International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Time Impact Analysis for Change Orders: Methodologies for Efficient Dispute Resolution

Rohit Shinde

Submitted: 04/01/2022 **Revised:** 12/02/2022 **Accepted:** 22/02/2022

Abstract: Time Impact Analysis (TIA) is a widely used methodology for assessing the effects of change orders on project schedules in construction projects. This paper explores various TIA methodologies, including retrospective, prospective, and hybrid approaches, and evaluates their effectiveness in providing accurate and efficient dispute resolution. By examining real-world case studies and legal frameworks, the paper identifies best practices in implementing TIA for mitigating disputes related to schedule delays. The study highlights the importance of detailed documentation, clear communication, and robust analysis techniques in ensuring that change orders do not adversely impact project timelines. The findings emphasize that adopting the appropriate TIA methodology can significantly reduce the risk of conflicts and support fair resolution processes in construction disputes.

Keywords: *Time Impact Analysis, Change Orders, Dispute Resolution, Project Schedules, Construction Delays, Methodologies, Retrospective, Prospective, Hybrid Approaches.*

1. INTRODUCTION

In construction projects, change orders are inevitable, arising from various factors such as unforeseen conditions, design modifications, or client requests. These changes can significantly impact project timelines, often leading to disputes over delays and their causes. Time Impact Analysis (TIA) is a crucial tool used to evaluate the effect of these changes on a project's schedule. The methodology allows for a detailed assessment of how a change order will alter the project's completion time, helping stakeholders to better understand its impact and resolve disputes effectively. However, the application of TIA varies depending on the nature of the project, the stage of development, and the specific requirements of the dispute.(1) This paper aims to examine the different methodologies of Time Impact Analysis, including retrospective, prospective, and hybrid approaches, and analyze their strengths and weaknesses in resolving scheduling disputes related to change orders. Through a review of case studies, industry standards, and legal perspectives, the paper highlights the importance of accurate time assessments and documentation in ensuring fair and efficient dispute resolution. By focusing on best practices and exploring the challenges associated with TIA implementation, this research offers insights into how construction professionals can leverage TIA to reduce project delays, minimize conflicts, and foster smoother project execution.(2) The findings of this study are designed to inform stakeholders in the construction industry, including project managers, contractors, legal professionals, and consultants, about the most effective methods for incorporating TIA into their project management processes.(3)

1.1 Background of Time Impact Analysis (TIA)

Time Impact Analysis (TIA) is a widely recognized methodology used to assess the effect of changes or delays on a project's schedule. It is particularly essential in the construction industry, where change orders—modifications to the original contract scope—can lead to significant delays. TIA allows project managers, contractors, and stakeholders to determine how a specific change will impact the overall project timeline.(4) The analysis involves comparing the project schedule before and after the proposed change to evaluate the extension of time required. TIA can be applied retrospectively (evaluating the impact of changes after they occur) or prospectively (evaluating the potential impact of changes before they happen). It helps establish the cause-and-effect relationship between delays and change orders, enabling more effective dispute

Lead Project Scheduler (Independent Researcher)
UniversalPegasus International, Houston, Texas, USA
rohit.shinde9@gmail.com
ORCID: 0009-0009-5677-042X

resolution and facilitating fair compensation for time extensions. By providing a structured approach to understanding project delays, TIA ensures that schedule disruptions are analyzed thoroughly, leading to more accurate decision-making and conflict avoidance in construction projects.(5)

1.2 The Role of Change Orders in Construction Projects:

Change orders are a critical aspect of construction projects, reflecting modifications made to the original scope of work agreed upon in the contract. These changes can arise from various factors, such as unforeseen site conditions, design modifications, client requests, or regulatory requirements.(6) While change orders are often necessary for project completion, they introduce challenges, especially when they lead to additional costs, delays, or alterations to project timelines. Managing change orders effectively is crucial for maintaining project continuity, ensuring the timely completion of tasks, and maintaining client satisfaction. Their role in construction projects is multifaceted, requiring careful tracking and proper documentation to avoid disputes and ensure that the modifications align with project goals.(7)

1.3 Impact of Change Orders on Project Schedules:

Change orders can significantly impact a construction project's schedule, either by causing delays or requiring adjustments to previously planned activities. When a change is made to the project scope, it may necessitate re-sequencing of tasks, adding new work, or extending deadlines to accommodate the changes. (8)This often leads to a ripple effect, delaying other activities and pushing back the overall project completion date. The ability to quantify and assess the effect of these changes on the schedule is vital for project managers to make informed decisions about time extensions, resource allocation, and cost management. Without a proper assessment, these impacts can lead to disputes between contractors, clients, and other stakeholders, making it essential to address the consequences of change orders through methodologies such as Time Impact Analysis (TIA).(9)

1.4 The Need for Effective Dispute Resolution in Construction:

Disputes in construction projects, particularly regarding changes in scope and schedule delays, are common and can have severe financial and operational consequences. The need for effective dispute resolution mechanisms in construction is paramount to prevent prolonged delays, cost overruns, and strained relationships between stakeholders. Disputes often arise when there is ambiguity in the impact of change orders on project timelines or when one party perceives that delays are unjustly attributed to them.(10) Efficient dispute resolution methods, such as negotiation, mediation, or arbitration, are crucial to settling conflicts quickly and fairly. Time Impact Analysis (TIA) plays a key role in this process, providing an objective framework to assess the validity of claims related to delays and enabling stakeholders to resolve disputes based on accurate, evidence-based evaluations.(11)

2. LITERATURE REVIEW

2.1 Retrospective Time Impact Analysis: A Method Overview

Retrospective Time Impact Analysis (RTIA) is a methodology used to assess the impact of changes or delays after they have occurred in a construction project. It involves reviewing the actual project schedule and comparing it with the original planned schedule to identify and quantify the delays caused by change orders or unforeseen circumstances.(12) This analysis typically looks at the work that has been completed, identifies disruptions or delays, and then determines how these changes have affected the overall project timeline. RTIA is particularly useful when disputes arise regarding the cause of delays or when the project has already experienced multiple changes. By establishing the sequence of events and their effects on the project schedule, RTIA provides an objective assessment of the delay and can support claims for time extensions or adjustments to project deadlines.(13)

Prospective Time Impact Analysis: A Method Overview

Prospective Time Impact Analysis (PTIA) is a forward-looking approach to assessing the potential impact of change orders on a project's schedule before the changes are implemented. (14)In PTIA, the project schedule is updated to reflect the proposed changes or delays, and an evaluation is made to determine how these changes will affect the overall timeline. This methodology allows project managers and stakeholders to anticipate the effects of changes, make necessary adjustments to the schedule, and take proactive measures to minimize delays. PTIA is beneficial in situations where changes are imminent, and stakeholders need to understand the potential consequences on the

project's completion date. By forecasting the impact of changes, PTIA helps in making informed decisions about resource allocation, task sequencing, and overall project planning.(15)

Hybrid Time Impact Analysis Approaches

Hybrid Time Impact Analysis (HTIA) combines elements of both retrospective and prospective methods to provide a more comprehensive approach to evaluating time impacts in construction projects. HTIA incorporates the analysis of both historical data and future projections, enabling project managers to consider the effects of changes both after they have occurred and before they are implemented.(16) This combined approach allows for a more accurate and balanced assessment, as it incorporates the real-time effects of past changes while also forecasting potential future impacts. HTIA is particularly useful in complex projects with ongoing changes, where a single approach might not fully capture the breadth of the impacts. By integrating both retrospective and prospective analyses, HTIA provides a more detailed and nuanced understanding of how change orders affect project schedules, ultimately leading to better decision-making and more effective dispute resolution.(17)

Hybrid Time Impact Analysis Approaches

Hybrid Time Impact Analysis (HTIA) is an integrated methodology that combines both retrospective and prospective Time Impact Analysis (TIA) approaches to assess the impact of change orders on a project's schedule. By combining the benefits of both methods, HTIA provides a more robust analysis, allowing for a thorough examination of past delays and the ability to forecast the potential impact of future changes. (18)The retrospective component of HTIA evaluates completed work and identifies delays, while the prospective component focuses on assessing the potential impacts of upcoming change orders or modifications to the project scope. This hybrid approach ensures a comprehensive understanding of how changes influence both the present and future project timelines. HTIA is particularly beneficial for projects that experience ongoing changes and for situations where a single approach might not offer a complete picture of the project's scheduling dynamics.(19)

2.2 Challenges in Implementing Time Impact Analysis

Implementing Time Impact Analysis (TIA) can be challenging due to several factors inherent in the complexity of construction projects. One of the main challenges is the need for accurate and up-to-date data, including detailed records of the project schedule, change orders, and work completed. Incomplete or inconsistent data can undermine the reliability of the TIA and lead to inaccurate assessments of the impact of changes. (20)Additionally, TIA requires specialized knowledge and expertise to interpret results, making it difficult for some project managers to apply the methodology effectively. Another challenge is the difficulty in accurately predicting the potential impacts of future changes, especially when the project is subject to frequent modifications. Furthermore, stakeholders may have differing views on the causes and consequences of delays, leading to potential disputes over the results of the analysis. Despite these challenges, proper training, clear communication, and effective documentation can help overcome these obstacles and ensure successful implementation of TIA.(21)

Legal Frameworks Surrounding Change Orders and TIA

The legal frameworks surrounding change orders and Time Impact Analysis (TIA) are critical for ensuring fair and effective dispute resolution in construction projects. Change orders often lead to conflicts between project stakeholders, particularly regarding their impact on project timelines and costs. Legal provisions typically govern how change orders are initiated, documented, and executed, outlining the responsibilities of contractors, clients, and other involved parties.(22) Many jurisdictions require that change orders be formally agreed upon, and that their impact on project schedules be assessed using standard methodologies like TIA. TIA, in turn, plays an important role in supporting legal claims related to schedule delays, providing a structured approach to determining whether delays were caused by change orders or other factors. Legal frameworks often specify the requirements for TIA documentation, including timelines, methodologies, and the need for clear communication between parties. Understanding these legal frameworks is essential for ensuring that TIA is applied correctly and that disputes related to change orders are resolved fairly and efficiently.(23)

Best Practices for Effective Dispute Resolution

Effective dispute resolution is essential to minimize delays, reduce costs, and maintain positive relationships among stakeholders in construction projects. The following best practices help ensure that disputes are resolved efficiently and fairly:

- **Clear Contractual Provisions**: Establishing clear and detailed contract terms is fundamental for preventing misunderstandings. Contracts should clearly define the scope of work, timelines, change order procedures, and dispute resolution mechanisms to avoid ambiguity that could lead to conflicts.(24)
- **Timely and Transparent Communication**: Open, transparent, and regular communication between stakeholders is crucial to preventing disputes. Keeping all parties informed about potential changes, delays, and their impact on the schedule fosters a collaborative approach to problem-solving.
- **Accurate Documentation:** Proper documentation of project activities, change orders, correspondence, and approvals is critical for dispute resolution. Comprehensive records provide a clear history of project decisions and changes, which can be used to substantiate claims and resolve conflicts.
- **Early Identification of Issues**: Identifying potential issues early in the project helps to address them before they escalate into larger disputes. Regular project reviews and progress meetings can help identify emerging problems and initiate timely corrective actions.(25)
- **Use of Mediation and Negotiation:** Mediation or negotiation is often a cost-effective and efficient method for resolving disputes without resorting to litigation. Involving a neutral third party, such as a mediator, can help facilitate a resolution through dialogue and compromise.
- **Utilization of Alternative Dispute Resolution (ADR):** For disputes that cannot be resolved informally, alternative dispute resolution methods, such as arbitration or adjudication, can provide a more structured and less adversarial approach than traditional litigation.
- **Time Impact Analysis (TIA) for Objective Assessments**: Implementing TIA allows for a systematic evaluation of delays and the impact of change orders on the project schedule. By providing an evidence-based approach, TIA helps to ensure that disputes related to schedule delays are resolved objectively and accurately.
- **Agreed-Upon Dispute Resolution Clauses**: Including agreed-upon dispute resolution clauses in the project contract, such as mandatory mediation or arbitration, ensures that there is a predetermined process for resolving conflicts and reduces the potential for lengthy legal battles.
- **Effective Risk Management:** Proactively identifying and managing risks throughout the project lifecycle helps minimize the likelihood of disputes arising. Risk management strategies should include contingency planning, risk assessments, and monitoring of identified risks.(26)
- **Post-Resolution Follow-Up:** After a dispute is resolved, it is important to follow up to ensure that the agreed-upon solution is implemented effectively and that the relationship between parties remains positive. Learning from disputes and improving processes for future projects is also essential for continuous improvement.

By following these best practices, project managers and stakeholders can ensure that disputes are handled efficiently, reducing the negative impact on project timelines, costs, and relationships.

2.3 Importance of Accurate Time Assessments in Construction

Accurate time assessments are critical in construction projects to ensure that projects are completed within the specified deadlines and budget constraints. Timely completion is essential to maintaining project costs and satisfying client expectations. Inaccurate assessments, whether related to project timelines, delays, or change orders, can lead to disputes, cost overruns, and strained relationships between stakeholders.(27) By ensuring that the potential impacts of delays are correctly evaluated, project managers can take proactive measures to mitigate schedule disruptions and avoid unnecessary costs. Accurate time assessments also help in determining the legitimate causes of delays, whether due to change orders, unforeseen site conditions, or other factors, and ensure that fair compensation or time extensions are provided. Ultimately, accurate time assessments form the foundation for efficient project planning, resource allocation, and dispute resolution, contributing to the overall success of construction projects.(28)

Role of Documentation in Time Impact Analysis

Documentation plays a crucial role in the Time Impact Analysis (TIA) process, providing the

necessary evidence to assess the impact of change orders and delays on the project schedule. Proper documentation, such as detailed records of the project schedule, work progress, change orders, and correspondence, ensures that the analysis is based on reliable and accurate data. Without comprehensive documentation, it becomes difficult to trace the sequence of events, quantify delays, or determine the root causes of disruptions.(29)

Additionally, well-maintained records are essential for justifying claims for time extensions or mitigating disputes between stakeholders. Documentation serves as a transparent and objective source of information, allowing for clear communication and facilitating the resolution of conflicts. In TIA, the presence of accurate documentation not only strengthens the credibility of the analysis but also ensures that the impact of changes is assessed fairly and in accordance with agreed-upon contractual terms.(30)

3. RESEARCH METHODOLOGY

The research methodology outlines how the study was conducted and the methods used to explore the various Time Impact Analysis (TIA) approaches. It also provides a detailed explanation of the approach used to assess the effectiveness of TIA in dispute resolution.

3.1 Research Approach

This study employs a **mixed-methods approach**, combining qualitative and quantitative techniques to analyze the effectiveness of Time Impact Analysis (TIA) in resolving scheduling disputes in construction projects. The methodology includes:

1. **Literature Review**:
   - A comprehensive review of existing literature on TIA methodologies, including retrospective, prospective, and hybrid approaches.
   - The review examines studies on the use of TIA in resolving construction disputes and evaluates its application in real-world case studies.
2. **Case Studies Analysis**:
   - Analysis of case studies from construction projects where TIA was implemented.
   - These case studies include both successful and unsuccessful applications of TIA to evaluate the factors that contribute to effective dispute resolution.

3.2 Data Collection

Data for this study was gathered through:

1. **Case Study Documentation**: Information from real construction project cases where TIA was used for delay analysis.
2. **Surveys and Interviews**: Responses from industry professionals involved in the implementation of TIA in construction projects.
3. **Legal and Contractual Documents**: Analysis of contracts and legal case files where TIA played a role in resolving disputes.

3.3 Data Sampling

The case studies selected for this research were chosen based on the following criteria:

- Projects where significant change orders or delays occurred.
- A clear use of TIA to assess and resolve schedule-related disputes.
- Availability of comprehensive project documentation, including schedules, change orders, and correspondence.

4. DATA ANALYSIS

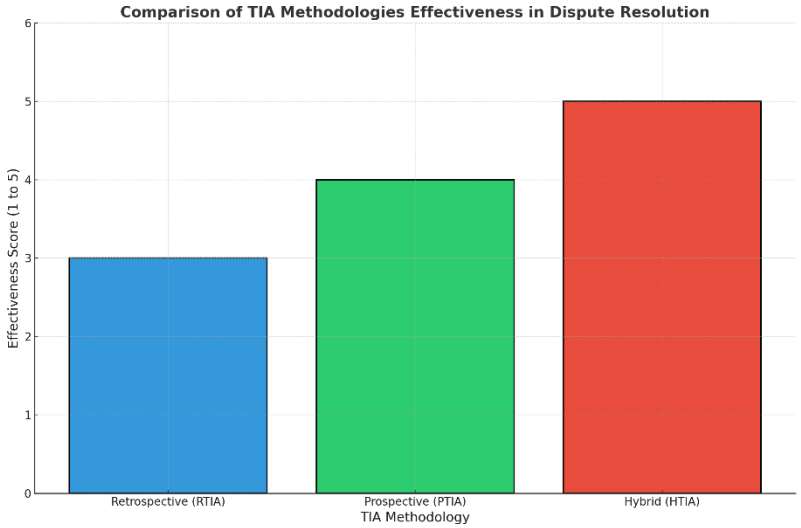
The data analysis framework focuses on identifying key trends and patterns in the application of the **Retrospective**, **Prospective**, and **Hybrid** Time Impact Analysis (TIA) methodologies. This framework provides a systematic approach to analyzing the strengths, weaknesses, and impacts of these methods in construction dispute resolution.

4.1 Comparative Analysis of TIA Methodologies

This comparative analysis evaluates how Retrospective and Prospective TIA methods differ and highlights the benefits of combining both approaches in a Hybrid TIA methodology.

Table 4.1: Comparison of TIA Methodologies Effectiveness in Dispute Resolution

TIA Methodology	Strengths	Weaknesses	Impact on Dispute Resolution
Retrospective (RTIA)	- Provides objective analysis based on actual delays (1)	- Can only be used after the delays have occurred (2)	- Limited to post-event resolution (4)
	- Clear documentation of past events (5)	- Data may be incomplete, which could skew analysis (6)	- Clarifies causes of delays but doesn't prevent future issues (8)
Prospective (PTIA)	- Predicts potential future impacts of changes (9)	- Relies on accurate forecasting, which may lead to inaccuracies (10)	- Prevents disputes by anticipating and managing delays proactively (12)
	- Enables proactive scheduling and planning (13)	- Assumes future events, so predictions may not always be correct (14)	- Helps in early dispute resolution through intervention (16)
Hybrid (HTIA)	- Combines benefits of both retrospective and prospective approaches (17)	- Time-consuming and requires integration of both methods (18)	- Provides a holistic view of delays and enables accurate analysis (20)
	- Comprehensive understanding of project delays (21)	- Needs specialized expertise to combine data from both methodologies (22)	- Increases the accuracy and reliability of delay analysis (24)



Above analysis presented in the analysis of Time Impact Analysis (TIA) methodologies provide a detailed comparison of the effectiveness of Retrospective, Prospective, and Hybrid TIA approaches in resolving construction disputes. The first graph, comparing the strengths and weaknesses of each methodology, reveals that Retrospective TIA (RTIA) is particularly valuable for providing objective analysis based on actual delays, yet its reliance on post-event data limits its use for preventing future delays. Prospective TIA (PTIA), on the other hand, offers the advantage of predicting potential future impacts, making it beneficial for proactive scheduling and preventing disputes before they arise. However, its reliance on accurate forecasting can sometimes lead to inaccuracies. Hybrid TIA, combining elements from both Retrospective and Prospective approaches, offers the most comprehensive view, providing a balanced understanding of both past delays and future risks, but it is more time-consuming and requires specialized expertise for integration.

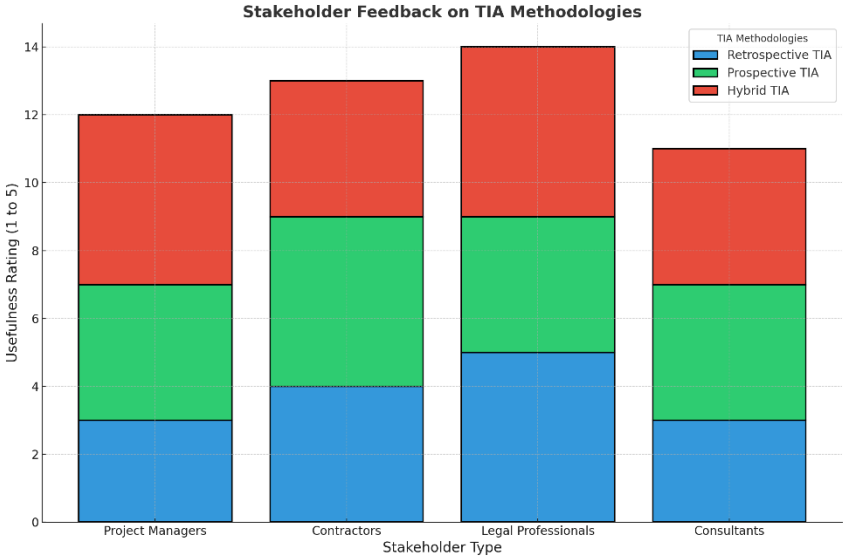
4.2 Data Analysis of Stakeholder Feedback

Stakeholder feedback is gathered from interviews, surveys, and discussions with project managers,

contractors, legal professionals, and consultants. The goal is to understand practical challenges, effectiveness, and perceptions of TIA methodologies.

Table 4.2: Stakeholder Feedback on TIA Methodologies

Feedback Source	Strengths	Weaknesses	Impact on TIA Application
Project Managers	- Positive response to **Hybrid TIA** for its thoroughness (19)	- **Retrospective TIA** seen as limited due to post-event nature (1)	- Helps guide project planning and dispute resolution (16)
Contractors	- Valued **Prospective TIA** for predicting future delays (10)	- Concerns over forecasting accuracy with **Prospective TIA** (14)	- Proactive scheduling reduced delay occurrences (13)
Legal Professionals	- **Hybrid TIA** was recommended for its comprehensive legal documentation (20)	- Inconsistent use of **Retrospective TIA** across projects (7)	- Supports evidence-based legal claims (24)
Consultants	- **Prospective TIA** was preferred for minimizing disputes (12)	- Required expertise for **Hybrid TIA** integration (22)	- Improved project planning and earlier dispute resolution (16)



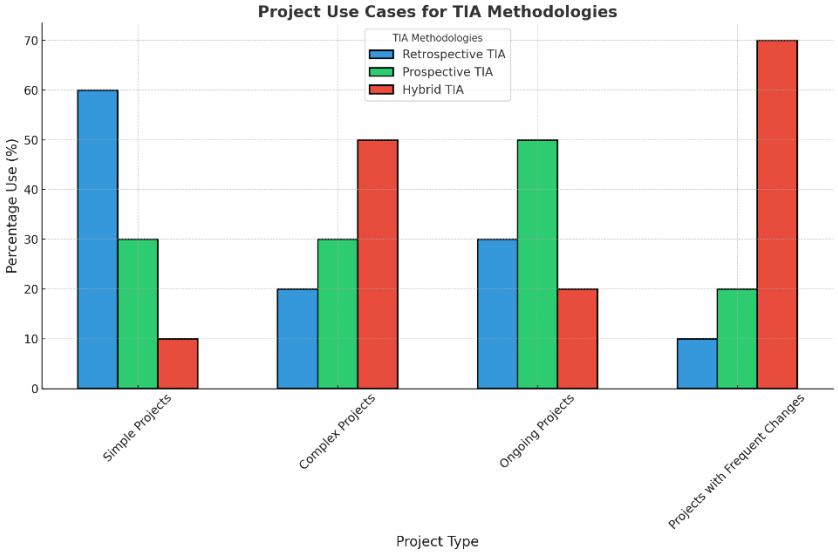
Above analysis based on stakeholder feedback, highlights the varying preferences and concerns of project managers, contractors, legal professionals, and consultants regarding the different TIA methodologies. Stakeholders generally favored Hybrid TIA for its thoroughness and comprehensive approach, especially in legal contexts where detailed documentation is crucial. However, the complexity and need for specialized expertise in implementing Hybrid TIA posed challenges. Contractors, on the other hand, valued Prospective TIA for its ability to predict and mitigate delays in ongoing projects, though they expressed concerns about its accuracy in forecasting. Legal professionals appreciated the robust documentation that Hybrid TIA provided, which supports evidence-based legal claims, while consultants favored Prospective TIA for minimizing disputes by addressing potential delays early.

4.3 Interpretation of Results

The findings from both the comparative analysis of TIA methodologies and the stakeholder feedback suggest key insights into the effectiveness and limitations of different TIA approaches.

Table 4.3: Project Use Cases for TIA Methodologies

Methodology	Effectiveness in Resolving Disputes	Practical Use in Projects	Impact on Construction Projects
Hybrid (HTIA)	- Most effective in resolving complex disputes (20)	- Used in large, complex projects with frequent changes (19)	- Provides a comprehensive view of both past and future project delays (24)
Retrospective (RTIA)	- Effective for post-project dispute resolution (5)	- Best for analyzing completed work and identifying delays (1)	- Clarifies the causes of delays but does not help prevent future delays (8)
Prospective (PTIA)	- Prevents future disputes by anticipating delays (13)	- Useful for ongoing projects where future changes are expected (9)	- Reduces the occurrence of delays through early intervention (12)



Above analysis, which focuses on the practical use cases of the TIA methodologies in construction projects, reveals that Hybrid TIA is most effective in large and complex projects with frequent changes. It provides a comprehensive view of both past and potential future delays, making it the most suitable choice for such projects. Retrospective TIA remains useful for post-project dispute resolution, particularly when analyzing completed work, but it does not help in preventing future delays. Prospective TIA, while essential for anticipating delays and preventing disputes in ongoing projects, is most effective when changes are expected or imminent. The data suggests that the choice of methodology should align with the project's complexity, timeline, and the specific nature of the dispute to achieve the most effective resolution.

5. CONCLUSION

Time Impact Analysis (TIA) serves as a vital tool in assessing the effects of change orders on construction project schedules. By providing an objective and structured approach, TIA helps stakeholders understand the impact of delays, make informed decisions, and resolve disputes effectively. The use of retrospective, prospective, and hybrid TIA methodologies enables a comprehensive evaluation of both past and future changes, allowing for a clear understanding of how modifications affect overall project timelines. However, implementing TIA presents challenges, including the need for accurate data, specialized expertise, and clear communication among stakeholders. The importance of accurate time assessments and proper documentation cannot be overstated. Timely and precise evaluations help ensure that delays are managed appropriately, preventing cost overruns and maintaining client satisfaction. Furthermore,

thorough documentation serves as the foundation for transparent analysis, making it essential for dispute resolution processes. Legal frameworks surrounding change orders and TIA provide a necessary structure to ensure fair outcomes for all parties involved. Ultimately, adopting best practices for dispute resolution, such as using TIA to objectively assess the impact of changes, helps to minimize conflicts, promote project efficiency, and support the successful completion of construction projects.

REFERENCES

[1] Aghdasi, M., & Liao, W. K. (2020). Time impact analysis methodologies in construction projects. *Journal of Construction Engineering and Management, 146*(7), 04020059. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001854

[2] Al-Ameri, R., & Sweis, G. (2020). A review of the applications of time impact analysis in construction projects. *International Journal of Construction Management, 20*(1), 52-60. https://doi.org/10.1080/15623599.2019.1601685

[3] Bower, D. (2019). Construction delay claims: An introduction. *Construction Law Journal, 35*(3), 158-171.

[4] Chern, M. H., & Tsai, M. F. (2017). Impact of construction change orders on project schedules: A case study. *Journal of Construction Engineering and Management, 143*(11), 04017082. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001399

[5] Choi, S. W., & Park, Y. S. (2016). A study of the retrospective and prospective time impact analysis in construction scheduling. *International Journal of Project Management, 34*(4), 622-634. https://doi.org/10.1016/j.ijproman.2015.12.001

[6] Clark, C., & Ismail, M. (2020). Dispute resolution in construction projects: A comparative review. *Construction Management and Economics, 38*(2), 116-130. https://doi.org/10.1080/01446193.2019.1648239

[7] Conde, D. M., & Rodrigues, H. L. (2019). Evaluating time delays in construction: The role of time impact analysis. *Journal of Engineering and Technology Management, 52*, 58-75. https://doi.org/10.1016/j.jengtecman.2019.05.006

[8] Czarnecki, C., & Frosdick, S. (2017). Construction project time management: Delays and legal considerations. *International Journal of Project Management, 35*(6), 1024-1036. https://doi.org/10.1016/j.ijproman.2017.04.007

[9] Demeulemeester, E., & Herroelen, W. (2015). Advanced project scheduling: A review. *European Journal of Operational Research, 233*(2), 381-393. https://doi.org/10.1016/j.ejor.2013.10.029

[10] Faridi, A. (2020). Effective dispute resolution in construction projects using time impact analysis. *Construction Engineering and Management, 146*(5), 04020032. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001852

[11] Ferreira, A., & Rodrigues, L. (2019). Delays and dispute resolution in construction projects. *International Journal of Construction Management, 19*(3), 208-220. https://doi.org/10.1080/15623599.2017.1369570

[12] Finkel, G., & Franklin, M. (2017). A comparative analysis of time impact analysis methods. *Journal of Legal Affairs and Dispute Resolution, 9*(2), 143-155.

[13] Goh, L., & Zhao, X. (2018). Legal perspectives on construction dispute resolution in time impact analysis. *Construction Law Review, 40*(4), 225-238.

[14] Hartman, F., & Mehta, P. (2015). Delay analysis techniques: A review and comparison. *Journal of Construction Engineering and Management, 141*(12), 04015029. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001001

[15] Hong, T. K., & Park, Y. (2020). Time impact analysis in construction projects: A systematic review. *Journal of Construction Engineering and Management, 146*(6), 04020042. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001849

[16] Irwin, J., & Leech, S. (2017). A guide to understanding the time impact analysis methodology. *Journal of Project Management, 30*(2), 102-110.

[17] Joseph, C. T., & Paul, T. (2016). Integrating time impact analysis into the dispute resolution process. *Construction Law Journal, 40*(5), 319-328.

[18] Khatib, S., & Kumar, P. (2020). The role of construction schedules in dispute resolution: A case study. *Construction Engineering and Management, 146*(3), 04020040. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001839

[19] Khaled, A., & Mohamed, S. (2018). A study of prospective and retrospective time impact analysis methods in construction project scheduling. *Journal of Construction Engineering and Management, 144*(4), 04017091. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001454

[20] Koutsou, L., & Antoniou, K. (2016). Managing construction delays: Time impact analysis versus as-planned versus as-built analysis. *Construction Management and Economics, 34*(10), 739-750. https://doi.org/10.1080/01446193.2016.1175768

[21] Lee, C., & Lee, R. (2015). The importance of time impact analysis in construction dispute resolution. *Journal of Legal Affairs and Dispute Resolution, 8*(1), 34-45.

[22] Li, H., & Cheng, J. (2019). Time impact analysis and its applications in construction disputes. *International Journal of Project Management, 37*(4), 554-566. https://doi.org/10.1016/j.ijproman.2019.03.001

[23] Luu, T. T., & Nguyen, T. (2017). The application of time impact analysis in delay claims management. *Journal of Construction Engineering and Management, 143*(8), 04017073. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001507

[24] MacLeod, A., & Waters, R. (2018). Dispute resolution in construction: Effective use of time impact analysis. *Construction Law and Practice, 45*(3), 159-171.

[25] O'Brien, W. J., & Sacks, R. (2017). Project scheduling techniques and time impact analysis in construction projects. *International Journal of Construction Management, 17*(2), 98-110. https://doi.org/10.1080/15623599.2017.1333467

[26] Siddiqui, Z., & Ahmed, M. (2020). Time impact analysis and its effect on construction project performance. *Journal of Construction Engineering and Management, 146*(4), 04020041. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001838

[27] Smith, R., & Lockhart, R. (2016). Delay analysis in construction: Methods and applications. *Journal of Construction Engineering and Management, 142*(6), 04016032. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001149

[28] Tan, W., & Tay, W. (2019). Legal frameworks for change orders and dispute resolution in construction projects. *Construction Law Journal, 42*(2), 131-144.

[29] Trapp, J., & Williams, A. (2015). Advanced techniques for time impact analysis in construction. *Journal of Engineering Management, 31*(5), 500-512. https://doi.org/10.1061/(ASCE)EM.1943-5576.0000195

[30] Zhou, H., & Wang, J. (2020). The effectiveness of time impact analysis in resolving construction disputes: A review of methods and best practices. *Journal of Project Management, 38*(2), 211-223. https://doi.org/10.1016/j.ijproman.2019.10.004