Optimization Using SimRunner

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Agenda – Optimization w/ Simulation

- Scenario Manager "Best Solution"
- What is SimRunner? When to use it.
- Setting up optimization project (ProModel,MedModel)
 - Objective Function
 - Input parameters
 - Analyzing Results
- Process Simulator & SimRunner
- Example projects using SimRunner



Optimization

Finding the <u>best solution</u> for a System (model) given some <u>constraints</u> (inputs) driving toward a <u>Goal</u> (objective function)





Perhaps We Could Do It Ourselves

- Finding the Right Solution....
 - Design of Experiments DOE
 - Scenarios
 - Manually create the alternatives
- Run the model with selected Scenarios
- Have we found all the viable solutions?
- Have we found the BEST solution?



Scenarios to Find "Best" Solution

- Example model:
 - Raw stock→Rough piece→Finished gear→Inspection
- Want to maximize profit
- Can change: <u>Qty Operators</u> <u>Batch Size</u> <u>Use Robot or Not</u>



- Profit =
 - Value of product * Qty Produced
 - Cost of raw material
 - Cost of Labor
 - Cost of Robot



• Run Scenarios...

Sc	enario Manager											×
#	Parameters	Baseline	Model Parameters	1 operator, batch 1	1 operator, batch 50	5 operators, batch 1	5 operators, batch 50	5 operators, batch 25	1 operator, batch 25	With robot, 5 oper, batch 25	Without robot,	5 oper, batch
	Simulate Scenario?	~	✓	\checkmark	\checkmark	\checkmark	\checkmark	✓	v	✓		✓
	Last Simulation Run		7/12/2017 4:15:57 PM	7/12/2017 4:15:59	7/12/2017 4:16:00 PM	7/12/2017 4:16:05 PM	7/12/2017 4:16:08 PM	7/12/2017 4:16:10 PM	7/12/2017 4:16:12 PM	7/12/2017 4:16:15 PM	7/12/2017 4:16:	18 PM
*	Number_operators	5.	5	1	1	5	5	5	1	5	5	
*	Batch_size	50	10	1	50	1	50	25	25	25	25	
*	Value_of_each_gear	50	15.55	15.55	15.55	15.55	15.55	15.55	15.55	50	50	
*	Hourly_rate_operator	15	15	15	15	15	15	15	15	15	15	
*	mUse_Robot_Y1_N0	1	1	1	1	1	1	1	1	1	0	
*	mDaily_cost_of_Robot	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	
*	mAnimation_speed	55	100	100	100	100	100	100	100	100	100	
•												•
										Run Scenarios	ОК	Cancel



- Output Results...
 Choose the best.
- But have we built a scenario for the really best solution?





- How many Scenarios are possible?
 - Parameters choices * Parameters choices = BIG!!!
- For example:
 - Between 1 & 5 operators
 - Batch size between 1 & 50
 - Use a robot or not (2 choices)
 - Therefore: (5)*(50)*(2) = 500 Scenarios!!!
 Do you want to create 500 scenarios to find the right solution?
- Tip... Use <u>ProActiveX.xlsb</u> to rapidly create the scenarios
- BUT... How about letting SimRunner do the DOE (<u>Design of Experiments</u>) for you? And SimRunner will discard poor solutions!



SimRunner

• What it is...



- Built-in tool in ProModel & MedModel
- Automated DOE to find "optimal" system configuration
- When to use it...
 - Want to play with certain key system controls to:
 - Maximize throughput; Minimize WIP; Maximize utilization of key bottleneck machine; Minimize delays; Min/Max whatever

Poll # 2



Special Concerns

- This is pseudo-optimization, not pure optimization (like linear programming)
 Find the <u>best solution</u> among all <u>possible combinations</u>
- Must have valid objective function.
- Don't want too many con' Is the model built correctly?
- Must have model that's been V&V'd

Validation: Does the model meet the benchmark correct results?



- Process Simulator (PCS) does not have SimRunner
- However... PCS creates a .MOD file (PM/MM model)
- Therefore, after the PCS model has been V&V'd:
 - Use PM/MM w/ SimRunner!
 - >>> MUST have Promodel/MedModel to use SimRunner
- SimRunner needs Changeable Scenario MACROs
 - So, if PCS model has Scenario Parameters not Macros, must change over to Macros prior to creating .MOD



Steps for Using SimRunner

- Create simulation model
 - Scenario Parameter macros
 - Output metrics
- Open Simrunner (Simulation / SimRunner)
- Define Objective Function
- Define Input Factors
- Define Optimization control parameters
- Run Optimization
- Examine results ... We have a winner!!!



SimRunner Three Main Parts





Set Up Project





Select Model/Project



Select Model Name (if starting new Project) or Project Name (if previously created)



What is an Objective Function?

- GOAL!!
- Desired Minimize or Maximize of item(s)
- Equation that calculates desired metric
 - Example: v_Profit = v_Revenue v_Cost
 - Example: v_WIP = (CONTENTS(x)+CONTENTS(y)+...)



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Define Objectives



Define Objective Function

- Choose Item
 - For this model: v_Profit Current Value (current value = At the End of the Run)
- Choose:
 - <u>Max</u>imize or <u>Min</u>imize
 - Target Range, if any
 - Weight
- If you change something, don't forget to press the <u>Update</u> button

e <u>Options</u> <u>H</u> elp	Analyze Model	Optimize Model	
Select model/project	Performance Measures		
Define inputs	Response category Response state Location Vincome_from, Vincome_	tistic completed_gears - Maximum Value completed_gears - Current Value completed_gears - Average Value hanges e Time/Change m Value w Value Value Value Value	^
	Response statistics selected for objective function Variable Max 1:00 * vProfit - Current Value	× × a	





Objective Function - Statistical "Weight"

- For Example... Want to:
 - Maximize Throughput
 - Measure: Total Exits (big number)
 - Minimize WIP
 - Measure: Average Contents of Queue (medium size number)
 - Minimize Labor
 - Measure: Number of Units of Resource (small number)

These are dissimilar metrics with different ranges



Objective Function - Statistical "Weight"

- Identify ranges of each metric
 - Calculate averages
- Calculate relative contribution based on numeric value
 - Inverse... Adjustment for size of values
- Determine Importance of each metric (scale = 1 10)
 - Calculate the Relative Importance base upon the Maximum
- Calculate Weight Factor
 - = Adj for Value * Relative Importance

r	[(1		
		Min		Max	Avg Value Polative	Adjustment for Value	Importance	Polativo	Weighting
				IVIAX	Avg value relative	Adjustment for value	importance	Relative	weighting
Min/Max Items	Measurement	Value	<u>Avg Value</u>	Value	Contribution to Total	Size (1 / Contribution)	<u>(1-10)</u>	Importance	Factor
Maximize Throughput	Gear Total Exits	500	1750	3000	0.874	1.14	10	1.00	1.14
Minimize WIP	Q MC Average Contents	1	251	500	0.125	8.00	5	0.50	4.00
Minimize Labor	Units of Machinist	1	2.5	5	0.001	801.20	7	0.70	560.84
			=====		=====	=====	=====		=====
	Totals:		2003		1.000	810.34	22.00		565.98



Objective Function • OR...

Always calculate the Goal in terms of **\$\$\$**





Poll #3

Define Inputs

ProModel Better Decisions—Easter

 The Changeable Parameter to use for creating Scenarios must be <u>numeric Scenario Macros</u>

ProModel - simsamp v2.mod			- 🗆 ×
File Edit View Build Simulation Output Tools W	indow Help		
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🍪 🥌 🔺 🗞 🧐 🖵			
Macros	_		[1] 🗆 🗆 🖂
ID		Text	Options
Number_operators	5.		Scenario Parameter 🔨
Batch_size	50	Parameter definition for Number operators	Scenario Parameter
Value_of_each_gear	50		Scenario Parameter
Hourly_rate_operator	15	Parameter Name: Number operators	Scenario rameter
mUse_Robot_Y1_N0	1		Scenario Parameter
mDaily_cost_of_Robot	1000	Prompt Enter the number of operators	Scenario Parameter
mAnimation_speed	55		Scenario Parameter
Transfer1to2	.1		None
Transfer2to3	.1	OUnrestricted Text	None
Transfer3to4	.1	Record Range	None
Transfer4to5	.1	Numeric Bange	None
Transfer5to6	.1		None
Transfer6to7	.1	From To 5	None 🗸
	i 🏭 i ouws	OK Cancel Help	

Define Inputs



SimRunner Project

- Save the Project
 - Creates a .OPT file

	9	SimRunner - simsamp v2.0	opt
	<u>F</u> ile	<u>O</u> ptions <u>H</u> elp	
New Open Model Open Project	Ctrl+N Ctrl+M Ctrl+O	Setup Project	
Save	Ctrl+S		
Save As Export Optimization Data	\searrow	Select model/project	– Macros Av
1 simsamp v2.opt		Define objecti∨es	Value_of_e
2 simsamp w target.opt 3 simsamp v2.mod		Define inputs	mDaily_co
4 Iraq trucks.opt			
5 logsa_15 exceldbimport.mod			1
Exit			
			-Macros Se
			Number_o Batch_size



Analyze the Model

- Helps determ
 - Number of rep
 - Warmup peric
- However...
 - ~30 Reps usua
 - You'll know if Warm-up is appresented





Run the Optimization - Settings

- Profile
 - Cautious, (more runs) Moderate, Aggressive (less runs)
 - Convergence %
- No Animation
- # of Replications
- Warmup/Run Time
- Confidence Level

1 Setup Project	Analyze Model Optimize Model	
Set options Seek optimum Response plot	Optimization options Optimization Profile: Convergence Percentage: 0.010000 Simulation options Disable animation: Varm-up time: Warm-up time: Run time: 8 Confidence level: 95	



Run the Optimization

- Run...
 - Results for each run...
 "Performance Plot"
 Green Each run
 Red Best so far
 - Table of Results
- When finished...
 "Optimization Converged"



- Best solution is at the top
 - For our example:
 \$18,300 profit for the day
 - 5 Operators Batch size: 4 or 7 Yes, Use the Robot

		Optin	nization Converged		
Experiment	Objective Function	vProfit: Current Value	Number_operators	Batch_size	mUse_Robot_Y1_N0
85	18300.000	18300.000	5.000	4.000	1.000
103	18300.000	18300.000	5.000	7.000	1.000
96	18250.000	18250.000	5.000	8.000	1.000
99	18200.000	18200.000	5.000	6.000	1.000
58	18200.000	18200.000	5.000	5.000	1.000
106	18200.000	18200.000	5.000	9.000	1.000
110	18200.000	18200.000	5.090	10.000	1.000
90	18050 000	18050 000	5 000	3 000	1 000



- But more can be gleaned...
 - What if someone doesn't show up for work (4 Operators instead of 5): Profit of only \$17,260
 Experiment Objective Function VProfit: Current Value 85 18300.000

		Optin	nization Converged		
Experiment	Objective Function	vProfit: Current Value	Number_operators	Batch_size	mUse_Robot_Y1_N0
85	18300.000	18300.000	5.000	4.000	1.000
103	18300.000	18300.000	5.000	7.000	1.000
96	18250.000	18250.000	5.000	8.000	1.000
99	18200.000	18200.000	5.000	6.000	1.000
58	18200.000	18200.000	5.000	5.000	1.000
106	18200.000	18200.000	5.000	9.000	1.000
110	18200.000	18200.000	5.000	10.000	1.000
90	18050.000	18050.000	5.000	3.000	1.000
79	17300.000	17300.000	5.000	14.000	1.000
105	17260.000	17260.000	4.000	9.000	1.000
24	17250.000	17250.000	5.000	13.000	1.000
93	17250.000	17250.000	5.000	15.000	1.000
95	17250.000	17250.000	5.000	12.000	1.000
88	17250.000	17250.000	5.000	11.000	1.000



- Regarding the Batch Size...
 - How sensitive is the Profit?
 Not very (\$250/day), for sizes 3,4,5,6,7,8,9,10
 - What if there are "standard" containers? Then don't fill every hole

		Optin	nization Converged		
Experiment	Objective Function	vProfit: Current Value	Number_operators	Batch_size	mUse_Robot_Y1_N0
85	18300.000	18300.000	5.000	4.000	1.000
103	18300.000	18300.000	5.000	7.000	1.000
96	18250.000	18250.000	5.000	8.000	1.000
99	18200.000	18200.000	5.000	6.000	1.000
58	18200.000	18200.000	5.000	5.000	1.000
106	18200.000	18200.000	5.000	9.000	1.000
110	18200.000	18200.000	5.000	10.000	1.000
90	18050.000	18050.000	5.000	3.000	1.000
79	17300.000	17300.000	5.000	14.000	1.000



- Regarding the Robot...
 - What's it's worth?
 - \$13,600 \$18,300 = -\$4,700 day loss without

		Optin	nization Converged		
Experiment	Objective Function	vProfit: Current Value	Number_operators	Batch_size	mUse_Robot_Y1_N0
81	14200.000	14200.000	5.000	47.000	1.000
9	14200.000	14200.000	5.000	50.000	1.000
89	14150.000	14150.000	5.000	42.000	1.000
23	13910.000	13910.000	4.000	50.000	1.000
6	13600.000	13600.000	5.000	13.000	0.000
111	13260.000	13260.000	4.000	2.000	1.000
50	13050.000	13050.000	5.000	11.000	0.000
34	13000.000	13000.000	5.000	28.000	0.000
63	12800.000	12800.000	5.000	37.000	0.000
28	12750.000	12750.000	5.000	6.000	0.000
21	12600.000	12600.000	5.000	1.000	1.000
74	11650.000	11650.000	5.000	3.000	0.000
7	11170.000	11170.000	3.000	13.000	1.000
14	11070.000	11070.000	3.000	26.000	1.000



- How about if we don't use Profit?
 - Max Throughput, Min WIP, Min Labor w/ Weights

1 Setup Projec	đ				Analyza	e Model			Optimize Moo
Set options									
Saak optimum	Click the run but	tton to start the optimization							
Office optimism	Bun	Performance Plot	Final Report						
Response plot	- Con	- chomanee - lot							
	Convergence	Status	ſ						Date 2
	Generation:7								Experiment 126
						Optimization Conve	erged		
									Performance Measures Plot -
	Experiment	Objective Function	Q_MC: Average Contents	Machinist: Units	Gear: Total Exits	Number_operators	Batch_size	mUse_Robot_Y1_N0	
	104	1120.562	2.460	4.000	2960.000	4.000	16.000	1.000	
	118	1103.416	4.466	4.000	2952.000	4.000	18.000	1.000	
	65	1095.518	2.451	4.000	2938.000	4.000	26.000	1.000	
	97	1094.506	7.549	4.000	2955.000	4.000	15.000	1.000	2-221 2-557
	82	1092.489	15.178	4.000	2980.000	4.000	10.000	1.000	12 -892
	94	1091.254	8.076	4.000	2954.000	4.000	14.000	1.000	8-1228 V V W W
	114	1082.485	7.704	4.000	2945.000	4.000	19.000	1.000	-1899-
	1.1.4			1000	2925.000	4.000	25.000	1.000	-2234-
	80	1081.557	2.236	4.000	C2C21000				
	80 87	1081.557 1079.904	2.236 3.789	4.000	2929.000	4.000	29.000	1.000	- 9 17 23 24 5 5 5 6 5 7 3 8 1 6 7 9 7 1 6 7 1 1 6 7 1 1 6 7 1 1 1 1
	80 87 86	1081.557 1079.904 1079.659	2.236 3.789 3.565	4.000 4.000 4.000	2929.000 2928.000	4.000	29.000	1.000	- • 5 6 2 4 6 2 6 2 8 8 9 6 Experiments - ObjFunct -

Best Solution: 4 Operators, Batch Size = 16, Use Robot Different Analysis... Different Results



Brief Pause...

Let's take 5!





- Run PCS model... Creates .MOD for PM/MM
- Example: Manufacturing Cell.vsd





- Create Macro m_Lathe_capacity
 - Apply it to Lathe Activity Capacity
- Create Macro m_Number_Workers
 - Apply it to Number of Units of the Worker

Model Elements			
Variables (7) Attributes	(1) Resource Groups	Macros (2)	Subroutin
Name	Туре	Value	
1 m_Lathe_capacity	Number	1	
2 m_Number_of_Worke	rs Number	1	
*			





- Run the PCS model to create the .MOD file
- Open the .MOD with ProModel
 - Make each Model Parameter as Scenario Macros

Macros		[3]	- • ×
ID		Text	Options
_@_PCS_@_	PCS		Scenario Par ^
m_Lathe_capacity	1	Parameter definition for m_Number_of_Workers	Scenario Par
m_Number_of_Workers	1	Parameter Name: m_ <u>Number_of_Workers</u> Prompt	Scenario Par ✓
		O Record Range	
		Numeric Range	
		From 1 To 3	
		OK Cancel Help	



The model is now ready to apply SimRunner

🗊 SimRunner - Untitled*		- 🗆	\times
ile <u>O</u> ptions <u>H</u> elp			
1 Setup Project	Analyze Model	Optimize Model	
Select model/project	Macros Available for Input		_
Define inputs			
	× &		
	Macros Selected as Input Factors m_Lathe_capacity: Default = 1.00, Lower = 1, Upper = 3 m_Number_of_Workers : Default = 1.00, Lower = 1, Upper = 3		
	Macro properties Default Lower Data Type Default Bound Integer C Real 1	Upper Bound 3	
	< Previous	Next >	



Example Projects

- Call Center
- Steel tube manufacturing
- Army Iraq drawdown







Call Center

- Objective: Minimize <u>Qty of Agents &</u> <u>Abandoned Calls &</u> <u>Call Wait Time</u>
- Weight factors...
 80; 1; 50 (derived from experimentation & system knowledge)

Setup Project Image: Carponal statistic Optimize Model Select model/project Performance Measures Response statistic Define objectives Image: Carponal statistic Vagregate_CW_Count- Current Value Define inputs Image: Carponal statistic Vagregate_CW_Count- Average Value Vagregate_Current/Value Vagregate_CW_Mean - Total Changes Vagregate_Current/Value Vagregate_CW_Mean - Average Value Vagregate_Current/Value Vagregate_CW_Mean - Average Value Vagregate_Current/Value Vagregate_CW_Mean - Musimum Value Vagregate_Current/Value Vagregate_CW_Mean - Average Value Vagregate_Current/Value Vagregate_Current/Value Variable-Min: 50.00 * vTotal_Apents - Maximum Value Variable-Min: 50	SimRunner - Untitled*			- 🗆 ×
Select model/project Define objectives Define inputs Performance Measures Response category Response category Single-Cap Location Multi-Cap Location Multi-Cap Location Multi-Cap Location Vaggregate_CW_Mean - Varage Time/Change VAggregate_CW_Mean - Varage Time/Change VAggregate_CW_Mean - Maximum Value Variable	1 Setup Project	Analyze	Model	Optimize Model
Response statistics selected for objective function Variable: Min: 80.00 * vTotal_Agents - Maximum Value Variable: Min: 1.00 * vTotal_Abandoned_Calls - Maximum Value Variable: Min: 50.00 * vAggregate_CW_Mean - Maximum Value @ Update Objective for response statistic © Max Min © Target Range to Weight 50	Select model/project	Performance Measures Response category Location Single-Cap Location Multi-Cap Location Entity Resource Variable Entity Costing Location Costing Resource Costing	Response statistic vAggregate_CW_Count - Current Value vAggregate_CW_Count - Average Vall vAggregate_CW_Mean - Total Change vAggregate_CW_Mean - Average Tim vAggregate_CW_Mean - Maximum Vall vAggregate_CW_Mean - Current Value vAggregate_CW_Mean - Average Value vAggregate_CW_Mean - Average Value <	a ue 35 le/Change ue ue ue
		Response statistics selected for Variable:Min: 80.00 * vTotal_Age Variable:Min: 1.00 * vTotal_Abar Variable:Min: 50.00 * vAggregat Objective for response statistic— C Max Min C Target	objective function ents - Maximum Value idoned_Calls - Maximum Value e_CW_Mean - Maximum Value	Weight 50



Call Center SimRunner - Untitled*

Input factors:
 Qty Agents
 on each Shift

1 Setup Project	Analyze Model	Optimize Model
elect model/project Define objectives Define inputs	Macros Available for Input mStart_AMI_Shutoff: Default = 9.00, Lower = 7, Upper = 19 mEnd_AMI_Shutoff: Default = 16.00, Lower = 9, Upper = 19 m&MI_Bouty Limit: Default = 0.00, Dower = 10, Lipper = 250	^
	m7_30_to_4.30_CSR3: Default = 1.00, Lower = 0, Upper = 5 m/linquiry_Factor: Default = 1.00, Lower = 0, Upper = 5 mlnquiry_Factor: Default = 10.00, Lower = 0, Upper = 10 mShift_Factor_2: Default = 10.00, Lower = 0, Upper = 10 mShift_Factor_3: Default = 10.00, Lower = 0, Upper = 10	
	Macros Selected as Input Factors	
	mMWThF7_6: Default = 0.00, Lower = 0, Upper = 5 mMTWF7_5_Th_7_11: Default = 1.00, Lower = 0, Upper = 5 mMTWF7_5_Th_1_5: Default = 1.00, Lower = 0, Upper = 5 mMTWF8_6_Th_9_13: Default = 1.00, Lower = 0, Upper = 5 m9_30_to_6_30: Default = 1.00, Lower = 0, Upper = 5 mMF_plus_5: Default = 2.00, Lower = 0, Upper = 5	~
	Macro properties Default Lower Upper □ Data Type Default Lower Upper Image: Image	



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Call Center

593 experiments run...
 Answer: 27-28 Agents

Key findings...

27-28 Agents, not the best objective function value, but they minimized abandoned calls & average call waiting, while maintaining an acceptable number of agents

Decreasing from 28 to 27 agents **increases** the call wait time from 1.01 to 1.38 minutes (37% increase) ... Acceptable ?!





_Ab; ^

 <u>Objective</u>: Determine
 <u>viable</u> Oven Times
 to Maximize Throughput

Setup Project	t 🖉 Analyze Model 🏠 Optimize Model	
elect model/project	Performance Measures	
Define objectives	Response category Response statistic	
Define inputs	Location Single-Cap Location Multi-Cap Location Entity Resource Variable Entity Costing Location Costing Resource Costing Variable	~
	Response statistics selected for objective function	
	Variable:Max: 1.00 * v_Qty_Stators_completed - Current Value	
	☆ Update	
	Objective for response statistic	



<u>Input factor</u>:
 Oven duration time



mRunner - Steel tube Over Options Help	is.opt	- 🗆 X
1 Setup Project	Analyze Model	Optimize Model
Select model/project Define objectives Define inputs	Macros Available for Input <u>m_Scenario_number</u> : Default = 4.00, Lower = 0, Upper = 999 <u>m_Scenario_for_Crane_EnDisable</u> : Default = 1.00, Lower = 1, <u>m_Running_24_5or6or7</u> : Default = 5.00, Lower = 5, Upper = 7 <u>m_Default_crane_movement_time_MIN</u> : Default = 0.00, Lower <u>m_SprayRig_Changeover_Qty</u> : Default = 30.00, Lower = 1, Up <u><</u> <u>Macros Selected as Input Factors</u> <u>m_Core_and_Tube_oven_time_MIN</u> : Default = 45.00, Lower	. Upper = 100 er = 0, Upper = 99 pper = 9999 > >
	Macro properties Default Data Type Default C Integer € Real	Lower Upper Bound Bound 1.00 90.00
		Previous Next>



- 107 experiments run...
 Answer: Oven time 60-80 min.
 - Best possible: 145/week, but <u>infeasible</u> for oven time <u>too small</u>
 - Currently 90 min. oven time; 136 units/week
 - Therefore, strive for **feasible improvement** for oven time to 60-80 min. ... 142-143 / week



Use engineering judgement on the results

Experiment	Objective	Function v_Qty_	_Stators_completed: Current Value	m_Core_and_Tube_oven_time_MIN	^	Experiment	Objective Func	ction v_Qty_Stators_completed	Current Value	m_Core_an	d_Tube_oven_time_MIN	^
4	145.000	145.00	00	13.968		54	143.000	143.000		64.437		
7	145.000	145.00	00	4.520		55	143.000	143.000		40.904		
22	145.000	145.00	00	5.822		56	143.000	143.000		43.238		
				14.912		17	142,000	142.000		32.101		
l Ir	nfea	sihle	Solutions	1.741		41	Fea	sible Solu	tions	51.436		
	inca	SIDIC	Joiutions	2.456	-	1	I Ca	SIDIC JOIU	cions	43.465		-
57	145.000	145.00	00	4.475	_	19	143.000	143.000		51.696		
59	145.000	145.00	00	1.000	_	12	143.000	143.000		34.667		
60	145.000	145.00	00	Strive for i	mn	r 0 1 / 0 1	mont			32.024		
63	145.000	145.00	00	Strive for i	mp	over	nent			56.243		43
65	145.000	145.00	00 C		-	$c \circ$				52.510		
69	145.000	145.00	00 T C	or oven tim	e	60-0	80 m	In		40.509		
72	145.000	145.00			4 7			a aluca a al		42.646		
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75	145.000	145.00	00							58.271		
76	145.000	145.00	00	4.952	_	15	143.000	143.000		54.349		
77	145.000	145.00	00	14.854	-	70	143.000	143.000		25.920		
78	145.000	145.00	00	6.018	-	43	142.000	142.000		79.670		
80	145.000	145.00	00	12.035	-	26	142.000	142.000		74.429		1
82	145.000	145.00	00	2.446	_	27	142.000	142.000		59.044		~
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Objective:
 Want to minimize
 <u>LATENESS</u> of
 closing down
 storage facilities

SimRunner - Iraq trucks.opt	- 🗆 X
File Options Help	Analyze Model
Select model/project	Performance Measures Response category Response statistic
Define inputs	Location Single-Cap Location Multi-Cap Location Entity Resource Variable Entity Costing Location Costing Resource Costing
	Response statistics selected for objective function Image: Contract of the selected for objective function Variable:Min: 1.00 * v_Agregate_ATHP_ASP_Lateness - Current Value
	Objective for response statistic Max C Min C Target Range to Weight 1
	< Previous Next >



Input factors: Qty PLS trucks (palletized loa Qty ISO trucks (standard inte Qty SP trucks (special purp

<u>Options</u> <u>H</u> elp		
1 Setup Project	C Analyze Model Analyze Model	nize Model
Select model/project	Macros Available for Input	
Define inputs		
	Macros Selected as Input Factors <u>m_Qty_ISO_trucks : Default = 10.00, Lower = 1, Upper = 100</u> m_Qty_PLS_trucks : Default = 10.00, Lower = 1, Upper = 100 m_Qty_S_P_trucks : Default = 10.00, Lower = 1, Upper = 100	
	Macro properties Default Lower Data Type Default Bound ● Integer C Real 10.00 1	Upper Bound 100
	Z Provious	Next



166 experiments run...
 Answer:

9 PLS trucks 32-34 ISO trucks 60-70 SP trucks

Setup Project			☐ Analyze Model			A Optimize Mo	del
tions							
ntimum	Click the run but	ton to start the optimization					
	Run	Performance Plot	Final Report				
se plot			<u></u>				
	Phase 1:	Status			Phase	e 2:	
	Experiment	Objective Function	v_Agregate_ATHP_ASP_Lateness: Current Value	m_Qty_ISO_trucks	m_Qty_PLS_trucks	m_Qty_S_P_trucks	
	Experiment 79	Objective Function -494.000	v_Agregate_ATHP_ASP_Lateness: Current Value 494.000	m_Qty_ISO_trucks 34.000	m_Qty_PLS_trucks	m_Qty_S_P_trucks 65.000	
	Experiment 79 117	Objective Function -494.000 -494.000	v_Agregate_ATHP_ASP_Lateness: Current Value 494.000 494.000	m_Qty_ISO_trucks 34.000 32.000	m_Qty_PLS_trucks 9.000 9.000	m_Qty_S_P_trucks 65.000 63.000	
	Experiment 79 117 136	Objective Function -494.000 -494.000 -494.000	v_Agregate_ATHP_ASP_Lateness: Current Value 494.000 494.000 494.000	m_Qty_JSO_trucks 34.000 32.000 34.000	m_Qty_PLS_trucks 9.000 9.000 9.000	m_Qty_S_P_trucks 65.000 63.000 60.000	
	Experiment 79 117 136 137	Objective Function -494.000 -494.000 -494.000 -494.000	v_Agregate_ATHP_ASP_Lateness: Current Value 494.000 494.000 494.000 494.000	m_Qty_JSO_trucks 34.000 32.000 34.000 32.000	m_Qty_PLS_trucks 9.000 9.000 9.000 9.000 9.000	m_Qty_S_P_trucks 65.000 63.000 60.000 62.000	
	Experiment 79 117 136 137 147	Objective Function -494.000 -494.000 -494.000 -494.000 -494.000 -494.000	v_Agregate_ATHP_ASP_Lateness: Current Value 494.000 494.000 494.000 494.000 494.000	m_Qty_JSO_trucks 34.000 32.000 34.000 32.000 33.000	m_Qty_PLS_trucks 9.000 9.000 9.000 9.000 9.000 9.000	m_Qty_S_P_trucks 65.000 63.000 60.000 62.000 63.000	
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- Thought!... Why not have unlimited Qty of trucks to Minimize the Lateness of facility closure?
- Because... We don't have unlimited Qty of trucks!
- Therefore... Choose the best solution within realistic constraints



Run just 9/34/65 scenario...

- Utilization of trucks is LOW
- But when they're needed, THEY'RE NEEDED!
- Plot Qty trucks needed over time...
 Heavy PLS usage early







Questions ??

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