

TECHBRIEF



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Assessment of Federal Highway Administration Highway Project Cost Estimation Tools

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This document is a technical summary of the Federal Highway Administration report *Assessment of Federal Highway Administration Highway Project Cost Estimation Tools* (forthcoming).

OBJECTIVE

The primary objective of this task order was to identify what, when, why, and how the Federal Highway Administration (FHWA) and the Office of Federal Lands Highway (FLH) oversee and/or develop cost estimations for transportation construction projects. FHWA will use this information to provide more consistent oversight of project cost estimates by State transportation agencies (STAs). For the purpose of this publication, FLH includes projects on Federal lands that are managed by the U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, U.S. National Park Service, and the U.S. Forest Service.

INTRODUCTION

Transportation agencies are charged with developing and delivering highway construction and maintenance programs that enhance the safety, mobility, and economic competitiveness of communities. While the design and construction of these projects are vital, accurate estimates of project costs during the multiple developmental stages are incredibly important in both developing the agency's project budget as the project advances and verifying that contractor bids represent fair market value during award (Georgia Department of Transportation (GDOT) 2020). Having consistent and reliable cost estimates provides agencies with numerous benefits when making financial decisions and providing oversight related to estimating project funds, conducting benefit-cost analysis to prioritize projects, determining the funds needed to deliver projects, obligating funds for specific project phases, and determining the basis for cashflow requirements over time. The researchers identified and ranked a series of five practices used to oversee the cost estimation process. These practices are useful for providing oversight for a single project cost estimate. However, the researchers went further and used the research project to integrate the practices into a comprehensive cost oversight program to maximize their benefits.

For FHWA, accurate and effective cost estimating is critical during the National Environmental Policy Act process and the development of the initial financial plan for a number of reasons, including establishing the basis for significant project decisions, establishing a baseline cost to help measure project success, and communicating the project's status to internal and external stakeholders (House of Representatives 2020a; FHWA 2018). The ability to develop reasonable and defensible cost estimates is also important in maintaining public trust and confidence during a project.

Cost estimate methods typically fall within five different approaches (Molenaar, Anderson, and Schexnayder 2013):

1. Historical bid-based estimation—uses a bid-history database to estimate unit bid costs for major items. Based on the historical averages, FHWA can use the estimated quantities of a proposed project to develop a target price. Much of this approach's accuracy relies on the quantity and level of detail in the bid-history database.
2. Conceptual estimation—is usually performed during the early planning and scope development stage and typically uses primary project parameters (e.g., project location, length, type of project, scope details, design parameters, site characteristics, and broad design assumption) to develop a cost estimate.
3. Risk-based estimation—involves developing probable costs for project components and the project as a whole based on identified known quantities, costs, and contingencies developed from a list of identified uncertainties from both opportunities and threats and their potential impact on the project.
4. Cost-based estimation—involves estimating the cost for items of work based on the cost of each component of a project, considering the associated labor, equipment, and materials costs. The method also involves adding a reasonable amount for a contractor's overhead and profit. The process mimics the same method that a contractor uses for preparing a bid-day estimate. When prepared with the proper skill, experience, and effort, cost-based estimates are usually considered the most accurate of the five methods.
5. Combination of historical and cost-based estimation—involves estimating the cost for items of work based on the cost of each component of a project and considering the associated labor, equipment, and materials costs, based on historical bid items of past projects. The method also involves adding a reasonable amount for a contractor's overhead and profit. The process involves developing cost estimates for each project (like the cost-based method). However, it uses

a bid-history database instead of cost estimates from material suppliers and historical production rates that are typically used in a cost-based method.

Familiarity with these methods is an important aspect of helping provide oversight for other agencies that conduct cost estimates required by FHWA (FHWA 2018).

METHODOLOGY

This research project used a qualitative research method in which the two major components were an extensive literature review and interviews with subject matter experts. The literature review was instrumental in developing the questionnaires used in the interviews. The research panel selected and later contacted the subject matter experts. The following sections describe the literature review and data collection process.

Literature Review

The team conducted a literature review to compile the most common practices for cost estimating and cost estimate development oversight for transportation agencies. A portion of the literature used for the development of the project was obtained from extensive internet research. Additionally, multiple agencies from different States, including FHWA Federal-aid division offices (DOs) and STAs, provided guidelines and documentation on how to create, document, review, and oversee cost estimates.

Data Collection

Once the researchers gathered relevant information from the literature review, they created the survey for the first of two rounds of structured interviews (appendix A and appendix C in the final report) (Nevett and Goodrum forthcoming). They distributed the survey to the previously selected subject matter experts. The experts were asked to review the survey, which was completed during a video conference interview conducted by the researchers. These interviews were then used to determine the most useful methods for cost estimate development and oversight methods.

The participants in both rounds of interviews were subject matter experts from DOs, STAs, and FLH. The participants were selected because of their experience, roles, and responsibilities in the cost estimate development and oversight processes in their respective agencies.

The purpose of the first round of interviews was twofold. First, the interviews were conducted to validate the cost estimate development and oversight practices found in the literature. Second, the interviewees played a key role in contributing information about practices used in

their States as well as practices that they had seen used in other agencies. After the first round of interviews, the researchers compiled a list of best practices for the second round of interviews along with diagrams describing the cost estimate oversight processes.

The purpose of the second round of interviews was to validate the practices obtained during the first round. After the second round of interviews, the researchers developed a final list of practices and multiple diagrams to include in the final report.

First Round of Interviews

In total, eight DOs, six STAs, and one FLH office participated in the first round of interviews. The interviews consisted of a series of questions related to the participant's knowledge of approaches used in cost estimation, efficacy of the methods, perception of counterparts' knowledge of cost estimation (i.e., what do STAs think of the DOs and vice versa), challenges, cost performance measures, cost estimate development, estimate oversight, and post-bid practices. Copies of the interview guides are provided in appendix A and appendix C of the final report (Nevett and Goodrum forthcoming).

The report identifies States using unique capital letters to protect the interviewees' privacy. If experts from a DO and STA from the same State were interviewed, they are presented as *X-DO* and *X-STA*, respectively. Compiled transcripts of the interviews can be found in the appendices: appendix B includes the compiled transcripts from STA interviews, and appendix D includes the compiled transcripts from DO interviews (Nevett and Goodrum forthcoming).

Second Round of Interviews

After conducting the first round of interviews and writing the interim report, the research team met to review the report and evaluate the next steps. They decided to conduct a second round of interviews to evaluate the subject matter experts' views on the identified best practices for cost estimate oversight, cost estimate oversight checklist, and process diagrams developed for cost estimate oversight at a project and program level. The followup interview document can be found in appendix E of the full report (Nevett and Goodrum forthcoming).

RESULTS

This research generated guidelines to assist agencies in overseeing cost estimates. The project was limited to DOs, STAs, and FLH. The practices described herein are not the only acceptable or used practices; however, they are a product of the literature review and validation method described in the methodology. The best practices mentioned are applying the Pareto principle, comparing

historical projects, identifying factors that influence project costs, monitoring and updating cost estimates, and analyzing cost estimate procedures.

The research team created three flowcharts on how to oversee cost estimates at a project level for STAs, DOs, and FLH, as well as a program-level cost estimate oversight flowchart for DOs and STAs. The research team created these diagrams to be used in conjunction with a checklist and the list of best practices, both of which can be found in the full report (Nevett and Goodrum forthcoming).

Program-Level Oversight Process

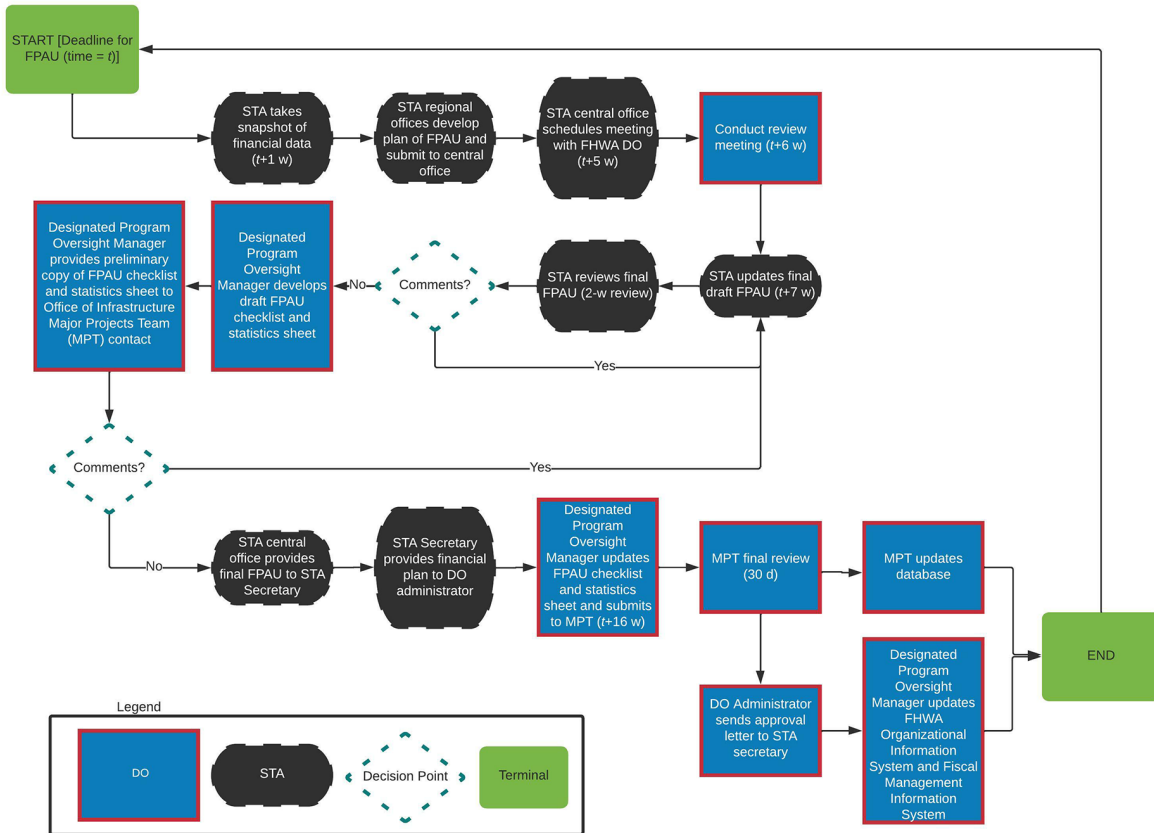
This section describes the procedures that DOs must follow to ensure that the program-level cost estimate is overseen as established by the laws and regulations described in section 106(h) of title 23 United States Code (House of Representatives 2020b). This section also ensures that individuals are aware of their roles and responsibilities as well as the expected timeframes for each specific deadline.

The program-level oversight process should use the following general procedures:

1. The deadline for the financial plan annual update (FAPU) is reached. This date should be the end of the State fiscal year, hereafter referred to as *t*.
2. The STA takes a snapshot of the financial data, and the STA starts to develop the FAPU, as well as the final financial plans (*t+1 w*).
3. The STA central office submits a draft of the FAPU to the DO and schedules a review meeting (*t+5 w*).
4. The STA addresses any comments received by the DO during the review meeting and updates the FAPU (*t+7 w*).
5. The program oversight manager submits any comments to the STA, and the DO makes final draft financial plans available for STA (*t+9 w*).
6. The STA submits the final FAPU to the DO (*t+13 w*).
7. The designated program oversight manager updates FAPU and the statistics sheet and submits them to the FHWA Office of Infrastructure Major Projects Team (MPT) (*t+16 w*).
8. The MPT conducts the final review (30 d).
9. The MPT updates the database while the DO administrator sends an approval letter to the STA, and the project oversight manager updates the FHWA organizational information system and Fiscal Management Information System.

Figure 1 shows the program-level oversight process between DOs and STAs.

Figure 1. Flowchart. Program-level oversight process (Nevett, Goodrum, and Corrigan 2022).



Source: FHWA.

Project-Level Oversight Process—STA Perspective

There are different perspectives to consider for the project-level oversight process. Since the STAs and DOs use different internal processes, the research team created different diagrams for the same process as viewed by STAs and DOs. Additionally, since FLH operates as a hybrid between STAs and DOs by creating their own estimates but only receives internal oversight instead of oversight from a DO, there is also a diagram that describes the FLH process.

Overall, the process has to meet several milestones, regardless of which perspective is considered. These milestones are described as follows:

1. The initial cost estimate should reflect anticipated preliminary engineering, reimbursable utility, right-of-way (ROW), construction, and other costs.
2. The initial cost estimate approval must be followed by the project manager (PM) requesting estimates from the ROW and utilities offices.
3. The preliminary field plan review (PFPR) must include all updated cost estimates, including ROW,

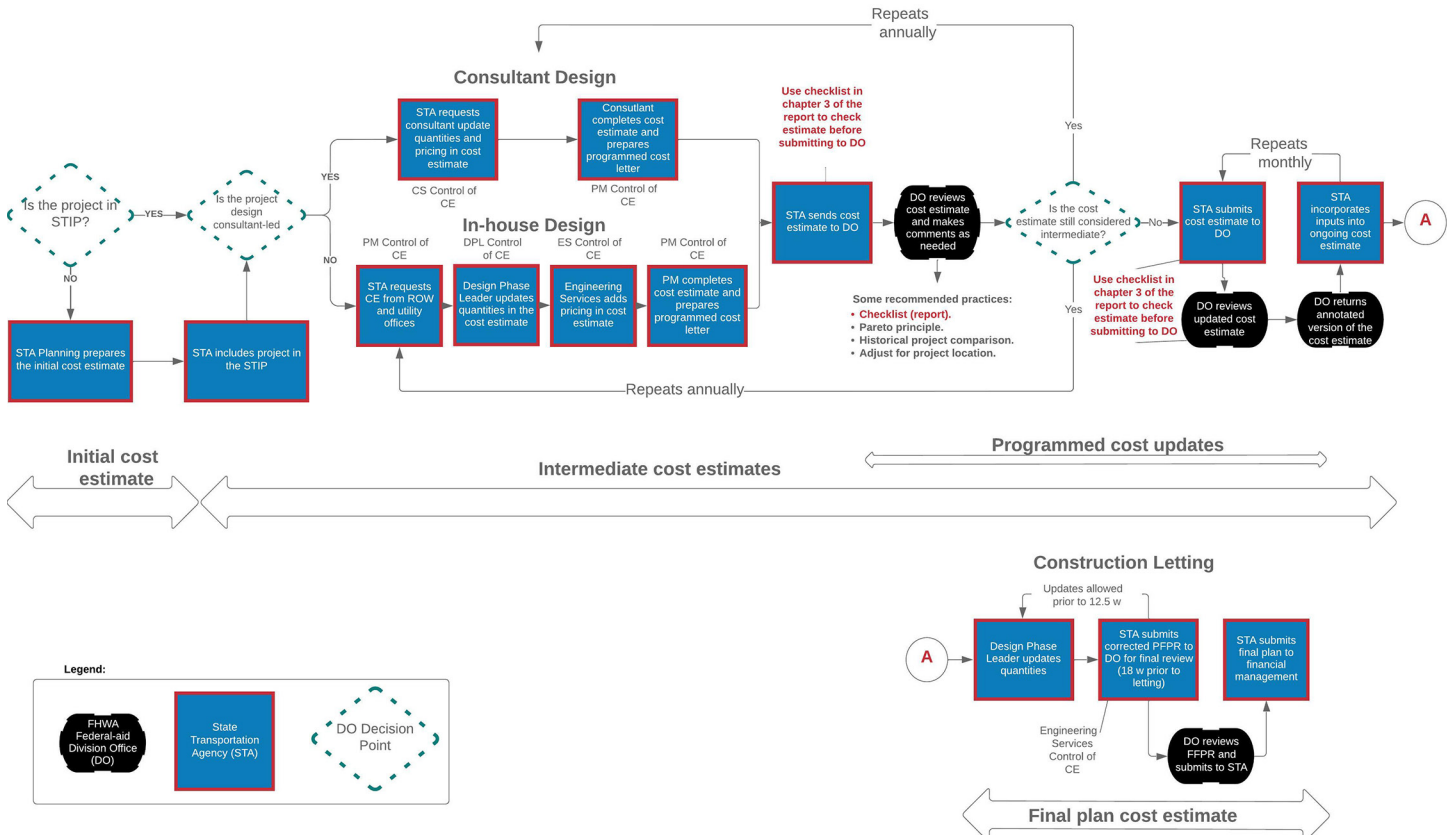
utilities, and design phase leader (DPL) approval (GDOT 2012, 2013, 2020).

Figure 2 shows the project-level oversight process from the STA perspective. The diagram depicts the interfacing between DOs and STAs for project-related activities selected by the DO risk assessment. The described process only happens for projects in which the DOs provide oversight.

Project-Level Oversight Process—DO Perspective

Figure 3 describes the oversight process from a DO perspective. It only shows what would interest someone from a DO providing oversight to an STA. The DO receives the initial cost estimate from the STA, which is then revised by the DO and sent back to the STA for comments or amendments. This process is repeated until the estimate is not considered intermediate, and the STA prepares the final field plan review. The DO diagram is more condensed than the STA diagram because the STA internal processes (ROW, utilities, consultant oversight) are not relevant to the DO. This oversight process only occurs for projects considered major projects, which are usually deemed high-risk projects (FHWA 2018).

Figure 2. Flowchart. Project-level oversight process—STA perspective (Nevett, Goodrum, and Corrigan 2022).

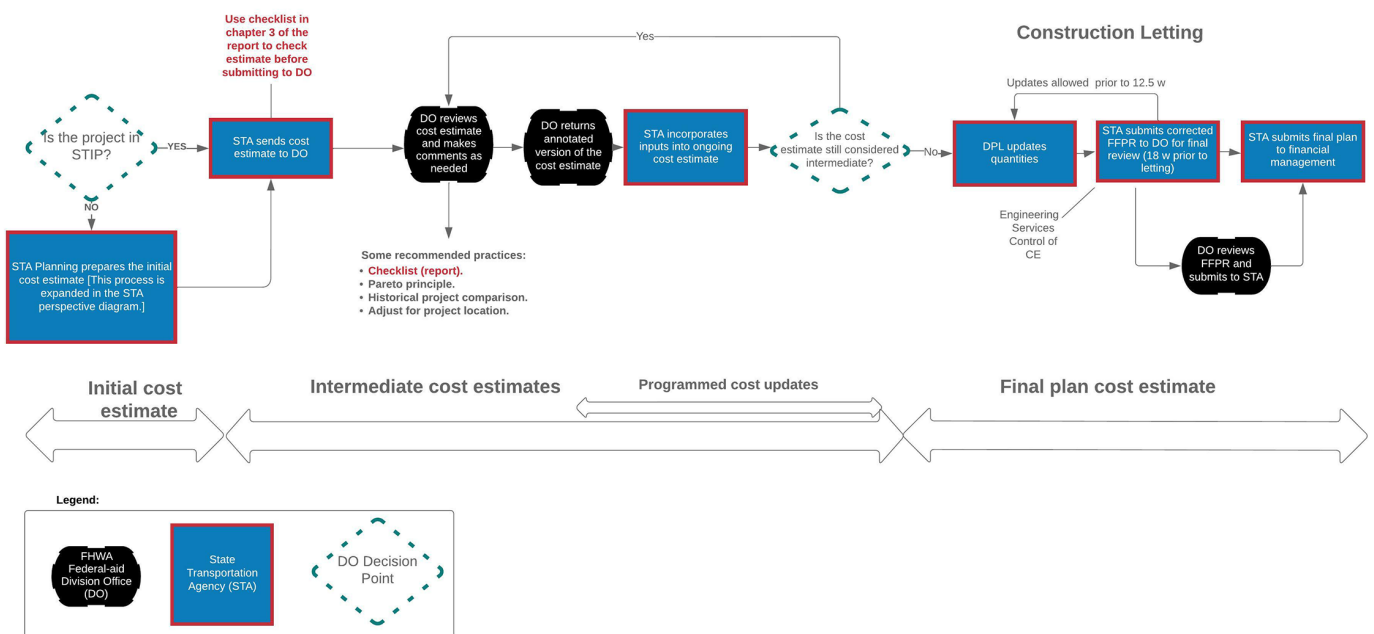


Source: FHWA.

CE = cost estimate; CS = consultant; ES = engineering services; FFPR = final field plan review; STIP = State Transportation Improvement Program.

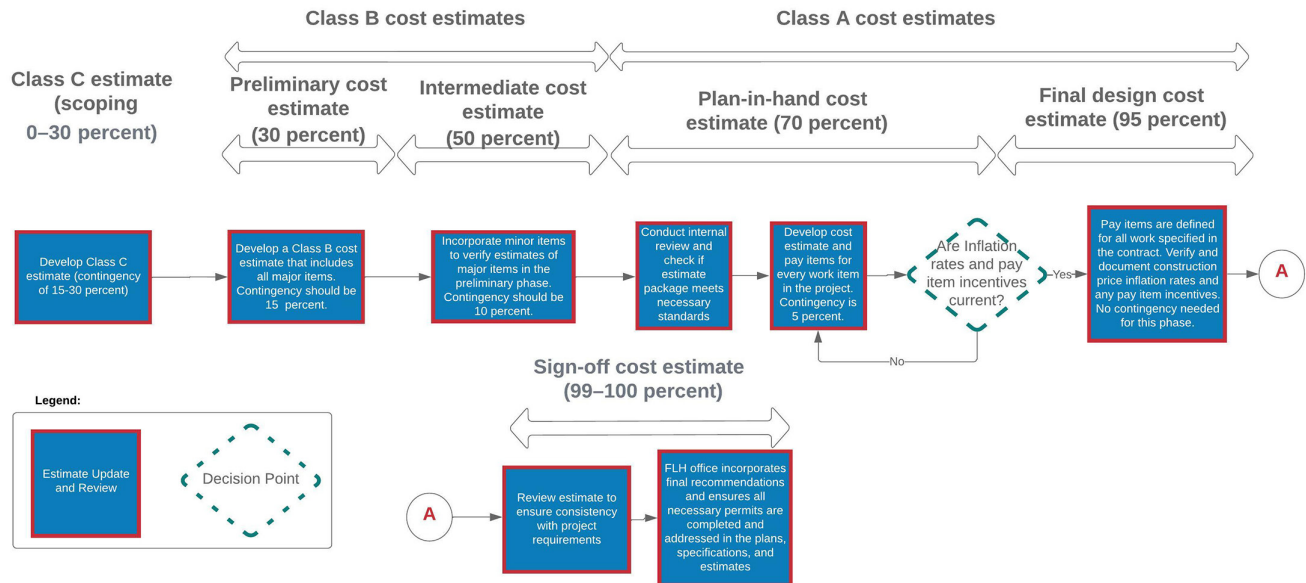
Note: "A" indicates the continuation of the process.

Figure 3. Flowchart. Project-level oversight process—DO perspective (Nevett, Goodrum, and Corrigan 2022).



Source: FHWA.

Figure 4. Flowchart. Project-level oversight process—FLH perspective (Nevett, Goodrum, and Corrigan 2022).



Source: FHWA.

Note: “A” indicates the continuation of the process.

Project-Level Oversight Process—FLH Perspective

Figure 4 represents the internal oversight process that an FLH project goes through in its lifecycle. Because FLH does not receive oversight from other agencies, all the interfacing described happens internally. Otherwise, the process is similar to that of STAs. In general, there are three major milestones in the FLH oversight process:

1. The initial cost estimate should reflect anticipated preliminary engineering, reimbursable utility, ROW, construction, and other costs.
2. The initial cost estimate approval must be followed by the PM requesting estimates from the ROW and utilities offices.
3. The plans, specifications, and estimate must include all updated cost estimates, including ROW and utilities, and DPL approval. This estimate is revised by the chief engineer, who then approves it for submission.

CONCLUSION

The overall intention of the research was to analyze the benefits, complexities, similarities, and differences in the roles FHWA provides for cost estimate reviews. The researchers successfully identified and ranked a series of five practices used to oversee the cost estimation process. The researchers developed and validated a set of tools, including an oversight checklist and multiple

process diagrams. These tools are useful for providing oversight for a single project cost estimate. However, the researchers went further and used the research project to show how to integrate the tools into a comprehensive cost estimation oversight program to maximize their benefits.

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Researchers—This study was conducted by the University of Colorado at Boulder in a subcontract role under prime contract DTFH6117D00005 held by Engineering & Software Consultants, LLC. The researchers were Paul Goodrum (ORCID: 0000-0002-5656-1240) and Guillermo Nevett (ORCID: 0000-0003-4967-7015).

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