Heery International's Spreadsheet Optimization Model for Assigning Managers to Construction Projects

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When assigning managers to construction projects, Heery International tries to minimize the total cost of the assignments while maintaining a balanced workload for different managers. We developed and implemented an Excel spreadsheet optimization model for problems with up to 114 projects. As time passes, new projects arise, old projects terminate, and occasionally new managers join the team, and existing ones resign or transfer out. Because the model is in a spreadsheet environment, Heery can easily add or remove projects and managers from the model. As a result of our model, Heery has managed its projects without replacing a manager who resigned and has reduced travel costs, because the model assigns managers to projects that are closer to their homes than previously.

Heery International's Nashville office contracts with the State of Tennessee, various municipalities, and occasionally with private firms for a large number of construction projects. Some recent projects have included hospitals, office buildings, state park facilities (hotels and cabins), higher-education facilities (libraries, classrooms, and dormitories), armories, and prisons. Typical projects vary in size from approximately $50,000 to $50,000,000, with an average of about $2 million. Managing these projects requires expertise in several areas—a knowledge of the bidding and building processes, personal-interaction skills, and supreme organiza-

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tional skills. To solve its ongoing problem of assigning managers to projects, Heery uses an optimization model that we developed.

Previous Solution Methods

There are different ways to assign managers to building projects. One is the standard resource-loading process of listing in detail all the tasks required to manage all projects. Each task would have an estimated duration, and managers would be assigned to multiple projects to work on concurrent tasks. The number of hours per individual per week would be tallied, and the workload shifted appropriately among individuals as conditions change. For large projects, listing each task in such detail is very laborious.

Because of its simplicity, companies more often use the method of historical comparison to staffing levels and tasks in previous similar projects. However, in doing this they make several questionable assumptions. One assumption is that the first project was well managed. Another is that neither project has any unique aspects (for example, architectural intricacies or unusual construction materials) that will cause extra or lesser workloads. Another assumption is that the contracting environments are similar. Staffing levels for a project in Nashville where little labor strife occurs and a spirit of cooperation exists in the construction community would not be the same as those for a project in New York City, where union issues and adversarial relations prevail. Thus, this method of determining staffing requires a great deal of judgment to adjust for differences in locations.

Quantifying the Assignment Process

During earlier projects for the State of Tennessee, Heery tried to remove some of the subjectivity and second guessing and at the same time tried to simplify the process of assigning managers to projects. Instead of estimating the hours for each of the many tasks, it used a monthly intensity, which is a dimensionless number for each project, to quantify the management effort. The intensity function assigns relative values for construction projects based on the projects' dollar values. Towle [1990] discusses the use of these intensity functions for predicting future management effort. He notes that project dollar value implies management workload because it implies pay requests, change orders, design reviews, value engineering studies, scheduling, construction coordination, and so forth.

One questionable assumption is that the first project was well managed.

This intensity function is traditional in managing construction for the Tennessee government. It has a logarithmic shape similar to the shape of curves that have long been in general use to determine architects' fees. The logarithmic shape is appropriate because as projects get larger, there is less difference between the intensities necessary to manage them. The function is strictly empirically based; Towle [1990] notes that he tried various curves to find the best fit to management efforts for different size projects before selecting one (Figure 1). Ever since then, the State of Tennessee has successfully used it to determine total staffing for managing capital-improvement projects.

Prior to our modeling efforts, Heery de-

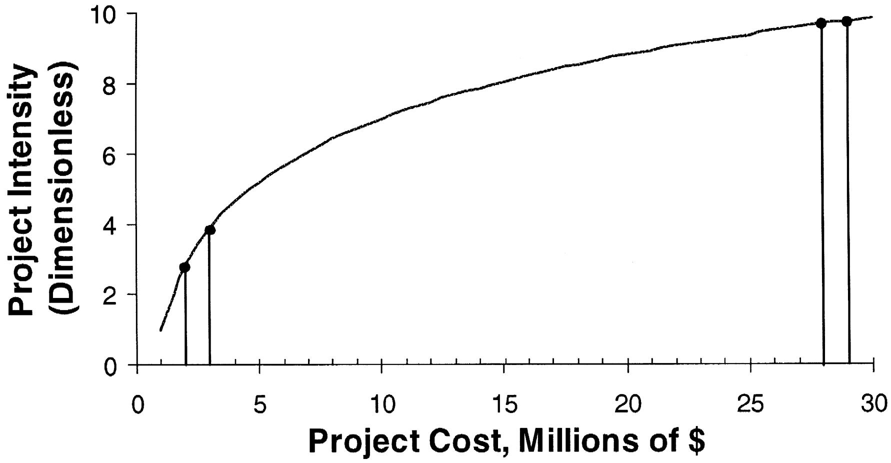

Figure 1: The intensity curve for various projects is given by project intensity = 6 · log (project cost in $000,000) + 1. There is a large difference between intensities for a $2 million and a $3 million project but a much smaller difference between those for $28 million and $29 million projects.

veloped an initial intuitive assignment of managers on a simple spreadsheet. It calculated intensities and plotted them over time to help balance workloads (Figure 2). Unfortunately, this method was generally unsatisfactory. Because managers were assigned to projects manually, assignments were not optimized. More important, the meetings for this method were taking nearly all day once or twice a month, because the managers frequently questioned and argued over the fairness of the result-

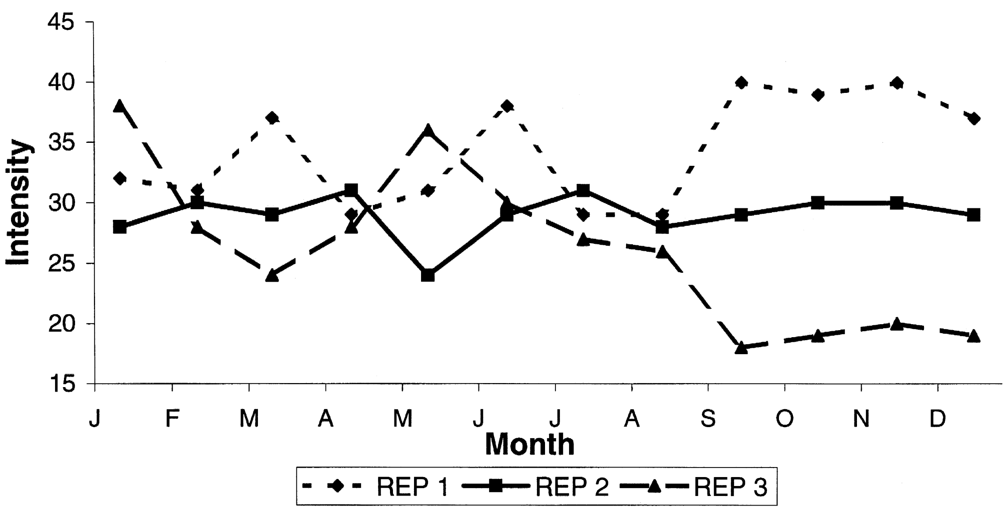

Figure 2: This shows a comparison of intensities for three construction representatives. Obviously, transferring some projects that are ongoing in the last few months from rep 1 to rep 3 would result in a more balanced workload. Thus, intensity curves facilitate a comparison and adjustment of anticipated future workloads.

ing assignments. Finally, assigning a single intensity value to each project ignores the fact that managers live in different cities, making it easier for some managers to visit a given project to manage it.

Our new procedure for project assignments began while the first author (LeBlanc) was working for Heery as a consultant on an unrelated project. He recommended an optimization-based approach. The large number of organizations benefiting from previous similar applications was instrumental in gaining Heery's interest.

Literature Review

To convince Heery's management of the value of optimization modeling for assigning managers, LeBlanc discussed previous similar applications. The classic assignment model allocates a set of employees to an equal number of jobs so that each employee performs only one job, each job is performed by only one employee, and the total cost is minimized [Hillier and Lieberman 1986]. Numerous applications have extended this model to more detailed scenarios. Grandzol and Traaen [1995] assigned balanced workloads to employees for the US Department of Defense. Thompson [1997] assigned telephone operators to shifts at the New Brunswick Telephone Co. Jarrah and Diamond [1997] assigned airline crews to month-long assignments, and Abara's [1989] model for assigning aircraft fleets to flight schedules was used by American Airlines. Powell et al. [1988] modeled the assignment of North American Van Lines drivers to loads. Grandine [1998] used an assignment model to assign tickets from a season-ticket package to individuals. Awad and Chinneck [1998] assigned proctors to exams at a university.

Heery's Optimization Model

We developed a Microsoft Excel spreadsheet optimization model for determining the best assignment of managers to construction projects. We chose a spreadsheet model rather than an algebraic one because Heery's managers, like most managers, tend to think in terms of spreadsheets rather than functions, linearity, and so forth [Powell 1997]. Compared to algebraic models, spreadsheet models for this problem have some disadvantages, such as not being suitable for very large problems. However, we felt that the advantages outweighed the disadvantages [Savage 1997]. Grossman [1997] and Willemain et al. [1997] discuss the advantages of spreadsheets as delivery vehicles in the context of teaching management science.

The meetings for this method were taking nearly all day.

The spreadsheet was designed so that it could be easily modified [Conway and Ragsdale 1997], since Heery continually takes on new projects, finishes old ones, and occasionally adds new managers and loses existing ones. By working within a spreadsheet, Heery can add or remove projects from the model easily by simply inserting or deleting columns. Similarly, it can add or remove managers by inserting or deleting rows. The spreadsheet's careful distinction between input data, changing cells, and outputs using borders and shading was a help to the users.

In our model, we calculated the intensity for each different manager-project combination, not simply for each project.

Managers	Typical Construction Projects	
Denise	1 TSU—Renovate Harned Hall Lab	8 ChSCC—Warehouse Facility
Mike	2 TSU—Administration Building	9 ChSCC—Energy Management System
Chuck	3 TSU—Student Housing	10 TTC at Hartsville—Addition-Renovation
Julie	4 MTSU—Stadium	·
Dean	5 MTSU—Bookstore Expansion	·
Tim	6 MTSU—New Library	·
Ed	7 ChSCC—Fire Line	114 TTC at Shelbyville—Addition-Renovation

Table 1: These are the seven managers and some of the projects at Tennessee State University (TSU), Middle Tennessee State University (MTSU), Chattanooga State Community College (ChSCC), and Tennessee Technology Centers (TTC).

An important consideration in calculating intensities was the driving time for the managers to the various projects, so we redefined intensities as follows:

$$\text{project intensity} = [1 + \text{driving time}] \cdot [6 \cdot \log(\text{project cost}) + 1] .$$

Thus, if driving time is one hour, then the intensity is half that of a project with identical cost but with three-hour driving time. We could calibrate this intensity by scaling (multiplying) it by a small constant such as 0.01. This is not necessary, however, because the solution to any optimization model is unchanged regardless of any scaling factor. These intensities were calculated in a separate Excel file and then input as data cells in the optimization model.

We let $C_{\text{Manager,Project}}$ denote these intensity values (C denotes cost). With this definition of manager-project intensity, Heery can include in the model the fact that a new hire is not able to manage as efficiently as more experienced managers. However, Heery has no new managers, so in the current model the assignment intensities do not reflect this variation.

We will explain the changing cells in our Excel optimization model in terms of the seven managers and some of the 114 projects to be assigned in a recent problem (Table 1). Changing cells equal one if the manager is assigned to the project and zero if not. This method of using ones to indicate manager-project assignments is consistent with algebraic models' use of zero-one decision variables defined for each manager-project combination as

$$X_{\text{Manager,Project}} = \begin{cases} 1 \text{ if the manager is} \\ \quad \text{assigned to the project,} \\ 0 \text{ if not.} \end{cases}$$

For example, $X_{\text{Denise},3}$ equals 1 if Denise is assigned to manage project 3 and equals 0 if she is not. These variables are often referred to as go/no-go variables.

In many cases, certain managers are assigned a priori to certain projects. For example, the most experienced manager might be assigned to very important projects, while recent hires are assigned to smaller ones. Also, maintaining continuity of previous assignments to ongoing projects is important. The user specifies a priori assignments by manually entering 1s and 0s in the changing cells' range of the spreadsheet (Table 2A) and reducing the changing cells' range so that the optimization model excludes these assignments. A priori assignments result in partially fixed intensity workloads for managers, which are automatically considered when the optimization model chooses the remaining manager-project assignments.

Since go/no-go assignment decisions must be made for each project, for each manager, there are $7 \cdot 114 = 798$ such decisions in this problem instance. However, 54 projects were assigned a priori, so the model contained only 60 projects to be assigned. Thus, the model contains $7 \cdot 60 = 420$ $X_{\text{Manager,Project}}$ variables. Each decision involves choosing from two possibilities—assign (1) or don't assign (0), so there are $2^{420} = 10^{126}$ combinatorial possibilities for the model to choose from. We anticipate solving the model occasionally with every manager-project combination allowed in order to see whether reassignments of ongoing projects would be desirable. However, the Premium Solver Plus software [Fylstra et al. 1998; Straver 1998] currently used for solution is limited to 800 0-1 changing cells, so if the number of projects or managers increases so that the number of managers times the number of projects exceeds 800, Heery will have to use different software.

The optimization model described in Tables 2A and 2B is to assign managers to

	A	B	C	D	E	F	G	H	I	J	K	…	DP
1		**Manager/Project Assignment Intensities (Input Data)**											
2		**Project**											
3	**Manager**	1	2	3	4	5	6	7	8	9	10	**...**	114
4	Denise	4.8	55.2	1.6	41.6	3.2	16.3	1.6	3.9	1.7	16.3		5.9
5	Mike	2.8	32.7	0.9	24.6	1.9	9.6	0.9	2.0	1.1	10.4		21.5
6	Chuck	0.8	8.7	0.3	6.6	0.5	2.6	0.3	1.7	0.4	4.2		37.1
7	Julie	1.3	15.1	0.4	11.4	0.9	4.5	0.4	2.0	0.3	2.4	**...**	40.0
8	Dean	2.0	23.2	0.7	17.5	1.3	6.9	0.7	2.8	0.5	4.8		45.9
9	Tim	0.8	8.7	0.3	6.6	0.5	2.6	0.3	1.7	0.4	4.2		37.1
10	Ed	4.8	55.2	1.6	41.6	3.2	16.3	1.6	5.5	1.4	13.5		68.4
11													
12		**Changing Assignment Cells: Manager/Project Assignments Indicated by 1s**											
13	**Manager**	1	2	3	4	5	6	7	8	9	10	**...**	114
14	Denise	1											
15	Mike										1		
16	Chuck					1	1						
17	Julie							1				**...**	
18	Dean								1	1			
19	Tim		1	1	1								
20	Ed												1
21													

Table 2A: The Excel model shows input data in cells with double borders and changing assignment cells (decision variables) in single heavy orders (actually red borders). Rows 4 through 10 give the intensity data cells for each manager-project combination. Rows 14 through 20 show the changing cells using 1s and 0s, sometimes input by the user, and sometimes chosen by the model, to specify manager-project assignments. Each column must have a single 1, since each project must have only one manager assigned to it. This shows that Denise is assigned to the first project, Tim is assigned to the next three, Chuck to projects five and six, and so forth. The intensity of the assignments shown is [4.8] + [8.7 + 0.3 + 6.6] + [0.5 + 2.6] + [0.4] + [2.8 + 0.5] + [10.4]. . . + [68.4] = 106.0 plus the intensity of assigning projects 11 through 113, which are not shown.

projects to minimize the sum of the intensities corresponding to the chosen assignments. The model chooses assignments subject to constraints that balance the workload given to each manager in each month. The first set of constraints is that each manager's total intensity cannot exceed a specified amount in each of the next 12 months. In a problem instance with seven managers (Table 1), there are $7 \cdot 12 = 84$ such constraints, which ensure that the chosen assignments are not unfair to any individual. The next constraint set also has 84 constraints to ensure overall fairness—each manager's total intensity must be at least a specified amount in each month. (Column B of Table 2A shows that if Mike is assigned to manage project 1, he will be busy at intensity level 2.8. Column B of Table 2B shows that this intensity will last during months 4, 5, and 6.) Finally, constraints ensure that project management is not split among different managers—each construction project must have exactly one manager assigned to it. In a problem instance with 114 projects, with 54 projects assigned a priori (Table 1), there are 60 such constraints.

The key data that our model requires are the intensity values for manager-project assignments. We did not have data on the maximum or minimum intensities allowed for each manager. (These were available for the earlier single intensity values for projects, but not for the manager-project intensities that we used.) Therefore, we used the following procedure. We first solved the model with zero

	A	B	C	D	E	F	G	H	I	J	K	…	DP	DQ	DR	DS	DT	DU
22		Project Activity Status (Input Data)																
23	**Month**	1	2	3	4	5	6	7	8	9	10	…	114					
24	1		1	1	1		1		1				1					
25	2		1	1	1		1		1		1		1					
26	3			1	1		1		1	1	1		1					
27	4	1		1	1		1		1	1	1							
28	5	1		1	1	1	1		1	1	1							
29	6	1		1	1	1	1	1	1	1	1							
30	7			1	1	1		1	1	1	1							
31	8			1		1		1	1	1	1							
32	9			1		1		1	1		1							
33	10			1				1	1		1							
34	11			1				1	1		1							
35	12			1					1									
36																		
37		Upper/Lower Limits																
38		1	2	3	4	5	6	7	8	9	10	…	114		**Max**			**Min**
39	Denise Mo. 1		55.2	1.6	41.6		16.3		3.9				5.9	≤	55		≥	35
40	Denise Mo. 2		55.2	1.6	41.6		16.3		3.9		16.3		5.9	≤	55		≥	35
41	Denise Mo. 3			1.6	41.6		16.3		3.9	1.7	16.3		5.9	≤	55		≥	35
42	Denise Mo. 4	4.8		1.6	41.6		16.3		3.9	1.7	16.3			≤	55		≥	35
43	Denise Mo. 5	4.8		1.6	41.6	3.2	16.3		3.9	1.7	16.3			≤	55		≥	35
44	Etc.																	

Table 2B: Rows 24 through 35 of the Excel model contain data cells specifying the months in which each project is active, using ones to indicate active months. Rows 39 onward contain coefficients for the minimum and maximum intensity constraints for each manager in each month. Row 39 shows the two constraints for Denise in month 1. These constraints sum the intensities for projects 2, 3, 4, 6, 8, . . . , 114. Projects 1, 5, 7, 9, and 10 are ignored in these two constraints because they are not active in month 1.

$X_{Denise,Stadium}$	$X_{Mike,Stadium}$	$X_{Chuck,Stadium}$	$X_{Julie,Stadium}$	$X_{Dean,Stadium}$	$X_{Tim,Stadium}$	$X_{Ed,Stadium}$
$X_{Denise,BStore}$	$X_{Mike,BStore}$	$X_{Chuck,BStore}$	$X_{Julie,BStore}$	$X_{Dean,BStore}$	$X_{Tim,BStore}$	$X_{Ed,BStore}$
$X_{Denise,Library}$	$X_{Mike,Library}$	$X_{Chuck,Library}$	$X_{Julie,Library}$	$X_{Dean,Library}$	$X_{Tim,Library}$	$X_{Ed,Library}$

Table 3A: These are the 21 individual manager-project changing cells referring to the three MTSU projects: stadium, bookstore, and library.

$X_{Denise,MTSU}$	$X_{Mike,MTSU}$	$X_{Chuck,MTSU}$	$X_{Julie,MTSU}$	$X_{Dean,MTSU}$	$X_{Tim,MTSU}$	$X_{Ed,MTSU}$

Table 3B: In the seven manager-project-location changing cells, the first variable indicates whether Denise gets all three projects at the MTSU campus; the other variables are defined similarly.

minimum and very large maximum allowable intensities. Next, we observed the minimum and maximum values that the model assigned to any manager. We then tightened these values by one unit and resolved the model. We continued this procedure until further tightening resulted in no solution to the model. We implemented the solution to the model with the tightest minimum and maximum allowable intensities for which a solution exists. This took only a few iterations to complete.

The Revised Manager-Project Assignment Model

After solving the assignment-optimization model, we realized that occasionally the solution did not have one important characteristic—all construction projects in certain outlying locations must have the same manager. (We had assumed that the solution to the assignment model would always have this property.) For example, three projects (projects 4 through 6 in Table 1—MTSU Stadium, MTSU Bookstore, and MTSU Library) should all be managed by one person. We refer to this as the single-site policy. Since all projects in some locations must have only one manager, we could reduce the number of decision variables by defining some variables to refer to a certain location (Tables 3A and B).

The difficulty with this approach is that projects at a site may not all have the same schedule, with some active all year and others only in some months. With each project no longer described by its own spreadsheet column specifying its intensities and active months, the partially active nature of the combined project complicates the maximum and minimum intensity constraints. To cope with this difficulty, we used another approach that keeps the larger number of variables (separate project-manager combinations) and adds additional constraints (Table 4). These constraints ensure that a single manager handles all projects at one site.

Experience with the Model

The natural progression of construction projects as they begin, end, and occasionally stall dictates a monthly update of project data and model solution at Heery's Nashville office. Since the model's inception, Heery's program administrator (Swann) has used it in each of the nine successive months. During this time, one manager resigned, and many projects were added and removed (completed). It is a tribute to the model's simplicity that since the initial run, the program administrator has needed no expert assistance to modify the model to reflect the new projects and managers even though he had no

$X_{\text{Denise,Stadium}} = X_{\text{Denise,BStore}}$
$X_{\text{Mike,Stadium}} = X_{\text{Mike,BStore}}$
$X_{\text{Chuck,Stadium}} = X_{\text{Chuck,BStore}}$
$X_{\text{Julie,Stadium}} = X_{\text{Julie,BStore}}$
$X_{\text{Dean,Stadium}} = X_{\text{Dean,BStore}}$
$X_{\text{Tim,Stadium}} = X_{\text{Tim,BStore}}$
$X_{\text{Ed,Stadium}} = X_{\text{Ed,BStore}}$

$X_{\text{Denise,BStore}} = X_{\text{Denise,Library}}$
$X_{\text{Mike,BStore}} = X_{\text{Mike,Library}}$
$X_{\text{Chuck,BStore}} = X_{\text{Chuck,Library}}$
$X_{\text{Julie,BStore}} = X_{\text{Julie,Library}}$
$X_{\text{Dean,BStore}} = X_{\text{Dean,Library}}$
$X_{\text{Tim,BStore}} = X_{\text{Tim,Library}}$
$X_{\text{Ed,BStore}} = X_{\text{Ed,Library}}$

Table 4: These constraints insure that the stadium, bookstore, and library all have the same manager. If Mike manages the stadium ($X_{\text{Mike,Stadium}} = 1$), then he must also manage the bookstore and library ($X_{\text{Mike, BStore}} = 1$ and $X_{\text{Mike,Library}} = 1$). This increases the solution time for the model but makes the model easier to update.

prior exposure to optimization modeling or to the Solver software. However, the single-site-policy aspect of the model has proven more difficult. Because this problem occurs for very few projects and because the model's solution often satisfies these constraints even when they are not formally included, the program administrator has ignored the constraints and manually overridden the model's solution when a difficulty occured. For example, in a recent month the model's solution assigned separate projects at Tennessee Technological University to both Mike and Chuck, but the program administrator overrode this, assigning them all to Mike, after verifying that the total intensity assigned to each manager was still within the allowable range. Except for this type of change, the program administrator made actual assignments according to the model's solution in each of the past nine months.

Some managers reacted to the use of the model as follows:

—"I initially thought that Julie should manage the TTC McKinsey project, but the optimal solution called for Dean to manage it. After thinking it over, it does make more sense for Dean to manage this project."

—"Using the model greatly simplifies the process of assigning managers to projects."

—"Assignments are now much less controversial. In the past there were time-consuming and sometimes heated discussions about assignments."

Solution time using the Premium Solver Plus add-in for Microsoft Excel 97 for the model with 420 go/no-go variables varied considerably, depending primarily on the minimum and maximum intensities allowed. Many problems required only seconds or a few minutes to solve for the exact optimal solution, but some took a few hours (on a Pentium 133 Mhz laptop with 32 meg running Windows 95). A very few did not solve even after running overnight. There may be no feasible solution to these problems, meaning that the minimum and maximum total allowable intensities for each manager in each month were inconsistent with the intensities for managing the projects. From a practical point of view, there is no difference between a model with no feasible solution and one with a feasible solution that the available software cannot find in acceptable time. Solver quickly identified those problems that were obviously infeasible. Generally, for problems that had no feasible solution but were almost feasible, Solver took a long time to conclude that there was no feasible solution.

In a real sense, there is no cost of using the model. The Premium Solver Plus upgrade (which solves larger models more efficiently than the basic Microsoft Excel Solver) did cost $800, but it has paid for itself just by reducing the time it takes to assign managers to projects.

Heery has saved money by using the intensity function and our assignment model. Heery officially reported to the State of Tennessee that it has been saving the state $1 million per year in construction management costs. Most of this was due to the earlier use of the intensity formula rather than our assignment-optimization model. However, shortly after Heery began using the assignment model, one manager transferred out and has not been replaced. Heery attributes its successful project management with the reduced staff entirely to the use of our optimization model. It has also saved travel costs because the model's solution assigns managers to projects close to their homes (subject to allowable total intensities) more often than the previous method. This is reflected in the fact that Heery has not increased its travel budget even though the state has imposed additional travel requirements.

Nonfinancial benefits include improved morale, because managers now perceive workloads as fair. Managers are given a clear picture of their job responsibilities and schedules well into the future, allowing them to keep the big picture in view and plan for maximum efficiency. The program administrator now spends about four hours during the last week of each month updating and running the model and then notifies managers of their assignments. They have made essentially no complaints and only occasionally questioned their assigned tasks. This modeling effort succeeded because all the affected managers wanted a better method of assignment, and they see the model's assignments as fair. We anticipate continued positive results, with the model eventually being offered to all departments in the worldwide Heery organization.

> The affected managers see the model's assignments as fair.

We combined model development and user training during a six-month period. The program administrator and the first author (consultant) met for a few hours one or two days each month. We could have completed model development and training in one month, but Heery gave priority to obtaining new projects, so we conducted training sessions intermittently.

It may be necessary in the future to prevent certain managers from being assigned to certain projects, such as a new hire to a multimillion dollar project. We can do that by setting the intensity of that assignment to a huge number so that the solution will not include that assignment. We think that the alternative of deleting the corresponding $X_{\text{Manager,Project}}$ variable would be more difficult for the users.

To test the robustness of our model for larger problems, we also solved several instances in which all 114 projects had to be assigned to seven managers. This model has $7 \cdot 114 = 798$ go/no-go decision vari-

Minimum intensity allowed	Maximum intensity allowed	Percent optimality	Solution time (hours:minutes:seconds)
0	100	5	0:0:10
3	79	5	0:1:30
10	55	5	0:2:03
12	40	10	2:33:12
12	39	10	1:16:55
12	38	10	0:26:31
12	37	10	No solution

Table 5: The solution time on a Pentium 200 PC varies for different model instances. Solution times generally (but not always) increased for tighter constraints. Solution times for exact-optimal solutions would have been substantially higher. No solution means that no feasible solution was found in eight hours.

ables (changing cells). Since the Premium Solver Plus software that we used for solution is limited to 800 changing cells, any additional managers or projects would result in a model too large for it to solve. To reduce the solution times for these larger problems, we set the Solver *tolerance* equal to five percent or 10 percent for these problems. As a result, the solution found was known to be accurate to within five percent (or 10 percent) of optimality but was not necessarily exactly optimal (Table 5).

Many other organizations could use a similar approach to assigning managers. Examples include assigning bus drivers to routes, sales representatives and stock brokers to customers, programmers to modules, and classes to classrooms. The key requirement is that the costs or times that each manager takes to perform each task are known. The use of intuition or gut feeling when assigning managers is very prevalent in construction management (and probably in other fields). Our experience confirms the fact that using formal optimization modeling can provide better solutions for an important ongoing problem.

APPENDIX

Notation for the algebraic optimization model for assigning managers to projects is the following:

Parameters:

C_{ij} = intensity of assigning manager i to project j.

$$A_{jt} = \begin{cases} 1 & \text{if project } j \text{ is active in period } t \\ 0 & \text{if not.} \end{cases}$$

m_{it} = minimum intensity allowed for manager i in period t.

M_{it} = maximum intensity allowed for manager i in period t.

Decision variables:

$$X_{ij} = \begin{cases} 1 & \text{if manager } i \text{ is assigned to project } j \\ 0 & \text{if not.} \end{cases}$$

The optimization model is

$$\text{Min} \sum_{\substack{\text{managers} \\ i}} \sum_{\substack{\text{projects} \\ j}} C_{ij} \, X_{ij}.$$

(Whenever the variable X_{ij} equals 1, the corresponding assignment intensity C_{ij} is incurred.) Constraints are that total intensity given to each manager as a result of project assignments cannot exceed a specified amount and must be at least a specified amount in each period:

$$m_{it} \leq \sum_{\substack{\text{projects} \\ j}} [A_{jt}\, C_{ij}]X_{ij} \leq M_{it}$$

for each manager i and each period t.

Because of the coefficients A_{jt}, this is the sum of active projects in each period. Because of the variables X_{ij}, this is the sum of projects assigned to manager i that are active in period t.

Additional constraints are that each project must have exactly one manager assigned to it:

$$\sum_{\substack{\text{managers} \\ i}} X_{ij} = 1 \quad \text{for each project } j.$$

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Emory F. Redden, Vice President, Herry International, Inc., 999 Peachtree Street NE, Atlanta, Georgia 30367-5401, writes: "The optimization model described . . . has been very helpful for assigning managers to projects . . .. We have been satisfied with the assignments chosen at the Nashville office . . .. We look forward to using the model in our Atlanta office and elsewhere in the Heery organization."