Future of Licensure Experiment

Phase 2 : Mobility Engineering Regulatory Model Alternative Analysis

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Table of Contents

1. Introduction 1
2. Mobility Engineering Fundamental and Legal Framework 2
  2.1. Major Findings from Phase I Study 2
  2.2. Mobility Engineering Legal Environment 2
3. Analysis Method and Steps 5
4. Mobility Engineering Regulation Models 6
  4.1. Overarching Regulatory Framework 7
  4.2. Regulatory Framework Model Alternatives 8
    Option 1. ISO/ANSI Collaboration Model 8
    Option 2. Mobility/Future Engineering Institute Model 9
    Option 3. NCEES-Based New License Model 10
    Option 4. NCEES-Based Certification Model 11
5. Model Alternative Analysis 13
  5.1. Evaluation Criteria 13
  5.2. Evaluation Results 14
    Opportunity Analysis 15
    Risk Analysis 17
6. Conclusion 20
7. Acknowledgement 20
References 21
Appendix A: Review of Existing Certification Models 22
Appendix B: Survey Results on Model Evaluations 25

1. INTRODUCTION

The current landscape of engineering is being reshaped by the Fourth Industrial Revolution, demanding novel solutions to address licensure challenges, particularly in emerging fields. Among these, Mobility Engineering stands out as a swiftly evolving discipline, necessitating innovative regulatory models to effectively certify and guide engineering practices. This is crucial not only for the advancement of the field but, more importantly, for ensuring public safety and well-being. The Phase 1 study, a crucial foundation for understanding the landscape, delves into the multidisciplinary nature of Mobility Engineering. Through an exhaustive examination of education programs, course content, job markets, and regulatory requirements, alongside insights gleaned from crash data and personal interviews, the study unveils key insights.

The review reveals that education programs in Mobility Engineering often stem from various traditional engineering disciplines, augmented by additional certificates and courses specifically tailored to the unique demands of this evolving field. This interdisciplinarity reflects the dynamic nature of Mobility Engineering, which draws on diverse principles and practices. Moreover, the job market in this field demands a broad spectrum of expertise, showcasing a correlation that is not always aligned with traditional education programs. This divergence underlines the unique challenges and requirements of professionals in Mobility Engineering. However, amidst the promising advancements, there are critical issues that loom large and demand attention. The Phase I study identifies a lack of safety feature implementation, regulatory documentation processes, and supporting infrastructure and AI-related capabilities as significant hurdles. These issues not only impact public safety but also pose challenges to the existing engineering licensure system. Addressing these concerns is imperative for the sustained growth and responsible practice in the realm of Mobility Engineering.

Moving forward, the study envisions Phase 2 as the next crucial step. The Phase 2 study aims at further refining and solidifying the foundations laid in Phase 1 and focuses on developing and evaluating various prototype regulatory models. This is achieved through a collaborative approach involving in-depth discussions and cooperation with the Engineering Change Lab – USA (ECL-USA) Steering Committee and other stakeholders. These models are carefully crafted based on the insights gleaned from Phase 1 findings. The evaluation criteria encompass effectiveness, efficiency, and feasibility, ensuring that the selected regulatory model aligns with the overarching goal of guaranteeing competence, upholding the highest standards of integrity, promoting responsible behavior, and ensuring ethical conduct in the realm of Mobility Engineering professional practices. In essence, Phase 2 is a pivotal stage in the evolution of regulatory models in Mobility Engineering. By collaboratively refining and developing prototypes, demonstrating their value through qualitative analysis, and offering alternatives for implementation, the study aspires to not only address current challenges but also to lay the groundwork for a regulatory framework that ensures the highest standards of safety, competence, and ethical conduct in the rapidly advancing field of Mobility Engineering. This comprehensive approach is envisioned to enhance public safety and well-being while fostering industry-wide acceptance and support.

2. MOBILITY ENGINEERING FUNDAMENTAL AND LEGAL FRAMEWORK

2.1. Major Findings from Phase I Study

Phase I study revealed a significant absence of licensure and called for comprehensive technical guidance and ethics education for the protection of the public interest. The investigative efforts included an extensive review of the knowledge base in mobility engineering and interviews addressing specific licensure and regulatory issues. The findings, organized into five critical aspects, are as follows:

- Mobility engineering education programs are typically housed within a traditional engineering department, supplemented by specialized certificates and courses tailored for mobility engineering.
- The job market signals a demand for mobility engineers with expertise spanning a broad spectrum, loosely correlating with educational programs from diverse traditional perspectives.
- Advanced Driver Assistance Systems (ADAS) technologies, designed for public safety, align with the knowledge base emphasized in mobility education programs and reflect corresponding job market demands.
- Bottlenecks hindering optimal safety were identified, including insufficient implementation of safety features, unregulated documentation processes, and a lack of supporting infrastructure and AI-related capabilities, observed through engineering failures and interviews.
- Significant contributors to severe accidents in mobility engineering include data issues and ethical concerns.

Collectively, these Phase I findings underscore the need for a robust regulatory framework to address challenges and uphold the highest standards of safety and ethical conduct in the rapidly evolving field of mobility engineering.

2.2. Mobility Engineering Legal Environment

Analyzing data sourced from the National Conference of State Legislatures (NCSL) provides a comprehensive overview of the legislative landscape related to Connected Autonomous Vehicles (CAV). The findings, presented below, shed light on the trends and focus areas within state-level legislation. By the year 2020, formal legislative enactments had occurred in 28 states, complemented by executive orders in six states. Additionally, a combined legislative and executive approach was adopted in four states. Specifically, 12 states showed neither legislative nor executive measures taken, suggesting gaps in addressing the regulatory aspects of CAVs.

To understand the trajectory of legislative bills related to CAVs from 2017 to 2023, we examined the total number of bills and their statuses (Figure 1a). The peak in overall legislation occurred in 2018, with a noticeable decreasing trend afterward. Enacted legislation, represented by the orange line, remained relatively steady, with spikes in 2021 and 2022. This hints at a potential latency in the legislative process, possibly indicating delays from proposal to enactment. Examining legislative status, pending bills maintained a relatively high volume, showcasing a possible influence on CAV growth and development in the U.S. Figure 1b indicates a decline in pending legislation alongside a rise in enacted ones, emphasizing the potential impact of pending regulations.

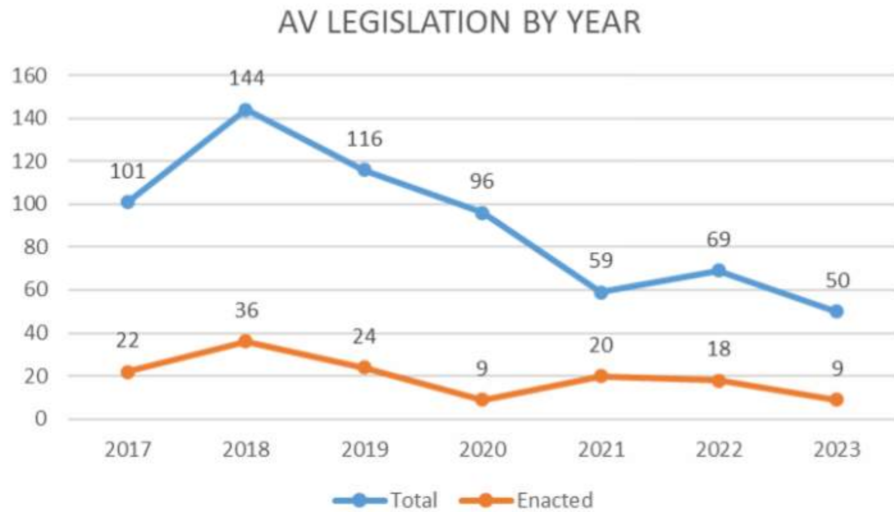

Figure 1 (a). Total Number of State CAV Legislation by Year

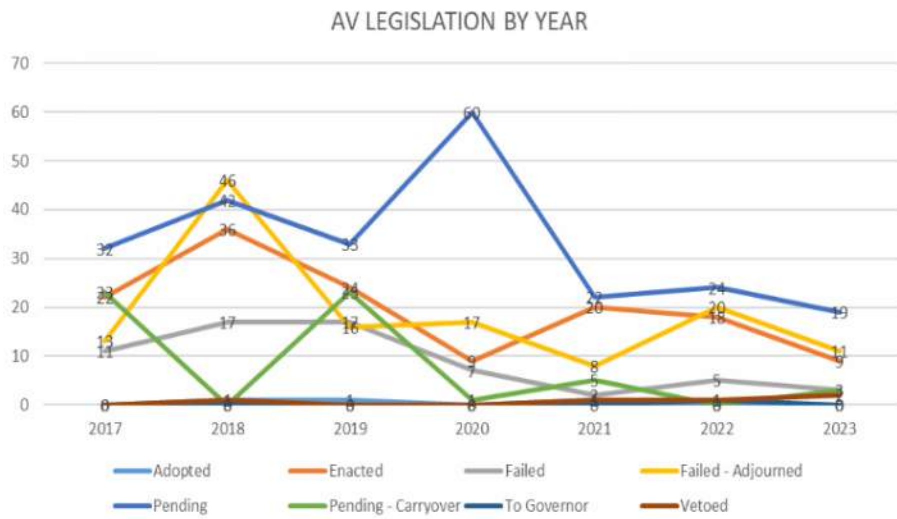

Figure 1 (b). State CAV Legislation Status by Year

Conducting a thorough topic analysis on bills related to Connected Autonomous Vehicles (CAVs) has revealed intriguing insights into the legislative landscape, particularly in terms of focus areas and their evolution over time.

The top three categories identified by the total number of bills are Definitions, Operation on Public Roads, and Vehicle Testing (Figure 2). The prevalence of the definition topic suggests that the legislative focus on CAVs is in its nascent stages of development and deployment. This indicates a keen interest in precisely defining the parameters and characteristics of autonomous vehicles, reflecting the need for a solid foundation as the technology advances. The prominence of Operation on Public Roads and Vehicle Testing showcases a significant emphasis on safety considerations within the legislative discourse. As autonomous vehicles increasingly share public roads, legislators are prioritizing frameworks that ensure the safe operation and testing of these vehicles. This prioritization aligns with the evolving landscape of autonomous vehicle technology and its integration into real-world scenarios.

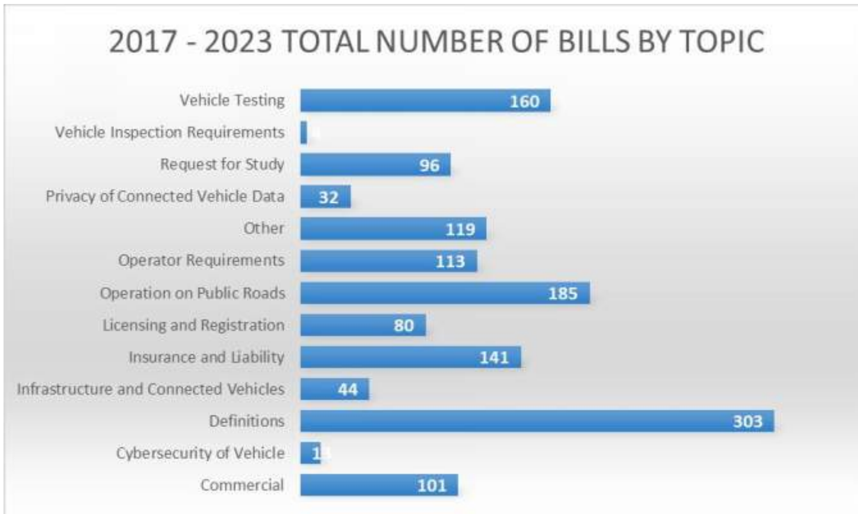

Figure 2. Topic Analysis of State CAV Legislation

Expanding the analysis to a temporal scale in Figure 3, we observe a deeper dive into the bill numbers based on topics. The topic of Definitions exhibits a relatively broad and consistent band over the years. This consistency suggests that CAV technologies are continuously evolving, prompting ongoing efforts to establish and refine definitions at the legislative level. The broad and consistent nature of this topic underscores the dynamic and rapidly evolving nature of autonomous vehicle technologies, requiring a comprehensive and adaptable legislative understanding.

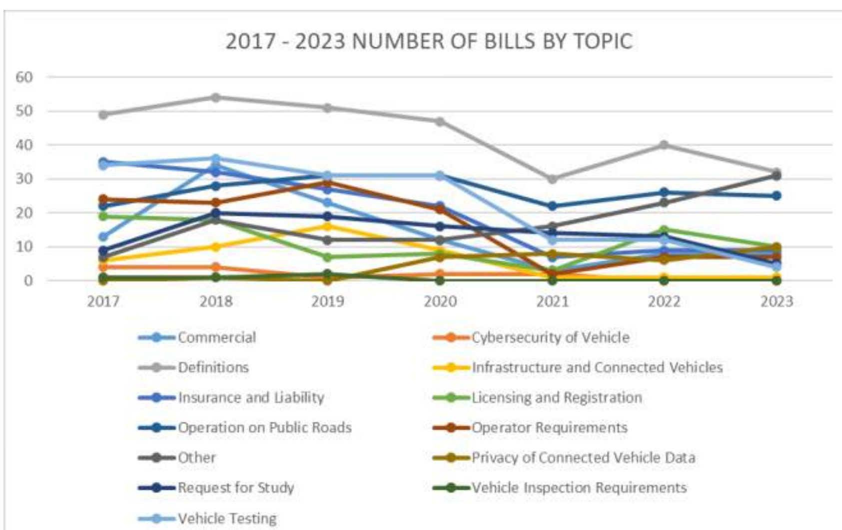

Figure 3. Topic Analysis of State AV Legislation by Years

Moving beyond the overall count of legislative bills, Figure 4 isolates the subset of enacted bills, acknowledging their substantial influence on the prospective landscape of the mobility engineering industry. Notably, in the year 2020, there was a noticeable decline in the total number of enacted pieces of legislation, a trend likely attributed to the unprecedented impact of the COVID-19 pandemic. Despite this decline, two distinct and prominent trends emerge from the enacted bills.

One trend centers around the topic of definitions, indicating a continued focus on refining and specifying the characteristics and parameters of autonomous vehicles. This persistence highlights the legislative commitment to staying abreast of technological advancements and ensuring clarity in the regulatory framework. The second trend is prominently focused on the operation on public roads, emphasizing the paramount importance of safeguarding public roads in the legislative discourse. As autonomous vehicles become more prevalent on public roadways, lawmakers recognize the critical need for robust regulations ensuring their safe and responsible integration into existing traffic systems. This trend reflects a proactive approach to addressing the challenges and concerns associated with the practical deployment of autonomous vehicles.

In summary, this in-depth analysis provides valuable insights into the legislative priorities surrounding Connected Autonomous Vehicles. The identified trends underscore the evolving nature of autonomous vehicle technologies and the legislative commitment to fostering their safe and effective integration into society. As the landscape continues to develop, these insights will play a crucial role in shaping comprehensive and adaptive legislative frameworks for the mobility engineering industry.

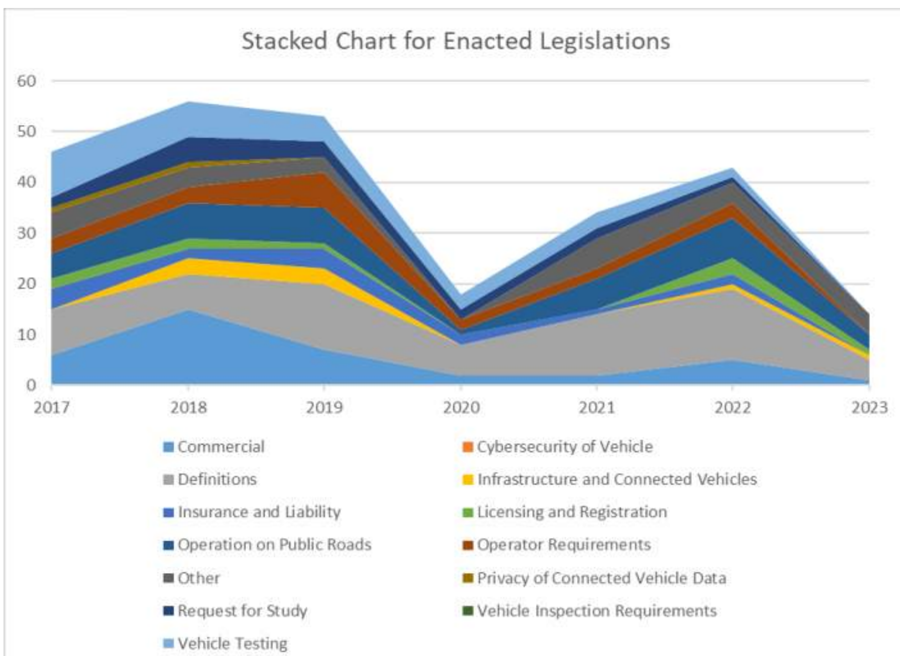

Figure 4. Enacted AV Legislative Bills By Topics

3. ANALYSIS METHOD AND STEPS

To accomplish the comprehensive objectives of this study, a set of pivotal research questions was formulated to unravel the intricacies of the existing licensure framework and the regulatory landscape within mobility engineering. A crucial aspect involves evaluating whether the current licensure framework adequately supports the establishment of a specialized system tailored for the unique requirements of mobility engineering.

Additionally, the research explores the potential advantages derived from integrating a dedicated licensure model for mobility engineering. To address these questions, a blend of qualitative and quantitative research methodologies has been outlined. This approach includes the meticulous execution of two major tasks, ensuring a thorough and comprehensive exploration of the licensure landscape within the mobility engineering domain.

- Workshop on June 28th, 2023:

The workshop conducted on June 28th, 2023, served as a pivotal component in the pursuit of the study's objectives. The workshop was strategically designed to achieve several key milestones. The initial phase involved an in-depth review of the Phase I Report, meticulously focusing on key insights and conclusions drawn during the preliminary phase of the study. Subsequently, participants actively engaged in the design process, collaboratively crafting a Prototype Regulatory/Licensure system specifically tailored for the dynamic practice of mobility engineering. Following the design/brainstorming phase of the workshop, a thorough evaluation was undertaken, systematically assessing the prototype framework’s strengths and weaknesses. The workshop culminated in identifying the subsequent steps for the Phase II Study, offering a structured roadmap for the ongoing research and development endeavors. The workshop's outcomes provided a solid foundation for the subsequent alternative analysis of the Mobility Engineering Regulatory Model.

- Literature Survey:

A literature survey was conducted to explore existing engineering licensure models pertinent to mobility engineering. The objective was to identify transferable knowledge from established engineering models that could be seamlessly applied to the unique landscape of mobility engineering. The survey delved into regulatory frameworks from established organizations such as the International Organization for Standardization (ISO), the American National Standards Institute (ANSI), the U.S. Green Building Council (USGBC), the Project Management Institute (PMI), the National Institute for Certification in Engineering Technologies (NICET), and the Federal Aviation Administration (FAA). Through critical analysis, insights were synthesized from diverse certification models, identifying transferable knowledge that could significantly contribute to the development and enhancement of mobility engineering regulatory models. The results of this comprehensive literature survey are presented in Appendix A.

In essence, these tasks and methodologies constitute a robust framework for addressing the research questions and accomplishing the overarching objectives of the study. The combination of workshop insights and the synthesis of existing certification models ensures a holistic and informed approach to advancing the discourse around mobility engineering regulation.

4. MOBILITY ENGINEERING REGULATION MODELS

After active participation in the workshop and an in-depth literature survey, the foundational prototype for the mobility engineering regulatory model has been crafted. This prototype is systematically categorized into four alternative implementation models. Subsequent to this categorization, a comprehensive alternative analysis has been undertaken, critically evaluating the strengths and weaknesses of each option.

4.1. Overarching Regulatory Framework

The prototype of the mobility engineering regulatory framework, illustrated in Figure 5, encompasses four essential elements: Principles, Regulatory Elements, Process, and Federated Administration.

In the Principles dimension, a commitment to a team-based approach is central, highlighting the significance of collaborative efforts and cohesive teamwork. Recognizing that synergy from a collective contributes significantly to effective decision-making, the principles for the regulatory framework emphasize interdisciplinary integration, acknowledging the value of insights from diverse fields for holistic perspectives. Adhering to a certification standard ensures that teams meet specific qualifications, reinforcing the commitment to excellence and expertise. The organizational principle underscores the need for alignment and coordination within the organizational structure, fostering efficiency and unified efforts. Moreover, the principles also address the national and international aspects of mobility engineering.

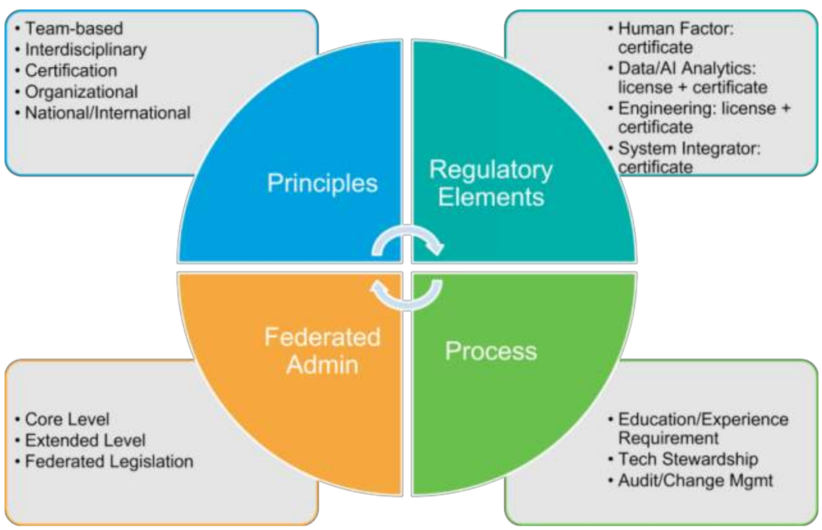

Figure 5. Prototype of ME Licensure Model

The Regulatory Elements are rooted in the knowledge base of mobility engineering identified in the Phase I study. The role of the Systems Integrator is recognized as a key element of inter-disciplinary, mobility engineering teams. Human factor and system integrator elements follow a certification mode, while data analytics and engineering elements are governed through a hybrid mode, integrating licensing and certification mechanisms.

In the Process dimension, the regulatory framework incorporates essential processes to define requirements for team certification and ensure responsible team management. Education/Experience Requirements establish necessary qualifications, and Tech Stewardship emphasizes responsible technology management. Audit/Change Management processes ensure continuous evaluation and adaptability, reflecting a dynamic approach to the evolving landscape of mobility engineering.

Federated Administration delineates the levels of governance within the licensure model. The Core Level includes central administration functions, ensuring uniformity and adherence to overarching principles. The Extended Level broadens administrative responsibilities to particular units or departments, enabling a more customized approach that addresses the various aspects of mobility engineering practice, e.g. customized assessments, tailored training, departmental liaison, industry partnerships, and mentorship education. The federated structure provides flexibility and adaptability, ensuring effective governance across different organizational levels.

This comprehensive regulatory prototype establishes a robust foundation for the mobility engineering licensure model, integrating principles, regulatory elements, processes, and federated administration to meet the dynamic and evolving demands of the mobility engineering landscape.

4.2. Regulatory Framework Model Alternatives

To craft and assess a regulatory model suitable for the field of mobility engineering, we embraced the approach of alternative analysis, a systematic method that involves a thorough examination of various options to address challenges or achieve specific objectives. This method allows stakeholders to gain a holistic understanding of potential outcomes and associated risks by considering multiple alternatives, each with its distinct advantages and drawbacks. Initially, four regulatory framework implementation models were conceptualized, and a SWOT analysis was conducted to evaluate and compare these options, seeking to ascertain their respective values.

Option 1. ISO/ANSI Collaboration Model

The first option involves leveraging existing international standards organizations, specifically those established by the International Organization for Standardization (ISO) and the American National Standards Institute (ANSI). ISO is a global, non-governmental organization that collaborates with 165 national standards bodies to create voluntary, consensus-based standards. These standards promote efficiency, safety, and consistency across industries globally. ISO's impact extends to enhancing product quality, facilitating international trade, and fostering business credibility. In this collaboration model, ANSI serves as the official U.S. representative to ISO, contributing to the development and adoption of these international standards.

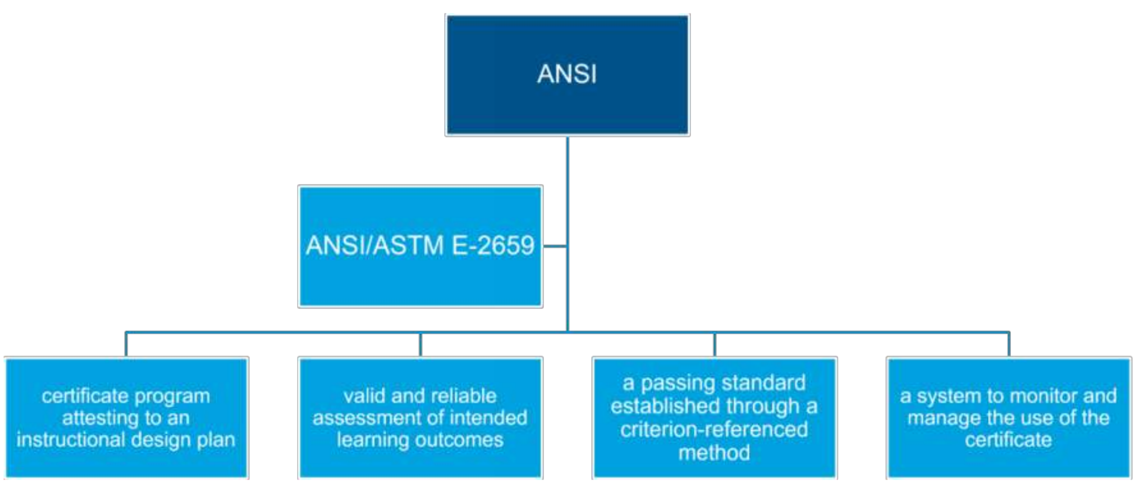

Figure 6. Option 1: ISO/ANSI Collaboration Model

Option 2. Mobility/Future Engineering Institute Model

The second option proposes the development of a Mobility Engineering Institute (MEI) model, which constitutes a three-tier governance structure tailored specifically for mobility engineering. The layers include Standards Development, Governance Structure, and Certified Organizations.

Layer 1: Standards Development

This layer involves two key components—the Mobility Engineering Institute (MEI) and the R&D Office. MEI, a national consortium of disciplinary standards bodies, collaborates to create, consensus-based standards through expert knowledge sharing. The R&D Office engages in creative exploration and systematic efforts to expand knowledge and devise novel applications based on existing information.

Layer 2: Governance Structure

Comprising three indispensable components—the Certification Office, Compliance Office, and Membership Management Office (for certified organizations)—this layer is responsible for overseeing adherence to MEI Standards. The Certification Office conducts independent verifications, the Compliance Office assesses conformity, and the Membership Management Office administers activities related to membership. This layer interacts with the Certified Organizations layer.

Layer 3: Certified Organizations

The Certified Organizations layer includes recipients of an accredited certificate who demonstrate conformity to MEI standards after successfully completing an audit process conducted by the governance structure layer.

The MEI model is designed for potential expansion, with the potential to incorporate additional emerging engineering disciplines in the future, leading to the creation of a Future Engineering Institute (FEI). The structure and processes of the MEI model aim to ensure rigorous adherence to standards, robust governance, and flexibility for future developments in the rapidly evolving field of mobility engineering.

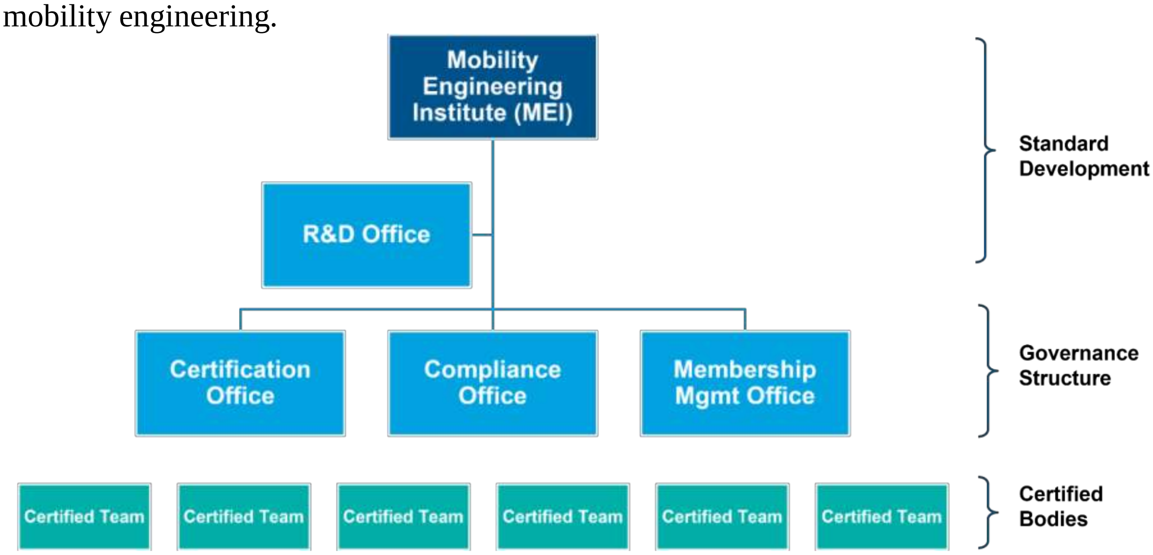

Figure 7. Option 2: Mobility Engineering Institute Model

Option 3. NCEES-Based New License Model

NCEES, as a leading authority, assigns significant importance to its leadership role in establishing optimal practices for professional licensing. This entails fostering collaboration to guarantee that licensure procedures are robust and uphold public protections. These efforts are integral to ensuring that the fields of engineering and surveying continue to safeguard the American public both presently and in the future. To adhere to the existing roadmap established by NCEES, the third option is to develop a new Professional Engineer license for mobility engineers based on NCEES principles. To achieve this, the formal Examination Development Policies (EDP) should be followed. These policies are a comprehensive set of guidelines designed to maintain the highest standards in licensure examination development. According to the Professional Policies (PP), particularly PP 2 Uniform Qualifications for Licensure, NCEES promotes uniform standards for licensure based on education, experience, and examination.

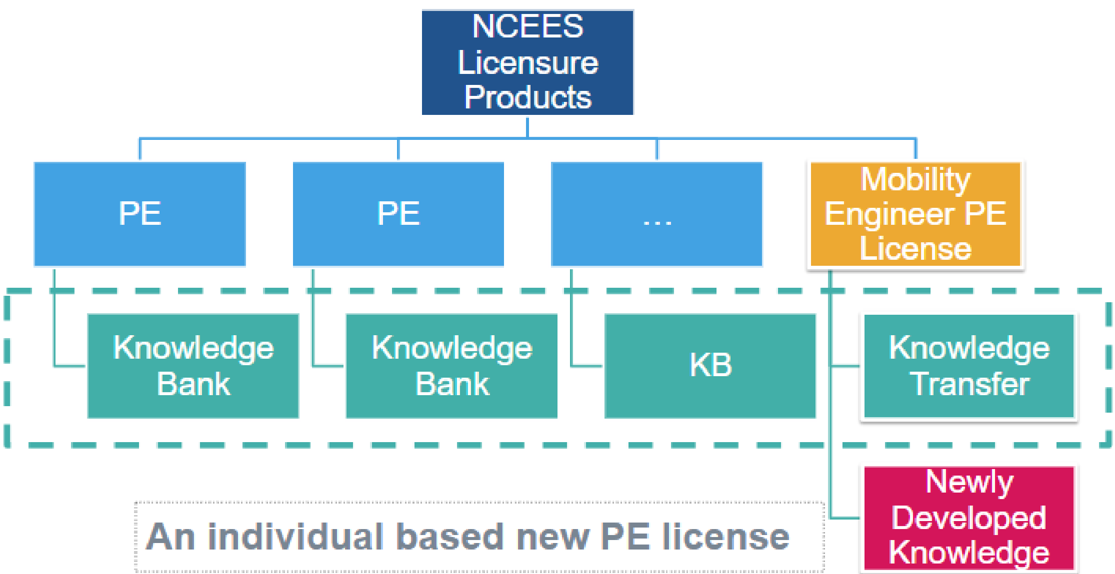

Figure 8. Option 3: NCEES-Based New License Model

In the realm of education, the NCEES framework is closely aligned with the criteria set by the Accreditation Board for Engineering and Technology (ABET). ABET has outlined program criteria for various engineering disciplines. However, it is noteworthy that as of now, mobility engineering does not fall within the scope of these criteria. The most approximate engineering discipline is Civil Engineering. ABET defines both general and program-specific criteria for Baccalaureate level programs. These encompass students, program educational objectives, student outcomes, continuous improvement, curriculum, faculty, facilities, and institutional support.

Moving to the examination component, NCEES currently does not offer a Professional Engineering (PE) exam specifically tailored to mobility engineering. Thus, it is imperative to create a customized Professional Engineering (PE) exam explicitly designed for mobility engineers. This aligns with EDP 4 Entry of a New Discipline or Depth Module or Reinstatement to PE Examination Status. According to this policy, any new licensure, such as the proposed Mobility Engineering (ME) licensure, must meet several stringent requirements.

The first key requirement is the Accreditation Requirement. This stipulates that no discipline can be added or reinstated to the examination program unless there is an EAC/ABET-accredited program in the discipline. This ensures that the educational programs supporting the discipline maintain high-quality standards. The technical society involvement requirement adds another layer of scrutiny, stating that no discipline should be added or reinstated unless a technical society agrees to support the examination. This ensures that the broader industry recognizes and supports the new discipline.

The Member Board Requirement is another critical aspect, where requests for examinations and/or depth modules must be made by no fewer than 10 member boards collectively. Each member board must demonstrate a need for the examination or depth module in their jurisdiction. This request must include proof of need, an estimate of usage, and an analysis of the impact on safeguarding the health, safety, and welfare of the public. Moreover, the request shall include evidence that knowledge areas and skills are not adequately measured in an existing examination or module.

The Minimum Number of Exam Candidates requirement ensures that no discipline or depth module is added or reinstated unless the number of candidates for an ongoing examination conforms to NCEES policies and procedures. If that is demonstrated, a professional activities and knowledge study (PAKS) shall be conducted to establish that the addition in question is composed of a unique set of knowledge important for safeguarding the health, safety, and welfare of the public.

A critical element in the implementation of the new licensure model is the CBT Format requirement. The request to add a new licensure exam must include a plan to develop the exam in a Computer-Based Testing (CBT) format. This acknowledges the shift toward technology-based examination methods, ensuring efficiency and security.

Finally, the Notification to Member Boards requirement ensures transparency and allows sufficient time for member boards to prepare. Member boards shall be notified one year in advance of the addition or reinstatement of any discipline or depth module to the PE examination program. This ensures that the member boards are informed and prepared for any changes to the examination program.

Option 4. NCEES-Based Certification Model

The distinction between licensure and certification lies in their regulatory nature and the level of recognition they entail. Licensure involves a governmental regulatory process, ensuring individuals comply with specific standards to practice in regulated professions. On the other hand, a certificate is issued by an organization or institution, signifying the completion of a course or program without the legal obligations associated with licensure. Licensure is mandatory and carries legal implications, while certification is typically a voluntary acknowledgment of educational or professional achievement.

Considering the multidisciplinary nature of mobility engineering and the likelihood of vehicles crossing state borders, a licensure-based model may encounter challenges in determining legal obligations for practices that transcend geographical boundaries. The fourth proposed model aims to strike a balance by leveraging the resources of NCEES to establish a team-based regulatory system based on certification.

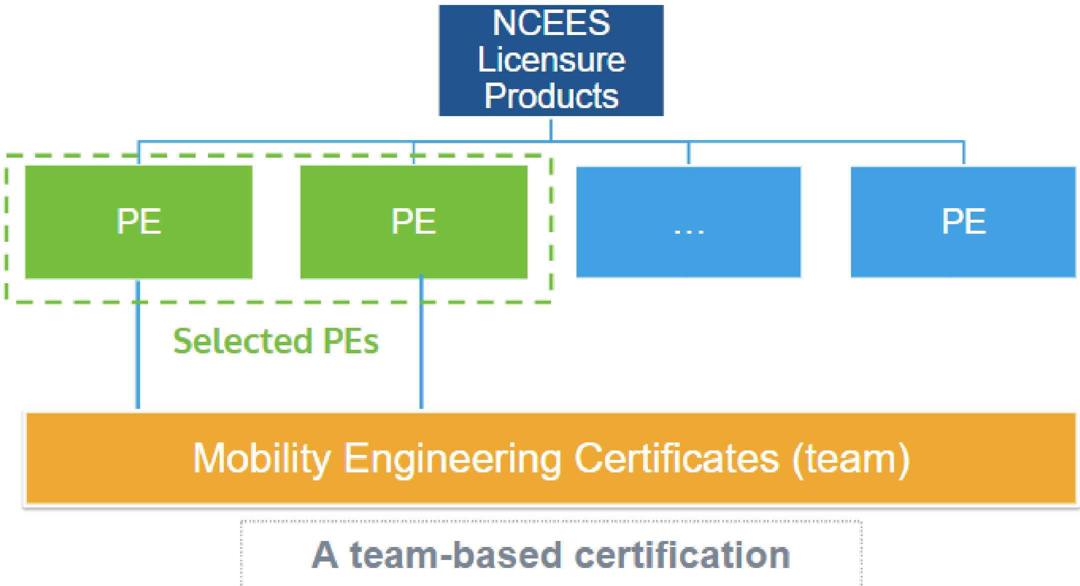

Figure 9. Option 4: NCEES-Based Team Certification Model

In terms of system administration, a federated administration framework for this regulatory system is outlined in Figure 8. Three types of knowledge and standards are crucial for consideration:

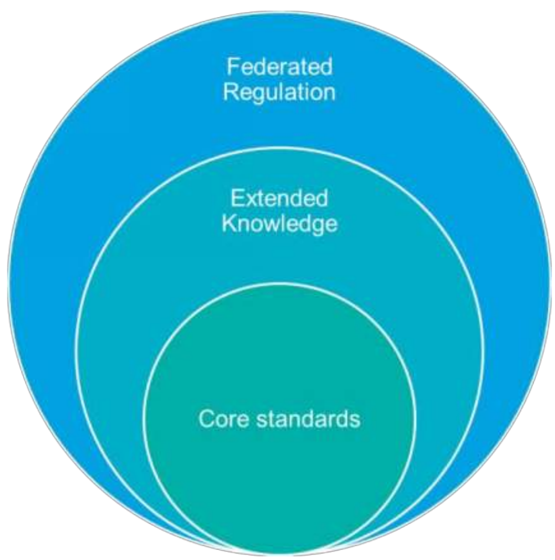

Figure 8. Federated Administration Framework

- Core Standards: These are fundamental principles or benchmarks serving as the foundation for a particular industry, system, or process. Core standards specifically pertain to the knowledge held by the regulatory team.

- Extended Knowledge: This refers to information and understanding that goes beyond fundamental concepts, encompassing a broader and more in-depth scope of expertise.
- Federated Regulation: Involving collaboration and coordination among multiple governing bodies, possibly across different jurisdictions or levels of government, federated regulation ensures a cohesive approach to regulatory practices in the field of mobility engineering.

5. MODEL ALTERNATIVE ANALYSIS

To evaluate the strengths and weaknesses of the proposed regulatory models, we adopted the Likert-scale rating system [4] to understand the opportunities and risks of the proposed model.

5.1. Evaluation Criteria

The evaluation of the proposed regulatory models against key criteria provides a comprehensive understanding of their robustness and challenges. The following breakdown are the evaluation items considered:

- **Applicability**: The approach's versatility across various technologies ensures its adoption beyond mobility engineering. It has the potential for application across other multi-disciplinary areas of practice.
- **Compatibility**: The model seamlessly integrates within existing systems, avoiding the need for significant disruptions or overhauls. It aligns with established processes, fostering a smooth transition and minimizing resistance to change.
- **Agility**: The approach allows for continuous improvement and adaptation to evolving technologies. It ensures flexibility and responsiveness, enabling the model to keep pace with advancements in the dynamic landscape.
- **Value Proposition**: The model offers a compelling value proposition to individuals and organizations. Potential benefits, including improved safety, enhanced public trust, professional credentials, and increased market competitiveness, contribute to its overall value.
- **Endeavor**: Establishing the model requires a committed and purposeful effort, demonstrating a proactive approach. Dedication to investing necessary time, resources, and expertise is essential for successful creation and realization.
- **Bureaucracy**: The implementation of a certification system may introduce some level of bureaucracy. Administrative processes and oversight require funding and resources to sustain and represent potential challenges.
- **Acceptance**: Public or market acceptance is crucial for the endorsement and approval of the model. Broader community acceptance reflects perceived value and relevance, influencing the model's success.
- **Scalability**: The model’s ability to adapt and expand efficiently in response to increased demands or changing circumstances is a key consideration. Maintaining effectiveness and integrity during expansion is vital for sustainable scalability.
- **Innovation**: The model's potential to incorporate new ideas, methods, products, or services is evaluated. Creative thinking, problem-solving, and the implementation of novel solutions are essential components of innovation.

- **Partnership**: Potential collaborations with other partners are considered. Combining resources, expertise, and efforts for shared success enhances the model's overall impact.
- **Ambiguity**: The risk associated with a lack of clarity or precision in language is considered. Preventing multiple possible interpretations or meanings is crucial for successful model implementation.
- **Effectiveness Assessment Risk**: The risk related to the systematic evaluation of how well the model achieves its intended goals is assessed. Measuring against predetermined criteria or standards ensures effective performance evaluation.
- **Implementation Challenge**: Obstacles or difficulties faced during the execution of the model's plan, project, or strategy are examined. Identifying and addressing implementation challenges is essential for successful model deployment.
- **Transition**: Challenges or obstacles encountered during the process of change or shift from one state, system, or condition to another are considered. Ensuring a smooth transition enhances the model's adaptability and acceptance.

The evaluation items outlined above are divided into two categories: opportunity and risk. Based on the formulated survey questions, the criteria in the opportunity category show a positive correlation with the responses. For instance, a higher level of the agreement indicates a model that could provide more opportunities. Evaluation criteria in the opportunity category include Applicability, Compatibility, Agility, Value Proposition, Scalability, Innovation, and Partnership. Conversely, the responses regarding the criteria in the risk category exhibit a negative association with the model performance. A higher level of agreement implies that a model could be more risky. For example, if respondents agree that the proposed model requires a significant investment of effort, it indicates the model has a relatively higher risk. The criteria in this category include Endeavor, Bureaucracy, Acceptance, Ambiguity, Effectiveness, Implementation Challenge, and Transition.

A comprehensive assessment could provide a nuanced viewpoint on the suggested models in terms of opportunity and risks from various dimensions. The detailed analysis is presented in the following section.

5.2. Evaluation Results

As of January 2024, we have gathered feedback from six (6) participants on the Engineering Change Lab – USA Steering Committee, who utilized a Likert-scale rating system to assess the proposed models across the 14 evaluation criteria. In our analysis, we assumed equal importance for each criterion in evaluating the proposed regulatory models. To consolidate the responses, we computed the average score for each evaluation criterion within each model. The evaluation results are organized into dimensions of Opportunity and Risk, depicted in Figure 9.

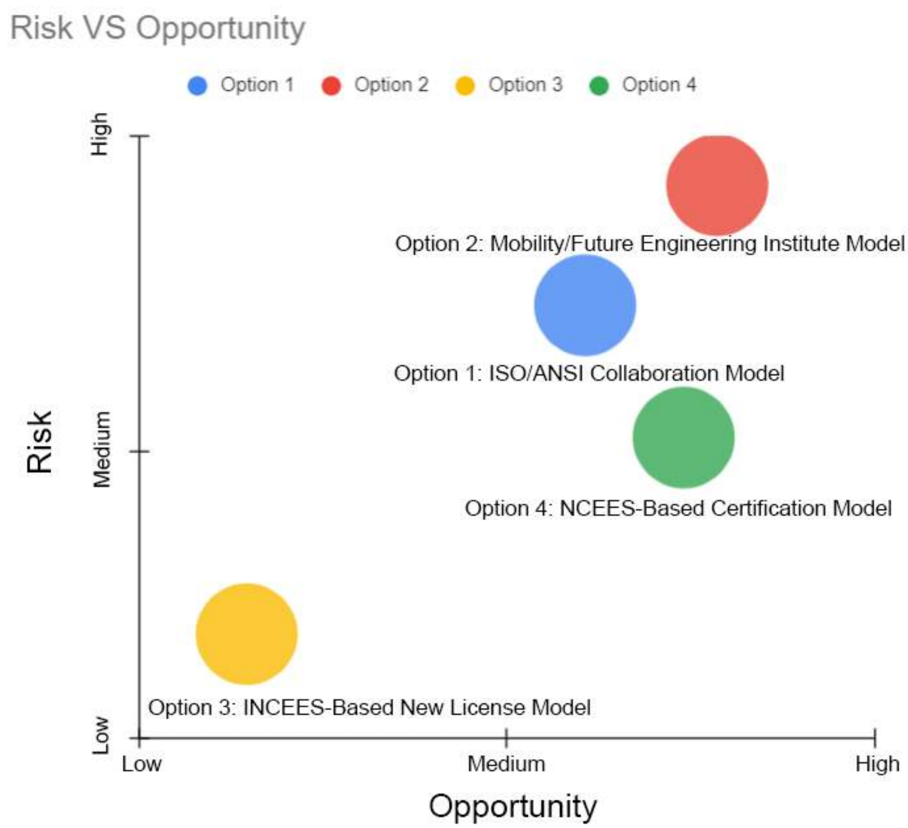

Figure 9. Risk-Opportunity Analysis of Model Options

As an overview, the consolidated opinion for model opportunities are as follows: Option 1 (Medium), Option 2 (High), Option 3 (Low), and Option 4 (High). The integrated opinions for model Risks are Option 1 (Medium), Option 2 (High), Option 3 (Low), and Option 4 (Medium). We consider Option 3 as a baseline because it is an individual-based licensure model similar to existing engineering practice. From the result, Option 3 is not desired to deliver a disruptive solution to meet the needs of mobility engineering professionals, even though it has the lowest risks. Regarding the remaining three options, both Option 2 and Option 4 attained a High rating in terms of opportunities. When comparing the two, there exists a trade-off between opportunity and risk. Option 2 is anticipated to offer greater opportunities at the expense of higher risk. Conversely, Option 4 takes a more conservative approach, potentially yielding fewer opportunities but with lower risk. The opportunity of Option 1 is slightly lower than Option 2 and Option 4, but still significantly better than Option 3. However, in the what-if scenario, if Option 1 is chosen, it should be replaced by Option 4 due to its scarcity of opportunities and higher risk. Therefore, Option 1 is suboptimal in the analysis.

Opportunity Analysis

Concerning the opportunities presented by the proposed models, Option 2 and Option 4 have garnered the highest ratings, categorizing them as the best choices. Consequently, they have been selected for a comprehensive comparison. The rating results at each criteria is shown in Figure 10.

Option 2 has positive opinions in the dimensions of Applicability, Agility, Value Proposition, and Innovation. In comparison, positive dimensions in Option 4 are Value Proposition, and Partnership. Both Option 2 and Option 4 are expected to convey the best value proposition among the 4 alternatives. However, the opportunities they could provide are different. Option 2 exhibits greater flexibility and versatility, paving the way for future engineering endeavors. The rationale behind this lies in the fact that Option 2 has been designed to address the requirements of mobility engineering professionals, while also accounting for the evolving needs of future engineering experts in the era of the Fourth Industrial Revolution driven by advanced technology. By establishing a new and innovative organizational structure, it is tailored and customized with the regulatory objective, and agile to future technical challenges. Furthermore, as a standalone institute, it possesses full ownership and is anticipated to respond swiftly to changes in the technological landscape. Conversely, Option 4, built upon the existing NCEES structure, demonstrated benefits in the dimension of partnership. Being a team-based certificate, it was considered to possess the capability to encourage partnerships between established licensed professional engineers, as well as with future integrator roles like those involving human factors, legal considerations, and ethics. Due to the evaluation assumption assigning equal weights to the criteria, Option 2 outperforms the others in this analysis. However, if future studies emphasize the dimensions of others, Option 4 could be the best alternative.

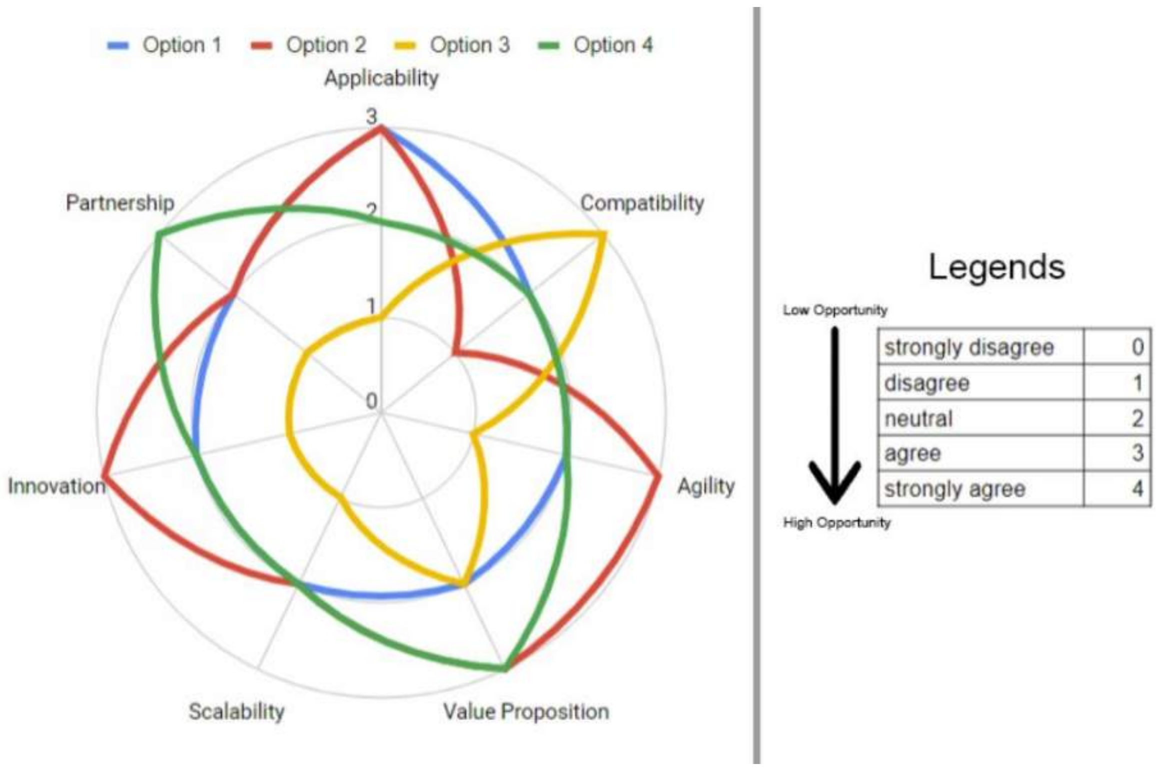

Figure 10. Opportunity Evaluation Result

Option 1 falls short compared to Option 2 and Option 4, yet it outperforms Option 3. Upon closer examination of the criteria, Option 1 received positive opinions in Applicability, benefits that could also be delivered by Option 2. This diminishes the competitiveness of Option 1 in terms of providing opportunities and suggests it should not be selected.

Option 3 follows the traditional PE licensure pathway and received the most negative opinions in 5 dimensions. It reflected the inadequacy of the current PE licensure model for the regulation of the team-based practice of mobility engineering. Possible reasons include inherent characteristics geared toward individual expertise and limitations imposed by licensure boundaries.

Given that our assumption has allocated equal weights to each evaluation criterion, it becomes imperative to rank the results to understand the quality of the model at the criterion level. Opinions expressing agreement and strong agreement are categorized as positive, while opinions indicating disagreement and strong disagreement are categorized as negative. To evaluate, we count the number of positive and negative opinions. In the event of a tie among the options, we proceed to investigate the distribution of intensity in greater detail. The significance lies in providing information to an audience that prioritizes particular dimensions in their decision-making process. The raw survey responses are presented in Appendix B, while the results are depicted in Figure 11. The higher the ranking, the stronger the opportunity the model presents regarding that specific criterion.

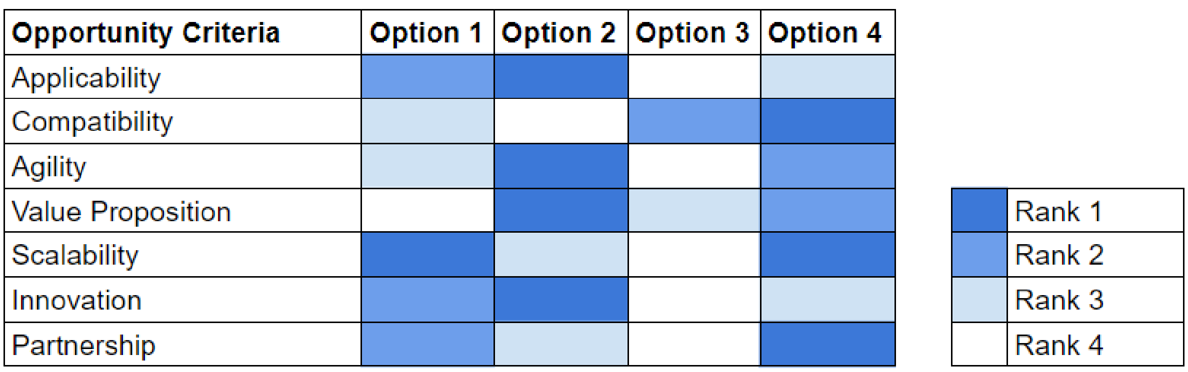

Figure 11. Opportunity Evaluation at Dimension Level

Risk Analysis

According to the risk assessment, the ratings are as follows: Option 1 is classified as Medium risk, Option 2 as High risk, Option 3 as Low risk, and Option 4 as Medium risk. The outcome indicates that Option 2 poses the highest level of risk among the choices. To understand the risk items, we delved into the specifics at the criterion level, as illustrated in Figure 12. As per the questionnaire settings, a higher number of positive outcomes indicates greater risk, whereas more negative outcomes imply reduced risk. The result shows that Option 2 received positive opinions in 4 dimensions, which are Endeavor, Effectiveness, Implementation Challenge, and Transition. It suggests that one should anticipate encountering efforts, challenges, and uncertainties when developing a future regulatory model guided by Option 2. Hence, while Option 2 holds promise for opportunities, the deliberation on its implementation's value and the strategy for balancing opportunities against risks remains a matter for future consideration.

From Figure 12, Option 1 poses risks in the domain of Endeavor and receives a neutral opinion in other dimensions. The gap between ISO's scope and procedures and the regulatory demands of mobility engineering professionals might account for the evaluation result. Given the global nature of ISO, which is not specifically tailored to mobility engineering, one should anticipate efforts in the development, implementation, and collaboration process. Moreover, the implementation pathway may involve uncertainties, requiring additional input from both ISO and ANSI. Therefore, neutral opinions are received at this early evaluation stage.

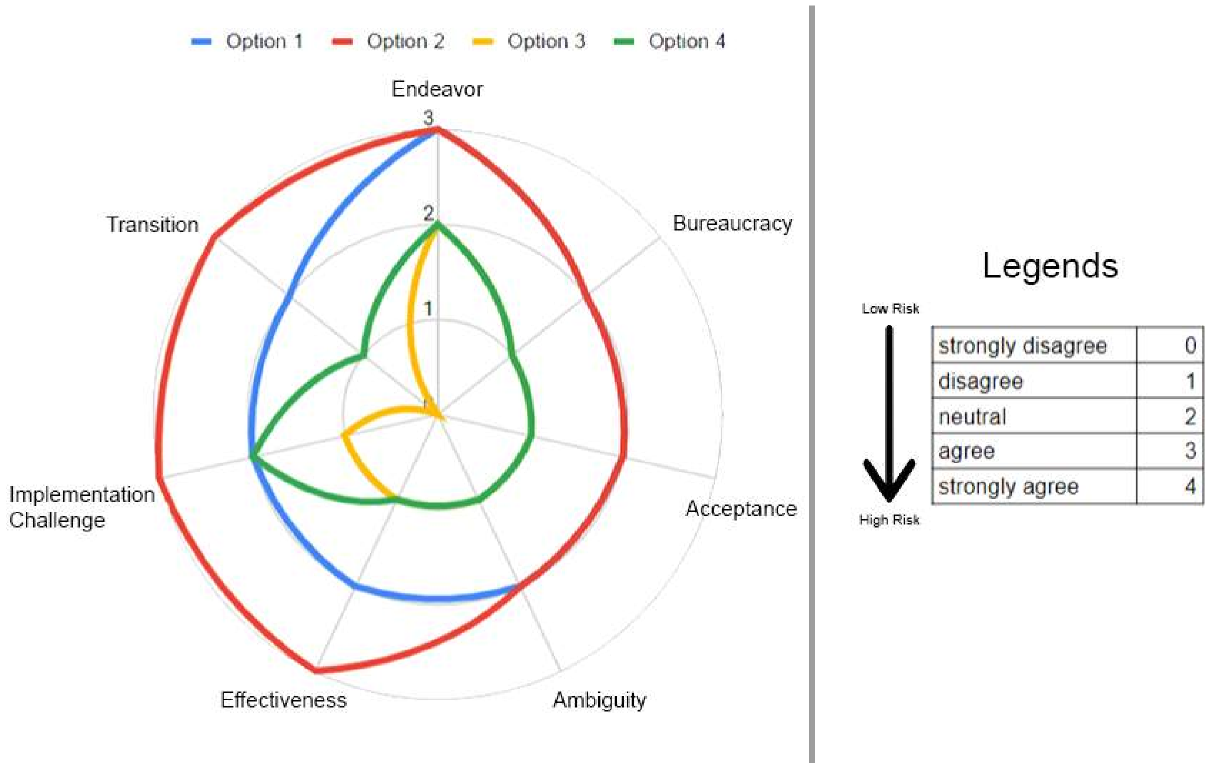

Figure 12. Risk Evaluation Result

Option 3 and Option 4 have no positive feedback on potential risks. Option 3 attains a negative rating in 6 dimensions, which makes it the least risky one among the four alternatives. The result confirms that adhering to the traditional PE licensure pathway, Option 3 is the most conservative one in transitioning to the mobility engineering industry. However, due to its significant shortcomings in opportunity evaluations, it is not the favored choice.

Option 4 garnered 5 negative ratings, excluding Endeavor and Implementation Challenge. In terms of risk evaluation, it is slightly less favorable than Option 3 but still significantly better than both Option 1 and Option 2. While both Option 1 and Option 4 are evaluated as having a medium level of risk, Option 4 outperforms Option 1 across all dimensions within the risk category.

We ranked the alternatives according to each rating criterion. Similar to the opportunity evaluation, opinions indicating agreement and strong agreement were classified as positive, while opinions expressing disagreement and strong disagreement were categorized as negative. The assessment criteria included counting the number of positive and negative opinions. In the case of a tie among the options, we proceeded to examine the distribution of intensity in more detail. In contrast to the opportunity analysis, a higher number of negative opinions indicates a better model option with less risks. The ranking order is structured from the option with the highest risk to the one with the lowest risk. The raw survey responses can be found in Appendix B, while Figure 13 illustrates the results. The higher the ranking, the greater the risk the model presents regarding that specific criterion.

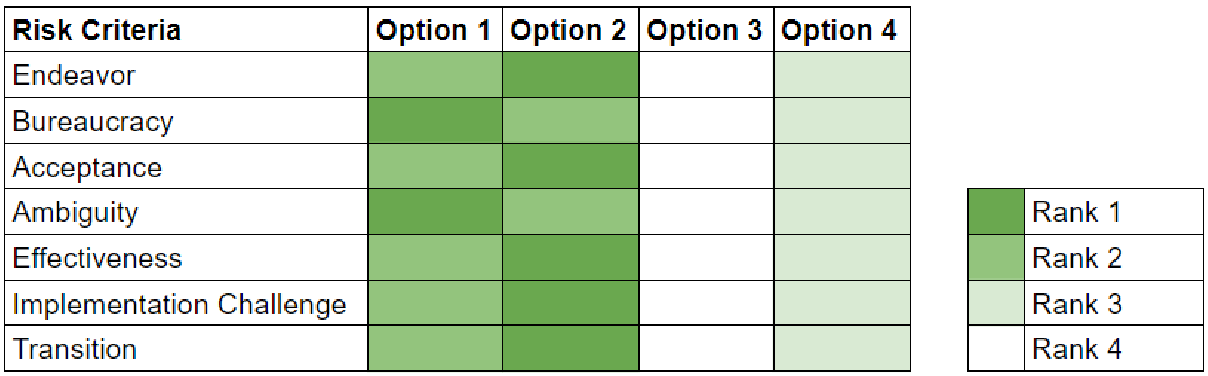

Figure 13. Risk Evaluation at Dimension Level

To conclude, Option 2 performs the best in opportunity assessments, especially at the dimensions of Applicability, Agility, Value Proposition, and Innovation. It is anticipated to provide the most advantageous opportunity for mobility engineering professionals since it targets them specifically and possesses complete ownership of the development process. It demonstrates agility in adapting to future technological changes within the engineering community, particularly in the context of Industry 4.0, and also fosters innovation. Nonetheless, there exists a trade-off between its benefits and risks. On the risk side, Option 2 has received positive feedback in four dimensions: Endeavor, Effectiveness, Implementation Challenge, and Transition. This implies that the development of a future regulatory model guided by Option 2 will likely involve efforts, challenges, and uncertainties. Although the risks are relatively higher, NCEES can play a vital role in mitigating them by creating streamlined implementation plans that require minimal effort.

In comparison, Option 4 also exhibits strengths in opportunity analysis, especially in the criteria of Value Proposition and Partnership, making it an ideal alternative to Option 2. It presents a relatively conservative model transition approach grounded in the well-established NCEES PE licensure, potentially minimizing risks throughout the process. Therefore, if decision makers prefer a less risky approach compared to Option 2, Option 4 emerges as a strong alternative to contemplate. At this initial stage, we've assigned equal weights to the evaluation criteria. In the future, as we identify additional constraints like time, budget, and resources, we can analyze the risk capacity of these models in finer detail to inform decision-making. Option 1 and Option 3 are deemed suboptimal based on the aforementioned analysis and are consequently not selected.

6. CONCLUSION

In the exploration of regulatory options for the mobility engineering industry, this study revisits the knowledge base of mobility engineering established in Phase 1 and conducts a further examination of the legal environment. The trend analysis of state legislation suggests an initial supportive environment at the legal stage to facilitate the innovation of autonomous vehicles. Yet, there has been no regulatory framework devised specifically for mobility engineering professionals. In light of the lack of a mobility engineering regulatory system, this study develops four regulatory model options based on a comprehensive framework outlined in a workshop. Option 1 advocates for collaborative engagement with ANSI/ISO, leveraging international standards to establish a robust regulatory structure. Option 2 suggests creating a Mobility/Future Engineering Institute (MEI/FEI) to address future changes in the technology environment. This institute would provide a customized and agile governance structure for mobility engineering practice as well as other emerging technologies nurtured within the 4.0 Industrial Revolution. Option 3 proposes the creation of a new Professional Engineering (PE) license modeled after the framework provided by the NCEES. Lastly, Option 4 proposes a team certificate approach grounded in the NCEES framework, highlighting collaborative efforts with traditional PEs and multidisciplinary functionality.

Using a Likert scale evaluation framework, the study gathered responses from 6 participants on the Engineering Change Lab – USA Steering Committee, subsequently analyzing each option from the aspects of opportunity and risk. Through the evaluation across 14 criteria, Options 2 and 4 could provide the best values, albeit in different dimensions. However, Option 2 is slightly better than Option 4, but there is a trade-off between opportunity and risk. It is also expected to have a high risk regarding the expected efforts and difficulties in development and implementation. In comparison, Option 4 is a more conservative one because it could leverage resources from NCEES but may sacrifice agility in reacting to future changes.

This extensive study aims to offer insights into the creation and selection of an effective regulatory pathway for mobility engineering professionals, with a primary focus on enhancing public safety. The system should utilize existing resources, accommodate dynamic requirements, and adapt to the continuously evolving technological landscape. Given the limitations of this study, it is advised that future decision-making processes consider weighting the criteria based on real-world constraints.

7. ACKNOWLEDGEMENT

This study is sponsored by the Engineering Change Lab-USA, and special acknowledgment is given to the people and entities whose contributions were instrumental in its successful completion. Gratitude is extended to Mike McMeekin, Monika Schulz, Bill Atkinson, Kyle Davy, Rick Guerra, Caitlin Kenney, Patty Mamola, Brian Robertson, Jyotsna Vishwakarma, Lance Kinney, Karl Tonander, Edwin Friedrichs, and Timothy Jacobs for their valuable insights, support, and assistance throughout the research process. Their expertise and dedication greatly enriched the quality and depth of this study. Furthermore, their active participation and valuable discussions during the workshop and online survey played a substantial role to reach the study's findings. The study could not have been accomplished without their efforts.

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APPENDIX A: REVIEW OF EXISTING CERTIFICATION MODELS

ISO

ISO stands for the International Organization for Standardization. It is an independent, non-governmental international organization that develops and publishes standards to ensure the quality, safety, and efficiency of products, services, and systems across various industries. ISO standards are globally recognized and aim to facilitate international trade and promote innovation and sustainability.

Figure A1. . ISO Goverance Structure

Figure A2. . ISO Process

ANSI

ANSI stands for the American National Standards Institute. It is a private, non-profit organization that oversees the development and use of voluntary consensus standards for products, services, processes, and systems in the United States. ANSI acts as a coordinator and facilitator, bringing together various stakeholders to develop and maintain standards that enhance safety, quality, and interoperability. These standards cover a wide range of industries, including manufacturing, technology, telecommunications, and more. ANSI is the representative of ISO in the United States.

USGBC LEED Certificates

LEED (Leadership in Energy and Environmental Design) stands out as the globally prevalent green building rating system, applicable to a diverse range of building types. Offering a blueprint for creating environmentally friendly, resource-efficient, and economically sound structures, LEED certification serves as an internationally acknowledged emblem of accomplishment and leadership in sustainability. There are two primary types of LEED certificates:

LEED Professional Certifications:

- LEED Green Associate: This entry-level certification demonstrates basic knowledge of green building principles and practices.

STAGE	SUBSTAGE			90 Decision			
	00 Registration	20 Start of main action	60 Completion of main action	92 Repeat an earlier phase	93 Repeat current phase	98 Abandon	99 Proceed
00 Preliminary	00.00 Proposal for new project received	00.20 Proposal for new project under review	00.60 Close of review			00.98 Proposal for new project abandoned	00.99 Approval to ballot proposal for new project
10 Proposal	10.00 Proposal for new project registered	10.20 New project ballot initiated	10.60 Close of voting	10.92 Proposal returned to submitter for further definition		10.98 New project rejected	10.99 New project approved
20 Preparatory	20.00 New project registered in TC/SC work programme	20.20 Working draft (WD) study initiated	20.60 Close of comment period			20.98 Project deleted	20.99 WD approved for registration as CD
30 Committee	30.00 Committee draft (CD) registered	30.20 CD study initiated	30.60 Close of comment period	30.92 CD referred back to Working Group		30.98 Project cancelled	30.99 CD approved for registration as DIS
40 Enquiry	40.00 DIS registered	40.20 DIS ballot initiated: 12 weeks	40.60 Close of voting	40.92 Full report circulated: DIS referred back to TC or SC	40.93 Full report circulated: decision for new DIS ballot	40.98 Project cancelled	40.99 Full report circulated: DIS approved for registration as FDIS
50 Approval	50.00 Final text received or FDIS registered for formal approval	50.20 Proof sent to secretariat or FDIS ballot initiated: 8 weeks	50.60 Close of voting. Proof returned by secretariat	50.92 FDIS or proof referred back to TC or SC		50.98 Project cancelled	50.99 FDIS or proof approved for publication
60 Publication	60.00 International Standard under publication		60.60 International Standard published				
90 Review		90.20 International Standard under systematic review	90.60 Close of review	90.92 International Standard to be revised	90.93 International Standard confirmed		90.99 Withdrawal of International Standard proposed by TC or SC
95 Withdrawal		95.20 Withdrawal ballot initiated	95.60 Close of voting	95.92 Decision not to withdraw International Standard			95.99 Withdrawal of International Standard

Figure A3. ISO International Harmonization Process (Source: International harmonized stage codes [2])

- LEED Accredited Professional (AP): There are various specializations within LEED AP, such as Building Design + Construction (BD+C), Interior Design + Construction (ID+C), and Operations + Maintenance (O+M). These certifications signify advanced knowledge in specific areas of sustainable building design, construction, and maintenance.

LEED Building Certifications:

- LEED Certified: Buildings that meet the basic requirements for sustainable design and construction can receive LEED certification.
- LEED Silver, Gold, or Platinum: Buildings can achieve higher levels of certification (Silver, Gold, or Platinum) based on the number of credits earned across categories like energy efficiency, water conservation, indoor air quality, and innovation.

PMI Certificates

PMI, or the Project Management Institute, offers a range of certificates in the field of project management. Some of the notable PMI certificates include Project Management Professional (PMP), Certified Associate in Project Management (CAPM), PMI Professional in Business Analysis (PMI-PBA), Program Management Professional (PgMP), Portfolio Management Professional (PfMP), PMI Risk Management Professional (PMI-RMP), PMI Scheduling Professional (PMI-SP), etc.

NICET Certificates

NICET certifications are recognized in the United States and are often sought by individuals to demonstrate their competence and proficiency in specific technical areas. Some key NICET certifications include NICET Certification in Civil Engineering Technology, NICET Certification in Fire Protection Engineering Technology, NICET Certification in Electrical Power Testing, NICET Certification in Land Surveying, etc.

FAA Certificates

The Federal Aviation Administration (FAA) issues various certificates and licenses for individuals and organizations involved in aviation. Some of the key FAA certificates include Private Pilot Certificate, Commercial Pilot Certificate, Airline Transport Pilot (ATP) Certificate, Remote Pilot Certificate (Part 107), Aircraft Mechanic Certificate, Air Traffic Controller Certificate, ane etc.

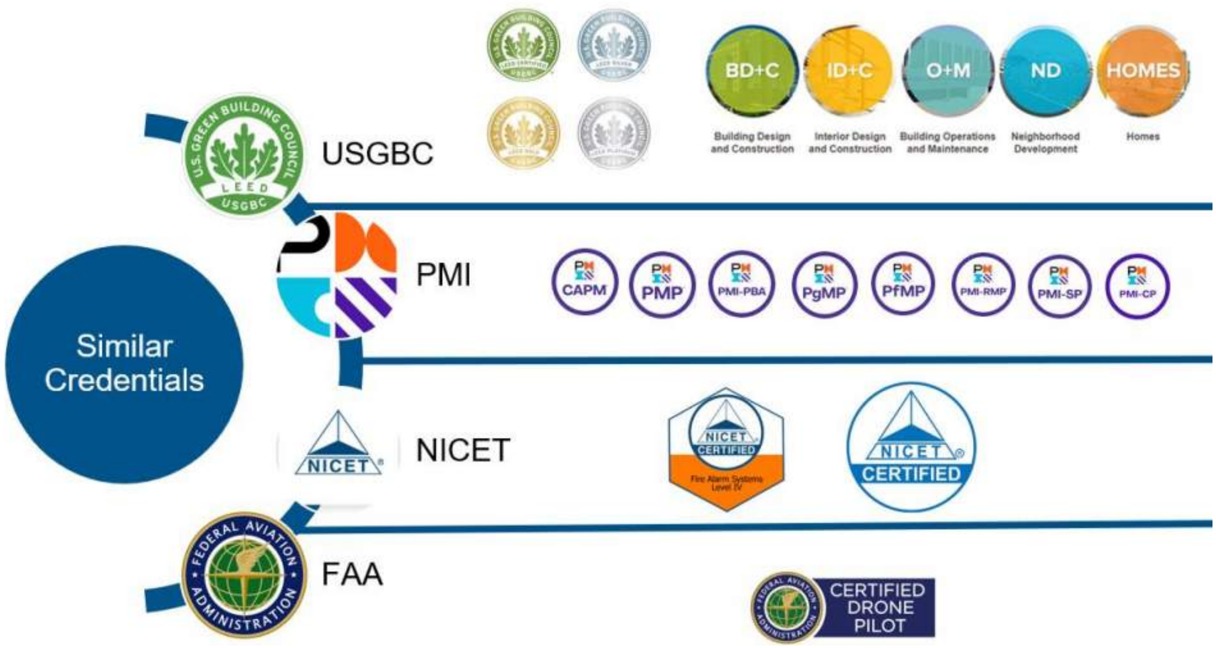
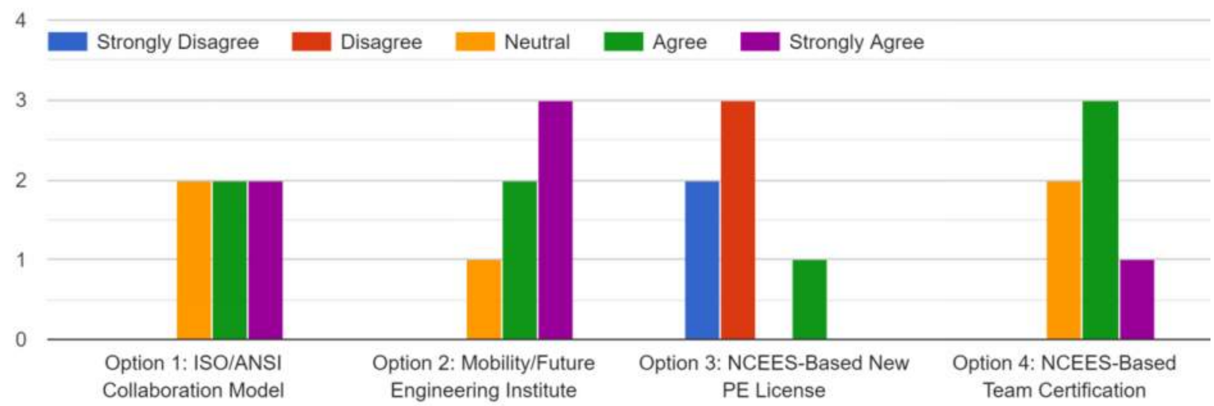


Figure A4. Similar Credential Products

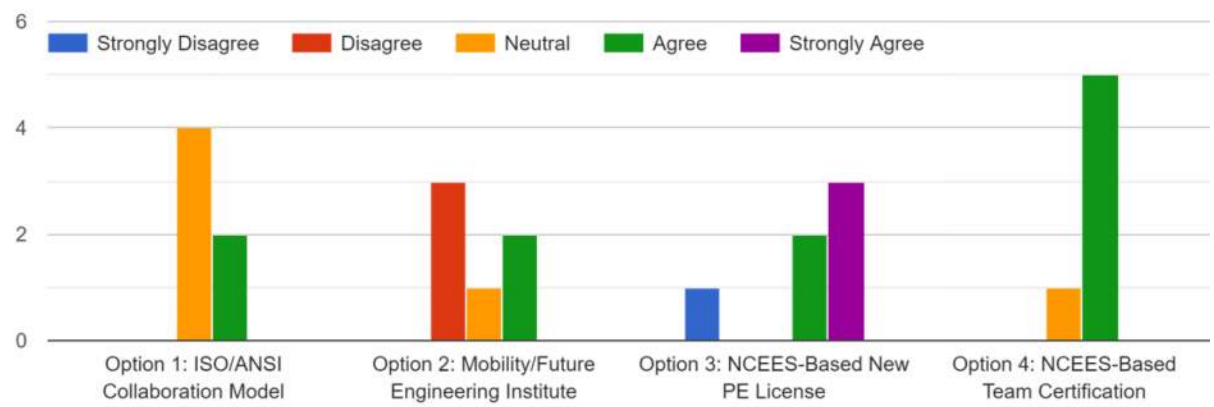
APPENDIX B: SURVEY RESULTS ON MODEL EVALUATIONS

Opportunity Rating

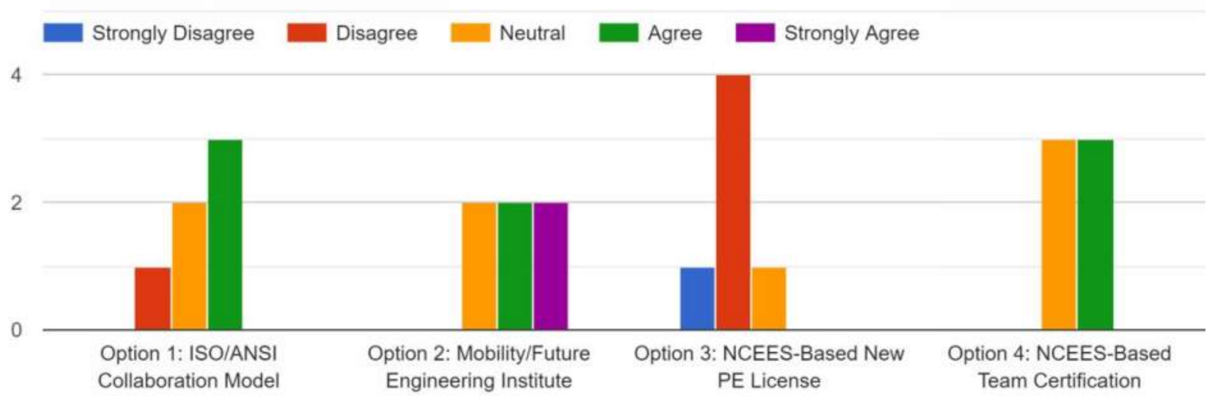
The model is applicable for multi- disciplinary practice characterized by mobility engineers. (Applicability)



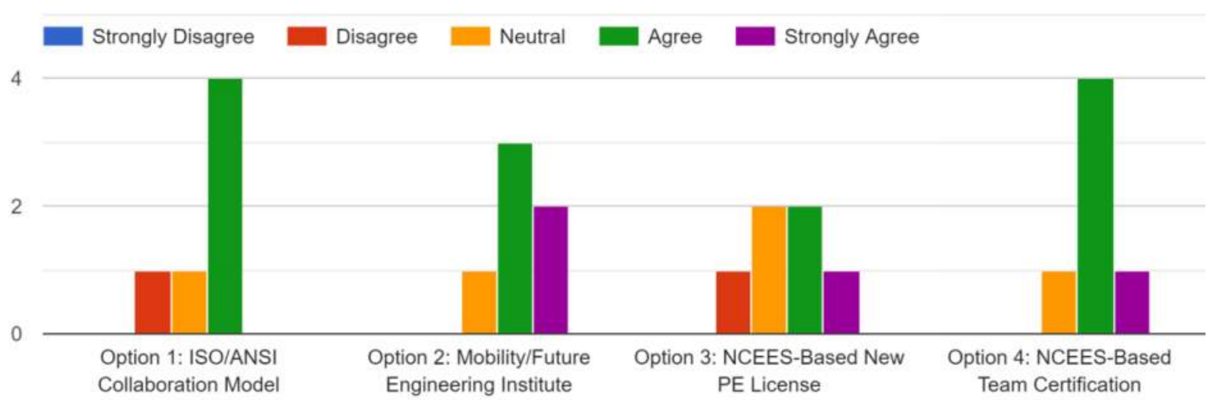
The model is compatible to existing system. (Compatibility)



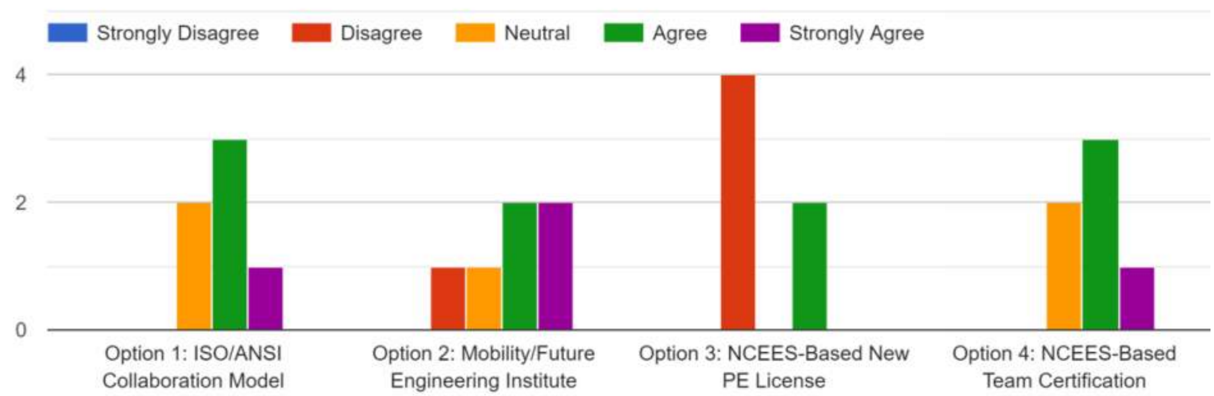
The model is agile to changes. (Agility)



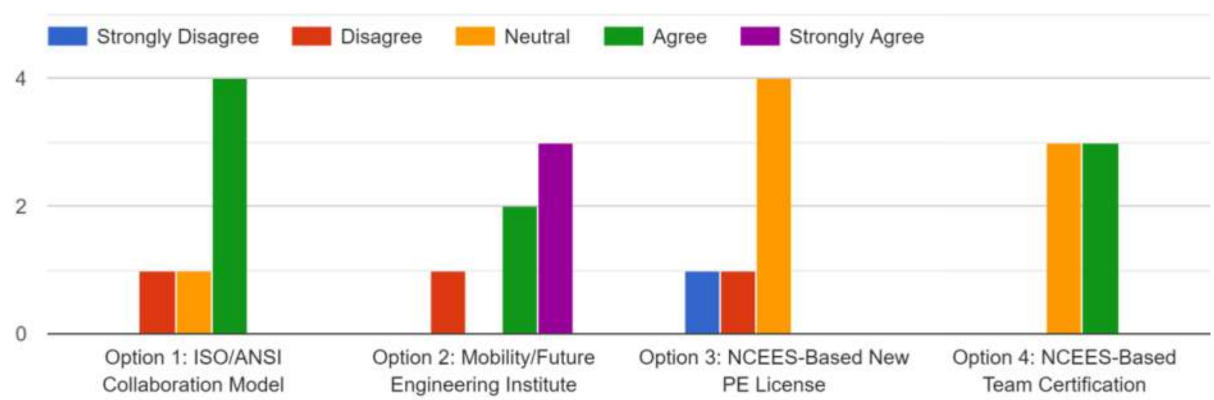
The model possess value proposition to protect public safety. (Value Proposition)



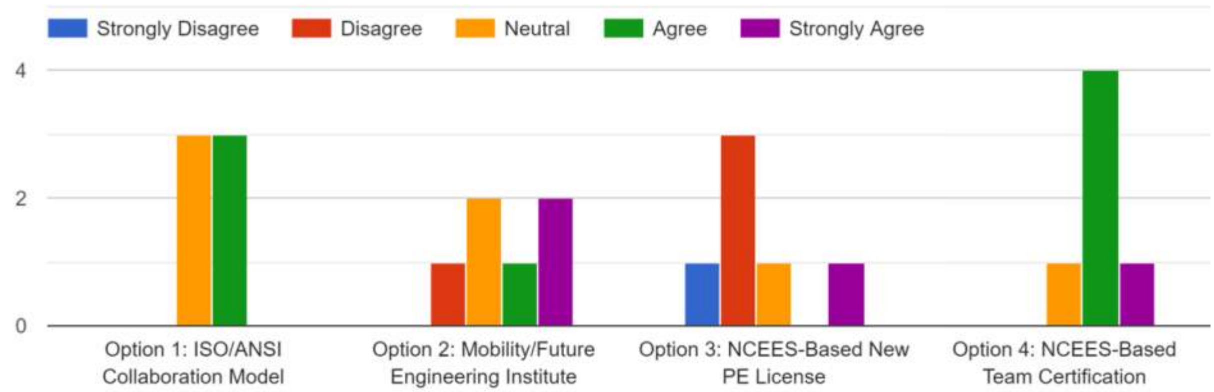
The model would possess chances for future scaling up. (Scalability)



The model would encourage innovation in technology. (Innovation)

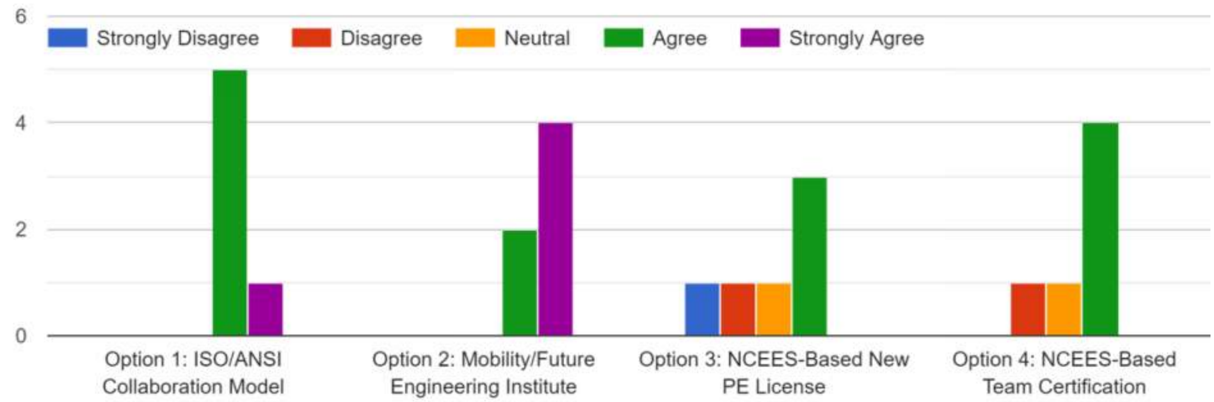


The model is receptive to advancing future partnerships. (Partnership)

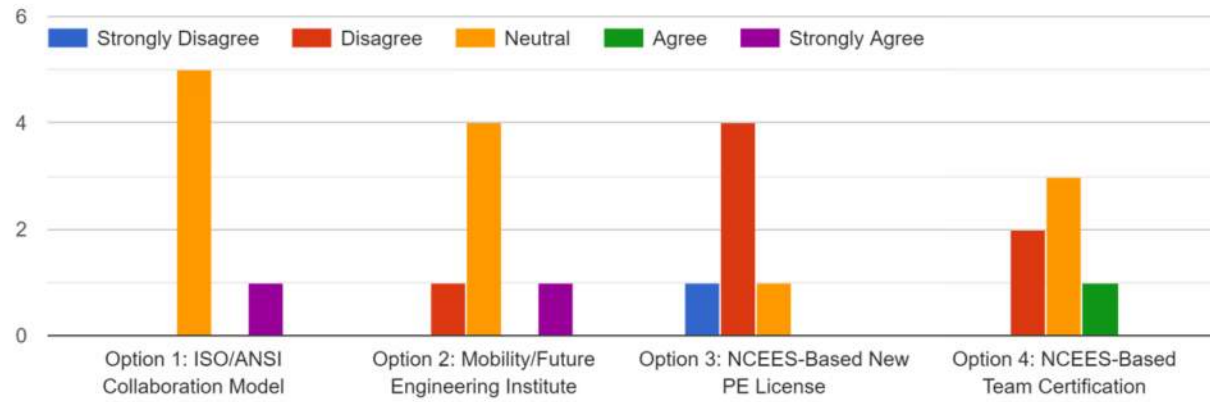


Risk Rating

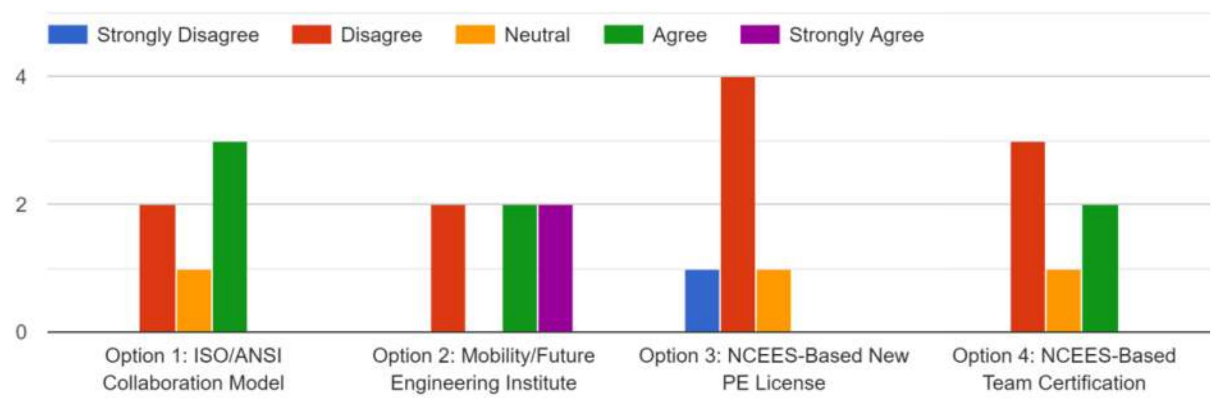
Creating the model would require a significant amount of effort. (Endeavor)



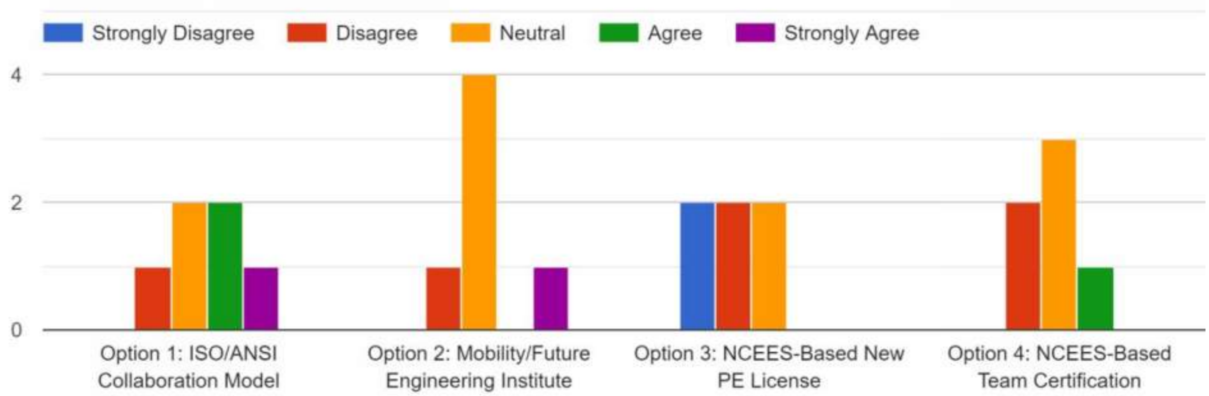
The model would introduce bureaucracy beyond reasonable limits. (Bureaucracy)



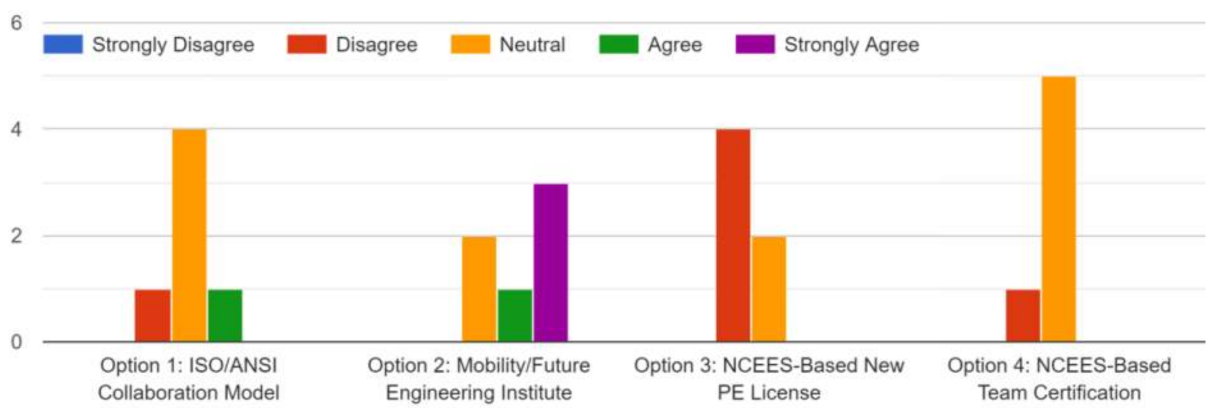
The model would encounter obstacles in gaining acceptance from stakeholders. (Acceptance)



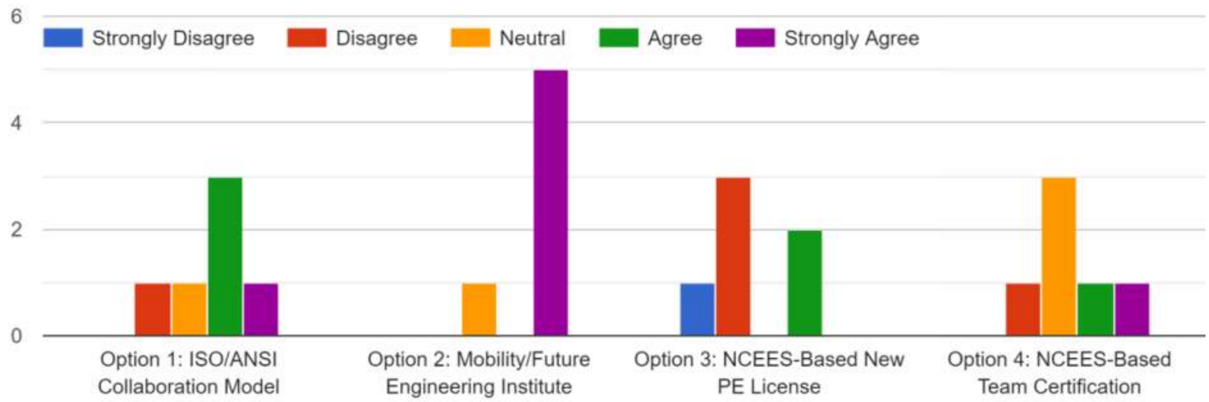
The description of the model is ambiguous. (Ambiguity)



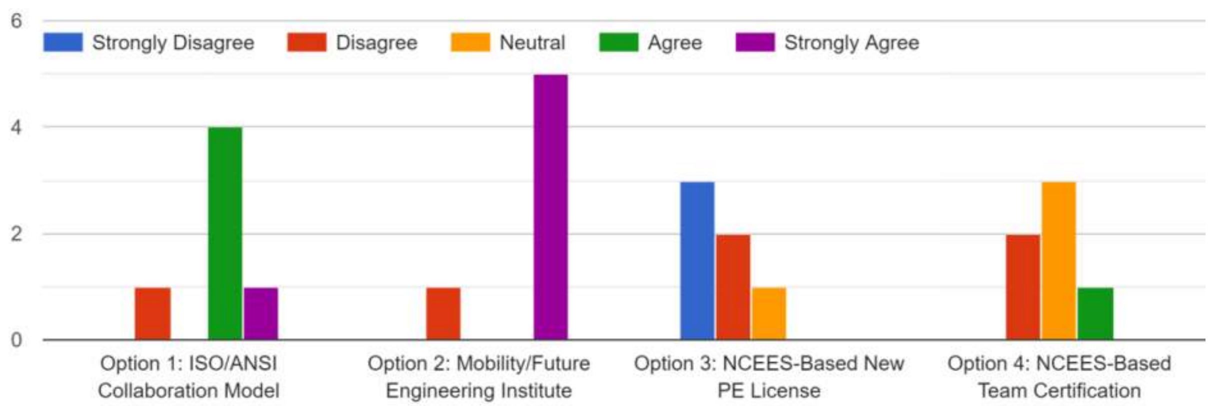
Assessing the effectiveness of the model would involve potential risks. (Effectiveness)



Unforeseen implementation challenges may make the model fail. (Implementation Challenge)



Transitioning the regulatory system could present considerable risks. (Transition)



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