INTRODUCTION

According to American Airlines Decision Technologies, pioneers in the field of yield management, yield management can best be described as "the control and management of reservations inventory in a way that increases (maximizes it possible) company profitability, given the flight schedule and fare structure." Simply put, it's "selling the right seats to the right customers at the right prices" (Smith, Lamkin, and Darrow, 1992).

Yield management can be set up as a non-linear mathematical model that takes into account such factors as passenger demand, cancellations, fare categories, and other variables that help explain passenger behavior. The SAS System, with its robust set of tools for decision support, is ideally suited to decipher this complex set of issues.

Although yield management technology had its roots in the airlines industry, problems facing the cruise line industry are so similar that many of the same techniques can be applied to this industry as well.

Royal Caribbean Cruises Ltd. (RCCL), founded in 1969, has experienced growth of over 300% in the past four years, and is now the largest cruise line in the world. Its nine ships range from the "megaships", Sovereign of the Seas, Monarch of the Seas, and Majesty of the Seas, which can accommodate more than 2200 passengers, to the 3- and 4-day cruise ships, the Nordic Empress and Viking Serenade, to the seasonal ships that make longer cruises, Song of Norway, Nordic Prince, Sun Viking, and Song of America. These ships sail on 46 different itineraries, not only in the Caribbean, but also to Europe, Alaska, Mexico, Bermuda, and South America.

Travel agents book both groups and individuals for 17,000 to 18,000 berths sailing per week, in cabins ranging from the Royal Suite on the Bridge Deck, to inside staterooms on the "B" Deck. Sailing dates fall into the categories of "Peak Season," "Value Season," and "Economy Season." Special discounts, such as the six month advance purchase discount, and upgrades are offered. With so many variables to keep track of, it became evident that manual techniques were no longer efficient.

In 1989, Royal Caribbean Cruises Ltd., with the help of American Airlines Decision Technologies (AADDT), decided to pursue yield management technology to help manage their increasing inventory. Now RCCL is considered the leader in the cruise line industry in yield management technology.

DEVELOPMENT OF THE YIELD MANAGEMENT SYSTEM

RCCL had several objectives in developing the Yield Management System. They wanted to be able to:

- Maximize revenue or profit
- Set reservations availability based on passenger value
- Adjust the minimum available rate based on demand (on more popular cruises, the number of lower-priced cabins would be limited)
- Limit exposure to market share erosion
- Reduce spoilage of unsold cabins (spoilage of cabins occurs when a cabin category is closed before all demand is exhausted for that category - a sold-out ship can sail with unsold cabins, resulting in lost revenue)
- Track the performance of the system and identify areas of improvement

The SAS System was chosen to build this system for a number of reasons:

- It was easy for analysts/programmers to learn
- Powerful data manipulation
- It had the statistics required for the forecasting models
- Excellent graphical capabilities
- Macro processing
- Report generation capabilities
- Screen design through SAS/FSP and SAS/AF software
- Supported on Sun workstations
- Online user support

In developing the Yield Management System (YMS), RCCL encountered the same barriers most companies face when implementing an information delivery system for decision support. First, reservation data necessary for the yield management analysis was located in AS/400 systems. These data had to be downloaded to the Sun network once a week and read into the SAS System for analysis. PCs residing on a Token Ring network needed to be connected to the Sun network, as well, to enable ship managers to interface directly with the YMS.

A number of applications were required, including looking at data on each ship's bookings by sail date, and determining when a ship's cruise was at a critical status. By creating a Yield Management
Finally, a number of different types of users are required to interact with the system. These users range from programmers and yield management analysts who maintain the system, to vice presidents and ship managers who simply want to get the information they need to make informed decisions. A menu system, complete with an online help facility, was developed using SAS/AF and SAS/FSP software to make the system more accessible by these users.

THE YIELD MANAGEMENT SYSTEM COMPONENTS

Royal Caribbean and American Airlines Decision Technologies worked together for about two years - building a database of reservations history, setting up retention and demand forecasting, and developing the system's reporting.

The Yield Management System was set up with 13 production jobs running 65 SAS programs. These production jobs perform such tasks as initializing weekend processing, validating and downloading data into SAS software, making group retention reports, preparing New Voyage Analysis and Critical Sailing index reports, producing performance reports, and making uploads to the AS/400 reservation system.

THE YIELD MANAGEMENT DATABASE

The Yield Management Database contains reservations history for the past 3-5 years. These historical data were downloaded from the AS/400s, converted from flat files into SAS data sets, and manipulated by SAS software to prepare the data for forecasting. The data in the reservation system were not originally designed to provide all of the information required by the Yield Management System and was not as complete or as accurate as it should have been. The SAS System proved to be very effective when dealing with inconsistencies and missing data. A series of IF-THEN/ELSE statements was used to check for errors, and error messages were then displayed to the user.

RETENTION FORECASTING

One of the first areas to be addressed in developing the YMS was retention forecasting - the ability to predict how many booked passengers will actually sail. The Retention Forecasting Subsystem (RFS) is one of the most important components of the Yield Management System because it helps to account properly for pre-departure cancellations. With this knowledge the inventory control group can try to minimize the number of empty cabins. Retention forecasting is applied to both groups and individuals with a number of variables considered. For example, for group forecasting, the booking agent, type of group, payment status, number of names received, and weeks to departure, are all used to help determine the retention rate.

Together with the Demand Forecasting Subsystem, the Retention Forecasting Subsystem is designed to help support the decision to leave a cabin category open or to close it. The RFS also provides necessary information for monitoring the performance of the Yield Management System.

The old method for determining retention forecasts was a hand-capping formula that used a fixed projection rate. The new method uses a much more dynamic and flexible approach, using available historical data to quantify the factors that may affect passenger retention. The Retention Forecasting Subsystem uses estimates based on a 2-year moving average of data, thereby reflecting changes in historical patterns.

In the category, "Groups with No Names" (the significance of "names versus no names" is that if actual names of group members have been given to the travel agent, there is a higher chance of those people sailing than if the agent doesn't have the names), there is sometimes not enough information in one or more of the required factors to develop a detailed estimate. In these cases the RFS uses a more general, "hierarchical estimation" that considers fewer factors. In the best case scenario, factors considered will include ship, group type, payment status, agent type, itinerary, quarter of year, and weeks to departure. In the worst case, the two factors considered will be ship and payment status.

To make the decision whether or not to implement the new RFS, comparisons were made with the way that retention had been forecast in the past, and the results were presented as a series of plots. This study looked at categories and groups at different levels of detail. Methods were compared by ship, cabin category, group type, and booking status. SAS/GRAPH® software was used to present these plots, making conclusions readily apparent. A comparison was made of mean errors, mean absolute deviation, and mean absolute percentage errors. In almost every instance the new Retention Forecasting Subsystem was better.

 DEMAND FORECASTING

Demand forecasting allows RCCL to determine the net untruncated demand - which is the spilled demand (or demand that is turned away) plus the actual demand. It looks at historical data to establish a booking profile that can be useful in deciding how much to overbook the ship.

Different variables are examined - for example, forecasts are determined for each ship, each cabin category, and for the different weeks to departure. SAS/ETS® software was used to establish the proper model. In setting up the demand forecast, several categories were clustered, and the same profile was determined to be valid for more than one ship. These booking profiles serve as the short-term demand forecasts. For the long-term forecasts, time series (via PROC FORECAST) is utilized. The two forecasts are combined to produce the final demand by category. As the sail date approaches, more weight is given to the profiles.

Data are collected once a week and analysis is done on two years' worth of data. For demand forecasting, airlines analyze their data once a day, but because cruise line itineraries are set, and the number of variables affecting demand does not change as rapidly, weekly forecasting is adequate.

PERFORMANCE REPORTING

The Performance Reporting functions of the Yield Management System were set up to handle important aspects of the system. The first function of Performance Reporting was to provide feedback mechanisms for monitoring the accuracy and effectiveness of the yield management models. Since RCCL's operating environment is growing rapidly, it is important to update the YM model parameters to reflect current or planned operating conditions. This area of the YMS is the primary means of identifying modal areas requiring adjustments or temporary overrides for holidays or special events.

Another important function of the Performance Reporting part of the YMS is its feed-forward mechanism. This function reports projected demand, cabin utilization, and corresponding revenues to help plan and identify critical sailings. For example, if bookings are behind where they should be, general priding reductions may be required to stimulate demand. Both functions are important in that they allow timely corrective actions to be taken to minimize model errors and identify potential revenue opportunities.
Two time parameters are studied in performance reporting: post-sailing and pre-sailing. Post-sailing reports include statistics relating to both reservations and yield management model performance. Pre-sailing information is based on reservations data for a particular sailing and is available for online viewing at any point prior to the sail date.

There are six main performance reports that are processed in batch once per week. Three are printed weekly: "Performance Statistics to Date," "Performance Statistics by Cabin Category Paid For," and "Net Reservations Holding Summary." "Net Reservations Holding Build Summary," "Historical Build at Same Weeks to Departure," and "Forecast Performance" are processed weekly but only printed on demand.

The report, "Performance Statistics by Cabin Category Paid For," shows reservations and yield management data broken down by cabin category so that the user can monitor the performance of specific categories or the entire ship. It incorporates information on demand, retention, reservations activity, and revenue associated with these data.

The "Forecast Performance Group Demand" report is meant to be used primarily by yield management analysts to help them identify when changes to the demand model parameters may be necessary. Statistics such as the mean absolute deviation and mean absolute percent error are used to compare forecasted activity versus actual and to help identify historical sources of error. This report will also warn the user if large errors in the forecast are expected.

**NEW VOYAGE ANALYSIS REPORT**

The initial implementation of the Yield Management System produced two other types of reports. Probably the most important report of the entire system, the New Voyage Analysis Report, is used primarily by ship staff. This report, replacing the old Voyage Analysis Report, provides basic reservations and group retention information by category to help with the inventory control decision-making process.

There are five main sections of the NVA Report:

1. Old Voyage Analysis Information
2. Individuals, London, Groups, and Guarantees Indicators
3. Availability Information
4. Category paid for information, including demand forecasts
5. Open/Close status indicators

The old Voyage Analysis Report calculates inventory without the use of retention rates, listing capacity by categories. It also lists information about triple and quad cabins. These indicators have been retained mainly to make a smooth transition from the old to the new report.

Information is broken down by cabin category for reservation data for individuals, groups, and individuals who are booked in the London office, and those cabins that have been guaranteed at an upgrade, or discount rate. All passenger categories are further broken down by booking status - whether the cabins have been offered or booked.

Limits on the number of acceptable guarantees are set in the reservation system and brought over to this report. The sum of offered and booked guarantees, broken out by passenger category, is an easy check of the limits specified in the reservation system.

Availability at 100% retention is given. This is the best-case scenario where none of the cabins that are booked cancel. As the sail date comes closer, this number becomes more realistic with the use of "expected availability." Calculations number of cabins by category minus individual and group retention totals, and represents the most realistic estimate of current availability.

Category paid for information includes the number of cabins paid for by individuals and groups and the remaining demand. The remaining demand is useful when used with the current retention estimate and the suggested limits. By comparing these three numbers, the decision to open or close a cabin category may be made.

The open and close status suggestions are given for individuals and groups, along with the color code (e.g., "Y" = yellow, check with the ship manager before booking) brought over from the reservations system. The open/close model suggestions are based on calculations using demand forecasting and fare information.

**CRITICAL SAILING INDEX REPORTS**

The Critical Sailing Index (CSI) Report lists the sailing date and whether the sailing is considered critical or routine. Routine sailings don't require any other controls than what are currently in effect. Critical sailings, however, require special attention. This distinction by the system is known as exception processing and results in more effective use of the ship staff's time. In addition to being used by the ship staff, this information is also used by the revenue analysis staff to help them decide if changes to group targets are necessary, or if special promotions are needed to stimulate demand.

There are seven codes that denote criticality. Explanations of these codes give the system users such information as whether or not the remaining ship demand is high compared to what is expected to be available, or if spoilage is expected to be high due to inappropriate closings.

The report gives additional information about such time-related occurrences as when final payment or second deposits are due, or when groups are reviewed.

Through the VMS, comments can be attached or removed from the CSI report showing that actions have been taken. There is also the ability to retain a history of comments and changes made. Remarks are made directly from the computer screen by the ship manager. Other input that can be made by the Yield Management Analyst is the ability to specify threshold values by itinerary, ship, and other criteria for a range of sail dates.

**GROUP EVALUATOR MODEL**

The GroupEvaluator Model provides the means to screen group requests by estimating APDs (average price per diem). The Group Request form gives the data of the request, number of cabins required, gateway information, group type, agent, and other pertinent information.

By looking at the APD, as well as other information, such as the date of request and number of cabins requested, the Financial Officer of the ship can make the decision to approve the request, put it on a "wait list" to be reviewed in thirty days, or to reject the request.

Although it is an integral part of the Yield Management System, the GroupEvaluator Model is processed on the AS/400 and is written...
in Report Program Generator (RPG). Information on the retention rates of the travel agents, the ships, and week of departure, as well as the projections on which the APBs are based, are all generated by the Yield Management System (and the SAS System) on the Sun workstations, then uploaded to the AS/400 for inclusion into the Group Evaluator Model.

THE MENU SYSTEM

Once the forecasting models were determined, the reports were written, and the production jobs established, a menu system was built with SAS/AF software to front-end the system so non-programmers could easily get the information they needed. With SAS/FSB software, customized data entry screens were written to allow the users to override the system retention rates.

The first menu selection listed on the main menu, "Yield Management Override and Display," is "Retention Group - Override." After making this selection the user is prompted for the ship he or she wants to study. By default the current departure date and first group ID is filled in. These can be changed by the user.

The report lists group descriptions, including group ID, payment status, and type of group, by departure date. Retention percentage is included for both named and non-named passengers, and predicted retention rates are given by payment status. Sometimes the ship managers have more recent information that the system has not had time to model. For example, a ship manager may know that a certain travel agent with a bad track record has just done a major marketing promotion to get more cruise passengers. The ship manager may then want to override the retention forecasting that is being done by the system. If this is the case, the change can be entered directly on the screen. To keep up with changes that are made, the system rates are maintained on the second line, and the changes are noted on the first line with the user ID and the date of override being recorded in the system.

Similar menu selections allow overrides for retention of individuals and demands by category and sailing. Also available as a selection is the ability to browse the logs, all of the overrides that have been made.

In addition to making overrides to the retention forecasting system, one of the menu selections allows the end user to request interactivity with the retention estimates reports, review them, and print them. If changes have been made to the retention rates, the modified reports are shown. If no changes have been made, the reports that have been generated in batch mode over the weekend can be viewed.

DECISIONS SUPPORTED BY THE YIELD MANAGEMENT SYSTEM

Yield Management reports are distributed weekly to the Inventory Control Department, Groups Department, and Marketing. Managers using YMS include the Inventory Control Manager, Passenger Services Vice President, the Fleet Manager, and Ship Managers.

Based on the information provided by the YMS, Inventory Control works with the Marketing Department to suggest when promotional campaigns or other demand-stimulating activities should be undertaken. Decisions to keep a category open, or close it to further reservations are also made from the YMS information. Overbooking rates can better be determined using this information. All of these decisions supported by the YMS help increase revenue by providing information in a timely manner, so that actions can be taken before the ships sail.

RCCL just recently rewrite their Reservation System, and after several months, has put it into production. As an unexpected benefit of the Yield Management System, bugs and problems in this new system are being detected in the YMS reports, so that corrective action can be taken.

As a "spin-off" from the YMS, ad-hoc reports are being generated using SAS software and data in the Yield Management Database to help answer a wide variety of questions.

HOW THE SAS SYSTEM WAS USED

As stated earlier in this paper, the procedures within SAS/ETS software were explored during the initial design phase to set up the proper models for Retention and Demand Forecasting. By using the presentation capabilities of SAS/GRAPH software, the new modeling and forecasting techniques were proven to be superior over what were then the current forecasting methods, and the switch to the new system was justified.

Once it was decided to proceed with the new system, AADT and RCCL implemented the production system making extensive use of DATA step programming. DATA step and macro programming were used to automate and help optimize the system's performance.

The powerful data management features of the SAS System, such as sorting and merging data sets, were used to get the data in the format necessary for analysis.

With the combination of DATA step programming and the analytical capabilities of the FREQ and SUMMARY procedures, the SAS System produces and applies the retention rates across all categories.

The SAS System's flexible report-writing functionality allows RCCL to set up the reports to depict the information in an easy to understand format. In many cases, labels are used, instead of variable names, for clarity. The report-writing features make designing and maintaining the reports a simple task.

FUTURE ENHANCEMENTS

On an annual basis the Yield Management analysts will be reviewing the forecasting models being used, and make adjustments if necessary. Non-linear regression techniques in SAS/ETS software possibly may be used to further refine the model, and demand forecasting techniques may be worked on and improved.

Currently, RCCL is working on a pilot project to determine the feasibility of using the SAS System analyses to optimize category closings by gateway. Lower cabin categories could potentially be closed to passengers coming from cities at greater distances from their points of departure.

In the short-term, Royal Caribbean may want to investigate all variables affecting retention. They have determined major factors but want to see if there are other factors that perhaps contribute to the bottom line just as much. Better tracking methods need to be implemented, and more factors need to be quantified.

As a step toward implementing total quality management, RCCL would like to begin the analysis of customer complaints. With the help of SAS/QC software they could establish acceptable limits for numbers of complaints by sailing, and by cabin category, etc. Pareto charts could help identify causes of complaints.
Within the area of quality control, RCCL may also want to monitor its demand forecasting, as American Airlines is currently doing. Quality control reports help identify passenger demand forecasts that have become biased. This bias in the forecasts can be caused by permanent changes in passenger behavior that time-series analysis does not quickly identify (Smith, Leimkuhler, and Darrow, 1992).

Optimization of the Yield Management System is also potentially in RCCL’s future plans. SAS/OR software would be used to help automate the open/close status of cabin categories and to fine-tune the retention rates. More control over the decision-making would be given to the system, freeing up time for the ships’ staff to concentrate on other aspects of the business.

CONCLUSION

As a company, Royal Caribbean is reorganizing to concentrate more on the Yield Management System. Personnel who can focus more attention on the information coming from the YMS are changing roles within the company to better assist the ship managers in making decisions that will maximize the company’s profits.

With RCCL’s increasing inventory, the Yield Management System has proven to be effective in improving the flow of information throughout the organization so that decisions can be made that increase the revenue of the company. On a weekly basis executives of RCCL meet to discuss the critical sailings. The YMS provides the information necessary to define these potential problem areas.

The use of the YMS within RCCL will continue to grow - just as its inventory is expanding. In the next three years three more ships will be added to the fleet. Revenue maximization, through the use of the YMS, not cost-cutting, is where RCCL’s emphasis will be.

It is estimated that if the average yield per passenger goes up $1 per day, RCCL would realize an increase of $5.5 million in revenue. According to Brian Rice, Director of Revenue Planning and Analysis, paying close attention to the revenue on a day-to-day basis has brought them monetary benefits of over $20 million (*Royal Caribbean Breaks Through*, Scorecard, 1992). This is a prime example of getting information to the right people in a timely manner so that they can make decisions that affect the company’s profitability. RCCL’s Yield Management System is an example to be followed as an information delivery system of SAS software for decision support.

REFERENCES


Royal Caribbean Cruise Line Yield Management System User’s Guide.

SAS, SAS/AF, SAS/ETS, SAS/FSP, SAS/GRAPH, SAS/OR, and SAS/QC are registered trademarks or trademarks of SAS Institute Inc. in the USA and other countries. *indicates USA registration.

All other brand and product names are registered trademarks or trademarks of their respective companies.