# From the Classroom to the Operating Room: Cutting Edge and the Student[1]

*Philip Kazemersky[2] PhD, PE, Joshua Stephenson[3], Ricky Thompson[4], Anthony Lopez[5], and Mena Aziz[6]*

**Abstract** – This paper describes the elements undertaken in the project of defining processes conducted and methods for improvement of the turn around time of operating rooms. In the course of initiating and executing this project, the realities of working in a functioning environment outside of academia were encountered and are detailed. The team's learning needs are discussed and presented as the project progressed to completion. The team was able to deliver suggestions for change in the current turn around methods after three months of working on the project. The significant benefit to the team beyond the capstone project experience is the experience of defining, stating, planning, executing, reporting, and concluding of an actual, physical project in the healthcare arena which is evolving as a productive and high profile area for IEs.

*Keywords:* industrial engineering, industrial design projects, workplace design, health care improvements

## INTRODUCTION

Healthcare continues to be an important section of our economy and is forecasted to be in short supply. Severe workforce shortages continue to threaten hospitals' from being open at full capacity to care for their communities. An aging baby boomer generation and fewer individuals entering healthcare related fields have decreased the ability for a hospital to supply the proper care to everyone in need. One solution is to increase the efficiency of the hospitals and make it possible to treat more patients with the same volume of resources.

---

[1] This paper presents an observational study project conducted at a hospital. The Industrial Engineering Project class at the University of Tennessee at Chattanooga, working with a physician and hospital, defined a project to recommend procedures and methods to improve operating room (OR) turn around time (TAT). Specifically, this study is focused on the time it requires to clean and prep a room for surgery between two cases. This study is not intended to infer any information or recommendations on the surgery procedures themselves, but solely on the tasks that are required to prepare the room.

[2] Professor, College of Engineering and Computer Science, University of Tennessee at Chattanooga, Dept. 2402, 615 McCallie Avenue, Chattanooga, TN, 37403, phil-kazemersky@utc.edu

[3] Former Student now Graduate Student, College of Engineering and Computer Science, University of Tennessee at Chattanooga, Dept 2402, 615 McCallie Avenue, Chattanooga, TN 37403, Joshua-Stephenson@utc.edu

[4] Former Student, College of Engineering and Computer Science, University of Tennessee at Chattanooga, Dept. 2402, 615 McCallie Avenue, Chattanooga, TN 37403

[5] Former Student, College of Engineering and Computer Science, University of Tennessee at Chattanooga, Dept. 2402, 615 McCallie Avenue, Chattanooga, TN 37403

[6] Former Student, College of Engineering and Computer Science, University of Tennessee at Chattanooga, Dept. 2402, 615 McCallie Avenue, Chattanooga, TN 37403

The opportunity of applying industrial engineering methods and techniques for improvement in the healthcare arena, specifically at hospital facilities, is receiving increased attention. This interest is exhibited by increasing number of articles in various publications including many society's publications. A quick scan of recent "*Industrial Engineer*" magazines illustrates this situation.

As such, the interest of a physician and the University in building a relationship for cooperative projects for engineering students led to defining and execution of an in-hospital project. The project affords the experience of defining, planning, and executing a project as if they we in the work environment. It also permits the students to learn and develop their methods and techniques in an actual work, service, and systems process environment versus an "in-class" environment."

The OR turnaround time (TAT) is seen differently depending on the perspective of different hospital personnel such as the following:

- For Nurses**:** A patient leaving the OR to the next patient entering the OR.
- For Anesthesiologists: A patient's exit and the next patient's anesthetic induction.
- For Surgeons**:** The closure of one patient's surgical wound to the next patient's incision.

## CURRENT WORK

The research team focused on two areas: researching current published reports/papers regarding OR TAT and working in a hospital environment. For the former, various hospitals, consultants, universities, and other organizations are investigating and pursuing techniques, methods and processes for improving health care and its delivery, specifically OR TAT. Some ideas implemented at hospitals include:

- Standardization of procedures and instruments
- Techs and nurses beginning to clean and breakdown tables while the surgeon is closing
- Having limited doctor specific trays and eliminating seldom used instruments
- Leave the instruments in the trays on the back table to reduce setup time
- Use smaller instrument sets for minor cases.

These are just a few techniques that have been implemented at other hospitals that have decreased their TAT in the OR and increased their revenue all while making the OR more efficient. Selected works [1] - [12] are noted in the reference section. This project seeks to expand and enhance previous work and ongoing activities

## PROJECT EXECUTION

### Project Statement/Objective

This project provides recommendations for improvement that can reduce the TAT in the OR for the hospital to move toward its TAT goal. The TAT definition used is from the perspective of the hospital's utilization of the rooms. It is defined by the amount of time it requires to clean and prep the OR from when the patient whose surgery is complete leaves the OR until the time the next patient is brought into the room. This is for any following procedure case to the next case and not procedure and/or physician specific. The study focused entirely upon events within the OR that affect TAT. Observational data of these events was correlated and analyzed to determine the opportunities for the system improvement. Recommendations and steps for implementation to improve on the procedures were provided both from projects analyses as well as published results from other related studies.

### Project Organization and Conduct

The research team devoted much of the first month of the project focused on the second area: reviewing hospital policy on patient confidentiality. The team devoted time to and observing the system and how each member of the OR conducted their individual tasks. Each team member underwent the appropriate training in policy and responsibilities for functioning with the hospital environment. Once gaining an understanding of the current process, the focus was to conduct structured observations on the travel path of the patient from pre-op to the OR and how the hospital staff communicated current patient and room status. The project moved the team outside the manufacturing arena usually associated with industrial engineering. Similarly, the project integrated the definition with few details, working with line personnel, and functioning in a service environment with regulatory policies.

**Observation Overview**

The driving force for TAT is the breakdown and setup time for the surgical instruments. This process begins when the patient is awakened from anesthesia and removed from the room having completed surgery. The scrub tech begins storing the used instruments into the instrument cart and sterilizing the work area to prepare for the next scheduled surgery. Once the area is clean and the instruments are all stored, the tech will then push the cart into the breezeway between the rooms and obtain another cart that contains sterile instruments. The quantity of trays for each surgery will vary by the type of surgery and the doctor who performs the task. Although much of the instrumentation required for a particular surgery may be standard, some physicians may prefer a specific instrument much like any individual who works with their hands may prefer certain tools over others. Simple procedures may require as few as one to two instrument trays while more complicated ones can have fifteen or more. This variable coupled with the quantity of workers helping to setup the room greatly impacts the set up times. Figure 1 is a broad system's view of the required inputs, outputs, and controls to perform the turnaround function.

The UTC team discovered early that capturing accurate information on the specific tasks that determine the TAT was paramount in uncovering which element of the job dictated the overall time of the complete event. Also, the need for data collection beyond the ability of the team was evident. The team had limited time to visit the OR, and only captured 2 to 3 TATs per week for a total of 42 TATS. This need for more data and information about the system, led the team to coordinate personnel and implement a time log sheet in each room and have the scrub techs and nurses fill in the time elements for two TATs per day for an entire business week. Figure 2 illustrates the instrument utilized in the OR for the time log.

The TAT time log sheet contained the elements deemed most critical for collection and influencing TAT. A database was also built to maintain the records for each observation and to easily generate various reports on the data as necessary. This provided the team with a snapshot of the weekly activities and provided the much needed data to analyze this system. With this approach the team developed recommendations for procedure and process improvement of TAT.

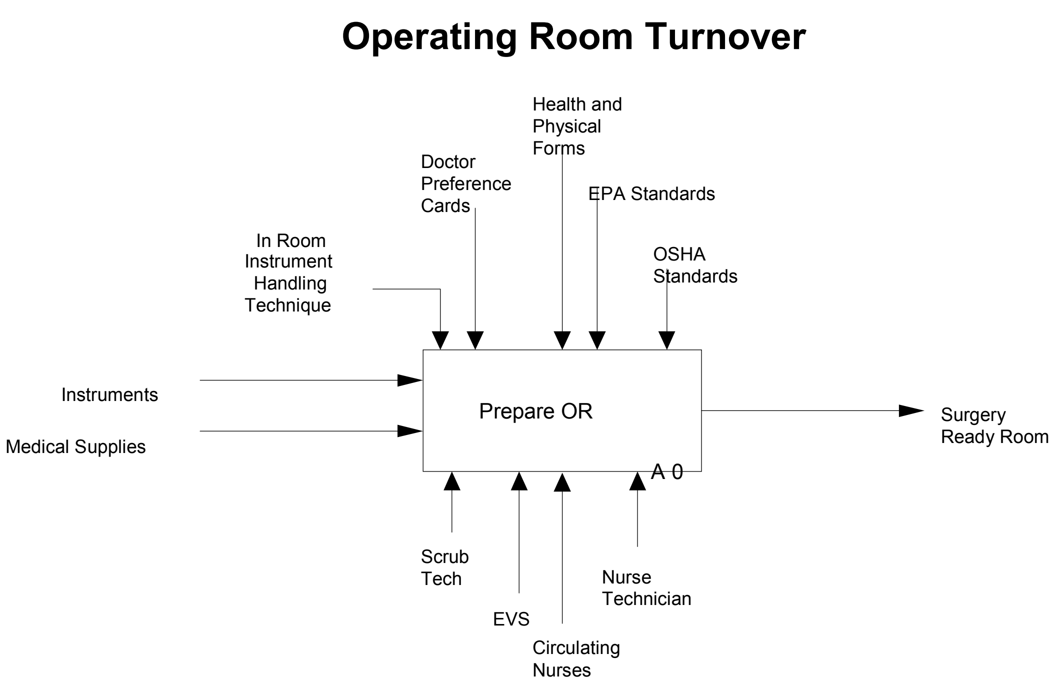


**Figure 1. Context Diagram of TAT System**

| | Task | Start | Stop | Qty Workers |
|---|---|---|---|---|
| Date | Wheel Out | | Please see note below | |
| | Scrub Tech Break Down | | | |
| Next Scheduled Start Time | EVS Cleans Room | | | |
| | Scrub Tech/Circulating Setup | | | |
| Room # | Counts Complete | | Please state the Qty and Classification of employee under the QTY Worker category. Please use the following Abbreviations: | |
| | Dr. in Room | | | |
| Total # Instrument Trays Opened | Patient in Room | | RN (circulating), ST (scrub tech), MGR(Coordinator) | |
| | Room Ready | | | |
| Notes | | | | |

**Figure 2. Data Collection Instrument**

**Processes of TAT**

The TAT of preparing the OR from team observation was broken down into the following sub processes:

First: Wheel out patient

Once the surgery is complete, the patient transport and a nurse come in to move the patient to the recovery room. The constraints for this sub-process are OSHA standards and EPA standards. The output from this process is an unsterile room ready for anesthesia breakdown, cleaning of the instruments, and cleaning of the room.

Second: Clean Instruments

Once the patient from the previous surgery is wheeled out leaving an unsterilized room, instruments/equipment cleaning begins. The constraint for this sub-process is the n-room instrument handling technique. This requires the scrub tech and a nurse technician. The output of the sub-process is sterilized equipment ready for the next case.

Third: Anesthesia Breakdown

The process of breaking down the anesthesia equipment begins once the patient from the previous surgery is wheeled out. The constraint for this sub-process is the in-room instrument handling technique. This sub-process requires an anesthesia nurse to break down their equipment. The output of this sub-process is sterilized equipment ready for the next case setup.

Fourth: Clean Room

The process of cleaning the room begins once the patient from the previous surgery is wheeled out. The constraints for this sub-process are the standards set by OSHA and EPA. This sub-process requires EVS personnel to clean the room. The output of this sub-process is a sterilized room ready for the next case setup.

Fifth: Setup Room

The process of setting up the room for the next case is complete once the instruments/equipment are cleaned, anesthesia breakdown, and the room is cleaned. The constraints for this sub-process are the doctor preference cards, EHS in-room instrument handling technique, and the health and physical forms. This sub-process requires circulating nurses, scrub technicians, and nurse technicians to work together and setup the room. The output of this sub-process is a surgery ready room.

**Indirect Processes**

The indirect processes that affect the TAT are Pre-Op Processing, Scheduling OR, Equipment Availability, Case Instruments Availability, and Staff Availability.

**Data Analysis**

The data compiled consists of forty-two (42) observations distributed over a ten week period. These observations began with a limited concept of the task-level activities inclusive to the TAT process. Thus many of the early observations lacked focus and relied mainly upon good judgment and apt questioning of the staff while compiling the data. As the understanding of the process developed the data collection became more selective in what was recorded. One factor of importance that the team identified was the surgery-specific, and at times doctor-specific, quantity of instrument trays required. Some simple procedures may only require one tray while more complex cases such as a hip replacement may require fifteen or more instrument trays.

The data most closely approximated a triangular distribution as demonstrated in Figure 3. Other distributions offering some fit are normal and lognormal.

An interesting observation from the data was the downtime of the room due to tardy arrivals of the medical staff. The data revealed that approximately half of the cases resulted in some downtime due to late arrivals. This information is summarized as: a) tardy patient: 5.38 minutes relative frequency 53.5% and b) tardy medical staff: 5.75 minutes relative frequency 46.5%. The average was over 5 minutes of non-value added time to approximately half of the cases due to the patient's detention in pre-op, or due to the surgeon arriving after the room is ready for surgery.

**Student Findings**

Patient flow in surgery consists of several sequential steps. A balance of capacity and flow of patients will result in an efficient process that will reduce the TAT. The design team compiled the following recommendations for future study or incorporating into the O.R. turn around process. These recommendations are a result of the project's review of work in the area, observational analysis, personnel inputs, and data analyses.

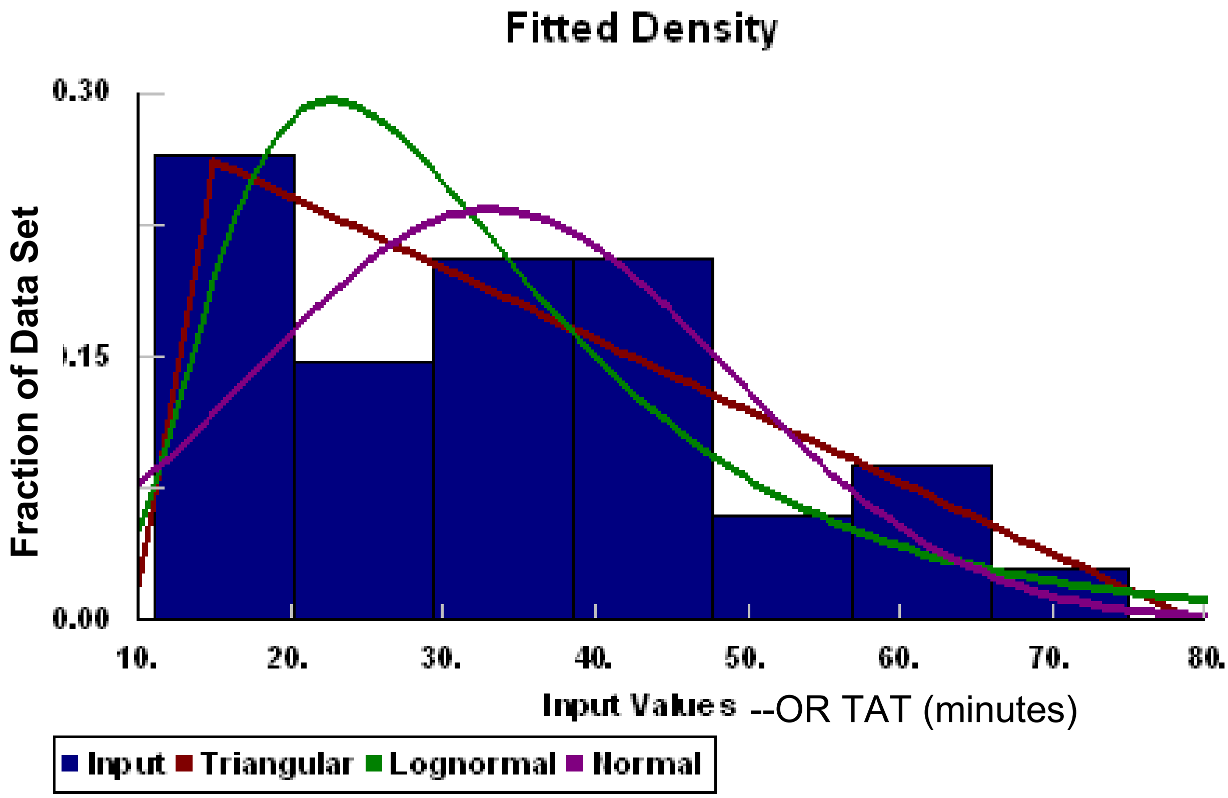


**Figure 3. Distribution Fit of TAT data**

To make the TAT process more efficient:

- Use personnel involved with the turnaround process more efficiently on tasks that do not require specialized training.
- Standardize instrument sets (e.g., limited "doctor-specific" trays). Standardizing instrument sets will allow the set-up process to flow more smoothly. Personnel will become more familiar with the standardized sets and eliminate some ineffective tasks.
- Regularly review instrument trays' contents to eliminate seldom/never used items. Eliminating seldom/ never used items will eliminate wasteful set-up time.
- Leave instruments in their trays on the instrument table. Instrumentation requires a significant labor time when laid out individually. If instruments can be left in their trays and placed on the instrument table it will reduce the set-up time.
- Regularly review pack contents and preference cards eliminating never used items to facilitate back table management.
- Discontinue full body draping for minor procedures performed on head/neck and/or limb.
- Reduces the amount of raw material being used for the surgery which in turn reduces the amount of clean up required for the case.
- Standardize a set-up process that will eliminate wasteful tasks. A standard set-up procedure will eliminate ineffective activity during case OR preparation.
- Continue the set-up process as the patient is rolled into the room. Minor set-up procedures that will not affect the start of the surgery can be performed while the patient is being rolled into the room.

## CONCLUSIONS

The project as designed provided the students several significant benefits beyond a "traditional type" project. Several of these are: application of learning and skills in a service environment, work on current issues in the IE arena, involvement in the healthcare field, understanding a project from definition, planning, to execution within a highly attendant regulatory, interfacing and working with non-engineering personnel, and understanding change culture of organizations. The benefits overall will extend to the students as they complete their education as well as they enter into their careers.

The project also presented attendant issues and difficulties. Several of these are: project initiation with appropriate approvals, availability and schedules of personnel and students, variations within the OR environment, OR procedure scheduling and seasonal demands and complex intertwine of processes for pre-OR and post-OR with the OR usage. These were dealt with as one would approach an actual project. The students were involved in the discussion, arrangements, and planning of the project. This included obtaining requisite training and instruction in procedures when functioning in an OR environment and with patients. The students interfaced with hospital personnel, completed reporting requirements, and made progress and completion presentations. Hospital personnel were integrated into the project review team. The students also experienced and learned the value of listening to OR personnel as part of project execution.

Although the project is the first of its kind in this environment and presented a number of barriers, it proved of value and it can serve as a model approach for additional such project activities. With the learning (for the instructor as well as) the project provided, it is anticipated that future projects would develop along similar lines. The interaction between the industrial engineering students and hospital personnel has offered a significant learning component which could not otherwise be achieved.

## REFERENCES


[1] University of Southern California. "Operations Engineering For More Efficient Operating Rooms." Science Daily 5 December 2008. 26 February 2009 <http://www.sciencedaily.com/releases/2008/12/081202153525.htm>.

[2] Healthcare Performance Partners. “Model OR…Proves Continuous Improvement Never Stops.” 22 February 2006. <http://www.leanhealthcareperformance.com/healthcaredocuments/HPPCaseStudyModelOR.pdf>.

[3] SMI Group. “Rapid Operating Room Turnover Improving Surgeons' Personal Productivity.” 26 February 2009. <http://www.surgerymanagement.com/presentations/rapid-operating-room-turnover1.php#turnaround>.

[4] Journal of Nursing Administration. “Decreasing Turnaround Time Between General Surgery Cases.” 5 March 2004. Volume 34, Number 3, pp 140–148. <http://hfrp.umm.edu/workflow/Adams2004JNA_Decreasing%20Turnaround%20Time%20Between%20General%20Surgery%20Cases.pdf>.

[5] Anderson, Heather, Brazda, Marilyn, Struble, Stephanie, and Pexton, Carolyn. "Six Sigma Trims Turnover Time for Orthopedic Surgeries." 28 Feb 2007 iSixSigma.com. 27 Feb 2009 <http://healthcare.isixsigma.com/library/content/c070228b.asp>.

[6] Juan C. Cendán and Mike Good. “Interdisciplinary Work Flow Assessment and Redesign Decreases Operating Room Turnover Time and Allows for Additional Caseload.”Arch Surg, Jan 2006; 141: 65 - 69. <http://archsurg.ama-assn.org/cgi/content/abstract/141/1/65>.

[7] MetroHealth Medical Center, Case School of Medicine. “Improving operating room efficiency through process redesign.”<http://www.ottawa-anesthesia.org/journalclub/Harders_Surg2006.pdf>.

[8] Quality Progress. “Eight Steps To Sustain Change.” < http://www.asq.org/quality-progress/2007/11/change-managementment/eight-steps-to-sustain-change.html>

[9] Medical University of South Carolina. FJ Overdyk, SC Harvey, RL Fishman and F Shippey. "Successful strategies for improving operating room efficiency at academic institutions." Anesthesia & Analgesia, Vol 86. <http://www.anesthesia-analgesia.org/cgi/content/abstract/86/4/896>.

[10] David M. Ferrin, Martin J. Miller, Sherry Wininger, Michael S. Neuendorf "Analyzing Incentives And Scheduling In A Major Metropolitan Hospital Operating Room Through Simulation." 8 November 2004. <http://www.informs-sim.org/wsc04papers/264.pdf>.

[11] Dexter, Franklin; Epstein, Richard H.; Marcon, Eric; Ledolter, Johannes. "Estimating the Incidence of Prolonged Turnover Times and Delays by Time of Day." Anesthesiology June 2005 - Volume 102 - Issue 6. pp 1242-1248 <http://journals.lww.com/anesthesiology/pages/articleviewer.aspx?year=2005&issue=06000&article=00026&type=fulltext>.

[12] Angelo Pellicone and Maude Martocci. "Faster Turnaround Time." 21 February 2006. < http://www.asq.org/healthcaresixsigma/pdf/qp0306pellicone.pdf

**Philip Kazemersky**

Philip Kazemersky, P.E., Ph.D. is a Professor of Engineering, College of Engineering and Computer Science, UTC. He received a PhD and MS from The Ohio State University in Nuclear Engineering and BS in Mathematics from WPI. He is currently in the industrial engineering program area and Assistant Director of the Center of Excellence of Applied Computational Science and Engineering. He has served as acting dean of the College of Engineering and Computer Science from July of 2001 to July 2004. Prior to joining UTC he had 18 years experience at the Tennessee Valley Authority. He leads the development of a nuclear power engineering option, an industrial engineering-hospital research alliance, and maintains research interest in energy systems. He teaches a spectrum of industrial, engineering and design courses.

**Joshua Stephenson**

Joshua Stephenson is currently a graduate student in the MS Engineering Management program. He is a recent graduate of the University of Tennessee at Chattanooga with a BS Engineering degree, Industrial Option. He served as a team member for this capstone IE project.

**Ricky Thompson**

Ricky Thompson is currently and Engineer at Siskin Steel in Chattanooga, Tn. He is a recent graduate of the University of Tennessee at Chattanooga with a BS Engineering degree, Industrial Option. He served as project manager and team member for this capstone IE project.

**Mena Aziz**

Mena Aziz is a recent graduate of the University of Tennessee at Chattanooga with a BS Engineering degree , Industrial Option. He served as a team member for this capstone IE project.