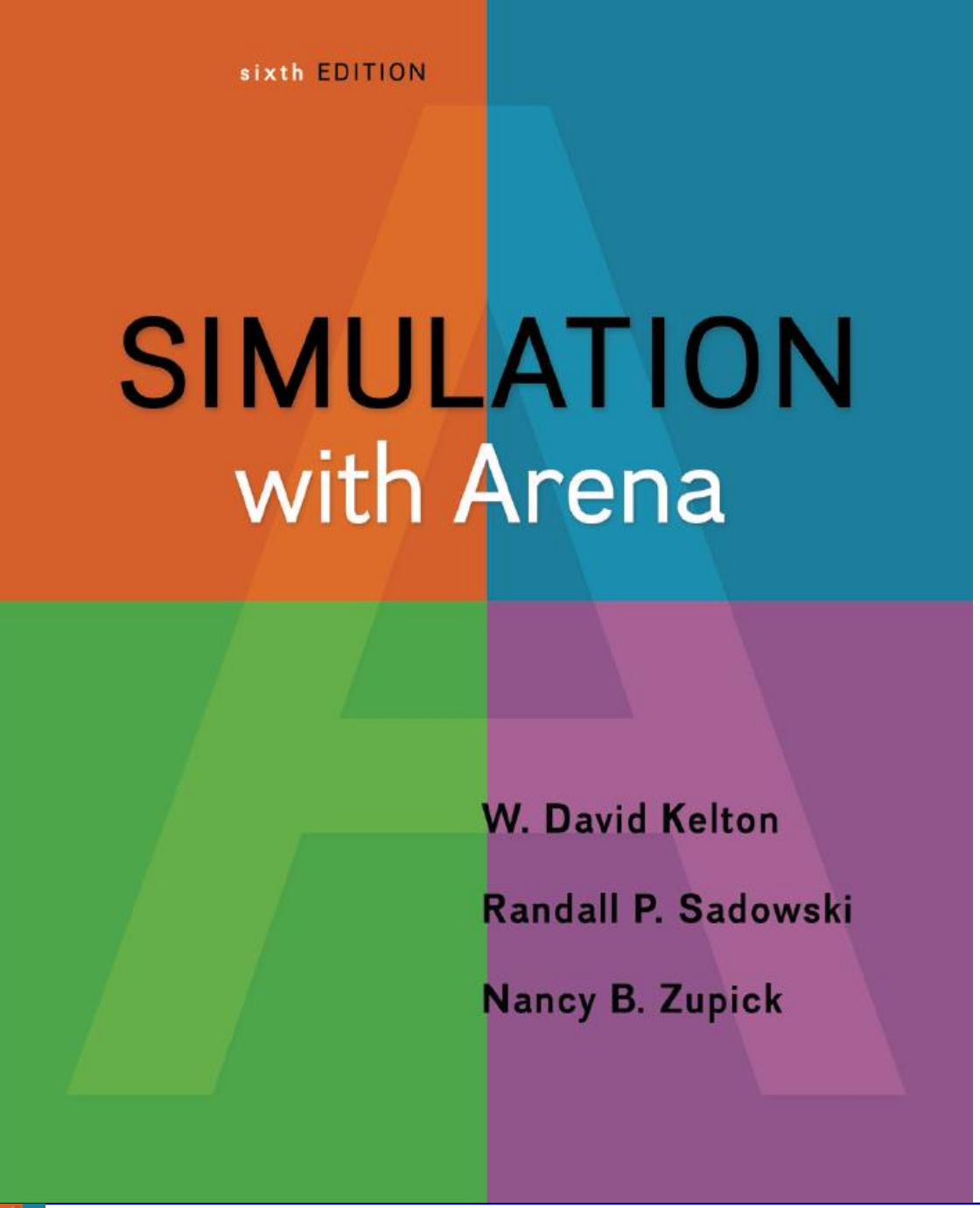


A Guided Tour Through Arena

Chapter 3

Last revision September 22, 2017

What We'll Do ...

- **Start Arena**
- **Load, explore, run an existing model**
  - Basically same as hand simulation in Chapter 2
  - Browse dialogs and menus
  - Run model
  - Look at results
- **Construct same model from scratch**
- **Use just these basic building blocks in case study to address real operational question**
- **Tour menus, toolbars, drawing, printing**
- **Help system**
- **Options for running and control**

Behavior of Arena

- **Arena is a true Windows application**
  - Appearance, operation, functions, are standard
  - Interoperability with other software (MS Office, CAD)
  - Interact, communicate with other software (Chapter 10)
- **Assume you already know basics of Windows:**
  - Disks, files, folders, paths
  - Mousing, keyboarding
  - Resizing, moving, maximizing, minimizing windows
  - Menu operations
  - Ctrl, Alt, Shift keys
  - Cut, copy, paste
  - Filling out dialog fields

Starting Up

- **Installing Arena – Appendix D**
- **Locate icon or shortcut; double-click**
  - Or, *Start > All Programs > Rockwell Software > Arena > Arena*
  - Licensed Mode vs. Training/Evaluation Mode (STUDENT)
- **See File, View, Tools, Help menus**
  - Other menus present if a model file is open
- **Toolbars with buttons**
  - Unless a model file is open, only New model file, Open model file, Template Attach/Detach, Context Help (click it, then click on buttons or menu items)
- **Tooltips – roll over toolbar buttons for names**
- **Quitting Arena: *File > Exit*, Alt+F4, or top right ✕**

Opening an Existing Model

- ***File > Open* … or  button**
  - Navigate to desired disk/directory
  - *Click* > *Open* or double-click **`Model 03-01.doe`**
  - Book example models: www.mhhe.com/kelton, Student Edition, **`BookExamples.zip`**, put where you want
  - More examples (typical location on Windows 7): **`C:\Users\Public\Public Documents\Rockwell Software\Arena\Examples`**

Why the **`.doe`** *default filename extension for Arena models?*

- **Model window (right side of Arena window)**
  - Where model is built
  - Resize, maximize, minimize, scroll/pan, zoom
  - Can have multiple model windows open at once
- **Cut, Copy, Paste within Arena, and between Arena and other applications (when sensible)**

Flowchart and Spreadsheet Views

- **Model window split into two views**
  - *Flowchart* view
    - Graphics
    - Process flowchart
    - Animation, drawing
    - Edit things by double-clicking on them, get into a dialog
  - *Spreadsheet* view
    - Displays model data directly
    - Can edit, add, delete data in spreadsheet view
    - Displays all similar kinds of modeling elements at once
  - Many model parameters can be edited in either view
  - Horizontal splitter bar to apportion two views
  - *View* > *Split Screen* (or push ) to see both flowchart and spreadsheet views (otherwise, only get view for active module type)

Project Bar

- **Usually down left edge of Arena window**
- **Hosts panels with modeling building blocks: *modules***
  - Both flowchart and spreadsheet modules
- **Displays one panel at a time**
  - Switch to different panels via horizontal buttons
  - Panels for Basic Process, Reports (after running), Navigate (to different views within a model or to different hierarchical submodels, thumbnail), … others can be attached (Template Attach button ) for different modeling levels, specialties
- **Usually docked to left edge but can move, float**
- **Hide it via *View* > *Project Bar* or its own small** 

Status Bar

- **At very bottom of Arena window**
- **Displays various information sensitive to status**
  - Coordinates of cursor in “worldspace”
  - When simulation is running:
    - Simulation clock value
    - Replication number being executed
    - Number of replications to be done
- **Hide by clearing (unchecking) *View* > *Status Bar***

Moving Around, Up, Down in Flowchart View of Model Window

- **Underlying *world space* for model**
  - (*x*, *y*) coordinates, arbitrary units (±32K in all directions)
- ***Pan* with scroll bars, arrow keys, thumbnail**
- ***Zoom* in (down):  or + key or thumbnail**
- **Zoom out (up):  or – key or thumbnail**
- **See all at min altitude:  or * key**
- ***Named views***
  - Save a pan/zoom view for different parts of model
  - Assign a *Hot key* (case-sensitive)
  - Access via *View* > *Named Views …* or ? key or 
- **Display *grid* (), *snap* to grid () toggles**
- **Rulers, alignment, guides, glue – see text**

To navigate via keyboard, flowchart view of model window must be active ... click in it.

Modules

- **Basic building blocks of simulation model**
- **Two basic types: *flowchart* and *data***
- **Different types of modules for different actions, specifications**
- **"Blank" modules: on Project Bar**
  - Add a flowchart module to model: drag it from Project Bar into flowchart view of model window
    - Can have many instances of same kind of flowchart module in model
  - Use a data module: select it (single-click) in Project Bar, edit in spreadsheet view of model window
    - Only one instance of each kind of data module in model, but it can have many entries (rows) in spreadsheet view
    - Can edit via dialog – double-click on number in leftmost column

Flowchart Modules

- **Describe dynamic processes**
  - Nodes/places through which entities flow
  - Typically connected to each other in some way
- **Basic Process panel flowchart module types:**
  - Create, Dispose, Process, Decide, Batch, Separate, Assign, Record
- **Other panels – many other kinds**
- **Shape like flowcharting (later, colors for hints)**
- **Two ways to edit**
  - Double-click to open up, then fill out dialogs
  - Select (single-click) a module type in model or Project Bar, get all modules of that type in spreadsheet view

Data Modules

- **Set values, conditions, etc. for whole model**
  - No entity flow, no connections
- **Basic Process panel data module types:**
  - Attribute, Entity, Queue, Resource, Variable, Schedule, Set
- **Other panels – many other kinds**
- **Icons in Project Bar look like little spreadsheets**
- **To use a data module, select it (single-click) in Project Bar, edit in spreadsheet view**
  - Can edit via dialog – double-click in leftmost column, or right-click and select Edit via Dialog
  - Double-click where indicated to add new row
  - Right-click on row, column to do different things
- **At most one instance of each kind of data module in a model**
  - But each one can have many entries (rows)

Relations Among Modules

- **Flowchart, data modules related via names for objects**
  - Queues, Resources, Entity types, Variables, Expressions, Sets, … many others
- **Arena keeps internal lists of different kinds of names**
  - Presents existing lists to you where appropriate
  - Helps you remember names, protects you from typos
- **All names you make up in a model must be unique across model, even across different types of modules**

Internal Model Documentation

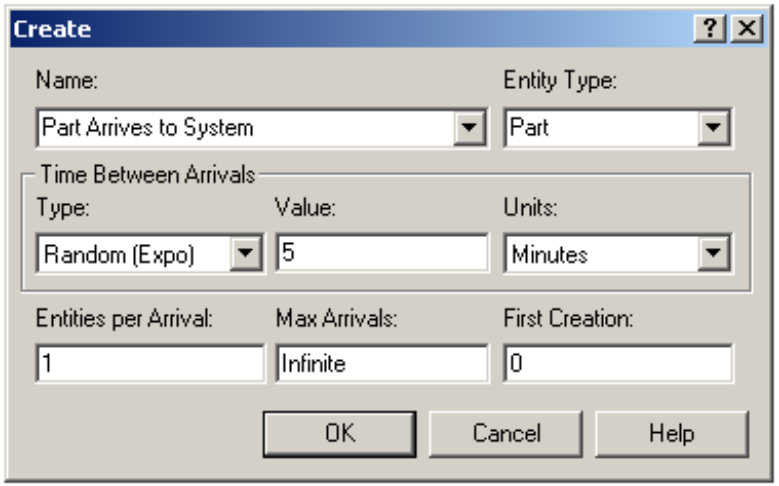
- ***Data Tips*** **on modules, graphics – hover mouse over object to see**
  - Default part – generic info on object (name, type)
  - User-specified part – right-click on object, select Properties, enter text under Description
  - Toggle display of Data tips via *View > Data Tips*
- ***Project Description*** **– *Run > Setup > Project Parameters,* enter text under Project Description**
- ***Model Documentation Report*** **– *Tools > Model Documentation Report***
  - Generates HTML file with model details (can choose which kinds of details to include)

Browsing Through Model 3-1

- **Open `Model 03-01.doe`, Book Examples folder**
  - www.mhhe.com/kelton, Student Edition, **`BookExamples.zip`**, unzip and put folder where you want on your system
- **Three flowchart modules**
  - Create, Process, Dispose
- **Entries in three data modules**
  - Entity, Queue, Resource
- **Animation objects**
  - Resource animation
  - Two plots
  - Some (passive) labels, “art” work

Create Flowchart Module

- **"Birth" node for entities**
- **Gave this instance of Create-type module the Name `Part Arrives to System`**
  - If we had other Create modules (we don't) they'd all have different Names
- **Double-click on module to open property dialog:**



Create Flowchart Module (cont'd.)

- **Name – for module (type it in, overriding default)**
- **Entity Type – enter descriptive name**
  - Can have multiple Entity Types with distinct names
- **Time Between Arrivals area**
  - Specify nature of time separating consecutive arrivals
  - Type – pull-down list, several options
  - Value – depends on Type … for Random (Expo) is mean
  - Units – time units for Value
- **Entities per Arrival – constant, random variable, very general "Expression" (more later …)**
- **Max Arrivals – choke off arrivals (from here) after this many arrivals (batches, not entities)**
- **First Creation – time of first arrival (need not be 0)**

Editing Flowchart Modules in Spreadsheet View

- **Alternative to dialog for each instance of a module type**
- **See all instances of a module type at once**
  - Convenient for seeing, editing many things at once
- **Selecting a module in either flowchart or spreadsheet view also selects it in the other view**
- **Click, double-click fields to view, edit**
- **Right-click in row to Edit via Dialog, define user Data Tip (via Properties)**
- **Right-click in expression fields to get Expression Builder for help in constructing complex expressions with Arena variables (more later …)**

Entity Data Module

- **A data module, so edit in spreadsheet view only**
- **View, edit aspects of different entity Types in your model (we have just one entity Type, `Part`)**
- **Pull-down lists activated as you select fields**
- **Our only edit – Initial Picture for animation**
  - Picked **`Picture.Blue Ball`** from default list
  - Menu option *Edit* > *Entity Pictures ...* to see, modify

Process Flowchart Module

- **Represents machine, including:**
  - Resource
  - Queue
  - Entity delay time (processing)
- **Enter Name – `Drilling Center`**
- **Type – picked `Standard` to define logic here rather than in a submodel (more later …)**
- **Report Statistics check box at bottom**
  - To get utilizations, queue lengths, queue waiting times, etc.

Process Flowchart Module (cont'd.)

- **Logic area – what happens to entities here**
  - Action
    - *Seize Delay Release* – entity Seizes some number of units of a Resource (maybe after a wait in queue), Delay itself there for processing time, then Release units of Resource it had Seized – chose this option
      - *Delay* entity (red traffic light) – no Resources or queueing, just sit here for a time duration
      - *Seize Delay* (no Release … presumably Release downstream)
      - *Delay Release* (if Resource had been Seized upstream)
    - Priority for seizing – lower numbers ⇒ higher priority
    - Different Action choices could allow stringing together several Process modules for modeling flexibility
  - Resources – define Resource(s) to be seized, released
    - Double-click on row to open subdialog
    - Define Resource Name, Quantity of units *to be Seized/Released here*
      - *Not* where you *say* there are multiple Resource units ... do that in Resource *data* module
    - Several Resources present (Add) – entities must first Seize all

Process Flowchart Module (cont'd.)

- **Delay Type – choice of probability distributions, constant or general Expression (more later …)**
- **Units – time units for delay (*don't ignore*)**
- **Allocation – how to "charge" delay in costing (more later …)**
- **Prompts on next line – change depending on choice of Delay Type – specify numerical parameters involved**
- **Can also edit in spreadsheet view**
  - Subdialogs (e.g., Resource here) become secondary spreadsheets that pop up, must be closed

Resource Data Module

- **Defining `Drill Press` Resource in Process module automatically creates entry (row) for it in Resource data module**
- **Can edit it here for more options**
  - Type – could vary capacity Based on Schedule instead of having a Fixed Capacity
    - Would define Schedule in Schedule data module … later
  - Capacity (if Type = Capacity) is number of units of this resource that exist
  - Failures – cause resource to fail according to some pattern
    - Define this pattern via Failure data module (Advanced Process panel) … later

Queue Data Module

- **Specify aspects of queues in model**
  - We only have one, named **`Drilling Center.Queue`** (default name, given Process module name)
- **Type – specifies *queue discipline* or ranking rule**
  - If Lowest or Highest Attribute Value, then another field appears where you specify which attribute to use
- **Shared – if this queue will be shared among several resources (later …)**
- **Report Statistics – check for automatic collection and reporting of queue length, time in queue**

Animating Resources and Queues

- **Got queue animation automatically by specifying a Seize in Process module**
  - Entity pictures (blue balls) line up here in animation
- **Don't get Resource animation automatically**
  - To add it, use Resource button  in Animate toolbar … get Resource Picture Placement dialog
    - Identifier – link to Resource name in pull-down list
    - Specify different pictures for Idle, Busy states

      For pre-defined "art" work, Open a picture library (.plb filename extension)

      Scroll up/down on right, select (single-click) a picture on right, select Idle or Busy state on left, then  to copy picture
  - To edit later, double-click on picture in flowchart view

Dispose Flowchart Module

- **Represents entities leaving model boundaries**
- **Name the module**
- **Decide on Record Entity Statistics (average, maximum time in system of entities exiting here, costing information)**

Check boxes for statistics collection and reporting:

- *Most are checked (turned on) by default*
- *Little or no modeling effort to say yes to these*
- *But in some models can slow execution markedly*
- *Moral – if you have speed problems, clear these if you don't care*

Connecting Flowchart Modules

- **Establish (fixed) sequence of flowchart modules through which entities flow**
- **To make a connection**
  - Connect  (*Object* > *Connect*), cursor becomes cross hairs
  - Click on exit point ▶ from source module, then entry point ■ on destination module
    - Green, red boxes light up to aid in hitting exit, entry points
  - Intermediate clicks for non-straight line in segments
- **To make many connections**
  - After each connection, right-click in blank space, select Repeat Last Action from pop-up menu
  - Or, double-click on  , place multiple connections (no right-click needed), right-click or Esc to end

Connecting Flowchart Modules (cont'd.)

- **Object menu toggles**
  - Auto-Connect – automatically connect entry point of newly placed module from exit point of selected module
  - Smart Connect – force segments to horizontal/vertical
    - Makes for a tidy-looking flowchart, but has the disadvantage that it can cause connection lines to be directly on top of each other, making it impossible to tell them apart
  - Animate Connectors – show entity moves along connectors (zero time for statistics collection), for verification
- **Move entry/exit points relative to their module**
  - Right-click on entry/exit point
  - Select Allow Move from pop-up
  - Drag entry/exit point around

Dynamic Plots

- **Trace variables (e.g., queue lengths) as simulation runs – "data animation"**
- **Disappear after run ends**
  - To keep, save data, postprocess in Output Analyzer ... later
- **Plot button  from Animate toolbar**
  - Six tabs across top; many options (best just to explore)
  - Data Series tab – click Add button for each curve to be plotted on same set of axes
    - In right "Properties" area, enter Name, define Expression

      Pull down Build Expression, "+" Basic Process Variables, "+" Queue, Current Number in Queue, select **`Drilling Center.Queue`** in Queue Name field pull-down, note Current Expression **`NQ(Drilling Center.Queue)`** automatically filled in at bottom, OK button to copy this expression back out
    - DrawMode – Stairs or PointToPoint
    - Line/fill color, vertical-axis on left/right

Note automatic context-sensitive mini Help window on right

Dynamic Plots (cont'd.)

- Axes tab – choose Time (X) Axis on left
  - X axis is always simulated time
  - Scale area on right ("+" to open it) – specify Min/Max, MajorIncrement, AutoScroll ("windows" axis during simulation)
  - Title on right – type in Text (mention units!), set Visible to True
- Axes tab – choose Left Value (Y) Axis on left
  - Note possibility for a different right Y axis scale for multiple curves
  - Scale area on right – specify Min/Max, MajorIncrement, usually leave AutoScaleMaximum at True so Y axis scale will automatically adjust to contain whole plot during run
  - Title on right
- Legend tab – clear Show Legend box since we have only one curve, and Y axis is labeled
- Other tabs – Titles, Areas, 3-D View ... just explore

- **Drop plot in via crosshairs (resize, move later)**

Dressing Things Up

- **Add drawing objects from Draw toolbar**
  - Similar to other drawing, CAD packages
  - Object-oriented drawing tools (layers, etc.), not just a paint tool
- **Add Text to annotate**
  - Control font, size, color, orientation

Setting Run Conditions

- ***Run* > *Setup* menu dialog – seven tabs**
  - Project Parameters – Title, Name, Project Description, stats
  - Replication Parameters
    - Number of Replications
    - Initialization options Between Replications
    - Start Date/Time to associate with start of simulation
    - Warm-up Period (when statistics are cleared)
    - Replication Length (and Time Units)
    - Hours per "Day" (convenience for 16-hour days, etc.)
    - Base Time Units (output measures, internal computations, units where not specified in dialog, e.g. Plot X Axis time units)
    - Terminating Condition (complex stopping rules)
  - Tabs for run speed, run control, reports, array sizes, visuals

Terminating your simulation:
- *You must specify – part of modeling*
- *Arena has no default termination*
- *If you don't specify termination, Arena will usually keep running forever*

Running It

- **Plain-vanilla run: Click ▶ from Standard toolbar (like audio/video players)**
  - First time or after changes: *Check*
  - Enters *run mode* — can move around but not edit
  - Speed up or slow down animation display via slider bar
    - Or tap > on keyboard to speed up, < to slow down
  - When done, asked if you want to see summary reports
  - Click ■ to get out of run mode (*can't edit until you do*)
  - Can *pause* run with ❚❚ or Esc key
- **Other run control, viewing, checking options**

Viewing Reports

- **Click Yes in Arena box at end of run**
  - Opens new reports window (separate from model window) inside Arena window
  - Project Bar shows Reports panel, different reports (each one would be a new window)
  - Remember to close all reports windows before future runs
- **Default installation shows Category Overview report – summarizes many things about run**
  - Reports have “pages” to browse ( and )
  - Also, “table-of-contents” tree at left for quick jumps via 
- **Times are in Base Time Units for model**

Viewing Reports – Examples

- **Entity → Time → Total Time → Part:**
  - Avg. time in system was 6.4397 min., max was 12.6185
- **Resource → Usage → Instantaneous Utilization → Drill Press:**
  - Utilization was 0.9171 (busy 91.71% of the time)
- **Process → Other → Number In → Drilling Center:**
  - During run, 7 parts entered **`Drilling Center`**
- **Process → Other → Number Out → Drilling Center:**
  - 5 entities left **`Drilling Center`** (so were produced)
- **Entity → Time → Wait Time → Part:**
  - Avg. wait time in all queues was 3.0340 min. (counts only entities that left the *system*, but Queue → Time → Waiting Time → Drilling Center.Queue counts all entities that left *this queue*, so these results can differ)
- **Entity → Other → Wip → Part:**
  - Average Work in Process was 1.7060, max WIP was 4

Types of Statistics Reported

- **Many output statistics are one of three types:**
  - *Tally* – avg., max, min of a discrete list of numbers
    - Used for discrete-time output processes like waiting times in queue, total times in system
  - *Time-persistent* – time-average, max, min of a plot of something where *x*-axis is continuous time
    - Used for continuous-time output processes like queue lengths, WIP, server-busy functions (for utilizations)
  - *Counter* – accumulated sums of something, usually just nose counts of how many times something happened
    - Often used to count entities passing through a point in model

More on Reports and their Files

- **Reports we just saw – based on MS Access `.mdb` database that Arena actually writes as it runs**
  - `.mdb` file is saved and can be viewed later
  - Viewing within Arena via SAP Crystal Reports to query Access database, produce reports like Category Overview
- **Arena also produces a plain-text summary report (`.out` filename extension)**
  - Previous versions of Arena, underlying SIMAN language
  - Fairly cryptic, but gives quick view of lots of output data
    - Also contains a few things not in Access/Crystal Reports
  - Multiple reports for multiple replications
- **"Half Width" columns – 95% confidence intervals on outputs in long-run simulations … later**

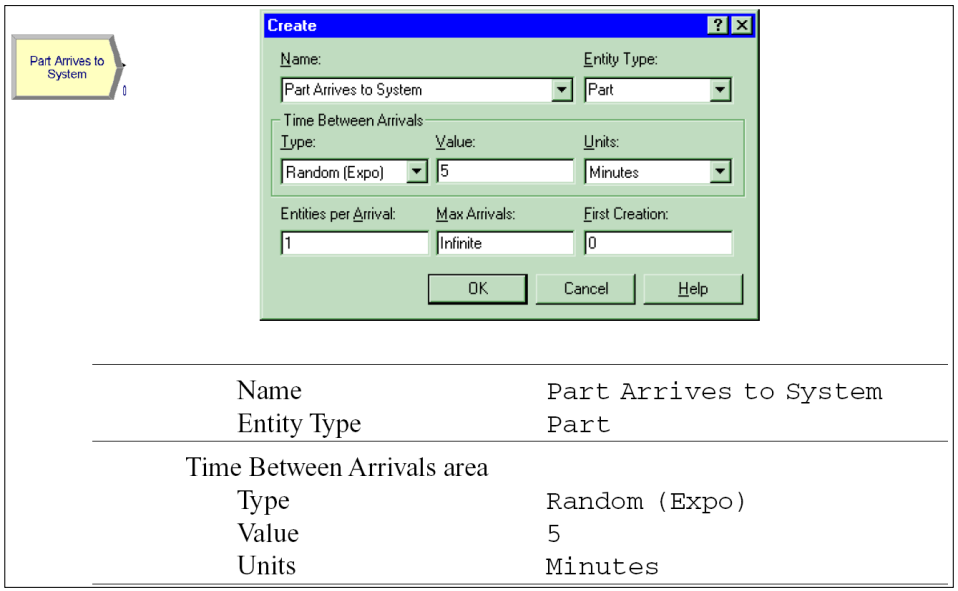
Build It Yourself

- **Build same model from scratch – details in text**
- **Handy user-interface tricks:**
  - Right-click in an empty spot in flowchart view – small box of options, including Repeat Last Action … useful in repetitive editing like placing lots of same module type
  - Ctrl+D or Ins key – duplicates whatever's selected in flowchart view, offsetting it a bit … drag elsewhere, edit
- **Open new (blank) model window – name it, save it, maybe maximize it**
- **Attach modeling panels you'll need to Project Bar if not there**

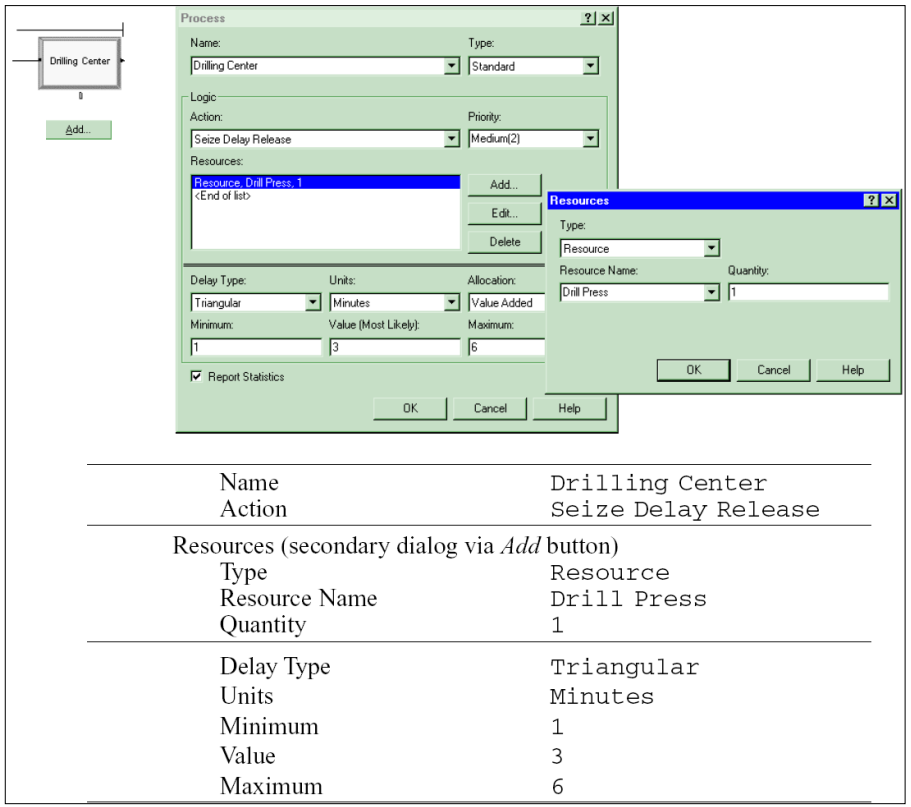
Build It Yourself (cont'd.)

- **Place, connect flowchart modules**
- **Edit flowchart, data modules as needed**
  - Experiment with Expression Builder – right-click in expression field
- **Add plots, animation, artwork**
- **Add named views (? key or *View* > *Named Views* or ), with hot key (case-sensitive)**
- **Edit *Run* > *Setup* dialog**
- **"Displays" in text**
  - Compact way of saying what needs to be done in a dialog
  - Omits Arena defaults
  - Shows completed dialogs, table of actions needed

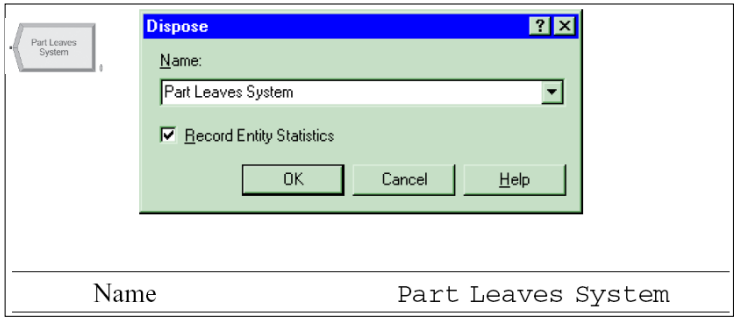
"Displays" for Create, Process, Dispose Modules



Name	Part Arrives to System
Entity Type	Part
Time Between Arrivals area	
Type	Random (Expo)
Value	5
Units	Minutes

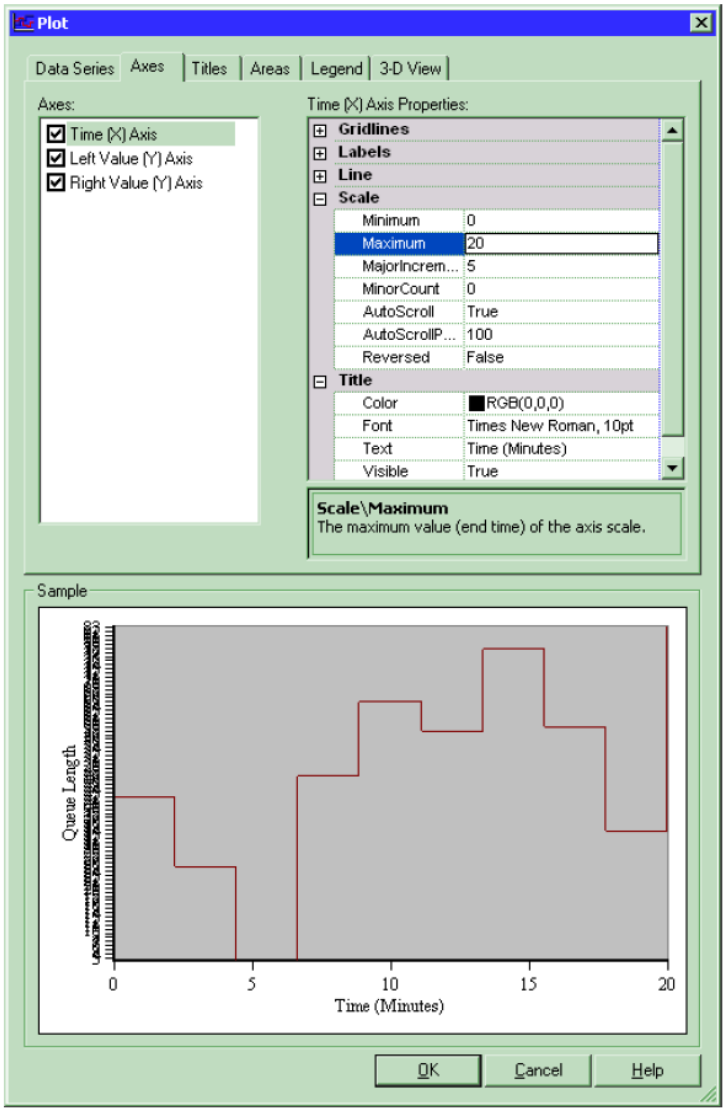


Name	Drilling Center
Action	Seize Delay Release
Resources (secondary dialog via *Add* button)	
Type	Resource
Resource Name	Drill Press
Quantity	1
Delay Type	Triangular
Units	Minutes
Minimum	1
Value	3
Maximum	6



Name	Part Leaves System

“Display” for Queue-Length Plot



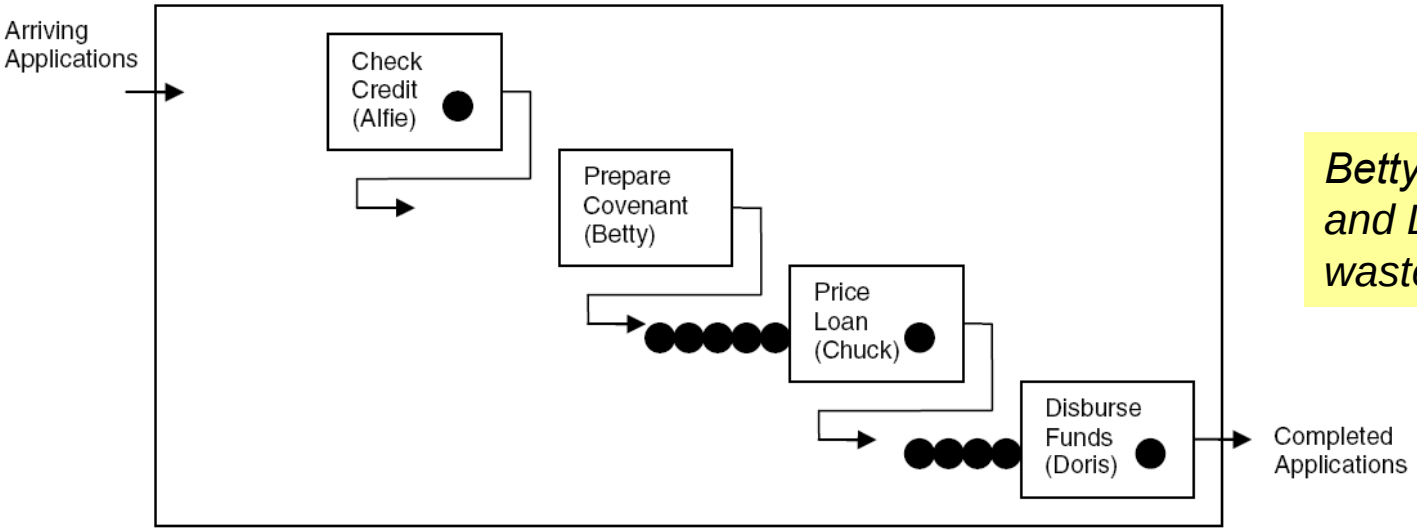
Data Series tab	
Add button	*click*
Series1 Properties > Source Data > Name	`Queue Length` (changes Series1 Properties above to `Queue Length Properties`)
Queue Length Properties:	
Source Data > Expression	`NQ(Drilling Center.Queue)` (or use Expression Builder)
Line > DrawMode	`Stairs` (select from pull-down)
Axes tab	
Axes > Time (X) Axis	*click* (on text to highlight, leave the box checked)
Time (X) Axis Properties:	
Scale > Maximum	`20`
Scale > MajorIncrement	`5`
Title > Text	`Time (Minutes)`
Title > Visible	`True` (select from pull-down)
Axes > Left Value (Y) Axis	*click* (on text to highlight, leave the box checked)
Left Value (Y) Axis Properties:	
Scale > MajorIncrement	`1`
Title > Text	`Queue Length`
Title > Visible	`True` (select from pull-down)
Legend tab	
Show Legend check box	*clear* (uncheck)

Axes tab showing here ...
Figure 3-14 in book shows Data Series tab

Case Study: Specialized Serial vs. Generalized Parallel Processing

- **Loan applications go through four steps**
  - Check credit, prepare covenant, price loan, disburse funds
  - Each step takes expo (1 hour)
  - Applications arrive with expo (1.25 hour) interarrival times
    - First application arrives at time 0
  - Run for 160 hours
  - Watch avg, max no. applications in process (WIP); avg, max total time in system of applications
  - Four employees, each can do any process step
- **Serial specialized processing or generalized parallel processing?**
  - What's the effect of service-time variability on decision?

Case Study: Model 3-2, Specialized Serial Processing



Betty's now idle but Chuck and Doris are overloaded – wasted capacity?

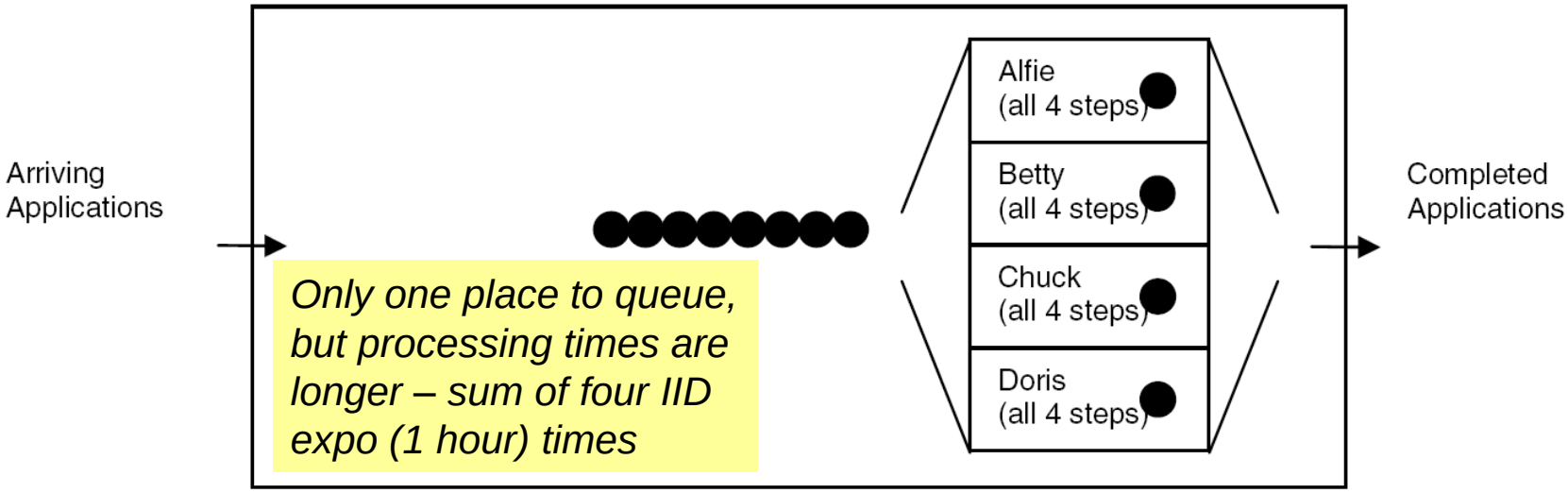
- **File `Model 03-02.doe`**
- **Create module – similar to Model 3-1 except expo mean, time units**
  - Set Entity Type to **`Application`**

All files in book: www.mhhe.com/kelton, Student Edition, **`BookExamples.zip`**

Case Study: Model 3-2, Specialized Serial Processing (cont'd.)

- **Four Process modules – similar to Model 3-1**
  - Four separate Resources
  - Expo process time: Expression (via Expression Builder)
- **Dispose module similar to Model 3-1**
- **Default entity picture (report) is OK**
- **Default Resource animations almost OK**
  - Make Idle picture same as Busy
  - Select correct Resource name in Identifier field
- **Queue, Resource data modules OK**
- **Plot WIP – use Expression builder to find `EntitiesWIP(Application)`**
  - Fixed Y axis max = 25 to compare with next three models
- **Fill in *Run* > *Setup*, lengthen queue animations**

Case Study: Model 3-3, Generalized Parallel Processing



- **File `Model 03-03.doe`**
- **Create, Dispose, plot, *Run* > *Setup* almost same**
  - Just change some labels, etc.

Case Study: Model 3-3, Generalized Parallel Processing (cont'd.)

- **Replace four earlier Process modules with just a single Process module**
  - One Resource (**`Loan Officer`**), but four units of it
  - Still set Quantity to 1 since application just needs 1 officer
  - Delay type – Expression

    `EXPO(1) + EXPO(1) + EXPO(1) + EXPO(1)`
    - Why not **`4*EXPO(1)`**?
- **Modify Resource Animation for four units**
  - Open Model 3-2 Resource Animation to get Resource Picture Placement window, open Idle picture
  - Duplicate white square three times, realign; copy to Busy
  - In model window, double-click Seize Area, then Add three
  - Still not completely accurate animation (order) – need Sets

Case Study: Compare Model 3-2 vs. 3-3

Model	Total WIP		Total Time in System		Total Waiting Time		Number Processed	Avg. Utilization
	Avg.	Max.	Avg.	Max.	Avg.	Max.		
3-2 (serial)	12.39	21	16.08	27.21	11.98	22.27	117	0.78
3-3 (parallel)	4.61	10	5.38	13.73	1.33	6.82	135	0.87

- ***Caution*: This is from only one replication of each configuration, so there's output variability**
  - Are differences statistically significant? (Exercise 6-19)

Case Study: Effect of Task-Time Variability

- **Is parallel always better than serial under any conditions?**
  - Many aspects could matter
  - Focus on task-time variability
- **Now, each task time ~ expo (1 hour)**
  - Highly variable distribution

    P(task time < 10 minutes) = 0.15
    P(task time > 2 hours) = 0.14
    } *See text*
  - In serial config., just one large task time congests greatly
    - In parallel config. it would also congest, but probably not by as much since other three tasks are probably not all large too
- **Other extreme – each task time is *exactly* 1 hour**
  - Leave interarrival times as expo (1.25 hours)
  - Models 3-4 (serial), 3-5 (parallel) – alter Process modules

Case Study: Effect of Task-Time Variability (cont'd.)

	Model	Total WIP		Total Time in System		Total Waiting Time		Number Processed	Avg. Utilization
		Avg.	Max.	Avg.	Max.	Avg.	Max.		
Expo service	3-2 (serial)	12.39	21	16.08	27.21	11.98	22.27	117	0.78
	3-3 (parallel)	4.61	10	5.38	13.73	1.33	6.82	135	0.87
Constant service	3-4 (serial)	3.49	12	5.32	11.38	1.32	7.38	102	0.65
	3-5 (parallel)	3.17	11	4.81	10.05	0.81	6.05	102	0.66

- **For constant service, parallel improvement appears minor**
  - Maybe not even statistically significant (Exercise 6-19)
- **Some further questions**
  - In parallel, work is integrated/generalized, so would it be slower per task? (Exercises 3-13, 6-20)
  - Effect of worker breaks? (Chapters 4, 5)
  - Differences statistically significant? (Exercises 6-19, 6-20)

More on Menus – File Menu

- Model-file management
- Template attach/detach
- DXF import (from CAD packages), Visio import
- Color palettes
- Printing
- Send (e-mail) open model file
- Recent models
- Exit from Arena

Edit Menu

- Undo/Redo
- Cut/Copy/Paste
- Paste Link (create OLE link)
- Duplicate, Delete selection
- Select/Deselect All
- Entity Pictures – change content, definition of pictures presented in Entity data module
- Find – searches all modules, animation objects for a text string … useful for finding wrong names, typos after an error message from Arena

Edit Menu (cont'd.)

- Replace – replaces all instances of a text string with another text string
- Properties – display internal Arena object properties
- Links – to link to other files (spreadsheets, sounds, etc.)
- Insert New Object/Control – from other applications (e.g., graphics, VBA, ActiveX)
- Object – edit object imported from another application

View Menu

- **Zooming – discussed before**
  - Zoom Factor – step size when zooming
- **Views – canned Arena views of flowchart view**
- **Named Views – define, change, use views**
- **Rulers, Grid, Guides, Snap, Glue – align objects**
  - Page breaks – shows page breaks if printed
- **Data Tips – toggles display of Data Tips**
- **Connector Arrows – show entity-flow direction**
- **Layers – which objects show up in which mode**

View Menu (cont'd.)

- Split Screen – if checked, shows both flowchart, spreadsheet views
- Runtime Elements Bar – if checked, displays window allowing choice of what is displayed during execution
- Toolbars – decide which toolbars show up
- Project/Status Bar – toggle to show up or not
- Debug Bar – if checked, displays window of debugging tools during run

Tools Menu

- **Arena NewsFlash – internet feed for updates, etc.**
- **Arena Symbol Factory – make animation symbols**
- **Separate applications for modeling, analysis**
  - Input Analyzer – fit probability distributions for input, using field-collected data … more in Chapt. 4
  - Process Analyzer – run, compare many "scenarios" at once … more in Chapt. 6
    - Also Output Analyzer … not on menus ... start from Start menu
  - Visual Designer for 3D animation, etc.
  - Expression Builder – very useful tool (described earlier)
- **ReportDatabase – export results to CSV file**
- **Model Documentation Report – generate HTML file with many details of this model**

Tools Menu (cont'd.)

- Import/Export model to/from Database – bring in, save model details to Excel or Access
- OptQuest for Arena – separate application that "takes over" running of model to search for an optimal scenario … more in Chapt. 6
- AVI Capture – record actions (editing, animation) to .avi file for playback
- Macro – create Visual Basic macros (mini programs), VB editor ... more in Chapter 10
- Module count – reports module instances
- Options – control many aspects of how Arena works, looks

Arrange Menu

- For modeling, graphics objects – first select object(s)
- Bring object to Front, Send to Back – “stacking”
- Group, Ungroup objects (move together, etc.)
- Flip around Vertical, Horizontal line
- Rotate object (90° clockwise)
- Align objects on top, bottom, left, or right edges
- Distribute objects evenly (horizontally, vertically)
- Flowchart Alignment – arrange flowchart modules (horizontally, vertically)
- Snap Object to Grid – for selected object(s)
- Change Object Snap Point on snapped object

Object Menu

- **Connect tool – changes cursor to cross hairs**
  - Hit twice for repeated connections, right-click or Esc to exit
- **Auto-Connect new module to selected module**
- **Smart Connect – new connections in horizontal/vertical segments only**
- **Animate Connectors – show entities moving (at infinite speed for statistics collection)**
- **Animate At Desktop Color Depth – use desktop color depth (could slow run)**
  - If not checked, color is 8-bit (256 colors), runs faster
- **Submodel – define, manage hierarchical submodels, useful for large, complex models**

Run Menu

- Setup – control model run conditions
- Entries to run, check, pause, step through
- Alternatives to watch execution, view results (or errors)
- Control how run goes and is displayed
- Most capabilities on Run Interaction Toolbar – details later
- Access “code” in underlying SIMAN simulation language

Window Menu

- **Cascade, Tile multiple open model windows**
- **Arrange Icons for any minimized model windows**
- **Use system Background Color – use Windows colors rather than Arena settings**
- **List of open model windows**

Help Menu

- One of several ways to get into Help system
- Arena Help – TOC, Index, Search
- What's This? – adds ? to cursor, then click on things for brief description
- Release notes – recent changes, requirements
- Arena Smart Files – subject-based index to many small but complete models that illustrate specific modeling techniques (*very* useful)
- List of attached modeling panels – select to get Help on that one

Help Menu (cont'd.)

- Arena Product Manuals – detailed PDF reference documents on Arena components
- Activation – for licensing
- Copy protection information for commercial, research, and lab versions
- About Arena... – version number, licensing information, etc.

More on Toolbars

- **Collections of buttons for "frequent" operations**
  - Most are duplication of menu entries
  - Standard, Draw, Animate, Integration, View, Arrange, Run Interaction, Record Macro, AVI Capture, Animate Transfer, Dialog Design, Project/Status/Debug Bars
- ***View* > *Toolbars* (or right-click in a toolbar area) to decide which ones show up, which to hide**
- **Toolbars can be torn off ("floating" palettes), or "docked" to an edge of screen**
- **Arena remembers Toolbars for next time**
- ***View* > *Toolbars* > *Customize* to alter how toolbars and buttons are displayed**
- **See text for run-through description of toolbars and buttons (or, just experiment)**

More on Drawing

- Draw via toolbar buttons only (no menus):

- Line, Polyline (Shift for 45°), Arc, Bézier Curve
- Box, Polygon, Ellipse (fill, line, shade)
- Text (font, size, style)
- Colors for Lines, Fill, Text, Window Background
- Line Width, Style, Arrow Style, Pattern
- Show Dimensions – shows sizes, lengths for precise drawing
- Best way to learn: play around on scratch model

Printing

- **Print all or parts of flowchart view of active model window – supports color**
- **Usual Print, Print Preview, Print Setup (File menu)**
- **Could consume many pages … also prints named views separately**
  - Print Preview, select only what you want for printing
- ***View > Page Breaks* to show how pages will break**
- **Alternative to printing from Arena: Windows Snipping Tool or PrintScreen key – sends screen to clipboard, paste into another application**
  - Alt+PrintScreen – sends only active window to clipboard
  - Could first pass through a paint application to crop, etc.

Help!

- **Extensive, comprehensive online system – including complete (electronic) manuals**
- **Interlinked via hypertext for cross referencing**
- **Multiple entry points, including Help menu (described above), links to websites**
-  **button for context-sensitive help**
  - Click it, then click what you're curious about
- 

button in most dialogs
-  **button (What's This?) in dialogs for info on things in that dialog**

Help! (cont'd.)

- **Tooltips – roll over something, get sticky note**
- **SMART library – small models illustrating points – subject index via *Help > Arena Smart Files***
  - See the Help entry for location of files on your system
    - Typical location on Windows 7:
      `C:\Users\Public\Public Documents\Rockwell Software\Arena\Smarts`
- **Online Help –**
  http://www.rockwellautomation.com/support
- **Examples folder – several detailed, complete examples, some fairly complex**
  - Typical location on Windows 7:
    `C:\Users\Public\Public Documents\Rockwell Software\Arena\Examples`

More on Running Models

- **Run Menu; Standard & Run Interaction toolbars**
- ***Run > Setup* – many options to control run**
  - These are attached to model, and are not global
- ***Run > Go***  **– run simulation "normally" (depends on selections from *Run > Run Control* and *Tools > Options > Run Control*)**
- ***Run > Step***  **– one "step" at a time (verify, debug)**
- ***Run > Fast-Forward***  **– disable animation (faster)**
- ***Run > Pause***  **(or Esc key) – freeze run, resume with Go**
- ***Run > Start Over***  **– go back to beginning of simulation**

More on Running Models (cont'd.)

- *Run > End* – get out of run mode
- *Run > Check Model* – like compiling
- *Run > Review Errors* – for most recent Check
- *Run > Run Control > Command* – bring up interactive command-line window to control run
- *Run > Run Control > Breakpoints* – set times, conditions to interrupt for checks, illustration
- *Run > Run Control > Watch* – bring up a window to watch a variable or expression during run

More on Running Models (cont'd.)

- *Run > Run Control > Break on Module*  – set/clear break when an entity enters or resumes activity on a module
- *Run > Run Control > Highlight Active Module* – highlight flowchart module being executed
- *Run > Run Control > Batch Run (No Animation)* – run model with no animation … this is even faster than Fast-Forward … usually used for "production runs" for statistical analysis
- *Run > SIMAN* – view or write model (.mod) and experiment (.exp) files for underlying SIMAN model