SIMULATION IMPROVES STAFFING PROCEDURE AT AN OIL CHANGE CENTER

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ABSTRACT

Discrete-event process simulation has long ago expanded from its initial bailiwick of manufacturing and production usage to benefit businesses across a broad spectrum of service industries such as travel, lodging, restaurants, and health care. The study presented here arose in the context of a senior-level university simulation class as a semester project. In this study, simulation was applied to the day-to-day operations of a drive-in facility to service customers' privately owned motor vehicles. As a result of the simulation study, managers of the business, supported by industrial engineers, became both more aware of improvement opportunities and better able to assess their comparative potential impacts on the profitability of the business.

INTRODUCTION

The client of this simulation study was the management of a vehicle drive-in service center; these managers sought to improve the quality of service, hence the competitiveness, and hence the profitability, of their business. Simulation, with which they were initially unfamiliar, has long been entrenched in the manufacturing industry (Miller and Pegden 2000), and has now moved decisively into the field of productivity improvement in the service industries (Herbst, Junginger, and Kühn 1997). Examples of the wide-ranging uses of simulation within the service sectors include an examination of the information technology support function of a multinational construction firm (Hlupic and Bosilj-Vuksic 2004), improvement of emergency response to floods (Wattanapanich and Tandayya 2004), improvement of urban bus operations (Osmólski, Osmólski, and Kaczalski 2003), and improving the operations of a drive-through credit union (Williams and Zottolo 2001). In this study, the business owner and his two managers identified their primary concern that of achieving a proper and effective staffing configuration, thereby increasing the profitability of the business by decreasing service times and thus surely increasing throughput and customer satisfaction. Several analytical obstacles and complexities en route to this goal included highly variable customer arrival rates, highly variable service times (attributable both to different menus of services requested and to different vehicles requiring different service times even for the same service), and staff scheduling constraints imposed by different skill mixes and levels among the employee service technicians. As an example of the interrelationships among these considerations, the different skill levels among the technicians were a heavy additional contributor to the high variability in service times.

In this paper, we first present an overview of operations at the service center. Next, we describe collection of the data, and the construction, verification, and validation of the simulation model. We then provide a summary of the conclusions our client and we collaboratively reached.

OVERVIEW OF OPERATIONS

The locus of this simulation study was a drive-in vehicle service center of the type very common in the United States. These centers, a well-known and plausible pathway to entrepreneurship for aspiring businesspersons, sometimes via franchise (Horowitz and Shilling 1989) are certainly fraught with significant challenges, such as vulnerability to thuggish crime (Meyer 2005), employee selection, training, and retention problems, and chronic necessity for "hands-on" management. A layout of the center appears in Figure 1 near the end of this paper. The owner of a vehicle drives into the center from a main trunk road, selects a queue leading to one of the three service bays (bay one, closest to the road, is the default), and waits in that queue (due to constraints of vehicle size relative to maneuvering space, jockeying is well-nigh impossible) until that bay is open. However, balking is occasionally observed, typically when all queue lengths exceed seven vehicles, inasmuch as it is both unsafe and technically illegal to wait in queue while the vehicle is still physically on the busy trunk road. Then, guided by a technician, the customer carefully advances into the bay

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(the vehicle's wheels must straddle the "pit" wherein some technicians work, not fall in!) and remains in the vehicle while the vehicle receives routine maintenance services such as a change of engine oil, flush of transmission fluid, and/or flush of coolant fluid. Insofar as possible, these services are performed at least approximately concurrently. The customer then pays for the service(s), again typically without leaving the vehicle, and drives off the premises and returns to the trunk road. Of necessity, inbound and outbound traffic is rigorously separated by rigid enforcement of unidirectional ("One Way") signs and directives. Additional services, although available upon request, constitute less than 1% of the center's total business. About 85% of the business volume is compressed into three high-volume days per calendar week (Mondays, Fridays, and Saturdays); therefore, efficient peak business staffing and employee utilization received high attention during the study. All services are performed as soon as a technician able to perform them is available. The mechanical training the technicians receive is primarily "on the job" or "hands-on;" therefore, the skill level of each technician is approximately proportional to their seniority at this and/or similar service centers. At present, there is neither certification nor formal training required to perform these services.

DATA COLLECTION

In view of the client's stated objective of improving the business's staffing configuration, data collection began with a careful overview of current operational practices before undertaking collection of numeric data. The observed, and quite informal, work assignments were: managers gather information from the customers on arrival and receive payment from them on exit, whereas technicians, both low- and high-skilled, check and replenish fluids (oil, transmission, and coolant) or drain old oil. The technicians' duties are conspicuously divided into "topside" (work at ground level, such as checking fluid levels) and "pit" (draining old oil); predictably, any technician much prefers "topside" duty to "pit" duty. As a typical workplace privilege, the high-seniority employees gravitate to the "topside" work; since, as stated above, skill level is strongly correlated with seniority, management had drifted, largely unawares, into a situation in which the "topside" tasks were performed by the more experienced, skilled technicians. Rather than have explicitly scheduled meal and break times, both managers and technicians take brief breaks as lulls in customer arrivals permit; therefore, no such breaks were included in the model. Times for various services are related to the size of the customer's vehicle; therefore, when a customer requests more than one service, there exists positive correlation between pairs of service times. Even though services can often be performed at least partly concurrently when a customer requires multiple services, a vehicle of course cannot leave its service bay until the last or longest service time is complete. During the project team's entire data collection (observational data were collected during periods of several peak hours on several different Mondays, Fridays, and Saturdays), no instances of equipment failure or serious service error were observed. Therefore, neither downtimes nor "same customer immediately returns angry, seeking correction" were included in the model. However, the client was apprised of this omission relative to potential extensions of the model to further uses and/or similar business establishments, in keeping with an important principle of successful simulation projects: Ensure the client understands and agrees to the scope and limitations of the model (Sadowski and Grabau 2004).

More obviously and routinely, data collection included gathering data on arrival times, service times, and the frequency with which each of the three primary services (oil, transmission, or coolant) was requested. Since each of these three services could be requested independent of the other two, there were eight (2^3) possible service "menus." Since these data could be collected unobtrusively and checked against the client's recollection and various logbooks, the Hawthorne effect (Dilworth 2000) did not arise despite the fact that all services are inherently "manual."

MODEL BUILDING, VERIFICATION, AND VALIDATION

In keeping with the university course syllabus within which this project was undertaken, the Arena® simulation software tool (Bapat and Sturrock 2003) was used throughout. Arena® provided many standard features and conveniences for this model-building effort, including *Create*, *Process*, and *Dispose* modules, the ability to construct a *Schedule* specifying the changes in arrival rates as an empirical function of time of workday, and the ability to relegate details of the individual processes (transmission flush, oil change, and coolant flush) to *Submodels*. The use of *Submodels*, in keeping with traditional and thoroughly vetted concepts of "structured program design," (Hoffer, George, and Valacich 2002) eased the subsequent tasks of verification, validation, and high-level, non-technical explanation of the model to the client, and may confidently be expected to ease subsequent modification and expansion of the model. A screen shot of one submodel is shown in Figure 2 at the end of the paper. More specific to this real-world process, the possibility of multiple services being performed approximately concurrently was handled by conceptually cloning the customer's vehicle in a *Separate* module. A downstream *Batch* module later allowed the vehicle to proceed to payment and exit when all service(s) requested by the customer were complete. The ability of the Arena® *Batch* module to batch the clones by the unique entity attribute assigned to them just upstream from the *Separate* module corrected the initial error that vehicle #1's oil change, for example, and vehicle #2's coolant flush were incorrectly batched into an exiting vehicle (Kelton, Sadowski, and Sturrock 2004). Arena® also provided features easing the task of constructing the model so that no customers could enter after closing time, yet all customers already in the system could continue until their requested services and "cashing out" were complete.

The base model, representing current conditions and operating procedures, was then verified and validated. Verification and validation techniques used included structured walkthroughs, sending only one entity with specified attributes through the model on a step-by-step observational basis, historical data validation, directional tests (e.g., if input rate is increased, queue lengths should either remain the same or increase), and, last, a Turing test in collaboration with the client (Sargent 2004). After correction of errors, the input and performance metrics of this initial model matched system observations to within 4%.

A second model, representing proposed changes of staffing and labor pooling, was then constructed, verified, and validated. In contrast to the initial model, whose construction required several weeks, the second model was constructed in less than a week, since the initial model served as a firm foundation. To construct this model, the additional Arena® feature of *Resource Sets* was used. When using this feature, the modeler first defines *Resources* (as had already been done in the base model), then defines a *Resource Set* comprising *Resources* in descending order of desirability of use, and then assigns the *Resource Set* to completion of a task. In this way, use of the model experimented with possibilities of using less skilled employees during less busy times (allowing them to be trained and coached in unhurried, non-stressful situations), using more skilled employees during less busy times (allowing managers time to attend to administrative functions such as preparing tax returns or quarterly reports), or allowing a trainee to complete a task but immediately having a technician experienced in the same task check the quality of the work.

RESULTS AND CONCLUSIONS

As often happens in successful simulation studies, the client derived ideas and insights beyond the straightforward examination of predictions and confidence intervals pertaining to standard performance metrics (Profozich 1998). In this case study, quantitative results of the model helped managers reassign technicians to teams to simultaneously meet the training needs of the less experienced workers, avoid unnecessarily annoying the higher-seniority workers with "pit" work assignments, and ameliorate the long-standing line imbalance due to the fact that "topside" processes take much longer than "pit." Additionally, the possibility of having a single queue for "the next available bay" (a thought which immediately occurs to anyone who has studied queueing theory and/or waited for a teller inside a modern bank) proved very enticing when tried in the model. Indeed, so promising were its performance metrics that management is considering it anew, even at the cost of restriping the lot, and emplacing signage and plastic cones. Qualitative insights spawned by the project included the realization that customers' waiting time (during this time, in the manager's words, "most people read, talk on their cell phones, or just stare into space") could become an opportunity for gentle marketing (e.g., providing leaflets describing services the customer had not already requested). The first author, in particular, was reminded of how hotels have "improved" elevator service by placing mirrors in the halls near the elevators, thereby allowing customers to preen themselves. More recently, McDonald's Corporation has similarly systematically added value to customers' times in queue by displaying menu choices and touting new promotions (Schlosser 2002).

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Map of Service Center Facility

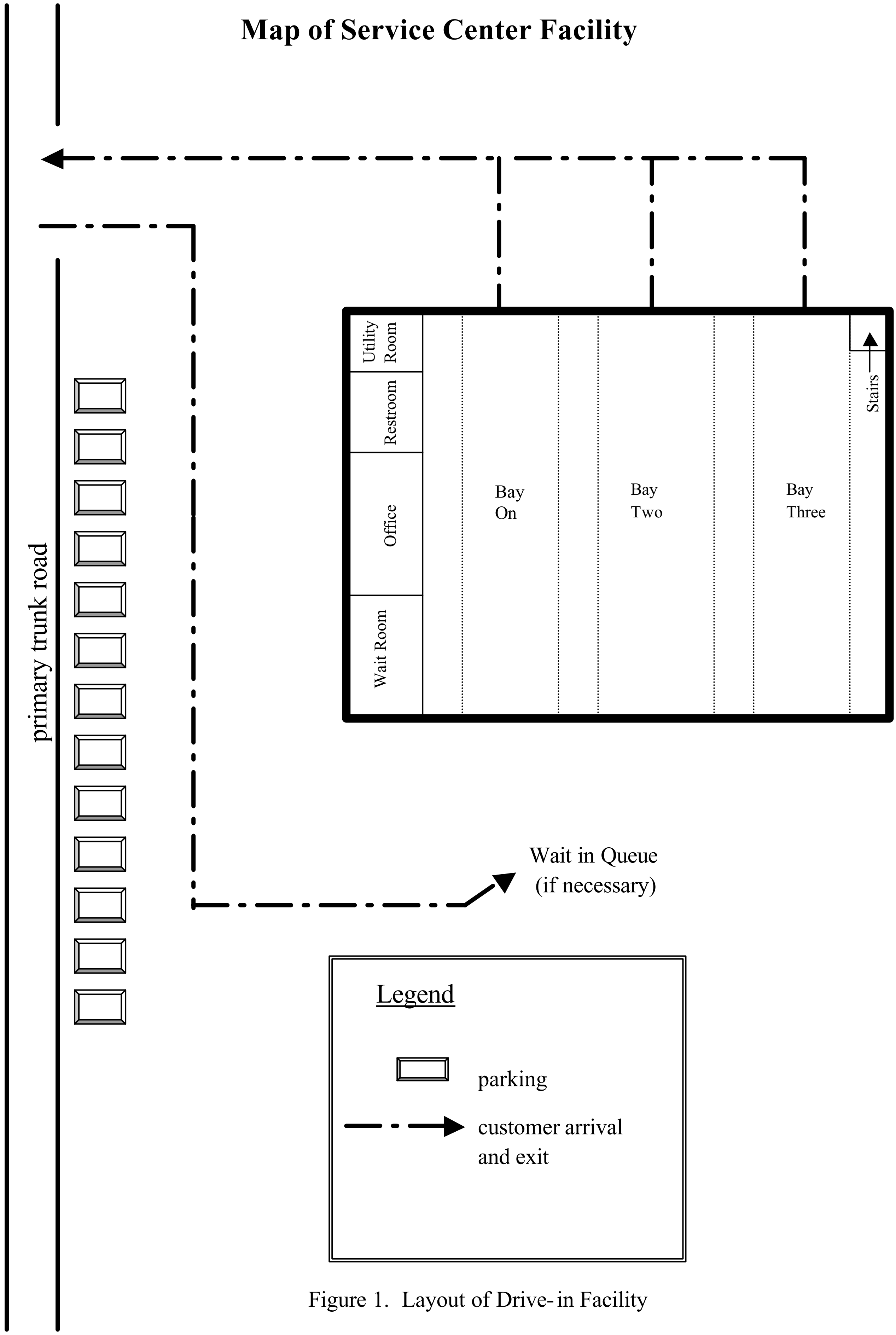

Figure 1. Layout of Drive-in Facility

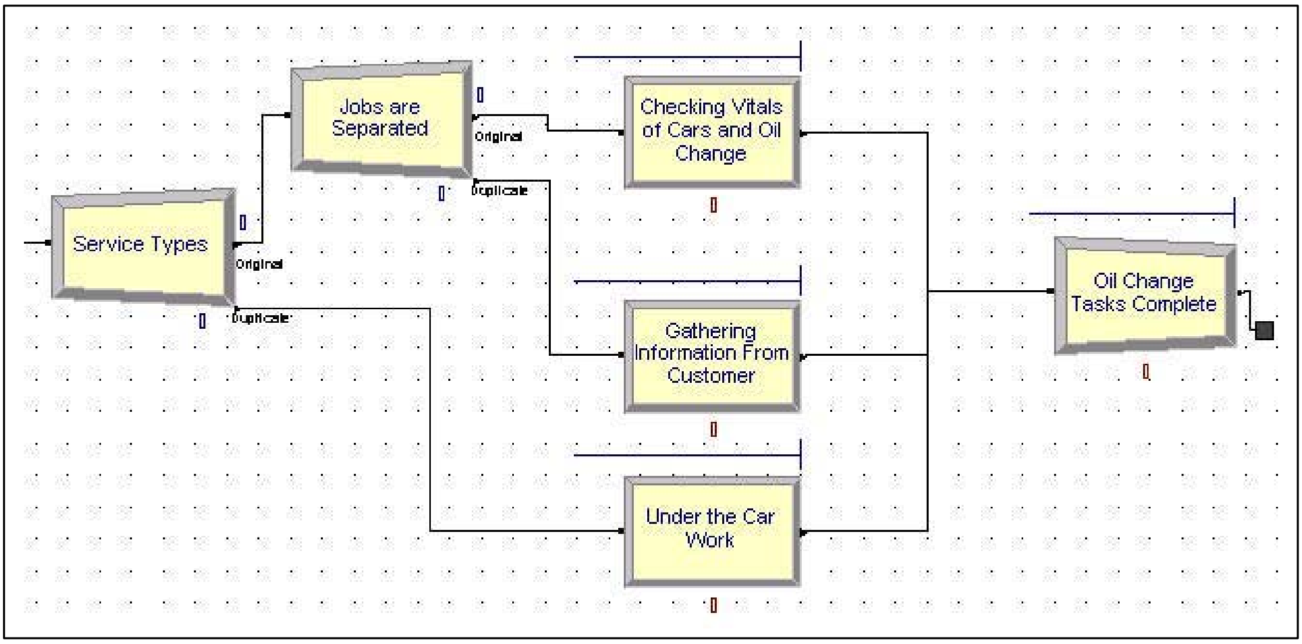

Figure 2. Screen Shot of Submodel