# MATHEMATICAL MODELING OF IPMA 4-L-C CERTIFICATION: DEVELOPMENT OF PROCESS IMPROVEMENT MODEL

**Sara STOJILJKOVIĆ,** University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia, sara.stojiljkovic@fon.bg.ac.rs

**Bisera ANDRIĆ GUŠAVAC,** University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia, bisera.andric.gusavac@fon.bg.ac.rs

**Vladimir OBRADOVIĆ,** University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia, vladimir.obradovic@fon.bg.ac.rs

**Abstract:** The paper focuses on the mathematical modeling of project manager certification according to the IPMA 4-L-C standard for project management, aiming to maximize the number of certified professionals across all four levels of certification. By analyzing existing processes and constraints that affect certification success, a mathematical model has been developed to identify key improvement points in this process, contributing to the objective function of increasing the number of certified professionals in project management. The model integrates multiple parameters and constraints, including candidate qualifications, years of experience, project complexity, programs, portfolios, candidate leadership positions, available training resources, evaluation process efficiency, and other relevant factors adopted by the International Project Management Association (IPMA). The goal of the paper is to present the mathematical model under these constraints, providing guidelines for optimizing this process to achieve the maximization of the objective function. The methodology includes steps such as analyzing current certification body processes, identifying key certification elements, formulating the mathematical model based on relevant factors and parameters, and proposing implications derived from the model. The application of this methodology can assist organizations and individuals in more efficient planning and resource management during the certification process, resulting in improved performance and achieving desired certification goals. The expected contribution is to clarify the complexity of the certification process for project managers across all four levels of 4-L-C (Four Level Certification) and provide concrete solutions for improving these procedures, which would further result in an increase in the number of qualified professionals in the field of project management according to the adopted international IPMA standards.

**Keywords:** Certification bodies; Certification; IPMA 4-L-C; Mathematical model.

Corresponding author: Sara STOJILJKOVIĆ, sara.stojiljkovic@fon.bg.ac.rs;


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## 1. Introduction

The paper emerged as an initiative to address the issue of insufficient certification of project managers according to the International IPMA standards for project management. The existing problem also includes the inadequate recognition and significance of holding a certificate in this field. The objective function in the later development of the mathematical model for simplifying the certification process is to maximize the number of certified project managers according to the 4-L-C (Four Level Certification) levels of certification, adopting the constraints set by the International Project Management Association (IPMA). Holding an international certificate in project management is a key component in developing professional skills and standardizing practices in this field. Although certification is highly significant, especially for leadership roles, we face issues of insufficient recognition that may stem from various factors, including inadequate promotion, lack of understanding of the role of certified project managers in the industry, misunderstanding of the certification process, insufficient experience for the desired certificate, lack of competencies, or unclear benefits that certification brings to projects and organizations. As a result, certified project managers may be undervalued or their contributions insufficiently recognized, which can affect their professional development and advancement opportunities, as well as their chances of being selected as leaders of projects, programs, or portfolios if they do not hold an internationally recognized certificate. It is important to explore critical points and issues to raise awareness about the importance of project manager certification and ensure that their competencies and contributions are properly recognized and valued in the everyday work in the project industry. To overcome these problems, the paper relies on mathematical modeling of the certification process, providing clear guidelines for increasing the number of certified project managers and offering recommendations for improving the identified gaps.

## 2. Certification Levels According to the IPMA Level Certification Model (4-L-C)

In today's competitive business environment, organizations are constantly seeking ways to enhance and optimize their processes and improve overall efficiency (Lin et al., 2009). Implementing a systematic approach to process improvement, such as IPMA 4-L-C certification, can enable project-oriented organizations to identify areas of inefficiency and implement strategies to improve their processes. The International Project Management Association (IPMA) has developed a certification program where, depending on the level of knowledge, understanding, and practical experience in project/program/portfolio management, candidates apply and demonstrate specific competencies that are assessed by the relevant certification body. The certification system approves the introduction of the IPMA model based on the assessment of competencies—technical, behavioral, and contextual—relying on two key documents as legal foundations: the regulations and guidelines for certification (ICRG) and the IPMA Competence Baseline (ICB) (Toljaga-Nikolić et al., 2011). Below are the certificates according to the 4-L-C competence system offered by the International Project Management Association (IPMA). As research topic trends fluctuate in the future, the conclusion is that the certification of project managers will grow in its influence, as it covers a broader spectrum of scientific disciplines and industries (Slavinski et al., 2023).

### 2.1 Certificate for Level D

The Level D certificate – Certified Project Management Associate – is the most common certification among students and individuals new to project management, with no prior experience. The IPMA Level D certification in project management requires that a potential candidate, often a student, has knowledge of the competencies needed for project management, as assessed according to the IPMA ICB4 (Individual Competence Baseline) Standards. Candidates applying for this certification generally have basic knowledge of project management and can work on specific project tasks within a project team (Nahod & Radujković, 2013). This is the only level without restrictions; therefore, there will be no constraints in the overall mathematical model.

### 2.2 IPMA Level C Certificate

Interest in the IPMA Level C – Certified Project Manager – has been growing in recent years due to the expanding field of project management. However, there is a gap in the number of certified project managers that needs to be addressed (Goff, 2013). The IPMA Level C certification for project management requires candidates to have worked in a moderately complex project environment. An additional parameter for the mathematical model is that potential candidates must have at least three years of project management experience in the past six years on moderately complex projects and/or at least three years of experience in a responsible leadership position or as a project team member assisting the project manager on complex projects.

### 2.3 IPMA Level B Certificate - Certified Senior Project/Program/Portfolio Manager

The need for this certification is expected to grow as it is one of the more complex certifications, requiring candidates to work in a complex project environment within their organization (Bartoška et al., 2012). IPMA Level B and Level A certifications extend to program and portfolio managers, not just project managers. For Level B – Certified Senior Project Manager, the mathematical model constraints are that candidates must have at least five years of experience as a project manager in the past eight years, with more than three years in a responsible leadership position managing complex projects (IPMA, 2015). Similarly, for the IPMA Level B certification in program management, candidates must have five years of program management experience in the past eight years, with at least three years in a leadership position managing complex programs. The Certified Senior Portfolio Manager certificate requires candidates to have five years of portfolio management experience in the past eight years, with at least three years in a leadership position managing complex portfolios. A complex project is defined as one where the candidate applies most of the competence elements prescribed by ICB4 (IPMA, 2006), and the candidate's competence in applying relevant processes, methods, techniques, and tools for the proposed technical, behavioral, and contextual competencies must be demonstrated to a sufficient extent supported by the complex project (Kühn, 2021).

### 2.4 IPMA Level A Certificate - Certified Project/Program/Portfolio Director

The IPMA Level A certification in project management, which grants the Certified Project Director certificate, requires candidates to work in a highly complex project environment with strategic impact on the organization. Candidates must have at least five

years of experience as a project manager in a leading position on complex projects in the past 12 years, with at least three years at a strategic level. The same criteria apply for the Certified Program Director and Certified Portfolio Director certifications, where the complexity of the programs and portfolios respectively increases (Vukomanović et al., 2016).

One of the main advantages of certification is the verification and validation of candidate suitability in project, program, and portfolio management, and the ability to motivate PPP managers to:

- Validate their knowledge in these areas;
- Expand their knowledge, abilities, and skills in project management;
- Obtain an internationally recognized certificate to differentiate themselves in the market;
- Gain employment advantages and faster career advancement;
- Demonstrate their qualification expertise for working on projects;
- Broaden their horizons in project, program, and portfolio management;
- Propose improvements to management quality;

Improve their work outcomes in the domains of projects, programs, and portfolios. Certification can be established over maturity models for project, program, and portfolio management, including process areas that contribute to achieving successful outcomes (Bushuyev & Verenych, 2018).

## 3. Development of a Model to Improve the 4-L-C IPMA Certification Process

Tracking the entire process of building mathematical models is crucial for the successful application of operations research in the processes being implemented. The process of building mathematical models encompasses many activities or steps to reach an effective solution for applying this model (Andrić Gušavac, 2022).

Based on the mentioned constraints regarding certification levels, to formulate a summary mathematical model, notations will be used which will later imply the desired objective function. We assume that there are n potential candidates who wish to certify at different levels (D, C, B, A) over a one-month period. Constraints and parameters for each certificate will be presented depending on whether the constraints are adopted by the International Project Management Association – IPMA or by the certification bodies of IPMA member countries.

### 3.1 Constraints Adopted by the International Project Management Association

If the year 2024 is denoted as yi, the constraint "the candidate must have at least 5 years of experience in the last 12 years" can be denoted as yi-12 years and is observed for Level A. Similarly, the period in the last 8 years for Level B where the candidate must have 5 years of experience is represented as yi-8 years. Finally, for Level C, the period in the last 6 years where the candidate must have 3 years of experience is represented as yi-6 years.

The purpose of the interview is to assess the competencies required for Level A, B, and C certificates. The interview is conducted by two assessors who identify competence

elements and competence indicators for each candidate and ask pre-prepared questions based on the material submitted by the applicant.

### 3.2 Constraints Adopted by Certification Bodies of IPMA Member Countries

Depending on the desired certificate, and based on the mentioned parameters, additional parameters related to resources provided by the certification body are introduced.

One of the constraints is that bodies may have specific requirements regarding the qualifications of instructors and assessors conducting the certification processes, such as a certain level of education, industry experience, or specific certifications. The certification body may have limited capacity for training/assessment facilities, affecting the number of candidates that can be certified within a given period, which in the mathematical model reflects as a specific constraint if group training is conducted. Legal constraints are increasingly present in member countries that refer to the law of the competent government, which explicitly states that to implement a project in the observed country, the project manager must possess an internationally recognized certificate. For example, Croatia applies this law to its certification body. Legal constraints and regulations are related to the implementation of certification activities, which can affect the certification process (Obradović, 2018). Additionally, the certification body limits the number of attempts a candidate can make to obtain the desired certificate when taking tests or evaluations. Constraints regarding recertification are that the certification body may have rules regarding the recertification of candidates after a certain period or changes in standards over time. Certificates are valid for 5 years, after which the certificate holder can apply for recertification at a new or the same level depending on the experience gained in the observed 5 years. Geographical constraints, also a significant constraint of the presented model, affect the spread of activities and the availability of certification resources and facilities for candidates from different regions. Therefore, certificate holders from other countries do not necessarily have to certify in the country they come from, and accordingly, the rules of the country where the potential certificate holder is being certified apply (Bartoška et al., 2012). Finally, technical constraints in terms of limited technical resources such as testing software, hardware equipment, and other IT resources needed for conducting certification activities during the examination and evaluation of candidates.

Below is a model that consolidates in one place the objective function – maximizing the number of applicants per the 4-L-C system while adhering to the constraints.

$$\max f(x) = \sum_{i=1}^{4} xi \quad (1)$$

x*i*, *i=1,..4* – variables representing the number of issued certificates by the Certification Body for levels D, C, B, and A.

x1= number of issued certificates for level D;
x2= number of issued certificates for level C;
x3= number of issued certificates for level B;
x4= number of issued certificates for level A;

Subject to constraints:

$\sum_{i=1}^{4} ti * x$i <=T
(2)

$\sum_{i=1}^{4} tci * xi$ <=P
(3)

$\sum_{i=1}^{4} ci * xi$ <= B
(4)

$\sum_{i=1}^{2} xi$ <= E
(5)

$\sum_{i=3}^{4} Bn + An$ <= I
(6)

$\sum_{i=1}^{n} Lxi$ <= 2
(7)

$\sum_{i=1}^{2}$ TL$x$i <= K
(8)

x*i* >= 0, x*i* - *integer*

*ti* – time required to prepare certificates for the exam for each certificate
*tci* – time required to prepare the exam by the certificate holder
c*i* – cost per candidate
P – predefined time for taking the certificate exams
T – total available time for preparing certificates
B – budget allocated for the Certification Body
E – time required for taking exams, which is 3 hours for levels D and C
I – interview time for candidates taking certificates for levels B and A
L – number of exam attempts;
TL – total number of tests for levels D and C
K – number of exam periods

Additional parameters and constraints specified by the International Project Management Association (IPMA) that the Certification Bodies must adhere to in accordance with defined procedures:

ei ≥3, if *ci* =1;
(9)
ei ≥5, if *bi* =1;
(10)
ei ≥5, if *ai* =1;
(11)
*ci; bi; ai* = 1 U *li* ≥ 3;*
(12)

*di* - indicator whether the candidate is eligible for a level D certificate (1 if yes, 0 if no);
(13)
*ci* - indicator whether the candidate is eligible for a level C certificate (1 if yes, 0 if no);
(14)
*bi* - indicator whether the candidate is eligible for a level B certificate (1 if yes, 0 if no);
(15)
*ai* - indicator whether the candidate is eligible for a level A certificate (1 if yes, 0 if no);
(16)
*ei* – indicator of the candidate's experience in project/program/portfolio management (depending on the certificate);
(17)
*li* – indicator whether the candidate held a leadership position (1 if yes, 0 if no);
(18)
*iia* – limitation on the number of assessors during interviews for levels A, B, and C (exclusively 2 assessors);
For a level D certificate: $di \in \{0,1\}$;
(19)
For a level C certificate: $ci \in \{0,1\}$; $ei \geq 3$; $li \geq 3$;
(20)
For a level D certificate: $bi \in \{0,1\}$; $ei \geq 5$; $li \geq 3$;
(21)
For a level D certificate: $ai \in \{0,1\}$; $ei \geq 5$; $li \geq 3$.
(22)
*qii* – limitations on the qualification of instructors;
(23)
*qai* – limitations on the qualification of assessors;
(24)
*ri* – limitations on the availability of rooms for conducting training, if there is group certification (group certification involves a group of more than 5 candidates)
(25)
gs – group size for certification >= 5
(26)
*li* – legal restrictions;
(27)
*at* – restriction on the number of exam attempts
(28)
*rs* – restrictions on recertification
(29)
*ii* – interview duration of 90 minutes (for certificates A, B, and C);
(30)
*gi* – geographical restrictions;
(31)
*ti* – technical restrictions.
(32)

### 3.3 Implications of the Model

The attractiveness of certification is a unique and important factor that makes certain certificates appealing in some parts of the world, while in others, they are not as well-

known. Popularity can influence whether a particular certification will even be recognized by potential certificants. Popularity depends on several factors, including (Goff, 2013):

- Correlation with project and business outcomes;
- Initial market introduction of the certificate in a country or region;
- Word of mouth and recommendations;
- Market visibility;
- Ease of acquisition;
- Cost.

Many certificates available on the market are tailored for the operations of organizations or government-mandated conditions, and some of them are standard certificates from leading professional associations or organizations such as IPMA, PMI, GPM, and PM2.

The implications of the proposed model are the consequences arising from the application of the model in real situations. Parameters related to experience (ei) imply that candidates must meet a certain minimum experience to qualify for certification at a certain level. This can have implications for candidate preparation and strategies for gaining project management experience, which can later relate to instructors conducting group training at this level. Time constraints related to leadership positions (li) suggest that candidates with experience in such positions have an advantage over other candidates, meaning they can differentiate themselves during interviews conducted by independent evaluators. This can be important for candidates when planning their careers and seeking advancement opportunities, which they should be aware of before applying.

Geographical constraints (gi) can limit the availability of certification resources for candidates from different regions. This may require tailored strategies for providing certification services to meet the needs of candidates from various locations, adhering to the rules and procedures of the country where the certification is conducted.

## 4. Solutions for Improving the Certification Process 4-L-C

The model provides guidelines for improvement by identifying key points where evaluation processes can be optimized to be more efficient and transparent. This may include reviewing evaluation criteria, standardizing evaluation procedures, and applying technology to facilitate and digitalize the process.

Conducting individual training for candidates to ensure they have the necessary knowledge and skills to successfully pass the certification. This may include developing online courses, workshops, and learning materials. Implementing mentoring programs where experienced certified professionals provide support and advice to candidates during their preparation for certification, thereby building candidates' confidence and helping them better understand the certification process. Developing clear advancement paths that demonstrate how to achieve higher levels of certification. The certification body should inform candidates in advance about the recommended steps, required qualifications, and experience for new certifications. Regular monitoring, updating, and evaluating the effectiveness of the certification process to identify potential problems and opportunities for improvement by collecting feedback from certificants. Partnering with companies and organizations in the field of project management to ensure that the certification meets the real needs of the market and that candidates develop relevant skills.

Educating the public about the importance of project manager certification according to IPMA standards to increase awareness of the benefits and value of certification. Implementing the above proposals can help optimize the certification process for project managers according to IPMA standards and achieve the goal of the mathematical model, which is to increase the number of qualified professionals in the field of project management.

Enhancing the certification process for project managers according to the International Project Management Association (IPMA) standards can significantly improve the quality and efficiency of the entire certification process. The proposed model provides a framework for optimizing key points of the certification processes, including the revision of evaluation criteria, standardization of procedures, and subsequent implementation of digitalization.

A recommendation for Certification Bodies during the application of this mathematical model is to regularly analyze and update the criteria to ensure they meet contemporary standards and methodologies, as well as the needs of the industry. Certification Bodies should also develop standardized evaluation procedures to ensure consistency and fairness in the assessment of candidates. Regarding digitalization, software solutions should be utilized for candidate application, evaluation, and tracking to reduce administrative burdens and increase data transparency. Plans should include developing interactive online platforms that allow candidates to access learning materials according to IPMA standards. Certification Bodies could also leverage this model to create online courses and workshops covering all necessary certification aspects and help candidates acquire the required knowledge and skills for desired certification levels. Furthermore, implementing mentoring programs where experienced certified professionals from the industry assist candidates in preparing for certification is recommended. To ensure the security and efficiency of the optimized certification model, Certification Bodies should regularly collect feedback from candidates to identify potential issues and opportunities for improvement. Continuous collaboration with industry companies and establishing partnerships with organizations in the field of project management are crucial to ensure that the certification aligns with real market needs. Finally, it is essential to educate the broader public about the importance and benefits of project manager certification according to IPMA standards and actively promote the advantages of certification to increase its recognition and value in the market.

Integrating these guidelines can significantly improve the process within Certification Bodies. The proposed optimization mathematical model includes all key aspects—from technological enhancements to individual training and collaboration with candidates, as well as industry cooperation and continuous evaluation of the certification process. This approach ensures efficiency, transparency, and relevance of the certification process, contributing to a greater number of qualified professionals in the field of project management.

## 5. Discussion

The focus of the work is for the Certification Bodies of the International Project Management Association (IPMA) to monitor the entire process to successfully optimize the certification process through the proposed model. The mathematical model

encompasses many activities and steps to achieve an effective solution in its application by the Certification Bodies, including all mentioned constraints, with an emphasis on the output obtained - certified professionals. The constraints mentioned in the context of candidate certification for levels D, C, B, and A are crucial for the proper implementation of the certification process and ensuring quality in training and evaluation programs. It is also important to note that the constraints in the model are not only theoretical but rely on the real needs and resources of certification bodies, so depending on the country where the certification is conducted, the model can be adjusted to resource requirements. For example, constraints regarding resources such as instructors, assessors, training facilities, technical resources, and other factors have a direct impact on the certification process, but not necessarily on the candidate applying, as these are constraints from the Certification Body's side, which are assumed by the candidate. These constraints must be considered when planning and implementing certification programs to ensure adequate support for candidates and maintain the quality of the process.

The contribution of this optimization mathematical model of certification is to provide a tool for effectively managing the certification process, allowing certification bodies to make informed decisions about certifications based on clear criteria and constraints. This model can be very useful for improving the certification process and ensuring its efficiency and transparency during validation by independent individuals who control the certification process and its compliance with the procedures and regulations adopted by IPMA. By integrating the certification model into their operations, organizations can create new horizons of efficiency and achieve sustainable competitive advantage in an increasingly demanding business environment (Stojiljković et al., 2024).

## 6. Conclusion

The paper presents a model for developing the certification process, and future research plans include developing a mathematical model that demonstrates the optimization process of recertifying project managers. The proposed mathematical model can serve certification bodies to improve the optimization processes of certification and to recognize at any time the constraints contained in the model and, if necessary, conduct certification in an optimized manner. The proposed model can be used to improve the certification processes conducted by the Certification Bodies of the International Project Management Association (IPMA), but with further development including recertification, the model can gain a new dimension and optimize the outputs in the number of issued certificates according to the 4-L-C system for managing projects, programs, and portfolios. The limitations and future implications of the proposed certification model lie in the current inability to determine the model's value before pilot projects that will demonstrate its effective application. Without model validation, the practicality and usefulness of the model remain uncertain at this point. Although the paper proposes a mathematical model for optimizing the certification process, the practical application of this model in different organizational and geographical contexts may be complex and challenging.

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