Exploring the Association Between Current State and Future State Technology-Mediated Collaborative Workflow

Christopher Bondy

Keywords: workflow, technology-mediated workflow, collaboration

Abstract

Advances in technology, coupled with continuous process improvement, have provided opportunities for expanded information exchange among key participants in the graphic communications value chain. The promise of more effective collaboration among all parties using enhanced workflow solutions is often compromised due to a variety of barriers that minimize the value of an integrated workflow. Understanding the association between the current-state workflow and future-state technology-mediated workflow can provide valuable insights into the barriers that impact effective collaboration and the benefits that result from improved graphic communications workflow. This paper will explore a generalizable method to qualify and to quantify the collaboration space between creators and producers in the graphic communications workflow.

Introduction

The graphic communications industry is in constant flux. To orchestrate increasingly complex workflows that are built to deliver a variety of cross-media solutions, new technologies are incorporated into the workflow and new processes are introduced. Service providers have become systems integrators, judicially acquiring a wide-range of equipment and software to configure unique workflows that deliver differentiated services. The interpretation of market requirements, the deciphering of best-in-class systems, and the integration of these elements into an optimized workflow create a high-stakes business concern for service providers.

Making a good decision on the acquisition of equipment or a software solution does not guarantee that the value proposition of each will ultimately resonate with the market nor contribute to the bottom line. The burden of technology selection

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and seamless integration into an optimized workflow falls largely on the shoulders of service providers. For service providers, as the complexity and diversity of technology required to deliver graphic communication services increase, so does the risk for realizing the value of their workflow investments.

Graphic communications workflows are typically built over time with two primary objectives: (1) the optimization of work processes (resulting in cost reduction), and (2) the introduction of new services (resulting in revenue growth). Optimizing workflow provides cycle-time benefit to both creators and service providers (i.e., producers), essentially presented as a time-saving benefit to creators and a cost-saving benefit to producers. Integrating new services provides expanded capability and features for creators, and new revenue streams for producers.

The graphic communications industry has a rich history of workflow integration along these two precepts of workflow optimization and feature enhancement. In order to realize the value of these new innovations, each technological revolution has enabled a new wave of capability that needs to be interpreted by producers and ultimately to be synthesized into their operation for creators. Producers with expertise in monitoring emerging technology and incorporating new technologies into prototype and production workflows have a competitive advantage. To successfully keep pace with the complexity of new technologies introduced in this digital era, graphic communications service providers need the ability to integrate new technology into their workflows.

Those service providers are balancing scarce resources, both in time and capital; thus, they seldom commit the resources or the process regimen to step through a major technology integration with a systematic approach in order to validate the contribution of workflow investments. This paper introduces the *Collaborative Space–Analysis Framework* (CS-AF), a method for evaluating the association between current-state and future-state workflow from both a qualitative and a quantitative perspective.

This research incorporates elements from four distinct disciplines to create the CS-AF, which can be adapted for use in any domain where a technology-mediated workflow is required (Figure 1). Unique attributes from each of the four disciplines provide a novel and comprehensive way to characterize and to evaluate workflow.

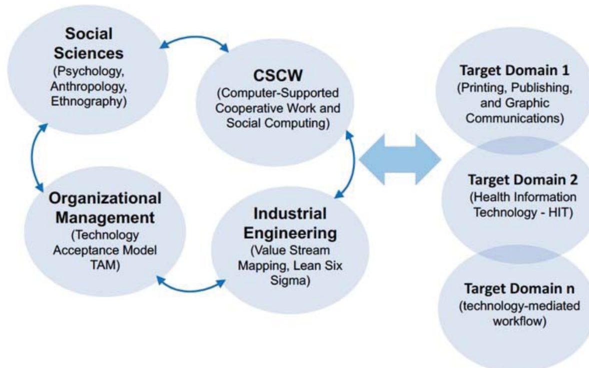

Figure 1: *CS-AF insights from four key disciplines.*

The four disciplines include (1) Social Sciences (e.g., ethnography, psychology), (2) Computer-Supported Cooperative Work and Social Computing (e.g., Lee & Payne's Model of Coordinated Action and Carroll & Rosson's Activity Awareness Model), (3) Industrial Engineering (e.g., Value Stream Mapping), and (4) Organizational Management (e.g., Technology Acceptance Model).

The formulation of the CS-AF incorporates relevant attributes from these four disciplines and a procedural methodology that can be replicated in a variety of domains.

This research is focused on the graphic communications (printing, publishing, and packaging) industry. Future research will aim to validate the generalizability of the CS-AF in other industries, such as the Health Information Technology (HIT) space. This research is targeted at graphic communications workflow. It builds off of prior work focused on the analysis and modeling of current-state graphic communications workflows. Excerpts from this work led to development and issuance of a workflow process and solutions engagement patent [4]. The prior research provides a foundational reference model (taxonomy) and seven use case workflow models that describe and catalog graphic communications and printing workflows. The graphic communications/printing workflows that were evaluated and encompass the primary traditional and emerging digital print workflows are:

- Static Offset Printing
- Hybrid Digital-Offset Printing
- Print-on-Demand
- Variable Data Printing
- Transactional Printing
- Web-to-Print
- Photo Services Printing

A deep understanding was gained from this in-depth ethnographic study of the graphic communications workflows (listed above) and, coupled with decades of domain knowledge, provided the foundational context to develop the CS-AF for targeted field use at a commercial printer site [1].

The CS-AF is intended to be used in a consistent manner to evaluate both an existing, current-state workflow and an enhanced, technology-mediated future-state workflow. The CS-AF data gathered from the current-state and future-state workflow assessments are analyzed (i.e., compared and contrasted) to formulate quantitative and qualitative views of the association between the technology-mediated workflow (i.e. the future-state) compared with the current-state workflow.

Collaborative Space – Analysis Framework (CS-AF)

The Collaborative Space – Analysis Framework (CS-AF) provides both a reference model and a structured analysis methodology to evaluate the association between current-state and future-state technology-mediated workflows. The CS-AF comprises five key components that are designed to direct the consistent collection of important data points regarding workflow. When comprehensive baseline data can be collected for a current-state workflow and are then compared with the same data points for a technology-mediated future-state workflow, a meaningful evaluation between the two workflows can be conducted.

The CS-AF provides a structured framework and a methodology to conduct a detailed workflow evaluation and comparison. The five sections of CS-AF are Context, Process, Technology, Outcomes, and Behavior.

1. CS-AF Context
   Identifying the *context* of the workflow refers to the collaborative user groups that work together, and to the specific settings and modality in which they work. Characterization of the workflow context provides a view into the intended scope or functional containment of the workflow, enabling more precise focus on the intended environment and conditions of the workflow.

   Lee and Paine's Model of Coordinated Action (MoCA) [7] provides a functional approach to describing the context of a collaborative workflow from seven key attributes included in the CS-AF. These attributes are *synchronicity, physical distribution, scale, communities of practice, nascence, planned permanence, and turnover.*

2. CS-AF Process
   The *process* element of the workflow refers to the specific sequential steps that are involved in the workflow. Each workflow has a number of discrete steps or segments that make up the unique set of processes required to complete a

specific work function. All workflows to be evaluated are divided into a series of sequential steps; this exercise provides better precision for the analysis of idiosyncrasies in the workflow.

An industrial engineering technique for measuring workflow time and information quality, *Value Stream Mapping* (VSM). [8], [9] is applied in the process stage. Each workflow step or key element of the process is first measured for time consideration, which includes cycle time (i.e., duration of task from start to completion), *lag time* (i.e., time that the workflow is held up waiting), and *total time* (i.e., entire time required for a workflow step). Quantitative data for the current-state and future-state workflow is recorded though the survey process.

In addition to evaluating process time, each workflow step is also evaluated from an information quality perspective in order to determine the accuracy and accessibility of information entry and retrieval as it pertains to users at each workflow step.

3. CS-AF Technology
   Davis's Technology Assessment Model (TAM) [5] is leveraged to assess external variables that affect *technology* adoption. Specifically, two aspects of the TAM are used for technology assessment. *Perceived usefulness* (PU) provides visibility into whether the workflow delivers optimized performance or not. *Perceived ease-of-use* (PEU) provides visibility into whether the workflow delivers freedom from effort. These technology acceptance data points are captured using a qualitative research survey for both the current-state and future-state workflow.

4. CS-AF Outcomes:
   Outcomes refer to primary and secondary objectives of the workflow as viewed by each unique participant in the workflow. *Awareness* and *common ground*, two key aspects of outcomes which are measured, are leveraged from the Activity Awareness Model of Neale, Carroll, and Rosson [10].

   Awareness refers to how individual users of the workflow feel others involved in the workflow are aware of their communications needs. Do they provide the information that is needed? Do they know when there is an information request?

   Common ground refers to how individual users of the workflow feel others involved in the workflow share mutual goal alignment with respect to desired outcomes of the workflow. The data points of outcomes are captured using a qualitative research survey for both the current-state and future-state workflow.

5. CS-AF Behavioral

The *behavioral* component is adapted from Davis's Technology Assessment Model (TAM) [5] and provides insights into the users' disposition regarding their attitude and behavioral intention associated with the workflow being evaluated.

Behavioral data points are captured using a qualitative research survey for both the current-state and future-state workflow. Questions provide insight into how users feel regarding the workflow. Do they like using the workflow? Questions also frame users' intent to use the workflow. Will they be using the workflow on a regular basis?

Those five integrated components of the CS-AF (Figure 2) provide a systematic method for evaluating the essential aspects of a technology-mediated collaborative workflow. Both qualitative and quantitative data can be extracted from a current-state and future-state technology-mediated workflow using the CS-AF and can be compared to determine the associated benefits and barriers.

The CS-AF expanded the concepts of the Collaboration Space Model (CSM) developed by Eikey, et al. [6], as a theoretical model incorporating a 25-year system-wide review of collaboration research in Health Information Technology (HIT).

The CSM provides a structure to investigate critical dynamics of collaboration in a workflow by incorporating the four collaborative components of Context, Process, Technology, and Outcomes. Each of these components, when fully integrated, provide a more expanded view of collaboration that can be used to evaluate workflows. Although the CSM is a theoretical model and has not been tested in field research, it was a catalyst for the development of the CS-AF, which is both a model and methodology for field use.

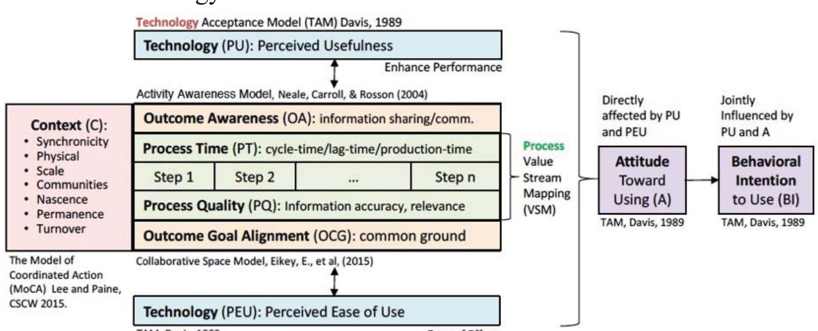

Figure 2: *Collaborate Space-Analysis Framework, CS-AF (Bondy, 2018)*

This research incorporates some aspects of the CSM and extends the scope and usage by integrating additional elements into the model and by designing a complete methodology for field deployment. The CS-AF (Figure 2), integrates context attributes from MoCA [8], components from the TAM (external variable, perceived usefulness, and perceived ease-of-use) [5], with VSM techniques [9], [10]. The CS-AF is a generalizable model and process methodology that is designed for field research to explore and to evaluate the association between current-state and future-state technology mediated workflows, and to derive meaningful qualitative and quantitative data from the process.

CS-AF Methodology

Part 1: CS-AF Workflow Steps and Qualitative/Quantitative Survey Design

The initial step in the CS-AF is to identify and document the specific process steps that are required for current-state workflow. Each workflow step is considered to be a discrete segment of the workflow that requires an action (input, process, and output) and advances the process forward to the next logical juncture in the sequential process from start to finish. Defining the process steps is an import aspect of the CS-AF as it provides the structured steps necessary for development of the qualitative and quantitative survey and data collection materials for the specific workflow.

The survey design is also a critical step in the CS-AF methodology since the survey instrument is custom designed for each workflow and is used to collect all workflow information that is included in Part 2 and Part 3 of the CS-AF methodology. Designing the survey instrument based on the CS-AF and the specific workflow process steps will provide a consistent methodology to evaluate and record all important aspects of the current-state and future state workflow.

Part 2: Current-State Workflow Analysis

Establishing a current-state workflow baseline is an essential step of the CS-AF. This includes identifying the key stages in the workflow and determining the cycle-time and information requirements of each stage and for the primary participants in the collaborative workflow. The integration of industrial engineering disciplines, such as VSM coupled with the use of the TAM, provide quantitative and qualitative data.

i. Determine the current-state workflow context (synchronicity, physical distribution, scale, communities of practice, nascence, planned permanence, and turnover).

- Establishing the context or setting for the workflow is essential since this effort provides boundary conditions, manages the scope, and ensures a focused effort in the workflow analysis. The MoCA [7] establishes seven dimensions that can be considered as a range or continuum for the workflow; for example, the synchronicity continuum ranges from activities that occur at the same time (i.e., synchronous) to activities that occur at different times (i.e., asynchronous). Evaluating the current-state workflow from a continuum across these seven different context dimensions establishes the framework for the workflow analysis.

ii. Determine the process metrics for the current-state workflow.
- Analyze the process aspects of the current-state workflow. For each workflow step, record process times: cycle time (start to finish time of each workflow step), lag time (time in between workflow steps), total production time (beginning to end of the entire workflow). Analyze the information quality requirements for key participants, information provided, information required, and identification of gaps; use VSM and use case models to collect this information [8], [9].

iii. Assess technology acceptance for the current-state workflow.
- Analyze the participants' perspective of the technology used in the current-state workflow based on two specific elements: (1) perceived usefulness, and (2) perceived ease-of-use [5]. Participants are presented survey questions in a 5-point Likert scale ranging from very important, slightly important, neutral, slightly unimportant, to very unimportant.

iv. Determine attitudes and behavior associated with the current-state workflow.
- Analyze the participants' attitude and behavior toward the technology used in the current-state workflow based on two specific elements: (1) What is your attitude toward using the technology incorporated in the workflow? (2) What is your intention to use the workflow/technology? [5].

v. Determine desired outcomes of the current-state workflow.

- Determine specific goals and information requirements for each step of the workflow (from two primary perspectives: awareness and goal alignment) [10]. Participants are presented survey questions in a 5-point Likert scale ranging from very aware, slightly aware, neutral, slightly unaware, to very unaware for these questions: (1) Awareness information sharing and communications: For each stage in the workflow, how aware do you feel people are of your goals? (2) Goal Alignment: Is there a shared common ground? How likely does the information quality meet your needs at each step in the workflow? How aligned do you feel people are with your goals at each step of the workflow?

Part 3: Implement Future-State Technology-Mediated Workflow

Through the iterative and agile software development process; define, develop, integrate, and validate the specific workflow enhancements aimed at optimization or expanded capability to the workflow.

- Utilize the information collected from the current-state workflow analysis (Part 2) to identify specific inconsistencies and inefficiencies that can be addressed (i.e., improved or eliminated) with a future-state technology mediated workflow. Specific enhancements to the workflow (including streamlining, integration or elimination of steps, improved information quality, and ease of use) should all be considered at this stage.

- Upon completion of a thorough workflow analysis, and prior to beginning development on the future-state workflow, a development plan (including a usability study and prototypes) should be completed and vetted with stakeholders and users.

- The future-state workflow can now be developed with specific design and workflow objectives established. To ensure that the optimization goals for the future-state workflow can be achieved with minimal disruption to the operations, adherence to an agile development process (including typical software development processes and controls) is essential in this step.

- Once development and a thorough design verification test have been completed, the future-state workflow can be staged alongside the current workflow and then deployed into mainstream operations as each step of the workflow proves to be complete and error-free.

- When the future-state technology-mediated workflow is fully implemented and operational, it is time to advance to Part 4 of the CS-AF.

Part 4: Future-State Workflow Analysis

Follow Steps 1-5 in Part 2 and conduct the qualitative and quantitative survey for the future-state technology-mediated workflow.

- For the future-state workflow, follow the same process and rigor established for the current-state workf low. It is imperative that the exact same qualitative and quantitative survey instruments are used with the exact same participants, such that the subsequent analysis is a direct 1:1 comparison, with the only variable being the technology-mediated future-state workflow.

Part 5: Tabulate and Analyze Results from Part 2 and Part 4

Compare and contrast the current-state and future-state workflow using the qualitative and quantitative approach from the CS-AF, analyze results, and formulate conclusion.

- Independently summarize the qualitative and quantitative results separately from the current-state and future-state workflows.

- Compare and contrast the results for each element of the CS-AF.

- Identify areas of optimization, as well as areas where tangible progress in the workflow, are negligible.

- Prepare a summary analysis of the workflow initiative.

Cohber Press Case Study: Sales Quote Process

Introduction and Problem Statement

Cohber Press is a third-generation commercial printing company in Rochester, NY, that specializes in a wide range of quality commercial print and graphic communication services. Like many traditional printing companies, Cohber is looking for ways to streamline their sales quote process to provide more immediate pricing and alternative job options for their customers.

Wide-scale use of the internet and cloud-based services by print buyers have heightened the need for printers, like Cohber, to emulate real-time and interactive quotations processes that empower print buyers to determine pricing as fast as possible.

The leadership of Cohber Press has determined that equipping their sales force and providing their clients with an automated cloud-based sales quotation system will increase their company's ability to be considered for more printing work than with their current semi-automated process.

The Sales Quote Quality Improvement Project:

The Cohber Press leadership team decided to embark on a quality improvement project to refine their sales quote system. This project included (1) an evaluation of their current-state workflow, (2) a definition of their workflow requirements, (3) the development of a web-based mobile application that provides a consistent and automated way for their sales representatives to capture the details concerning a customer print quote, and (4) an analysis of the impact of the technology-mediated workflow on the organization. (Note: The Cohber Press current-state workflow diagram is found in Appendix 1, the future-state workflow is illustrated in Appendix 2, and the technology-mediated development roadmap is in Appendix 3).

The scope and requirements for this workflow project for Cohber Press were directly aligned with the CS-AF methodology; they are indicative of most technology-mediated workflow improvement projects. Cohber Press agreed to participate with the current-state and future-state workflow analysis process using the CS-AF methodology, and they provided captive participants that agreed to conduct the appropriate pre- and post-surveys.

The specific CS-AF methodology described in this paper was followed at Cohber Press. The preliminary results are shown below in summary form for the Business Development Department (n=4 participants). The data from the sales department, customer service, and estimating departments have yet to be tabulated.

CS-AF Observations for Cohber Press Sales Order Workflow

The following analysis data reflects the information collected through CS-AF at Cohber Press from both the current-state and future-state surveys that were conducted. Each component of the CS-AF was evaluated. The specific analysis for each attribute of the CS-AF for the Cohber Press Sales Order workflow is summarized in the right column of each entry in the table below.

A summary of the relationship between the current-state and the future-state technology-mediated workflow follows.

CONTEXT	Current-State	Future-State	Analysis
Synchronicity	Synchronous/Mixed	Synchronous/Mixed	No change
Physical Distribution	Mixed	Mixed	No change
Scale	5 people	2 People	Reduce involvement of 3 people
Communities	4 Departments	2 Departments	Eliminated participation of 2 departments
Nascence	Routine	Developing	New emerging workflow
Planned Performance	Long-term	Long-term	No change
Turnover	High	Low	Reduced iterations in and out of the workflow

Table 1: *Context analysis between current-state and future-state technology-mediated workflow.*

PROCESS	Current-State	Future-State	Analysis
Number of Steps	10 Steps	7 Steps	3 Steps eliminated
Total Minimum Production Time (cycle time - all tasks)	3,346 min. 55.76 hrs. 2.32 days	1,545 min. 25.75 hrs. 1.07 days	Cut minimum production time more than in half (53.8%)
Total Maximum Production Time (cycle time - all tasks)	14,553 min. 242.55 hrs. 10.11 days	3,440 min. 57.3 hrs. 2.38 days	Cut maximum production time more than three-quarters (76.5%)
Production Time Rating	Neutral to Unacceptable	Slightly to Very Acceptable	Increased production time rating one-and-a-half categories
Process Quality Rating (quality/accuracy of info.)	Slightly Important to Very Important	Very Important to Slightly Important	Slightly better information quality for future-state workflow

Table 2: *Process analysis between current-state and future-state technology-mediated workflow.*

TECHNOLOGY	Current-State	Future-State	Analysis
Perceived Usefulness: How useful is the Technology used in the workflow?	Slightly Useless	Slightly Useful	Moved two levels more useful
Perceived Usefulness: Do you feel Technology can enhance usefulness?	Slightly Likely that the workflow can be enhanced	Slightly Likely that the workflow can be enhanced	Users perceived improvements can be enhanced from current-state to future-state workflow
Perceived Ease-of-Use: How useful is the Technology used in the workflow?	Slightly Useless	Slightly Useful	Moved two levels more useful
Perceived Ease-of-Use: Do you feel Technology can enhance ease-of-use?	Slightly Likely	Very Likely	Moved one level more likely that the technology can enhance ease-of-use

Table 3: *Technology analysis between current-state and future-state technology-mediated workflow.*

ATTITUDE and BEHAVIOR	Current-State	Future-State	Analysis
Positive opinion regarding the workflow	No	Yes	Users have more positive attitude toward future-state workflow
Perceives that using the workflow is good for them	No	Yes	Users perceive that the future-state workflow is better for them
Perceives that using the workflow is appropriate for them	No	Yes	User perceive that the future-state workflow is more appropriate for them
Intend to use the workflow in the next week	Yes	Yes	Users intend to use both workflows
Expect to continue to use the workflow in the future	No	Yes	Users expect to use the future-state workflow in the future

Table 4: *Attitude and Behavior analysis between current-state and future-state technology-mediated workflow.*

AWARENESS and GOAL ALIGNMENT	Current-State	Future-State	Analysis
How aware do you feel people are with your goals?	Slightly Unaware	Slightly Aware	Future-state workflow is two levels more aware of users' goals
How likely does the info quality meet your needs?	Neutral to Slightly Unlikely	Slightly Likely	Future-state workflow is two levels improved on info quality
What is your primary goal for the workflow?	Efficiency and accuracy Quote/estimate to win business revenue	Efficiency and accuracy Quote/estimate to win business revenue	Goals swapped in priority based on implementing a new workflow
How aligned do you feel people are with your goals?	Neutral (neither aligned nor misaligned)	Slightly Aligned	Future-state workflow is one level improved on goal alignment

Table 5: *Awareness and Goal Alignment analysis between current-state and future-state technology-mediated workflow.*

Conclusion

Using the CS-AF model and methodology to determine the association between current-state and future-state technology-mediated workflow proved to be an effective process for Cohber Press that yielded valuable qualitative and quantitative insights.

The CS-AF provided a structured and comprehensive approach to measure improvements to the workflow in meaningful business terms. The CS-AF provided unique visibility to the value gained through the technology-mediated development invested in the future-state workflow, compared to the "as-is" or current-state workflow. Through the quantitative analysis, the CS-AF was able to demonstrate true return on investment (ROI) data, as well as qualitative behavioral insights into the receptibility of the new workflow from the viewpoint of intended users.

The following summary points were derived directly by the use of the CS-AF model and methodology:

- Cohber optimized their workflow and substantiate the development investment. They reduced their minimum production-time by 53.8% (from 2.3 days to 1.07 days) and maximum production-time by 76.5% (from 10.11 days to 2.38 days). Optimizing workflow and reducing production-time is paramount for Cohber Press; with a daily gross revenue budget of $36,900 per day, delivering finished goods to clients is less time has a direct and positive impact on the company's cash flow. The optimization gained in sales quote cycle-time proved to provide meaningful business value to Cohber Press.

- Using the CS-AF Cohber was able to identify design gaps, and optimization opportunities, refine their sales quote workflow, and quantify future improvements.

- Using the CS-AF helped Cohber to better understand the context of the workflow, attitudes, and the behavior of users. These insights helped advance user-adoption and overall user satisfaction.

- Documenting, qualifying, and quantifying the benefits of technology-mediated collaborative workflow provided insights into the cost/benefits of the workflow investment benefits and helped everyone to comprehend the value of the technology-mediated workflow development effort.

Future Work

The CS-AF was designed to capture valuable metrics associated with a current-state workflow in such a manner that this information can be used to measure and to compare technology-mediated investments aimed at future workflow optimization. A future goal for the CS-AF is to refine the model, methodology, survey development, tools, and analysis process for the CS-AF to be used as a generalizable model for analysis of any workflow (current-state – future-state comparison). Future work is targeted to refine and test the CS-AF in other diverse workflow scenarios, while continuing to work in the graphic communications industry.

Future work includes a focus in these areas.

- Additional workflow studies conducted in other areas of the graphic communication value chain using CS-AF.

- Refinement of the CS-AF model, methodology, and process optimization (survey design, data collection, data analysis, and tools) for more efficient use.

- Testing of the generalization of the CS-AF model and validate its use in other industries, specifically the Health Information Technology (HIT) industry.

Appendices

Appendix 1: Cohber Press Sales Quote Current-State Workflow

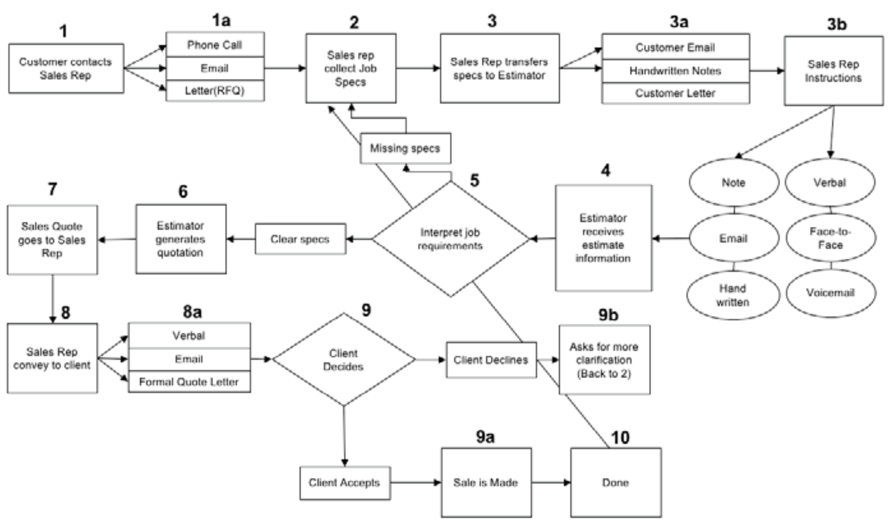

Figure 3: *Cohber Press 10-step current-state workflow derived from on-site Value Stream mapping analysis.*

Appendix 2: Cohber Press Sales Quote Future-State Workflow

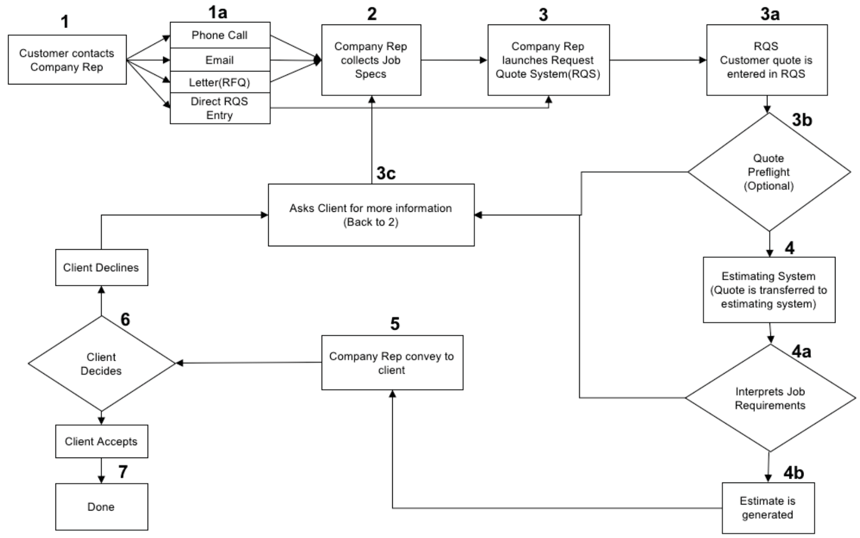

Figure 4: *Cohber Press 7-step future-state sales quote workflow derived from on-site Value Stream Analysis.*

Appendix 3: Future-State Technology-Mediated Workflow Development

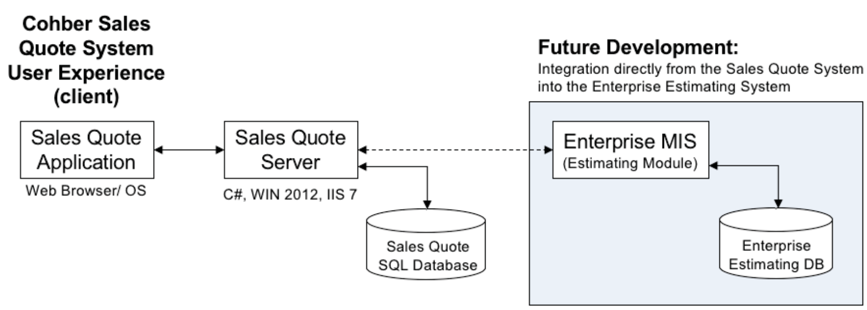

Figure 5: *Cohber Press future-state technology-mediated workflow development model.*

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