Hospitality Review

Volume 20
Issue 2 *Hospitality Review Volume 20/Issue 2*

Article 2

January 2002

Systems Engineering Perspective of the Cruise Industry

Ronald E. Giachetti
Florida International University, hospitality@fiu.edu

Systems Engineering Perspective of the Cruise Industry

Abstract
The maturation of the cruise industry has led to increased competition which demands more efficient operations. Systems engineering, a discipline that studies complex organizations of material, people, and information, is traditionally only applied in the manufacturing sector; however, it can make significant contributions to service industries such as the cruise industry. The author describes this type of engineering, explores how it can be applied to the cruise industry, and presents two case studies demonstrating applications to the cruise industry luggage delivery process and the information technology help desk process. The results show that this approach can make the processes more productive and enhance profitability for the cruise lines.

Keywords
Ronald Giachetti, Cruise, FIU

Systems engineering perspective of the cruise industry

by Ronald E. Giachetti

The maturation of the cruise industry has led to increased competition which demands more efficient operations. Systems engineering, a discipline that studies complex organizations of material, people, and information, is traditionally only applied in the manufacturing sector; however, it can make significant contributions to service industries such as the cruise industry. The author describes this type of engineering, explores how it can be applied to the cruise industry, and presents two case studies demonstrating applications to the cruise industry luggage delivery process and the information technology help desk process. The results show that this approach can make the processes more productive and enhance profitability for the cruise lines.

The largest and most recognizable sector of the Florida economy is the tourism and hospitality industry. Tourism is defined as people from out of state who travel to a destination for pleasure, business, or both. The arrival of tourists and business travelers supports the hospitality industry (hotels), car rental, restaurants, local attractions, and the entertainment industry.

A growing and significant part of the South Florida hospitality industry is the cruise industry. In 2000 this segment experienced a 17 percent growth in passengers served. Cruises, a destination in themselves, provide exclusive vacation experiences that include hotel, restaurant, and entertainment. Florida is the center of the cruise industry with 15 corporate or administrative headquarters and 101,000 jobs. Florida accounts for more than one-third of the cruise industry's national impact and accounts for 70 percent of U.S. cruise embarkments. The cruise industry contributes toward a positive trade balance in the services with a growth of foreign visitors from 12 percent in 1990 to 18 percent in 2000. Overall spending by the cruise companies themselves and their passengers combine for an economic impact of 257,067 jobs in retail, travel, hotel, and entertainment.[1]

The rapid growth of the cruise industry, increased competition, utilization of technology, and the large size of the organizations calls out for systematic management of the people, resources, and systems used to deliver service to the customer. In attempting to manage the complex cruise organizations, hospitality managers encounter many problems that fall within the province of systems engineering. Often, the problems encountered are similar to those routinely faced in the manufacturing industry by systems engineers.

However, hospitality managers are often unaware of the tools and techniques utilized in manufacturing. Likewise, engineers and others from manufacturing who study these issues are not cognizant of how their knowledge can be applied to the hospitality industry. This schism exists due to the educational backgrounds of the respective groups, emphasis of the government on manufacturing for the creation of wealth, and the view that services are non-technical and engineering efforts are therefore not applicable.

A literature search of hospitality journals including *Cornell Hotel and Restaurant Administration Quarterly, FIU Hospitality Review, Tourism Management,* and *Hospitality Management* reveals little prior recognition of engineering and turns up few references to such keywords as engineering, engineer, or even information technology.

However, if hospitality researchers are unaware of the engineering principles and methods that can aid them in addressing their issues, the same criticism can be leveled at engineering researchers. Engineering research conducted in the service industry almost exclusively draws on engineering literature and uniformly ignores the literature available in the service industry. Engineering researchers have for the most part overlooked the hospitality industry. An exhaustive search of major engineering journals and a search of the abstract index reveals the only application of engineering specifically for the hospitality industry to be in revenue management. There is almost no engineering work that has addressed other hospitality specific issues such as productivity, systems integration, quality, or employee training and retention. As a consequence, those in the services have little knowledge of the potential contributions of engineers.

Services recognized

While the reasons for the lack of engineering emphasis in hospitality specifically and services in general is deeply rooted, there is a trend toward inclusion of the service industry into engineering programs. The engineering community has been working in the service industries for some time now. As the leading sponsor of academic research on engineering methods, the National Science Foundation (NSF) has been active in some phases of the service sector for many years. Still, NSF engineering programs have largely overlooked a number of large and rapidlygrowing components, including health care delivery, financial services, retail, and hospitality/ entertainment. Indeed, quantitative modeling and analysis in those sectors may not even be recognized as engineering, even though it relies on the rigorous problem-solving techniques that exemplify systems-level engineering practice. There is an opportunity for engineering to bring productivity gains in service delivery similar to the gains achieved in the manufacturing sector.

Human interaction is core

Systems engineering, a discipline that studies complex organizations of material, people, and information in order to accomplish a proscribed mission, covers any complex organization, whether a manufacturing or service firm. It embodies the tools, techniques, and methodology for the understanding, analysis, design, and control of a system. Systems engineering projects usually seek to improve the system cost, performance, productivity, or quality of the system or the services it produces. Pertinent to the cruise industry is the emphasis systems engineering places on the human-system interactions. As noted by Tien and Berg[2], it is an eclectic combination of disciplines which is able to adopt new technologies and methods and to evolve and work in a multidisciplinary environment.

There are 19 academic programs that offer degrees specifically in systems engineering.[3] They classify the programs into four groups of systems analysis and design, industrial engineering, traditional control systems, and a mixture of control systems with other topics. Many of these degree programs are offered within departments entitled industrial and systems engineering. The distinction between industrial engineering and systems engineering is not clear. The definition from the Institute of Industrial Engineers (IIE) says, "Industrial engineers figure out how to do things better. They engineer processes and systems that improve quality and productivity. 'Industrial engineer' is synonymous with systems integrator." The primary difference between industrial engineering and systems engineering is that the heritage of industrial engineer is tied to manufacturing; many of the tools, techniques, and methodologies are specialized to the manufacturing industry.

Math solves problems

An important sub-discipline of systems engineering is operations research, the application of mathematics to determine an optimal solution to a problem. OR utilizes mathematical models of the system, linear programming or related techniques to model, analyze, and optimize the system.

Systems engineering is inclusive of systems in all industries, including manufacturing, service, and government. Within the service industry this includes financial, medical, transportation, utility, professional, and hospitality services. The trend of the U.S. economy from a manufacturing to a service base has resulted in many of the graduating industrial engineers today not working in manufacturing. At Florida International University it is estimated that approximately 70 percent of undergraduate students earning a B.S. in industrial and systems engineering start their career in a service industry. This percentage is probably not uncommon in other engineering programs, especially in those located where there is little traditional manufacturing industry.

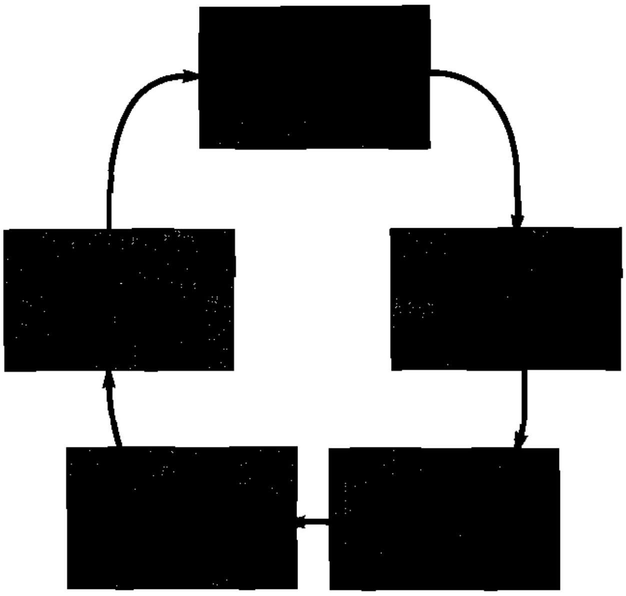
Opportunities exist

Increasingly, engineers are finding opportunities in the cruise industry and hospitality in general. The most conspicuous application of systems engineering in the cruise industry is revenue management, which utilizes many operations research models, tools, and techniques. Other applications of OR include scheduling, optimizing allocation of resources, inventory control, minimizing wait times (queuing theory), and many more problems faced by the cruise industry and not yet addressed through systems engineering methods. The growth area for systems engineering is in the new knowledge economy.[4]

Figure 1 illustrates the systems engineering methodology, which is used to show how it can be applied to the cruise industry. There are many variations on the basic analysis and design methodology. The systems engineering methodology shown is atypical and emphasizes the life cycle of a system from problem recognition to system operation and illustrates continuous improvement in that once one problem is addressed, other problems or issues are addressed. An important hallmark of systems engineering is the strong problem-solving methodology. Each phase of the methodology is described as follows.

- **Problem and requirements analysis:** A systems engineering project addresses problems which are conditions that must be improved, opportunities for improvement, or mandates from government regulation agencies or upper management that must be addressed. Problem and requirements analysis starts with collecting data about the system being studied. This involves interviews of stakeholders, observation of the process, surveys, review of documentation, and collection of quantitative data for analysis. All problems and system requirements are documented for traceability through the following phases.
- **System modeling and analysis:** To understand a system, engineers typically create a model of the system. A model is an abstraction that emphasizes the system properties of interest while de-emphasizing other system properties. All models have a purpose

Figure 1
Systems engineering methodology



and reveal the modeler's perspective concerning the system. The same system can have many different models to represent it. Engineers have developed descriptive, analytical, and simulation models. Descriptive models are used to understand a system or component of a system. Analytical or mathematical models are used to analyze, optimize, and design systems. Simulation models are created to capture the dynamic behavior of a system for analysis and design.

Analysis is the process of studying a system to reveal its properties. In systems engineering much of the analysis is quantitative. The model and analysis go hand-in-hand since for a particular type of analysis only one modeling approach is suitable. Many of the systems engineering tools are associated with models and analysis. These include general modeling and analysis approaches such as queuing analysis which studies waiting times, simulation models to study the dynamic behavior of a process, and linear programming models to quantitatively analyze and optimize systems. Moreover, there are modeling and analysis tools specialized for certain domains such as inventory models, IDEF1x models for information systems, and forecasting models.

- **System design:** System design includes specification of the hardware, software, work processes, work policies, the human-system interface, and related decisions. Systems design can be specifications for purchase of a commercially available system, design of a custom solution, or a combination of both.

- **Construction and deployment:** Construction is the phase in which the system is built. Deployment involves introducing the system to the organization. Change management or the introduction of new systems, work processes, and tools is an important aspect of systems engineering.
- **Monitor, control, and systems operation:** Systems engineering does not end with the deployment of a system into the organization. Systems engineering is a continuous process involving the monitoring and control of the system for efficient operation. Monitoring is the measurement of the system parameters. Performance measurement, quality control, and related techniques are system monitoring. Control is the measurement of system output, its interaction with the environment, and modification of the system and/or its input to achieve a desired output. At the lower level of the enterprise, control involves computer control such as is found on assembly lines in factories. At higher levels control is a management function.

Processes describe industry

The model of the cruise industry found in Figure 2 captures the business processes of an atypical cruise company. Processes are divided into three categories of management processes which define actions managers should take to support the business, administrative, and support processes which produce output invisible to the external customer but essential for effective management of the business, and customer processes where the output of the process is received by the external customer. As a consequence, the model is at a high level to capture the commonalities of cruise companies in general.

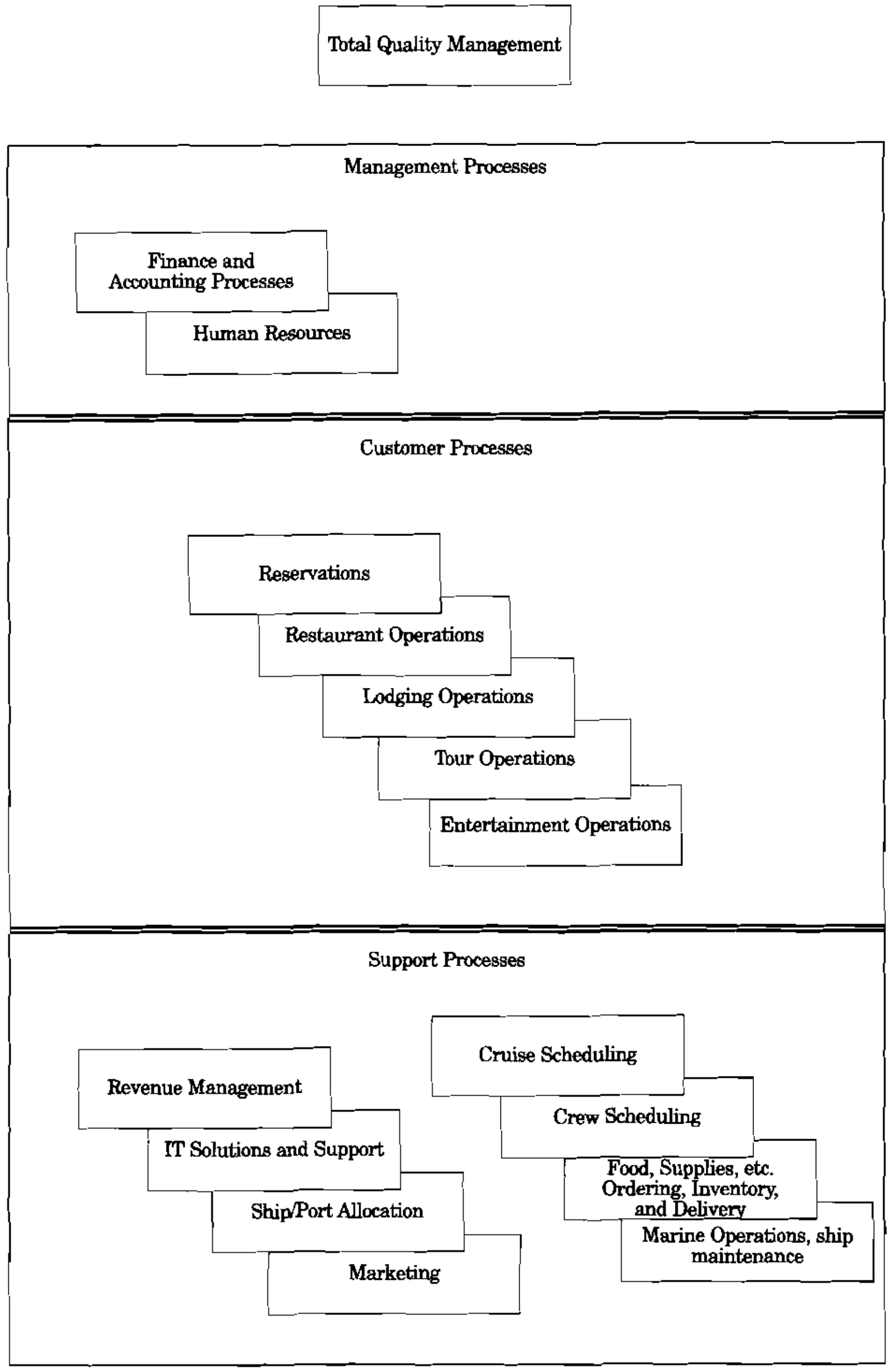
Given the definition of systems engineering, description of the systems engineering analysis and design methodology, and a reference model of an atypical cruise line, Table 1 lists opportunities for application of systems engineering in the cruise industry and identifies where in manufacturing it has been traditionally applied.

Luggage delivery is analyzed

One example to illustrate the application of the systems engineering methodology to problems in cruise industry processes involved analyzing and improving the luggage delivery process at a major cruise line operating out of Miami, Florida.[5] The process involves taking the guests' luggage at their arrival at the port terminal and delivering it to their corresponding cabins. Luggage delivery is a subprocess of lodging operations and a customer process.

In the cruise industry, luggage delivery is an important process that has great impact on guest expectations and satisfaction while

Figure 2
Cruise line systems model



taking a cruise vacation. Lost luggage becomes a critical incident that cruise guests would recall regardless of the rest of the cruise experience.[6] For this reason management wished to improve its current service level agreement (SLA), which stated that 85 percent of the luggage would be delivered to the cabin within 120 minutes of guest arrival.

Luggage delivery is a complex logistical process which must be completed in a short time-frame just prior to cruise departure. The systems engineering methodology was used to analyze the luggage delivery process, identify process gaps, and improve the system performance.

First, the luggage delivery process was studied to understand its operation, the problems involved, and the involved stakeholders' perspective of the process. The former was studied by observing the process end-to-end (from airport to cabin). The stakeholders' perspective was obtained through a survey designed and distributed to stakeholders in the cruise organization. The results of the problem analysis led to creation of a cross-functional flow chart (i.e., model) of the luggage delivery process.

Figures 3 and 4 show the luggage delivery process as conducted on the port side and ship side, respectively. Luggage arrives in one of three ways (see Figure 3), either by truck from the airport loaded directly onto the conveyor, with guests who arrive independently, or with guests who arrive in a group by bus.

After being loaded onto the conveyor, luggage goes through a port-side process in the terminal and is sorted onto carts by the deck for which it is designated. All carts are taken to a single entrance on deck one. Once on the ship (see Figure 4) the carts wait for the elevator to be transferred to their respective deck. Upon reaching the deck, the carts are sorted onto smaller trolleys which employees use to bring luggage to the cabins.

Analysis identifies gaps

Analysis of the data collected identified several potential process gaps that might affect luggage delivery performance. These included the time the process starts, since if it starts too late there is a larger queue to handle and some employees remain idle; the sorting policy, which was to wait until each cart was full before loading onto the ship; the handling of the un-tagged luggage, which can have a significant deleterious impact on through-put; the allocation of employees to decks and the coordination between decks; and the segregation policy on the destination decks which affects through-put.

Based on the preliminary analysis it was decided to create a simulation model of the luggage delivery process so the gaps could be quantitatively analyzed, the different luggage policies evaluated, and final recommendations made. A simulation model is a computer model that simulates the behavior

Table 1
Opportunities for system engineering

Cruise industry process	Similar manufacturing sector process	System engineering opportunity
Reservations	Order entry	Model process to improve performance, statistical analysis of reservation data, and integration of reservation systems (telephone, group, web) with back-end systems
Restaurant operations	Factory operations (main difference is level of automation in factories)	Model process to improve performance, quality control, inventory management of food items, scheduling of staff, allocation of resources among the different restaurant options available on a cruise, and cost analysis
Lodging operations	Factory operations (main difference is level of automation in factories)	Model process to improve performance, staff scheduling, integration of information systems supporting operations, analysis and improvement of sub-processes (e.g., luggage delivery, concierge), and quality control
Tour operations	Factory operations (main difference is level of automation in factories). Also, supplier management	Coordination of shore excursions and related tours, scheduling staff, inventory analysis, and supplier qualification
Revenue management	Manufacturers are now investigating revenue management	Forecasting demand, mathematical models to optimize revenue, integration of information systems, development of decision support systems for conducting revenue management
Cruise scheduling, crew scheduling, and ship-to-port assignment	Employee scheduling, allocation of resources (often machines) to facilities, departments, etc.	Mathematical and heuristic models for schedule optimization, mathematical models for assignment
IT support	Same	Process improvement, investment cost/benefit analysis, project management, and systems integration
Foods supply and inventory management	Inventory management and supply chain management	Inventory models and optimization, coordination of supply chain, optimization of purchasing

of the actual system under study. The model was created in Arena™, a commercial discrete-event simulation package. A successful simulation model requires input data on the guests' arrival rate, process times, and other stochastic variables. The required data were collected on four different weekends by tagging the luggage and tracing it through the process, marking the time it passed each milestone.

The simulation model was used to determine the effect of three key variables management could control: crew on deck 1, crew on deck xx, and sorting policy. Recommendations were made that resulted in a 22 percent reduction in average through-put time, which would help the cruise line increase its SLA. Moreover, the simulation model was packaged with a user-friendly front end so that management could investigate luggage delivery improvements for different class ships and different ports.

Help desk is improved

The second project was to analyze and improve the performance of the information technology (IT) help desk.[7] This function has grown in importance as information technology has proliferated throughout the cruise industry. The IT help desk involves the problem resolution process which is a sub-process of the IT support administrative process. The primary objective of the help desk is to resolve problems related to IT in the organization. As such, the agents in the help desk must be very knowledgeable of the information systems, applications, and technologies used by each organizational unit within the cruise line. Most efforts at improving help desk performance have been to make the current system more efficient through application of information technologies. In this project the result was to propose a new approach called a knowledge management-centric help desk.

When the help desk was first formed, it was composed of a single person who attended to the phone calls and wrote on a paper form the problems to be solved. Often to resolve a simple problem, like connections to printers, took as much time as a week. This process was very inefficient; many calls were abandoned because the phone line was busy. Those calling had to leave a message on voice mail, and if it was full, there was not another way to communicate with the help desk agent. Calls waited in the voice mail queue until the single agent had time to check it and either resolve or assign the problem to someone else.

Levels added to desk

Two years previous to this project the company changed to a multi-person, multi-tier help desk. Now the help desk is composed of four support levels. The first is the agents who answer the telephone calls; the second, called senior support, consists of the senior help desk agents. The third includes

Figure 3
Luggage delivery process shore-side

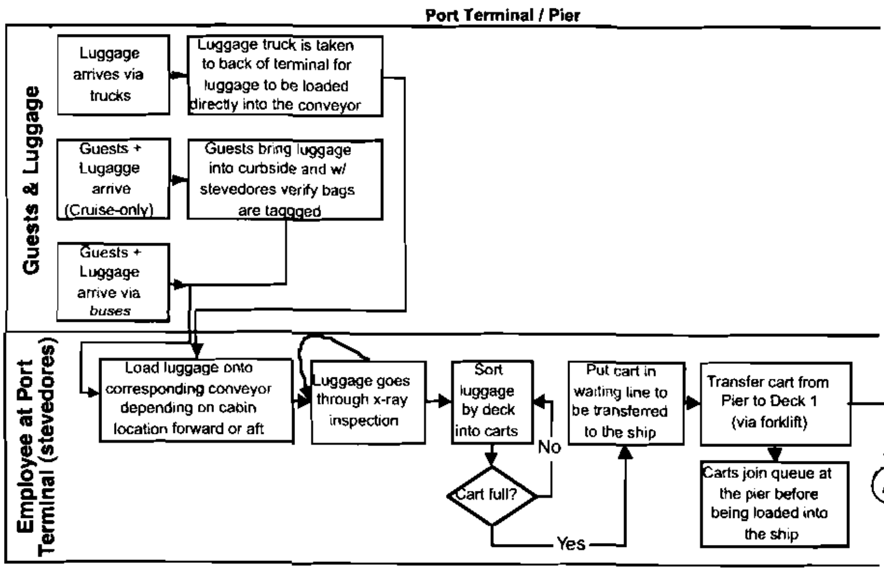
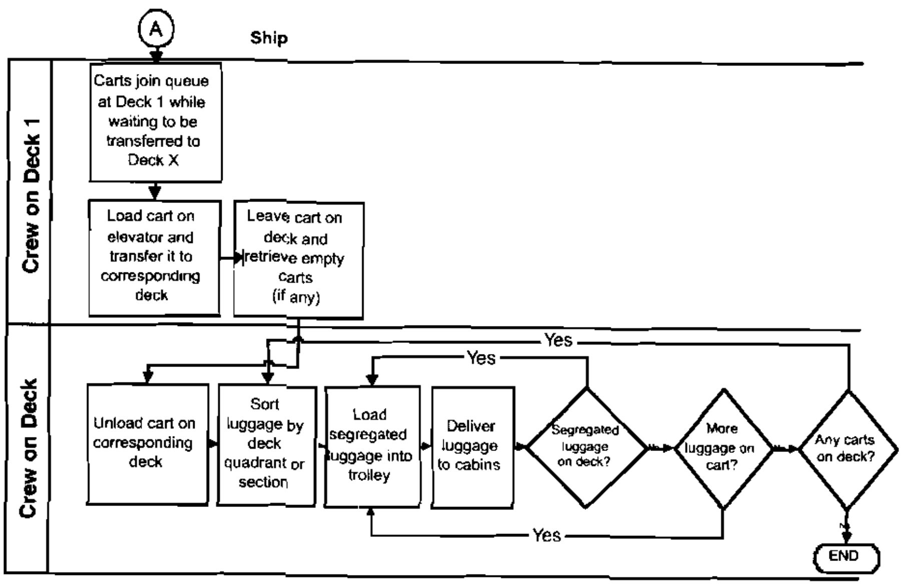


Figure 4
Luggage delivery ship-side



specialists who do not directly work for the help desk but are called when a problem occurs in their specialty, and the fourth includes the technicians who will travel to the business unit to make any necessary repairs and resolve the problem. Now a computer telephony integrated software package called Remedy™ is used to track calls and their resolution. Remedy™ features ensure that a case is entered quickly and tracked through its life cycle, thus providing a better service.

The existing help desk is shown in Figure 4. The agent resolves the problem by accessing many different information and knowledge sources ranging from files on the agent's computer to access to the database to communication with other agents to access to the Internet. This is the agent-centric approach, since the onus of finding and collecting the requisite information and knowledge to solve a problem is the responsibility of the agent.

In the problem and requirements analysis phase, unstructured interviews were held with management and help desk agents to learn operating procedures, key performance indicators (KPI), demand levels, and insight from agents working there. KPIs are management performance tools to help determine the help desk performance in meeting objectives and established service-level agreements.

Among the KPIs identified, the relevant ones were amount of calls received versus abandoned calls, calls resolved at first contact, and time to resolve a problem at each level. Based on these KPIs, data requirements were identified in order to build a simulation model. Data were collected from the Remedy™ CTI system for four separate weeks randomly selected with a total of 4,965 calls consisting of the time between arrivals, number of resources, types of calls, and service times.

System is intermediary

Rather than incremental improvement of the existing system, it was hypothesized that a knowledge management approach would lead to more dramatic performance improvements. Knowledge management systems (KMS) are systems that gather, organize, and disseminate an organization's knowledge, as opposed to information or data. Several characteristics can be defined that would make a KMS successful in the help desk; one is that it must be able to gather knowledge from humans and other sources. In a help desk environment, information and knowledge resides in many disparate forms, including databases, files, people, electronic documents, and procedures. Part of the knowledge management task is the organization of the stored information and knowledge so that it can be put to use in resolving problems. The use of the knowledge is accomplished by the help desk agents with support of a knowledge management system.

The knowledge management

centric approach to a help desk is shown in Figure 5. In this approach the KMS serves as an intermediary between the help desk agent and all data, information, and knowledge sources. The strength of this approach is twofold; first, it becomes the intermediary through which all knowledge in the system passes and thus should facilitate the knowledge acquisition function. Knowledge acquisition is often an obstacle, since busy knowledge workers may overlook the capturing of knowledge into the system; thus the KMS would stagnate. A second advantage of the knowledge management centric architecture is that it specifies a single uniform interface for the help desk agent to access various knowledge sources. It is recognized that the help desk agent must access a multitude of knowledge sources with different file formats which are often organized differently and at remote locations.

Except for the knowledge base, knowledge from other sources is not organized since the sources are external to the system. Rather the interface for searching for the knowledge is organized. The knowledge management system points to the location where the knowledge can be found. For example, if the knowledge resides in a document on a file server, the system contains an entry for the source and a pointer to link the location to the entry.

Models are simulated

To determine whether the proposed knowledge management system would in fact improve the performance of the help desk, both the agent-centric and knowledge-management centric help desks were modeled in the simulation package Arena™. The simulation model was verified to make sure that it worked properly in terms of Arena™ functionalities and the entities (problem calls) followed the same path as described in the conceptual model. Experiments were then designed so that a comparison of the two models, the agent-centric help desk and the proposed knowledge management-centric help desk, could be made. The experimental design was a three-factor, two-level design of experiments. The experiments were analyzed using the analysis of variance (ANOVA) for full factorial design to test the main effects of the factors and identify any interactions.

The simulation study showed the knowledge management-centric help desk would have greater than 50 percent decrease in average time to resolve a problem and a 19 percent increase in through-put. These improvements are significant and provide justification for implementing the knowledge management system.

Cost savings would result from this improved performance for several reasons. First, the knowledge management-centric approach enables the resolution of problems at lower levels. Typically, the agents at lower levels are also at lower salary levels. Second, the knowledge management-centric system resolves problems in a shorter time. If the problem was

Figure 5
IT help desk with agent-centric collection of data, information, and knowledge

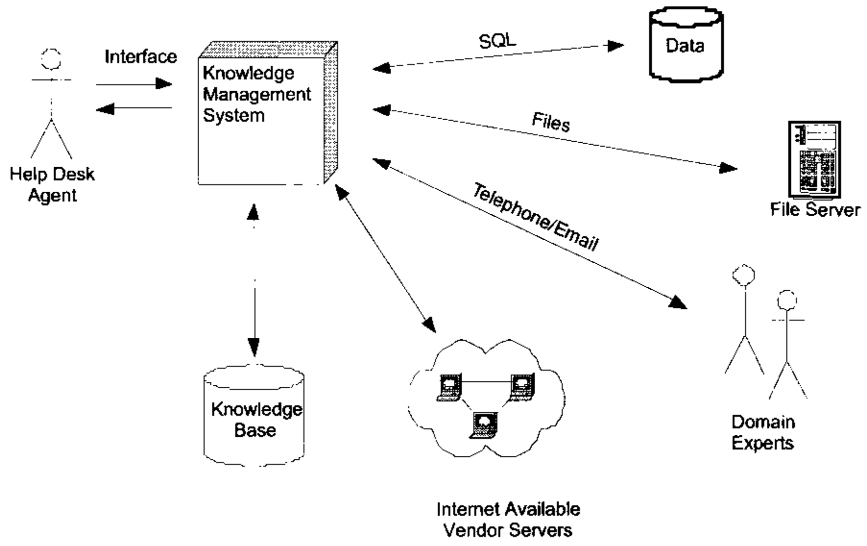
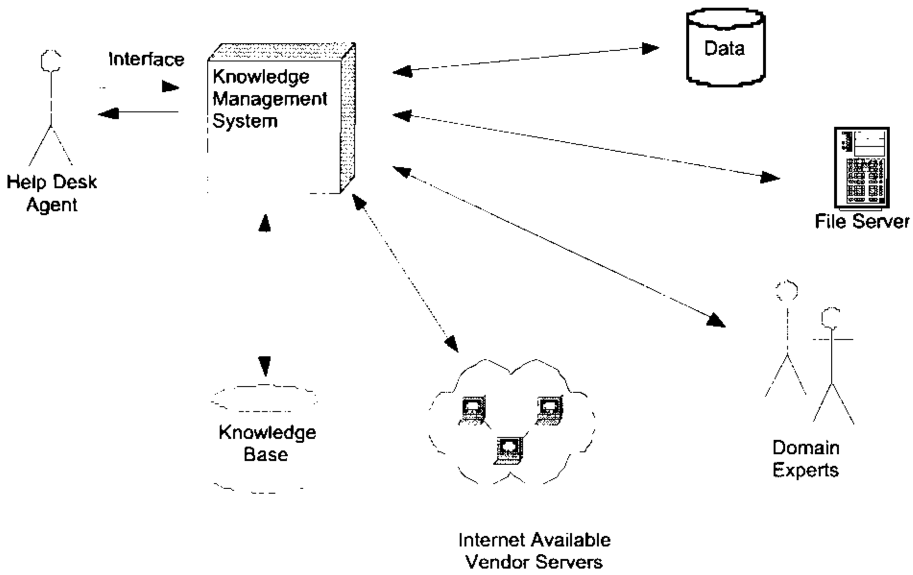


Figure 6
Knowledge management centric IT help desk



causing downtime to a business unit, this meant the unit could resume normal operations faster; decreased downtime is a cost savings. Finally, the knowledge-centric approach increases the productivity of the help desk and reduces staffing requirements; thus staff can be assigned to other tasks within the organization.

Case studies show results

The two case studies demonstrate the application of systems engineering to two different types of processes in the cruise industry. The first case study of the luggage delivery process is an important customer process and illustrates a very traditional application of systems engineering. The results led to policy and process changes that improved the through-put and service level agreements.

The second case study demonstrates the application of systems engineering to an information technology system, the IT help desk. In this case a new type of system called a knowledge management-centric help desk was proposed. Modeling and experimental analysis suggest the proposed system would significant improve the performance of the help desk. Further work needs to be done to create a prototype system and pilot test it in the work environment. Success with the pilot study would lead to full-scale deployment.

Both case studies demonstrate some of the strengths of the systems engineering methodology. First, it can be applied to processes with different characteristics, including a largely manual process (luggage delivery) and a knowledge-based process (help desk). The knowledge management project demonstrates the future of systems engineering with a greater focus on information systems; however, the systems engineering approach does not change. Simulation was used in both cases and found to be desirable since it permits a study without disrupting the operations of the actual process. The quantification of the processes and its performance lets hospitality managers more objectively make decisions concerning those processes. Participants in the projects often note that simply modeling and documenting the processes is valuable since it reveals informal work activities and tasks and leads to an overall better understanding of the process.

Systems engineering is still a largely untapped discipline that can greatly add value to cruise industry operations. The perspectives of systems engineers add a diversity of opinion as to systems functioning, methods for addressing problems, managing work, and viewing the organization. Every model has a particular purpose and perspective, with each model being equally valid. Multiple perspectives of the cruise company from hospitality managers, marketing people, financial people, accounting people, operations managers, and system engineers can provide a truer view of the cruise company and result in greater operational efficiency and performance.

As the cruise industry becomes increasingly competitive, it is important for companies to have efficient operations to maximize profits. Systems engineering focuses on the analysis and design of systems for improved performance. To adopt these techniques cruise lines should create a position focusing on systems engineering, management engineering, or internal business consulting, to do systems engineering projects within the organization. Many cruise lines do hire internal business consultants from an engineering discipline. For example, one cruise line has a department entitled Total Guest Satisfaction that employs mostly industrial engineers to do projects to improve the guest experience.

References

[1]ICCL, *The Contribution of the North American Cruise Industry to the U.S. Economy in 2000*, International Council of Cruise Lines, 2001, available online at: http://www.iccl.org/index.shtml.

[2]J. M. Tien and D. Berg, "Systems engineering in the growing service economy," *IEEE Transactions on Systems, Man, and Cybernetics* 25, no. 5 (1995): 721-25.

[3]D. E. Brown and W. T. Scherer, "A comparison of systems engineering programs in the United States," *IEEE Transactions on Systems, Man, and Cybernetics* – Part C: Applications and Reviews 30, no. 2 (May 2000): 204-12.

[4]T. H. Davenport and J. E. Short, "The new industrial engineering: information technology and business process redesign," *Sloan Management Review* 31, no. 4 (Summer 1990): 11-27.

[5]A. Nuñez, "A decision support system for the luggage delivery process at Royal Caribbean Cruise Lines," master's thesis, Department of Industrial and Systems Engineering, Florida International University, Miami, Florida, 1999.

[6]M. J. Bitner, J. D. Nyquist, and B. H. Booms, "The critical incident as a technique for analyzing service encounters," in Boch, *et al.* (eds.) *Service Marketing in a Changing Environment* (Chicago, Ill.: American Marketing Association, 1985), 48-51.

[7]L. M. González, "Evaluation of knowledge management information system support for a call center," master's thesis, Department of Industrial and Systems Engineering, Florida International University, Miami, Florida, 2002; L. M. Gonzalez, I. Gonzalez, R. E. Giachetti, and G. Ramirez, "A Knowledge Management System Centric Call Center: Performance Analysis," Proceedings of the Twelfth Annual Conference of the Production and Operations Management Society, POM-2001, March 30-April 2, 2001, Orlando, Florida; L. M. Gonzalez, R. E. Giachetti, and G. Ramirez, "Knowledge management centric call center: specification and performance evaluation," currently under review by Decision Support Systems, July 2002.

***Ronald E. Giachetti** is an assistant professor in the Department of Industrial and Systems Engineering in the College of Engineering at Florida International University*