



上海财经大学  
SHANGHAI UNIVERSITY OF FINANCE AND ECONOMICS



# 智能素养与计算社会科学方法论

## 社会科学中的仿真计算方法

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## 3-4 创建仿真模型



# 课程目标

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- (1) 熟练掌握Arena基本操作面板中的流程模块和数据模块，学会用模块建立实际系统模型。
- (2) 掌握对模型运行结果的分析方法，看懂Arena运行结果报告。
- (3) 了解对实际问题的分析过程。通过运行仿真模型，了解该生产线运行状况（生产周期、设备利用率、等待加工时间、生产能力等）。
- (4) 能够根据模型运行报告，分析该生产线存在的问题，针对该生产线的管理提出改进建议。



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- 背景描述
- 建立模型
- 运行模型
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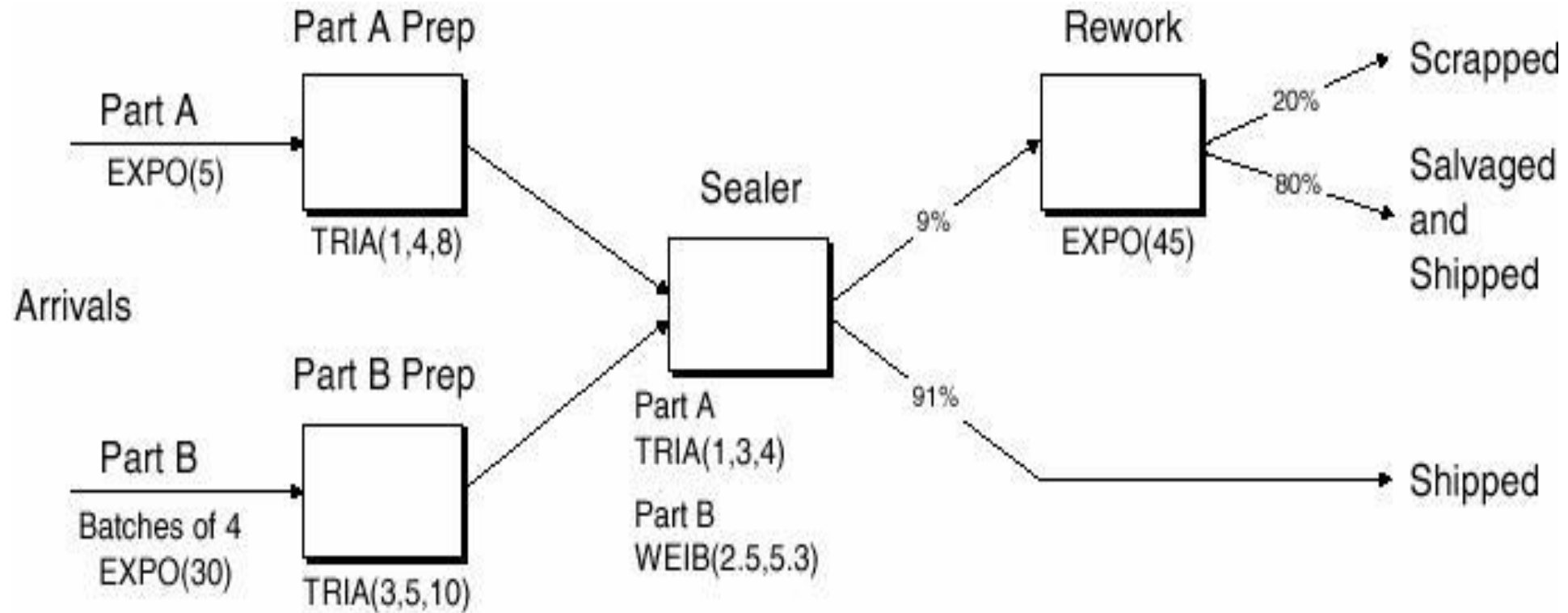
# 背景描述

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- 该场景描述的是两种需要封装的电子产品的最后一道工序，到达产品需进行预处理，然后再装配。流程如下：
  - 分别制造两个电子元件A，B；
  - 制造过程包括预处理和装配两个操作；
  - Sealer步骤完成后进行检测，然后根据检测结果来判断是Rework还是Shipping；
  - Rework过程包括Salvage且Shipping或者是Scrapped。



# 模型数据



电子装配与测试系统流程图



# 运行条件及输出要求

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- 开始启动为Empty&Idle，运行4个8小时/班
- 对于每个工作区，统计
  - Resource Utilization
  - Number in Queue
  - Time in Queue
- 对于每个退出点(Shipped, Salvaged, Scrapped)，统计系统中总停留时间(cycle time)。
- 统计每个退出点的产品数量



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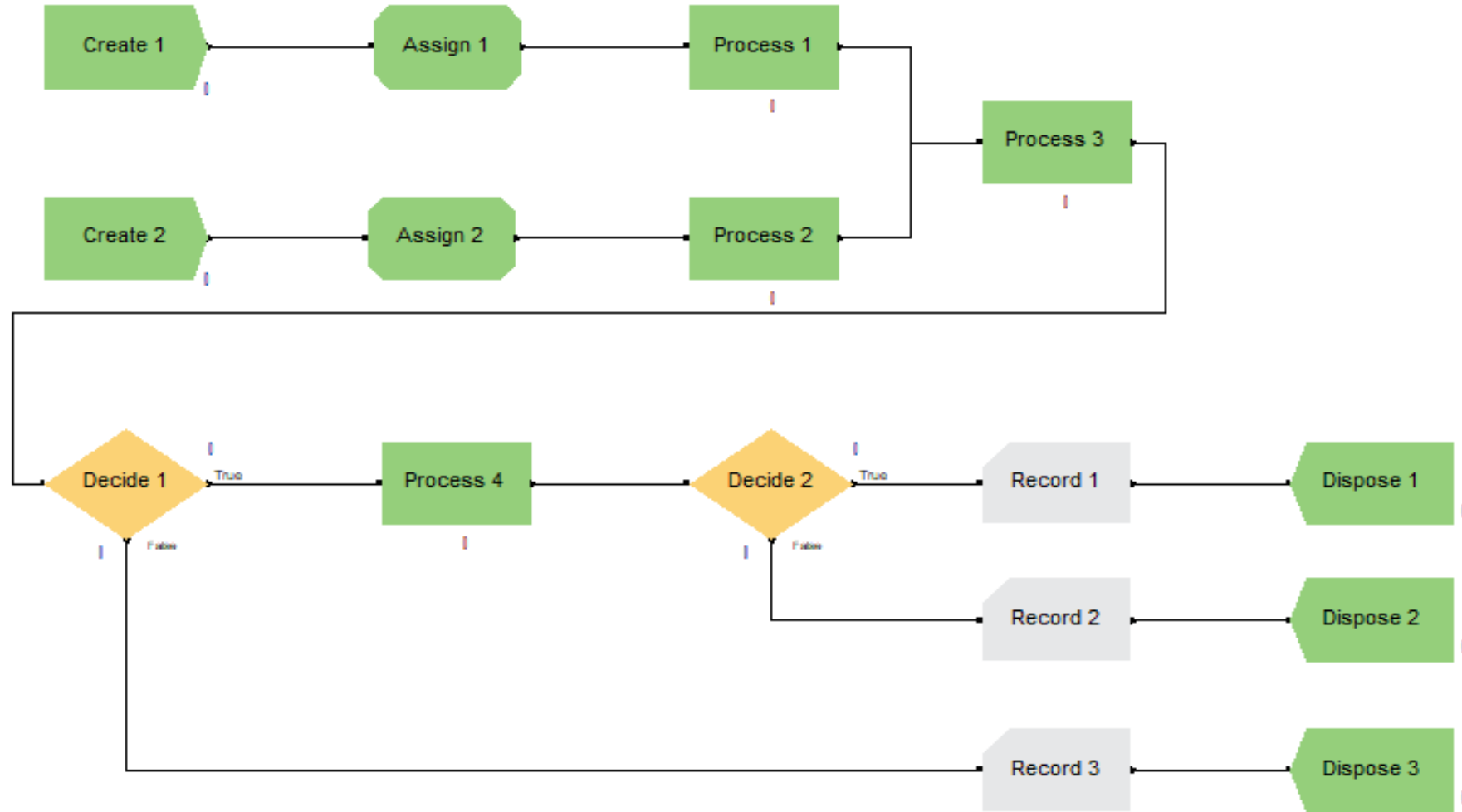
# 建立模型

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- ❑ 分析 “系统、系统边界、实体、资源” 等系统要素
- ❑ 从Arena软件Project Bar找到相应模块构建模型
- ❑ 通过数据模块为模型赋数据
- ❑ 为模型设置运行条件
- ❑ 运行模型



# 建立电子组装测试系统流程图





# 为Create 模块赋值

Create ? X

Name: Entity Type:

Part A Arrive Part A

Time Between Arrivals

Type: Value: Units:

Random (Expo) 5 Minutes

Entities per Arrival: Max Arrivals: First Creation:

1 Infinite 0.0

Comment:

OK Cancel Help

Create ? X

Name: Entity Type:

Part B Arrive Part B

Time Between Arrivals

Type: Value: Units:

Random (Expo) 30 Minutes

Entities per Arrival: Max Arrivals: First Creation:

4 Infinite 0.0

Comment:

OK Cancel Help



# 为Process模块赋值

Process

Name: Prep A Process Type: Standard

Logic

Action: Seize Delay Release Priority: Medium(2)

Resources:

Resource, Prep A, 1	Add...
<End of list>	Edit...
	Delete

Delay Type: Triangular Units: Minutes Allocation: Value Added

Minimum: 1	Value (Most: 4	Maximum: 8
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☒ Report Statistics

Comment:

OK Cancel Help

A的预处理过程

Resources

Type: Resource

Resource Name: Prep A Units to Seize/Release: 1

OK Cancel Help

添加A的预处理过程占用资源

Process

Name: Prep B Process Type: Standard

Logic

Action: Seize Delay Release Priority: Medium(2)

Resources:

Resource, Prep B, 1	Add...
<End of list>	Edit...
	Delete

Delay Type: Triangular Units: Minutes Allocation: Value Added

Minimum: 3	Value (Most: 5	Maximum: 10
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☒ Report Statistics

Comment:

OK Cancel Help

B的预处理过程

Resources

Type: Resource

Resource Name: Prep B Units to Seize/Release: 1

OK Cancel Help

添加B的预处理过程占用资源



# 封装操作的处理

Process

Name: Sealer Process Type: Standard

Logic

Action: Seize Delay Release Priority: Medium(2)

Resources:

Resource, Sealer, 1  
<End of list>

Add...  
Edit...  
Delete

Delay Type: Expression Units: Minutes Allocation: Value Added

Expression: Sealer Time

☒ Report Statistics

Comment:

OK Cancel Help

Resources

Type: Resource

Resource Name: Sealer Units to Seize/Release: 1

OK Cancel Help



# 返工操作的处理过程

Process

Name: Rework Process Type: Standard

Logic

Action: Seize Delay Release Priority: Medium(2)

Resources:

Resource, Rework, 1  
<End of list>

Add...  
Edit...  
Delete

Delay Type: Expression Units: Minutes Allocation: Value Added

Expression: EXPO(45)

☒ Report Statistics

Comment:

OK Cancel Help

Resources

Type: Resource

Resource Name: Rework Units to Seize/Release: 1

OK Cancel Help



# 合格品与返工品的决策

Decide ? X

Name: Type:

Failed Sealer Inspection 2-way by Chance

Percent True (0-100):

9 %

Comment:

OK Cancel Help

Decide ? X

Name: Type:

Failed Rework Inspection 2-way by Chance

Percent True (0-100):

20 %

Comment:

OK Cancel Help



# 利用Assign模块为产品A的流程定义新属性

对Part A/Part B Attributes Assign模块进行参数修改，令其满足在Sealer模块中不同的处理时间Sealer/Arrive Time，如同对每个零件做简单的标签和描述

**Assign** ? X

Name:  
Assign Part A Sealer and Arrive Time

Assignments:

Attribute, Sealer Time, TRIA(1,3,4)
Attribute, Arrive Time, TNOW
<End of list>

Add... Edit... Delete

Comment:

OK Cancel Help

**Assignments** ? X

Type: Attribute Attribute Name: Sealer Time

New Value: TRIA(1,3,4)

OK Cancel Help

**Assignments** ? X

Type: Attribute Attribute Name: Arrive Time

New Value: TNOW

OK Cancel Help





# 利用Assign模块为产品B的流程定义新属性

Assign

Name:  
Assign Part B Sealer and Arrive Time

Assignments:

Attribute, Sealer Time, WEIB(2.5,5.3)	Add... Edit... Delete
Attribute, Arrive Time, TNOW	
<End of list>	

Comment:

OK Cancel Help

Assignments

Type: Attribute Attribute Name: Sealer Time

New Value: WEIB(2.5,5.3)

OK Cancel Help

Assignments

Type: Attribute Attribute Name: Arrive Time

New Value: TNOW

OK Cancel Help



## 利用Record模块记录实体在系统内的停留时间

Record

Name:  
Record Scrapped Parts

Statistic Definitions:  
Time Interval, Arrive Time, No, Record Scrapped Parts  
<End of list>

Add...  
Edit...  
Delete

Comment:

OK Cancel Help

Statistic Definition

Type:  
Time Interval

Type NOTE: Records the difference between the current simulation time

Attribute Name:  
Arrive Time

☐ Record into Set

Tally Name:  
Record Scrapped Parts

OK Cancel Help

Record

Name:  
Record Salvaged Parts

Statistic Definitions:  
Time Interval, Arrive Time, No, Record Salvaged Parts  
<End of list>

Add...  
Edit...  
Delete

Comment:

OK Cancel Help

Statistic Definition

Type:  
Time Interval

Type NOTE: Records the difference between the current simulation time

Attribute Name:  
Arrive Time

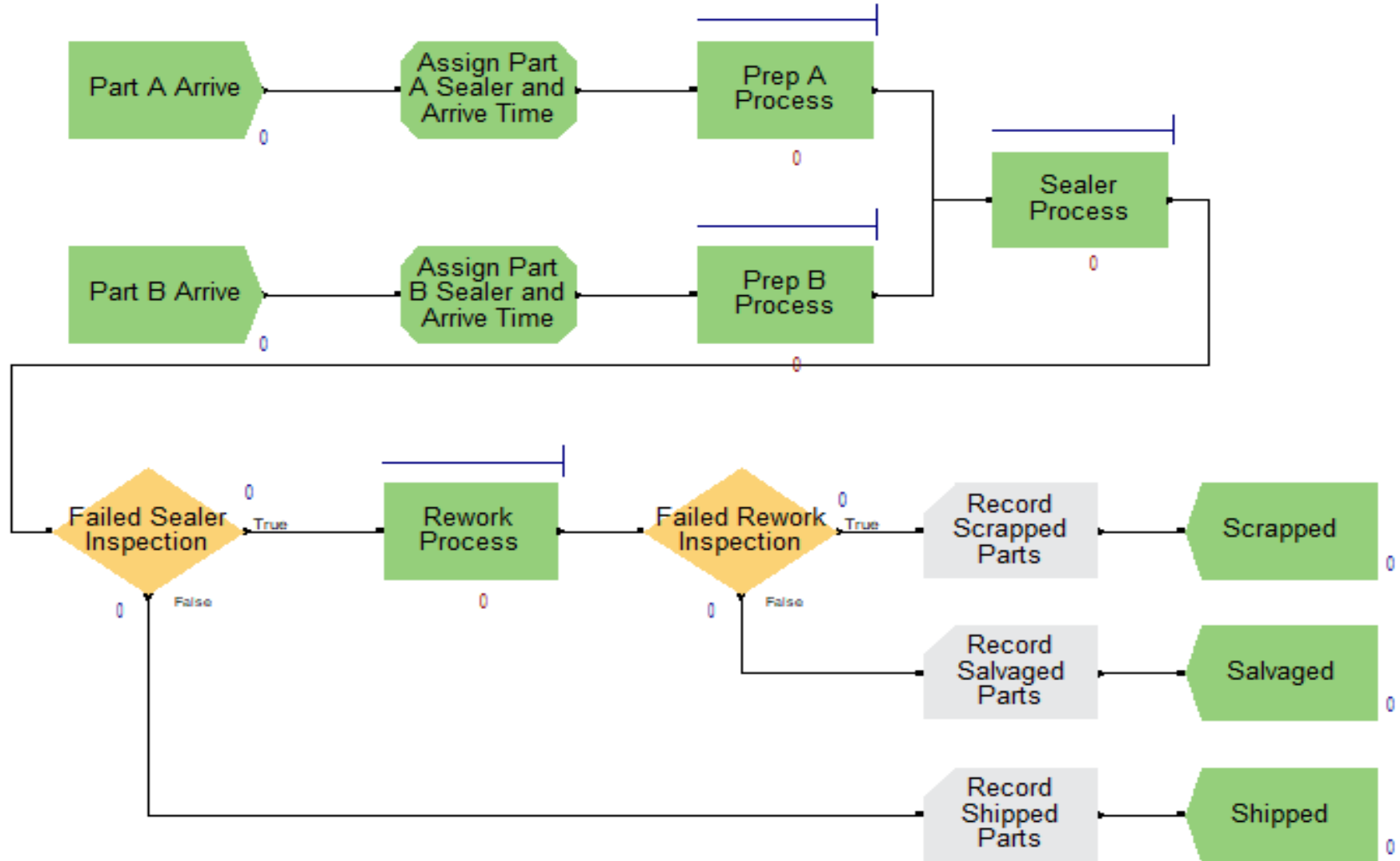
☐ Record into Set

Tally Name:  
Record Salvaged Parts

OK Cancel Help



# 电子组装与检测系统仿真模型





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# 运行仿真模型

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- ❑ 运行方式：如同Media player一样：
  - 在运行之前先进行Check Model;
  - 然后可以开始Run;
  - 可以进行Speed up(>键)或Speed down(<键);
  - 结束后，系统会提示是否要查看报告;
  - 点击stop按钮，才能退出run模式，否则无法对模型进行修改;
  - 可以在运行过程中pause



# 运行条件设置

Run Setup

Run Speed

Run Control

Reports

Project Parameters

Replication Parameters

Array Sizes

Arena Visual Designer

Establish the project settings for the current model. Settings include the project title and analyst name to be displayed on reports, as well as types of statistics may be collected.

Project Information

Project

Electronic Assembly and Test

Analyst Name:

Rockwell Automation

Project

The first version of the electronic assembly and test model,as described in Section 4.1.

Statistics Collection

☐ Costing

☒ Queues

☐ Transporters

☐ Tanks

☐ Entities

☒ Processes

☐ Conveyors

☒ Resources

☐ Stations

☐ Activity Areas

确定

取消

应用(A)

项目信息设置

Run Setup

Run Speed

Run Control

Reports

Project Parameters

Replication Parameters

Array Sizes

Arena Visual Designer

Establish replication-related options for the current model. Settings include the number of simulation replications to be performed, the start date and time of the simulation, warm-up time length, time units, and the type of initialization to be used.

Replication Parameters

Number of

1

Start Date and Time:

2024年10月18日 11:02:23

Warm-up Period:

0.0

Hours

Replication Length:

32

Hours

Hours Per Day:

24

Terminating

Base Time Units:

Minutes

Parallel Replications

☐ Run Replications in Parallel

☐ Disable Parallel Replications Status Dialog

Number of Parallel

16

Parallel Replication Input Data Files:

Data File

Add

确定

取消

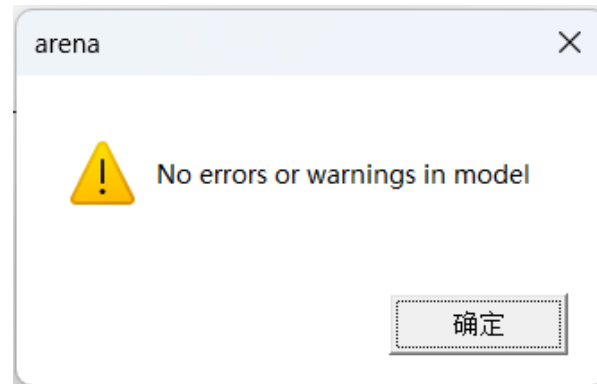
运行条件设置



## 增加模型的动画效果

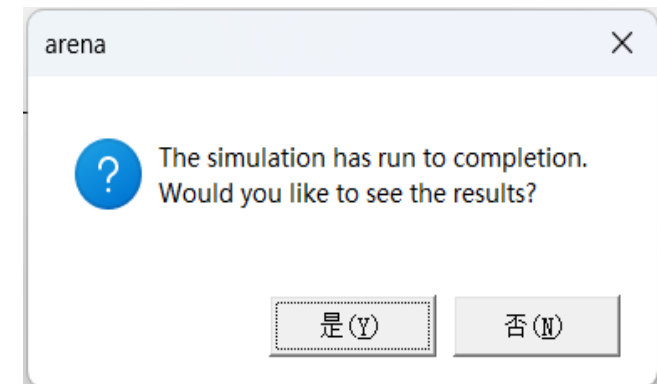
	Entity Type	Initial Picture
1 ▶	Part A ▼	Picture.Blue Ball
2	Part B	Picture.Red Ball

## 模型检验



ERROR:  
Unconnected exit point

## 运行模型





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# 观察结果

## (1) 各工作区域的资源利用率

Name	Type	Source	Average Of Replication Averages
Prep A	Instantaneous Utilization	Resource	0.878815701
	Number Busy	Resource	0.878815701
	Number Scheduled	Resource	1
Prep B	Instantaneous Utilization	Resource	0.647251796
	Number Busy	Resource	0.647251796
	Number Scheduled	Resource	1
Rework	Instantaneous Utilization	Resource	0.857936345
	Number Busy	Resource	1.329420117
	Number Scheduled	Resource	1.5
Sealer	Instantaneous Utilization	Resource	0.775294358
	Number Busy	Resource	0.775294358
	Number Scheduled	Resource	1

## 各工作区域的队长（单位：个）

Name	Type	Source	Average Of Replication Averages
Prep A Process.Queue	Number Waiting	Queue	2.64540515
Prep B Process.Queue	Number Waiting	Queue	3.766376584
Rework Process.Queue	Number Waiting	Queue	4.340004409
Sealer Process.Queue	Number Waiting	Queue	0.850000395

## 各工作区域的排队时间（单位：分钟）

Name	Type	Source	Average Of Replication Averages
Prep A Process.Queue	Waiting Time	Queue	12.63477087
Prep B Process.Queue	Waiting Time	Queue	35.49886194
Rework Process.Queue	Waiting Time	Queue	150.4218898
Sealer Process.Queue	Waiting Time	Queue	2.71413317

## 产品在各区域的系统停留时间（单位：分钟）

Name	Type	Source	Average Of Replication Averages
Prep A Process	Total Time Per Entity	Process	16.83209959
Prep B Process	Total Time Per Entity	Process	41.73689233
Rework Process	Total Time Per Entity	Process	201.5891812
Sealer Process	Total Time Per Entity	Process	5.193354452



# 分析系统的运行情况

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- 查看各资源负荷是否均衡
- 是否存在排队时间过长的工序、是否存在资源利用率较低或太高的工序？
- 瓶颈工序是哪里？
- 产品的加工周期是多长？
- 给出你的系统改善建议。

谢谢!

Thank you

