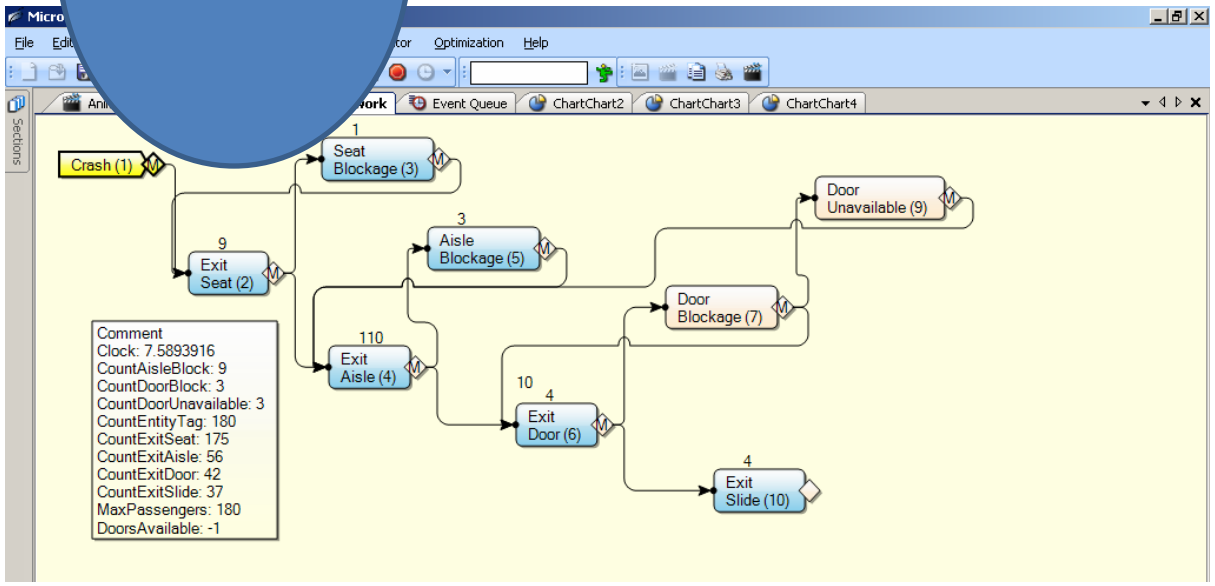
Airbus 380 Evacuation Demonstration

Demonstration?

OR

Simulation?



Simulation Studies of Evacuation from Large Transport Category Airplanes

Brian Peacock

Bill Waldock

Eric Savage

With

Chris Brandon, Chris Spiva, Erich Skoor, Erik Schmidt, Isabel Ruiz

SCSI Conference on Cabin Safety
Torrance CA
February10, 2009

Evacuation does not always stop at the slide

BET YOU DIDNT NOTICE THIS

Another reason to Upgrade to first class

90 Second Target for Demonstration!!

Factors which affect evacuation

- Configuration – The design
  - Exits, aisles, seats, obstructions
- Procedural – The Rules
  - Flight attendant training
- Environmental – The Conditions
  - Smoke, visibility, water etc
  - Available exits
- Behavioral – The People
  - Wide variability of abilities
- Blockages
  - Groups (kin behavior)
  - Slow passengers
  - Injuries
  - Obstacles

All these factors vary and combine to affect evacuation performance

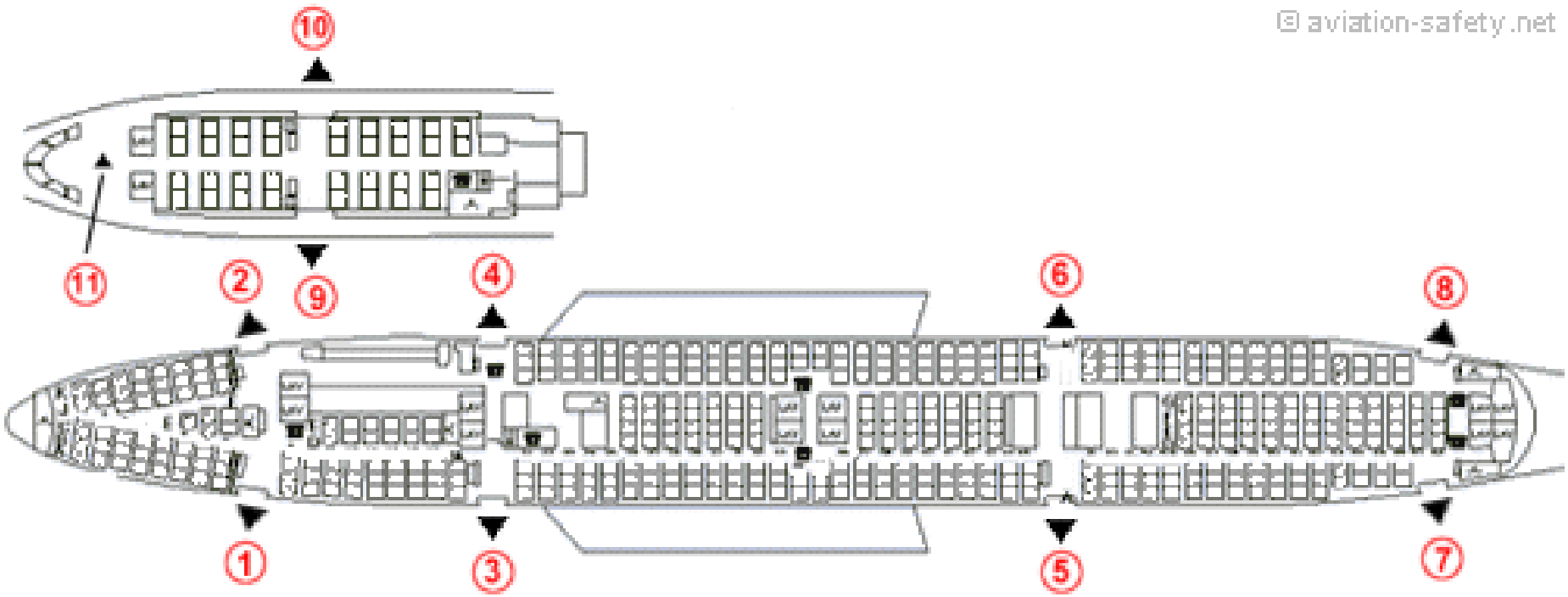
Regulations

- FAR 25.785 Seats berths, safety belts, and harnesses
- FAR25.803 Emergency evacuation
- FAR25.807 Emergency exits
- FAR25.809 Emergency exit arrangement
- FAR25.810 Emergency egress assist means and escape routes
- FAR 25.813 Emergency exit access
- FAR 25.815 Passenger aisle width
- FAR 25.817 Maximum seats per row
- **FAR 25 Appendix J Emergency evacuation certification**


The
Challenge

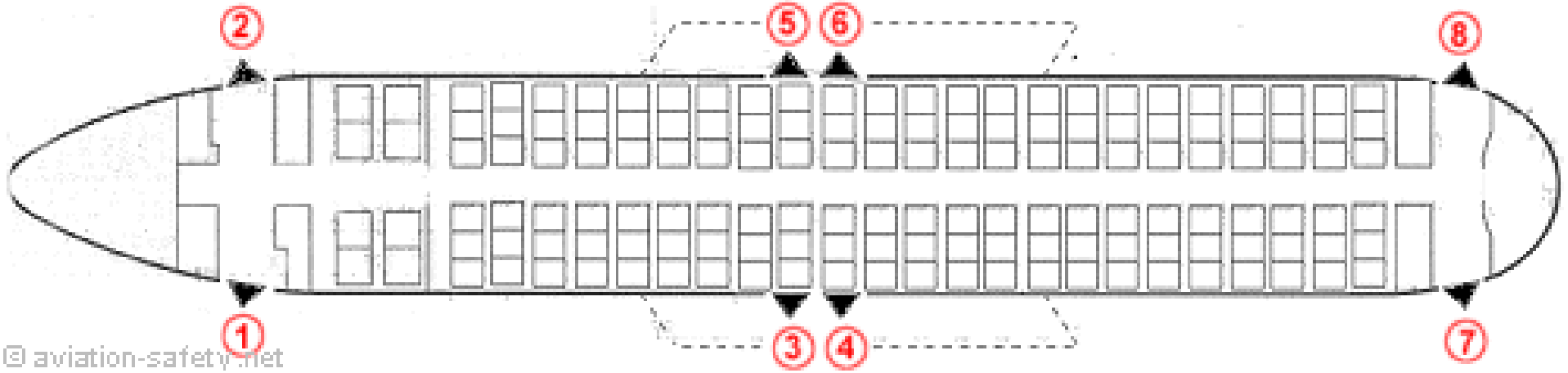

Two Aisles

B747



What about the Stairs?
And the height above the ground?

B737



1 or 2 Doors over the Wings

Different kinds of Door and Door Hardware

- Type I
  - Entrance 32 x 79
  - Service doors 30 x 65
- Type II
  - Over Wing 20 x 38
- Type III
  - Over wing on business jets

- **Different opening procedures**
  - Time taken / errors made in opening doors and deploying slides?
  - 10 – 30 seconds


非常口 EXIT
開OPEN
AUTO


WORLDWIDE
KLM
NORTHWEST
RELIABILITY
KLM


Transavia
OPEN
© Harro Ranter
aviation-safety.net


EXIT
© Harro Ranter
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Northwest Airlines DC-10-30 N230NW, 4 MAY 2003, © Harro Ranter


EXIT
SALIDA
ABRIR
OPEN
© Harro Ranter
aviation-safety.net


EXIT
TO OPEN
PUSH HERE
SPINGERE QUI
PER APRIRE
DANGER
ATTENZIONE
© Harro Ranter
aviation-safety.net


非常口 EXIT
開OPEN
AUTO
© Harro Ranter
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Over Wing

The Passengers Duty

- Special Instructions
- Capability Screening

Type III

After the Accident Context

- Available doors
- Orientation of the airplane
- Damage to the airplane
- Fire and smoke
- Water
- Cold and windy
- Condition of the
  - Passengers
  - Flight attendants
- First responders
- Available equipment

Check out these aftermaths

>>>>>>>>>


PR-GOO
2003 12 27


UR-VVB
Ukrainian Airlines
AeroSvit


2003 12 21
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CAMEROON AIRLINES


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Procedural Factors (a big variable)

- Flight attendant training & qualification
- Emergency training
- Passenger safety briefing

FAR 121.397-Emergency & emergency evacuation duties
FAR 121.417-Crewmember emergency training
FAR 121.571-Briefing passengers before takeoff

The People

- Young, old
- Fat, thin
- Handicapped passengers etc.
- Panicked, calm etc. (Muir)
- Encumbered (leave your carry on bags!)
- Family / other groups - inevitable
  - Kin behavior
  - Unaccompanied minors
- Behavior differences end up as
- **performance differences**
  - **Speed, stumbling, reverse flows**

Demonstration or Simulation

- Validity?
- Repeatability?
- Versatility?
- Cost?
- Safety?

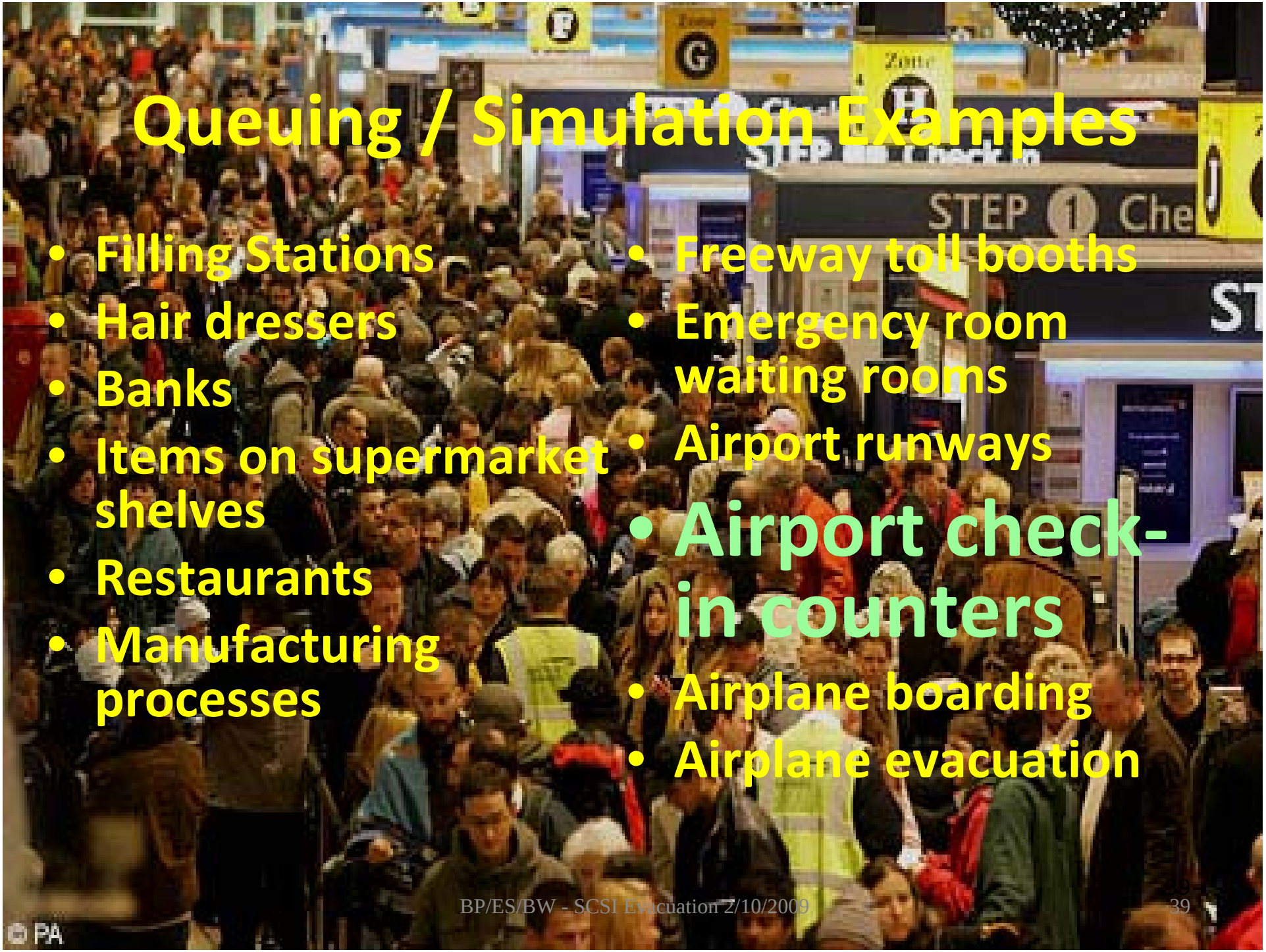
A simulation is only as good as the model, the data used to drive the model, and the experimental design

Discrete Event Simulation

- Based on Queuing Theory
  - appropriate where there are multiple interdependent entity arrival times, service activities, resource constraints, flow logic etc.
- Logic
  - Activities, Branches and Queues
- Times
  - Arrival and Service
- Random Number generation from statistical distributions
    - Poisson, Exponential etc.
- Outputs
  - Queue lengths, service rates etc.

Simulation

- Queuing theory becomes too cumbersome when there are may entities / resources and activities
- Therefore use (computer based) Monte Carlo simulation to vary:
  - number of resources
  - arrival and service rates according to Poisson / Exponential (or other distributions)
  - entity / resource characteristics / attributes
  - queue discipline (FIFO, LIFO)
  - activity logic to drive probabilistic branching
- Simplify the model
- Run the simulation just like an empirical experiment



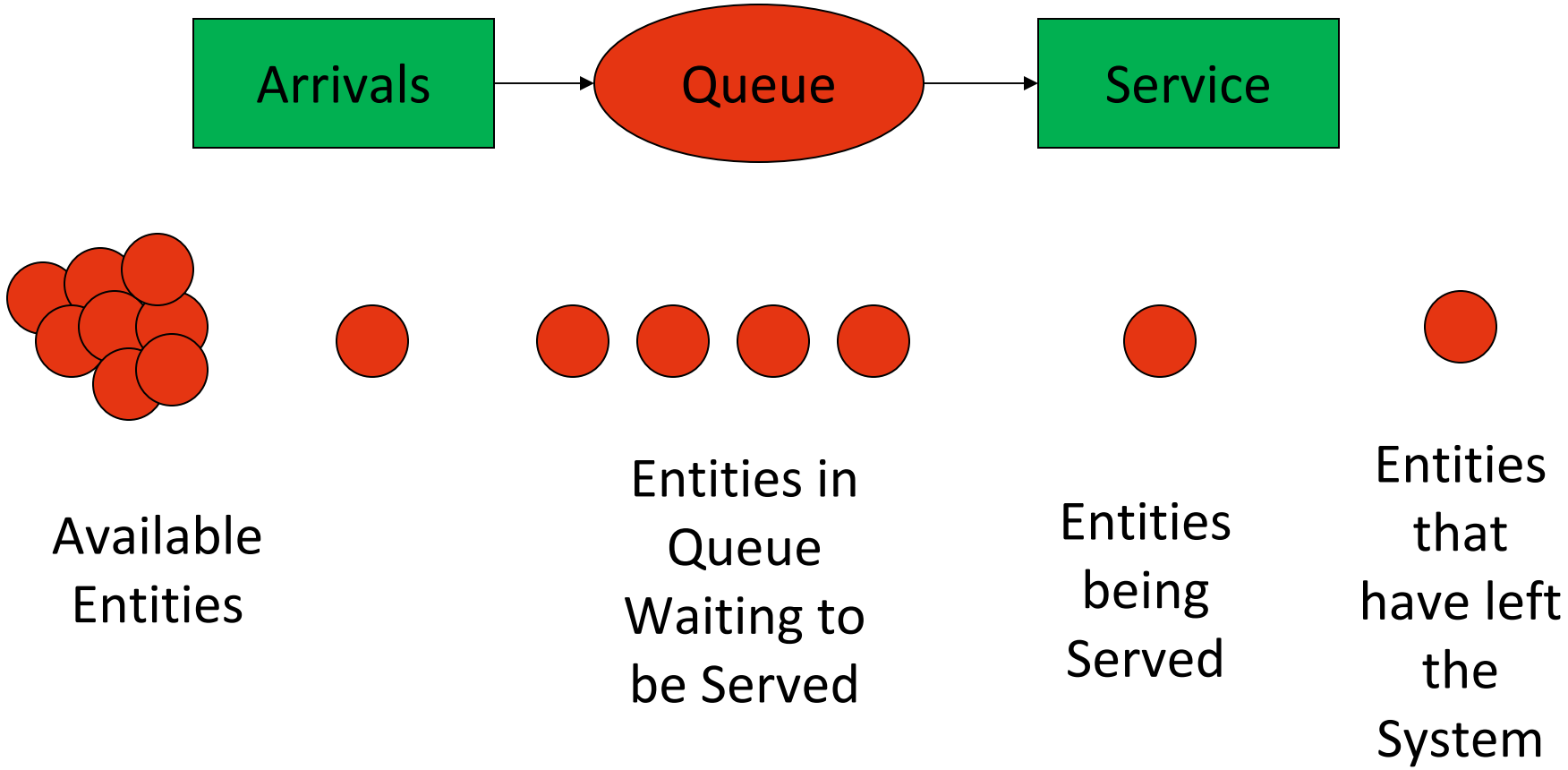
Queuing / Simulation Examples

- Filling Stations
- Hair dressers
- Banks
- Items on supermarket shelves
- Restaurants
- Manufacturing processes
- Freeway toll booths
- Emergency room waiting rooms
- Airport runways
- **Airport check-in counters**
- Airplane boarding
- Airplane evacuation

Simulation Process

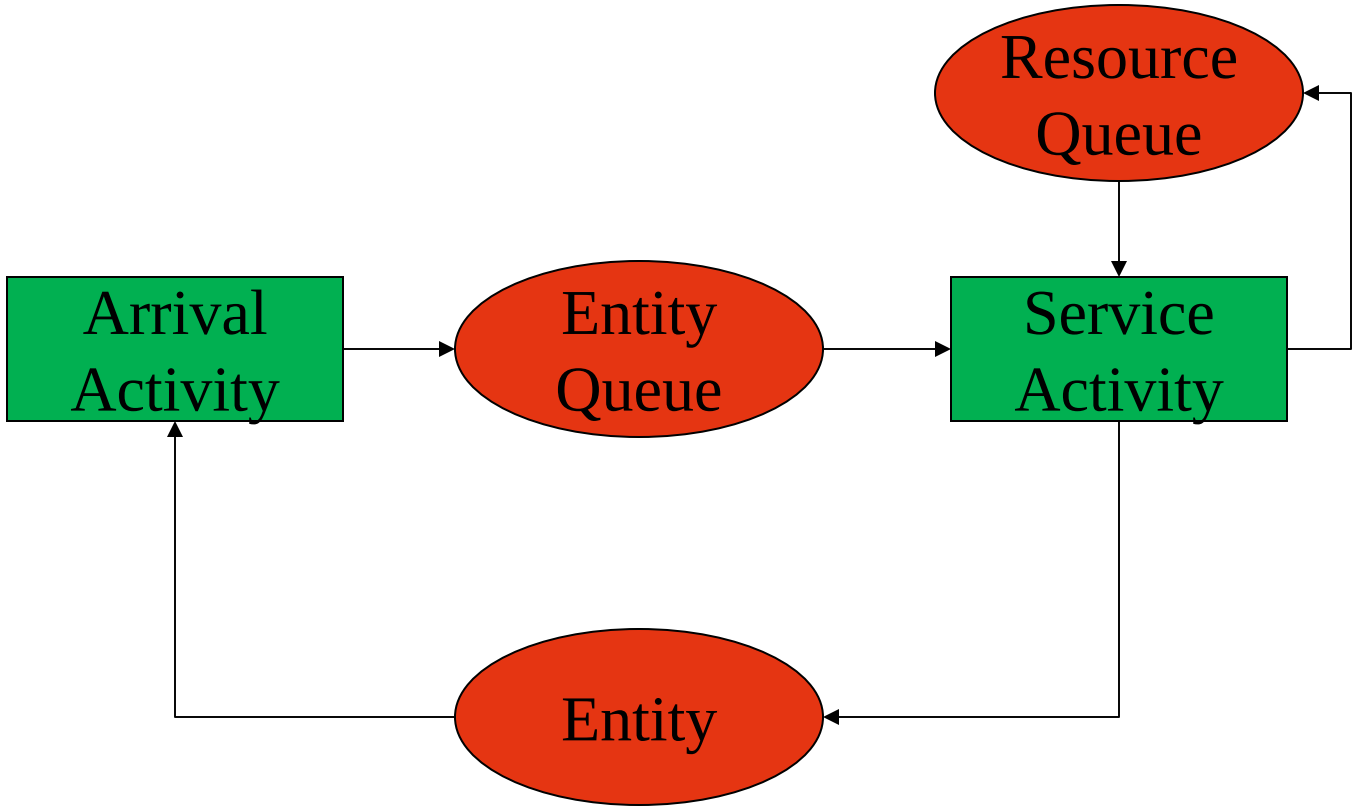
- Sketch the physical layouts of each of these examples
- Draw the queuing model for each example
  - Single queue / Multi server
  - Multi queue / Multi server
- Discuss service discipline
  - FIFO, LIFO, Priority, Random
- **Develop an Activity Cycle Diagram**
- Estimate average arrival rates and service times
- Calculate throughput, resource utilization and queue lengths and times

Queues


Arrivals
Queue
Service
Available Entities
Entities in Queue Waiting to be Served
Entities being Served
Entities that have left the System

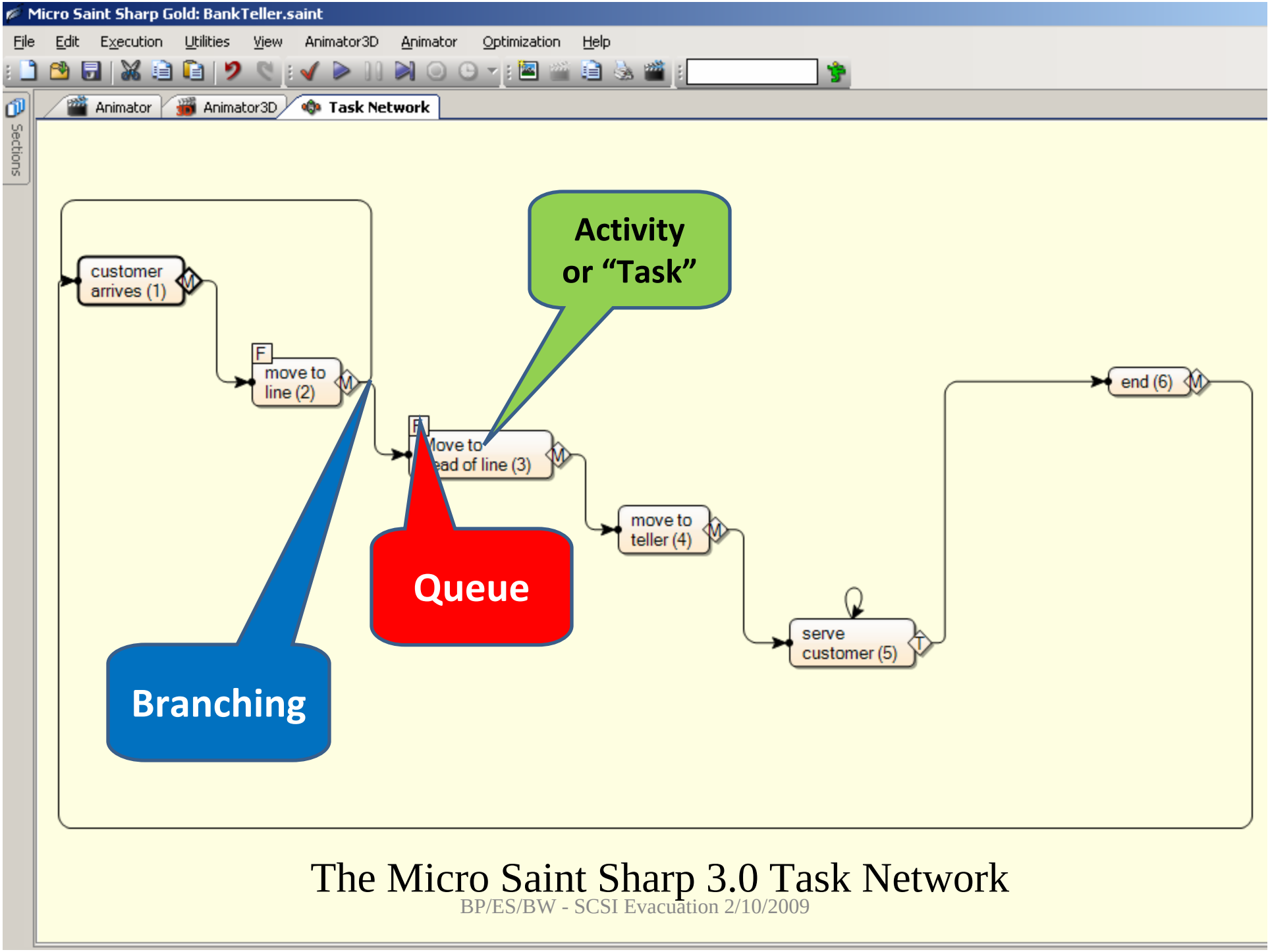
Activity Cycle Diagrams

(Network Diagrams)



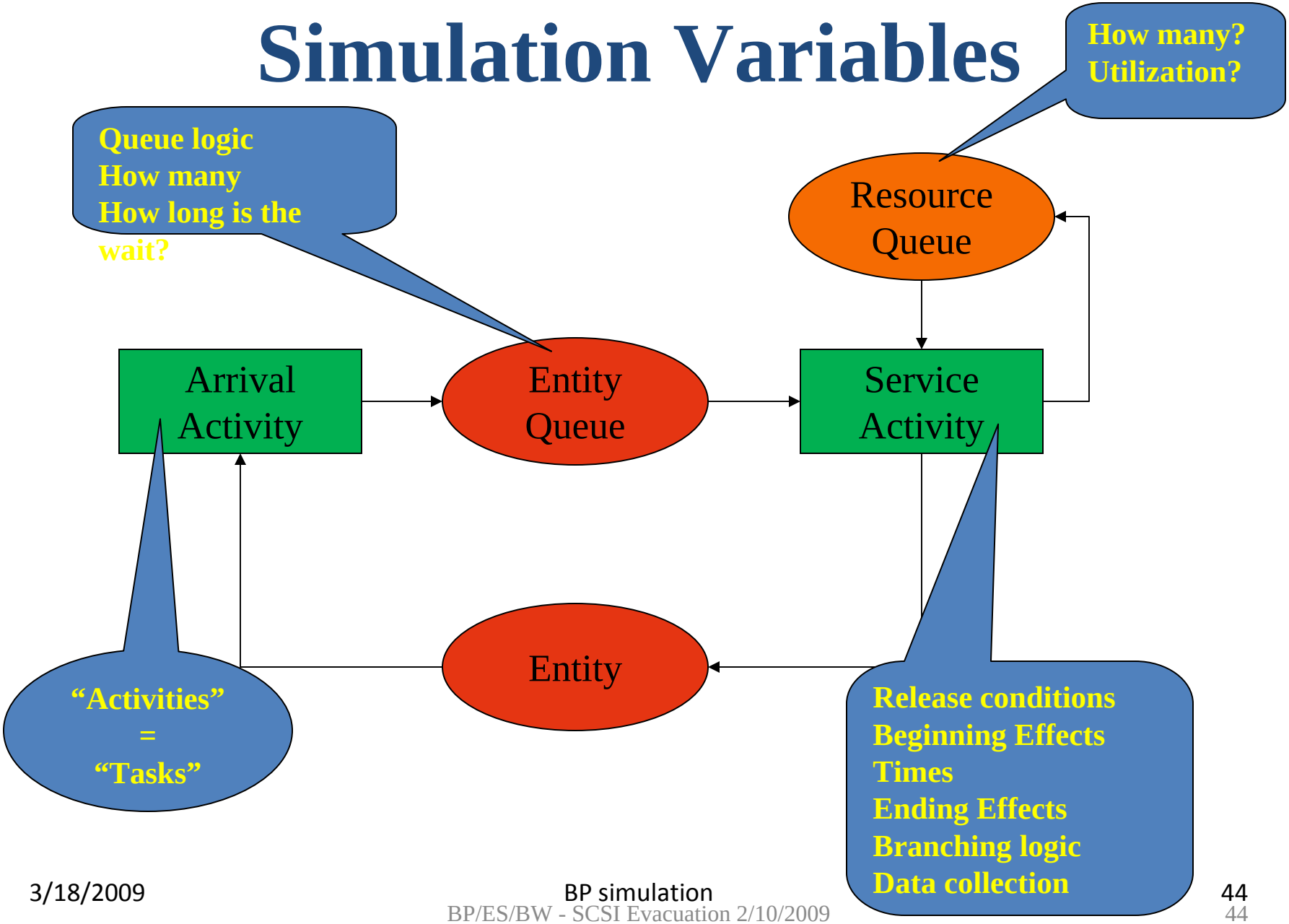
Note that all entities / resources have complete cycles

with alternating queues and activities



The Micro Saint Sharp 3.0 Task Network

Simulation Variables



Activities (or Tasks)

1. Release conditions

- Is an entity waiting?
- Is a resource available?
- Do the entity requirements match the resource characteristics?
- What is the queue logic?
  - FIFO, LIFO, Priority, Random

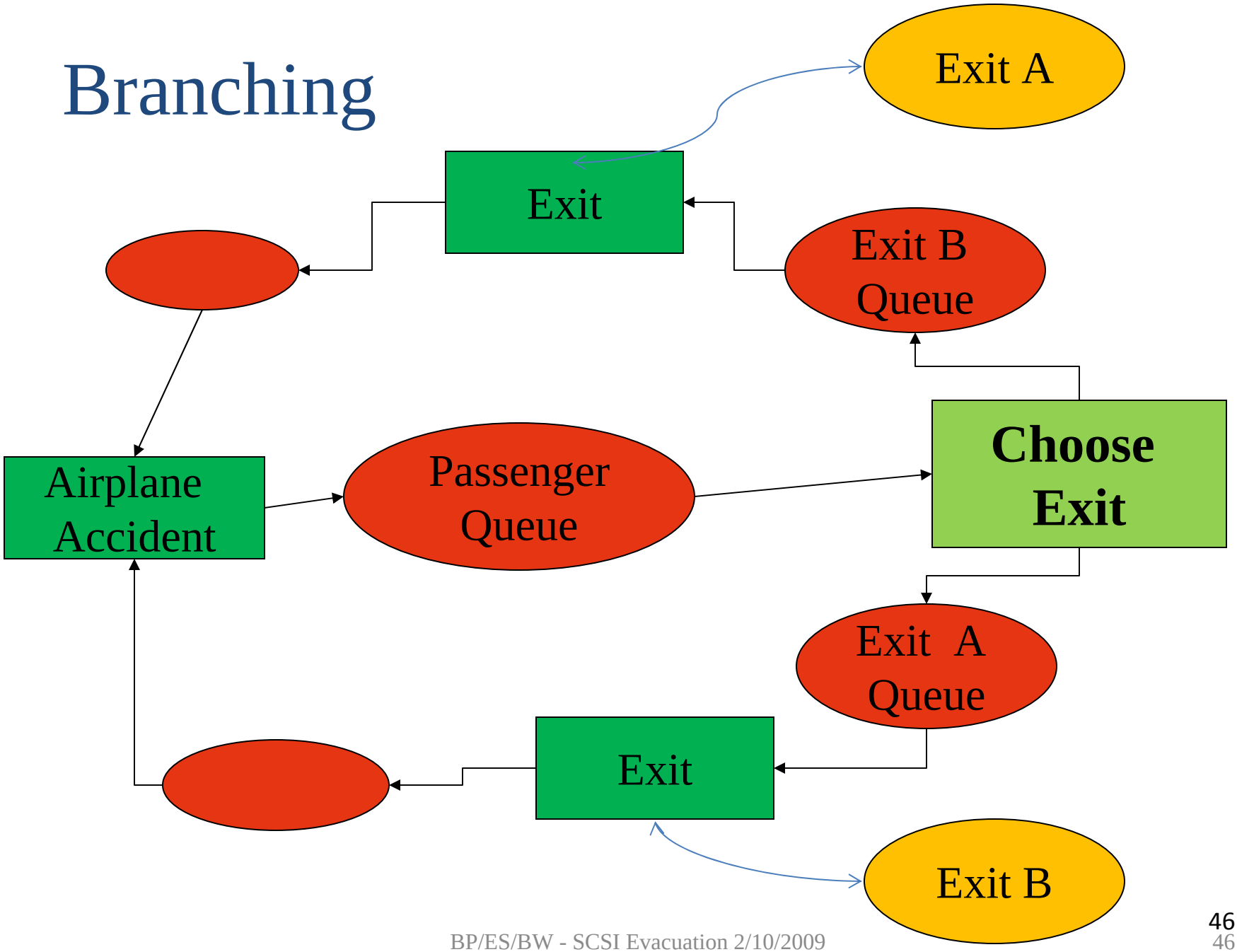
2. Beginning Effects

- An entity is removed from the queue
- A resource becomes occupied

3. Ending Effects

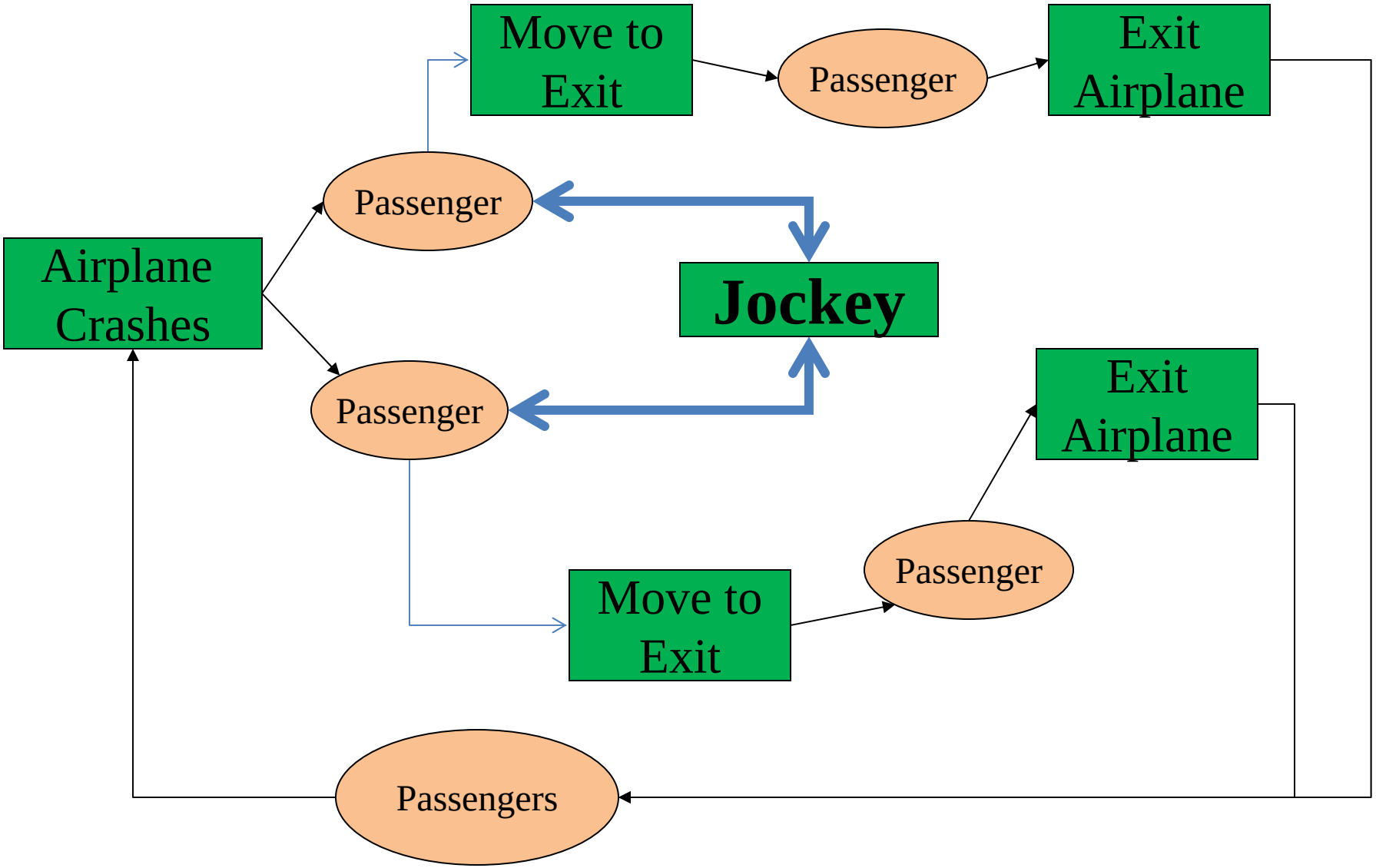
- The entity is released
- The resource becomes available for another task
- The characteristics of the entity (and the resource) will have changed (e.g. materials to finished goods)

Branching

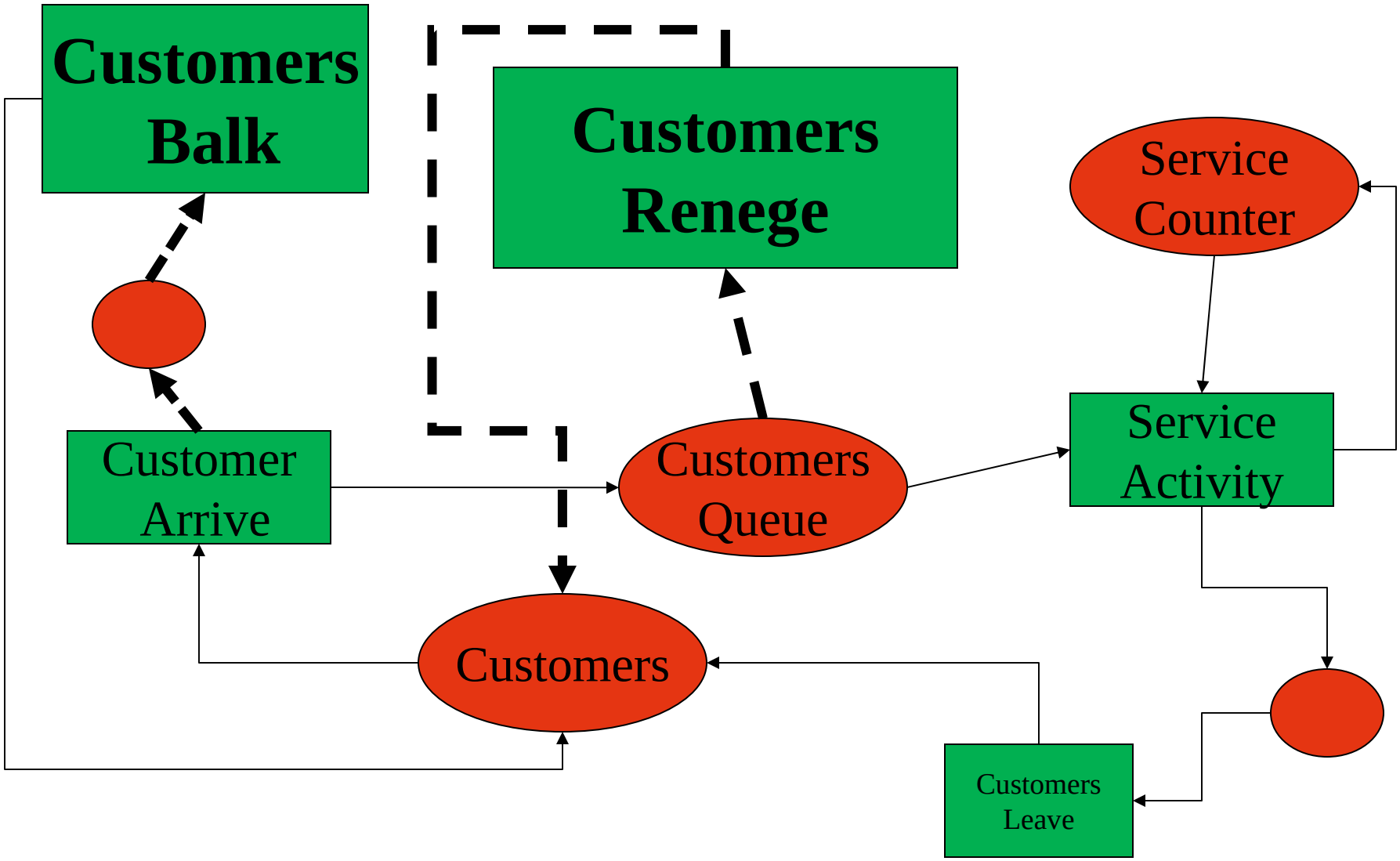

Exit A
Exit
Exit B Queue
Airplane Accident
Passenger Queue
Choose Exit
Exit A Queue
Exit
Exit B

What happens when there are multiple exits and lots of terrified passengers?

Jockeying (between queues)

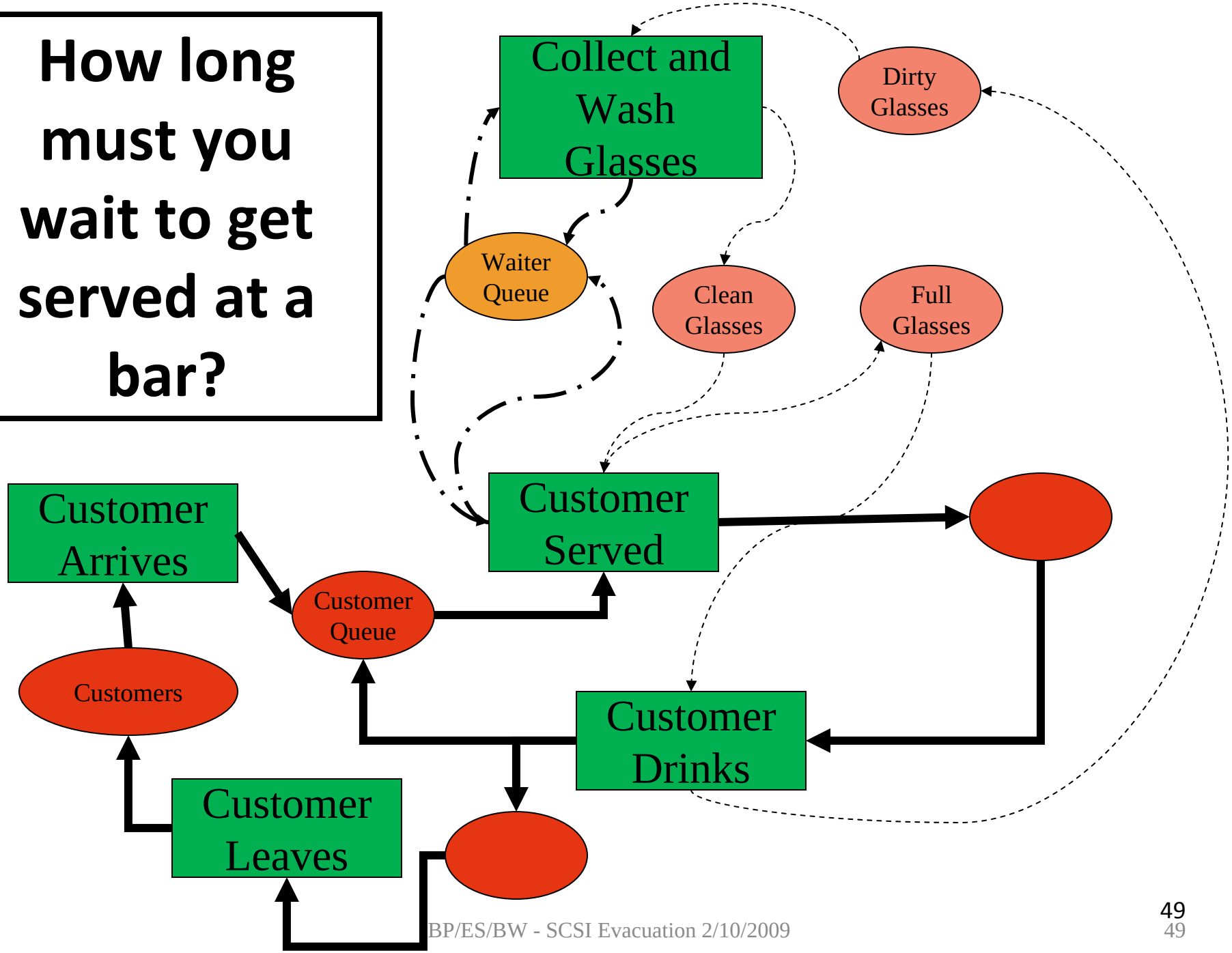


Baulking and Reneging



48

How long must you wait to get served at a bar?



Data Collection

- Length of time an entity has been in a queue
- How many entities are still in the queue
- How often a resource (e.g. an Exit) has been used (e.g. cycles, hours)
- What changes occur in an entity (e.g. stumble)

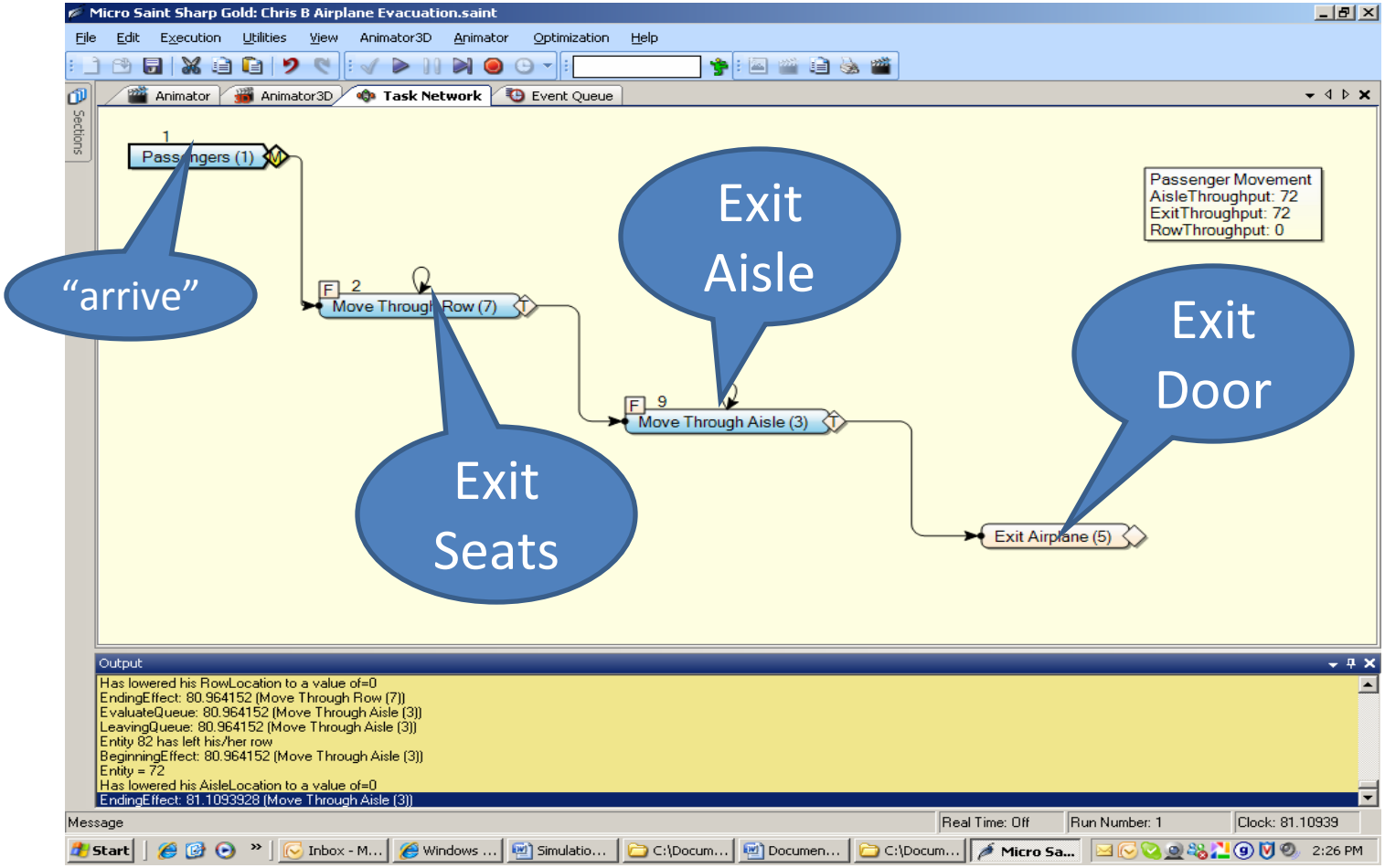
Experimental Design

- Run the simulation repeatedly, just like a physical experiment
  - 6 doors / 3 doors
  - Mobile / immobile passengers
  - Blockages / no blockages
  - etc

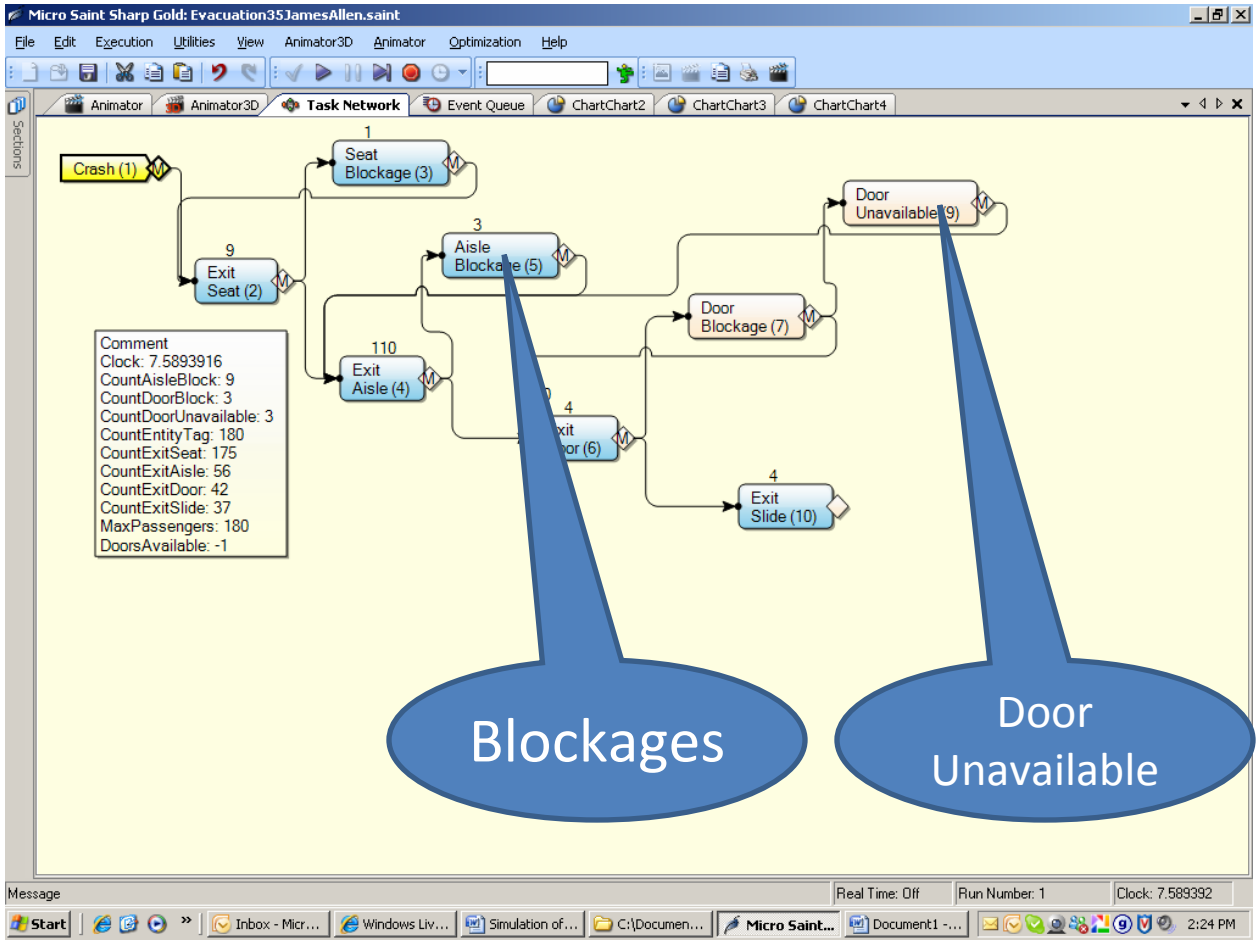
  - Many **combinations** and **replications** of each set of conditions
  - Note that a **demonstration** usually has one set of conditions and one replication and cost many $$$

Evacuation Models

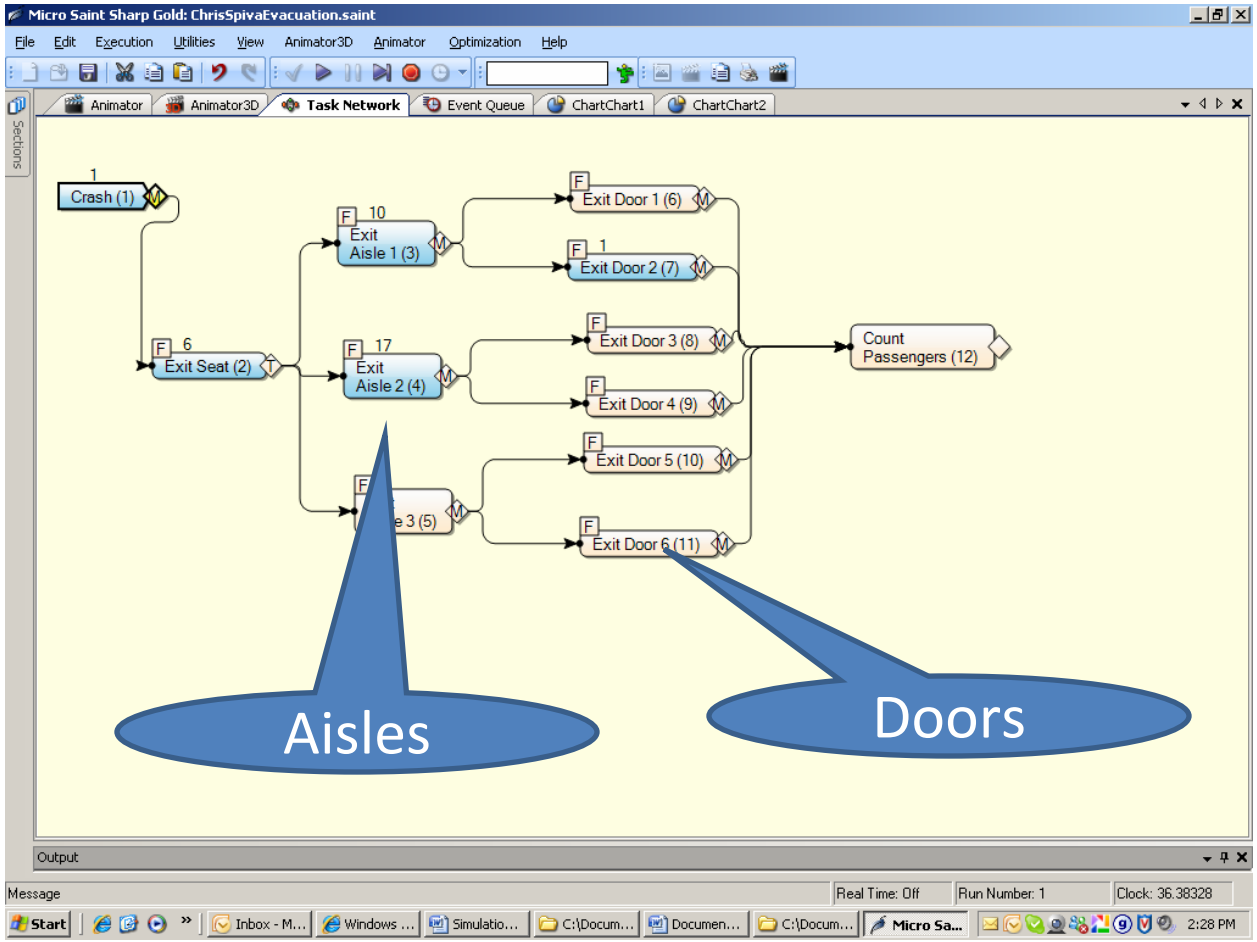
- There are very many possible models and model parameters
- The keys to modeling success are:
  - Accuracy
  - Validity
  - Efficiency
  - Simplicity



This basic model used exponential "service times" (Mean = 1 – 5 seconds per movement between "spaces") for each row, aisle and door exit activities and updated the location of a passenger as he /she moved incrementally along a row or aisle, or exited the airplane. Queues are allowed to form if a service "resource" (space) was not available.

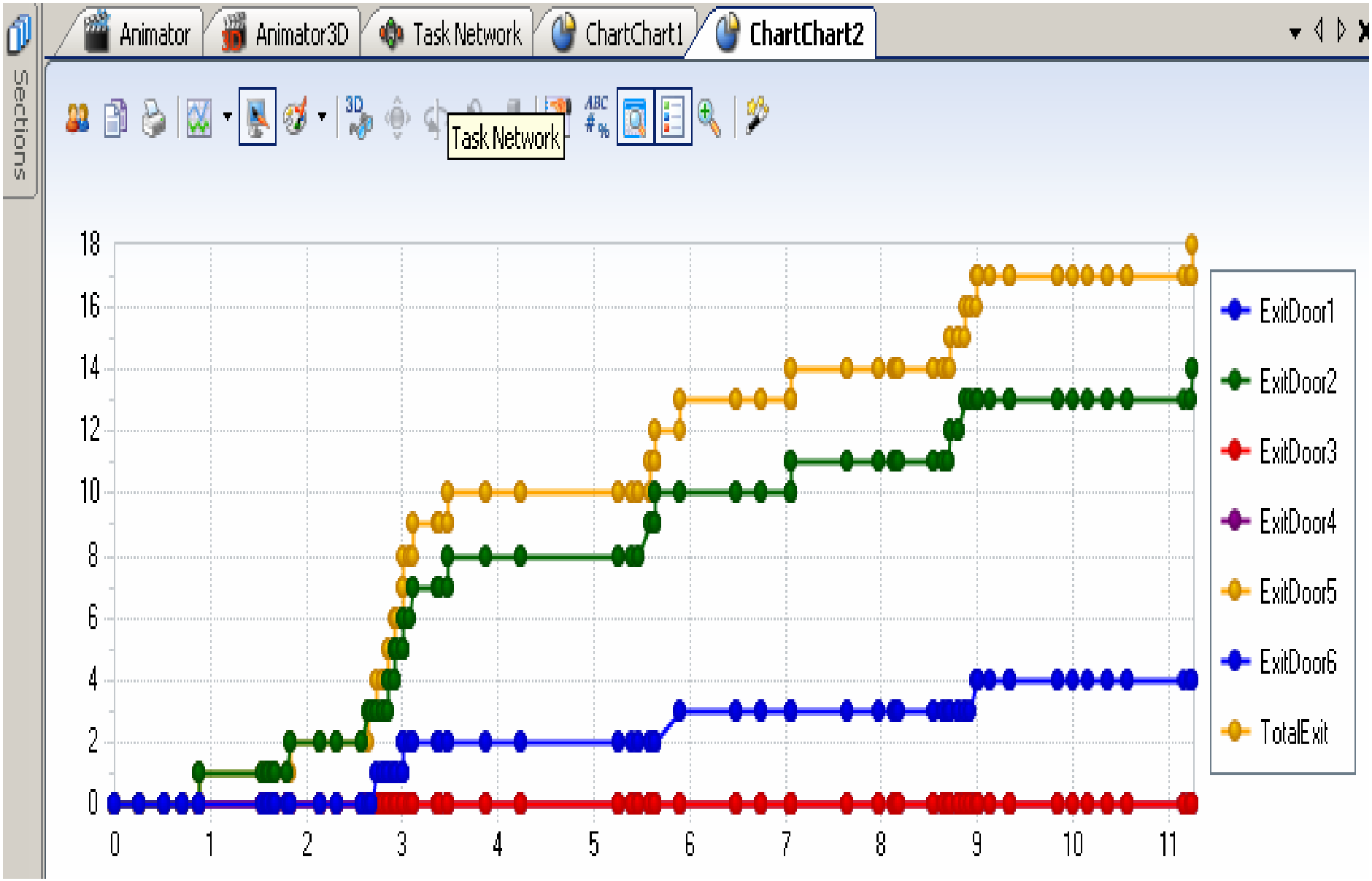


This model includes a probabilistic branch to a series (seat, aisle and door) of blockage conditions. The door blockage may develop into a “door unavailable” condition, on a probabilistic basis. Manipulation of the activity throughput times, using a Gamma distribution with means and standard deviations calculated based on the distance of the seat from the aisle and the distance of the seat row from the door. The probabilities of seat, aisle and door blockages were systematically increased from 0.0 to 1.0.

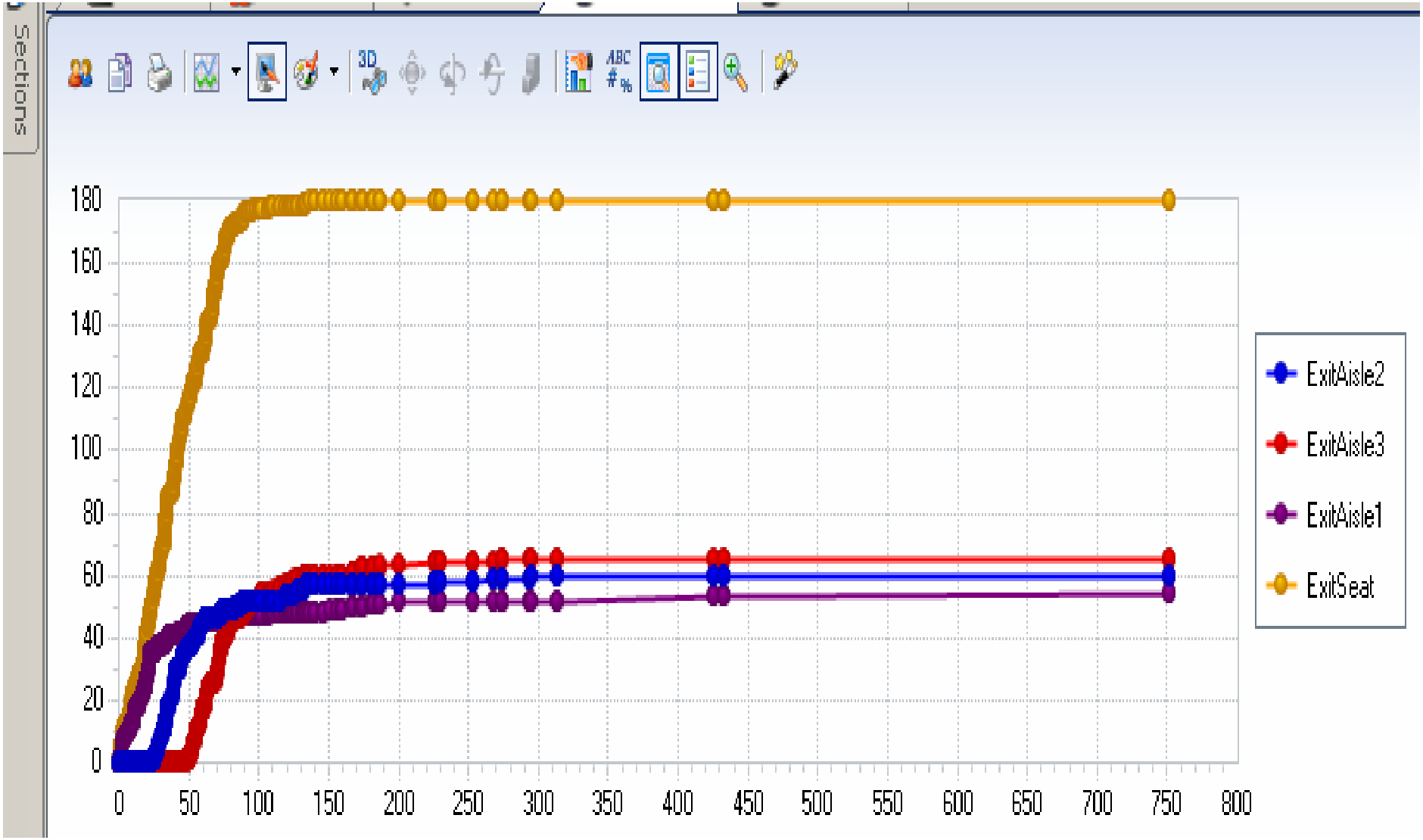


This model explored specific exit path assignments based on seat location. Exit times were related to position in row and location of row. An extension of this model addressed looping back to alternative routes if a resource became unavailable or the waiting time for the resource exceeded an assigned amount.

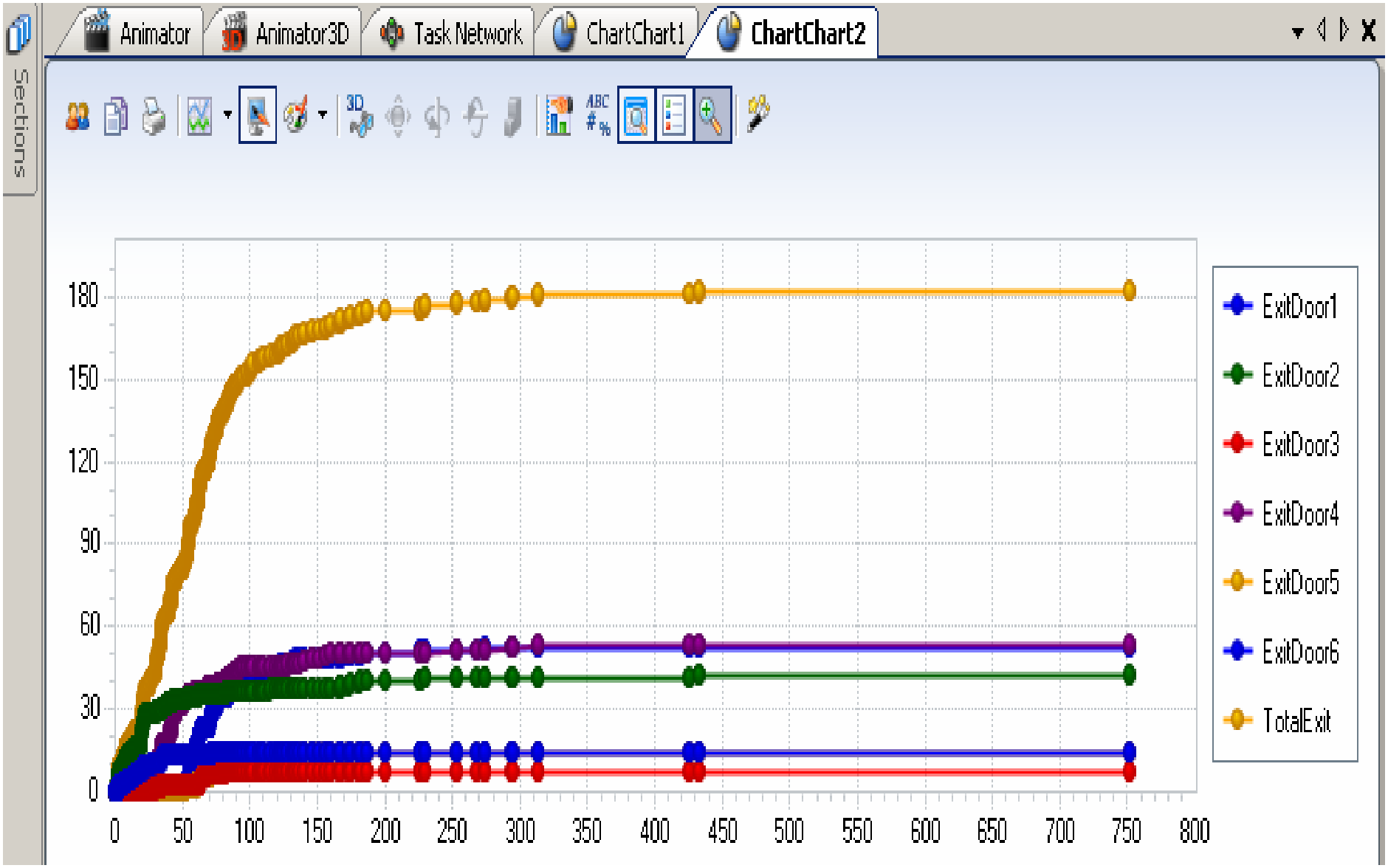
Mid simulation run output

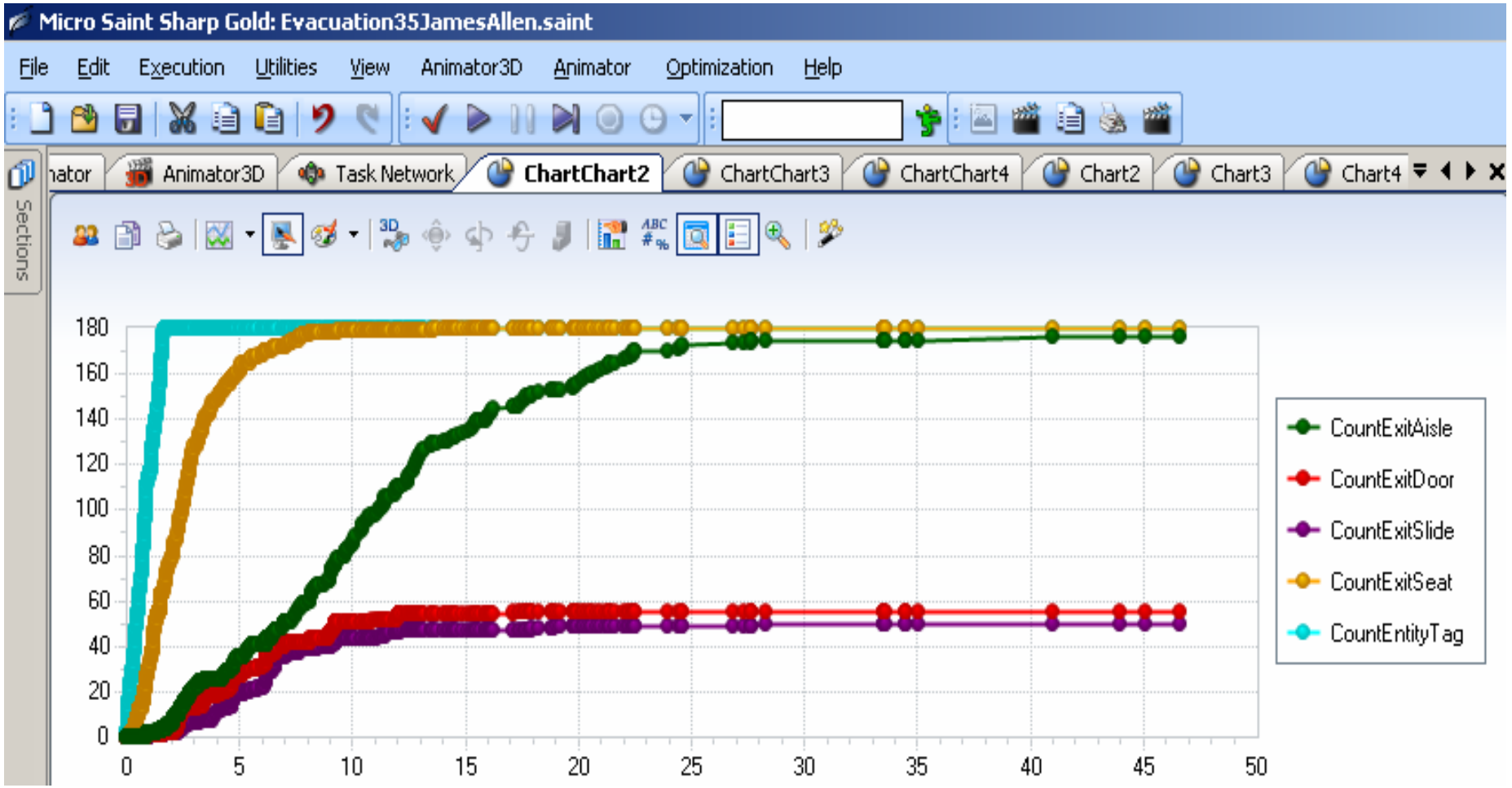


End of Simulation Run



End of Run


Animator
Animator3D
Task Network
ChartChart1
ChartChart2
Sections
180
150
120
90
60
30
0
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
ExitDoor1
ExitDoor2
ExitDoor3
ExitDoor4
ExitDoor5
ExitDoor6
TotalExit



The timeline of movement from rows, aisles, doors and slides. In this run, it can be seen that there were 180 passengers who all exited the seats after 5 seconds and the aisles after about 25 seconds. However, apparent congestion at the doors indicated that only about 50 passengers exited the doors and slides

Future / Ongoing Work

- Refine the models
  - Logic
  - Flows
  - Conditions
- Improve input data / assumptions
- Vary passenger / flight attendant behaviors
  - Abilities
  - Groups
- **Blockages**

Example Simulation Run

Demonstration?

OR

Simulation?