

ELECTRI International Contract No. 11-02
Innovative Uses of Native CAD Files
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Summary of the Literature Review

Literature reviews were conducted on the two main topics of this research: On-Screen Estimating and Native File Sharing. The bulk of the reviews took place October 2010 through June 2011 to monitor whether any additional literature has been published during this timeframe. Furthermore, a more general literature review was conducted on the topic of how contract and compensation structures drive sharing behavior at the individual and company levels.

The literature review aided the researchers in determining that there were no articles in academic journals that focus directly on “native file sharing” in the construction industry (essentially the sharing of CAD files). The literature review also did not locate any journal articles examining on-screen estimating software that were relevant to our specific area of research. One paper was found that is nearly ten years old that examined a very crude on-screen estimating tool used in automotive manufacturing, but it doesn’t contain any knowledge that can be applied to our topic. The results, while discouraging, support the need for more research specifically on the topics of sharing of native CAD files and on-screen estimating tools.

When considering the broader concept of “information sharing” (particularly, “sharing behavior”), two interesting theories were discovered during an extensive literature review: *Social Interdependence Theory* and *Regulatory Focus Theory*. These theories evolve from social psychology and appear to be promising in explaining the sharing behavior of owners and designers, because, as noted during our early research, discovering why people share information and also why they don’t share information has become the most difficult question to answer.

Johnson (Johnson, 2003; Johnson & Johnson, 2005; Johnson et al., 2006) summarized *Social Interdependence Theory* in several excellent articles. The premise of *Social Interdependence Theory* is that the way in which goals are structured determines how individuals interact, which in turn creates outcomes. Positive interdependence exists when there is a positive correlation among individuals’ goal attainments; individuals perceive that they can attain their goals if and only if the other individuals with whom they are cooperatively linked attain their goals. Negative interdependence exists when there is a negative correlation among individuals’ goal achievements; individuals engaged in such processes perceive that they can obtain their goals if and only if the other individuals with whom they are competitively linked fail to obtain their goals. Deutsch (1949) posited that positive interdependence results in promotive interaction (i.e., individuals encourage and facilitate each other’s efforts to complete tasks in order to reach the group’s goals), whereas negative interdependence results in oppositional interaction (i.e., individuals discourage and obstruct each other’s efforts to complete tasks in order to reach their goals). Promotive interaction is characterized by individuals engaging in such actions as providing each other with efficient and effective help and assistance and exchanging needed resources such as information and materials. Negative interdependence typically results in individuals opposing each other’s success. There is considerable evidence, therefore, that cooperative efforts tend to promote greater efforts to achieve, more positive relationships, and

greater psychological health than do competitive or individualistic efforts. Cooperation tends to induce and be induced by mutual assistance, exchange of needed resources, and trust. Competition tends to induce and be induced by obstruction of each other's success, tactics of coercion and threat, enhancement of power differences, deceptive communication, and striving to "win" conflicts. There is evidence that positive interdependence tends to motivate individuals to try harder, use higher level reasoning strategies more frequently, and develop new insights and discoveries more frequently. Social interdependence theory has been used as a guide for creating concrete practical procedures in education, business, and mediation, to name a few applications, and it shows considerable potential for explaining the sharing behaviors of stakeholders to the construction process.

Regulatory Focus Theory, when applied to contract structure (Weber & Mayer, 2011), differentiates between a prevention focus and a promotion focus, each of which leads to different (1) interpretations of goals in the exchange, (2) emotional and behavioral reactions to the contract structure, and (3) views and expectations of the exchange and the relationship. A prevention focus leads to an interpretation of a goal as minimal (something that must be met). Thus, under a prevention contract focus, all parties display vigilant behavior in the exchange in an effort to avoid missing the minimal goal (i.e., making a profit, meeting a deadline, etc.). The focus on detecting negative behavior in the exchange leads to neutral or negative emotions, which form the basis of arm's-length relationships. Most research on contracts tend to view them as prevention-focused devices, which induces vigilant behavior in all parties to prevent potential opportunistic behavior (Ghoshal & Moran, 1996; Malthotra & Murnighan, 2002). Conversely, under a promotion focus, parties view the same goal as maximal (something that would be ideal if reached). Thus, in an effort to reach the maximal goal, parties display more flexible and creative behavior. Promotion contracts focus on positive behavior in the exchange, inducing positive emotions, which set the stage for closer ongoing relationships. Thus, the decision to frame a contract in a prevention or promotion manner impacts both the contractual exchange and the broader relationship between firms.

The interviews conducted thus far with owners, designers, and electrical contractors have documented a variety of information sharing behaviors and, likewise, a range of reasons for sharing or not sharing information. Based on *Social Interdependence Theory* and *Regulatory Focus Theory*, the researchers are currently working to establish a plausible explanation for the patterns of behavior examined in order to develop practical advice to all parties on ways to improve the information sharing process that might make sharing of native CAD files possible, and more widespread, in the future.

In non-academic but nonetheless important trade publications, there have been a few articles written on the topics of file sharing in the construction industry and on-screen estimating. One individual who has addressed this issue is Stan Shook of Electrical Contractor Magazine, who, for over 15 years, has focused exclusively on estimating in electrical contracting. He enthusiastically endorses the use of on-screen estimating, as opposed to estimating by hand, and also sees potential in the more sophisticated automated estimating software, although he is reserved in his judgment about its omniscient power as an estimating tool.

On the topic of file sharing in the construction industry, there have been numerous articles written from the legal perspective of sharing. One such article published in Cadalyst's CAD Manager is by a CAD Sharing Consultant Robert Green. Mr. Green advises designers to essentially never share their .dwg files unless specifically required to do so and to have strong

legal contracts with the parties involved when they must share their files. While, on the surface, this might make legal sense, a lack of sharing of information has been tied to countless anecdotal problems during construction and does not promote efficiency in the construction process. By applying Regulatory Focus Theory to our problem of sharing of information (or lack of sharing), part of our future research will be to investigate how much of a role, if any, these legal perspectives and structures play in decisions about whether or not to share native files.

Progress Update on the Environmental Scan and Research Interviews

Between December 2010 and June 2011, Steve Kleps (research assistant) conducted a total of 22 interviews with the major parties involved in electrical design and construction. Because our travel budget is extremely limited, all of these interviews were conducted in Illinois. Nearly all of these interviews were conducted in person, but a few were conducted over the phone when meeting in person proved too difficult for the participant. The breakdown of the parties interviewed is as follows (please note that they do not add up to 22 because we interviewed three of the companies twice as the research progressed):

- Electrical Contractors (EC's): 8
- General Contractors (GC's): 2
- Architects/Engineers (A/E's): 4
- Large or Repeat Owners: 3
- Other Industry Experts: 2

Based on these interviews, we have developed a few preliminary findings.

1. Technology in the electrical design and construction industry and the company protocols that accompany this technology are changing fast. For example, when Steve first starting making initial contacts with EC's in the late summer and early fall of 2010, a number of them were unhappy that owners were still issuing paper drawings as opposed to PDF drawings. This made their estimating more time-consuming, especially if they were using on-screen estimating software. Of the people interviewed more recently, we have not encountered anyone still providing paper-only drawings and some owners have deliberately switched to PDF documents. Furthermore, most of the ECs have purchased a Total Station Trimble device within the last 18 months. The EC's have been very pleased with this device because it saves them time in the field for their layout, but it does require that they get the DWG files from the designer post-bid thus making this part of the sharing process even more critical.
2. One surprising finding is that there is not a big demand for native DWG files during the pre-bid stage. Rather, the demand for DWGs appears stronger during the post-award stage or during design-assist efforts. We asked contractors how they were currently using native DWG files during estimating, AND how they would use them if they could get them from the owner or designer. Most contractors reported that they were estimating satisfactorily by hand using paper documents or by employing on-screen estimating software using PDF documents. The contractors that estimate by hand indicated that they can use the PDF to print whatever size sheet they would like to estimate with and don't have to deal with any potentially confusing layers that might be in a DWG format. Contractors that use on-screen estimating software have only used the versions that require PDF as opposed to DWG. They are satisfied using the on-screen estimating software without the 'auto count' feature that

would be enabled if they had a DWG file. *Consequently, one of the largest barriers to receiving the native files is the lack of demand for such files from ECs.*

On a typical job this would likely mean that ECs are issued a PDF pre-bid and they get the DWG files post-bid. The rare exception to this is when the designer does not share the DWG files post-bid because the owner didn't contractually require them to do so.

3. There is a surprising juxtaposition in the use of the most current software in the electrical contracting industry. On one side, ECs are embracing the BIM concept, appreciating both the 3D coordination and the prefabrication possibilities that it can provide them and in turn willfully providing the large amount of technical manpower that BIM requires. In contrast, often at the very same company, many of the ECs are still estimating by hand either because they aren't aware of the benefits of on-screen estimating software or because they have evaluated the software and have decided against it. This was a very surprising finding.
4. The designers' views on sharing or not sharing native files vary significantly based on the type of job (public vs. private, highway v. commercial, etc.), the concerns of the lead designers within the company, and company policy (although this was harder to tease out of the interview). On one end of the spectrum are the designers that are very willing to share and/or will defer to the opinion of the owner. On the other end are the designers that do not want to share their files at all. Most of these designers consistently verbalized their concern about liability for errors and omissions as one of the primary reasons for not wanting to share native files. However, when required by the owner, all designers expressed a willingness to share (because they were contractually required to do so). We are currently searching for patterns in the sharing/non-sharing behaviors learned about in our early research and will likely focus more on this aspect in the next phase of the research.

As this research continues, we will be focusing on interviewing many more designers and large owners to gain additional insight into why some are sharing native files and others are not. We believe this is a profoundly perplexing question that needs much further exploration and getting to a plausible explanation will help us develop strategies for movement toward greater information sharing in the construction industry.

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