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HEALTH SYSTEM

Making Better Decisions Using Computer Simulation – A Case Study of St. Charles

CCO Oregon Innovations in Primary Care Conference
January 30, 2018

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Purpose

- Introduce computer simulation as a viable decision support tool
- Demonstrate the ease in which a simple simulation can be created
- Encourage others to begin using computer simulations (and to collaborate)

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Outline

- Ways to Study a System
- What is Discrete Event Computer Simulation?
- Why Use Simulation?
- Steps Involved to Create a Simulation
- Lessons Learned
- Micro Simulation Example with Arena Software
- Questions, comments and discussion

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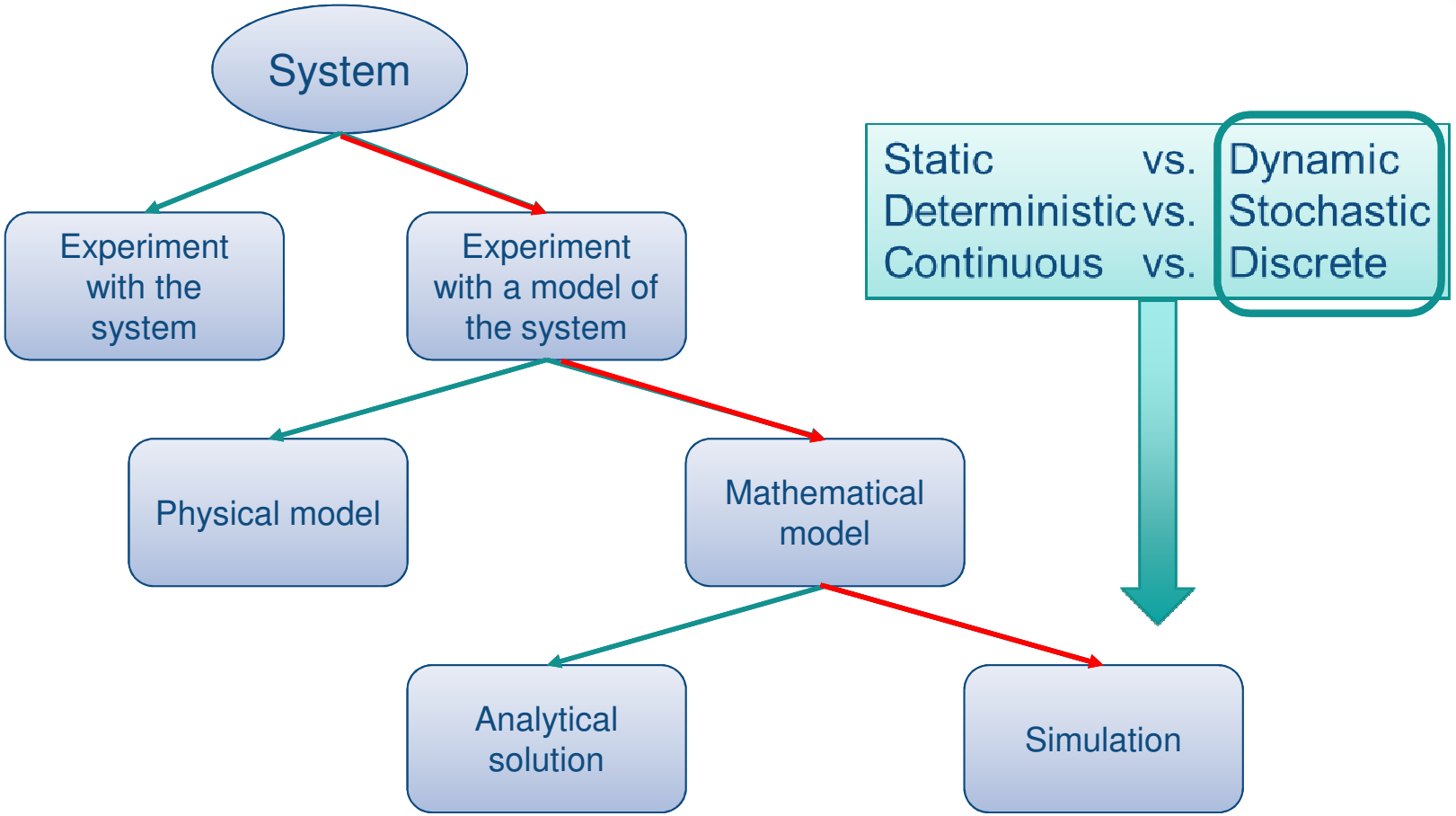
Ways to Study a System



Reference: *Law, A.M., Kelton, W.D., (1982) "Simulation Modeling and Analysis, 3rd Edition", Boston, MA, McGraw Hill.*

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What is Discrete Event Simulation?

- Discrete Event Simulation
  - **Discrete states** (patient arrival, lab work ordered, visit with provider, start of surgery)
  - **Event-driven** (each state depends on the occurrence of asynchronous discrete events over time)
  - Entities (such as patients) progress through the system
  - Resources (lab technicians, hospital beds)
  - Processes (doctor visit, surgery, lab work, transport from point a to point b)
  - Attributes (characteristics that differentiate entities or resources)
  - Metrics or Key Performance Indicators (for example)
    - Throughput
    - Queues (Average/Max/Min number waiting and wait time)
    - Resources (utilization rates, proportion of time at or above a specified threshold)

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Why Use Discrete Event Simulation?

- When your system is complex
  - More than one type of entity
  - Involves several resources
  - Includes multiple processes
  - Multiple paths through the system exist based up on attributes
- To analyze different factors that impact dashboards metrics
- You have several “what if” scenarios to evaluate
- To predict the outcome of future states

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Recent Simulations at St. Charles

- Emergency Department
  - Can we improve the efficiency of the ED by altering the process or changing the resources? Where are the bottle necks? How can we address these bottlenecks?
- Bend Cancer Center
  - Can we increase the number of providers? If so, how many can we support and what other resources need to be increased, and by how much?
- Redmond Cancer Center
  - What would be the impact of moving the pharmacy from the current location to the main hospital? How would this effect patient flow?
- Bend Construction of New Tower: Configuration of ICU and IMCU
  - Considering the anticipated increases in patient volume, does the current plan for 24 ICU beds and 55 IMCU beds provide a reasonable and appropriate configuration once the new tower becomes functional?

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7 Basic Steps

1. Problem and System Definition: Identify the goal and scope. Determine if simulation is the best tool. Identify the system components and what needs to be measured.

2. Model Formulation: Understand how the system works. Create a flowchart and identify sequences, resources, decision points and processes.

3. Input Data Collection and Analysis: Determine theoretical distributions for service times, arrival rates, capacities, etc.

4. Model Translation: Build the model using software.

5. **Verification and Validation: Ensure the model behaves as intended (verify) and no significant differences exist between the model and the real system (validate).**

6. Experimentation and Analysis: Develop models to examine various alternatives or scenarios and compare results.

7. Documentation and Implementation: Final report to discuss results and may recommend a best course of action.

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Some Lessons Learned

- Collaborate with many, and often. Meet frequently as the simulation progresses.
- Start simple and incrementally increase the complexity
- Use historical data for parameters if available, ALSO confer with SMEs
- If no data are available for the parameter, then you must rely solely on the SME. In these instances, sensitivity analyses are more important.
- Don’t oversell the results. They are only as good as the data used to create them.

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Micro Simulation Example

- ***Our clinic is expecting to have our patient volume double due to the upcoming closure of a neighboring clinic of similar size and patient volume.***
- ***Can we get by with just one more doctor, (and no increase in the number of lab techs or admin assistants)?***
- ***We do however, think we can shave a few minutes off the time it takes a patient to schedule their next visit with our new scheduling software.***
- Some Details:
  - Patients arrive on average every 30 minutes
  - 60% will see Doctor, 40% are only here for lab work
  - Two doctors are present and spend at least 25 minutes, most of the time 30 minutes at a max of 45 minutes with each patient
  - One lab tech takes at least 8 minutes, most of the time 12 minutes and at most 16 minutes to help a patient
  - Patients see receptionist and schedule next visit before departing. This takes at least 5 minutes, most often 10 minutes and at most 15 minutes.

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Software Demo

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Micro Simulation Results

Metric	Current State	Future Scenario 1	Future Scenario 2
Number of Patients seen	89	181	181
Utilization Rate for Doctor	33%	45%	45%
Utilization Rate for Lab Tech	20%	33%	32%
Utilization Rate for Admin Assistant	40%	70%	35%
Avg total time in clinic	43 minutes	51 minutes	38 minutes
Avg total wait time	5.7 minutes	16.0 minutes	3.1 minutes
Avg wait time for Doctor	0.2 minutes	2.1 minutes	2.1 minutes
Avg wait time for Lab Tech	1.2 minutes	3.0 minutes	2.8 minutes
Avg wait time for Admin Assistant	4.9 minutes	**13.5 minutes**	0.7 minutes
Max wait time for Doctor	34 minutes	64 minutes	53 minutes
Max wait time for Lab Tech	29 minutes	47 minutes	49 minutes
Max wait time for Admin Assistant	42 minutes	**72 minutes**	13 minutes
Max queue for Doctor	3 patients	5 patients	6 patients
Max queue for Lab Tech	3 patients	4 patients	4 patients
Max queue for Admin Assistant	5 patients	**9 patients**	4 patients

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Some More Complex Examples

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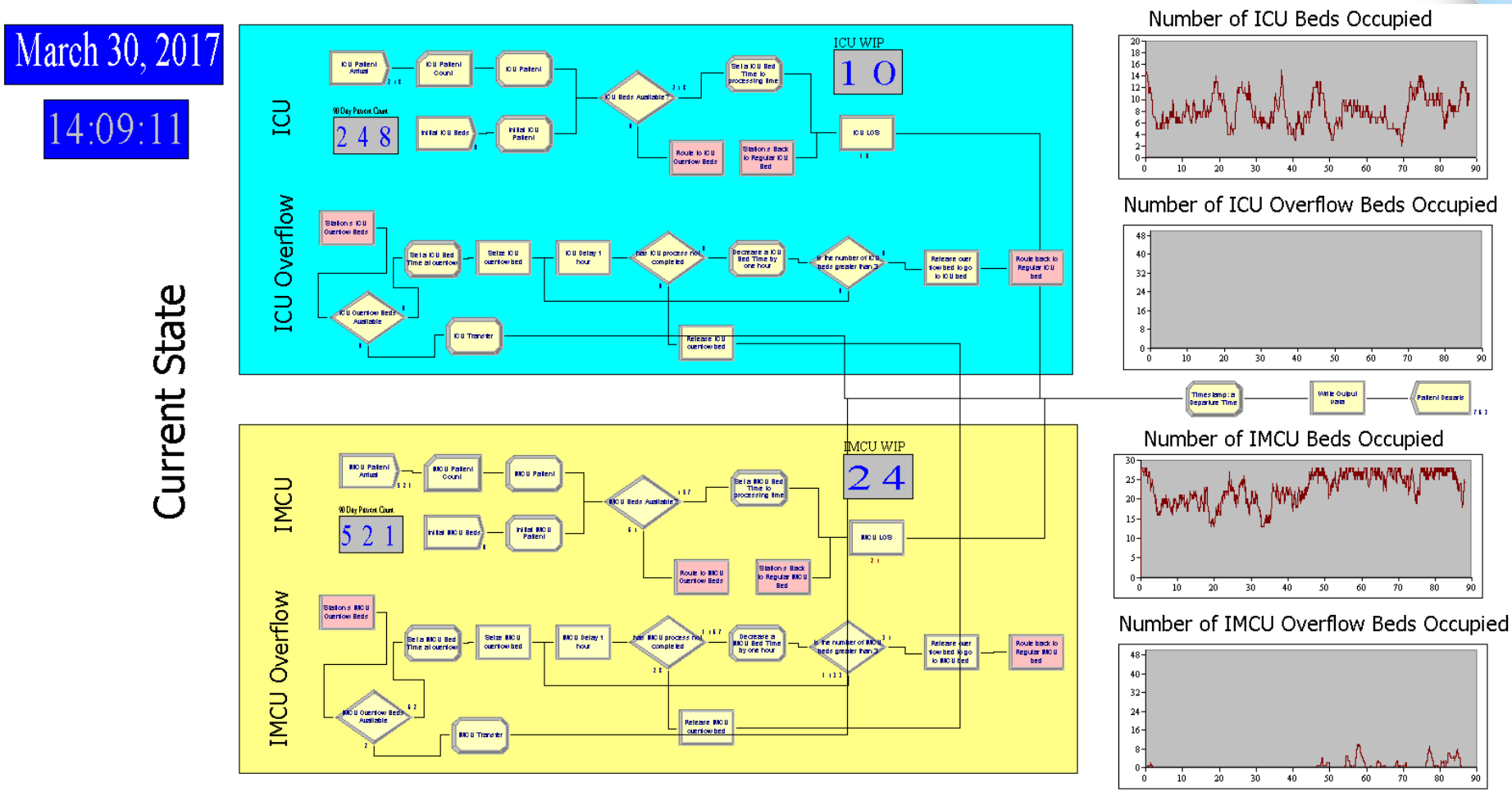
Screen Shot of Simulation Software – Current State



88 days into one of the 90-day simulations.

Capacity: 18 ICU beds
28 IMCU beds

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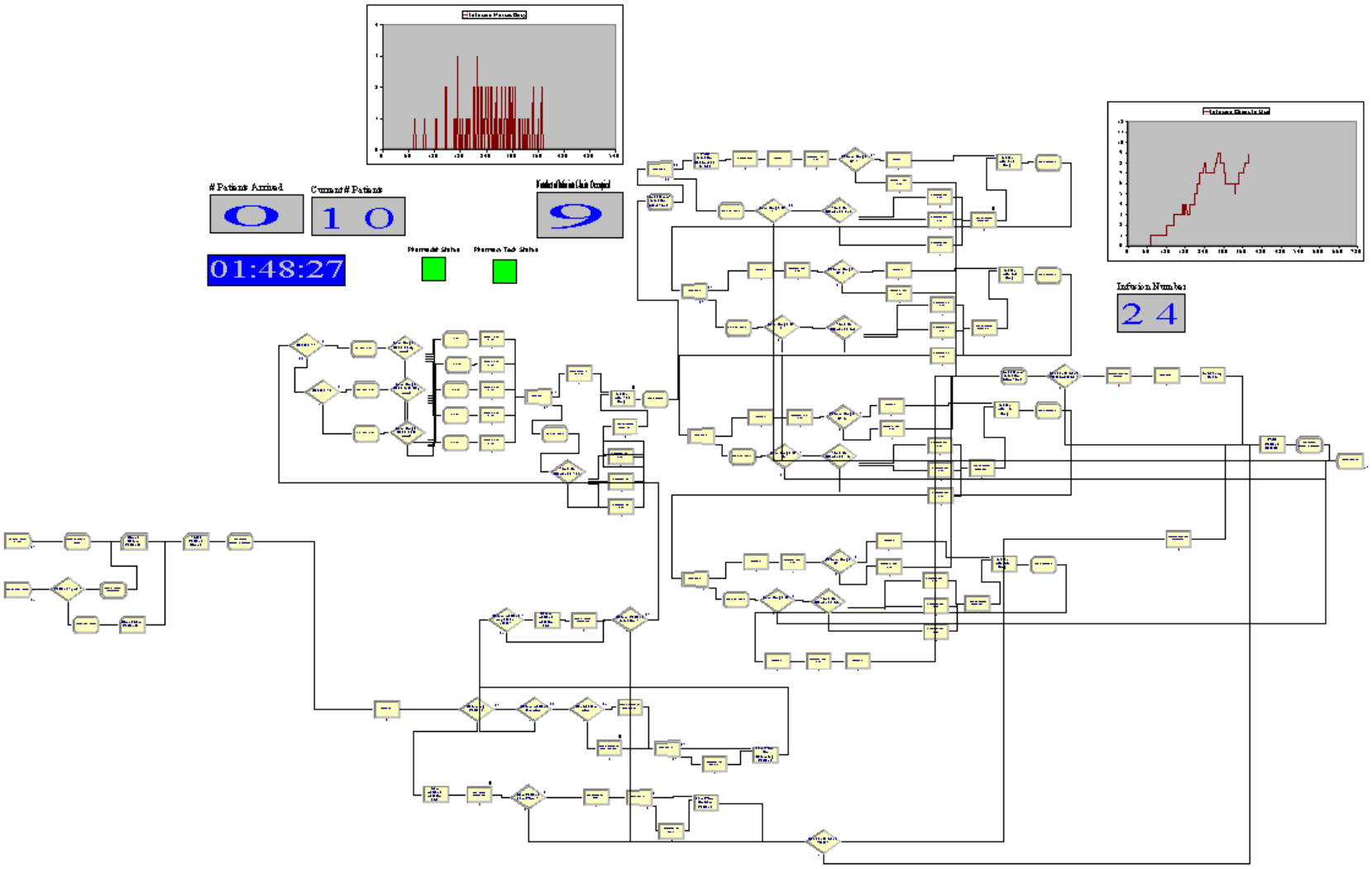
Redmond Cancer Center w/ Pharmacy Details



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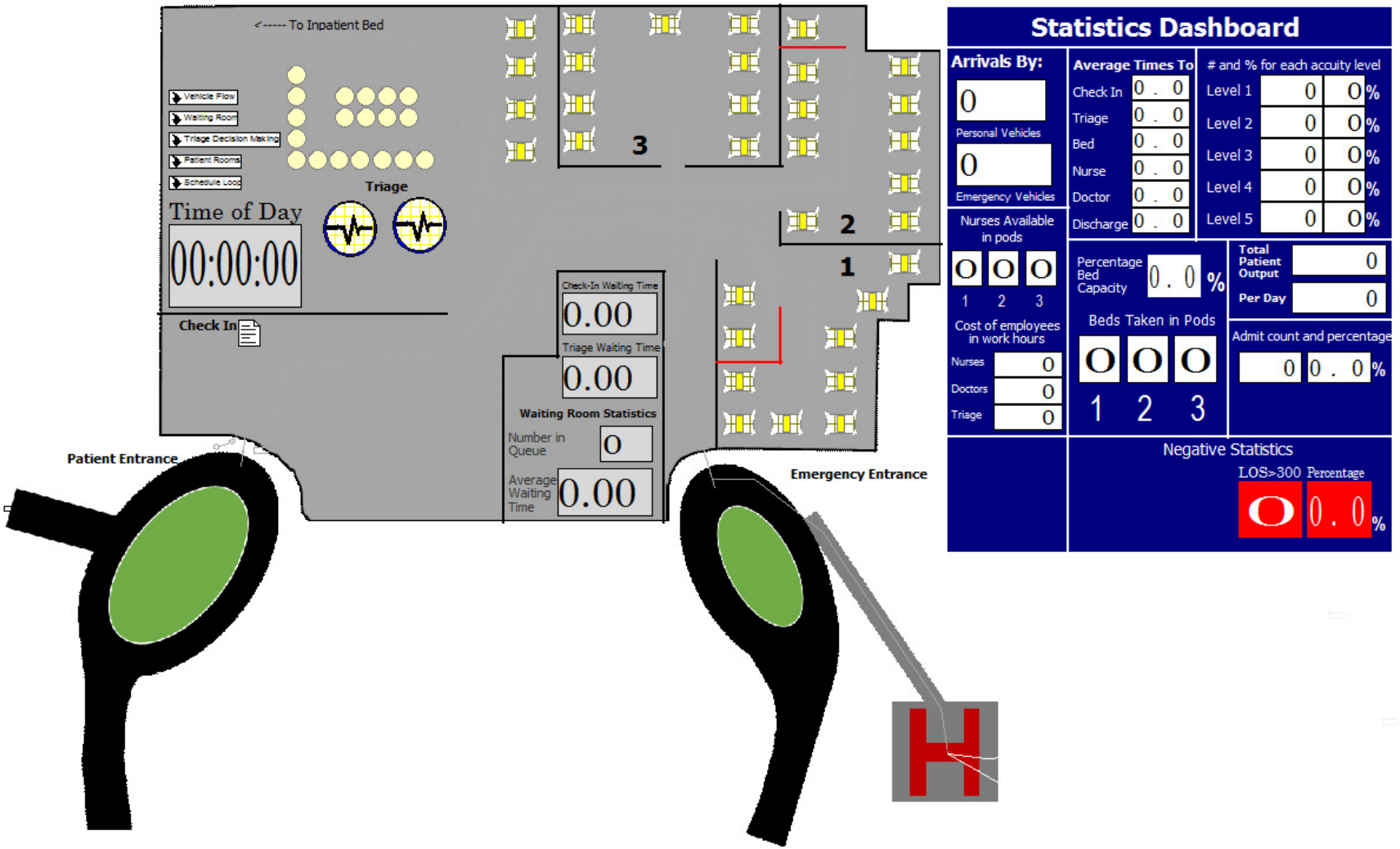
Animation View Bend Emergency Room Patient Flow



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Thank you…

- to the entire Decision Support Team for their support
- to the caregivers in the Bend Emergency Department, Bend and Redmond Cancer Centers and the leadership at St. Charles who have consistently supported our efforts to construct these simulations and used the results to improve patient care at St. Charles.
- to CCO Oregon for the opportunity to share our work.

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Future Collaboration and Sharing Ideas?

- Please feel free to contact us if you have questions regarding the presentation
- Please contact us if you are interesting in creating an informal group
  - That discusses analytical topics
  - That shares case studies and relevant research articles
  - Whose members collaborate to solve common data analysis problems
  - That serves as a sounding board for ideas, methodologies and data analysis techniques

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Questions, Comments & Discussion

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Backup Slides

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More Examples

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Screen Shot of Simulation Software – Future State

March 30, 2017

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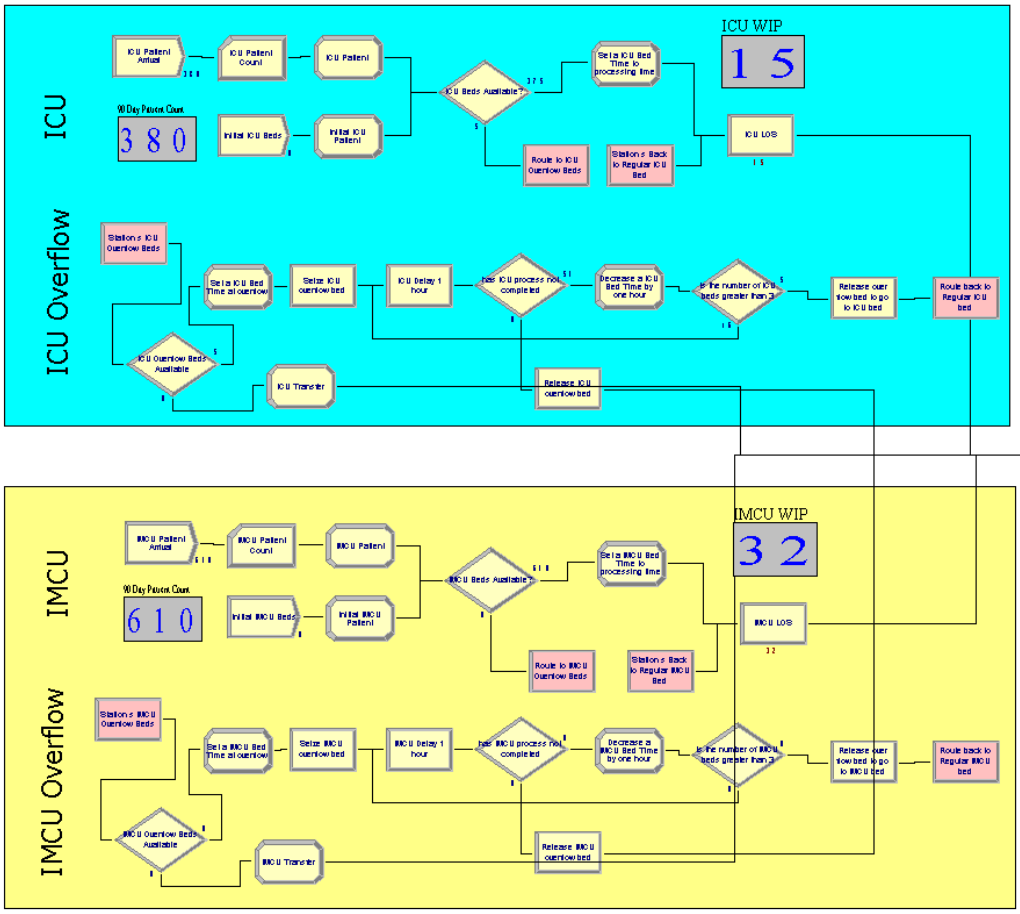
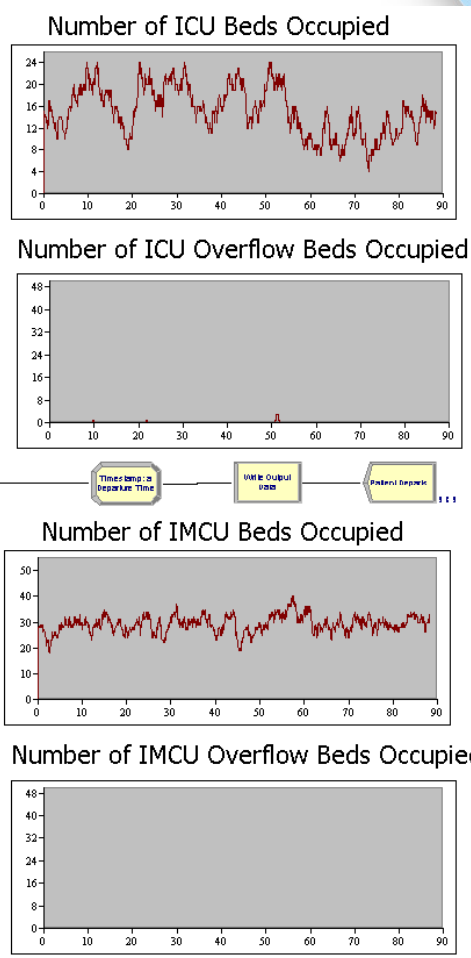
Future State





88 days into one of the 90-day simulations.

Capacity: 24 ICU beds
55 IMCU beds

Patient Volume: 41.3% ICU Increase
14.4% IMCU Increase

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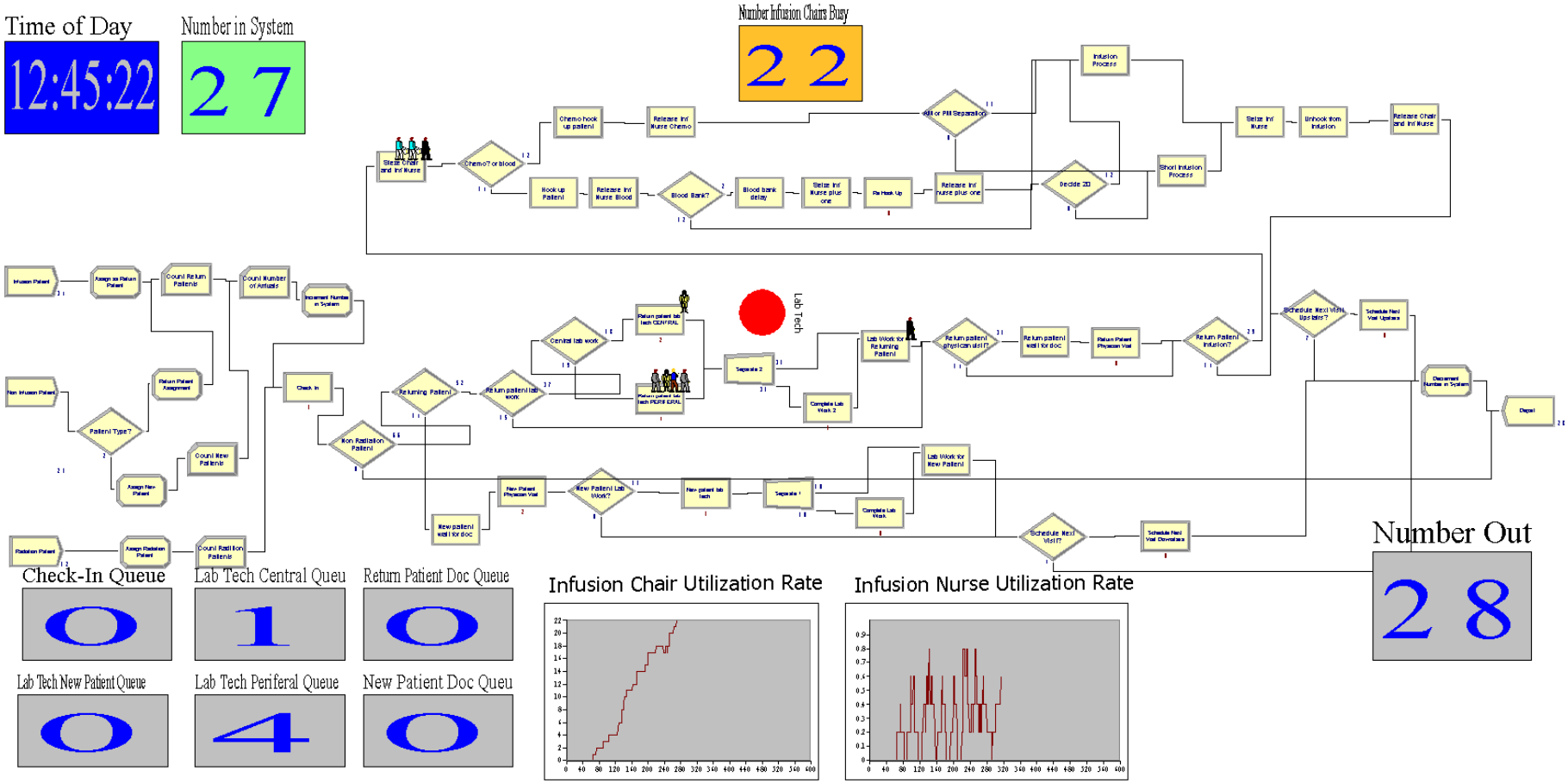
Bend Cancer Center – Current State



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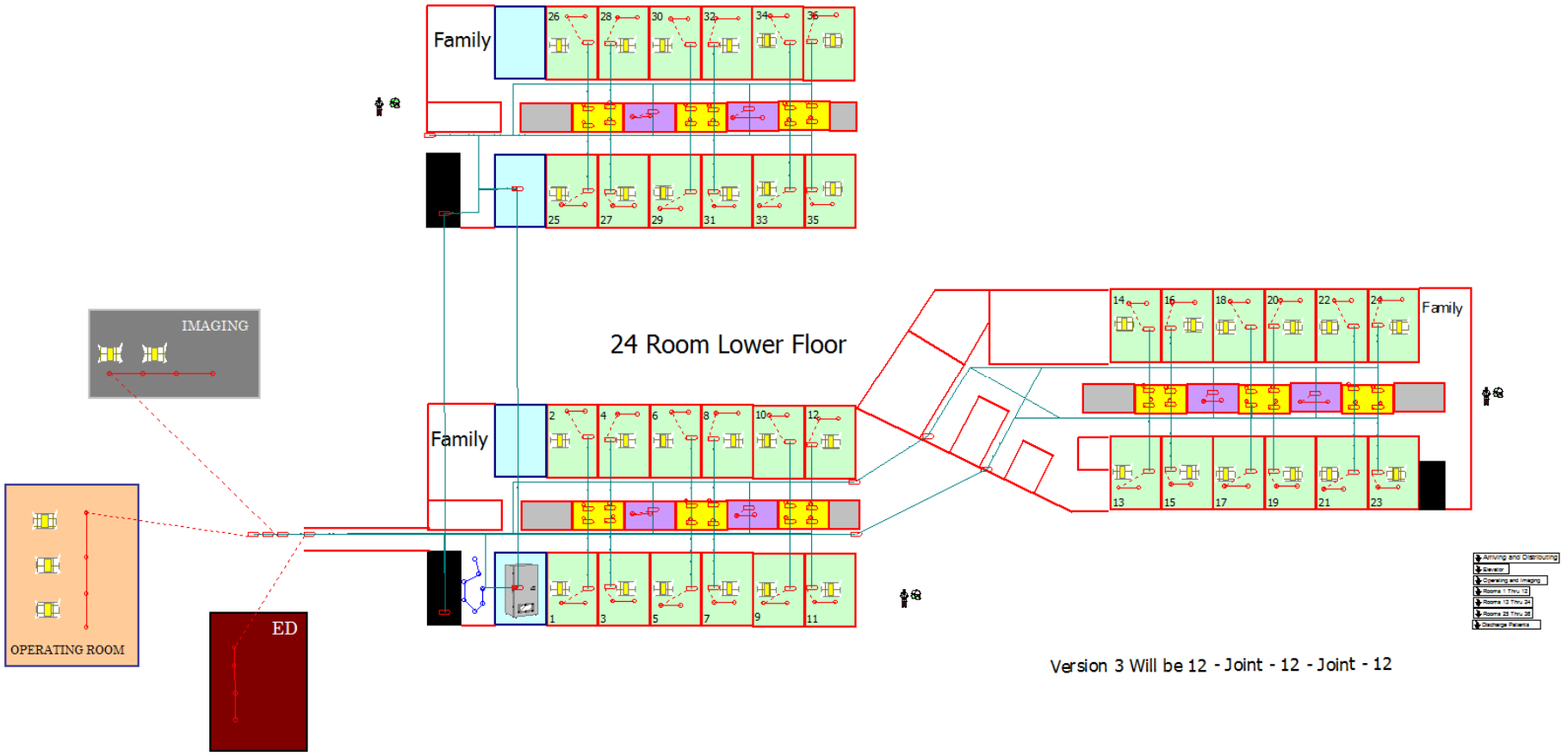
Animation View of New Tower Floor Plan



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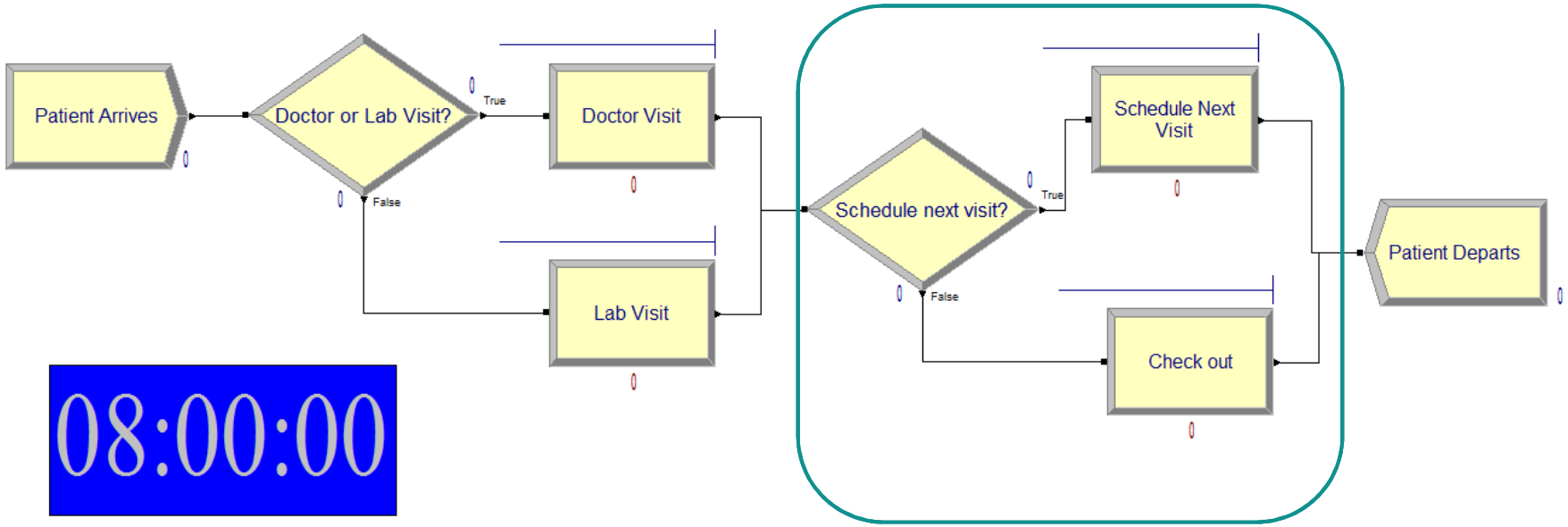
Making another improvement:
Adding more functionality to our example simulation

- Our example simulation with the addition of a decision node that separates patients who schedule a next visit (Triangular distribution (3,8,14)) from those who just check out (Triangular distribution (1,3,4)).



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More Motivation

- Hospitals are dynamic systems and must be analyzed and managed as such. We need dynamic tools and thinking to fix healthcare's dynamic systems.

Story, P., (2011) "Dynamic Capacity Management for Healthcare: Advanced Methods and Tools for Optimization", New York, NY, CRC Press.

- If there were no variation, if every observation were predictable, a mere repetition of what had gone before, there would be no need for statistics.

Good, P.I., Hardin, J.W., (2006) "Common Errors in Statistics (and How to Avoid Them), 2nd Edition", Hoboken, NJ, John Wiley & Sons, Inc.

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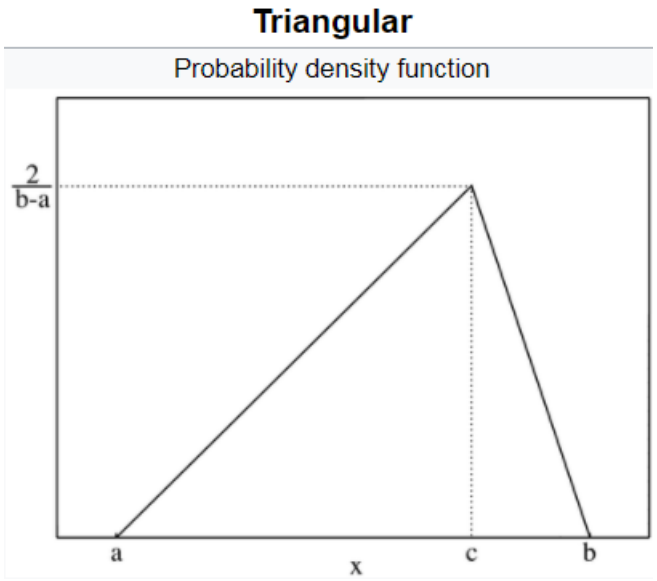
Triangular Distribution

- The triangular distribution is a continuous probability distribution with a lower limit *a*, upper limit *b* and mode *c*, where $a < b$ and $a \leq c \leq b$.
- The triangular distribution is typically used as a subjective description of a population for which there is only limited sample data, and especially in cases where the relationship between variables is known but data is scarce
- It is based on a knowledge of the minimum and maximum and an "inspired guess" as to the modal value. For these reasons, the triangle distribution has been called a "lack of knowledge" distribution. The triangular distribution is therefore often used in simulations.



- If the parameters are such that the triangle is symmetric, then the mean equal the mode, *c*.
- The mean can be calculated as follows.

$$\frac{a+b+c}{3}$$

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St. Charles Quick Facts

- Began in 2001, private, nonprofit corporation
- Largest provider of medical care, and largest employer in Central Oregon
- 4,200 Caregivers at four hospitals: Bend, Redmond, Prineville and Madras
- More than 350 active and about 200 visiting medical staff members
- Changing from Paragon to Epic in April 2018

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