

# **SIMULATION IMPROVES STAFFING PROCEDURE AT AN OIL CHANGE CENTER**

Edward J. Williams  
Jory D. Bales, Jr.

Justin A. Clark  
Renee M. Amodeo

Department of Industrial & Manufacturing Systems Engineering  
2330 Engineering Complex, University of Michigan – Dearborn  
4901 Evergreen Road, Dearborn, MI 48128  
U.S.A.

## **KEYWORDS**

Discrete-event process simulation, service industry, personnel staffing, Arena®

## **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

(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).

## ACKNOWLEDGMENTS

The authors, particularly the first author, express gratitude to professional friend and colleague Marcelo Zottolo, Production Modeling Corporation, Dearborn, Michigan, for a careful and helpful perusal of this paper.

## REFERENCES

- Bapat, Vivek, and David T. Sturrock. 2003. The Arena Product Family: Enterprise Modeling Solutions. In *Proceedings of the 2003 Winter Simulation Conference*, Volume 1, eds. Stephen E. Chick, Paul J. Sánchez, David Ferrin, and Douglas J. Morrice, 210-217.
- Dilworth, James B. 2000. *Operations Management: Providing Value in Goods and Services*, 3<sup>rd</sup> ed. Orlando, Florida: The Dryden Press.
- Herbst, J., S. Junginger, and H. Kühn. 1997. Simulation in Financial Services with the Business Process Management System ADONIS. In *Proceedings of the 9<sup>th</sup> European Simulation Symposium*, eds. Winfried Hahn and Axel Lehmann, 491-495.
- Hlupic, Vlatka, and Vesna Bosilj-Vuksic. 2004. Business Process Modeling Using SIMUL8®. In *Proceedings of the 16<sup>th</sup> European Simulation Symposium*, eds. György Lipovszki and István Molnár, 191-196.
- Hoffer, Jeffrey A., Joey F. George, and Joseph S. Valacich. 2002. *Modern Systems Analysis and Design*, 3<sup>rd</sup> ed. Upper Saddle River, New Jersey: Prentice-Hall, Incorporated.
- Horowitz, David, and Dana Shilling. 1989. *The Business of Business*. New York, New York: Harper & Row, Publishers.
- Kelton, W. David, Randall P. Sadowski, and David T. Sturrock. 2004. *Simulation with Arena*, 3<sup>rd</sup> ed. New York, New York: The McGraw-Hill Companies, Incorporated.
- Meyer, Zlati. 2005. Robbery Is Fatal at Repair Shop. In *The Detroit News and Free Press*, Volume 131 number 132 (1 January 2005), page 3A.
- Miller, Scott, and Dennis Pegden. 2000. Introduction to Manufacturing Simulation. In *Proceedings of the 2000 Winter Simulation Conference*, Volume 1, eds. Jeffrey A. Joines, Russell R. Barton, Keebom Kang, and Paul A. Fishwick, 63-66.

- Osmólski, Wojciech, Waldemar Olmólski, and Pawel Kaczalski. 2003. Simulation of City Bus Operation Processes as Transportation System Realization. In *Proceedings of the 15<sup>th</sup> European Simulation Symposium*, eds. Alexander Verbraeck and Vlatka Hlupic, 515-522.
- Profozich, David. 1998. *Managing Change with Business Process Simulation*. Upper Saddle River, New Jersey: Prentice-Hall, Incorporated.
- Sadowski, Deborah A., and Mark R. Grabau. 2004. Tips for Successful Practice of Simulation. In *Proceedings of the 2004 Winter Simulation Conference*, Volume 1, eds. Ricki G. Ingalls, Manuel D. Rossetti, Jeffrey S. Smith, and Brett A. Peters, 61-66.
- Sargent, Robert G. 2004. Validation and Verification of Simulation Models. In *Proceedings of the 2004 Winter Simulation Conference*, Volume 1, eds. Ricki G. Ingalls, Manuel D. Rossetti, Jeffrey S. Smith, and Brett A. Peters, 17-28.
- Schlosser, Eric. 2002. *Fast Food Nation: The Dark Side of the All-American Meal*. New York, New York: HarperCollins Publishers Incorporated.
- Wattanapanich, Chirawat, and Pichaya Tandayya. 2004. Distributed Simulation of an Emergency System for the Flood Disaster in Hat Yai, Thailand. In *Proceedings of the 18<sup>th</sup> European Simulation Multiconference*, ed. Graham Horton, 187-192.
- Williams, Edward J., and Marcelo Zottolo. 2001. Upgrading Drive-Through Services of a Credit Union Via Simulation. In *Proceedings of Harbour Maritime & Multimodal Logistics Modelling & Simulation Conference* [on compact disc], eds. Agostino G. Bruzzone, Yuri Merkurjev, Luca Maria Gambardella, and Norbert Giambiasi

## AUTHOR BIOGRAPHIES



**EDWARD J. WILLIAMS** holds bachelor's and master's degrees in mathematics (Michigan State University, 1967; University of Wisconsin, 1968). From 1969 to 1971, he did statistical programming and analysis of biomedical data at Walter Reed Army Hospital, Washington, D.C. He joined Ford Motor Company in 1972, where he worked until retirement in December 2001 as a computer software analyst supporting statistical and simulation software. After retirement from Ford, he joined Production Modeling Corporation, Dearborn, Michigan, as a senior simulation analyst. Also, since 1980, he has taught evening classes at the University of Michigan, including both undergraduate and graduate simulation classes using GPSS/H<sup>TM</sup>, SLAM II<sup>TM</sup>, SIMAN<sup>TM</sup>, ProModel®, SIMUL8®, or Arena®. He is a member of the Institute of Industrial Engineers [IIE], the Society for Computer Simulation International [SCS], and the Michigan Simulation Users' Group [MSUG]. He serves on the editorial board of the *International Journal of Industrial Engineering – Applications and Practice*. During the last several years, he has given invited plenary addresses on simulation and statistics at conferences in Monterrey, México; Istanbul, Turkey; Genova, Italy; and Riga, Latvia. He has just served as Program Chair of the 2004

Summer Computer Simulation Conference, and is serving as Program Chair for the 2005 IIE Simulation Conference and the 2005 Summer Computer Simulation Conference. E-mail address and university web pages: <[williame@umdsun2.umd.umich.edu](mailto:williame@umdsun2.umd.umich.edu)> and <<http://www-personal.umd.umich.edu/~williame>>.

**JUSTIN CLARK** is a senior student at the University of Michigan – Dearborn, studying Industrial Engineering with a business concentration. He is an active member of the Institute of Industrial Engineers (IIE). His professional interests include Simulation, Ergonomics, and Project Management. From 1996 to 2001 he performed machine setups for Draw-Tite Company. From 2001 to 2003 he worked as a line leader for Absopure Water Company. Upon graduation, in August 2005, he plans to pursue a master's degree in Engineering Management.

**RENEE M. AMODEO** is a senior at the University of Michigan – Dearborn studying Industrial and Systems Engineering with a personalized focus of Environmental Science. She is the Vice President of the student Institute of Industrial Engineers (IIE) chapter, and a member of the Michigan Association of Environmental Professionals (MAEP). She most avidly studies the interactions that business, ergonomics, and the environment have with engineering. Since 1995, she has worked in a family-owned restaurant, Sam's Sorrento Pizza of Utica, Michigan, and currently holds a management position. She has also acquired a second part-time job in 2001 at G2 Consulting Group, Troy, Michigan, as an Environmental Technician, where she assesses environmental impacts and writes technical reports. After her expected graduation date of August 2005, she plans on initiating/developing an engineering career, with the intention of continuing her education.

**JORY D. BALES JR.** is a senior at the University of Michigan – Dearborn. He is pursuing a bachelor's degree in Industrial Systems Engineering with a concentration in Manufacturing. He is an active member and president of the University of Michigan – Dearborn chapter of the Institute of Industrial Engineers. He is also a member of the Society of Manufacturing Engineers. His career interests include engineering sales, project management, and simulation. Jory has been an employee of Red Lobster, a seafood restaurant chain, for four years. During this time he has worked as a waiter and bartender. After graduation Jory plans to start his professional career, and pursue a master's degree in a job-related field.

# Map of Service Center Facility

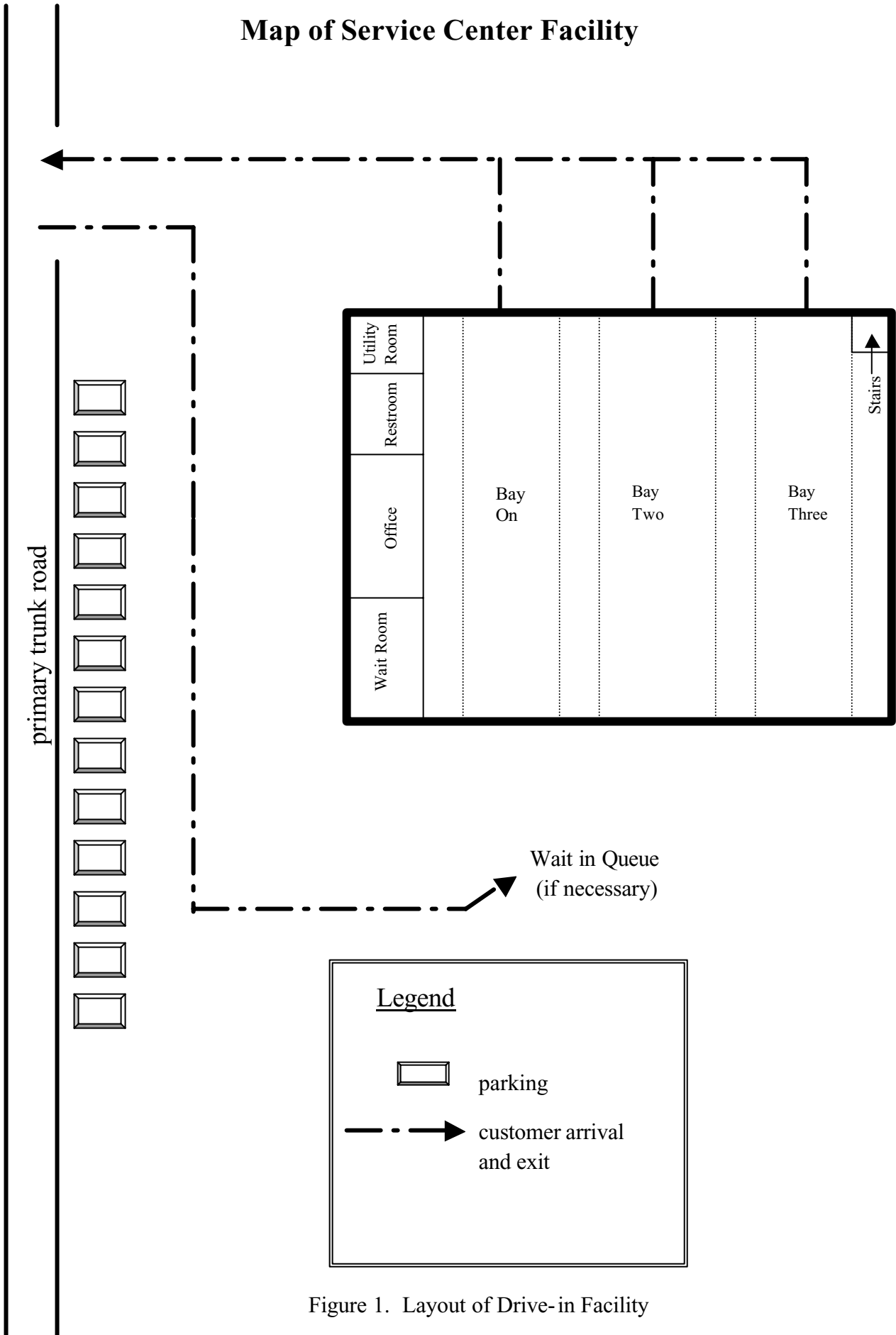


Figure 1. Layout of Drive-in Facility

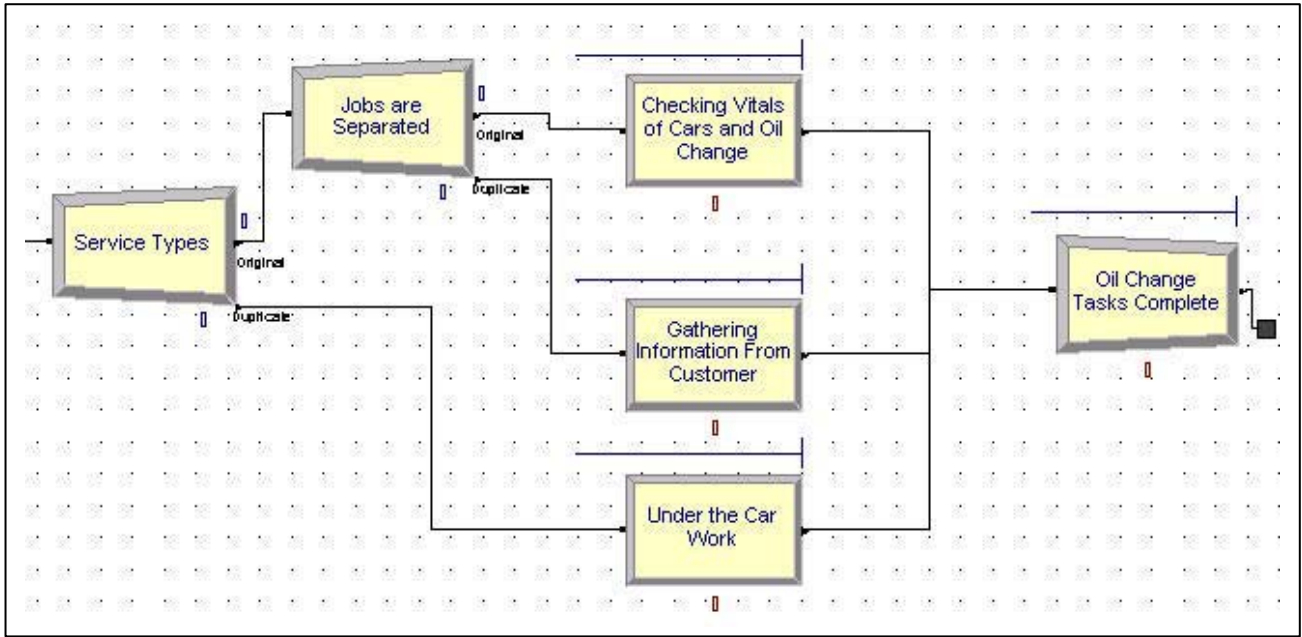


Figure 2. Screen Shot of Submodel