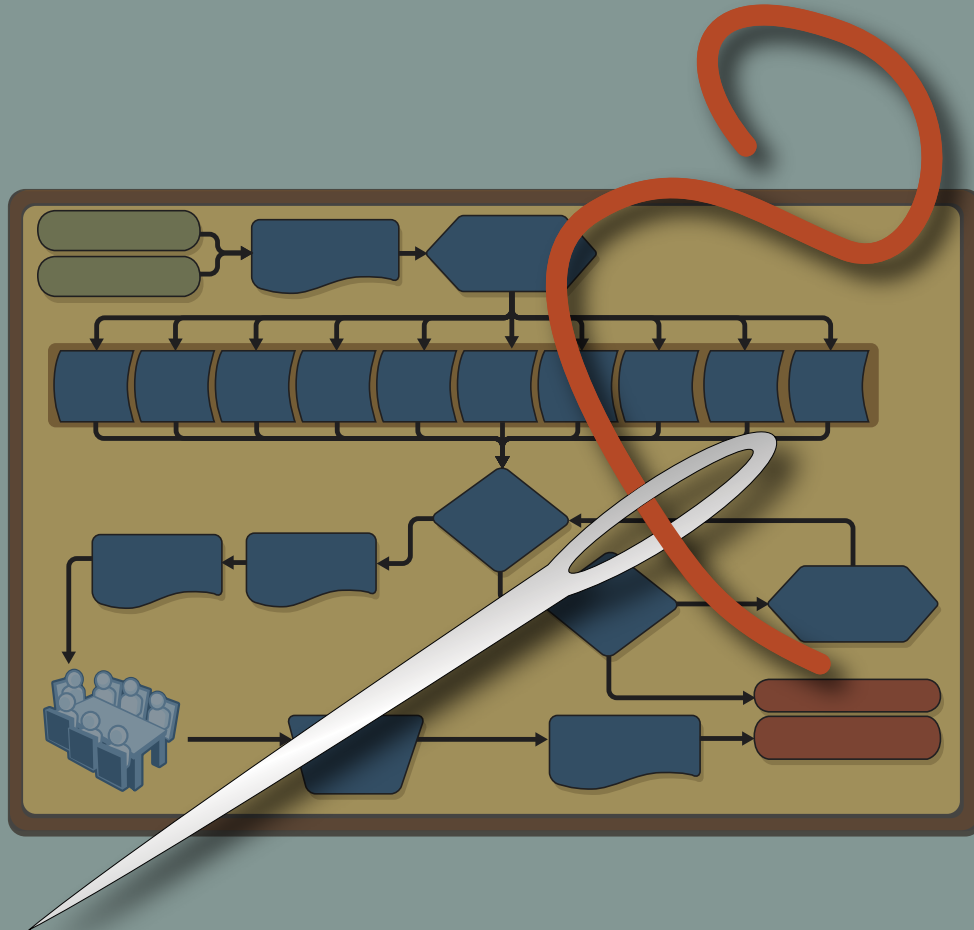


AWP “Digital Threads”

to Enable Supply Chain Visibility on Capital Projects



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AWP “Digital Threads”

to Enable Supply Chain Visibility on Capital Projects

*Research Team TC-03, AWP “Digital Threads”
to Enable Supply Chain Visibility on Capital Projects*

Technology Committee

Construction Industry Institute

*Final Report TC-03
Version 1.1*

May 2023

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The University of Texas at Austin

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Executive Summary

Supply chains have a critical impact on the overall success or failure of a capital construction project. The complexity of construction supply chains continues to increase as construction materials and methods become more intricate. Construction project stakeholders are encouraged to share information across the supply chain to foster stakeholder alignment and facilitate transparency. CII Research Team 344 (RT-344) recently concluded that two primary barriers to a transparent supply chain are found in information technology (IT) systems:

- Materials data unavailable in IT systems
- Fragmentation of IT systems

The members of Research Team TC-03 (RT-TC-03) agree with these findings from RT-344. Increasing the visibility of materials information for a supply chain provides one of the most significant opportunities for the advancement of capital projects. Increased supply chain visibility can enable the increased success of productivity and quality. The manufacturing industry has greatly benefitted from increased visibility and information sharing across supply chains.

The results of this project provide a systematic approach to communicate and visualize Advanced Work Packaging (AWP) “digital threads” to stakeholders across a capital project supply chain. This project has developed the following research deliverables:

- A map of digital threads associated with supply chain applications
- A proof-of-concept Excel-based tool for facilitating information sharing across the supply chain, the Material Responsibility Matrix (MRM)
- An MRM user manual (provided as Chapter 4) that supports using the tool

These research deliverables enable companies to increase supply chain visibility and incorporate stakeholders into effective supply chain decision-making. More generally, the RT-TC-03 research deliverables will promote the use of AWP through increased accessibility to stakeholders. The tool and its manual will encourage and facilitate information sharing across a capital project supply chain and promote the use of AWP “digital threads” concepts to better visualize supply chain elements.

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Chapter 1:

Introduction

This research was supported by the Construction Industry Institute (CII). The objective of the research was formulated by RT-363, which focused on identifying the leading best practices for effective involvement of the supply chain in AWP processes (CII 2020a). The objective of this project was to create a digital library containing specifications of the AWP “digital threads” for supply chain visibility. The intent of this library was to facilitate and promote supply chain visibility across various stakeholders on capital projects. The research deliverables will incorporate stakeholders into effective supply chain decision-making and coordination.

1.1. Digital Threads

A digital thread is defined as an integrated information flow that connects all phases of the product lifecycle using accepted authoritative data sources (Hedberg et al. 2016). Others have suggested that the main focus of a digital thread is the digital representation of the target or product from one phase to the next of its lifecycle, thereby creating a digital twin of the entity (Ben Miled and French 2017). Current research in digital threads focuses mainly on evaluating technologies to improve construction facilities, such as a round-trip method for production evaluation (Hedberg et al. 2020).

Identified challenges to implementing digital threads include interoperability issues and the lack of standards across an industrial sector (Hedberg et al. 2018). The automotive, aerospace, and medical industries have explored some data-driven processes, such as additive manufacturing, but these have failed to achieve widespread acceptance or integration due to the lack of a standard framework for the exchange of data related to design, modeling, build planning, monitoring, control, and verification (Nassar and Reutzel 2013).

Traditionally, information related to a specific aspect of a construction project has been likely to become categorized in its respective sector (Irizarry et al. 2013). For example, materials requested by contractors to fit a specified design requirement have been known to a specific manufacturer and the project-specific managers; however, they were not necessarily made available through a database to all potential suppliers (Behera et al. 2015). Although the concept of digital threads is gaining traction as a digital communication framework to streamline design, manufacturing, and operation processes in order to more efficiently design, build, and maintain engineering products, it lacks a principled mathematical formulation that describes how digital threads can be used for critical decisions (Singh and Willcox 2018).

1.2. Advanced Work Packaging

Advanced work packaging (AWP) provides an opportunity for construction companies to categorize project elements into project phases or contributing disciplines in an attempt to increase the effectiveness of management throughout a project lifecycle and ultimately improve productivity (Isaac et al. 2017). The initial purpose of AWP was to address challenges in the industrial construction sector, including high costs and schedule overruns (Halala and Fayek 2019). Advanced work packaging can equip companies with automated planning and construction processes to reduce risk and increase communication among integral project stakeholders.

Traditional methods of collecting data on the progress of construction projects often involve human judgment and high costs, and they are too infrequent to provide managers with timely and accurate control data (Ibrahim et al. 2009). AWP envisages a prioritization of the work, initially agreed upon by the various disciplines, with the ultimate aim of increasing performance in terms of time, cost, quality, and alignment of the three macro-phases: engineering, procurement, and construction (Calabrese et al. 2019).

Although several case studies conducted on AWP have reported a number of benefits in the areas of productivity, cost, safety, and schedule, there is no clear method to assess the costs and benefits of AWP implementation. This lack of quantitative evidence to support the benefits of AWP poses a significant challenge for its adoption in the construction industry (Halala and Fayek 2019). More research is required to better understand the impact of AWP on the success of a construction project.

1.3. Construction Supply Chain Visibility

Tohamy et al. defined supply chain visibility as “capturing and analyzing supply chain data that informs decision, mitigates risk, and improves processes” (Tohamy et al. 2003). The increasing complexity of construction projects and the industry-wide pursuit of technological advancements have spurred a desire for more efficient means of transferring data between parties throughout a project’s lifecycle (Jarkas 2017). In today’s construction industry, the method in which organizations manage and share information across their supply chain has a direct impact on their competitiveness (Edum-Fotwe et al. 2001). All information must be adequately managed in order to bring value to each project stakeholder (Titus and Bröchner 2005). Valuable management information is generated during the pre-planning and pre-design phases, as well as during active construction (Larson et al. 2018). A need exists to create a method for sharing information across the supply chain for stakeholder access.

1.4. Related CII Research

The research described in this report was motivated by a specific need identified by RT-363. A shared digital library promotes the integration of supply chain elements with AWP practices. The objectives of the RT-TC-03 research built upon the results from other CII research teams:

- RT-344 investigated supply chain integration of materials planning and work packaging (CII 2015).
- RT-272 provided foundational research findings on supply chain components across stakeholders (CII 2013).
- RT-319 identified a 25% increase in field productivity and 10% decrease in Total Installed Cost with increased savings for owners and increased profitability for contractors (CII/COAA 2015).

RT-TC-03's research aligned closely with work done by CII Working Group 19-01 (WG19-01), AWP Data Requirements. Throughout their parallel research processes, the groups shared findings and differentiated between data requirements and digital threads. Figure 1 offers a framework for past and current CII AWP research related to supply chain, and this shows how RT-TC-03 fits with the current CII body of knowledge.

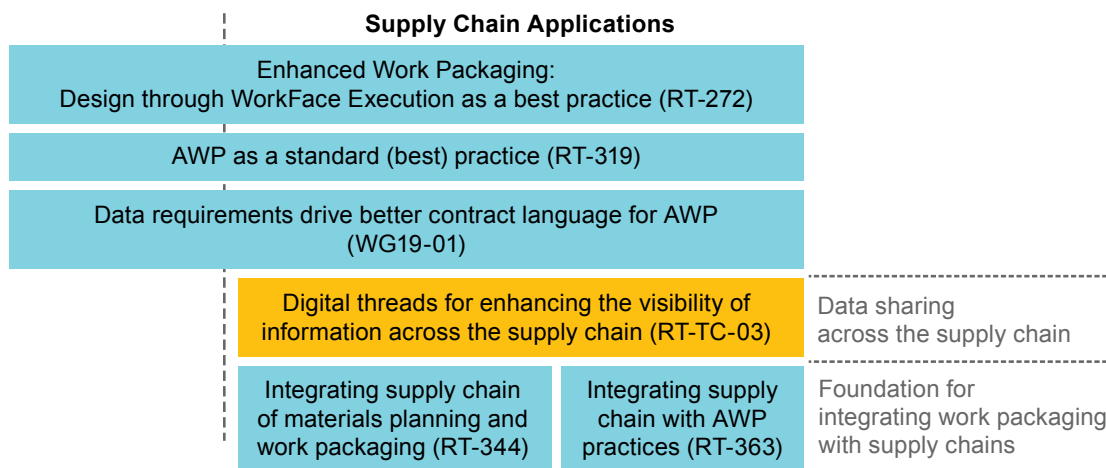


Figure 1. Framework for CII's Research of AWP

Table 1 summarizes how, although RT-TC-03 and WG19-01 collaborated closely, the two teams’ research focuses and final deliverables differed.

Table 1. Research Components of RT-TC-03 and WG19-01

	Research Team TC-03 AWP “Digital Threads” to Enable Supply Chain Visibility on Capital Projects	Working Group 19-01 AWP Data Requirements
<i>Research Focus</i>	Digital threads and material responsible roles associated with supply chain stakeholders	Rationalized all applicable data requirements for AWP
<i>Research Deliverable</i>	Collaborative tool to visualize data sharing	Specifications and contract language for data requirements

1.5. Report Structure

The remaining sections of the report are organized as follows:

- Chapter 2 provides a description of the methodology implemented.
- Chapter 3 focuses on the final supply chain digital threads.
- Chapter 4 provides implementation materials for the Material Responsibility Matrix (MRM).
- Chapter 5 presents a discussion of the conclusions and recommendations of the research.

Chapter 2:

Methodology

CII established RT-TC-03 with an overall goal of increasing the visibility of information for stakeholders across the supply chain of a capital project. The team pursued its research efforts through face-to-face meetings, web meetings, conference calls, emails, and surveys. Team members included owner representatives, technology providers, general contractors, and members of academia.

The motivation for this research was driven by the members of RT-344, who were investigating the integration of supply chain in materials planning and work packaging. As part of its findings, RT-344 identified the need for a digital library of digital threads associated with supply chain concepts.

The majority of the research content for RT-TC-03 focused on two areas:

1. Conducting a literature review of existing strategies for improving the visibility of digital threads across supply chains.
2. Documenting the current findings and needs of RT-344.

The team based a research need statement on these efforts.

2.1. Research Purpose, Objective, and Scope

The **primary purpose** of the RT-TC-03 research was to promote and expand CII's current body of knowledge focused on AWP and supply chain topics. This research provides a systematic approach to visualizing AWP digital threads and communicating them to stakeholders across a capital project supply chain. The **objective** of this research was to create a digital library that contained specifications for AWP digital threads for supply chain visibility. As part of the research scope, the team decided only to focus on capital projects. The **research scope** was limited to digital threads associated with supply chain concepts.

2.2. Research Methodology Steps

RT-TC-03 achieved its proposed research deliverables in five major steps:

Step 1: Identify and Review Critical AWP Digital Threads with Supply Chain Applications

The research team received a complete list of the data requirements created by WG19-01. Of these 19 data requirement packages, the members of RT-TC-03 identified seven to use as digital threads that are integrated with supply chains on capital projects. After identifying the list of potential digital threads with supply chain applications, RT-TC-03 reviewed and modified the contents of each digital thread.

RT-TC-03 divided each digital thread section into categories of information. Component information for each digital thread field included an identification number for the field, a description of the project data deliverable, and whether a component was required or optional. The outcomes of the review included a discussion of suggested modifications. Chapter 3 of this report contains the results of this review, and Appendix A offers the full database of digital threads integrated with supply chain components.

Step 2: Develop Material Responsibility Matrix

The research team also created a tool to define the responsibilities of stakeholders within a supply chain on a capital project: the Material Responsibility Matrix (MRM). Previous to the formation of RT-TC-03, its members had individually created a strong foundational framework on MRM. The major contribution of this research step was reviewing and verifying MRM by the team members. Members completed several iterations of review and comment to complete the final draft of the MRM, and the final draft was prepared for use in a tool.

Step 3: Survey Suppliers’ Digital Threads

The research team collectively agreed that supplier input for the final digital threads was critically important for acceptance across the supply chain. The team created a survey tool and administered it to nine supplier companies that were then clients of RT-TC-03’s owner members. Of the nine supplier companies that participated in the survey, eight recorded annual sales greater than \$1 million (in U.S. dollars), and one company experienced sales greater than \$100 million. The suppliers provided a variety of commodities: four companies supply structural steel, two companies manufacture mechanical equipment, two companies fabricate pipe spools, and one company sells electrical equipment.

Team members created and reviewed each question in the survey, and the final survey tool included 31 questions for each supplier participant. Table 2 shows the questions classified by topic.

Table 2. Breakdown of Question Topics in the Supplier Survey Tool

Question Topic	Number of Questions
Company commodity and sales	3
Data transmission methods with owners	6
Frequency of data transmission	3
Use of technology for data sharing	3
Digital thread review	6
Lack of information for digital thread submission	3
Issues associated with implementation for newly proposed digital threads	7

Step 4: Compare the Digital Threads Implemented by Two Owners

RT-TC-03 also compared the digital threads currently implemented by owner companies to the team's proposed set of digital threads. The comparison included two companies: one had representation on the team and the other did not. The research team attempted to match each digital thread implemented by an owner company with a matching or similar digital thread developed by the team. The research team cited the differences between the two parties for potential inclusion in its digital threads.

Step 5: Create an AWP Digital Thread Supply Chain Tool

The team's final research step focused on the creation of a library of the AWP digital threads. The results from the previous four research steps were included in a final visualization that represented the digital thread map and corresponding information. The Excel-based tool provides results from the collection of digital threads.

Chapter 3:

AWP Supply Chain Digital Threads

The foundational deliverable of RT-TC-03 is the establishment of digital threads associated with supply chain applications in a capital project. These digital threads originated from RT-363. Digital threads associated with supply chain applications were identified by members of RT-TC-03 and WG19-01, and they were then reviewed and modified by members of RT-TC-03. The following section provides insights into the purpose of the supply chain digital threads, how RT-TC-03 modified the digital threads through survey and interviews, and sample information from a published digital thread.

3.1. Purpose and Function of Digital Threads

The primary purpose of the AWP supply chain digital threads is to provide a strategy of communication and information sharing to improve efficiency among stakeholders across the supply chain on a capital project. The primary function of the digital threads is to facilitate this communication through visualization among stakeholders across the supply chain. The tool enables stakeholders to view the categories of information that should be shared and to identify which party would be responsible for providing that information.

3.2. Results of the Supplier Survey

RT-TC-03 conducted a survey of nine supplier companies to investigate and improve the efficiency of construction supply chains, then analyzed the collected survey data. The survey results are described below regarding current practices for data submission, stakeholders' recommended changes, non-existent supplier information, anticipated impacts, and envisioned benefits.

An essential aspect of AWP digital threads is to create a foundation for contractual data exchange between project stakeholders. There can be challenges with effective data exchange methods; therefore, the research team gathered current methods through this survey. Companies were asked to identify who submitted their data, how often they submitted, and what technology they used to submit data for general information transfer and purchase orders.

The respondents were evenly split between using a dedicated resource and using multiple non-dedicated personnel to submit data. Most respondents based their data submission frequency on the desires of the client and the manufacturing stages of the materials. These companies transferred data through email attachments; however,

most used a web-based data management system as well. In the case of a purchase order, all of the companies used company engineers to prepare the technical data. However, half chose to use document control specialists to submit data, while the other half used project managers. This information is important to understand the system in place and to identify any integration challenges with the research implementation.

The stakeholders were given the opportunity to provide feedback and recommend changes to the digital data threads in the survey. The research team analyzed and reviewed the results from the survey and determined that the suggested supplier content had already been captured by other categories of WG19-01’s data requirements guideline. Thus, it would be redundant to create a new digital thread.

Supplier survey participants were asked to review the existing data threads and identify which threads would be challenging to provide. Table 3 shows the digital threads that the supplier survey participants identified for which it was challenging to collect and submit data.

Table 3. Non-existent Supplier Digital Threads Information

Digital Thread	Subcategory Name	Supplier Commodity	Subcategory Attributes
Steel Fabrication	Steel Fabrication CWP Tracking	Structural Steel Supplier	CWP Delivery – Forecast CWP Delivery – Actual Shipment ETA
		Electrical Equipment Supplier	CWP
Pipe Fabrication	Pipe CWP Fabrication Delivery Requirements	Structural Steel Supplier	Project ID CWP CWP Delivery– ROS CWP Delivery – Planned CWP Delivery – Forecast CWP Delivery – Actual
		Electrical Equipment Supplier	CWP
	Pipe Spool Fabrication Tracking	Structural Steel Supplier	On Hold Release Hold Spool Piecemark Isometric

The team determined that all of the non-existent supplier digital thread information provided in Table 3 would be necessary to achieve the research objective. Therefore, the digital thread attribute remained in each case. The team members decided to provide this information for stakeholders implementing digital threads for supply chain applications, to potentially identify barriers to communicating specific data variables.

Other results of the survey led the team to conclude that most suppliers are unsure of the overall impact on their company after implementing the digital threads. The surveyed suppliers shared that they would likely not invest in new technology or add personnel in conjunction with implementing the digital threads. All survey participants indicated that they would probably make organizational adjustments and review commercial proposal policies.

Finally, the team asked the supplier companies it surveyed about the overall envisioned implementation benefits to their own company and about their current level of data sharing. A majority of the stakeholder companies agreed that they will benefit from digital data threads and that they already provide most of their required digital thread information during projects.

3.3. Results of the Digital Threads Comparison of Two Owners

In addition to surveying supplier companies in the supply chain, the research team asked selected owner companies to participate in an interview. Both owner participants were large corporate organizations that had company-specific digital thread frameworks for sharing stakeholder information across the supply chain. The main objective of the interview was to compare the digital thread information for each owner participant with digital thread information generated by the research team. Through this comparison, the research team was able to understand differences in the information in the various digital threads, and ultimately it could identify areas for improvement in its draft of digital thread content. Each interview included the owner's review of the company's digital thread information pertaining to steel and piping.

The research team compared two unique steel digital threads – one for each owner company interviewed – to the digital threads that the team had developed. Research team members decided not to create new digital threads for these categories, but rather identified other existing data requirements that captured the intended information. (The two unique steel digital thread information categories included “baghouse” and “freight carrier.”) One company interviewed had eight steel digital threads in common, while the research team and the other company had four.

The comparison of piping digital threads between the research team and the selected owner companies identified eight unique information threads (five for one company and three for the other):

- | | |
|------------------------|---------------------------------|
| • box number | • insulation type |
| • coating type | • loop code |
| • coating manufacturer | • manufacturer |
| • crate number | • special handling requirements |

As it had done with the unique steel digital threads, the research team reviewed each category and deemed whether it was unnecessary or already captured in WG19-01’s data requirements guideline (CII 2020).

3.4. Data Categories for a Sample Digital Thread

Each main digital thread reviewed and published by the research team used the following framework of standard variable fields:

- **Identification** – A unique identification number for each digital thread
- **AWP Project Data Deliverable** – A list of digital thread field names
- **Timing and Frequency** – A recommendation on when the digital thread field should be reviewed

For example, Table 4 shows the fields for the digital thread developed for pipe detailing.

Table 4. Variable Fields for “Digital Thread 190 – Pipe Detailing”

Identification	AWP Project Data Deliverable	Timing and Frequency
DT190-01	Pipe Isometric Detailing	Weekly throughout the pipe isometric detailing process
DT190-02	Pipe Isometric Transmittals	Updated when new CWA model(s) and drawings are issued for fabrication
DT190-03	Pipe Spools	Updated when new isometric transmittal is issued from detailing

The following categories of information were defined within each digital thread field:

- **Key** – Primary key identifier that the data will be compared
- **Tier** – Denotes the digital thread field as “required” or “optional”
- **Field Name** – Name of the attribute
- **Definition** – Description of the attribute

Table 5 shows information provided in a field from “Digital Thread 190 – Pipe Detailing” called “DT190-03: Pipe Spools.” The acronym “PK” listed beside the first two rows of digital thread fields indicates that each of these rows is a “Primary Key,” which signifies that the data set will be rolled up to list every unique combination of Project ID plus Spool ID. By using this method, the records would show a unique list of every spool for each project in the data set.

Table 5. Information for Digital Thread Field “DT190-03: Pipe Spools”

Key	Tier	Field Name	Definition
PK	Required	Project ID	Unique project identifier
PK	Required	Spool Tag	Pipe spool unique identifier
	Required	Isometric	Piping isometric drawing number
	Required	CWP	Unique Construction Work Package identifier
	Required	Length	Length of pipe spool
	Required	Length UOM	Length unit of measure (e.g., FT, M, etc.)
	Required	Material	Spool material of construction
	Required	Weight	Weight of pipe spool
	Required	Weight UOM	Weight unit of measure (e.g., TN, Lbs, Mt, Kg, etc.)

In addition, “sample entries” for each field within the digital threads were provided, offering actual project data that would be appropriate for the given field. The sample entries were generated by WG19-01 members, who used their professional experience and project data to populate the fields. In each case, the sample entry reflected information – either actual project data or simulated data – which would satisfy the specification for that particular field entry. The diversity of sample entries was intentional to be more illustrative. Table 6 shows an example of these sample entries. The complete digital threads and corresponding field information are provided in Appendix A.

Table 6. Example of Sample Entries for DT190-03: Pipe Spools

Field Name	Sample Entry 1	Sample Entry 2
<i>Project ID</i>	PR001	AN.9892
<i>Spool Tag</i>	HOR-CX-1492-0401	AA-IX-732-0101
<i>Isometric</i>	HOR-CX-1492-04	AA-IX-732-01
<i>CWP</i>	CWP-1001	280X810A-01-01
<i>Length</i>	40	18
<i>Length UOM</i>	M	Linear Feet
<i>Material</i>	STAINLESS STEEL	C156
<i>Weight</i>	320	180
<i>Weight UOM</i>	Kg	Lbs

3.5. Description of Supply Chain Digital Threads

RT-TC-03 reviewed the data requirements populated by RT-272 and WG19-01. Of the 19 data requirements, RT-TC-03 identified that seven had a direct impact on the supply chain aspects of a capital project. Figure 2 provides the foundational data requirements map in terms of the time flow established by RT-272 and WG19-01. The supply chain digital threads that RT-TC-03 selected are highlighted in gold.

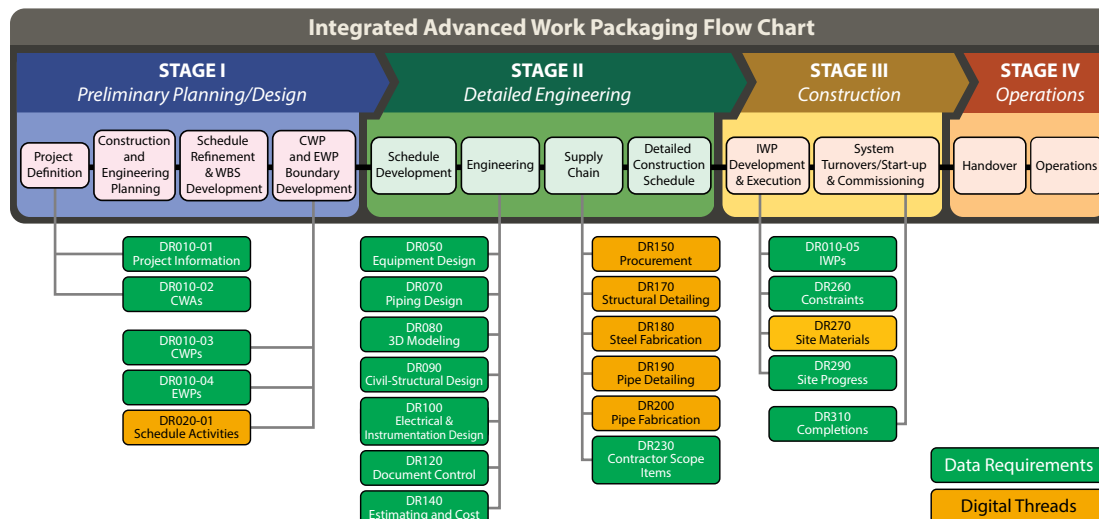
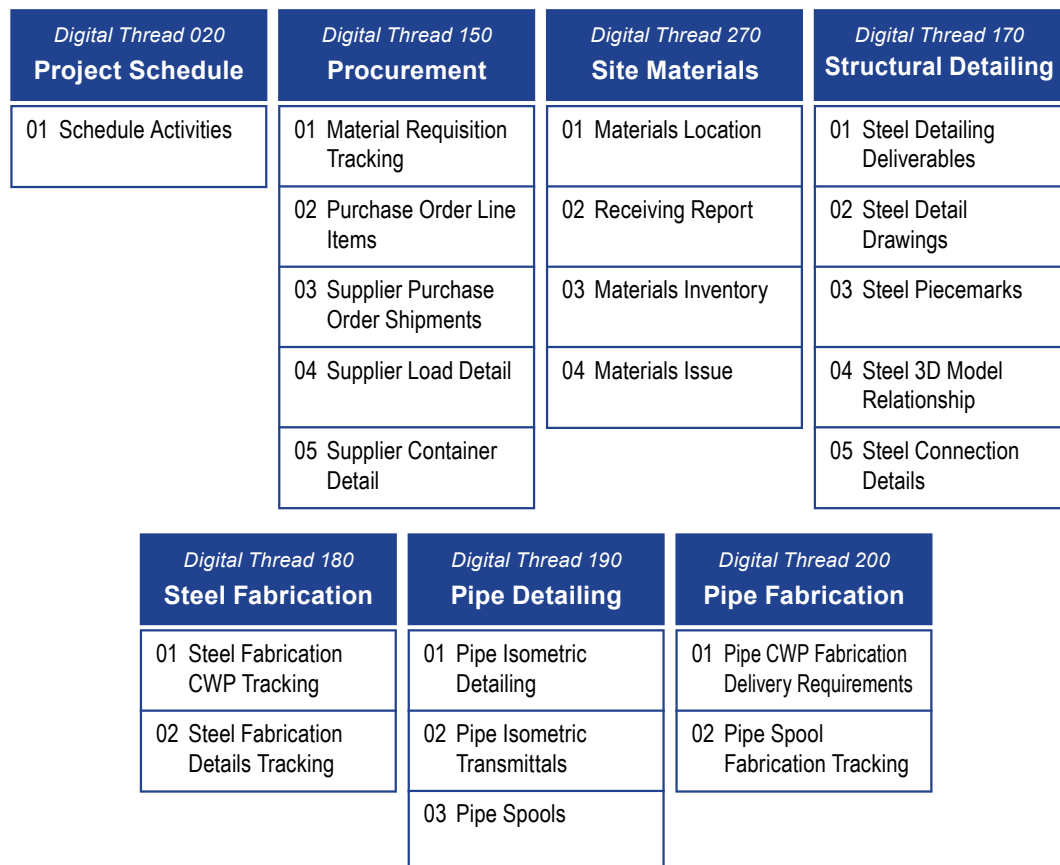


Figure 2. Supply Chain Digital Threads within AWP Data Requirements Flow Chart, Adapted from SR19-01 (CII 2020)

Table 7 shows the seven digital threads that RT-TC-03 selected with their supply chain applications. The table includes each thread’s identification number, title, and core function. Figure 3 shows the seven digital threads with their associated sub-threads. RT-TC-03’s digital threads use the data requirements and sample entries provided by WG19-01, but with additional overview information for each main digital thread. In this way, consistent data format and specifications are maintained between the digital threads and the data requirements for the AWP supply chain, improving information sharing among stakeholders.

Table 7. Selected Digital Threads with Supply Chain Applications

Identification Number	Digital Thread Title	Function
DT020	Project Schedule	Captures core information related to schedule management for a capital project
DT150	Procurement	Captures core information related to project procurement visibility
DT270	Site Materials	Captures core information related to site materials management for a capital project
DT170	Structural Detailing	Captures core information needed to finalize the planning of the steel structures to be changed or constructed
DT180	Steel Fabrication	Captures core information necessary to track steel fabrication of structural piece marks
DT190	Pipe Detailing	Captures core information related to pipe detailing work
DT200	Pipe Fabrication	Captures core information necessary to track fabrication of pipe spools

**Figure 3.** Digital Threads Architecture for Supply Chain

Chapter 4:

Material Responsibility Matrix

4.1. Introduction

RT-TC-03 developed the Material Responsibility Matrix (MRM) to clearly define responsibilities for material tasks among supply chain stakeholders. The matrix enables stakeholders to align by delineating responsibilities and roles in a capital project and establishing expectations during the planning phases of the project. MRM clearly defines which stakeholder is responsible for a specific aspect of construction material. MRM is anticipated to be effective when a task requires a multi-disciplinary effort involving multiple stakeholders. Stakeholders need to establish a clear understanding of what everyone is doing to ensure that all tasks are completed. It is much easier to set expectations up front than to confront misunderstandings later.

4.2. Scope

RT-TC-03 developed this MRM User Manual to help users understand how to incorporate this information into the current project framework and to support the Materials Responsibility Matrix spreadsheet. This documentation only explains one tab of the MRM spreadsheet.

4.3. Responsible Parties

To understand the spreadsheet, begin with the “Responsible Parties” list shown in Figure 4. This example for “Responsible Parties” is for reference purposes. The details change from project to project, but this sample set serves for the purpose of explanation. There could be additions to these Responsible Parties. “Pipe Insulation Vendor” could be another contractor based on the Project Scope, Location, and Contracts.

D-04.01.01 Responsible Parties					
Responsible Party ID	Description	Organization	Division	Location	Note
OO	Owner Client	Biggee-Oil, Inc.	Upstream Oil & Gas	Houston, TX	
EPC-DE-C	EPC Design Engineering - Civil/Structural	ACME, Inc.	Civil / Structural Design Engineering	Houston, TX	
EPC-DE-P	EPC Design Engineering - Piping	ACME, Inc.	Pipe Design Engineering	Houston, TX	
EPC-DE-M	EPC Design Engineering - Mechanical Equipment	ACME, Inc.	Equipment Design Engineering	Houston, TX	
EPC-DE-E	EPC Design Engineering - Electrical	ACME, Inc.	Electrical Design Engineering	Houston, TX	
EPC-DE-I	EPC Design Engineering - Instrumentation	ACME, Inc.	Instrument Design Engineering	Houston, TX	
EPC-PRO	EPC Procurement	ACME, Inc.	Procurement	Houston, TX	
EPC-CM	EPC Construction	ACME, Inc.	Construction Management	Houston, TX	
CON-A	Construction Contractor A	Build It Group, LLC	Construction	Baton Rouge, LA	

Figure 4. The Responsible Parties Worksheet in the MRM

4.4. MRM Planning and Execution Concept

Consider the example of concrete foundations design. EPC Design Engineering – Civil/Structural (EPC-DE-C) might be responsible for the concrete foundations design and engineering, and it might be involved with just providing specs and specs/data sheets. EPC-DE-C *may not* be responsible for doing the procurement activities and for the construction activities. To illustrate, see Figure 5, a close look at part of a tab.

D-04.01.04 Material Responsibilities						
Material Responsibility Matrix						
Discipline		ENGINEERING				
		Specs / Data Shts	Supplier Docs	Constr. Drawings	Material Take-Off	Purchase Req
Concrete Foundations	General arrangement for foundations	EPC-DE-C	NA	CON-A	CON-A	CON-A
	Reinforcing material (rebar)	EPC-DE-C	NA	EPC-DE-E	CON-A	CON-A
	Anchor bolts & sleeves	EPC-DE-C	NA	EPC-DE-E	EPC-DE-E	EPC-DE-E
	Expansion Bolts	EPC-DE-C	NA	EPC-DE-E	EPC-DE-E	EPC-DE-E
	Concrete embedded items	EPC-DE-C	NA	EPC-DE-E	EPC-DE-E	EPC-DE-E
	Slide Plates (Teflon Types)	EPC-DE-C	NA	CON-A	CON-A	CON-A
	Slide Plates (Other Types)	EPC-DE-C	NA	EPC-DE-E	CON-A	CON-A
	Non-Shrink Grout	EPC-DE-C	NA	EPC-DE-E	CON-A	CON-A
	Forming & framing consumables	EPC-DE-C	NA	EPC-DE-E	CON-A	CON-A
	Coatings (Bitumen)	EPC-DE-C	NA	EPC-DE-E	CON-A	CON-A

Figure 5. Detail of Material Responsibilities for Concrete Foundations Tab

Many activities and commodities may fall under the discipline Concrete Foundations:

- General arrangement for foundations
- Reinforcing material (rebar)
- Anchor bolts & sleeves
- Expansion bolts
- Concrete embedded items
- Slide plates (Teflon types)
- Slide plates (other types)
- Non-shrink grout
- Forming & framing consumables
- Coatings (bitumen)

But, depending on the contract scope and organization, EPC-DE-C might only perform the design and only generate the data sheet and specs. It might not produce the construction drawings. Instead, Construction Contractor A (CON-A) could produce the construction drawings and perform the material take-off, as the highlighting in Figure 5 shows.

4.5. Conclusion

The Materials Responsibility Matrix is effective when multiple disciplines and stakeholders are affected by or involved in a project. The MRM can support seamless task execution.

Chapter 5:

Conclusions and Recommendations

Research Team TC-03 identified seven digital threads with supply chain applications on capital projects. The research team reviewed existing digital threads against real digital thread data from suppliers and owners in the engineering, procurement, and construction industry. The team published its finalized digital threads in the provided Excel-based tool for implementation by stakeholders across the supply chain on capital projects.

RT-TC-03 closely collaborated with WG19-01. These teams worked in parallel to enable consistency in the identification, categorization, and descriptions of digital threads and data requirements. RT-TC-03 reviewed the data requirements generated by WG19-01 and added them to the supply chain digital threads provided in this report to ensure consistency.

RT-TC-03 also reviewed and modified the Material Responsibility Matrix (MRM) to delineate responsibility for materials on capital projects. MRM is intended to improve the visibility of data and responsibility across the supply chain to equip stakeholders with information for more efficient decision-making. MRM is very effective when multi-discipline and multi-stakeholders are affected by or involved in a project and can help seamless task execution. Using the MRM promotes CII's Best Practice of Advanced Work Packaging.

Previous research completed by CII research teams has found that project productivity and cost can benefit from AWP, with about 25% increase in field productivity and up to 10% decrease in total installed cost (CII/COAA 2015). The research team believes that project owners would be the best champion for implementing the MRM tool. The team identified a few methods to encourage continuity across stakeholders on a specific project:

- Provide contractual language to require or recommend implementing the Excel-based tool.
- Conduct alignment exercises during front end planning, including demonstrations of the tool.
- Clearly define the responsibilities and roles of stakeholders with regard to providing input data, updating data sets, and reviewing existing data sets – all using the prescribed requirements of the tool.

The team encourages project stakeholders to communicate AWP supply chain information by using the requirements provided in the digital threads, so other stakeholders in the supply chain and the industry will embrace the digital threads model.

The research team encourages users of the Material Responsibility Matrix to modify components to fit their specific project requirements better. The team has identified the following benefits for implementing supply chain digital threads:

- Increased alignment among stakeholders connected to the supply chain
- An increase in the visibility of supply chain information through the implementation of digital threads
- Improved data sharing among stakeholders across the supply chain
- Clearly defined project stakeholder responsibilities for materials

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