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Managing Specification Information Flow Through the Residential Construction Process

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To increase their profitability in a market that continually is becoming more competitive, builders must find ways to use technology to improve the effectiveness of their communication. The problem is that residential contractors lose profits as a result of inefficiencies and mistakes that are made because of poor communication of specification information through the construction process. The purpose of the study was to develop a specification information flow model and computer program which could provide a framework to convert large amounts of construction specification data into useful information for builders, suppliers and subcontractors, thereby increasing production efficiency and effectiveness. A series of interviews with residential builders was used to develop a specification information flow model. The information flow model was evaluated for conceptual correctness and completeness. Implementation of the model was accomplished through the development of a computer application to control and organize customer specification information. The builders' assessment of the software confirmed that the model greatly facilitated the organization and management of specification information and would improve communication efficiency and effectiveness. It was found that a communication system based on a project's schedule was an effective method of managing residential specification information.

Key Words: Specification Information Flow, Residential Construction Management, Computer Integration

Introduction

The demand to improve performance in construction is driven by increasing competition and declining productivity (Brown, 1983; Donohue, 1995; Rouda, 1993). To improve construction productivity, builders must focus on specific areas where daily operational and management tasks and procedures may be streamlined to be made more efficient.

Construction has been described as the process of converting inputs such as capital, labor, material, and technology, into outputs such as products and services. Koontz, O'Donnell and Weihrich (1984) described the construction operation as being a transformation process. Through planning, organizing, staffing, leading, and controlling, inputs from the environment are transformed into outputs (products) for use by consumers. Their approach demonstrates that the successful transformation process depends upon an effective communication system.

The primary role of a contractor is to process and communicate information. "In order to successfully plan and subsequently control the building process, the construction firm must collect, process, and interpret vast amounts of information and data. In fact, one might define a

contractor as a 'manager of information'" (Adrian, 1985, p. 5). Adrian pointed out the importance of information management in the building process; "One can state that contractor financial failure can be traced to data collection/processing functions more often than marketing or production causes" (Adrian, 1985, p. 5). For building companies to be successful, they must be able to keep accurate and current information in not only the accounting areas but also in all areas of the business (Donohue, 1995; Schleifer, 1990; Shinn, 1993).

One aspect of construction communication deals with the communication link between the customer, the construction manager/superintendent, and the subcontractors and suppliers. According to T. Clydesdale (1993) from Home Builder's Institute, the National Association of Home Builders estimated that there are approximately 29,000 items that must be accounted for during the construction of a new home. Building specifications and customer selections describe the colors, models, sizes, and delivery requirements for these items. These items are part of nearly 100 scheduled construction activities. Approximately 50-60 suppliers and subcontractors are involved with providing and installing materials for each new home. Construction managers must gather information from homebuyers about what they want their new homes to be like. This information must then be interpreted into construction terms, documented, organized and sorted, and communicated to the appropriate suppliers and subcontractors. The responsibility to communicate these specifications accurately and efficiently for each home is a demanding job. The concern is that when building 5, 50, 100 or more homes per year and combined with all of the other responsibilities related to managing a construction job, the communication task alone is very taxing.

The added and uncontrolled costs due to mistakes during the construction process are deducted directly from projected profits. For example, the roofing on a home represents one to two percent of the total cost of construction (Shinn, 1995). A seemingly small problem such as a miscommunication about the color of a home's shingles could ultimately cost a builder 50 percent of the typical profit for the home (Ibid.). Even if the mistake were discovered before the shingles were installed, the builder would suffer the costs of restocking the shingles and a delay in construction time. Assuming that oftentimes there are several communication breakdowns during the construction of a home, it is understandable that these wasted expenses could consume much of a builder's profit. If one were to multiply these costs by the number of homes the contractor builds in a year, the loss of revenue would be startling. The builder should not only be concerned with the monetary loss, but also with the loss of reputation that accompanies such mistakes.

The burden of organizing and communicating customer specifications through the residential construction process is very expensive in terms of the time needed for the process and the expenses due to errors in communication. Some residential contractors are experiencing expanding markets where the demand to build more homes is increasing. With this increase in workload, these contractors are required to organize and process more information. They can accomplish this either by hiring more people to help with the workload or they can find more efficient ways to use tools that are already available to accomplish the task. The apparent costs of hiring more employees may seem to be the same as the costs associated with implementing new technology; however, this may not be true. For example, payroll expenses carry the additional overhead burden of taxes, insurance, and other benefits that are paid to employees.

Training new employees is expensive in terms of time and money and new employees are prone to make more mistakes. Another problem with adding employees is that residential construction markets are cyclical. Many contractors avoid hiring during boom markets to avoid having to lay off employees during anticipated down cycles.

Problem Statement

To increase their profitability in a market that continually is becoming more competitive, builders must find ways to use the tools of technology to improve the effectiveness of their communication. The problem is that residential contractors are losing profits as a result of poor communication of specification information through the construction process.

Purpose of the Study

The purpose of the study was to develop a specification information flow model which would provide a framework to convert large amounts of construction specification data into useful information for builders, suppliers and subcontractors. The information flow model was used to develop a computer application that would facilitate the organization and control of specification information thereby improving communication efficiency and effectiveness.

Research Questions

Breaking the research problem into separate components facilitated the development and computer implementation of a model information flow system. The following research questions assisted in the development and implementation of the specification flow model.

1. What are the components of an effective specification communication system and how can they be applied to a residential specification information process flow model?
2. What components of the specification information process flow model can be integrated into a computer software application?
3. To what extent does the software computerization of the specification information process flow model impact efficiency and effectiveness in communicating specification information?
    a. To what degree is the software perceived to require more or less time?
    b. To what degree is the software computerization perceived to save or cost money?
    c. To what magnitude is the software computerization perceived to be more or less accurate?
4. What is the level of ease with which the user can operate the software?
5. To what extent is the software perceived to be able to accommodate the management of custom specification needs?

A review of literature and other research failed to produce any acceptable instruments which could suitably aid in answering the research questions. A questionnaire was developed to extract

the information needed to answer the research questions. A distinct jury of six residential construction experts who evaluated each question based on its content determined the face validity of the survey instruments. Each jury member was asked to judge each question as to its appropriateness to the study, whether or not the statement led to a particular response, and whether or not each question was clearly written and avoided ambiguity. Jury members were allowed to make additional comments on each item

Specification Information Flow Model

An initial builder survey was conducted to find answers to the first research question. Custom homebuilders were categorized according to the number of homes each built per year. Builders were divided into small volume builders, those who built 5 to 19 homes per year, medium volume builders, 20 to 79 homes per year, and large volume builders, 80+ homes per year. An interview with each of six builders who participated in the study (two from each category) was conducted to learn what builders were presently doing to gather, organize, and communicate specification information and what elements were essential for a specification communication flow model. Builders were asked to evaluate the effectiveness and efficiency of their own systems and to provide recommendations that would improve their systems.

Although the responses varied between builders, many responses were similar. All used a written contract to validate the sale of the home, whether it was a standardized real-estate sales contract or a custom contract for their own company. Each builder had some system developed to handle specification information. Some systems were as simple as putting all notes into a file under the customer name. Other systems were more sophisticated; for example, one builder had an elaborate system to organize all the specification information before construction started. The process, however, took several hours to complete by hand for each house.

Most of the builders gathered specification information from their customers during personal interviews. The information was typically gathered during pre-construction conferences or during a series of customer meetings.

The builders thought that their information systems could be improved but were not sure exactly how. While only one of the builders was still doing business without a computer, all thought that computerizing their specification information would help them to become more efficient. Some thought that their greatest unforeseen costs were those created by mistakes from deficiencies in their communication systems.

Creation of a Specification Information Flow Model

A model of the specification information flow was created (Figure 1) that included databases for buyer information, lot information, custom options, subcontractor and supplier information, schedule information, and a plan database that included the allowances for each plan. A sales summary sheet was used to help with the selection of information to be included in the sales contract. An addendum sheet was used to select options and colors from the options, colors, and

cost database. As options and colors were selected, costs for the upgrades or credits for less expensive choices would also be shown.

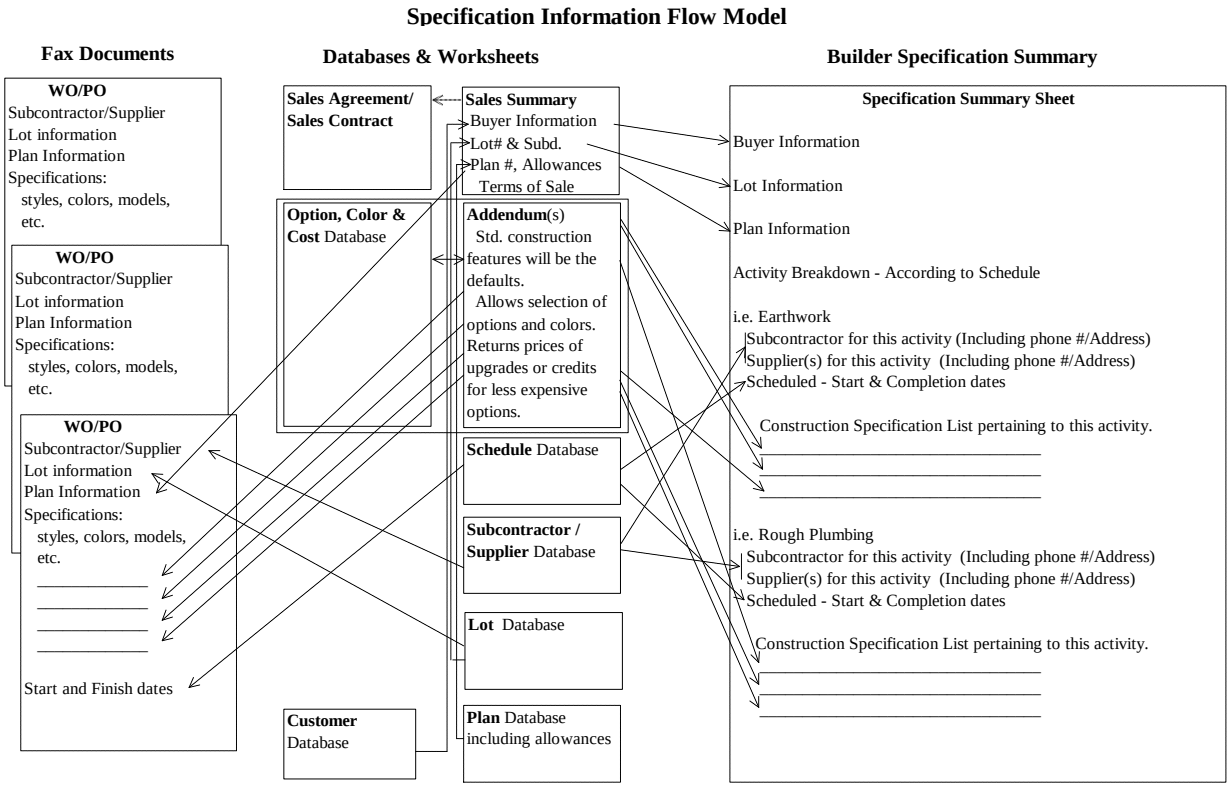

Figure 1. Specification Information Flow Model

The Builder Specification Summary report (Appendix A) is the main report for builders' use. It summarizes, according to the production schedule, all of the information needed to build the house. On it were recorded buyer, lot, and plan information. A list of construction activities including scheduled start and completion dates, the supplier/s and/or subcontractor/s associated with each activity, and any specification information pertaining to that activity.

Another important set of reports that are included in the information flow model are work orders and purchase orders to be mailed or faxed to the subcontractors and suppliers (Appendix B). These orders contain specification, lot, plan, and schedule information that the subcontractors and suppliers need to complete their jobs.

Validation of Specification Information Flow Model

The builders involved in the study were asked to judge the model for wholeness (completeness) and conceptual correctness (suitable for use) (Reingruber & Gregory, 1994). After reviewing the specification information flow model, the builders were asked to indicate their attitude relative to the completeness or wholeness and accuracy of the model.

The first survey question measured the wholeness of the model. The average response to this question, "Do the attributes of the model adequately describe the full scope of specification communication flow from the customer through a residential construction company to the subcontractors and suppliers?", was 6.0 (Seven was the maximum on the Likert scale). The second survey question measured the model's conceptual correctness. The average score for this question, "Does the model portray an accurate representation of the real world as it applies to specification information flow in residential construction companies?" was 6.3.

A Computer Application Of The Specification Flow Model

To answer the second research question, the flow model was used to develop a software application using Microsoft's Excel, Word, and Project. Microsoft products were chosen for two reasons; first, they are used by many builders (NAHB, 1994), and second, this software utilizes Object Linking and Embedding (OLE), a method of sharing information between programs. The procedural code was written using Visual Basic for Applications.

Application Walkthrough

The software application begins at the Sales Contract Summary sheet (Figure 2). This sheet allows the builder, with input form the homebuyer, to select pertinent information that will be used in the sales contract. The builder can retrieve information about the buyer if the salesperson has previously entered the buyer information into the database. The builder selects the customer by clicking the mouse over the correct name and clicking on OK. The associated customer information is automatically brought into the summary sheet.

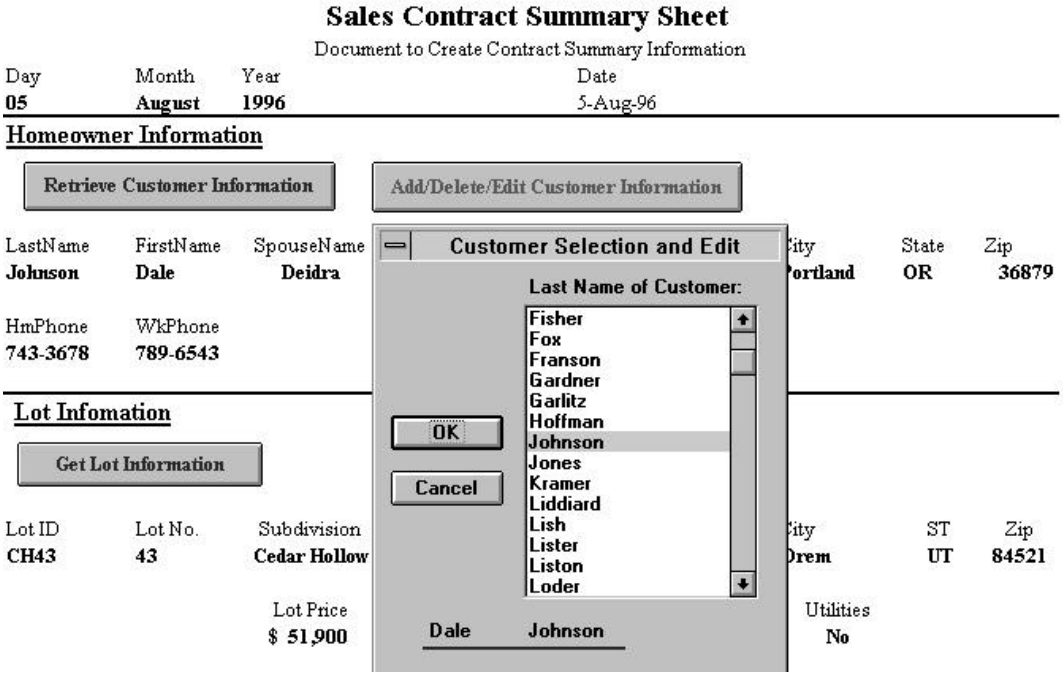

Figure 2. Retrieving Customer Information

Otherwise, the program allows the builder to enter the buyer information if the customer information is not yet in the database. Customer information can also be edited and deleted by clicking on the edit/add/delete button. Information about the lot and plan is handled in the same manner.

The plan information also contains the allowances included with specific plans (Figure 3). Adjustments to the allowances can be made. The base price of the plan and adjustments to the base price (adjustments to the allowances) is automatically added to the lot price to give the sum total of the contractual purchase price. If the buyer is in agreement, the Update Files button is clicked and a new work file for the lot (CH43 - Cedar Hollow lot 43 in this case) is created.

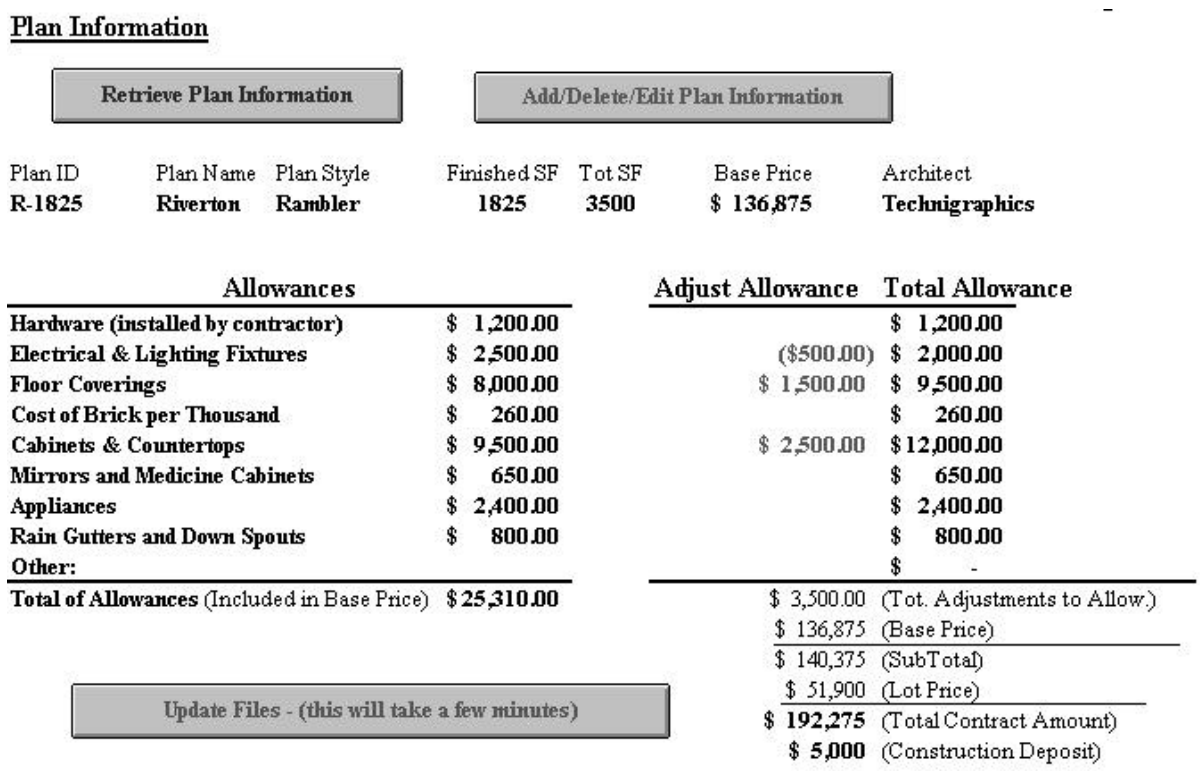

Figure 3. Working With Plan Information

The program then switches to Microsoft Word and the standard contract form is updated with all of the essential information from the Contract Summary sheet.

While the customer is with the builder, or at a later date, custom (or option) selections can be made using the Addendum sheet (Figure 4). The Addendum sheets summarizes the buyer, lot, and plan information and allows the customer to select from all options offered by the builder. By selecting the item to be changed and clicking on the bar on the left hand side, an option selection menu comes up which allows the user to add, delete, and select options from the database.

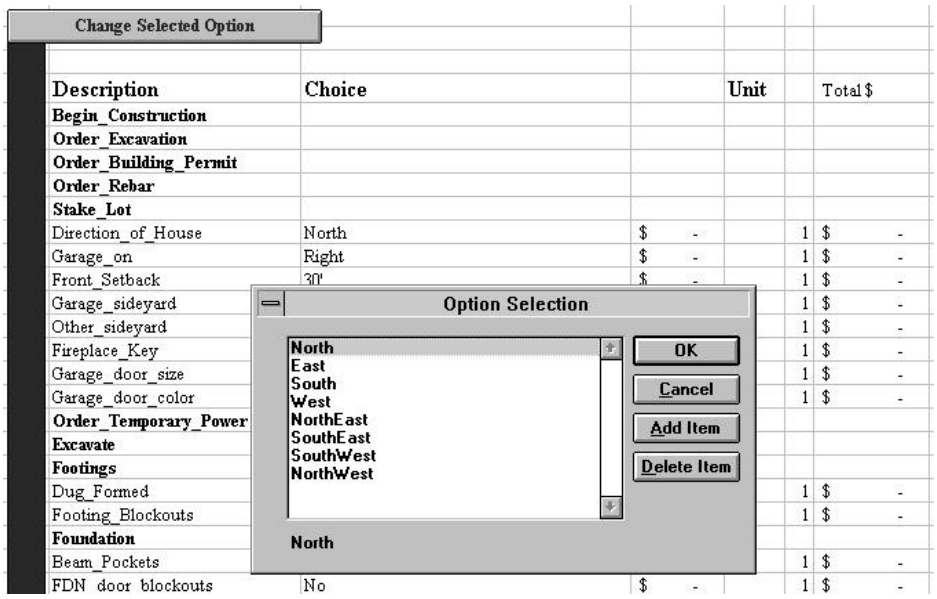

Figure 4. Selection of Options

Upgraded items will show an added cost and the upgrades will be totaled at the bottom of the addendum. Downgrades will be credited from the total. Once the buyer has selected all of the options (colors, styles, other specifications for the house), the total of the upgrades/downgrades is added to or subtracted from the original contract price of the house. The buyer/s then sign/s the addendum and it becomes part of the contract documents. The buyer is done and leaves the office.

The builder now begins to make selections of the subcontractors and suppliers who will be employed to complete the house. The Subselect sheet (Figure 5) is used to make the selection process faster.

Activity	Index	BusinessName	Contact	Phone	Phone2	Work
Termite	111	Recto Pest Control	Nathan Backman	545-8488	354-5456	Termite
VA/FHA Inspector	42	FHA	Nathan Russel	658-8210	580-5698	VA/FHA Inspec
Lumber	18	BMC West	Eric Healey	252-3000	580-6632	Lumber
Exterior Doors	5	Ace Doors	Brian Pratt	848-9554	854-6543	Exterior Doors
Windows	68	Jones Paint and Glass	Russel Jones	496-5887	463-558	Windows
Grading Labor	72	Kendall Jackson	Kendall Jackson	368-5899	0	Grading Labor
S & W	100	Jenson's Plumbing	Mike Carter	848-5433	843-6461	S & W
General Labor	141	Walter Jennings	Walter Jennings	545-8545	848-5466	General Labor
Plumbing	142	Wasatch Plumbing	Bill Quincy	848-5456	526-4156	Plumbing
City Inspector	96	Provo City	Bergen Merrill	547-8547	0	City Inspector
Flatwork	64	Jerry Monson Construction	Jerry Monson	459-6894	480-6589	Flatwork
Framing	104	Quality Framing	Frank Tenison	845-9953	848-3546	Framing
Roofer	71	Kelly Roofing	Kelly Baker	844-5466	545-2316	Roofer
Roofing	139	Valley Roofing	Guy Reynolds	321-6554	632-5622	Roofing
HVAC	55	Heating Systems	Stan Letterman	848-8984	545-5221	HVAC
Electrical	148	Wire Co.	William Peterson	545-5845	545-8858	Electrical
Cabinets	101	Quality Cabinets	Frank Osmond	525-5588	0	Cabinets
Fireplace	44	Fireplace Inc.	Harry Oaks	545-5454	361-8462	Fireplace
Insulation	116	South Town Insulation	Sally Nelson	545-6545	545-9874	Insulation
Drywall	120	SheetRockers	David Roland	232-8844	545-8885	Drywall
Garage Door	83	Martin Doors	Jed Anderson	636-6955	362-5968	Garage Door
Finish Lumber	26	Cubco	Jared Wilson	378-6554	0	Finish Lumber

Figure 5. Subcontractor and Supplier Selection Sheet

If, for example, the builder wanted or needed to select a new framer for this job, he or she could do so by selecting the Framing trade box and then clicking on the selection bar on the left. All framers from the Subcontractor/Supplier database are selected and the builder clicks on the number of the framer that will be used (Figure 6). If a subcontractor or supplier does not appear on the list, they can be added. Existing information can easily be modified or edited.

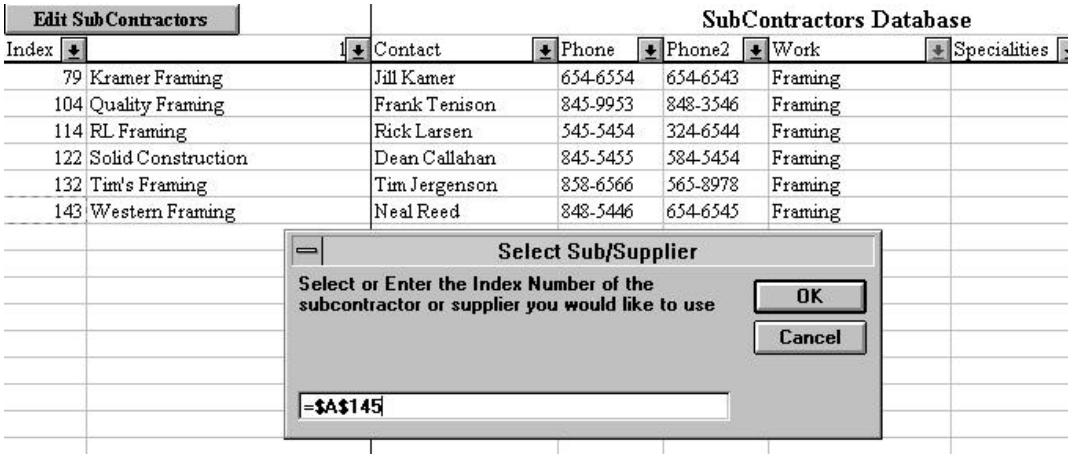

Figure 6. Selection of Individual Subcontractors and Suppliers

A baseline schedule was created in Microsoft Project as a standard for building the houses to a time scale. The baseline schedule can quickly and easily be modified and adjusted to meet existing requirements for specific houses. The construction start day can be changed as well as activity duration lengths. The new schedule is saved under the job identifier (CH43.mpp in this case).

The builder can now create the reports that will organize all of the specification and database details into useful information. The first of these reports is the Builder Specification Summary sheet (Appendix A). This report summarizes the buyer, lot, and plan information. It organizes all specification information according to the schedule. Schedule dates are given for each construction activity along with the subcontractor and or the supplier and all contact names, telephone, and mailing information. If the schedule needs to be adjusted during the course of construction, the dates on the Builder Specification Summary sheet can be updated by clicking the update button. Any changes of specifications, subcontractors, suppliers, etc. are automatically reflected in the appropriate place in the Specification Summary sheet.

The second major set of report documents are the mail-in or fax order sheets that will go to each of the subcontractors and suppliers involved in the construction of the house (Appendix B). These sheets act as work orders or purchase orders and detail all of the information required of the subcontractor or supplier to complete their part of the job including job address, lot number and subdivision, plan information, style, colors, model, special information, and dates for starting the work or delivering a product. These work orders and purchase orders can be faxed out all at one time or in batches to allow for changes and/or corrections to the schedule. Again, any changes to specifications, subcontractors, suppliers, or updates to the schedule are automatically reflected in these documents. The whole process of selecting and organizing information can

take as little as 45 to 60 minutes depending on the amount of time the customer takes to decide on options.

Software Efficiency and Effectiveness

To answer the third research question, "To what extent does the software implementation of the specification flow model impact efficiency and effectiveness in communicating specification information", the trial project was demonstrated to six residential builders. Each was allowed to interact with the program and ask questions about its operation. When the simulated exercise was completed, builders evaluated the program compared to their current method of communicating specification information.

The builders were asked to indicate the extent to which the software computerization would require their companies to spend more or less time. The average response was 6.2 (Seven was the maximum on the Likert scale). All thought that the software would require the builders to spend less time. They were asked how much time the software would cost or save each builder. The average hours expected to be saved per house, according to the responses of the six builders, was 16.

Comments from builders included; "set-up time would take some time, but once we are set up," "the project would go 10 times better," "the communication factor between the builder and the owner would increase 10-fold," "it's nice because once it's done, it's done," "software is friendly, hopefully less mistakes are made because the software tells you your critical paths," "looks like a great system, and depends on the skill level of your personnel".

Another question asked the builders to indicate the extent to which the software computerization would require their companies to spend more or less money. The average response from the builders was 6.0. The average savings was estimated at $2,467.00 per house. This figure seemed to be a hard one for the builders to estimate. Part of the savings were estimated based on the amount of time saved, and part was based on estimated costs saved as a result of reducing errors during construction. Values ranged from $250.00 to $10,000.00 per house.

Comments from builders included, "The program would save on mistakes such as ordering the wrong countertop colors," "Running-around time would be decreased and working with subs and owners would be a lot easier," "Based on the controls of a builder's current system, some could save thousands of dollars," "The biggest savings comes as a result of items not missed -- where you have to go back and fix them, " and "The time savings would be found in doing the job right the first time".

The builders indicated the extent to which the software computerization would be more or less accurate than their current methods of management. The builders' responses averaged 6.2. Comments from builders included; "It would always be only as accurate as the input but having this information always available and not relying on memory would save on mistakes," "You have to think to input into the computer. The information, hopefully, is making it (the process) more accurate," "It would save even on reconciliation and duplication and on items such as

telephone time, work, and mistakes," "It would be a lot more accurate than what we are now doing," and "The only errors would be initial input errors".

Software Ease of Use

To answer the fourth research question question, were asked to rate the ease of use of the program. The builders indicated that the program would be easy to use. The average response was 6.5.

Software Customization

To answer the fifth research question builders rated the flexibility of the program and made comments about the software's ability to fit the custom needs of the company. The builders were asked to indicate the extent to which the software computerization could be customized to fit their own needs. The average response to this question was 5.8. Comments from builders included; "it looks adaptable to the way I use my computer now," "Short period of training," "It would take about two days to set it up, but once set up, it would save time and money," "The user would just have to add their own information to the system," "The only concern is the number of allowable changes or options with the software," and "The initial setup would be time consuming but it would be well worth it."

The builders were asked to indicate the extent to which they thought the program would be useful in managing their own company. All of the builders thought that the software program would be very useful to managing their companies. The average response was 6.7. Comments from builders included, "Would love to implement it. [Sales] agents could each have a laptop with the program. It would save tons of money," "We would like to look at using it in our company," "Any good scheduling software will allow you to mange your company better," "We look always to expediting the sales, contract, and expediting process," "Managing our company would be made a lot easier. Sub control is a big problem. It would greatly help - with scheduling also," and "Very much needed**!".

Conclusion

The development of the specification information flow model that was tested through software implementation and validated by experienced builders demonstrates that this schedule driven program does help solve the communication problem associated with customer specifications. The builders thought that this computer implementation of the specification information flow model would be very useful in helping them organize and control their specification information. Improving the flow of specification information through the construction process will be an area of greater focus and emphasis for builders as they continue to look for ways to build better quality homes in a more highly competitive market.

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Appendix A

Sample Builder Specification Summary Page

Builder Specification Summary Sheet							
Lot ID	**Lot No.**	**Subdivision**		VA/FHA Case #			
CH43	**43**	**Cedar Hollow**					
		1465 E. 1940 N.		**Orem**	**UT**	**84521**	
Buyer(s)		Customer Last Name		First Name	Spouse Name		
		Johnson		**Dale**	**Deidra**		
		6881 Grand View		**Portland**	**OR**	**36879**	
		743-3678					
		789-6543					
Plan ID		**Riverton**		Fin SF	Tot SF	Architect	
R-1825		**Rambler**		**1825**	**3500**	**Technigraphics**	
		Original Contract Price		$ 192,275.00			
		Addendum 1		($370.00)			
		Total Contract Price		**$ 191,905.00**			
Update to Schedule							
Start Date	**Finish Date**	**Description**		**Selection or Company**	**Cost or Contact**	**Phone**	**Qty. or Phone2**
5/7/96	5/7/96	**Begin_Construction**					
5/7/96	5/7/96	**Order_Excavation**					
		Subcontractor	65	Jim's Excavating	Jim Holloway	444-2423	434-2344
5/7/96	5/13/96	**Order_Building_Permit**					
		Subcontractor	96	Provo City	Bergen Merrill	547-8547	0
5/7/96	5/7/96	**Order_Rebar**					
		Supplier	126	Superior Buck & Steel	Paul Murphy	561-5487	580-6531
5/7/96	5/7/96	**Stake_Lot**					
		Subcontractor	56	Nathan Black	Nathan Black	758-6985	580-6325
		Direction_of_House		North	$ 0.00	0	1
		Garage_on		Right	$ 0.00	0	1
		Front_Setback		30'	$ 0.00	0	1
		Garage_sideyard		8'	$ 0.00	0	1
		Other_sideyard		10'	$ 0.00	0	1
		Fireplace_Key		No	$ 0.00	0	1
		Garage_door_size		16 x 7	$ 0.00	0	1
5/7/96	5/24/96	**Order_Temporary_Power**					
		Subcontractor	148	Wire Co.	William Peterson	545-5845	545-8858
		Supplier	134	Utah Power & Light	Norm Shaw	265-6589	659-1254
		Temporary_Power		#N/A	#N/A	#N/A	
5/14/96	5/14/96	**Excavate**					
		Subcontractor	65	Jim's Excavating	Jim Holloway	444-2423	434-2344
5/15/96	5/15/96	**Footings**					
		Subcontractor	125	Summerville Construction	Ken Summmers	254-5441	580-3691
		Supplier	145	Westroc	Jenny Sorenson	368-7855	566-6537
		Dug_Formed		Formed	$ 0.00	0	1
		Footing_Blockouts		Yes	$ 0.00	0	1
5/16/96	5/17/96	**Foundation**					
		Subcontractor	125	Summerville Construction	Ken Summmers	254-5441	580-3691
		Supplier	145	Westroc	Jenny Sorenson	368-7855	566-6537
		Beam_Pockets		Yes	$ 0.00	0	1
		FDN_door_blockouts		No	$ 0.00	0	1
		Garage_Man_door_size		2' 8"	$ 0.00	0	1

Appendix B

Sample Subcontractor/Supplier Order Sheet

New Homes Construction Company
348 N. 800 E. Provo, UT 84209
(801) 354-7788

12/30/96

Subcontractor/Supplier Specification Checklist and Schedule

Earthwork

Company	30 Heartwood Dr.	Contact	Phone #'s
Jim's Excavating	Provo	Jim Holloway	444-2423
	UT		434-2344

Lot #	1465 E. 1940 N.
43	Orem
Subdivision	UT
Cedar Hollow	

Plan Identification
R-1825

Activity	Projected Start Date
Excavation	5/7/96
Direction_of_House	North
Garage_on	Right
Backfill	5/29/96
Gravel	No Gravel Import
Final Grading	7/15/96

Call Blue Stakes before excavating: 566-1245
2% grade minimum on final grade - 10' around foundation