3D Simulation Modeling in Healthcare Environments
Facts and Figures

FACTS & FIGURES (FISCAL YEAR END 2009)

1 tertiary care teaching hospital for The University of Texas Medical School:
   • Home of the nation’s busiest Level I trauma center,
   • Operates Houston’s Life Flight® air ambulance program,
   • Houston’s only Burn Treatment Center,
   • Children’s Memorial Hermann Hospital,
   • TIRR - one of the nation’s top rehabilitation and research hospitals,
   • Mischer Neuroscience Institute

8 suburban hospitals which include
   3 premier Heart & Vascular Institutes

8 comprehensive cancer centers
21 imaging centers
8 breast care centers
10 surgery centers
25 sports medicine and rehabilitation centers
19 diagnostic laboratories

Annual emergency visits: 411,591
Annual deliveries: 26,731
Annual Life Flight air ambulance missions: 3,485
Employees: 20,840
Beds (acute licensed): 3,581
Medical staff members: 4,857
Physicians in training: 1,821 (physicians and fellows)
Annual payroll: $1,087,570,000
Annual community benefit: Over $300 million
Memorial Hermann Healthcare System

Last year, Memorial Hermann partnered with Flexsim® to simulate a new ER patient model recently implemented by developing unique patient tracks that account for the different patient flow patterns.
Simulation using 3D Hospital AutoCAD Layouts of ED Unit
Contributing Factors Outside ED

- Ambulance and Helicopter Patient Transport Arrivals
- X-Ray, Ultrasound, MRI and/or CT Imaging, Lab or Pharmacy Order Processing outside of the ER Dept
Patient Flow Diagram

Emergency Department Entry / Triage Process

Start

EMS Entrance

Acute Bed Placement

Patient

Patient Placed into Acute Bed

RN / Provider conducts patient Assessment

Triage RN or Triage Tech or Charge RN

Staff RN / Physician / Mid-Level Provider

Acuteness 1 or 2

Physician writes orders and puts in Nurse Rack

Pyxis Drawer or Trauma Tackle Box Accessed?

Provider

Unit Clerk enters orders into Care4 and gives to RN

No

Copy of physician order sheet is sent via pneumatic tube to Pharmacy & wait

Yes

Pull out Meds from Pyxis / Trauma Tackle Box and Code Chart

RN / ER Tech

Sign order off in Order Sheet

Staff RN

Staff RN / ER Tech

Staff RN / Tech / Unit Clerk

Lab & Rad Diagnostics taken & Awaiting Report or Contrast Indications

Lab or Rad Tech

Pyxis Drawer or Trauma Tackle Box Accessed?

Lab & Rad Report or Contrast Indications are complete and returned to patient chart

Pulmonary interventions, procedures, medication administration, IVs, etc.

Staff RN / Tech / possibly Provider

Nurse Documents RX in MedHost

Staff RN

Provider Disposition

Nursing Assessment, Medical Screening Exam, Orders Initiated (Goal within 15 minutes of room placement)

Team Approach: MD, RN, ER Tech, Clerk

ER Intake Process

Patient Waits in Lobby

Are Protocols Needed?

No

Yes

Patient Waits in Lobby Patient

ER Bed Ready?

No

Yes

Lab / X-Rays are ordered & initiated

Triage RN / Lab Tech and/or Rad Tech

Patient Placed into Intake Bed

Nursing Assessment, Medical Screening Exam, Orders Initiated (Goal within 15 minutes of room placement)

Team Approach: MD, RN, ER Tech, Clerk

ER Intake Process
Patient Track Manager

Intake and Procedures

Time Distributions

Staff Assigned to Task
Distributed Patient Processing

Patient Movement:
- Arrival
- Quick Look
- Intake
- Acute or Continuing Care
Drag & Drop Connections Simplifies Patient Flow to Bundled Areas
Staff and Beds are Bundled in Groups and Areas

The Next Patient Fills the Next Available Bed from the Bundled Group
Patient Arrival Patterns Enter Simulation by Weekday and Hour of Day

Ambulatory Arrivals

Discrete Arrival Patterns within a given hour
How does the Simulation address patients that leave the ER of their own accord?

Patients leaving the ER fall into one of 3 classifications:

1. **Left Without Triage (LWOT)**
   Patient leaves the Waiting Room before Triage takes place.

2. **Left Without Being Seen (LWBS)**
   Patient is bedded but leaves before Doctor sees patient.

3. **Against Medical Advice (AMA)**
   Patient does not like course of patient care given (i.e. surgery, hospital stay, etc.) by Doctor and leaves the ER against medical advice.
After the Waiting Room Occupancy has reached 10 patients, Acuity Level 1 Patients have a 1.6% chance of leaving for each minute that goes by.
LWBS & AMA are addressed in the Patient Track Editor

<table>
<thead>
<tr>
<th>Track Name:</th>
<th>Amb_IntakeCC</th>
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LWBS and AMA patients have a 3% chance of leaving the ER.

<table>
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<th>Predecessors</th>
<th>Milestones</th>
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<th>NextActivityChooser</th>
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</table>
Staff’s clothes colors can be modified to indicate different staff level skills or roles staff provides.

Examples: ER vs. Imaging vs. Transport Techs or RN vs. LVN vs. PCA
Individualized scheduling is available for each staff position by day of week and hour of day.
Contingency Staff Based on Customized Skill Rankings
Patient Processing: Nursing Stations
Patient Groups

Changes in Adult and Pediatric patient acuity, point of origination, etc. can “trigger” changes in shirt color.
Transport: Ambulance
Transport: Helicopter
Imaging: XRay
Imaging: Ultrasound
Imaging: MRI
Imaging: CT
Equipment: Pyxis Machine
Object Processing: Lab, Radiology & Pharmacy

ER_Lab_Queue
CurContent: 0
MaxContent: 0
AvgStaytime: 0.0

ER_Lab_Processing
Output: 0
%Idle: 0.0
%Processing: 0.0

ER_Lab.Exit
Input: 0
Three Patient Exit Destinations

1. Ambulatory Exit
2. Transfer Exit
3. Admission Exit
Simulation Dashboard

Patient State Times:
1. WaitingForActivity (28.7, 13.6)
2. ReceivingAttention (77.4, 37.1)
3. ProcessWaitingStaff (4.8, 2.5)
4. WaitingForRoom (84.4, 42.4)
5. InTransit (2.8, 1.3)
6. WaitingForStaff (5.0, 2.9)

Patients Processed per Hour of the Day

Length Of Stay (LOS) by Track
- EMS_Acute_Lab.Rad: 152.8
- Amb_IntakeCC_Lab.Rad: 257

Patient Arrival to Release Time (mins)

Milestone Times
Average Time to Complete Milestones (mins)

Patient Costs by Track
- EMS_Acute_Lab.Rad: 145.49
- Amb_IntakeCC_Lab.Rad: 155.66

Patient Milestones by Track

Occupancy Levels
Percent of Area (time weighted)

Patients In-Process by Track
- EMS_Acute_Lab.Rad: 28

Milestone Completion Times
- 1. Arrival (2.0, 0.13)
- 2. Triage (15.4, 1.0)
- 3. Bed Placement (77.8, 1.7)
- 4. RN Assessment (37.6, 2.3)
- 5. MD Assessment (137.8, 8.5)
- 6. Draw Sample (55.7, 3.4)
- 7. MD Lab Review (70.3, 4.3)
- 8. Radology Exam (162.1, 10.0)
- 9. Radology Results (166.7, 10.4)
Arrivals and Discharges

Admits / Discharges / Transfers By Hour
Memorial Hermann Katy Hospital
1335500 Emergency Center

Source: HOREGS 01/01/2010 - 01/31/2010
Data Excludes the following: Bed transfers within the same location, Lengths of Stay < 20 minutes

Monday, February 22, 2010
Hourly Census vs. Staffing - All Worked Employees

Memorial Hermann Katy Hospital
1335500  Emergency Center

Source: HQREGS  01/01/2010 - 01/31/2010

ADT data excludes the following: Bed transfers within the same location; Lengths of stay < 20 minutes
Nursing FTE data excludes the following: Education, Orientation, and Called-off Pay.
Budget FTE and Total FTEs include ALL employees, including Education/Orientation and Exempt employees. Includes Productive time only.
Average Patient To Nurse Ratios By Hour

Memorial Hermann Katy Hospital
1334110  6th floor

Source: HQREGS  01/01/2010 - 01/31/2010

FTE data excludes the following: Education, Orientation, and Called-off Pay.

Monday, February 22, 2010
Experiment Manager
### Flexsim Simulation Sample Time Distributions in Minutes

#### PatientID

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#### Exit Destinations:

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<td>-</td>
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<td>31</td>
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<td>TotalLOS (mins)</td>
<td>321</td>
<td>1,653</td>
<td>266</td>
<td>2,304</td>
<td>31</td>
<td>388</td>
<td>155</td>
<td>760</td>
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<tr>
<td>TotalLOS (hrs)</td>
<td>5.4</td>
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Minitab Analysis – Scenario 1: What is the current state?

Scenario 1 – Exiting Model As Is

Summary for Total LOS

- Minimum: 32.58
- 1st Quartile: 315.10
- Median: 603.45
- 3rd Quartile: 726.96
- Maximum: 904.91

- Mean: 534.24
- StDev: 261.57
- Variance: 68419.68
- Skewness: -0.504179
- Kurtosis: -0.867588
- N: 30

95% Confidence Interval for Mean
- Lower: 436.57
- Upper: 631.92

95% Confidence Interval for Median
- Lower: 408.97
- Upper: 692.64

95% Confidence Interval for StDev
- Lower: 208.32
- Upper: 351.63

Anderson-Darling Normality Test
- A-Squared: 0.72
- P-Value: 0.055

95% Confidence Interval for Total LOS

95% Confidence Intervals
Scenario 2 – Add 2 Intake Beds and 1 full time Intake Nurse

Minitab Analysis - Scenario 2:
How significant of a shift takes place?

Summary for TotalLOS

Anderson-Darling Normality Test
A-Squared 1.10
P-Value 0.006

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<td>95% Confidence Interval for StDev</td>
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Box Plots of Length of Stay: Would we “feel” the proposed change?

Scenario 1 – Exiting Model As Is
Scenario 2 – Add 2 Intake Beds and 1 Fulltime Intake Nurse

Boxplot of Total LOS
Box Plots of Discharged Patients: Would we “feel” the proposed change?

Scenario 1 – Exiting Model As Is
Scenario 2 – Add 2 Intake Beds and 1 Fulltime Intake Nurse

[Boxplot of Discharge Time]
Box Plots of Admitted Patients: Would we “feel” the proposed change?

Scenario 1 – Exiting Model As Is

Scenario 2 – Add 2 Intake Beds and 1 Fulltime Intake Nurse