

SIMULATION OF RESTAURANT OPERATIONS USING THE RESTAURANT MODELING STUDIO

David M. Brann
Beth C. Kulick

Automation Associates, Inc.
512 Via de la Valle, Suite 209.
Solana Beach, CA 92024, U.S.A.

ABSTRACT

The operation of quick service restaurants (QSR) is a highly engineered process, with many factors coming into play: physical layout, equipment availability, and worker staffing levels, positioning, and priorities. The Restaurant Modeling Studio (RMS) provides an analysis platform for investigating the impacts of these factors on critical performance metrics, especially speed of service and service capacity. The key components of the RMS are a simulation engine built in Arena, and two custom applications built on Microsoft Visio—the Kitchen and Process Designers. The simulation engine supports a large number of behaviors, including parallel operations, inventory replenishment, prioritized task selection and many more. The Kitchen Designer and Process Designer provide the user with powerful tools for specifying the physical layout and order fulfillment processes. This paper presents the components of the RMS and its use in an analysis kitchen design comparison and labor deployment standards.

1 INTRODUCTION

This paper describes a modeling system that has evolved through 8 years of experience of working with numerous QSR operators. The RMS is the latest generation of a simulation-based tool that has matured both in functionality and in usability—it now incorporates many of the features that have been identified from applying simulation technology for actual QSR projects. The major enhancements to the tool are concentrated within a highly configurable user interface that provides state-of-the-art capabilities using widely used software applications such as Microsoft Office and Visio.

In addition to describing the features of the RMS, this paper describes some recent applications using it with a major QSR operator to make significant planning and operational decisions related to incorporating multiple brands within existing single brand stores.

2 WHAT IS THE RESTAURANT MODELING STUDIO?

The QSR industry is very dynamic and must continually respond to market and concept changes. A QSR must immediately respond to customer demands where trends can fluctuate from day-to-day or even hour-to-hour. In addition to dramatic customer demand changes, there are constant business changes that may involve new product introductions, marketing promotions, seasonality, or even new process designs. Even small changes to the design, staffing, or production process can have significant impacts on the customer experience and on the total sales volume capabilities of the QSR.

To provide the capability for analysis in this dynamic environment, the RMS is a flexible and highly configurable simulation-based decision support tool that allows for many potential time and money saving opportunities to be explored when engineering restaurant designs and operations. On a planning level, new store layout and alternative transaction processing methods may be explored. On an operational level, RMS can be used to explore labor productivity requirements to maximize sales volume while still maintaining a quality experience (speed of service) for customers.

RMS offers a “virtual test bed” that allows for concepts to be screened prior to actual construction or costly physically-staged mock-ups. It provides a test environment that is difficult, if not impossible to stage in a real-life test setting. The RMS can process many hours of simulated transactions in a matter of minutes, facilitating analysis and information gathering.

3 RMS CONSTRUCTION

3.1 Modeling System Architecture

The RMS is actually more than a simulation model—it is a system that includes multiple components that are all synchronized together. The architecture also follows a proven

software design that separates the system into 3 layers: 1) presentation (user interface), 2) business (simulation model and supporting Visual Basic), and 3) data (Microsoft Access). This deployment of RMS is based on a single-user, single-machine paradigm, but using this architecture does enable future web-based deployment possibilities.

Figure 1 shows a system architecture diagram that describes how the various components of the model system are organized into these layers and how they are connected. Note that the architecture allows for all input data and files to be external to the actual simulation engine such that it is possible to configure a restaurant concept without the need for any model code changes. This greatly expands the RMS user community to include those that are not trained in constructing simulation models. The system architecture also allows for alternate scenarios to be designed quickly and within software applications that are familiar to many users—Microsoft Office and Visio.

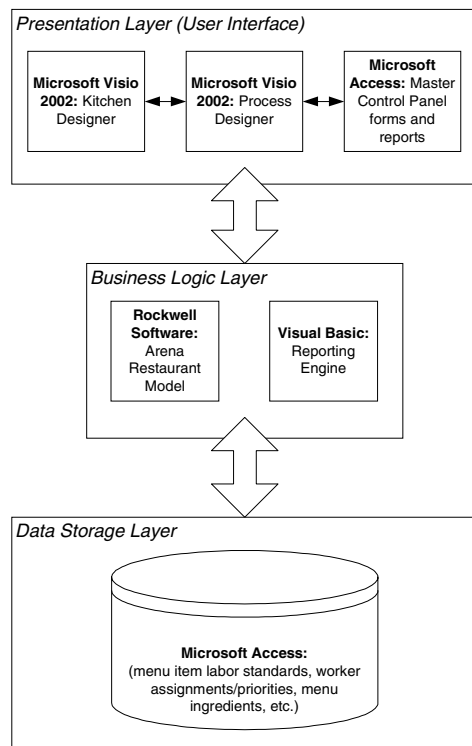


Figure 1: RMS Architecture

3.2 Simulation Engine

The simulation engine is constructed using the Arena simulation language that is commercially available and licensed by Rockwell Software. This product was chosen because it has the proven capability and flexibility to construct a model of this complexity. It also offers a significant Visual Basic object model that is useful for automatically translating the layout/CAD information contained in the Kitchen Designer to both the model and the animation.

The ability to have a real-time animation is also considered to be beneficial. Additionally, Arena provides fast execution such that results may be obtained in a few minutes.

3.3 RMS Microsoft Access Database

The primary purpose of the Microsoft Access database is data storage and management. However, there are some additional features provided within the database such as the ability to launch other RMS components, etc.—these are described in the following subsections.

3.3.1 RMS Master Control Panel

Within the Microsoft Access application, a “master control panel” is provided. This is the screen that the user first experiences when starting the RMS, and it is the central point where all supporting applications and forms may be launched. The following functions are included:

- Scenario Manager
- Visio Tasks:
 - Process Designer
 - Kitchen Designer
- Manage Data:
 - RMS Model Data
 - Download Data
 - Run Transaction Log Preprocessor
- Arena Tasks:
 - Run Simulation
 - Run Simulation with Animation
 - Open Reports.

3.3.2 Data Storage

The data storage layer is contained within Microsoft Access. There are numerous data tables provided within this database and it has been designed to provide entry forms that force synchronization with other data entries that are provided within the Process and Kitchen designers. Many of the data record building activities are automated and pull-down lists are offered to force the user to only select those options that have been specified in these Visio-based applications.

Additionally, data checking routines are incorporated that attempt to capture data inconsistencies, errors, etc., prior to running the simulation model. Some of the major data inputs that the user must provide within the database is described in the following outline:

1. Process Details
 - a. Worker vs. non-worker designation
 - b. Individual vs. batch execution
 - c. Service time standard expression

- d. Drive-thru customer position requirements
- e. Cooking equipment requirements
2. Worker Details per “Worker” Process Elements
 - a. List of available workers
 - b. Allowable processes/priorities per worker
 - c. Kitchen position where process is performed
3. Time/Labor Standards
 - a. General/service time standard probability distributions (ordering, payment, etc.)
 - b. Food item time standards—time at each process element per applicable food item
4. Menu Item Details
 - a. Required process elements to make item
 - b. Desired inventory levels—cook to order vs. staging levels
 - c. Bill of material information.

3.3.3 Scenario Management Utility

When using the RMS, users will be often creating numerous scenarios to perform analysis. For example in a labor productivity study, there are scenarios needed to support the varying deployment levels needed—a typical QSR will experience sales volumes that can support 3 to 15 workers—each one is considered to be a different RMS scenario. If this is multiplied by runs needed for different market segments, store layouts, day parts, etc., one can see the multitude of scenarios that may be created.

The RMS includes a sophisticated scenario management utility that allows for the user to name, save, delete, copy, and import/export scenarios from/to other users. A scenario includes all of the files needed to recreate it—including inputs and outputs and it is stored in a compressed format.

3.4 Process Designer using Microsoft Visio

The Process Designer is an application built upon Microsoft Visio. A customized stencil with specially designed RMS shapes is provided for the user to configure the transaction process sequence for each “arrival stream” (walk-up, drive-thru, delivery, etc.) The process designer supports the idea of “process groups” which are sequences of individual processes that must be performed until there is the possibility of merging them (or not merging them) with other process groups (see sample in Figure 2 below).

For example, if there is a QSR concept that involves grilled and fried menu item process groups, it is possible to define a grilled process group that can occur in parallel with a fried process group. These two groups can merge together to require a final service process group to bag it, and hand it off to the customer.

The stencil includes shapes to allow the user to configure the following types of process groups: service, menu

item assembly, cooking, time-based cyclic support tasks, and count-based cyclic support tasks.

The RMS Process Designer is constructed such that new transaction types can easily be added as envisioned—new types such as “speed pass”, “express orders”, etc. can be configured to analyze system impacts.

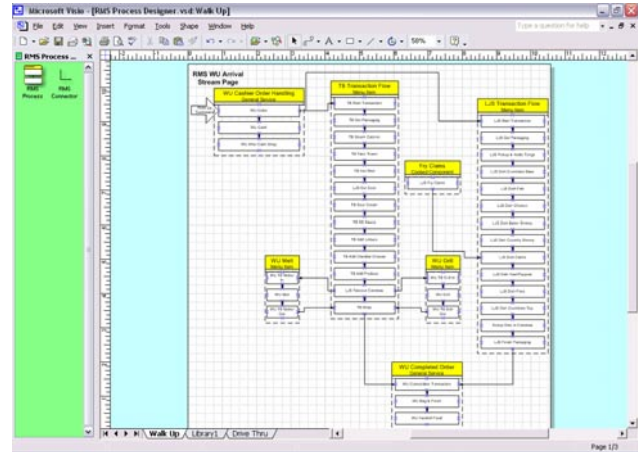


Figure 2: Process Designer Sample

3.5 Kitchen Designer using Microsoft Visio

The Kitchen Designer is a powerful solution that allows for a user to import a CAD drawing into Visio, and for the dimensional information to be appropriately translated into RMS.

The Kitchen Designer is built upon Microsoft Visio and there is a customized stencil with shapes that allow the user to define the various worker positions that need to occur within the layout. There is a shape that also allows for the user to configure kitchen “aisle ways”—the areas where workers move to access their work positions for food assembly or other service tasks (see sample in Figure 3 below).

Since many QSR concepts also require drive-through transactions, the Kitchen Designer also allows for the user to place the various drive-through customer positions. This allows the user to specify to the model cases where a drive-through customer must be available prior to executing a process elements (payment, order hand-off, etc.). This offers the flexibility to allow the user to configure different drive-through lane designs—one versus two windows, etc.

The Kitchen Designer automatically calculates the routes and distances between all workstations (and drive-through positions) such that this information is automatically translated into RMS for use in calculating worker movement delays and in the animation — this capability is a big time-saver allowing the user to import a new layout and start modeling it within minutes.

The Kitchen Designer is synchronized with other RMS components such that when the user is defining further in-

formation the user only has the option of assigning process elements to kitchen positions that have already been defined.

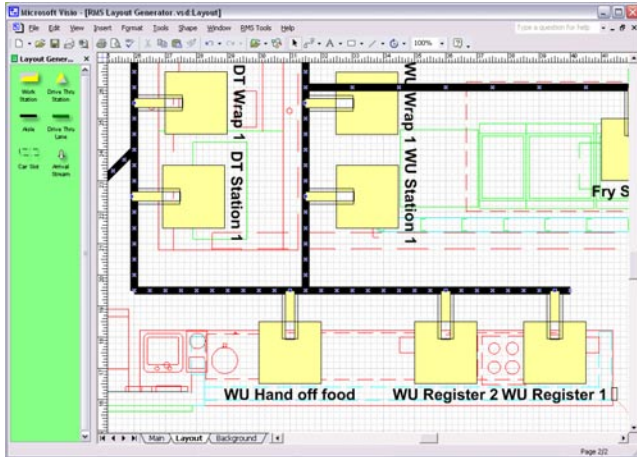


Figure 3: Kitchen Designer Sample

3.6 Transaction Log Preprocessor

The current version of the RMS uses actual point-of-sale (POS) data to create transaction order content. This offers the capability to create realistic menu mix for the different market segments for the model.

The RMS includes a “transaction log preprocessor” utility that allows the user to import a POS file and then filter it to include only the types of transactions required for the study. For example, it is sometimes desired to run a scenario to support a “lunch day part” analysis. The user can filter out only those transactions that occur during this day part using this preprocessor. Once the user executes this preprocessor, the POS data is in the appropriate format for the simulation model.

4 RMS SIMULATION MODEL

After all the appropriate configuration information is provided in the Visio files and the database, the user can launch the RMS simulation model. Once the model is launched, the model will initialize itself with all of this information—no data is “hard-coded” within the model itself.

4.1 Model Scenario and Run Period Assumption

In an actual QSR, a typical day may have different menu offerings, sales volumes, ordering preferences, etc. In order to respond to this, a QSR operator will often change the following operational elements: 1) worker staffing level, 2) cooking schedules, and 3) quantity of kitchen positions that are “open”. The model assumes that each of these items must be consistent throughout the run period—a different scenario must be created if any changes are to be made.

The model run period is not usually the same period where there is a consistent setting of the operational elements. In an actual QSR peak period, these elements can change as frequently as every 15 minutes. In most QSR environments, the greatest source of variability is the customer arrival times and order profile. This variability is often large enough that in order to analyze results, it is typically required to run the model for longer than 15 minutes, etc. to be able to process enough customers to analyze performance trends.

The model is designed to run in a “non-terminating” mode—the user selects a time period to run and the model ends when this time elapses. The user can select the time period and the number of replications to make. For each replication, the model includes a “warm-up” period, after which the statistics are cleared and the model continues to run for the specified duration. After the run period elapses, final performance statistics are reported.

4.2 Transaction Arrivals

The model includes user inputs that allow for an independent customer arrival rate to be specified for each arrival stream. The model assumes a Poisson arrival rate, and after each customer arrives in the model, the order content (quantity and type of menu items) is determined from the POS information that has been supplied.

The order information is attached with the transaction and this is used to determine the different process groups that are required to complete it.

4.3 Process Group Requirements

In the Process Designer, the user specifies the process groups that must be executed to process transactions within an arrival stream. The “general service” and “menu item” process groups are the ones that potentially must occur for each transaction. General service groups must be performed; menu item groups are needed if the food assembled within that group has been ordered by the customer.

The RMS supports other process groups such as cooking and cyclic groups. These groups are not directly associated per transaction. For example, the cooking groups are usually launched based on inventory levels—once the level has dropped below a reorder point, these processes are requested by the model.

When a customer arrives, the model determines which transaction-related and non transaction-related process groups need to be performed.

4.4 Process Group Sequencing Logic

In the Process Designer, the user specifies the precedence relationship, or the sequence in which the process groups need to be executed. For example, it might not be possible

to initiate a “hand-off order to customer” process until all the menu items in that transaction have been made. The model contains logic that determines when process groups can be initiated based on the precedence relationships defined in the Process Designer.

Additionally, in the Process Designer the user can specify the number of “instances” for a given process group. Many process groups will only have a single instance, but in some cases, such as ordering/cashiering there may be multiple positions where this occurs—the sequencing logic enforces the precedence relationships between process groups; it does not determine which instance will be used—this is determined in the worker selection logic.

4.5 Worker and Process Group Instance Selection

Once the model determines that a process group has permission to be executed, there is logic to determine which worker and position (if there are multiple options) to use. The model will attempt to find an idle worker that is capable of performing that process. There are two possible outcomes when this logical evaluation is made: 1) one or more workers are available, or 2) no worker is available. If there are one or more workers available, the model logic will pick the one at the primary station first, and if that worker is not available, the model will search to find the first position that has an available worker. If there is no worker available, the request to execute that process will wait or queue until a worker becomes available.

4.6 Process Element Execution

Once a worker and a position has been selected, the model will execute the process element based on the labor standards that have been specified. The model supports different labor standard definitions based on the type of process group. For menu item process groups, the time to execute it is based upon the labor standards for each menu item made at that process. For general service process groups the labor standard is based on a discrete probability distribution. The model forces the worker to stay at that process until all time delays associated with labor standards have elapsed for that transaction.

After completion, the worker is available to execute another process. The model logic attempts to use the same worker for additional processes for that transaction as long as precedence relationships (and other requirements) are satisfied and that worker has permission to do that process. If there are no process elements that the worker can validly perform, the model will examine if there are other transactions that need to have processes executed. If there are none, the worker goes idle and waits until a new process execution requirement emerges.

4.7 Performance Measures

The model tracks numerous performance measures during run time and also per transaction executed. The following outline highlights the most significant measures:

- Order statistics
 - Orders started
 - Orders completed
 - Avg. order to delivery time
 - Avg total time
 - Total sales started
 - Total sales completed
- Worker statistics
 - Percent idle
 - Percent walking
 - Percent busy
- Process statistics
 - Avg transactions waiting
 - Wait time
 - Count of executions
- Food statistics
 - Avg wait for item
 - Avg units in inventory
 - Avg units wasted
 - Amount consumed
- Worker position statistics
 - Avg utilization.

5 RMS CASE STUDY

The RMS can be used for a variety of different types of analyses. A case is presented here that illustrates how the RMS can be used to make design decisions.

5.1 Study Background

A major QSR operator used the RMS to assist in making decisions on a “multiple brand” store concept. The operator was planning to retrofit hundreds of stores to include the capability to offer additional brands within existing single brand stores. The operator had finalized three different store concepts for the multiple brand concept. The RMS was used to evaluate which store design would offer the most sales generation potential.

5.2 RMS Configuration

Three different scenarios were created by importing a CAD layout of each design into the Kitchen Designer. The transaction flow was determined for each design and uniquely represented for each layout using the Process Designer. The labor standards were determined and other details were entered into the RMS database.

5.3 Comparative Analysis

In order to compare the three designs, each one was tested with the same POS transaction data and arrival rate. It was desired to compare the designs at high sales volume to observe the “breakpoint” where they start to show differences in performance.

As a starting point, a staffing level of 9 was configured with each design—each worker was assigned to processes based on user estimates. The model was run for each design and the worker assignments “fine-tuned” to balance the workload and get best performance at that labor level. After the balancing was completed, the maximum sales volume was determined while still maintaining desired speed of service targets. The resulting sales volume is the maximum achievable volume that the design can maintain.

When analyzing the results from the 9 worker scenario, it was observed that 2 out of 3 designs had very similar sales capabilities at this level of deployment. One out of the 3 designs was clearly behind the others in terms of its capabilities.

The next step was to continue adding workers to see where there is a difference between the remaining designs. The original scenario was duplicated, adding a single worker to analyse a deployment of 10. The procedure of estimating the worker assignments, fine-tuning to balance workload to get best performance, and determining the maximum sales potential while still maintaining speed of service targets was repeated. A worker deployment of 10 started to show where one of the designs had more transaction throughput and sales capability. The conclusion was that one kitchen design clearly had more capabilities at higher deployment levels—it is preferred to have a design that can best accommodate a greater range of transaction volumes and associated staffing levels.

This design was presented to upper management and the achievable sales volume presented. A decision was made to use the design identified by the RMS as the preferred solution.

6 SUMMARY

The RMS is a proven simulation-based solution that has been used to make some enterprise wide decisions for major QSR operators. It has provided insights that would have been very difficult, if not impossible, using other methods such as physical mock-ups. The opportunities to use the RMS for making important business decisions are significant. Some of the initiatives and projects that the RMS has been used include the following:

- Test capacity of restaurant layout concepts before committing to construction

- Determine maximum sales volume that can be achieved by a given staff level and design while still providing a quality customer experience
- Identify kitchen designs and processes that provide flexibility and maximum sales potential while minimizing equipment investment and construction costs.
- Support development of labor management system productivity standards.
- Determine return-on-investment potential for new equipment types.
- Explore the service impacts of new product introductions and marketing promotions.

AUTHOR BIOGRAPHIES

DAVID M. BRANN is a Solutions Analyst at Automation Associates, Inc. He joined Automation Associates in 1999 as a Simulation Analyst and has created customized simulation models and business analysis tools for a variety of industries. He received a BS in Aeronautics and Astronautics from the Massachusetts Institute of Technology. His email and web addresses are <dbrann@automationassociates.net> and <<http://www.automationassociates.net>>.

BETH C. KULICK is Vice President of Automation Associates, Inc. She joined Automation Associates in 1988 as a Simulation Analyst and has created customized simulation models for a variety of industries. She received a M.S.I.E. from Texas A&M University and a B.S.M.E. from Purdue University. Her interests include creating advanced business analysis tools that are based upon simulation models and other software technologies. Her email address is <bkulick@automationassociates.net>.