

2017

An Exploration of Early Work Packaging in Construction Manager/General Contractor Highway Projects

Douglas Alleman
University of Colorado, Boulder

Dean Papajohn
University of Arizona

Douglas D. Gransberg
Iowa State University, dgran@iastate.edu

See next page for additional authors

Follow this and additional works at: http://lib.dr.iastate.edu/ccee_pubs



Part of the [Construction Engineering and Management Commons](#)

The complete bibliographic information for this item can be found at http://lib.dr.iastate.edu/ccee_pubs/109. For information on how to cite this item, please visit <http://lib.dr.iastate.edu/howtocite.html>.

Authors

Douglas Alleman, Dean Papajohn, Douglas D. Gransberg, Mounir El Asmar, and Keith R. Molenaar

1 AN EXPLORATION OF EARLY WORK PACKAGING IN CONSTRUCTION
2 MANAGER/ GENERAL CONTRACTOR HIGHWAY PROJECTS

3
4 **Douglas Alleman, P.E., Corresponding Author**

5 Ph.D. Student
6 Department of Civil, Environmental and Architectural Engineering
7 University of Colorado, Boulder
8 428 UCB, Boulder, CO 80309-0428
9 Tel: 815-663-7418; Email: douglas.alleman@iea.net

10
11 **Dean Papajohn, P.E.**

12 Associate Professor of Practice
13 Civil Engineering & Engineering Mechanics
14 University of Arizona
15 1209 E. 2nd Street, Tucson, AZ 85721-0072
16 Tel: 520-621-1713; Email: dpapajohn@email.arizona.edu

17
18 **Douglas D. Gransberg, Ph.D.**

19 Professor
20 Department of Civil, Construction, and Environmental Engineering
21 Iowa State University
22 404 Town Engineering Building, Ames, IA 50011-3232
23 Tel: 515-294-4148; Email: dgran@iastate.edu

24
25 **Mounir El Asmar, Ph.D.**

26 Asst. Professor and Senior Sustainability Scientist
27 Del E. Webb School of Construction
28 School of Sustainable Engineering and the Built Environment
29 Arizona State University
30 660 S. College Avenue, Tempe, AZ 85287-3005
31 Tel: 480-727-9023; Email: asmar@asu.edu

32
33 **Keith R. Molenaar, Ph.D.**

34 Professor
35 Department of Civil, Environmental and Architectural Engineering
36 University of Colorado, Boulder
37 428 UCB, Boulder, CO 80309-0428
38 Tel: 303-735-4276; Fax: 303-492-7317; Email: molenaar@colorado.edu

39
40
41 Word count: 5,992 words text + 5 tables/figures x 250 words (each) = 7,242 words

42
43 Submission Date: 01 August, 2016

1 **ABSTRACT**

2 Recently, state agencies have been successfully implementing construction manager/general
3 contractor (CM/GC) delivery on highway projects. While early work packaging is frequently cited
4 in the literature as a primary benefit of CM/GC, there is limited to substantiate or refute these
5 benefits. Additionally, agencies need a better understanding of the current state-of-practice of early
6 work packing in CM/GC to help with effective implementation. In an ongoing Federal Highway
7 Agency research project, 12 of 34 completed CM/GC projects reported the use early work
8 packaging, and will be the focus of this study. Research methods used within this paper include:
9 literature review, content review of agency manuals/instructions, project surveys, agency
10 interviews, and case studies. Triangulated findings suggest that early work packaging can
11 contribute to expediting project completion, mitigating project risks, reducing project cost, and
12 minimizing public impacts. To achieve these outcomes, agencies must perform detailed planning
13 to generate severable/independent packages that take into account all potential impacts to the
14 project. Trends in data indicate that early work packages can lead to cost savings, yet the sample
15 size does not provide statistical significance. Future research should explore the performance of a
16 larger data set of CM/GC projects with and without early work packaging along with a cost/benefit
17 analysis of early work packages.

18
19 *Keywords:* Alternative project delivery methods, early work packages, sequencing, construction
20 manager/general contractor, highway construction

21 **INTRODUCTION AND MOTIVATION**

22 In today's context of aging infrastructure, limited financial resources, and increased public scrutiny
23 of transportation projects, U.S. highway agencies are turning to innovative delivery methods like
24 design-build and construction manager/general contractor (CM/GC). The Federal Highway
25 Administration (FHWA) has made efforts to encourage these innovative delivery methods through
26 legislation such as the Special Experimental Project Number 14 (SEP-14) – Innovative Contracting,
27 section 1503 of SAFETEA-LU, the Every Day Counts (EDC) initiative, and The Moving Ahead
28 for Progress in the 21st Century Act (MAP-21). Through these efforts, several state and federal
29 agencies have successfully implemented projects with design-build and CM/GC. This paper
30 specifically focuses on CM/GC.

31 **Fundamentals of CM/GC**

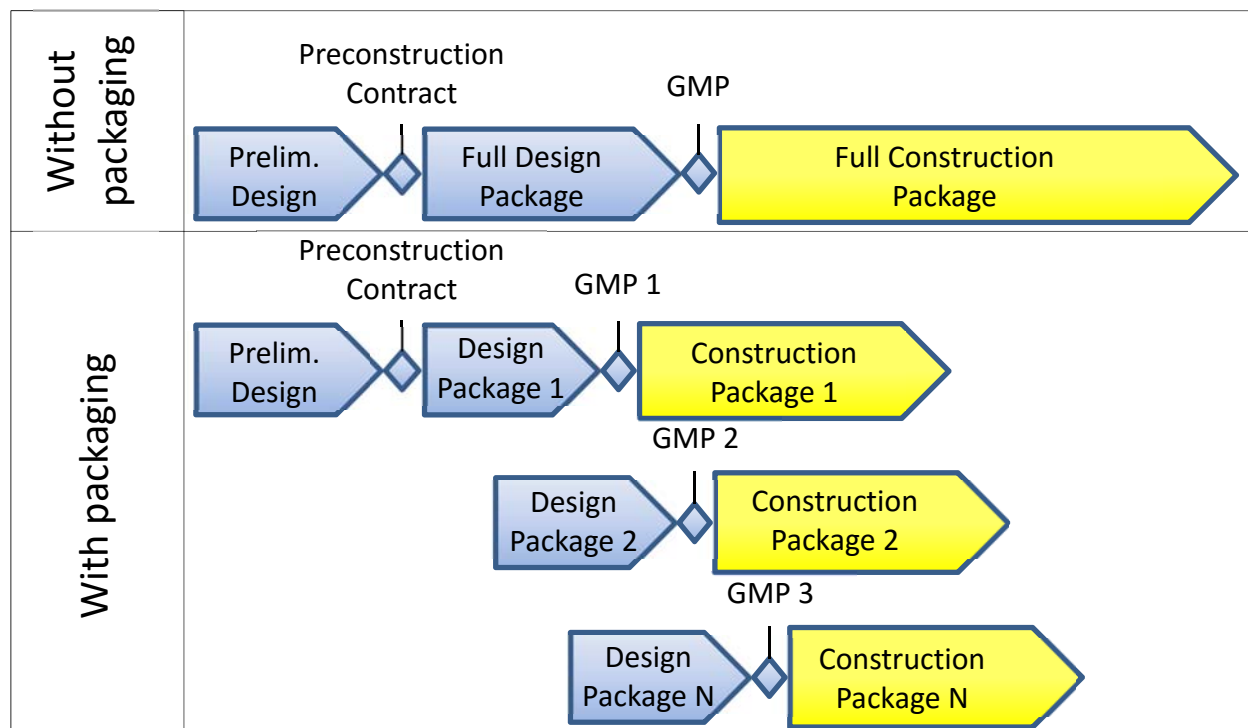
32
33 Of the delivery methods commonly used by agencies, CM/GC is the most recently adopted; its use
34 started in Arizona in the late 1990's (1). With CM/GC, the owner contracts with a construction
35 manager (CM) early in design development, contractually transferring the risk for the final cost
36 and time of construction while retaining design control. As design progresses a construction prices
37 (or guaranteed maximum price (GMP) for purposes of this paper) is agreed upon with the CM, at
38 which point, the CM becomes the general contractor (GC), hence CM/GC (2). The CM/GC
39 method allows for overlap between design and construction through early work packages. When
40 design and construction overlap, the contractor is filling both the CM and GC roles simultaneously.

41
42 With CM/GC project delivery, work packages can be developed from portions of the total
43 design. Because the contractor is already under contract, negotiation for the work package can
44 occur without the lengthy procurement process typically associated with the traditional method of
45 design-bid-build (D-B-B). The fundamentals of early work packaging are discussed below.

46

1 **Fundamentals of early work packaging**

2 One benefit for agencies pursuing CM/GC is the ability to package work and allow for early release
 3 for construction as they are completed. When an agency decides to release an early work package,
 4 the process is very similar to the CM/GC process as a whole: a design package is developed, scope
 5 documents are created, a GMP is reached, and a contractor is given the notice to proceed. Figure 1
 6 compares a project performed with and without early work packaging. An early work package can
 7 consist of, for example, procuring materials to constructing early project tasks. As seen in Figure
 8 1, *Design Package 2* continues to develop while *Design Package 1* is being completed and
 9 negotiated. Subsequent work packages follow the same process. As a result, overlapping of design
 10 and construction can accelerate project completion.
 11



12 **FIGURE 1 CM/GC Project Progression With and Without Early work packaging**

13 **RESEARCH OBJECTIVE AND METHODS**

14
 15 The objective of this paper is to explore early work packaging in CM/GC projects, presenting the
 16 current state-of-practice of CM/GC early work packaging. The data for this study is derived from
 17 an ongoing FHWA research project (25) which includes 34 CM/GC U.S. highway projects
 18 completed between 2004 and 2015, representing over 66% of the federally funded CM/GC projects
 19 during this time period. Of these 34 projects, 12 reported the use of early work packaging. With
 20 an understanding that there are few projects available, this research broadly explores the following
 21 questions:
 22

- 23
 24 a. What are the benefits gained from CM/GC early work packages and are they value adding?
 25 b. What are the best practices for implementing CM/GC early work packages?
 26 c. What future research is needed in the area of CM/GC early work packages?
 27

1 To address these research questions, a multi-method research approach was used to
2 triangulate results. The approach includes: [1] a review of current literature; [2] a content review
3 of agency manuals/instructions; [3] a performance survey of projects with early work packages;
4 [4] interviews with agencies experienced with CM/GC; and [5] case studies of CM/GC projects.

5 6 **1. Literature Review**

7 A literature review was conducted to understand how early work packaging is defined and to
8 identify benefits and best practices. The review included all sectors of design and construction,
9 but particular attention was given to transportation literature. The transportation literature came
10 primarily from CM/GC literature as cited by the National Cooperative Highway Research Program
11 (NCHRP), content presented at the FHWA CM/GC Peer Exchanges, and transportation-related
12 journals. Early work packaging has also been researched in industrial construction where it is
13 referred to as advanced work packaging (26,27). Other terms related to early work packaging
14 include phasing and sequencing. In addition to CM/GC project delivery, early work packaging is
15 cited in research on progressive GMPs and progressive target pricing.

16 17 **2. Agency Manual Content Analysis**

18 The authors performed a holistic review of the publicly available CM/GC manuals through the 50
19 State Departments of Transportation, District of Columbia, Puerto Rico, and the three Federal
20 Lands Highways divisions. CM/GC manuals were obtained from seven states: Arizona, California,
21 Colorado, Michigan, Minnesota, Nevada, and Utah. All but Utah address early work packaging to
22 some degree and five (Arizona, California, Colorado, Minnesota, and Nevada) discussed CM/GC
23 advantages and best practices (20-24).

24 25 **3. Project Surveys**

26 An ongoing FHWA research project collected survey responses from 29 CM/GC projects
27 completed between 2004 and 2015 (25). The survey asked if each CM/GC project had performed
28 early work packaging, and why. It also requested additional detail on the work packages used.
29 Twelve of the 29 projects responded as using early work packaging.

30 31 **4. Agency Interviews**

32 To supplement the survey findings, the researchers performed follow-up interviews and targeted
33 six of the 12 projects that used early work packaging. The projects were selected to obtain the
34 most diversity of states and project types. The following items were used to guide the interviews
35 with the project personnel:

- 36 • The agency process and reason for using the work packages;
- 37 • The successes and failures of the early work packaging for the project;
- 38 • The benefits gained from, and disadvantages of, early work packaging; and
- 39 • A discussion on CM/GC early work packaging best practices and lessons learned.

40 41 42 **5. Project Case Studies**

43 Three of the six interviewed projects were chosen for detailed case studies: two projects with early
44 work packaging success and one in which project goals were hindered by early work. These case
45 studies allowed for informative discussions of the cost, benefits, and impacts of early work

1 packaging. Further details on the project characteristics, reasons for early work packaging, early
2 work packaging characteristics, and project performance were gathered.

3 4 **RESULTS: WHAT WE LEARNED**

5 6 **1. Literature Review**

7 Although frequently stated as a benefit within CM/GC literature (2-19), minimal empirical
8 research exists on the added value of early work packaging. The majority of the literature focused
9 on lessons learned through case studies and industry experiences. NCHRP Report 10-85 (14)
10 supplies the most robust explanation of early work packaging's advantages, which are consistent
11 with the other early work packaging literature. The four key advantages of early work packaging
12 in CM/GC are:

- 13
14 • **Risk mitigation** (2,6,8,10,13,14-18): One of the primary advantages of early work
15 packaging is the ability to lock in volatile construction materials and/or subcontractor
16 prices, thereby mitigating the risk of price escalation. In addition to materials and
17 subcontractor work, work packages can be used to price and construct a segment of work.
18 As more details are available on the segment, uncertainty is reduced, which in turn reduces
19 project risk and the contingency for said risk.
- 20 • **Accelerated project schedule** (2,3,5,7,9,11-14,16,17,19): The project schedule can be
21 accelerated when the contractor starts the construction as soon as the first segment's work
22 package is ready, without waiting for completion of the entire design. Work packages
23 accelerate the project schedule through design and construction overlap. Long lead items
24 can be procured and potential conflicts can be resolved during the preconstruction phase,
25 which helps reduce or eliminate construction delays.
- 26 • **Reducing inconvenience to the traveling public** (14): Sometimes the reason for using an
27 early work package is the early completion of a segment (e.g., phase); not necessarily the
28 early start of that segment. This is applicable when a segment can be opened to traffic
29 independently, thus reducing inconvenience to the road segment users.
- 30 • **Project savings** (2,4,7,12-14): When early work packaging reduces risk, contingency, and
31 overall construction time, cost savings can occur. Early acquisition of materials, site
32 preparation work (i.e. utilities, right-of-way, subsurface, etc.), and/or overlap in design and
33 construction can lead to an early construction start and finish, which reduces the schedule
34 therefore reducing cost of agency and contractor overhead. Finally, a work package has the
35 potential to promote a more efficient construction process.

36
37 The literature contains a wealth of information on the potential advantages of early work
38 packaging; but it does not address the obstacles of performing early work packaging nor best
39 practices to ensure success. However, some agencies have CM/GC manuals that discuss the
40 agency's practices for early work packaging.

41

2. Agency Policies' Content Analysis

Similar to the literature findings, the Arizona, California, Colorado, Minnesota, and Nevada CM/GC manuals present the advantages of early work packaging as *risk mitigation* (20-24), *accelerated project schedule* (20,23,24), and *project savings* (23,24), with the addition of *matching funding* (21). Also identified are factors that should be considered when developing early work packages and are as follows:

- ***Be severable*** (20-24): As more packages are released prior to final GMP negotiations, it becomes more problematic if pricing cannot be agreed upon since construction is already underway. It is imperative that any early work packages can be severed from the remaining scope of work in a manner where they can be paid for as a single unit. This is required so that the agency can retain the ability to competitively bid the remaining scope of work as a traditional D-B-B project if GMP negotiations fail.
- ***Stand-alone*** (23): Similar to severability, the package should involve elements of project scope that can stand alone and have minimal technical interface with other elements of scope. This minimizes the impact one package has on the success of other packages.
- ***Be directly related to the overall project schedule*** (22): Each work package must have schedule requirements tied to it. This limits negative impacts of work packages that are predecessors to other packages. It is common to assign contractual milestones for completion of work packages to ensure that planning and scheduling of scope that has not been fully defined by the design process can be seamlessly merged into the schedule without detriment.
- ***Benefits the project goals*** (23): The agency must fully assess how the work package adds to, or detracts from, the project goals. Advantages may include cost savings, risk mitigation, and/or improved scheduling. Detriments may include increases in design, reduced agency negotiation power, administrative costs, and/or impact to the local community.
- ***Takes into account all potential impacts*** (24): The agency should consider such factors as “access and availability constraints, total time for completion, construction market conditions, availability of labor and materials, community relations, and any other factors pertinent” (24) when developing work packages.

3. Performance Survey

Eighteen projects of the 29 previously mentioned projects provided information on their use of early work packaging (twelve confirmed they did use early work packaging, six stated they did not use early work packaging): three from Arizona, 13 from Utah, two from Colorado, and one from Oregon. Colorado, Oregon, and Utah all have used early work packaging approaches in various degrees in their CM/GC projects. Utah is the state with the most CM/GC experience and responded that early work packaging was used on 9 of the 13 Utah CM/GC projects in the research database.

Of the 12 projects which reported using early work packages, 11 detailed the number of work packages and their reasons for early release of the work. As seen in Table 1, a majority of the projects had three or fewer work packages. Also shown in Table 1 are the reasons for packaging.

1 The most common reason for packaging is overlapping design and construction followed by
 2 procuring long lead items. Other reasons for packaging included locking in pricing, reducing cost,
 3 beginning pre-construction activities, and performing seasonal work.

4
 5

TABLE 1 Projects with Number of Work Packages and Reasons for Packaging

	Number of Work Packages						Total
	1	2	3	4	5	>5*	
Projects Responding to # of Work Packages	6	4	4	0	2	1	17
Reasons for packaging*:							
Overlap Design/Construction							16
Procure Long Lead Items							11
Construction Preparation Work							4
Cost Reduction							2
Lock in Material Pricing							2
Perform Seasonal Work							3

6 * Project includes 20+ early work packages; only first five chronologically released reasons shown.

7
 8 Table 2 depicts the cost growth of CM/GC projects with and without early work packaging.
 9 The formula for cost growth is shown in Equation 1.

10

11 Cost Growth =
$$\frac{\text{Final Contract Amount} - \text{Awarded Contract Amount}}{\text{Awarded Contract Amount}} \times 100 \quad (\text{Eq. 1})$$

12

13

TABLE 2 Performance Metrics for Projects Using Early Work Packaging vs. All CM/GC Projects

	Cost Growth
CM/GC Projects Identified as Using Early work packaging (N=12)	2.3%
CM/GC Projects Identified as NOT Using Early work packaging (N=6)	14.3%

4. Agency Interviews

The six project interviews were performed with the following characteristics: CM/GC projects conducted by a state agency; new and rehabilitation of road/bridge, tunnel widening, new road and drainage projects; and range from three to five work packages used for design/construction overlap, purchasing materials, preparation work, and seasonal work. The interview findings were as follows: *packages can accelerate the project, mitigate risk, contribute to project savings, reduce public impact, must be severable, involve contractor and stakeholder input, require increased agency planning and resources; and should not be performed by agencies new to CM/GC.*

5. Project Case Studies

The three case studies highlight the opportunities and challenges of implementing early work packaging in CM/GC projects. The content of work packages and the reason for preparing each work package is summarized in Table 3.

TABLE 3 Case Study Project Descriptions and Reasons for Packaging

	Description	Reason for Packaging		
Project #1	New Road & Bridge (\$156M)			
<i>Package 1</i>	Foundation Materials	1.	Long Lead Items	
<i>Package 2</i>	Work Structure Materials	1.	Long Lead Items	
<i>Package 3</i>	Foundation	1.	Overlap D/C*	2. Seasonal Work
<i>Package 4</i>	Work Bridge	1.	Overlap D/C	2. Seasonal Work
<i>Packages 5+</i>	Complete Project	1.	Overlap D/C	
Project #2	Road Reconstruction (\$100M)			
<i>Package 1</i>	Prepare Detour	1.	Overlap D/C	2. Long Lead Items 3. Lock in Pricing
<i>Package 2</i>	Bridge & Tunnel Widening	1.	Overlap D/C	2. Long Lead Items
<i>Package 3</i>	Restore Detour & Game Check Station	1.	Overlap D/C	
<i>Package 4</i>	Rock Excavation	1.	Prep Work	
<i>Package 5</i>	Remaining Work**	1.	Finish Work	
Project #3	New Road & Drainage (\$21M)			
<i>Package 1</i>	Aggregate & Piping	1.	Lock in Pricing	2. Long Lead Items
<i>Package 2</i>	Drainage & Piping	1.	Overlap D/C	
<i>Package 3</i>	Remaining Work	1.	Finish Work	

* D/C = Design/Construction; **Remaining Work = Final package comprised all remaining work not found in the previous packages.

Project #1 – New Road and Bridge

In this project early work packaging was detrimental to project performance. Project #1 constructed a new road and bridge with a contract value of \$156M, a 0% cost growth and 0% schedule growth. However, the zero cost and schedule growth values hide the fact that the scope

1 was significantly cut in order to meet the budget. The project representative believed the agency
2 “overpaid by 20%” for the project services received.

3 Early work packaging was performed on this job to accelerate the project schedule. The
4 bridge foundation and all other in-water construction were limited to a three-month period due to
5 environmental restrictions, creating a very complex and aggressive schedule. The use of early
6 work packaging can help a project meet an aggressive schedule (2,3,5,7,9,11-14,16,17,19,20,23,24)
7 and the 0% schedule growth on this project suggests early work packaging contributed toward this
8 schedule goal. However, the project’s *inability to develop severable and standalone packages*
9 and the *reactive rather than proactive planning* likely impacted the agency’s inability to receive
10 fair market value.

11 Because the footings and foundation work packages were not stand-alone and severable,
12 this agency’s ability to negotiate a GMP for subsequent work packages was greatly diminished.
13 The project representative summarized it this way: “*we were over a barrel with this contractor. It*
14 *was virtually impossible, and I believe it was completely impossible that we could have separated*
15 *ourselves from that contractor.*” (25)

16 Due to acceleration requirements and inexperience, the agency was not able to proactively
17 plan work packages. As pieces of design were completed, work packages were released for a total
18 of over 20 work packages. Though this strategy helped with the schedule, it was detrimental to
19 properly preparing appropriate work packages that can be negotiated to a fair market price. As
20 stated by the project representative, “*we had to do an early work amendment and get our*
21 *contractor in the water and get him going... So, added the foundation, added the substructure,*
22 *added the northbound superstructure, added another little bridge... I mean we just added, added,*
23 *added, added...*” (25)

24 Project #2 – Road Reconstruction

25 This project shows how making early work packages severable can contribute to a successful
26 CM/GC project. Project #2 was a combination of new construction, reconstruction, and
27 resurfacing and included road, bridge, and other work. The contract value was \$100M with a -12%
28 cost growth and 0% schedule growth. Early work packaging was used to accelerate the project.
29 By implementing early work packages to perform preparation activities and acquire long lead
30 items, the construction of the asset started immediately upon design completion.

31 The 0% schedule growth suggests early work packaging contributed toward meeting the
32 schedule goal and likely contributed to the 12% cost savings. For early work packaging to be
33 successful, it must not only achieve its intended purpose, in the case of project acceleration, but
34 also must not negatively impact other project goals (20). The project representative stated
35 “*packaging was very successful, we met all of the objectives of the project and met all of the*
36 *schedule goals*” (25). Factors contributing toward successful early work packaging include:
37 *maintaining severability, proper proactive planning, and contractor collaboration.*

38 The project representative stated that the project was able to maintain severability by
39 “*mak(ing) sure that each package has an ending... (and is) as independent as possible and as*
40 *severable as possible*” (25) and making the packages “*severable enough that you can walk away*
41 *from a package without being tied into another package*” (25). The project representative felt that
42 attaining severability and work package success is “*about strategy, it’s about making packaging*
43 *work for the contractor team-members, as well as the DOT and consultant team members*” (25).
44
45

1 Project #3 – New Road and Drainage

2 This project shows how early work packages can be used on small projects. Project #3 consisted
3 of a new road and drainage project with a contract value of \$21M that saw a 1% cost growth. The
4 project representative stated, “*we were probably a year ahead*” (25). This project used early work
5 packaging to meet multiple benefits referenced in the literature: schedule acceleration
6 (2,3,5,7,9,11-14,16,17,19,20,23,24), risk mitigation (2,6,8,10,13,14-18,20-24), cost savings
7 (2,4,7,12-14,22,23) by fixing prices, and minimizing impact to the public (14). This use of early
8 work packaging was deemed successful by the project representative who said, “*we went with*
9 *phasing on this contract because we knew we had some risks with wetland permitting, and some*
10 *right-of-way issues, and dealing with a lot of stakeholders, users, industries, and businesses that*
11 *needed to use the road... The phasing was really successful on this project*” (25).

12 Project #3’s early work packaging success was obtained by ***maintaining severability,***
13 ***contractor collaboration,*** and ***proper stakeholder management.*** Concerning severability, the
14 agency representative stated, “*you have to make sure it is severable. You have to make sure the*
15 *contractor is on board with that. That will help keep them honest too and getting the right price*”
16 (25). Additionally, the agency representative said, “*make sure you listen to your contractors and*
17 *let them be a part of (packaging)... you have to be willing to listen to what your contractor is*
18 *recommending you do and then let them help you work through the risks*” (25). These statements
19 suggest contractor collaboration was key to success.

20 Finally, the project’s success came from understanding how the early work packaging
21 would impact project stakeholders, namely other agencies. This is particularly important when
22 dealing with right-of-way, utilities, and/or environmental resources. The project representative
23 explained that the project team should “*make sure all the outside agencies are aware of what you*
24 *are doing... without all those other agencies knowing what you are doing and being a party to it,*
25 *you could really get yourself into some bad positions.*” (25)

26

27 **Summary of Results**

28 Table 4 provides a summary of the results with a column showing which research methods support
29 each result. The five research methods are shown, along with the sample size of each research
30 method, and the number of times each result is referenced in these samples. For example,
31 “Expedite project completion” was found as cited in 12 of the 18 literature documents, three of the
32 five agency policies, responded as a reason for packaging in 10 of the 12 survey responses, stated
33 in all six interviews, and found as a reason for use in all three case studies. Using a multi-method
34 research approach allowed the authors to triangulate the results and rank the findings by order of
35 importance, as shown in the table.

36

37

1 **TABLE 4 Research Findings Triangulated Using Different Methods**

	Lit. Review (N=18)	Agency Policies (N=5)	Perf. Survey (N=12)	Interviews (N=6)	Case Studies (N=3)
Early Work Packages Opportunities					
<i>Expedite project completion</i>	12	3	10	6	3
<i>Mitigate project risks</i>	10	3	10	4	1
<i>Reduce project costs</i>	6	2	1	1	0
<i>Minimize impact to public</i>	1	0	0	1	1
Critical Implementation Factors					
<i>Maintain severability</i>	1	5	2*	6	3
<i>Proactive planning</i>	0	1	N/A	6	1
<i>Involve contractor and stakeholders</i>	0	1	N/A	3	1
<i>Use after CM/GC experience is gained</i>	0	0	N/A	1	1

2 **Notes:** * Severability was not directly asked on the survey but respondents were requested to fill out “best practices.”

3 Only five filled this question out, two stated severability.

4 N/A – Survey did not request this information

6 **DISCUSSION OF EARLY WORK PACKAGING IMPACT ON PERFORMANCE**

8 **Expediting project completion**

9 Expediting project completion is the most commonly cited benefit of early work packaging in the
10 literature (2,3,5,7,9,11-14,16,17,19,20,23,24). Likewise, the surveys indicated 22 of the 23 early
11 work packages were motivated by project schedule acceleration either through procuring long-
12 lead items, overlapping design and construction, and/or preparation work. All agency
13 representatives interviewed stated schedule acceleration as a benefit to early work packaging.
14 Finally, all three case studies found the projects used and benefited from early work packaging’s
15 schedule acceleration. All five research methods applied in this study corroborated that accelerated
16 project completion is the most common benefit of early work packaging. As stated by one agency
17 representative, “*putting work out that will accelerate the main core of work is always why we do*
18 *extra packages.*” (25) This quote exemplifies acceleration being heavily valued, but as seen in
19 Table 1, there are other benefits gained from early work packaging.

21 **Mitigating project risks**

22 Mitigating project risks is the second most commonly cited benefit of early work packaging in the
23 literature (2,6,8,10,13,14-18,20-24). Twelve of the 23 early work package survey responses
24 expressed a desire to mitigate risk. Four of the six interviewed agency representatives stated
25 mitigating project risks as a benefit of early work packaging. The case study of project #3 revealed
26 that it successfully used and benefited from early work packages’ risk mitigation. All five research
27 methods applied in this study corroborate that risk mitigation is a benefit of early work packaging.
28 One agency representative stated that early work packaging “*can take a negative risk and switch*

1 *it to an opportunity” (25).*
2

3 **Reducing project costs and adding value**

4 Cost savings is a benefit cited in the literature (2,4,7,12-14,22,23) and is often achieved by
5 acquiring materials prior to price escalation, reducing overhead duration, and/or creating a more
6 efficient construction process. From the survey performed, only one of 23 work packages were
7 motivated by cost reduction. Early work packaging likely contributed to the 12% project savings
8 of project #2; and project #3 claimed early work packaging successfully met the cost performance
9 goals. However, only one of the six agency representatives claimed cost savings as a benefit to
10 early work packaging. Four of the five research methods applied in this study consider cost savings
11 as a benefit of early work packaging.

12 Several documents state that early work packaging mitigates cost risks (2,6,8,10,13,14-
13 18,20-24) and/or leads to project cost savings (2,4,7,12-14,22,23). It would be expected that in
14 mitigating cost risks, a project would mitigate cost growth from contract award to final cost.
15 Table 2 showed cost growth for the 12 CM/GC projects with early work packaging is lower than
16 that experienced by the six CM/GC projects without early work packaging. This trend needs to be
17 verified in the future with a larger data set.

18 Though the cost growth trends suggest the potential of added value, early work packaging
19 comes at a cost. According to one agency representative’s estimation, early work packaging costs
20 about 0.5% of the project award value (25). Packaging requires more work in pre-construction
21 activities such as creating separate packages and negotiating each package. During construction,
22 sites may have duplicate diaries, quality reports, etc. Additionally, there can be duplicate contracts
23 with duplicate accounting systems including unit pricing.

24 This research does not definitively confirm whether or not early work packaging adds
25 value. However, based on the trends displayed in Table 2, and the observations of five of the six
26 agency representatives who perceived value added through early work packages, it is likely that
27 early work packaging’s benefits can and often do outweigh its costs.
28

29 **Minimizing the impact to the public**

30 Impact to the public is often associated with accelerating the project’s completion date, but
31 NCHRP Report 10-15 (14) is the first literature that identifies this factor as an advantage of early
32 work packaging. None of the survey responses mentioned minimizing impact to the public as a
33 reason for early work packaging, and only one interview response stated it as a benefit. However,
34 project #3 successfully minimized impact to the public through early work packaging. Minimizing
35 public impact is only found in three of the five research methods applied in this study. It appears
36 to be a less understood benefit of early work packaging.
37

38 **DISCUSSION OF CRITICAL IMPLEMENTATION FACTORS FOR EARLY WORK** 39 **PACKAGING**

40 **Severability of work packages**

41 Severability is stated as a requirement in all CM/GC manuals that discuss early work packaging
42 (20-24) and is noted within the NCHRP 10-85 report as a quality of work packages (14). Of the
43 five projects that addressed best practices within the survey, two responded that packages must be
44 severable. As seen in project #1, if packages are not severable, the owner loses negotiating power
45 and may risk cost growth or scope reduction. Alternatively, projects #2 and #3 claim severability
46

1 as a reason for their success. All six interviews with agency representatives stated severability was
2 essential. As stated by one agency representative, severability is “*a cardinal rule that you cannot*
3 *break... make sure that the scope is independent, completely independent from the remaining*
4 *project... In that way, you are able to protect yourself as an owner from being committed or being*
5 *obligated to continue work with that contractor (25).*” All five research methods applied support
6 severability as being essential or a best practice of early work packaging.
7

8 **Proactive and detailed planning and taking into account project goals**

9 Planning is necessary to ensure early work packaging does not have unforeseen adverse impacts
10 on a CM/GC project. The Minnesota CM/GC manual requires that an investigation is made to
11 ensure early work packaging fosters, rather than negatively impacts, project goals (23). Proper
12 detailed planning and taking into account project goals was discussed in all six interviews with
13 project representatives. As stated by one agency representative, “*the owner needs to really think*
14 *through the risk and the schedule and the potential benefits and decide whether that is the best*
15 *approach for them*” (25). As seen in project #1, when packaging is reactive rather than proactive,
16 the project loses the ability to properly develop early work packages increasing the potential of
17 negatively impacting project performance. Three of the five research methods applied support
18 proactive and detailed planning and taking into account project goals when preparing work
19 packages.
20

21 **Contractor and stakeholder buy-in**

22 Buy-in is necessary to ensure that work packages are executed as intended without causing
23 disputes. The Colorado CM/GC manual states that the impact of all stakeholders, including
24 internal and external, should be reviewed when developing early work packages (21). Three of
25 the six interviewed agency representatives commented on contractor and stakeholder buy-in.
26 Concerning contractor collaboration, one representative stated, “*it’s about making packaging work*
27 *for the contractor team-members, as well as the DOT and consultant team members*” (25).
28 Another agency representative shared, “*the biggest key to success is having the team all on board.*
29 *If you get the right contractors, (packaging) works really successfully*” (25). Part of project #3’s
30 success was stakeholder engagement. When the process is not collaborative, the contractor may
31 suggest packaging to meet their own needs or take advantage of the process. Three of the five
32 research methods applied support contractor and stakeholder buy-in.
33

34 **Early work packaging works best after some CM/GC project experience is obtained**

35 This is not reported in the literature, agency manuals, or survey findings. However, this was a
36 lesson learned stated by one agency representative experienced with early work packaging, and is
37 corroborated by the poor performance of project #1 which was the first CM/GC project within that
38 agency. As stated by the agency representative, “*In almost every case that I have seen, people who*
39 *try to do multi-packaging CM/GC projects upfront (first project) get into the pitfalls much faster*
40 *and much easier than on a regular CM/GC project... You need the experience of what a CM/GC*
41 *is at its core before you start adding complications to it such as packaging.*” (25) This finding is
42 counter intuitive, since a primary benefit of CM/GC is project acceleration and early work
43 packaging is a key tool for achieving accelerations. Nonetheless, experience with CM/GC without
44 early work packaging can make the implementation smoother for early work packaging on future
45 projects.
46

1 CONCLUSIONS

2 This study explores the use of early work packaging in CM/GC transportation projects through:
3 reviewing the literature; reviewing agency manuals/instructions; surveying 18 projects;
4 interviewing six agency representatives; and conducting three project case studies. This research
5 contributes to the current body of knowledge by providing triangulated findings through a multi-
6 method approach that supports early work packaging's potential to improve project performance.
7 Research results point to these potential benefits of early work packaging: expediting project
8 schedule; mitigating risks; reducing project costs; minimizing impacts to public; and matching
9 funds. These goals are obtained by creating work packages which: procure long lead items and/or
10 volatile priced items; overlap design and construction; perform early work including right-of-way,
11 utility, subsurface, and/or general prep work; and avoid environmental restrictions or
12 disadvantageous seasons. Critical implementation factors include: maintain severability; proactive
13 planning; involve contractor and stakeholders; and use after CM/GC experience is gained. In
14 particular, severability is pivotal to creating early work packaging that does not diminish agency
15 negotiating power, and risk cost and schedule growth.

16 The CM/GC projects with early work packages in this study showed a trend toward
17 controlling project cost growth. Moreover, two of the three case studies support this finding with
18 one-year schedule acceleration due to early work packages; and the third case study with 12% cost
19 savings. Five of the six agency representatives interviewed also stated projects with early work
20 packaging experienced added value often exceeding project goals.

21 The small sample size in this study limits statistical analyses; however, a triangulated
22 approach ameliorated this shortcoming. Future research should compare the cost and schedule
23 performance of CM/GC projects with and without work packages. As CM/GC matures in highway
24 projects, a larger database of projects can be studied to provide empirical results.

26 ACKNOWLEDGEMENTS

27 The authors would like to thank the agency representatives that participated in this study and the
28 FHWA research panel for their guidance. Without their support, this study would have not been
29 possible.

31 REFERENCES

- 32 1. Colorado Department of Transportation, Innovative Contracting Program. *Construction*
33 *Manager/General Contractor Manual* (January, 2015). [https://www.codot.gov/business/](https://www.codot.gov/business/designsupport/innovative-contracting-and-design-build/documents/cmgc-manual)
34 [designsupport/innovative-contracting-and-design-build/documents/cmgc-manual](https://www.codot.gov/business/designsupport/innovative-contracting-and-design-build/documents/cmgc-manual).
35 Accessed May 23, 2016.
- 36 2. Gransberg, Douglas D., and Jennifer Sue Shane. *Construction manager-at-risk project*
37 *delivery for highway programs*. Vol. 402. Transportation Research Board, 2010.
- 38 3. Alder, R. *UDOT Construction Manager General Contract (CM/GC) Annual Report*,
39 Engineering Services and Bridge Design Section, Utah Department of Transportation
40 Project Development Group, Salt Lake City, Utah, 2011.
- 41 4. Armstrong, W.G. and R.M. Wallace. A Case Study of Construction Management on the
42 Boston Harbor Project, Reflections at Project Completion. *CM E-Journal*, Construction
43 Management Association of America, McLean, Va., Jan. 2001, pp. 22.
- 44 5. Gambatese, J., K. Dettwyler, D. Rogge, and L. Schroeder. *Oregon Public Contracting*
45 *Coalition Guide to CM/GC Contracting*. Oregon Public Contracting Coalition, Portland,
46 2002, p. 13.

- 1 6. Koppinen, T. and P. Lahdenperä. *The Current and Future Performance of Road Project*
2 *Delivery Methods*. VTT Publications 549, Helsinki, Finland, Espoo 2004, p. 63.
- 3 7. Kwak, Y.H. and R. Bushey. Construction Management at Risk: An Innovative Project
4 Delivery Method at Stormwater Treatment Area in the Everglades. Florida, Proceedings,
5 Construction Congress VI, Orlando, Fla., 2000, pp. 477–482.
- 6 8. Lee, J. CM/GC at Oregon DOT. Presented at WASHTO Conference, Portland, Ore.,
7 2008, pp. 14.
- 8 9. Mahdi, I.M. and K. Alreshaid. Decision Support System for Selecting the Proper Project
9 Delivery Method Using Analytical Hierarchy Process. *International Journal of Project*
10 *Management*, Vol. 23, 2005, pp. 564–572.
- 11 10. Martinez, P.H., Y. Rashida, and V. MacMurray. *Construction Manager's*
12 *Responsibilities: Pre-Design, Design and Pre-Construction Phase*. American Bar
13 Association, Chicago, IL, Jan. 2007, 58 pp.
14 <http://www.abanet.org/abastore/productpage/5570099PDF>. Accessed May 18, 2016.
- 15 11. Rojas, E.M. and I. Kell. Comparative Analysis of Project Delivery Systems Cost
16 Performance in Pacific Northwest Public Schools. *Journal of Construction Engineering*
17 *and Management*, Vol. 134, No. 6, June 1, 2008, pp. 387–398.
- 18 12. Uhlik, F.T. and M.D. Eller. Alternative Delivery Approaches for Military Medical
19 Construction Projects. *Journal of Architectural Engineering*, ASCE, Vol. 5, No. 4, 1999,
20 pp. 149–155.
- 21 13. Schierholz, J., D.D. Gransberg, and J. McMinimee. *Benefits and Challenges of*
22 *Implementing Construction Manager/General Contractor Project Delivery: The View*
23 *from the Field*. 2012 Transportation Research Board Paper #12-1206, National
24 Academies, January 2012.
- 25 14. Gransberg, D. *NCHRP Project 10-85: A Guidebook for Construction Manager-at-Risk*
26 *Contracting for Highway Projects*, April 2013.
- 27 15. Shane, J., & D. Gransberg. Coordination of design contract with construction manager-at-
28 risk preconstruction service contract. *Transportation Research Record: Journal of the*
29 *Transportation Research Board*, No. 2151, Transportation Research Board of the
30 National Academies, Washington, D.C., 2010, pp. 55-59.
- 31 16. Shane, J. and D. Gransberg. A Critical Analysis of Innovations in Construction Manager-
32 at-Risk Project Delivery. *Construction Research Congress 2010*, pp. 827-836.
- 33 17. West, N.J.N., Gransberg, D.D., and J. McMinimee. Effective Tools for Projects
34 Delivered Using the Construction Manager/General Contractor Method, *Transportation*
35 *Research Record: Journal of the Transportation Research Board*, No. 2268,
36 Transportation Research Board of the National Academies, Washington D.C., 2012, pp.
37 33-42.
- 38 18. Gransberg, D., “CMGC 101 Workshop,” Presentation, 2012 CMGC Peer Exchange,
39 FHWA, Boston, Massachusetts, 2012.
- 40 19. Bearup, W., “Local Government experience with Construction Manager at Risk,”
41 Presentation, 2012 CMGC Peer Exchange, FHWA, Boston, Massachusetts, 2012.
- 42 20. ADOT. *Construction Manager at Risk (CMAR) Process Guide*, Second Edition,
43 September 2014. [http://azdot.gov/docs/default-source/construction-](http://azdot.gov/docs/default-source/construction-group/cmar_manual_100510.pdf?sfvrsn=0)
44 [group/cmar_manual_100510.pdf?sfvrsn=0](http://azdot.gov/docs/default-source/construction-group/cmar_manual_100510.pdf?sfvrsn=0). Accessed July 19, 2016.
- 45 21. Caltrans. *Caltrans Alternative Procurement Guide*, April 2008.
46 <http://www.dot.ca.gov/hq/oppd/contracting/AlternativeProcurementGuide.pdf>. Accessed

- 1 July 19, 2016.
- 2 22. Colorado Department of Transportation, Innovative Contracting Program. *CMGC*
3 *Manual* (2015). [https://www.codot.gov/business/designsupport/innovative-contracting-](https://www.codot.gov/business/designsupport/innovative-contracting-and-design-build/documents/cmgc-manual/view)
4 [and-design-build/documents/cmgc-manual/view](https://www.codot.gov/business/designsupport/innovative-contracting-and-design-build/documents/cmgc-manual/view). Accessed May 23, 2016.
- 5 23. Minnesota Department of Transportation. *Progressive GMPs/Severable Work Packages*.
6 <http://www.dot.state.mn.us/const/tools/cmgc/SeverableWorkPackages.pdf>. Accessed 23
7 May 2016.
- 8 24. Nevada Department of Transportation. *Pioneer Program Guidelines*, Second Edition
9 August 2013. [http://www.nevadadot.com/uploadedFiles/NDOT/Micro-](http://www.nevadadot.com/uploadedFiles/NDOT/Micro-Sites/PioneerProgram/Pioneer%20Program%20Guidelines%202nd%20Edition%202013.pdf)
10 [Sites/PioneerProgram/Pioneer%20Program%20Guidelines%202nd%20Edition%202013.](http://www.nevadadot.com/uploadedFiles/NDOT/Micro-Sites/PioneerProgram/Pioneer%20Program%20Guidelines%202nd%20Edition%202013.pdf)
11 [pdf](http://www.nevadadot.com/uploadedFiles/NDOT/Micro-Sites/PioneerProgram/Pioneer%20Program%20Guidelines%202nd%20Edition%202013.pdf). Accessed July 23, 2016.
- 12 25. Federal Highway Administration. *Quantification of Cost, Benefits and Risk Associated*
13 *with Alternative Contracting Methods and Accelerated Performance Specifications.*
14 *Federal Highway Administration Project*. Contract No. DTFH61-11-D-00009, 2013-
15 2016.
- 16 26. *Project Delivery Systems: CM at Risk, Design-Build, Design-Bid-Build, Research*
17 *Summary RS 133-1*. Construction Industry Institute, Austin, TX, 1997.
- 18 27. Sanvido, V., and M. Konchar. *Project Delivery Systems: CM at Risk, Design-Build,*
19 *Design-Bid-Build, Research Summary RS133-11*. Construction Industry Institute, Austin,
20 TX, 1998.