

# Air Education and Training Command

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*Replenishing the Combat Capability of America's Air Force*

## Modeling the U.S. Military Intelligence Process



**U.S. AIR FORCE**

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ICCRTS

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*Integrity - Service - Excellence*



# Overview



- Problem Statement
- Background Information
  - Prior Work
  - Intelligence Cycle
- Intelligence Process Model
- Validation and Verification
- Analysis/Case Studies
- Conclusions



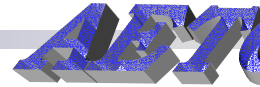
# Problem Statement



- Research sponsor needs
  - Assess Tasking, Processing, Exploitation, Dissemination (TPED) and/or Tasking, Processing, Posting, Using (TPPU) processes
  - Support current and future Intelligence, Surveillance, and Reconnaissance (ISR) operations
- Develop high-level model of generalized national or military intelligence process
- Focus on basic framework for intelligence process analysis



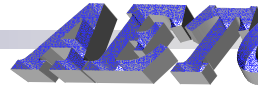
# Prior Work



- **ISR-TPED**
  - Analytical simulation
  - Rigid TPED structure
  - Single detailed radar sensor model
- **COSMOS (C4ISR Space and Missile Ops Simulation)**
  - Highly detailed
  - Multiple engineering level sensor models
- **QUICM (Quick ISR Conops Modeler)**
  - High level model with multiple sources
  - TPED or TPPU but not both
  - Nearest to required capability

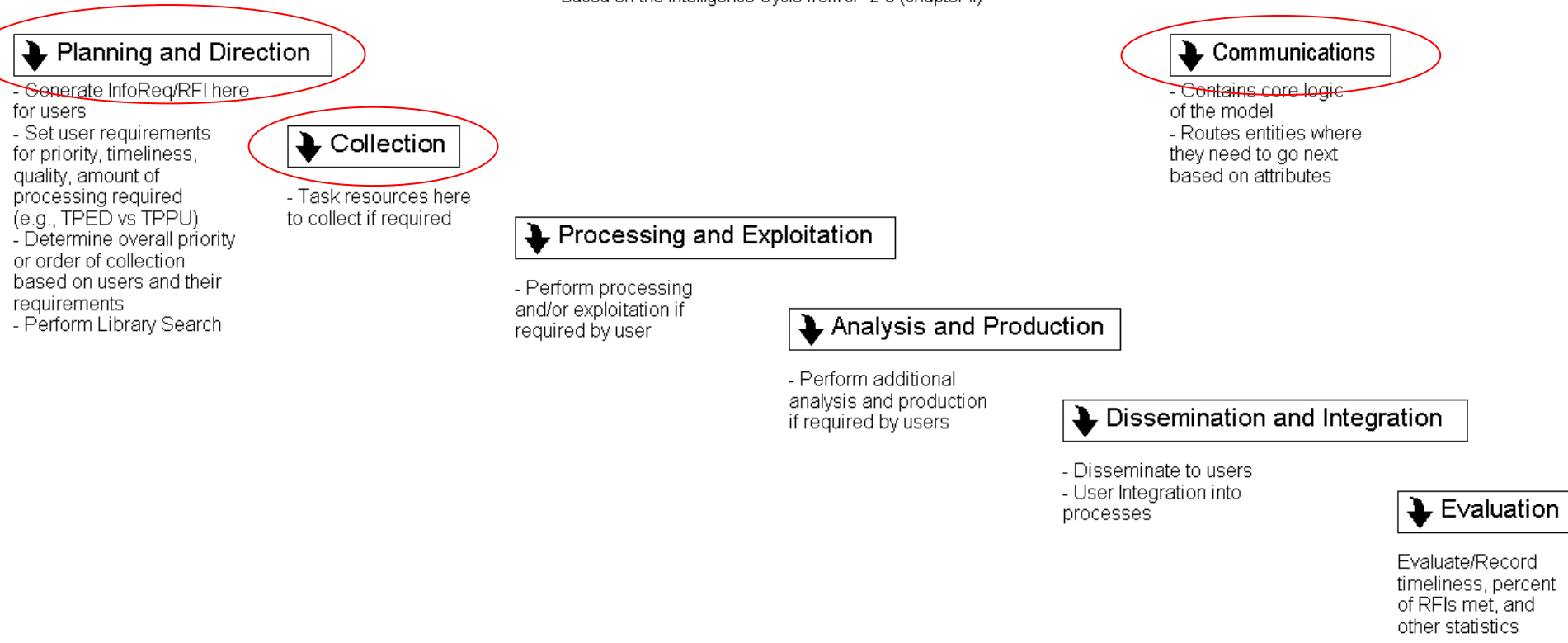


# Intelligence Process Model



## Intelligence Process Model

Based on the Intelligence Cycle from JP 2-0 (chapter II)



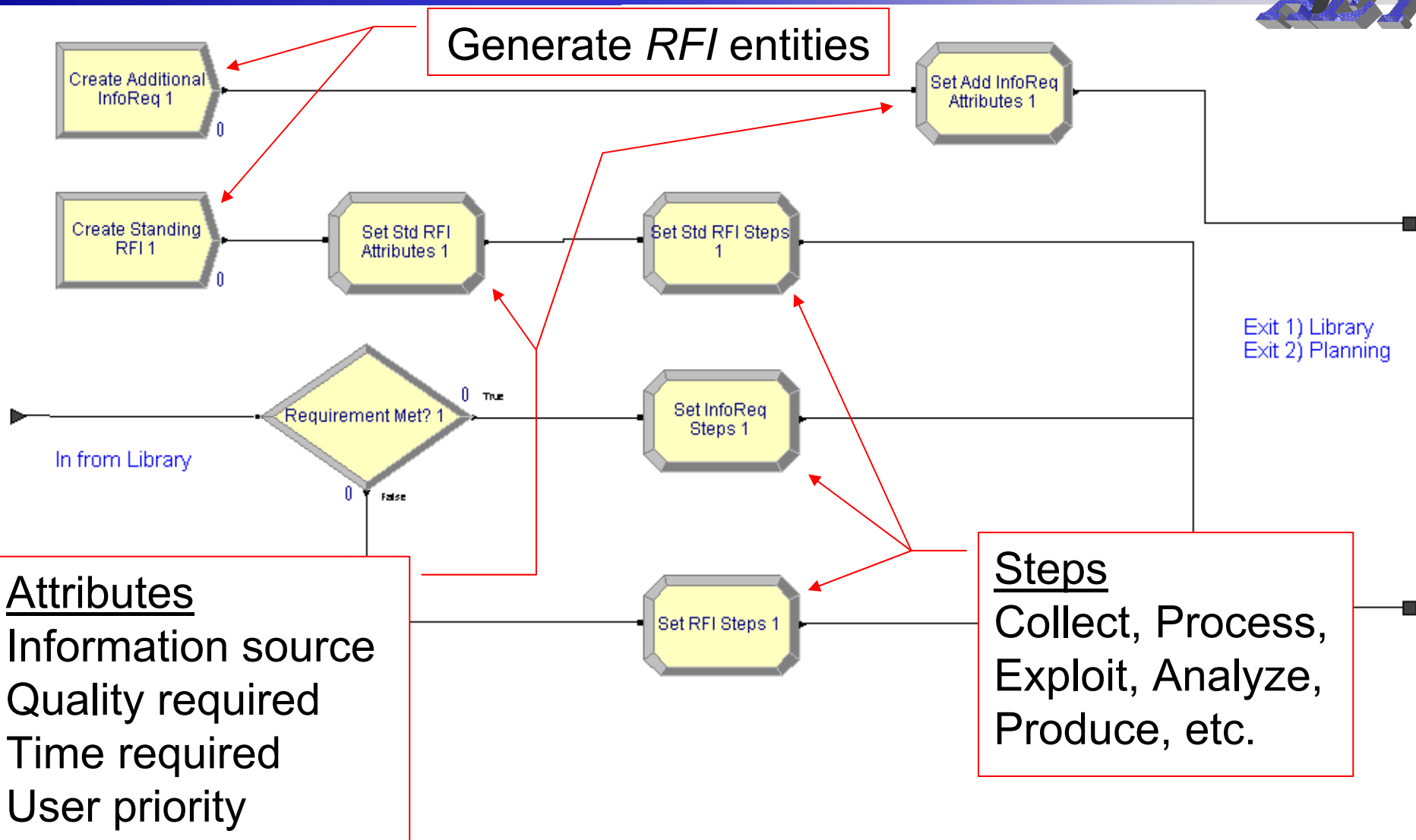
- Top-level model based on Intelligence Cycle
- Discrete Event Simulation
- Flexibility in modular design
- Easily expandable



# IPM – User 1 Planning



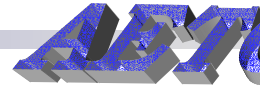
AMM



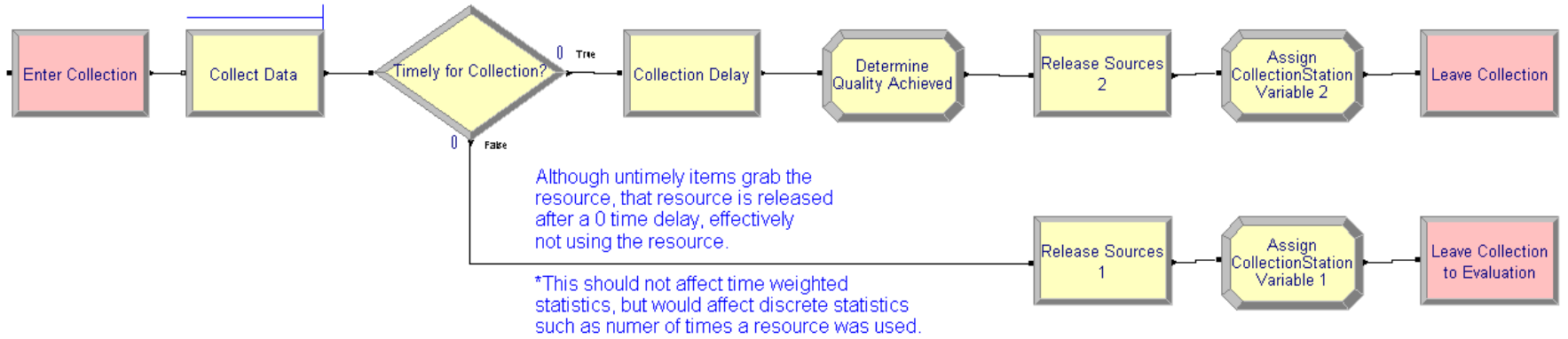
- 5 user modules represent beginning of process
- Model *RFIs* analogous to a tracking sheet for real *RFIs*



# IPM – Collection



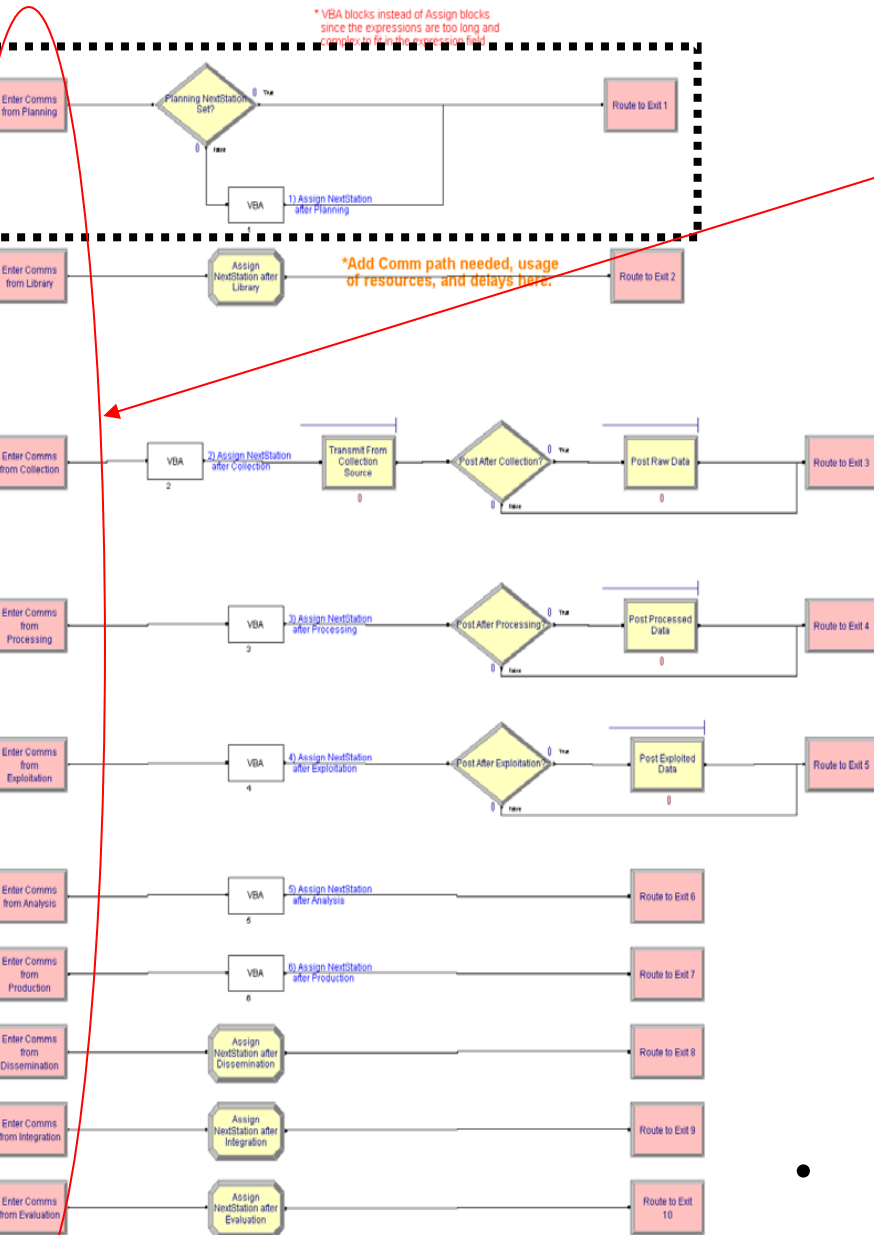
$$(TNOW - Entity.CreateTime) - TimeR \leq Timely\_Threshold$$



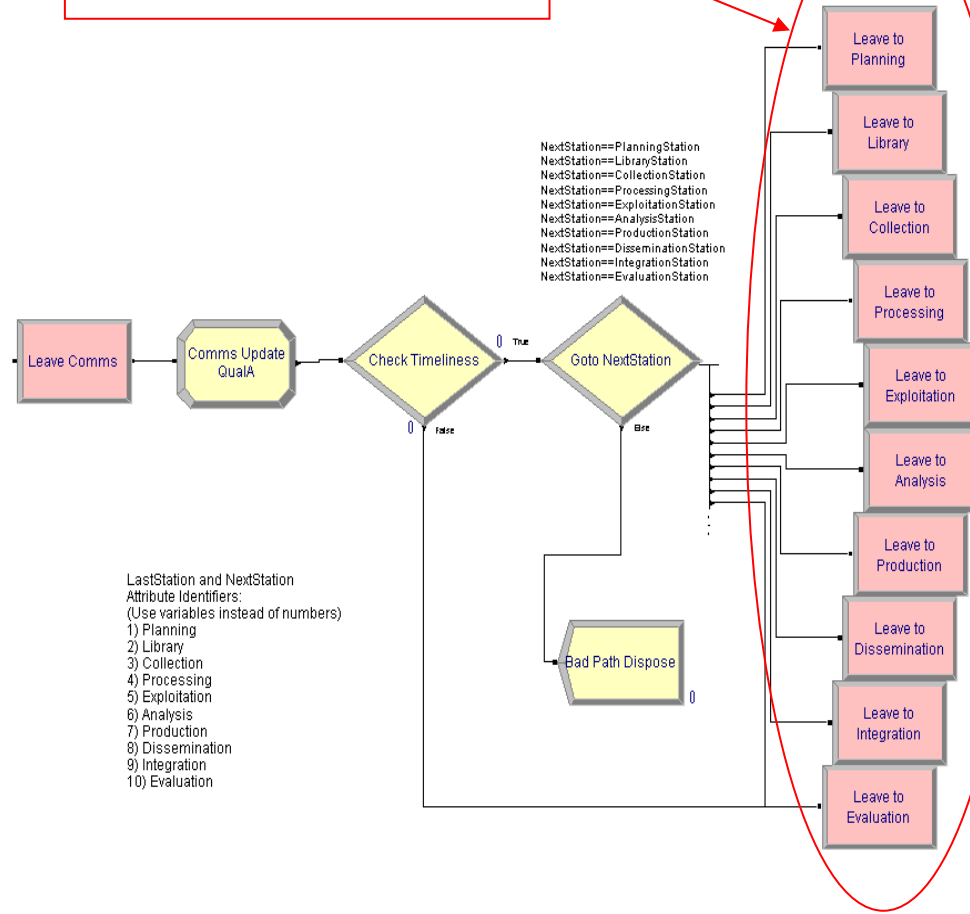
- Highest priority *RFIs* processed first
- Only processed when appropriate source is available
- Timeliness check avoids using resources on untimely *RFIs*
- Expression arrays based on source and required quality determine delay and achieved quality
- Similar structure in other submodels



# IPM - Communications



Entry and exit for each submodel



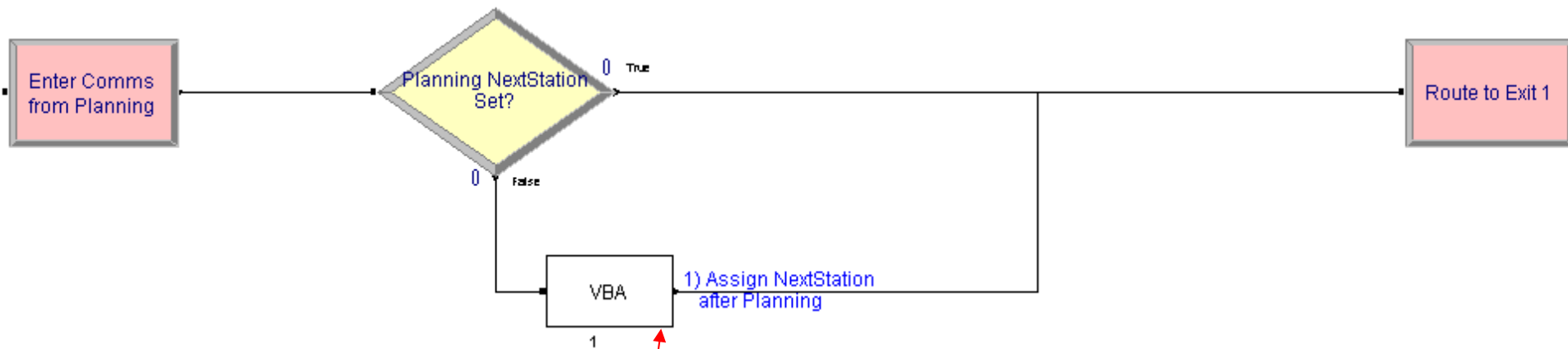
LastStation and NextStation Attribute Identifiers:  
(Use variables instead of numbers)  
1) Planning  
2) Library  
3) Collection  
4) Processing  
5) Exploitation  
6) Analysis  
7) Production  
8) Dissemination  
9) Integration  
10) Evaluation

- Contains the core logic for *RFI* routing
- Provides framework for updates if needed





# IPM - Communications

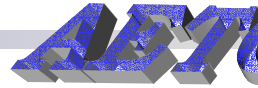


```
' Determine NextStation after Planning
If Need_Collect = 1 Then
    Next_Station = Stn_Collection
ElseIf Need_Process = 1 Then
    Next_Station = Stn_Processing
ElseIf Need_Exploit = 1 Then
    Next_Station = Stn_Exploitation
ElseIf Need_Analyze = 1 Then
    Next_Station = Stn_Analysis
ElseIf Need_Produce = 1 Then
    Next_Station = Stn_Production
ElseIf Need_Disseminate = 1 Then
    Next_Station = Stn_Dissemination
ElseIf Need_Integrate = 1 Then
    Next_Station = Stn_Integration
Else
    Next_Station = Stn_Evaluation
End If
```

- Determine where *RFIs* should go next based on steps needed and last step completed
- VBA routing logic
  - Adds flexibility
  - Simplifies structure
  - Central location for updates



# Data Request Sheet



NumUsers	Number of users for the study. This affects all arrays below with an User dimension.				<b>*Use streams 2,3,4,5 for InfoSource 1,2,3,4 draws respectively</b> <b>*Use stream 6 when indep. of InfoSource</b>								
	<b>NumUsers</b>	<b>Value</b>	<b>Max</b>										
		5	5										
NumInfoSources	Number of information sources for the study. This affects all arrays below with an InfoSource dimension.												
	<b>NumInfoSources</b>	<b>Value</b>	<b>Max</b>										
		4	13										
NumAnalystSpecialties	Number of specialties for all source analysts. This affects all arrays below with an AnalystSpecialty dimension.												
	<b>NumAnalystSpecialties</b>	<b>Value</b>	<b>Max</b>										
		4	13										

\*\*Note: If the values above are less than their max values, the remaining items in an array can be set to 0 (zero).  
 \*\*Note: Some Sample entries have been given  
 \*\*Note: Additional Variables or Expressions can be defined and used to fill out the datasheet if desired. Please add these items and definitions to the bottom of the sheet.

InfoCollectTimes	Each entry of the array corresponds to the distribution of time taken to collect information from a specified information source at a specified level of required quality.												
		<b>InfoSource</b>											
		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>
<b>QualR</b>	<b>1</b>	EXPO(3,1)	3	UNIF(0.8,1.6,3)	EXPO(0.3,4)	0	0	0	0	0	0	0	0
	<b>2</b>	EXPO(4,1)	4	UNIF(0.8,1.6,3)	EXPO(0.6,4)	0	0	0	0	0	0	0	0
	<b>3</b>	EXPO(5,1)	5	UNIF(0.8,1.6,3)	EXPO(0.9,4)	0	0	0	0	0	0	0	0
	<b>4</b>	EXPO(6,1)	6	UNIF(1.6,3.2,3)	EXPO(1.2,4)	0	0	0	0	0	0	0	0
	<b>5</b>	EXPO(7,1)	7	UNIF(1.6,3.2,3)	EXPO(1.5,4)	0	0	0	0	0	0	0	0

LibrarySearchTimes	Each entry of the array corresponds to the distribution of time taken to search the "Library" of information available for information from a specified information source and level of required quality.												
		<b>InfoSource</b>											
		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>
<b>QualR</b>	<b>1</b>	EXPO(0.08,1)	EXPO(0.08,2)	EXPO(0.08,3)	EXPO(0.08,4)	0	0	0	0	0	0	0	0
	<b>2</b>	EXPO(0.1,1)	EXPO(0.1,2)	EXPO(0.1,3)	EXPO(0.1,4)	0	0	0	0	0	0	0	0
	<b>3</b>	EXPO(0.12,1)	EXPO(0.12,2)	EXPO(0.12,3)	EXPO(0.12,4)	0	0	0	0	0	0	0	0
	<b>4</b>	EXPO(0.14,1)	EXPO(0.14,2)	EXPO(0.14,3)	EXPO(0.14,4)	0	0	0	0	0	0	0	0
	<b>5</b>	EXPO(0.16,1)	EXPO(0.16,2)	EXPO(0.16,3)	EXPO(0.16,4)	0	0	0	0	0	0	0	0

- One location for data collection and annotation
- Arrays easily transferred into Arena
- Flexibility for scenario customization without model framework modification
  - Over 2700 possible inputs (about 830 used for case studies)
  - Distributions, expressions, variables, resources, etc.



# Validation and Verification



- Multiple SME reviews
- Detailed model walk-throughs
- Arena animation
- Review of output statistics
- Analysis of sample case studies
  - Notional data
  - Examine general model performance and trends
  - Not predicting or assessing actual system performance



# Case Studies



- Stress IPM simulation with simple changes
- Baseline (BL): Notional data
- Cases selected to evaluate model framework
  - C1: *Timely\_Threshold* = 48 hours
  - C2: *Timely\_Threshold* = 12 hours
  - C3: *QualMet\_Threshold* = 3
  - C4: *QualMet\_Threshold* = 1
  - C5: Increase additional requirements by 50%
  - **C6: Increase exploitation times by 50%**
  - C7: Increase analysis times by 50%



# Case Study User Setup



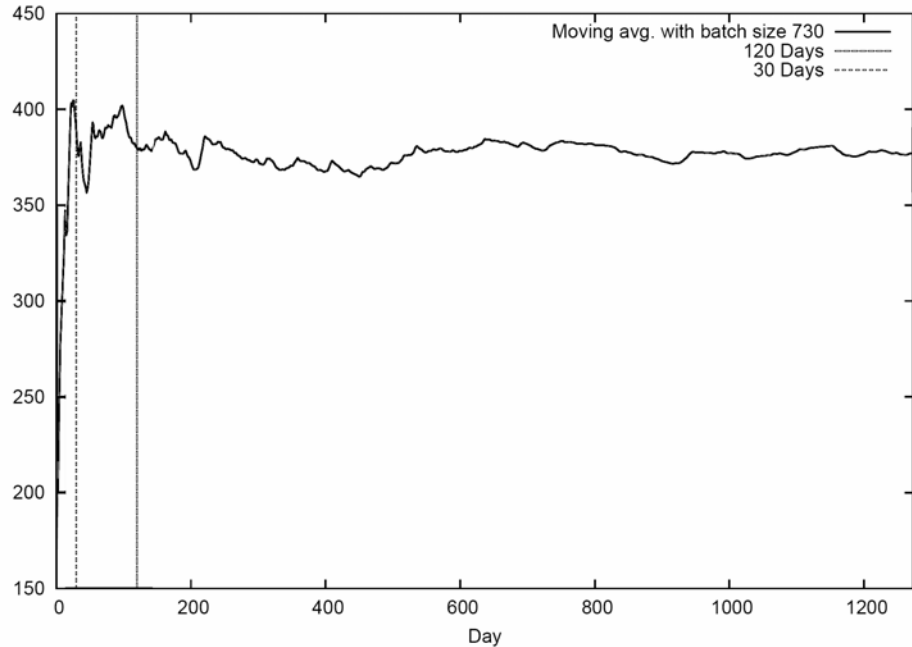
- For any *RFI* that needed collection, users required different steps to meet their needs
- User 1: All steps
- User 2: No exploitation
- User 3: No analysis
- User 4: Neither analysis nor production
- User 5: Neither exploitation nor production



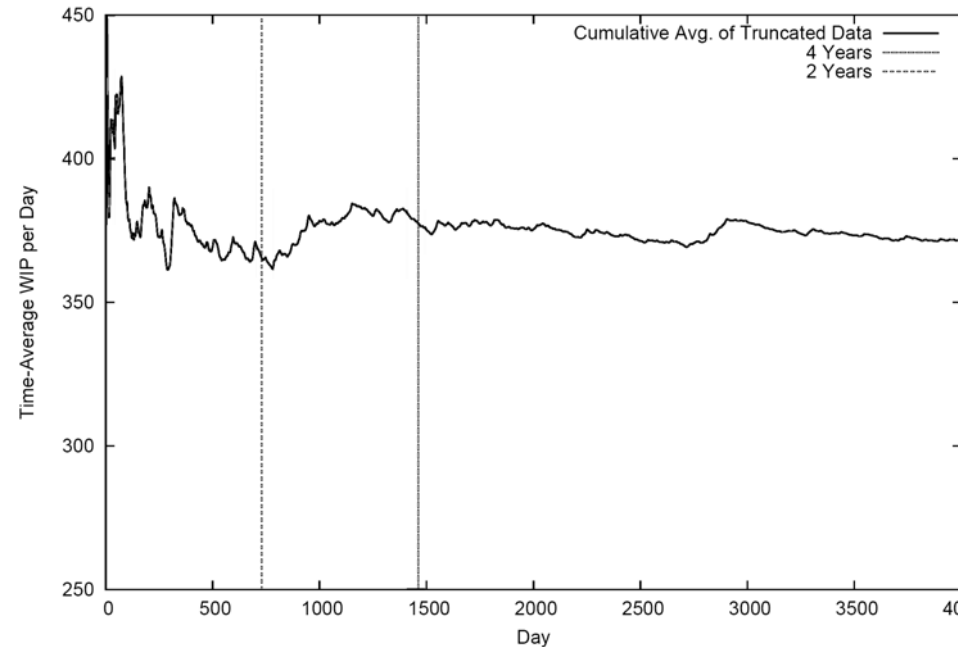
# Replication Parameters



Moving Average of Time-Average WIP per Day by Day



Cumulative Average of Time-Average WIP per Day by Day



- Goal: reduced bias and variation of simulation output
- Examined single long replication of baseline system
- Total work in process (plotted above) and total time in system
- Truncate to reduce bias, then terminate near steady state
- Multiple replications



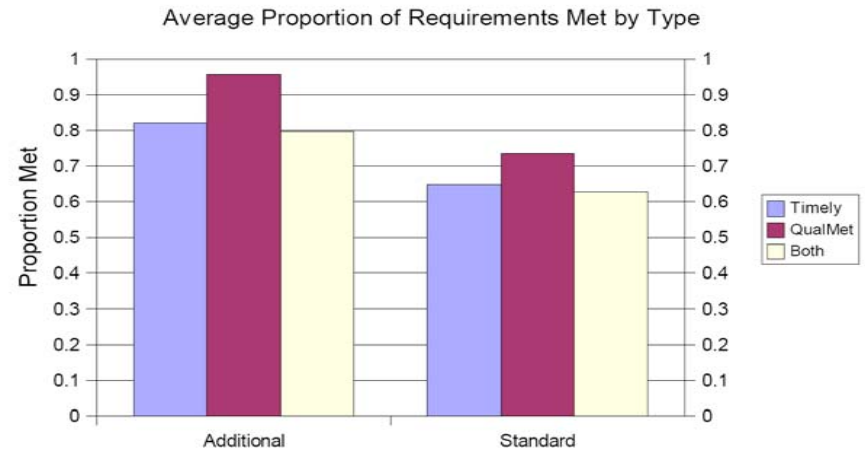
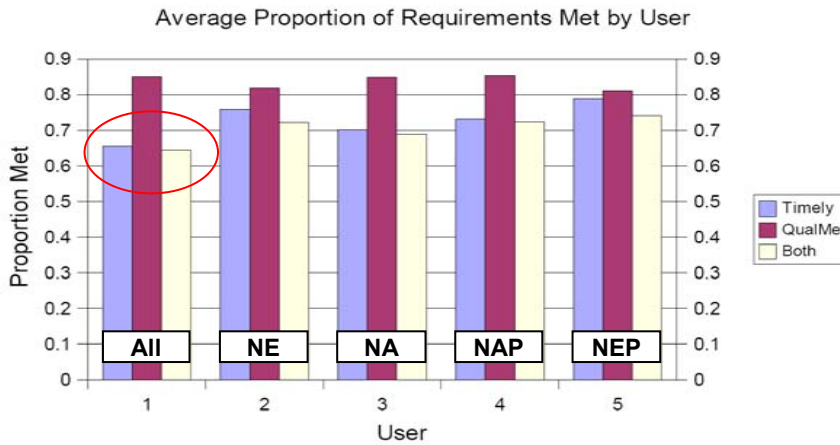
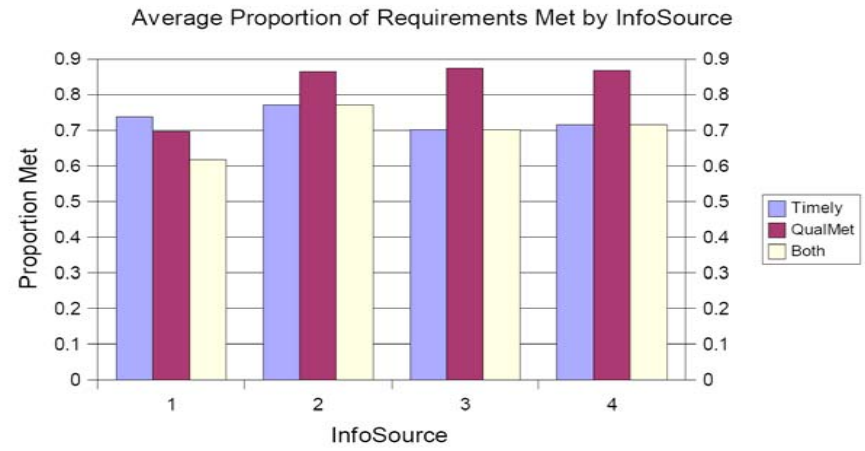
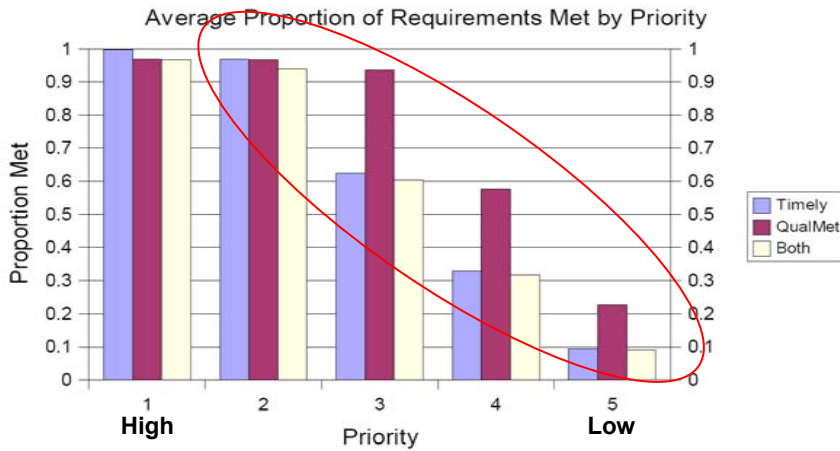
# Simulation Outputs



- Standard process simulation measures (total wait time, total time in system, work in process, number in queues, resource utilization, etc.)
- Proportion of timely, quality, and both requirements met partitioned by priority, source, user, type
- Total wait time by priority
- Many additional statistics can be easily added



# Simulation Results - BL



- Baseline system
- Proportion of requirements met for timely, quality, both

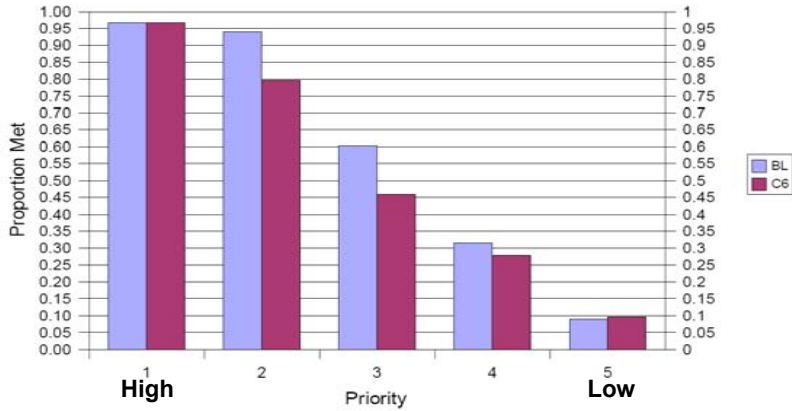




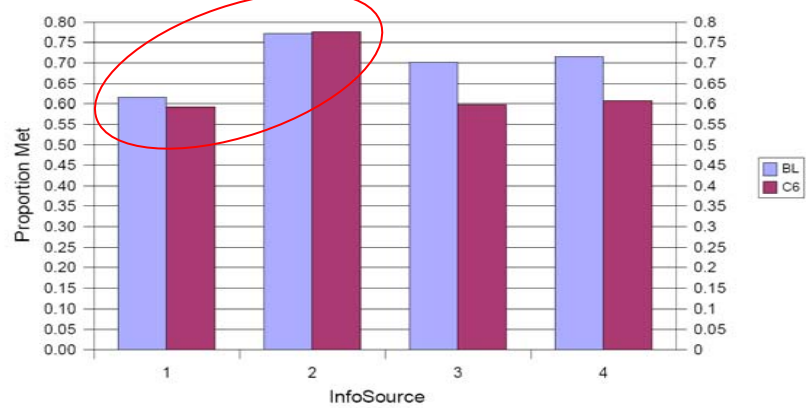
# Simulation Results – BL:C6



Average Proportion of Requirements Met by Priority



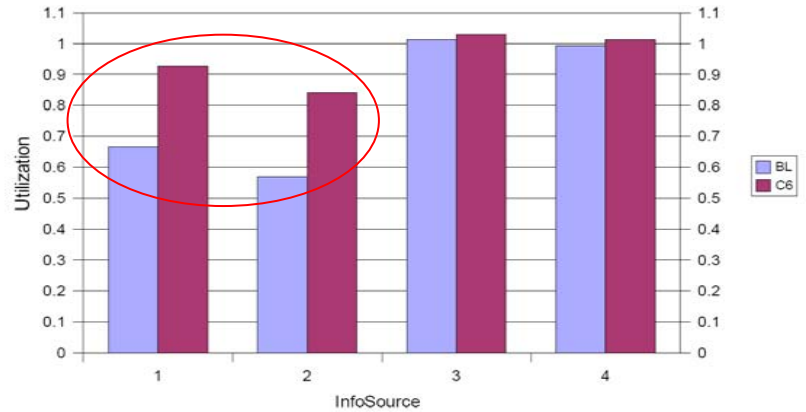
Average Proportion of Requirements Met by InfoSource



Average Proportion of Requirements Met by User



Average Analyst\_Src Utilization



- C6: Increase exploitation times by 50%



# Conclusions



- **Flexibility**
  - High level model developed from top down perspective
  - Modular framework
  - Centralized arrays of inputs
    - Customize without modifying framework
    - Aid input verification
  - Not restricted to any specific platform or traditional intelligence disciplines
- **Credibility**
  - Grounded on documented process
  - Validation and verification effort
  - Case study results



# Conclusions



- Application
  - TPED/TPPU comparisons in a hybrid system
  - Impact of proposed changes to the system
- Future Research
  - Additional *Communications* submodel detail
  - Information Integration/Fusion

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***Integrity - Service - Excellence***



# Sample of Paired-t Tests



**alpha = 0.05**

Insignificant differences **highlighted** based on alpha

**Paired-t test p-values for User 1 vs User 5 over 25 replications**

Case	Timely	QualMet	Both	
BL	0.00000000	0.00000000	0.00000000	mean diff = -0.000112
C1	0.00000000	0.00000000	0.00000000	
C2	0.00000000	0.00000000	0.00000000	
C3	0.00000000	<b>0.68767872</b>	0.00000000	
C4	0.00000000	<b>0.56661909</b>	0.00000000	
C5	0.00000000	0.00000000	0.00000000	mean diff = -0.000389
C6	0.00000000	0.00000000	0.00000000	
C7	0.00000000	0.00000000	0.00000000	

**Paired-t test p-values Case comparisons for User 1 over 25 reps**

	Timely	QualMet	Both	
BL – C1	0.00000000	0.00000000	0.00000000	mean diff = 0.000898
BL – C2	0.00000000	0.00099752	0.00000000	
BL – C3	0.00226316	0.00000000	0.00000000	
BL – C4	<b>0.49213783</b>	0.00000000	0.00000004	mean diff = -0.000452
BL – C5	0.00000000	0.00000000	0.00000000	
BL – C6	0.00000000	0.00000007	0.00000000	
BL – C7	0.00000000	<b>0.61116139</b>	0.00000000	
C1 – C2	0.00000000	0.00001316	0.00000000	
C3 – C4	0.00428745	0.00000000	0.00421697	

**Paired-t test p-values Case comparisons for User 5 over 25 reps**

	Timely	QualMet	Both	
BL – C1	0.00000000	0.00000000	0.00000000	mean diff = -0.000501
BL – C2	0.00055935	0.00000913	0.00513163	
BL – C3	0.00682321	0.00000000	0.00000000	
BL – C4	<b>0.70841705</b>	0.00000000	0.00000000	mean diff = -0.001241
BL – C5	0.00000000	0.00000000	0.00000000	
BL – C6	0.00000000	<b>0.12096061</b>	0.00000000	
BL – C7	0.00000000	0.00000007	0.00000000	
C1 – C2	0.00000000	0.00008434	0.00000007	mean diff = 0.003313
C3 – C4	0.03908054	0.00000000	0.03849555	