SUBMISSION: 30

TITLE: A Mixed Methods Study regarding Schedule Compression and Out-of-Sequence Work for Electri

AUTH

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Thank you so much, reviewers, for your thorough and actionable comments to improve this paper. Follows is a comment by comment response.

---------- REVIEW 1 ----------

Comment	Response
1. The author has to review the abstract and revise according to overall content. The author mentioned "aims to support electrical contractors in reducing waste", but never talk about waste later in whole proceedings.	Abstract has been revised to better summarize research performed and finding discovered.
2. "Time is of the Essence, is a consistent provision declared in construction subcontracts.", the first line of introduction you kept in Italic. Is that a quote from you or someone else. Need a citation to claim.	Formatting has been corrected and language has been softened. This is not a quote or citation.
3. Literature Review is very weak and citation provided is from the year of 1988, 1993. Suggested to reference from latest research.	Literature review section has been expanded with focus addressed on contemporary market conditions, electrical construction perspective.
4. The author performed research stating "yet little research has included the sources and results of forced out-of-sequence activity." in abstract. However, the author did not provide the research gap with extensive literature review. The author need to revise literature review.	Statement including “little” has been rephrased and literature review has been improved. Focus has been clarified to be electrical construction, rather than schedule change in general.
5. If possible, revise the summary of Figure 2 in short version to make comfortable for reader than long sentences. "Cost impacts due to schedule compression and out-of-sequence work for electrical contractors" is repeated words.	Figure 2 has been reformatted with summarized research topics for improved readability.
6. "Primary Causes of Schedule Compression and Out-of-Sequence Work" and "Leading Indicators of Schedule Change" in Findings: In-person Workshops are confusing and need revision. Your primary question were, "What are the primary causes of schedule compression? And 2. What are the primary causes of out-of-sequence work?" In the section you have mentioned both which is hard to understand.	The appendix includes the 11 research questions addressed in the in-person workshops. The findings section is organized into 7 sections with italicized headers for improved structure.
7. The author poorly presented in person findings from questions 3 to 11. It would be better if the author provided these findings in clear.	Author has addressed conciseness of paper and has added reference to related ELECTRI published playbook.
8. "Statistical Analyses by Group" is not additional findings. I would suggest keeping this section at first part of findings.	This content has been moved to more appropriate location within causes section.

1. Figure 1 can be presented in flow chart.	Figure 1 has been simplified and reformatted as a flow chart.
2. Table 1. should be according to ASC proceedings guideline.	Table 1 has been reformatted. Table 3 was also corrected.
3. The overall proceedings did not follow proper ASC guideline. The author need to review the ASC guideline and revise accordingly.	Authors have reviewed ASC guidelines and updated accordingly.
4. Need to review overall guideline and revise the structure of the paper.	Authors have reviewed ASC guidelines and endeavored to meet them.
5. Figure 5 can be presented in table than figure from software screen.	Figure 5 has been recreated as a table within MS Word.

---------- REVIEW 2 ----------

Comment	**Response**
Page 1, abstract, line 2: add “the” before enormity and proliferation	Added
Page 1, abstract, line 5: change to “change between 2020 and 2023.”	Corrected in two locations.
Page 1, abstract, line 10-11: The last sentence is a little awkward or unclear. Consider editing after “compensation” to add an antecedent to clarify what the contractors should be fairly paid for.	Abstract has been revised to improve the research’s focus and clarity.
Page 1, introduction, 2nd paragraph, 2nd line: add an “s” to “Contractor” for the correct full name of NECA	Corrected.
Page 1, literature review, 1st paragraph, 2nd line: Change “make up of lost time” to “make up for lost time”	Corrected.
Page 2, research methodology, paragraph 1, 4th line: Delete “used”	Literature review has been revised.
Page 3, Findings: In-person Workshops, 1st paragraph, third line: “in person” is missing a hyphen	Document search was conducted to ensure consistency of “in-person” throughout the paper.
Pages 2 (x3), 4 (x2) and 9: “on-line” should be “online”	Document search was conducted to ensure consistency of “online” throughout the paper.
Page 3, “Primary Causes of Schedule….” Section, 2nd paragraph, 1st line: Correct to “COVID-19”	Corrected.
Page 5 – Figure 4: Title within the actual figure has a spacing issue between “compression_and”	This figure has been reformatted as a table per reviewer suggestion.

Page 7, penultimate paragraph, line 4: I think the "4042" should not be here.	Corrected.
Page 8, summary, line 9: "baseline" not "base line"	Document search was conducted to ensure consistency of "baseline" throughout the paper.
---------- REVIEW 3 ----------	
The paper claims a mixed-methods approach, but the explanation doesn't connect the dots between the survey, workshops, and content analysis. Right now, it reads like three separate efforts instead of one integrated design. The authors should clarify: How each phase informs the next How the qualitative and quantitative findings reinforce each other Why this structure was chosen over other mixed-methods models	The research methods section has been improved to more clearly address the mixed methods approach. At the request of other reviewer, the research process has been succinctly represented by a flow chart.
Please clarify the statistical analysis and explain it deeper. The chi-square and Kruskal-Wallis tests are helpful, but the paper doesn't explain: the assumptions behind the tests, how categories were built, or why these specific tests were chosen. The JMP screenshot in Figure 5 is useful visually, but the authors need to narrate what it means in practice.	Additional clarification is added regarding selection of the Chi-square test. The data table has been reworked as a Table at request of another reviewer. The value of the comparison using Kruskal-Wallis test was minimal so it is deleted.
Some conclusions are stated strongly without enough supporting analysis. The paper claims schedule compression and out-of-sequence work are "statistically different", and they are, but the paper jumps quickly to practical conclusions without fully unpacking what that difference means for contractors on the ground. The authors should expand the implications: How should ECs respond differently to each? What documentation strategies differ? How should GCs behave differently? Right now, the meaning behind the difference gets lost.	This point is addressed in two ways: 1. Author has added reference to the ELECTRI playbook developed in this research project yet outside the scope in this technical paper, 2. Author has added a Future Research section to elevate these ideas for future work.
Opportunities for deeper insight are left on the table. The paper contains fantastic industry data (123 surveyed, 4 workshops, NECA SMEs) but doesn't fully leverage it. This is a rare dataset, the authors should push harder toward industry guidance and actionable practices instead of mostly describing conditions.	Author has added reference to the ELECTRI playbook developed in this research project yet outside the scope in this technical paper.
Baseline schedule documentation section needs more structure and clarity. This part of the findings is incredibly relevant, but it reads loosely. The paper should categorize the approaches more clearly, for example: Formal documented baseline Semi-formal communication-based baseline	Author has added reference to the ELECTRI playbook developed in this research project yet outside the scope in this technical paper.

No baseline practices / relying on GC schedule. This would help readers clearly see the maturity scale of EC planning practices.	
Some paragraphs are long and repetitive, tighten them up.	Another critical eye review has been conducted through the entire paper. The result is elimination of one page of the paper, now at 9 pages without loss of research intent.
A few misspellings and phrasing issues (“font line supervisors”).	Corrected to frontline supervisors.
Figures are useful, but some captions need more explanation	
Tables could use better alignment and bolder headings for readability.	Tables have been updated per ASC guidelines, also noted by another reviewer.
The transitions between workshop findings and statistical findings feel abrupt — add signposting.	Statistical findings have been incorporated into findings. Also, requested by another reviewer.

A Mixed Methods Study regarding Schedule Compression and Out-of-Sequence Construction for Electrical Contractors

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Electrical contractors are critical trade partners for construction projects, increasingly so with the electrification of transportation infrastructure, the proliferation of smart building technology, and the enormity of under-construction data centers. Profitable production by electrical contractors is challenged by schedule compression and out-of-sequence construction with 123 electrical contractors reporting that more than 60% of their projects incurred significant cost impacts due to these types of schedule change between 2020 to 2023. In the current market, electrical contractors are pushed to complete projects of increasing complexity within aggressive-commonly unrealistic-timeframes. Despite these operational demands, electrical contractors strive to maintain relationships of value and trust with their general contractor and owner clients. This research investigates and summarizes causes, implications and other topics related to third party-caused changes onto electrical contractors in their planned production. This research shares insights to support electrical contractors in identifying and mitigating the impacts of schedule change. This research uniquely provides data sourced from electrical contracting subject matter experts.

Keywords: Schedule Compression, Out-of-Sequence Construction, Electrical Construction, Scheduling

Introduction

Time is of the essence is a common provision included in construction subcontracts. This clause contracts parties to acknowledge and agree to work in a reasonably prudent and practical manner in the execution of their defined scope of work by a set time limit. Most construction professionals agree that if all parties work in a manner respecting each other's production, then the likelihood of project success is increased for all. With lost respect for the productivity of all project participants, specifically for trade contractors who are self-performing scope, the productivity and profitability of these firms are at risk and often reduced.

With the financial support of ELECTRI International and harnessing the experiences and insights of more than 150 electrical professionals, mostly employed by National Electrical Contractors of America (NECA) member companies, this research investigated the causes and implications of schedule change, specifically scheduled compression and out-of-sequence construction, forced onto electrical contractors. This paper presents leading indicators to assist electrical contractors in being proactive with general contractors. An adept and diligent electrical contractor, prepared with the processes and tools to manage schedule change, offers great value to the whole project, including the general contractor and other specialty trade contractors. By working together, the collective project team can reduce schedule changes and the financial detriments these changes cause, thereby benefiting all project stakeholders.

Research Methodology

The mixed methods research methodology has proven valid and reliable for construction management research involving qualitative and quantitative data sourced from industry professionals. The method effectively synthesizes data from online surveys, semi-structured interviews, in-person workshops and Delphi processes (Abowitz and Toole 2010 and Karakham et al. 2020). Given the expectation of both qualitative and quantitative data provided by electrical construction professionals, this study adopted a mixed-methods research design including three consecutive phases with each successor phase building upon findings of the predecessor phase (see Figure 1). The academic participants were guided and supported by an advisory committee comprised of industry subject matter experts who volunteered through NECA for this research project.

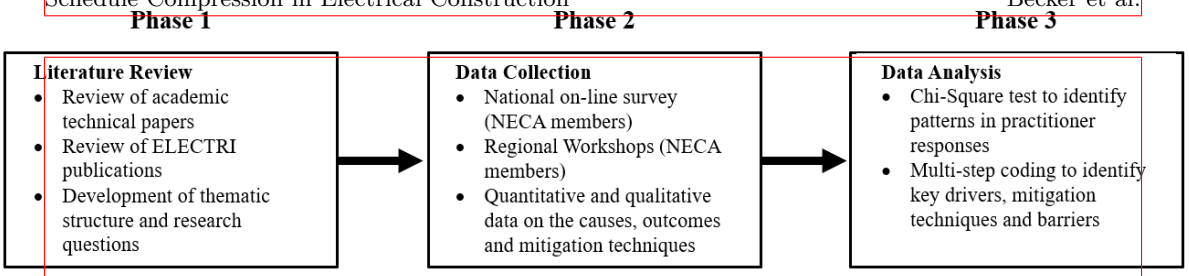

Figure 1. Overview of Research Methodology

A literature review was conducted to level set with existing publications on the topic of schedule change in construction, and to specifically identify any gaps in research addressing the contemporary perspective of electrical contractors. Google Scholar was used to search the Internet for related published literature. Search words included "schedule acceleration in construction" and "out-of-sequence construction." Further, investigators targeted research published specifically in the United States construction management domain, looking specifically for a focus on electrical construction. The literature review provided foundational knowledge upon which authors developed questions for the online survey and the research workshops.

The first step of data collection included a nationwide online survey of electrical construction practitioners (see Apprentices for the online survey questions). Responses were collected from 123 electrical construction professionals, primarily sourced through NECA. Researchers credit the high number of electrical contractor respondents of the survey to the distribution of a free 6" ruler to attendees of the 2023 Annual NECA Convention and Trade Show (see Fig. 2). Academic and industry members of the research team distributed these rulers printed with a QR code to the survey; and encouraged on-the-spot completion of the brief on-line questionnaire.

Figure 2. ELECTRI-branded Ruler with QR Code to Survey

Step 2 of data collection involved a series of four regional workshops (see Table 1). These half-day workshops were scheduled by regional NECA offices, and local NECA member companies were recruited to send qualified employees to contribute their professional insights and opinions. Participants of the research workshops were provided with a workbook in which they noted individual responses to structured research questions (see Apprentices for workshop questions). The academic members of the research team facilitated the sharing of ideas in a group setting, with data summarized on flip chart paper and later digitized into electronic records. A total of 37 electrical contracting professionals participated in four workshops.

Table 1. Summary of Research Workshops

Workshop Location	Date	No. of Participants	Host	Method
Phoenix, AZ, USA	8/24/23	9	AZ NECA	In-person
Hamilton, ON, CA	10/30/23	8	ECA-Hamilton	In-person
Atlanta, GA, USA	12/4/23	14	GA NECA	In-person
Remote session	2/22/24	6	OR-Columbia NECA	Online

Following the data collection steps, data analysis was conducted. Quantitative data were scrubbed, analyzed and presented in graphical displays for presentation. Qualitative data were coded and analyzed to rate causes and to prioritize impacts of schedule change. The study structure allowed for the identification of recurring patterns, project challenges and mitigation techniques for the electrical contracting industry.

Findings: Literature Review

Common definitions for schedule compression and out-of-sequence construction are given. Schedule compression is the reduction in the duration of project construction activities to achieve shortening of the total project duration, perhaps to make up for lost time caused by predecessor activities or to achieve project completion within a revised reduced owner-directed completion date (Gehrig et al. 1990). Directed schedule compression typically results in negative implications on the project's electrical contractor, e.g., overtime expense, reduced crew productivity and trade stacking/congestion (Thomas and Oloufa 1996 and Chang et al. 2005).

Out-of-sequence construction, also termed "out of logic," has been defined as "progress of an activity that starts or finishes contrary to the predefined relationship with its predecessor" (Suhail 1993). Out-of-sequence work can be characterized as performing project activities in a non- or sub-optimal manner. Directed departure from the originally planned sequences disrupts the most logical and efficient construction progression, causing cost productivity and schedule impacts (Abotaleb et al. 2019).

Research has been published on the causes and effects of schedule change. Thomas et al. reported that schedule acceleration may occur due to incomplete preceding work, delays in material delivery or client changes (1995). This research is based upon data from electrical contractors, however, is no longer contemporary. Abotaleb et al. (2019) published a comprehensive list of causes for out-of-sequence construction, yet respondents included less than 15% from specialty trade contractors. Revisiting the causes for scheduling change from the perspective of electrical contractors and uniquely addressing triggers for out-of-sequence work was found as a gap in current construction management literature.

Findings: Online Survey

The questionnaire assessed respondents' experiences with schedule change in the current market and their opinions on five management aspects related to schedule compression and out-of-sequence construction (see Figure 3). This is a topic worth researching as industry respondents reported that more than 60% of their projects experienced significant cost impacts due to schedule compression or out of sequence work between 2020 to 2023. An overwhelming majority of respondents indicated that owner/client furnished electrical gear and design changes increase schedule change. A similar percentage of respondents indicated that negotiated electrical subcontracts and pre-construction involvement of electrical contractors reduce schedule change.

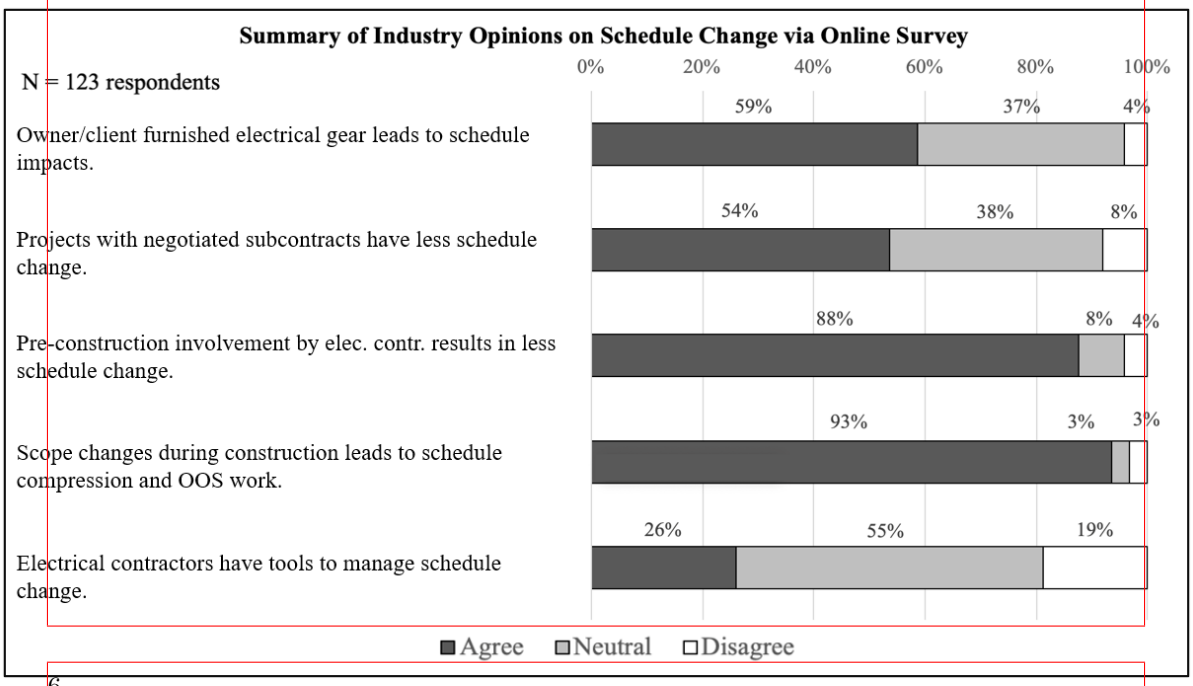

Figure 3. Summary of Industry Opinions on Schedule Change via Online Survey

Findings: Workshops

Abbreviated findings from the workshops are categorized and summarized in the following seven sections. The workshops resulted in a richness of electrical contractor perspectives and insights regarding schedule change. Additional explanation and practical management tools/templates designed for use by electrical contractors have been published in a playbook format, which is available at ELECTRI International (Becker and Federle 2024).

Primary Causes of Schedule Compression and Out-of-Sequence Work

The reported causes for schedule compression and out-of-sequence construction by electrical contractors are displayed in Figure 4. Delays in work by general contractors or other trades were one of the most mentioned reasons, which has a cumulative impact and leaves electrical contractors with less time to complete their jobs. When the electrical scope depends on the timely completion of mechanical or structural work, this has a particularly significant effect. Poor planning and impractical scheduling are closely related. These are frequently caused by unrealistic baseline schedules or a lack of buffer time, which leads to shortened timeframes when delays are unavoidable.

Another significant cause was the late procurement of supplies, particularly in the post-COVID19 pandemic context when long lead times and supply chain disruptions are frequent. Electrical contractors must expedite installation tasks to keep the project on time when materials arrive late. Similarly, scope modifications and unfinished design introduced during construction frequently result in rework or delayed starts. Despite this, electrical contractors are still expected to deliver within the planned timeline.

Unfavorable weather, lack of competent workers, and poor trade coordination were other reported factors for schedule change. Cash flow constraints or late submittals occasionally also contributed, especially when they affected early workforce or procurement decisions. These results demonstrate the interdependence of project delays and the resulting schedule compression and out-of-sequence work that ultimately affects labor productivity, cost and quality.

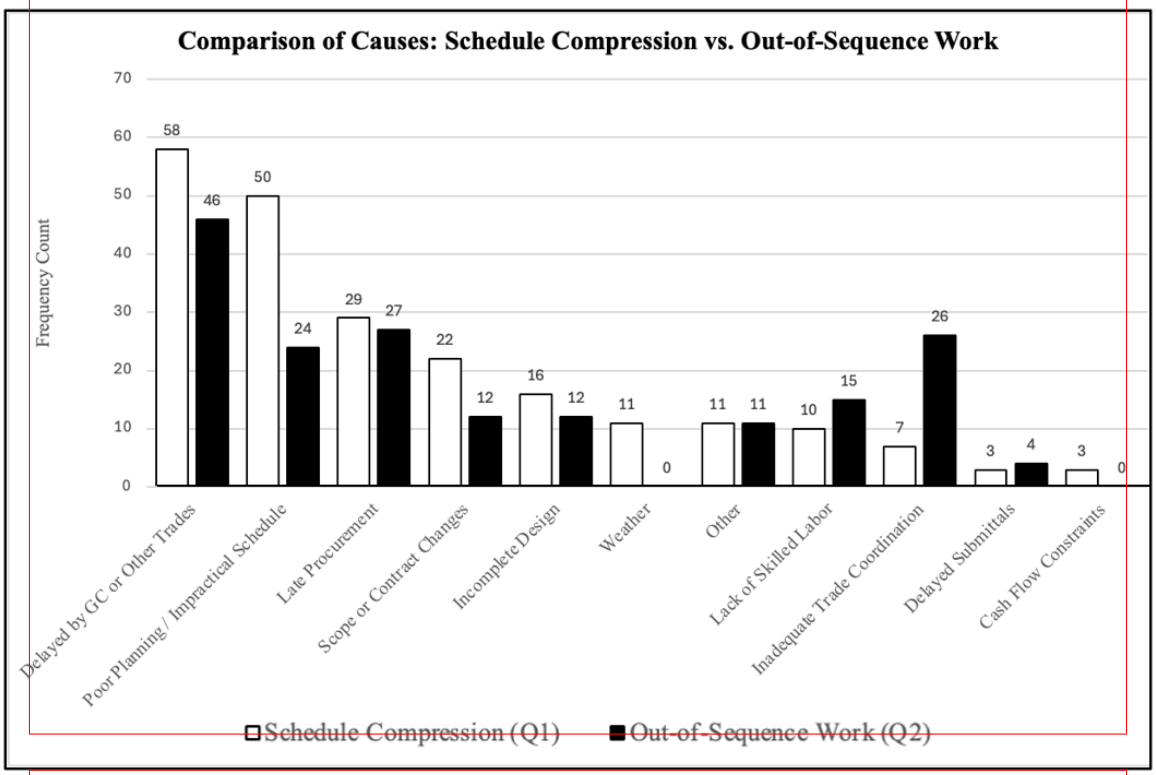

Figure 4. Comparison of Causes: Schedule Compression vs. Out-of-Sequence Work

As defined previously, schedule compression and out-of-sequence work are two different management challenges, although they regularly coexist on construction projects and have shared causes. Both situations were repeatedly driven by seemingly similar issues including incomplete or changing designs, late material procurement, delays from predecessor activities, and inadequate trade coordination. However, the causes reported by electrical contractors for schedule compression are statistically different from those for out-of-sequence work. A Chi-square goodness of fit test performed using JMP statistical software confirmed this understanding (see Table 2). The Chi-square goodness of fit test was selected for its usefulness for analyzing differences in nominal, categorical variables (Tran et al. 2014).

Table 2. Data Analysis Summary from JMP Analyzing Causes of Schedule Change

		Cash Flow	Changes	Delay-ed GC/ Trade	Design Gap	Labor	Mat'l	Other	Poor Plann -ing	Sub-mittal	Trade Misal.	Weath-er	Total
O-O-S Work	Count	0	12	46	12	15	27	11	24	4	26	0	177
	Total %	0.00	3.02	11.59	3.02	3.78	6.80	2.77	6.05	1.01	6.55	0.00	44.58
	Col %	0.00	35.29	44.23	48.86	60.00	48.21	50.00	32.43	57.14	78.79	0.00	
	Row %	0.00	6.78	25.99	6.78	8.47	15.25	6.21	13.56	2.26	14.69	0.00	
Sch. Compr.	Count	3	22	58	16	10	29	11	50	3	7	11	220
	Total %	.76	5.54	14.61	4.03	2.52	7.30	2.77	12.59	.76	1.76	2.77	
	Col %	100.00	64.71	55.77	57.14	40.00	51.79	50.00	67.57	42.86	21.21	100.00	
	Row %	1.36	10.00	26.36	7.27	4.55	13.18	5.00	22.73	1.36	3.18	5.00	
Total	Count	3	34	104	28	25	56	22	74	7	33	11	
	Total %	0.76	8.56	26.20	7.05	6.30	14.11	5.54	18.64	1.76	8.31	2.77	

Tests	N	DF	LogLike	RSquare U
	397	10	20.9421	0.0253
			ChiSq.	**Prob>ChiSq.**
	Likelihood Ratio		41.8884	<0.0001
	Pearson		35.95	0.0000858

A Chi-square test compared the causes of schedule compression and out-of-sequence work reported at the workshops. The test presented a chi-square statistic of 35.95 and a p-value of 0.0000858, indicating a significant difference between the two sets of causes. This research shows that, while these situations often coexist on projects, they originate from different causes. Schedule compression is typically associated with unrealistic deadlines, inadequate planning, or late procurement, whereas out-of-sequence work is frequently caused by trade delays and coordination issues. Most participants agreed that delays from other trades, incomplete designs, and late material deliveries were major contributors to schedule disruptions.

Leading Indicators of Schedule Change

The reported leading indicators of schedule compression and out-of-sequence work by electrical contractors are displayed in Figure 5. The findings represent a combination of project-level and trade-specific characteristics that frequently indicate future workflow interruptions. Delays from other trades were mentioned 13 times in the sample, making them the most often stated leading indicator. To reach set project milestones, respondents frequently cited instances in which they had to rearrange scheduled activities or shorten durations due to incomplete predecessor work or late handoffs. These variables directly affect labor flow and downstream coordination, and they usually show up early as a break in upstream trade progress.

Another important signal that was mentioned was inadequate planning or scheduling. Unrealistic starting times, a lack of trade coordination in baseline schedules, and a failure to adequately account for field limitations were some of these. According to the respondents, these planning concerns frequently begin during preconstruction, but don't become apparent until the project enters the field execution stage.

One of the primary causes and early indicators of schedule compression concerns mentioned was the late procurement of long-lead equipment or materials. Several contractors explained that supply chain bottlenecks, late approvals or submission delays had repercussions that forced late-stage acceleration or rescheduling. It has been suggested that inaccurate, changing, or conflicting documentation cause scope and sequence changes later, often too late for appropriate re-coordination without affecting the timeline.

Under the "Other" category, a wide range of responses were offered, including leading indicators such as staff or manpower turnover, problems with site access, and delayed decision-making. Despite their differences, these issues were all seen as early indicators of out-of-sequence work or the necessity of reactive compression techniques. These results support the notion that visible field-level and project-level signals frequently preceded schedule compression and out-of-sequence construction activity. Early detection and action on these indications may help minimize interruptions. The data indicate that many firms do not have reliable systems in place to monitor these indicators in a systematic manner, which emphasizes the necessity of improving planning tools and communication protocols that enable early action.

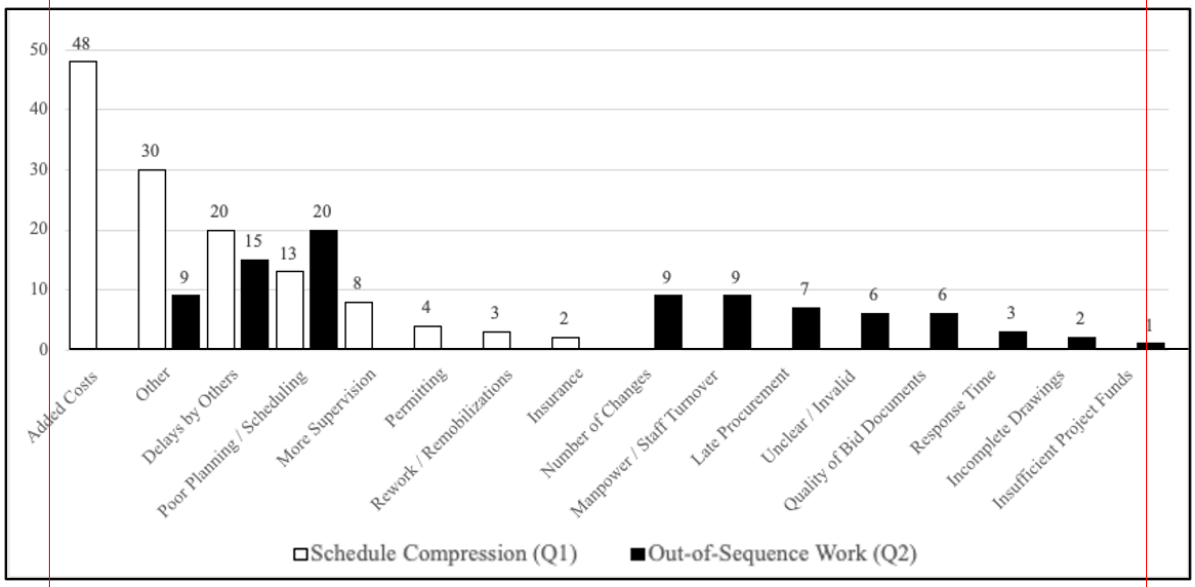

Figure 5. Leading Indicators of Schedule Compression and Out-of-Sequence Work

Costs of Schedule Change

To further understand the financial impact of schedule compression and out-of-sequence work beyond labor costs, participants were asked to indicate the typical out-of-pocket charges that their companies face in such situations. The most reported non-labor expense was for material handling and procurement. Respondents stressed the risk of expedited shipments, after-hours deliveries, and temporary storage, which frequently resulted in higher transportation prices, unplanned leasing charges, and additional coordination costs. These costs typically emerge when suppliers must be hurried to match changed timetables or rescheduled events. Experts also identified equipment rental extensions as a major cost factor, such as retaining lifts, scaffolding, generators, or temporary power sets on-site for longer than expected.

Documentation of Base Plan for Production

The study investigated methods used by electrical contractors to document their baseline approach for the work at the time of contracting, particularly in terms of timeline expectations. The results demonstrated significant diversity in formality and technique. Some electrical contractors create internal manpower loading curves or staffing plans during project planning, which are frequently supported by software such as Oracle Primavera P6, but these are rarely explicitly shared with general contractors. Others set expectations through early communication, e.g.,

preconstruction meetings, written proposals, or informal discussions, which aid in understanding but lack consistent documentation.

Other electrical contractors rely on assumed expectations or the general contractor's schedule without having their own developed schedule. This informal approach frequently causes misalignment and scope creep during project execution. A smaller percentage of companies use more formal approaches, such as contractual timetables, daily reports, or prefabrication planning built into bids. Overall, techniques range from proactive documentation to reactive or unstructured ways, indicating that irregular baseline communication is still a substantial contributor to schedule management difficulties in electrical contracting.

Practices for Reviewing Contract Language Related to Schedule Delay

The study examined how electrical contractors assess and comply with contractual notification requirements for schedule delays and scope changes. The findings show that most companies rely on informal, experienced-based assessments to determine whether notification is required. Typically, superintendents or project managers make these judgments without following a standardized internal protocol, instead relying on their professional judgment. While this may allow for quick answers, it frequently leads to inconsistent paperwork and missed notice dates. Some electrical contractors, particularly on especially high-risk projects, use structured internal reviews that include operations managers or executive oversight. These assessments may take place during project meetings or milestone reviews to determine whether to submit a formal notification. A lesser number of electrical contractors use estimators or preconstruction personnel to assess financial consequences before issuing notice, and a few use checklists or reporting tools to identify potential delays. Overall, the industry shows awareness but lacks formalization in managing contractual notifications, leaving contractors open to conflicts and reduced recovery chances.

Practices for Documenting Impacts of Schedule Compression and Out-of-Sequence Work

The study explored how electrical contractors document financial and operational impacts from schedule compression and out-of-sequence work. Most respondents reported use of daily field reports, lookahead plans, and constraint boards to document real-time jobsite conditions. These tools, usually maintained by forepersons or frontline supervisors, successfully record major disturbances, but they are frequently separated from formal contract documentation and change management procedures. Electrical contractors typically utilize informal letters and e-mails to document changes, which provide verifiable communication but lack uniformity or standardization.

More formalized documentation methods, such as change orders, RFIs, and Time Impact Analyses, were reported less frequently and primarily by organizations with dedicated project controls staff. Some electrical contractors complement written records with images or annotated as-built drawings, although they are inconsistently used and rarely structured for claim purposes. Overall, the findings show that, while field-level tracking is frequent, integration with formal cost recovery and schedule impact processes is limited, emphasizing the need for better documentation protocols and alignment of field and contract-level recordkeeping.

10-year Trends with Respect to Compensating Electrical Contractors for Schedule Change

Over the past decade, electrical contractors have continued to suffer the consequences of schedule compression and out-of-sequence work, yet appropriate compensation has not kept pace. Many electrical contractors noted a transition to a more claim-driven market, in which reimbursement is frequently based on thorough paperwork and strong contractual positioning rather than collaborative acceptance of project impacts. A few participants reported that in specific market sections and with project delivery models, owners and general contractors are more prepared to accept and compensate for schedule disruptions particularly when electrical contractors give clear, timely records. Still, most respondents described current market conditions as highly hostile, with fair reimbursement being disputed or delayed until clear responsibility can be demonstrated. Overall, while electrical contractors are more aware of their rights and more equipped to track consequences, cost recovery remains unequal and heavily reliant on documentation quality and negotiation skills.

Future Research

As construction projects continue to increase in complexity, the need for exceptional planning, including coordination at the specialty trade level, is paramount to achieving construction project success. This research has updated the understanding of causes and certain related management issues regarding schedule acceleration and out-of-sequence construction. Future research builds upon this foundation to address how electrical contractors should respond differently to these types of schedule change, e.g., documentation. This research could be expanded by investigating how general contractors manage schedule change involving electrical scope.

Summary

Given their critical contributions, ranging from temporary construction power to fire alarm testing, the role of the electrical contractor is instrumental to the successful completion of construction projects. Although most commonly a "subcontractor" contractually, electrical contractors should not be treated as an easily replaced commodity but rather recognized as a specialty trade partner in which contractual trust, effective collaboration, and respect for productivity is achieved. This research provides insights into the causes, implications and other topics related to schedule change, namely schedule compression and out-of-sequence work. To mitigate the impacts of schedule change, proactive electrical contractors must develop and implement tools and processes, both pre-bid and during construction, to communicate their baseline schedule, track leading indicators and document impacts should schedule compression or out-of-sequence work be directed. Given the incredible demand for highly qualified electrical contractors, perhaps now more than ever, the ability for electrical contractors to achieve fair compensation for schedule impacts caused by others has never been more obtainable.

Acknowledgements

This research was funded by a grant from ELECTRI International. Data was provided by employees of member companies of the National Electric Contractors of America (NECA). Appreciation is also expressed for the industry members of the research team who attended regular meetings to guide and support the research process.

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Appendices

Research questions addressed by online survey.

1. Over the past 3 years, roughly what percentage of your projects have experienced significant cost impacts due to schedule compression or out-of-sequence work?
2. Rate your agreement/disagreement with the following statements (agree-neutral-disagree scale).
   a. Cost impacts due to schedule compression and out-of-sequence work for electrical contractors are greatly increased when the owner/client furnishes key electrical equipment/gear.
   b. Generally, cost impacts due to schedule compression and out-of-sequence work for electrical contractors are reduced in negotiated subcontracts compared to hard bid subcontracts.
   c. Generally, cost impacts due to schedule compression and out-of-sequence work for electrical contractors are reduced when electrical representatives are included in pre-construction project planning.
   d. The likelihood of schedule compression and out-of-sequence work for electrical contractors increases with increasing quantity of changes in scope and changes orders.
   e. My company has effective tools and processes to seek fair remedies for schedule compression and out-of-sequence work.

Research questions addressed at in-person workshops.

1. What are the primary causes of schedule compression?
2. What are the primary causes of out-of-sequence work?
3. How is the base approach to the work by the electrical contractor documented at the time of contracting?
4. What are your company's practices for reviewing contractual notification requirements related to claiming schedule delay in scope and schedule?
5. What are your company's practices for documenting cost and other impacts related to schedule compression?
6. What are your company's practices for documenting cost and other impacts related to out-of-sequence work?
7. What are leading indicators of pending schedule compression?
8. What are leading indicators of pending out-of-sequence work?
9. Other than labor, what are typical out-of-pocket expenses associated with schedule compression or out-of-sequence work?
10. How has the industry changed over the past 10 years with respect to compensating electrical contractors for schedule compression and out-of-sequence work?
11. What aspects of current market conditions are making it easier or more difficult for electrical contractors to obtain fair compensation for schedule compression or out-of-sequence work?