of writing a business plan and protecting the names involved with the business. For the business plan, we follow the methodology of SBA (Small Business Administration), tuned both to venture capital and business angel approaches. For branding, we follow PTO (Patent and Trademark Office) methodologies, for protecting both the product and its name.

Once a sophisticated project is completed, meaning that a new product or a new service has been created, the next logical step, in a sophisticated environment of computer engineering, is to describe this product or service, first by writing a survey paper that educates interested readers about all possible solutions to the given problem, and then a research paper which tells the interested reader what has been done with this particular project, in what sense is it better compared to the best existing solution in the open literature, to what extent is it better, and under which conditions.

Once a successful business is established, it must be supported by a website for sales, an electronic shop, and an appropriate marketing campaign launched for that particular website. The next topic therefore covers various methods how to generate an electronic shop.

This part of the book introduces a specific approach to targeted marketing known as Mind Genomics, which has been rewarded by Sigma Psi and demonstrates a beautiful synergy between mathematics, marketing, mathematical logic, and industrial psychology.

Once again, the assumption is that successful business or successful research always creates a huge amount of related data that contains some hidden knowledge, which is potentially of interest for the specific mission of the activity, either the current one or a future one yet to be established. For that reason, this book also covers an introduction to data mining and business branding with heritage protection.

In addition to the practice-oriented topics mentioned so far, this book also covers four more theory-oriented topics. The first one is efficiency and relies on the famous book of Lloyd, the second one is effectiveness and relies on the famous book of Drucker, the third one is inventiveness, and the fourth one is creativity. In this context, efficiency is defined as the speed at which products and/or services are developed, while effectiveness is defined as the process in which we select the best possible way to achieve a given goal, in conditions where there are several ways leading to the same goal. Inventiveness is defined as the capability to come up with new concepts, ideas, or solutions, while creativity is defined as an activity that does both - invent and implement - i.e., create an idea and a product/service/whatever.

## **Week 2: Introductory Overview 2**

This week is dedicated to writing proposals funded by the European Union. There are over 100 mechanisms accessible to small and medium-sized companies, whether they are private or state-owned, as well as to small and large universities, both private and public.

The European Union, or rather the Ministry of Development of the European Union, also referred to as the Government of the European Union, approximately every five years assembles a conference aiming to determine priorities in the domain of scientific research and design with potential commercial outcomes, which is of European Union's future development interest. In a narrow sense, it can refer to the Political Union, and in a wider sense to the Scientific Research Union. The planning is conducted for five-year intervals, which are called Framework Project Intervals or FP.

This all started a long time ago. The first five-year plan was called FP1, then FP2, FP3, FP4, FP5, FP6 and FP7, and instead of FP8, it was decided to give the new interval a more creative name, so it was named “Horizon 2020” or H2020 for short. It was followed by Horizon Europe, which is essentially FP9. Both could have been named FP8 and FP9, given that there was no essential but only formal difference from the previous intervals. Horizon 2020 launches calls approximately every 6 months. In each of these calls, it is pointed out for which topics the European Union is ready to give out money for good proposals. This is not loaned money, but given money, which should be returned only if the results of the project, or the effort put in doing it, have not been as planned. In those calls, the topics for which they are willing to give out money are listed as challenges. If an idea does not quite match the challenges of the call whose deadline is, let’s say, in April 2025, this idea may fit well into some of the forthcoming challenges, in which case that may even be better, as there is more time to prepare the material and the presentation. In any case, once the call has been chosen, the next step is to write a proposal or a project plan for it. Every call has its closing day until which the proposal needs to be submitted. If the deadline is missed, even by a millisecond, the portal is simply closed, and there is nothing left of the submitted proposal as if it had never reached the database.

Luckily, if one version has been submitted, and then, within the next few days, a bit of improvement is done, but the portal crashes about five hours before the closing hour, this last submitted version is what will be reviewed. What is the lesson to be learned here? To approach the work agilely.

The projects that can carry from 1 to 4 million euros are small and are sometimes called STREP (S stands for small, P for the project). On the other hand, big projects, sometimes called IP projects (I stands for integrated, and P for projects), can carry up to 40 million euros.

It may sound like a lot of money for a firm but it is not. Why is that so? First of all, the company will never aim to get exactly 4 million for a small project, but a smaller amount instead, for a very simple logistic reason: imagine that, for the challenge, the H2020 program decided to offer 13 million euros and that your company requests 1 million for the project; for the same challenge there are 19 more requesters, each one requesting 4 million euros.



If all those 19 other requesters have better proposals than your company, all of them will score more than 10 points, and if your company scores exactly 10 points, this brings you to the rear of the ranking list. Assume that the first-ranked one requested 4 million, the second one also requested 4, the third one the same, and so on. This makes giving out the money simple: to those on top of the rank, while there is enough to give. And then, when there is little money left, money is given to the one who asks for the amount that is left. So, 4 million is given to the first, second, and third applicants, which is 12 million already. There is not enough money for the fourth one on the list, so the evaluators look at the bottom of the list and see a company that has a satisfying score, which can be your company, so your company gets the funding despite being ranked as the 20<sup>th</sup> best proposal.

So, what happens is that even though the company is at the bottom of the list, it is given the money, and the one in the fourth place is not. In this “zero-sum game”, everybody else was better scored, yet the company asking for less money does it satisfyingly, so the system selects that company as the company that will fill the “financial hole”. The system cannot give that last million to the fourth company in the ranking, since if given only one million, the fourth-ranked company would not be able to do what it promised to do with a 4-million grant. If it could, then it would turn out it lied in the proposal that it needed 4 million, which would be unfair, and such unfair behavior should not be rewarded.

The EU wants to create a melting pot of science and research institutions and trading development work, aiming to mash and mix the entire Europe. If all the partners are from EU countries, that is straightforward. If one of the partners is from a non-EU country, like those in the Western Balkans, except for Slovenia and Croatia, then the minimum number of partners is 3+1. So, if there are four partners, and the consortium receives 1 million and 200 thousand euros, which translates to 300 thousand per partner. For a three-year program, that is 100 thousand per partner per year, which is 8.333 thousand per month. In Western Balkan countries, if the company wishes to give someone a salary of about 100 dinars, on top of that, it has to give 75 more to the country, for social security, retirement plans, health, and everything else. This means that out of those 8.333 thousand a month, what is left is little. This example calculation serves to demonstrate the insufficiency of the resources given, but that they are enough to enable one to develop a good idea in a decent way.

If the idea gets commercialized, these resources are only a drop into the cup of funding to be used for future developments.

The correspondence between the proposal and the topic of the challenge must be 1:1 since even the slightest difference might lead to the elimination of the proposal from consideration for formal reasons. This is why one has to formulate the objectives and work packages carefully when writing the proposal. What is the difference between objectives and work packages? An objective is a goal; a work package is a job that needs to be done. This difference is best explained with the following catchword: “Does one wish to become a famous violinist, or does one wish to scrape the violin every day for many hours?” Wishing something is one thing, and doing the job to achieve the goal is a completely different thing. In other words, with objectives one defines the goals to be achieved (“I want to become a violinist”), and when describing the work package, one commits to practising eight hours a day, every day.

According to the “divide and conquer” principle, it is expected that there will be several of these objectives, and it is necessary to define success criteria for each of them. In a certain project, one of these goals may be to develop a piece of software for a platform with modest memory capacity and no specific speed demands. Such a product could, however, be very affordable, and thus have very good market success. In that case, a success criterion could be code size (in bytes) smaller than a previously specified one (for the same product of the previous generation); success could also be measured by the fact that the slowest application in the slowest environment would execute in less than previously determined time (in microseconds). This means that dissipation will not be bigger than it was previously the case.

In summary, every objective (1,2, ..., y) has to be accompanied by success criteria, and every work package has to be in 1:1 correspondence with objectives. There should also be three milestones, which are also in 1:1 correspondence with success criteria.

There is also a work package numbered with a zero, which relates to management and quality control. According to the “divide and conquer” principle, each work package is divided into several tasks. Usually, the last work package is dedicated to dissemination. Dissemination is an activity whose goal is to inform the entire world of completed work and its results, in case it might be in someone’s interest to buy the product.

This helps to successfully commercialize project results. It may involve television or radio appearances, participation in conferences, writing papers for prestigious magazines or journals, or commercial activities on Facebook or Twitter. For every task, it is expected that one or more deliverables be listed and that delivery deadlines are precisely specified in the proposal. For example, if there should be four presentations on television, a DVD has to be delivered for each of them. If the plan involves presentations at conferences, an agenda should be delivered for each conference, to prove that the project has been presented at the event.

Risks may be, so to speak, multi-fold (twofold, threefold) but the two most important risks of all are the ones that relate to logistics and success. Among those that refer to logistics, one may say the following: “In the seventh month of development of this project, I should realize which materials I need to acquire for testing, and then I will order them; if they arrive within a month, everything will be all right. But if I have to wait for the customs procedure for another three months, I will not be able to deliver the results of the phase that is due to be completed nine months after the beginning of the project.” In that case, EU authorities may even be able to help with the customs paperwork. Regarding the risks related to success, one can say: “The problem is a demanding one. We will do our best, as we believe in the idea, but there is a risk of failure.” If it is written like that, EU evaluators will evaluate the proposal and may say: “All right, there is a risk that the proposed research might end up with no results, but the authors are only asking for a million, so the EU institution may take the risk—what is a million in conditions when billions are spent on research?” Horizon 2020 had a budget of around 20 billion. So, EU evaluators may say: “Okay, let’s give them the money, and if we see they tried really hard, yet did not succeed, we will not ask for any money back. Namely, if no breakthrough is generated, the researchers will have acquired knowledge and skills that will help them through their next project. And after all, they have at least shown that the intended way is not a good one, as it has not led to the finish line with a successful completion.” In that case, the result is useful to others, so they will not try in vain.

All of the above refers to the first one of three parts of a proposal, called ST (Scientific and Technical). In the process of evaluation, one typically gets a maximum of 5 points for that part, in steps of half a point. There is another part called MF (Management and Finances), and another part called ED (European/USA Dimension).

In MF, one specifies down to the most precise details how the project will be managed in general, how will it be managed by a partner who is the leader of the work package number 0, and so on. In the ST part, it is important to include details on how the leaders of every task will report to the head leader; every message should be of the same structure and it should involve the same type of content.

The same scoring applies to the third part—ED. It specifies why the project is important for the future of the USA or Europe. It specifies if the result will be a great export item or a product will be of the best quality in the world in its category, or that a part of Europe will develop its potential, etc.

It is important to score well on all three parts. Assume that one gets 5 points on ST, 2 on MF, and 2 on ED. This is 9 in total, but the proposal has immediately sunk, even with a genius idea. This only means that one should not neglect the other two parts. For the ED part, it is crucial to find five reasons why the project is good for Europe. Let's say Europe already has a high-quality product, but one wishes to enforce it, and make it even better so that it beats the competition; this may lead Europe to a high peak where it has not been before.

A great example for the first case would be a dataflow supercomputer, and for the second one, an equivalent of the NVidia supercomputer, since Europe is not making any commercial manycore GPUs like NVidia in America, except for the efforts that ARM is putting into their work in England. Eligible is also the rise of a fallen-out part of Europe in a certain domain. For example, in the wine culture, the area around the Serbian town of Negotin has better natural conditions for good wine growth than the valley of Rhone in France, but wines from Negotin are not nearly as good. This shows that proposals are not just for ICT, but for all domains where some sort of economic activity does exist.

The second topic of this discussion is related to resource management. As previously mentioned, before a project starts, two preconditions need to be satisfied: the assets that allow one to start the work and the knowledge that enables one to maneuver the problem. In that sense, it is good to have people with an MBA degree on the team. Of course, there is an entrance exam for an MBA (Master of Business Administration) program. The same kind of exam is taken if one wishes to go for a regular master's degree in software engineering, or if one wishes to pursue a PhD.

These exams contain different types of questions but essentially have the same structure and logic behind them. GRE is for Engineers (e.g., students at schools of electrical engineering), GMAT is for students of mathematics and those studying organizational sciences. This is the case when one chooses to go for MBA studies in the USA.

When it comes to Europe, it is possible to get a spot at a university with complete financial support, which means a full scholarship for studies and living expenses. That is generally not an issue in Europe, as universities in Europe, all but the best 10, have a problem filling the positions reserved with full scholarships. The number of positions with full coverage is typically formed in a way that predicts sufficient support in their industry in the time that follows. Unlike in the USA, the entrance exam in Europe is not exactly standardized. While in the USA it is difficult to get in, if one succeeds in doing so, they have managed to acquire the potential for a truly successful career anywhere in the world.

When one chooses to take GRE or GMAT, what most people do not know is that the system considers a student as a laptop consisting of input, central, and output processors. The input processor is tested with a verbal subtest, a central processor with a quantitative subtest, and the output tests analytical abilities.

The verbal test shows how one acquires new knowledge, which is why this part of the test is made out of two parts that enable the examiners to see how well the candidate learns using their ears and how well using their eyes. The candidate is given headphones to listen to a paragraph that will be read out to them. After the person removes the headphones, they complete a multiple-choice test that consists of several questions that serve to show how well the person has understood what they read. As for the visual learning part, a paragraph is placed on the screen in front of a person and kept there for about 30 seconds. Then it gets removed, and the person is asked to complete a multiple-choice test again.

The quantitative part also consists of two subtests. The first one tests mathematical capabilities, and the second one tests the capabilities for solving logical exercises, just like a central processor (CPU).

The third part of the test checks how the output processor works. What does that mean? It means that the person is given a story that has three flaws and is asked to detect them.

The candidate then has to write a three-paragraph essay in which they are supposed to explain those three imperfections, why they are imperfections, as well as how to correct them under specified conditions.

The examinee is required to write two more essays: one of them tests Aristotle's logic (if-then-else) and the other one Zadeh's logic ("It may be, but it does not have to be"). These are important for those coming from American schools that are not too strong, i.e., schools whose only function is to form "screws" for the machine called "The New World's Order". The second and the third tests in particular are important for the most prestigious universities, whose social function is to constantly improve the "machine" that runs that world's order. If the goal is to educate the student to become a "screw", it is important for them to know that the student can follow lectures and understand them, and learn from books. It is a guarantee that the person will pass the exams. On the other hand, in the world's best schools such as Stanford, Harvard, UCLA, or MIT, they could not care less how one does the verbal part, but they are counting on the person being utterly capable of managing on their own. They are therefore more interested in the results of the other parts of the test, especially the third one, for the following reason: if a professor has 20 PhD students, the professor most certainly cannot write papers and reports to research sponsors for all of them, and especially not proposals. That is the work that a postgraduate student has to do on their own. So, to get into the best schools, one has to prove that they can write something beautifully and convincingly, for example, to justify the money given if it is a report for the research sponsor, or to build up a high reputation if it is a paper for a magazine or a conference.

### **Week 3: Introductory Overview 3**

Strategic planning is covered by CMMI. It is a framework, not a software tool, and contains a set of guidelines to ensure that nothing truly important is left out. CMMI was developed by DARPA and it is used not only for software engineering but for many other goals, from war operation planning in Afghanistan to the construction of an airport in Singapore. Another example might be the software designed for Raiffeisen Bank in Vienna when they were changing the core code for Eastern Europe with about 2000 programmers doing that work from India using CMMI for structure quality.

When the project is finished, the company should transfer the results of that project, which is typically a prototype, into the final market product, and in that sense, it is necessary to seek funds from potential investors, either from investment funds or banks. The two main options are venture capital and business angels. In the case of venture capital, if one asks them for money, they will say that they will give the money only if one manages to climb a chair and puts a rope around one's neck. So, if the project fails, and so does their investment, one will know what will be coming next. In other words, they are simply looking out for themselves, protecting themselves from failure in a way that requires giving them a house, apartment, or something else (like a mortgage) as collateral. But if a project succeeds, their profit out of it is a relatively small one-digit percentage. On the other hand, business angels do not require anyone to climb a chair or put a rope around one's neck because they know in advance that most projects are going to fail. However, out of the ones that become successful, they profit out to cover other failures, with a double-digit percentage profit. There is even a difference in the formalities of writing a business plan for each of them, as they evaluate things differently. There is an agency called SBA (Small Business Administration), which is funded by the US Government to help small and medium-sized companies navigate the system based on their template. Founding a company is not the only thing that needs to be done. It is necessary to patently protect the project, as well as the name of the company and the product. For that purpose, there is another template called PTO, or Patent and Trademark Office. The course assignment for this part is to make patent registration for what the result of the project is, and also for the protection of the product, which are in different forms. After this is all finished, the assumption is that the company does not intend to put something stupid on the market, but rather something sophisticated; the company needs to commit to what it is specifically. This book, therefore provides instructions for writing these two types of papers—survey and research.

In a survey paper, one has to show all the existing solutions for a given problem in the open literature, and there is a way in which this is done. For the research paper, one has to focus on the idea, and show what the best existing solution looks like and what its drawbacks are from the perspective of interest; one then needs to explain the idea and why it is expected to be better, once again from the interest perspective. Some methodologies help to show how an idea is better, under which conditions, and to what extent.

For writing the two types of articles (research and survey), there are two papers: “Best method” for the research paper and “A good method” for the survey paper. Both of them are “first-placers” because they are both published in the best magazine in a field and are very frequently referenced in America. Professors give them to postgraduate students as reading assignments.

Now that the business has taken off, information about it should be put on the Internet; if possible, an online shop should be set up, as well. There are zillions of various methods for targeted marketing, and they all brag about how very modern they are, even though they are not doing anything different from what has been done hundreds and thousands of years ago. When a customer comes to a shop in a village where everyone knows each other, the shop owner knows what to offer them and in what way. The only difference now is that this is to be done online as well, but it is now faster, and more than just one offer has to be made at a time. On the other hand, the downside is that upon entering the system, forms have to be filled out, which requires time and raises privacy concerns. As already indicated, Mind Genomics, on the other hand, does not do that. It waits for customers to come to it, and then offers them a value exchange, where the customer receives a small benefit in exchange for three simple clicks. With those three clicks, Mind Genomics comprehends the customer’s mindset and offers them something that their mindset is known for not being able to reject and that will be accepted with a very high probability. This idea received the Sigma Xi Award, which is like a Nobel Prize for marketing. In order to understand MindGenomics better, the chapter covers the most important algorithms regarding data mining based on the Google Scholar system, and four of them are presented in an anecdotic way, with no mathematics whatsoever. Later on, there will also be a section about branding methods.

## **Week 4: Introductory Overview Revisited**

Sybil the Pythoness was visited by soldiers who wanted to hear their destiny before the battle. She guessed it 100% each time. How did she manage to guess it right every time? She formed sentences in such a way that she was leaving it to the soldier to partition the sentence; she would pronounce the prophecy with no emphasis anywhere, in a singsong.



Shakespeare's works were quite sophisticated for his time when people were generally uneducated. Yet, he became famous because he used semantic divisions of sentences without exceptions. Perhaps that was the reason why he was so popular and understood.

This is best explained to people in the software engineering business, as one practically binds one line with one semantic rip. The one which is on a higher level of abstraction helps semantic division.

## **Week 5: Writing Research Proposals**

As mentioned before, the acronym FP stands for Framework Project. It implies planning in five-year intervals. The seventh five-year cycle was called FP7, while the eighth one was called Horizon 2020 and lasted until 2020. The one in which we are in at the time this text was generated, is Horizon Europe and it extends until 2027. A new call comes out every six months, with a closing date by which the proposal should be submitted. It is usually until 5 p.m. on that closing date.

Essentially, the money given is not a lot for research. Since it is shared with three other partners, one from the Western Balkans and three from the European Union, money gets divided. There could be even more partners. The project typically lasts for periods of 2, 3, 4, or even 5 years. One should therefore never aim for the highest amount possible, but somewhat less, so as not to request a huge amount of money, but enough to help develop an idea.

For topics covered by the calls, the resources are available even to the smallest companies. A proposal should be written in 1:1 correspondence with one of the chosen topics. Objectives and work packages must be specified.

According to the system "divide and conquer", goals are to be divided into several objectives, usually about 3, 4, or 5. The work package count is typically one more than the count of objectives because aside from those in 1:1 correspondence, there should be one more. This additional one is project management and quality control, which both are particularly important. For every objective, one has to describe one, two, three, or more success criteria (most often three). Success criteria are the achievements that prove the objective has been reached.

For every success criterion in work packages, accurate milestones have to be defined, of course in 1:1 correspondence. It is also important to specify at which moment and in what way one will measure what is significant for each of those success criteria. This means that “when”, “what”, and “how”, should all be in 1:1 correspondence with this proposal. Following the principle of “divide and conquer”, every work package should have multiple tasks within it. One of the tasks for each of these work packages should be dissemination and it is usually the last one.

What is the process of dissemination? It is the process that enables one to make the world aware of the results of a project, so people would buy it, use it, or whatever it is that people may do with it. The dissemination process can consist of the following activities: conference presentations, journal papers, radio interviews, television appearances, visits to investors, visits to potential users, and so on. Every task carries deliverables that also need to be included in the proposal. This is what gets delivered at the end when the product of the task is completed. For example, if dissemination is planned through conferences, deliverables would in that case be conference papers included in the report for the European Commission.

Project risks should be also specified. There are two types of risks. The first one is related to logistics, for example, when something is being held up for too long at the customs office. The second one is related to the difficulty of the problem at hand.

One will get the money despite the risks, providing that the proposal is good and the risks are minor. Even if the risks are major, the proposal has shown that there is still a big chance for success or a small possibility of a large success, and the proposal does not require huge resources, the proposal will still win. After the reviewers have examined and weighed the proposal, decision-makers will enter the calculated risk zone, which is something we face every day. An example would be a common dilemma, whether you should walk or take a bus for just one stop. There is a risk that the bus may appear right after you have crossed the road to start walking, so you cannot turn back, and as a result, you arrive 5 minutes later. On the other hand, if you decide to wait for the bus, the bus may get stuck somewhere, so you will arrive 10 minutes later.

If one scores above 10 points, one can ask for resources from the Ministry of Science and Technological Development of the native country.

This is usually a small amount that can help a promising applicant do further research on the problem, polish the proposal, and try again when a challenge that fits the initial idea reappears in one of the next calls.

TMG is a Slovenian company that is a good example of the above. They work in the area of tomography. They have developed a small device, the size of a remote TV controller, with which one can conduct physical analysis of all the muscle pairs in the body based on tomography (electrical stimulus). They have developed this to be used for sports since science has shown that the possibilities of sports injuries are enhanced if muscles are not symmetrical. They therefore created this little device that could determine muscle symmetry and suggest exercises for achieving symmetry. This is important even for the sports that are completely asymmetrical in terms of muscle use, like tennis. Nevertheless, even in sports such as tennis, both arms need to be equally developed and strong, since the other arm serves for balance, pointing to the target, etc. This device tests symmetry, indicates whether the person is symmetrical, and prescribes exercises, such as a daily exercise of lifting 5 kg five times with the right arm, but 50 times with the left arm for a month. Then, upon the completion of the month, it is necessary to come back and check the symmetry again.

After the initial success, staff at TMG got the idea that they could also use this technology for about 20 other applications. The EC reviewing system loves the term Use Cases, so they decided to write their proposal, not just for sports, but for healthcare, as well.

There is a lot more that can be found out using the TMG device: whether someone is talented in martial arts, athletics, etc., or whether they are fit for police forces or special units. As for healthcare, the device is capable of finding out if a person may develop symptoms of multiple sclerosis, a process that today cannot be reversed but can be slowed down. This slowdown is much more efficient if one starts the process 5 years before the first symptom appears than if one starts the process after it has appeared. Moreover, the device is useful for rehabilitation after an accident. The public medical system will rehabilitate one up to 80% of symmetry, and the rest would be up to the patient to finish through everyday life, walking, doing exercises at home, etc. That system is quite overloaded and wants to complete treatment as soon as possible, so this device may help the patient determine whether it is justified that the public system wants to stop supporting their further rehab.

However, when patients decide to visit private doctors, their treatment usually stalls. Namely, the doctors try to prolong the process. On the contrary, the device can say that the continuation of the process is not necessary and the patient knows that the treatment should be finished.

TMG developed about 20 use cases and partners have developed details for each one.

The partners from the School of Electrical Engineering in Belgrade had developed the architecture for the entire system. A company from Padua agreed to develop hardware details, and Barcelona Super Computing Center agreed to develop software details. It was also important to have an Artificial Intelligence assistant so that the doctors could look at data and then give instructions on what was to be done. So, an AI-based data mining software works for them and comes up with proper recommendations. Appropriate partners were selected for PoC (Proof of Concept) as well. PoC is an implementation that one should never release to the market, as it is always full of bugs and malfunctions and it is incomplete. It is the version that tests the idea and enables its developers to see what else needs to be done before a full version for the market is released.

The European Commission actually gives out money for PoC, since if the project is of the research type, in most cases the product for the market is not the ultimate goal.

After the PoC, on the road to the market version of the product or service, one has to look for investors to ensure additional funding. There are two options: venture capital and business angels. A hospital in Igalo, Montenegro, was selected for testing in clinical conditions; an institution in Koper, Slovenia, was selected for testing of athletes; a company from Spain was selected for the dissemination process; and a company from the Netherlands was selected for quality control and management.

The following step is the writing of the MF (Management and Finances) and ED (European Dimension) parts, which professors and students of organizational sciences manage a lot easier than engineering professors and students. There are also companies that offer resources for that kind of activity and charge for that service, but those should be avoided, as they are always the ones who benefit even if the proposal does not succeed.

Others do not ask for compensation in advance but only say:

“We will lead the work package number 0 in this proposal, which will reimburse our activity later through our work on the work package number 0, meaning that the European Commission will pay for it.” If such a company agrees to work with you, there is a pretty good chance that you will get the proposal funded, as those companies do have the experience to carefully evaluate your proposal and its success potential. If they decide to work with you, that means that they have evaluated your idea and believe that there is a good chance to succeed. Of course, they do not want to waste time on something that will not be successful. Typically, they also guarantee that if one scores 4.5 or higher on the first part, they will score 4.5 or higher on the other two parts.

The proposal for the ST part can score a maximum of 5 points through several elements. The first one, which is mandatory according to Clause 1.1. of the template of the European Commission, is “concept and objectives” and it can score 0, 0.5, or 1 point maximum. Other parts to be included by Clause 1.2. have to be “state of the art” and “progress beyond”, for each of which one may get 0, 0.5, or 1 point. One must also show awareness of all the possible solutions to the given problem, which are relevant to their work, which can also bring them 0, 0.5, or 1 point. Moreover, one has to explain the essence of their idea, why is it expected to do better than the best existing solution, as well as the quality of the idea itself. In the proposal itself, one is not expected to give the full elaboration but only the specifics of what one will elaborate on with the money given. Clause 1.3 is Scientific Technical Methodology, also bringing 0, 0.5, or 1 point. The same number of points could be scored for the Work Plan. All that adds up to 5 points. Then there are summaries, where one scores 0 points, but if this clause is missing, the proposal will be rejected without further consideration, and that will happen for formal reasons. The risks are to be explained separately. Another part that does not bring any points, but must be completed, is the ethics part.

As far as the statistics, only about 9% of the proposals typically pass, which means that the likelihood is not very high at all.

If one wants to look up the topics for which money is assigned, one has to visit the site of the European Commission, the ICT section, and look at its table of contents. The first pages provide information of strategic importance, like what is to be accomplished in general, with a formulated challenge. For example, a goal could be to form a melting pot of Europe.

In the USA, if people get a yearly wage higher by only 1,000 dollars, they will move from the East Coast to the West Coast, and vice versa, and leave behind everything they had there, friends, family, a house, etc. They would just sell it all and move. Would someone do something like that in Europe? Not very likely. Yet, that is one of the important preconditions for economic growth and economic strength. These subjects are addressed in the first pages. The pages that follow explain the challenges grouped by topics. For example, the ease of computing is present everywhere. Other topics include cognitive systems, hidden knowledge, how one works with those and what kind of help one can get in the realization of choices based on that knowledge, digital preservation of the national heritage, personalized healthcare and mobility, living out of home, etc.

On the last pages there are details that are important for tactical performance. For example, the statement that the minimal number of partners is three if they are all from the European Union, and 3+1, if one of them is from the Western Balkans or any of the other associated countries (Turkey, Moldova, Ukraine, Belarus, Switzerland, or Norway).

What does the template look like? As mentioned above, there are two ways of writing the proposal. One of them uses the template, while the other one is based on using an editor. When one uses the template, there are some instructions and spaces that one needs to fill out from scratch.

If one chooses to go with an editor, then one gets to see what someone else has already written, which may serve as guidance. Perhaps one may take a sentence or two from there, which is hardly possible in the Scientific and Technical section, but also indeed possible in the section regarding Project Management and European Dimension.

For instance, in the part related to management, it can be stated what the structure of communication with the person leading the project is supposed to look like. For example, every Friday an email is sent to the leader with a report on what needs to be done.

What does the template look like? It starts with the full title of the proposal. It can, for example, be “A Voting System for Digital Referendums on the National Level”. There is also a table for the acronym of the title, where one should also mark whether it is a STREP or an IP project. Of course, it should be indicated which challenge the proposal belongs to.