
Development of a Systems Engineering Model for Chemical Separations Process

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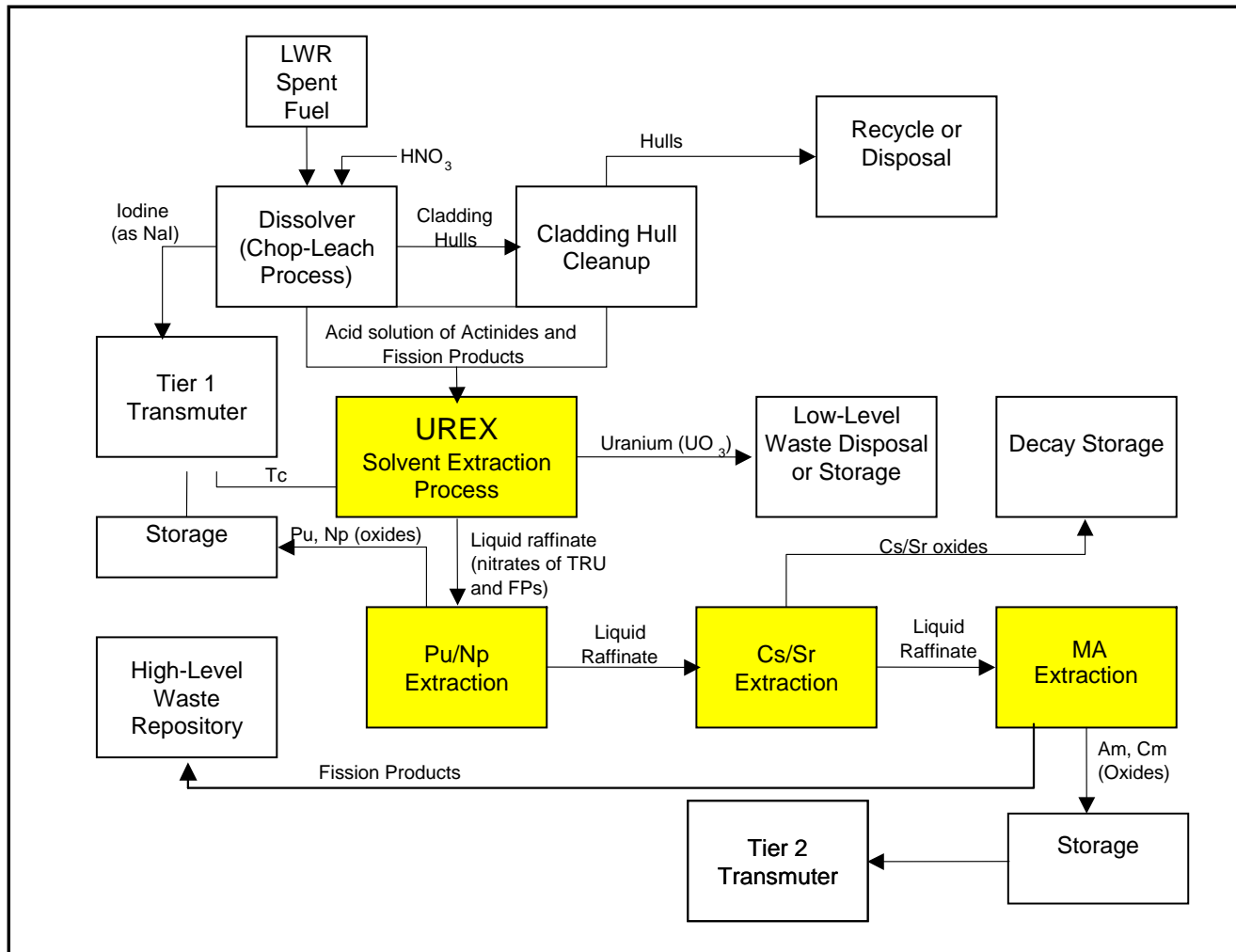
International Mechanical Engineering Congress and R&D Expo.
Washington, D.C., USA, November 16 - 21, 2003

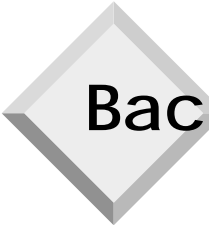
Overview

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- **Software Design**
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 - Software Process
 - System Architecture
- **System Demonstration**
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 - Chemical Model - AMUSESimulator
 - Integration of Glovebox Phase of UREX Process
- **Conclusion and Future Work**



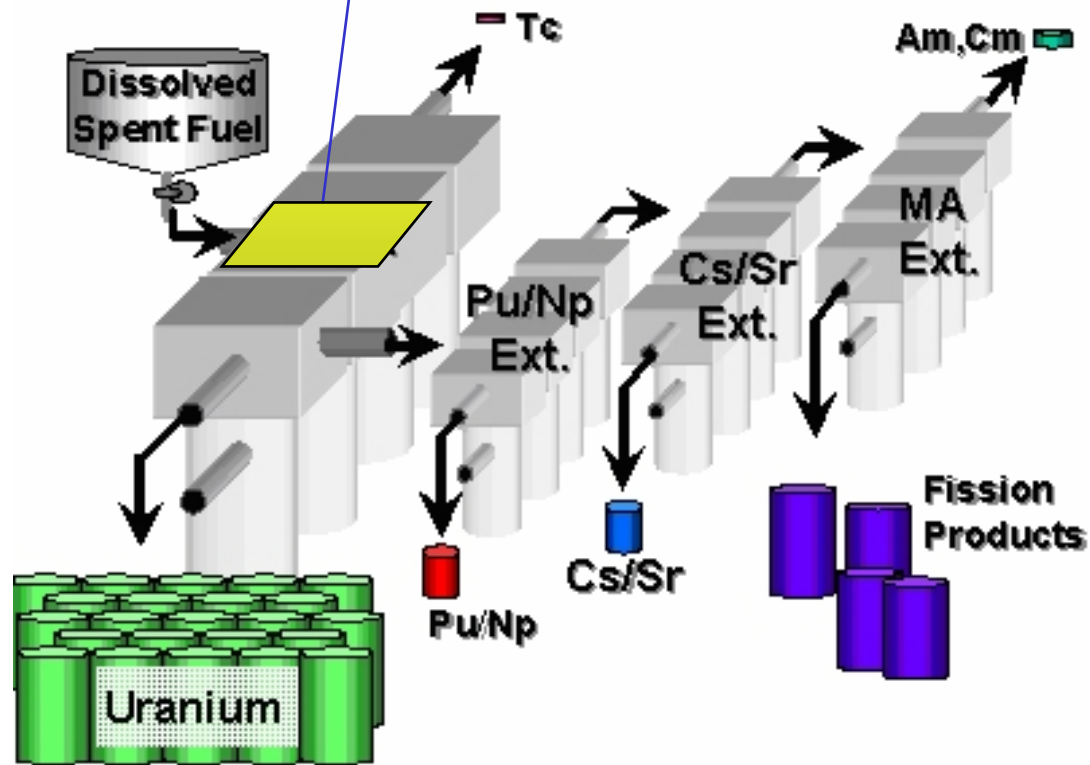
Background - Chemical Separation Process



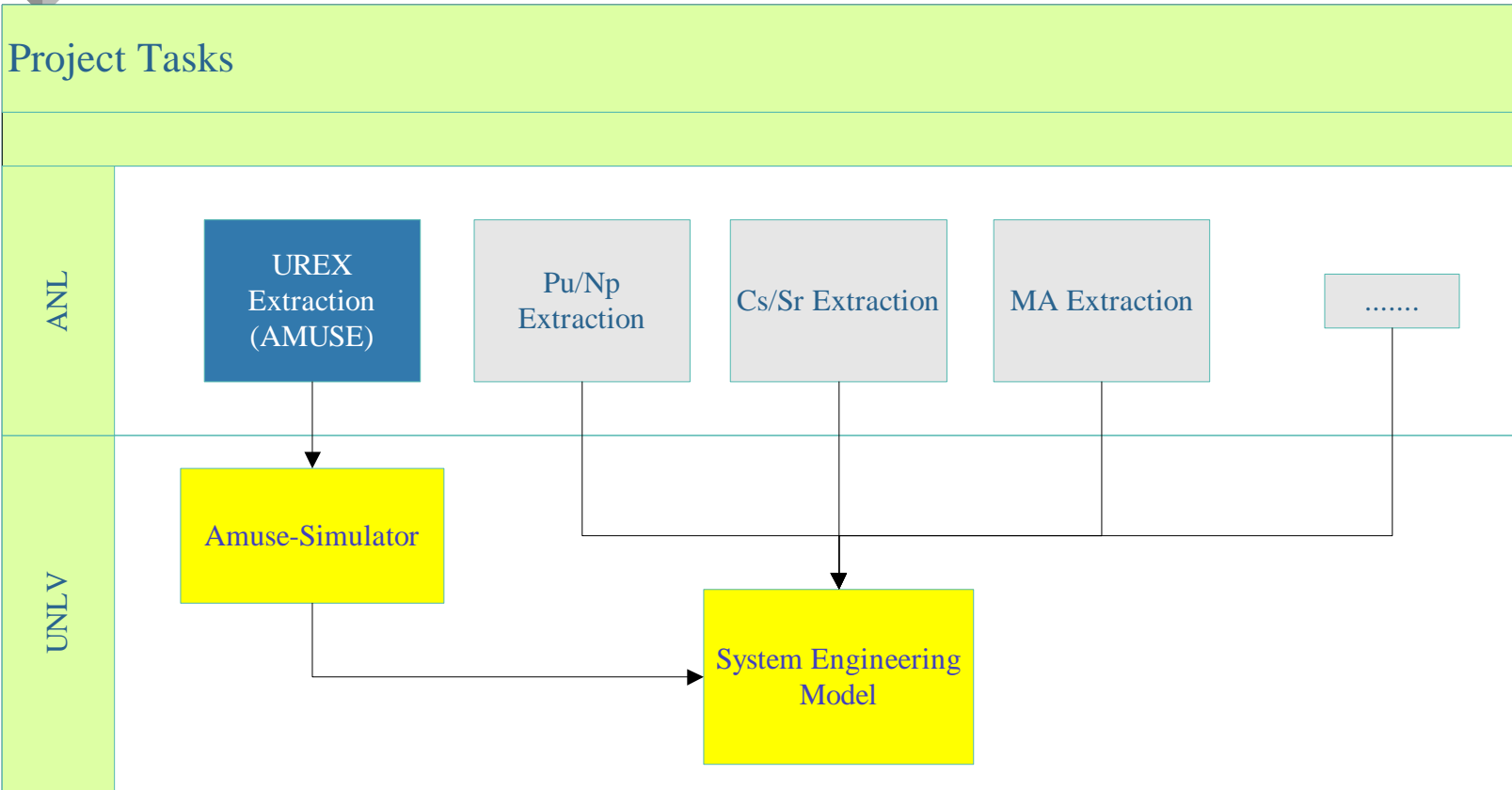


Background - UREX+ Process

Argonne Model for Universal Solvent Extraction (AMUSE)



Project Description



Development of A Systems Engineering Model for Chemical Separation Process

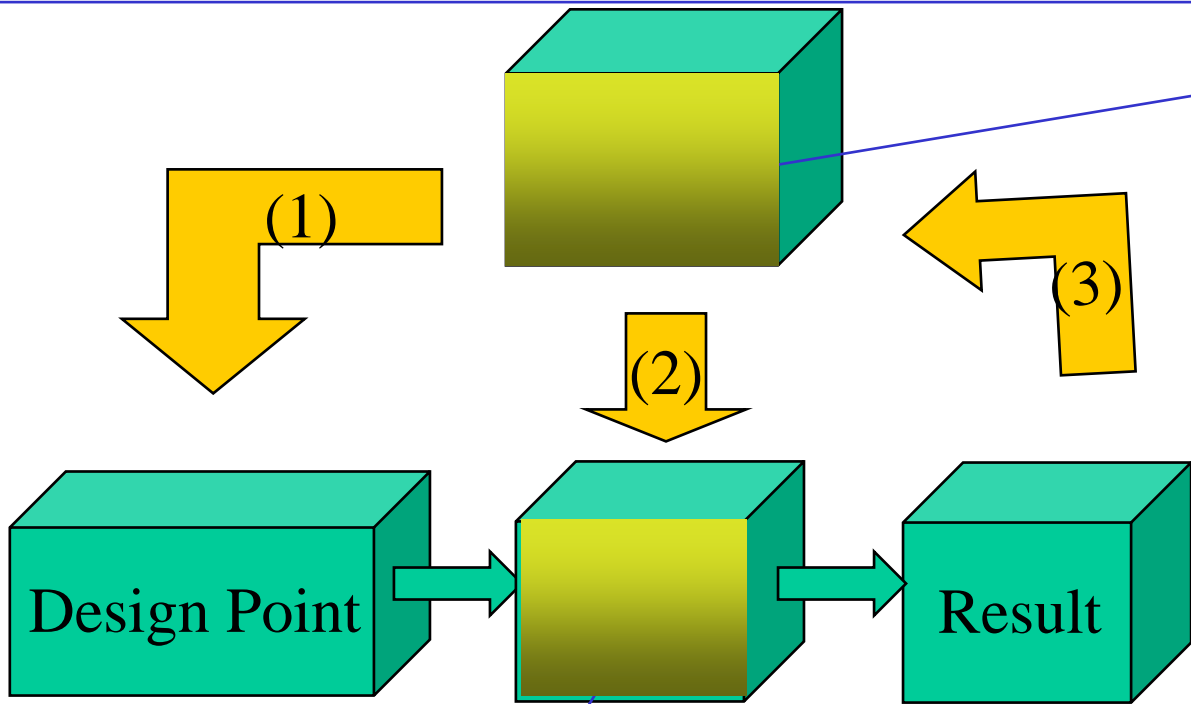




Automation of the Design Process

Replace Designer with Some Program Engine to Drive the Design Run

TRPSEMPro
(Transmutation Research Program System Engineering Modeling Project)



Chemical Separation Process

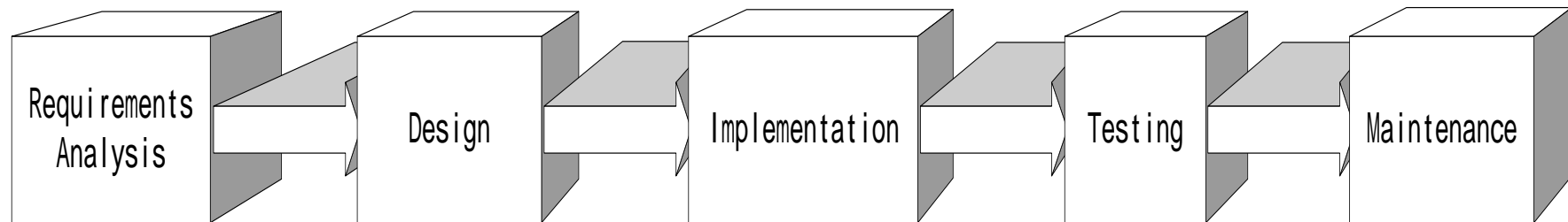


Objective

- Integrate chemical separation process into systems engineering model
- Identify core functions of system engineering model for the current or selected separation process scenarios
- Develop and implement software tool that allow to build system model and optimize the partial or entire chemical separation process
- Systems Analysis - Demonstrate software and model capabilities with various pre-defined scenarios

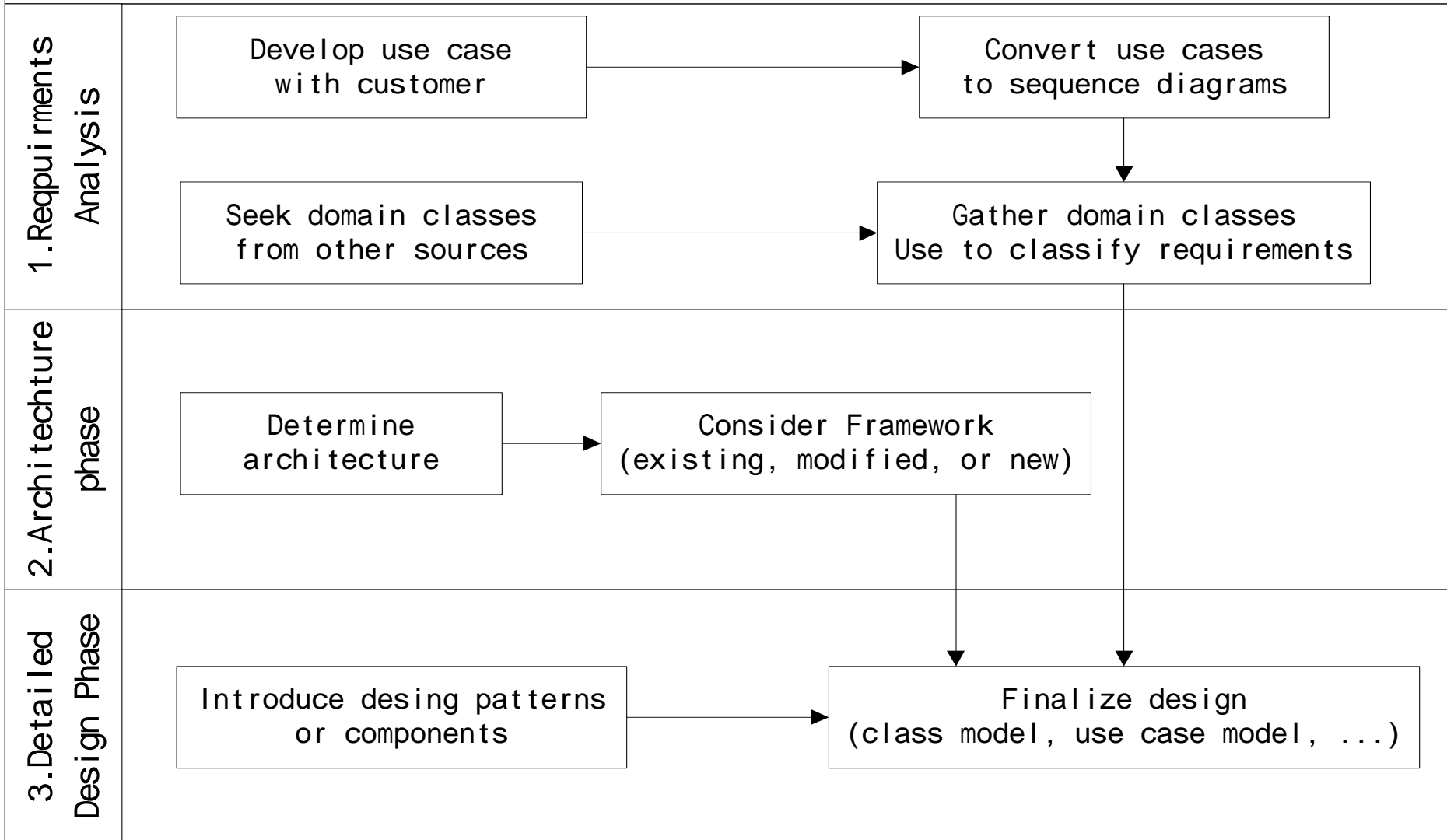


Software Design - The Phase of a Software Process



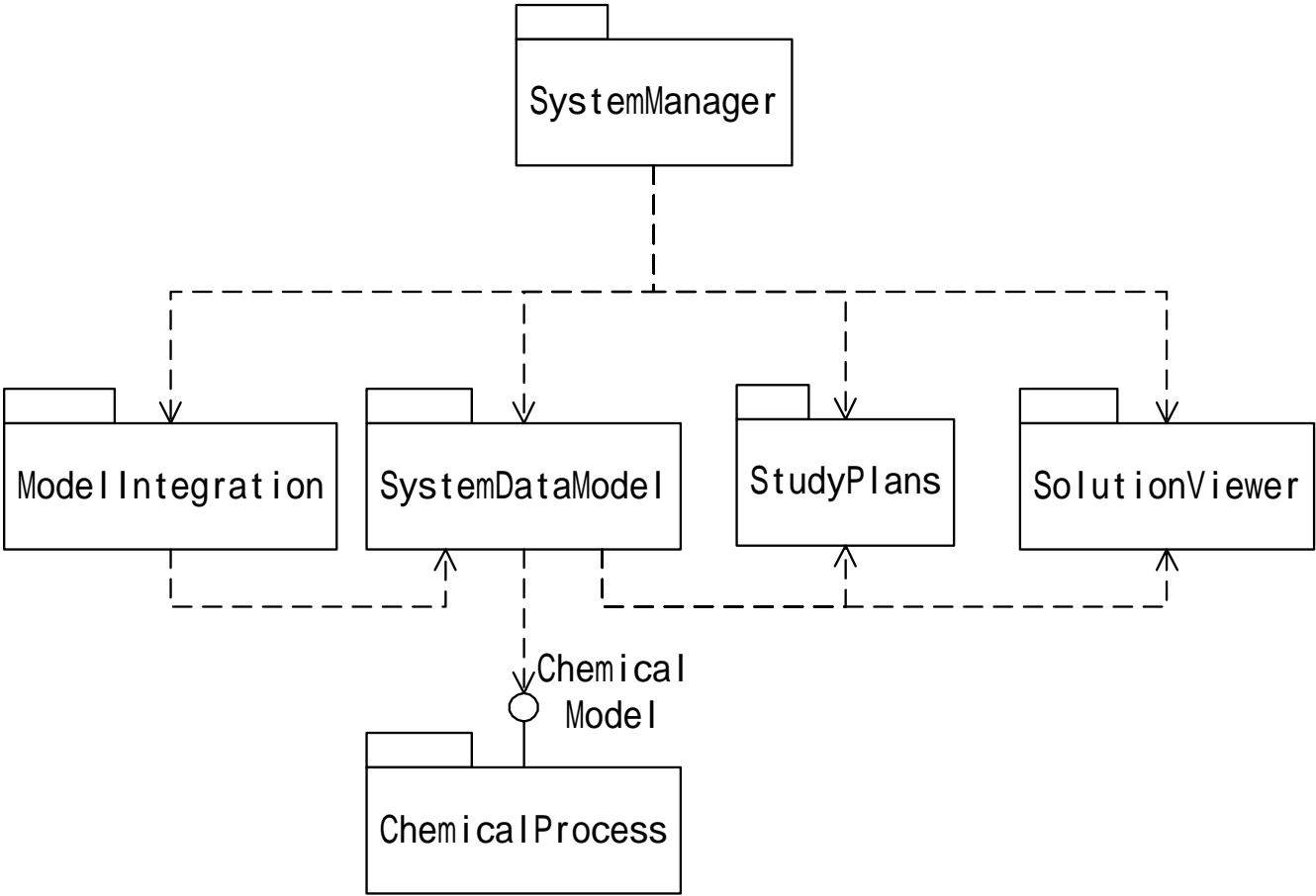
Object-Oriented Analysis and Design (OOA&D)

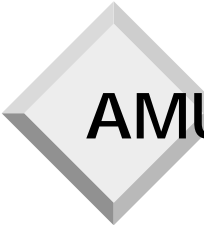
OOA&D Roadmap



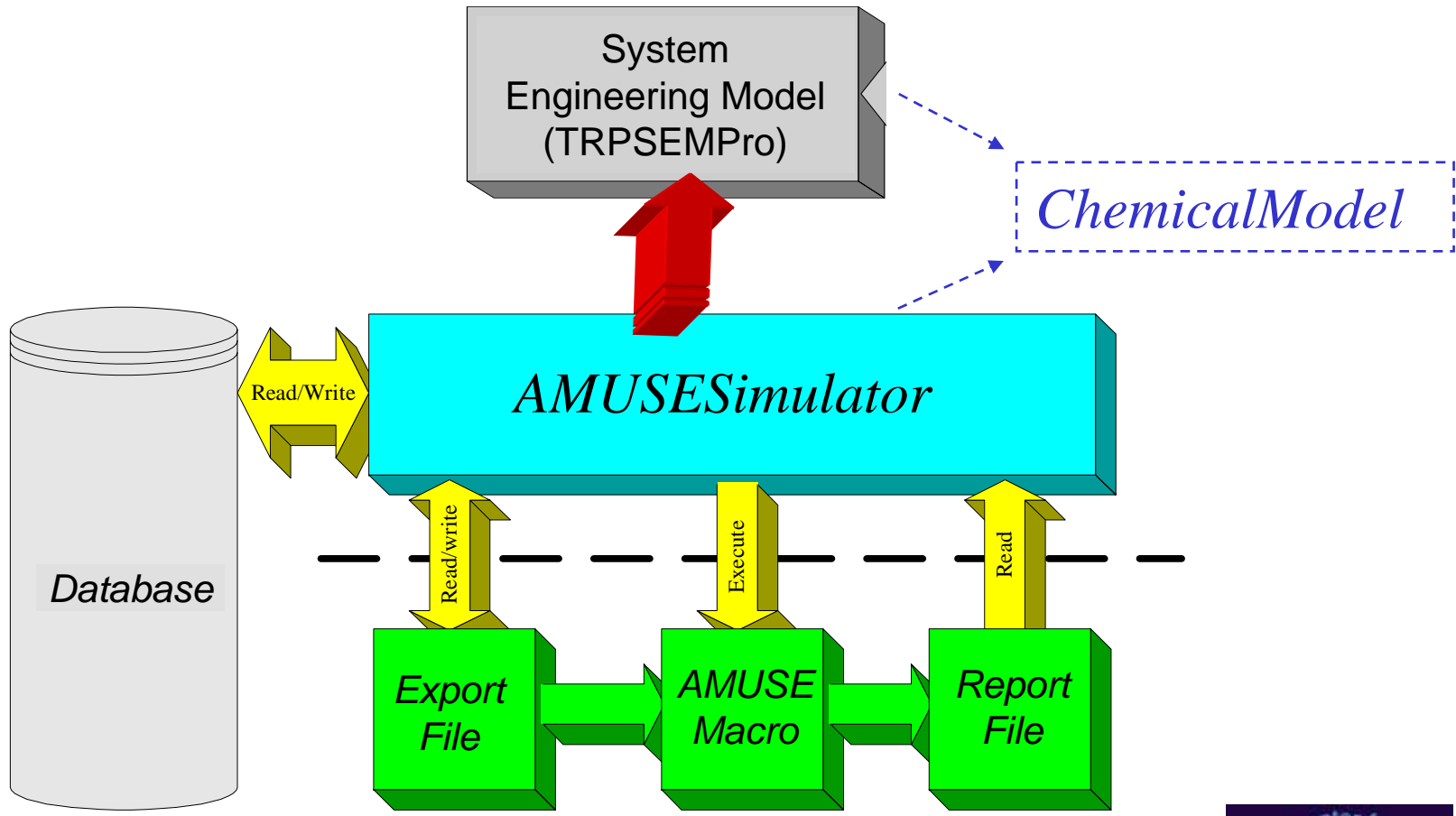


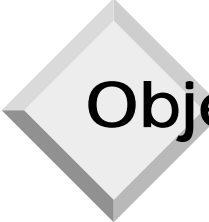
System Architectures



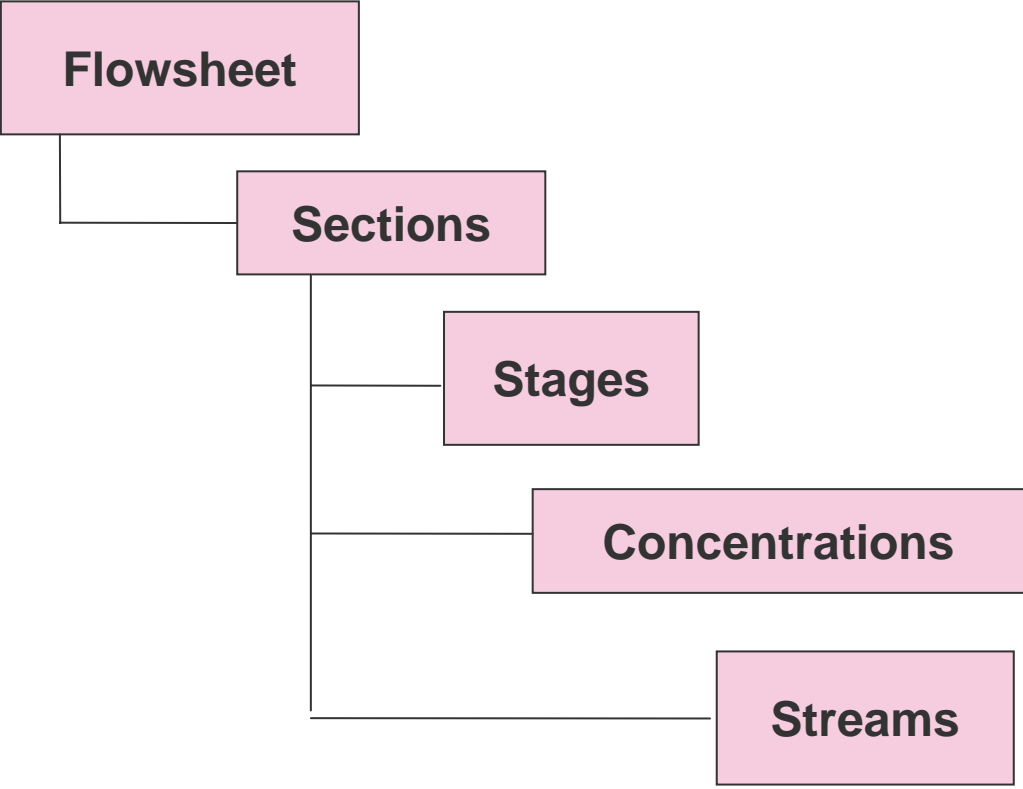


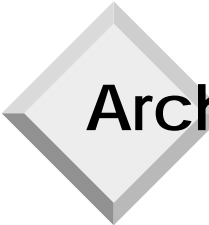
AMUSESimulator – Framework for UREX Process



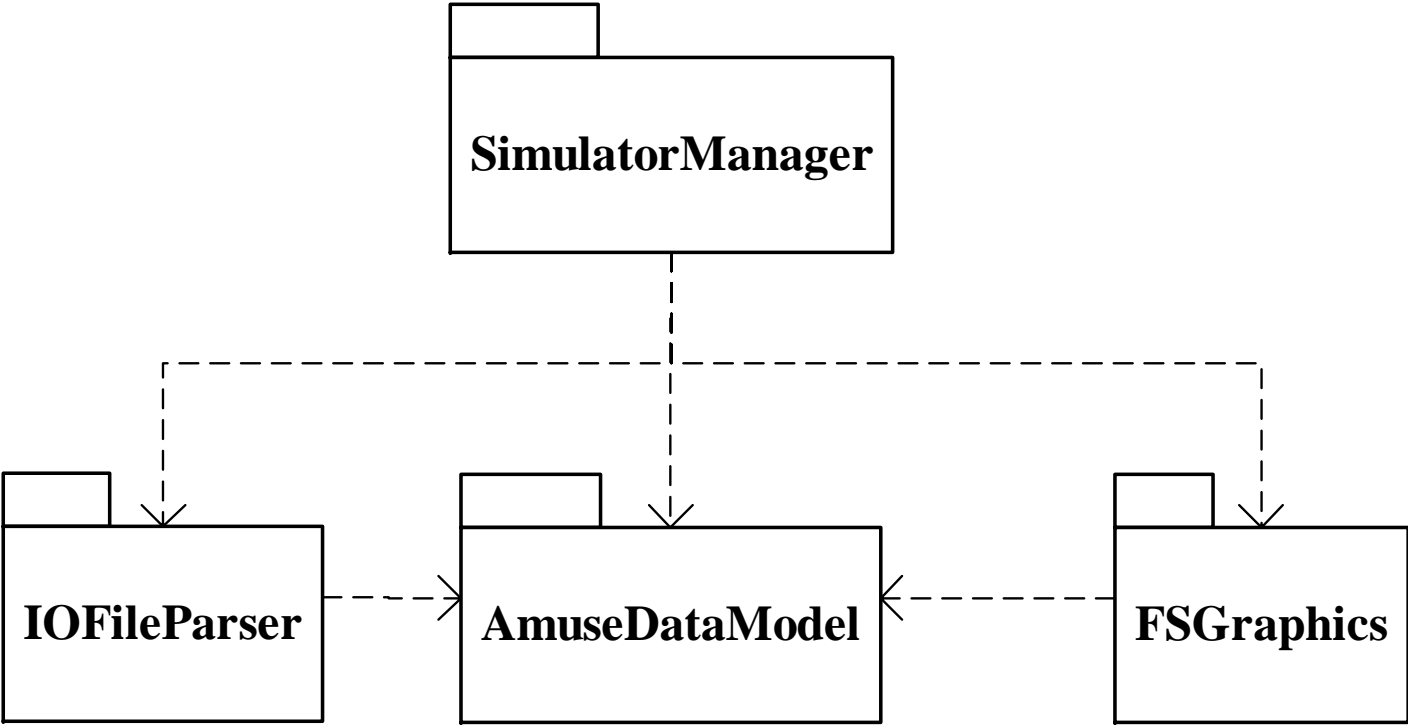


Objects Identification for UREX Process

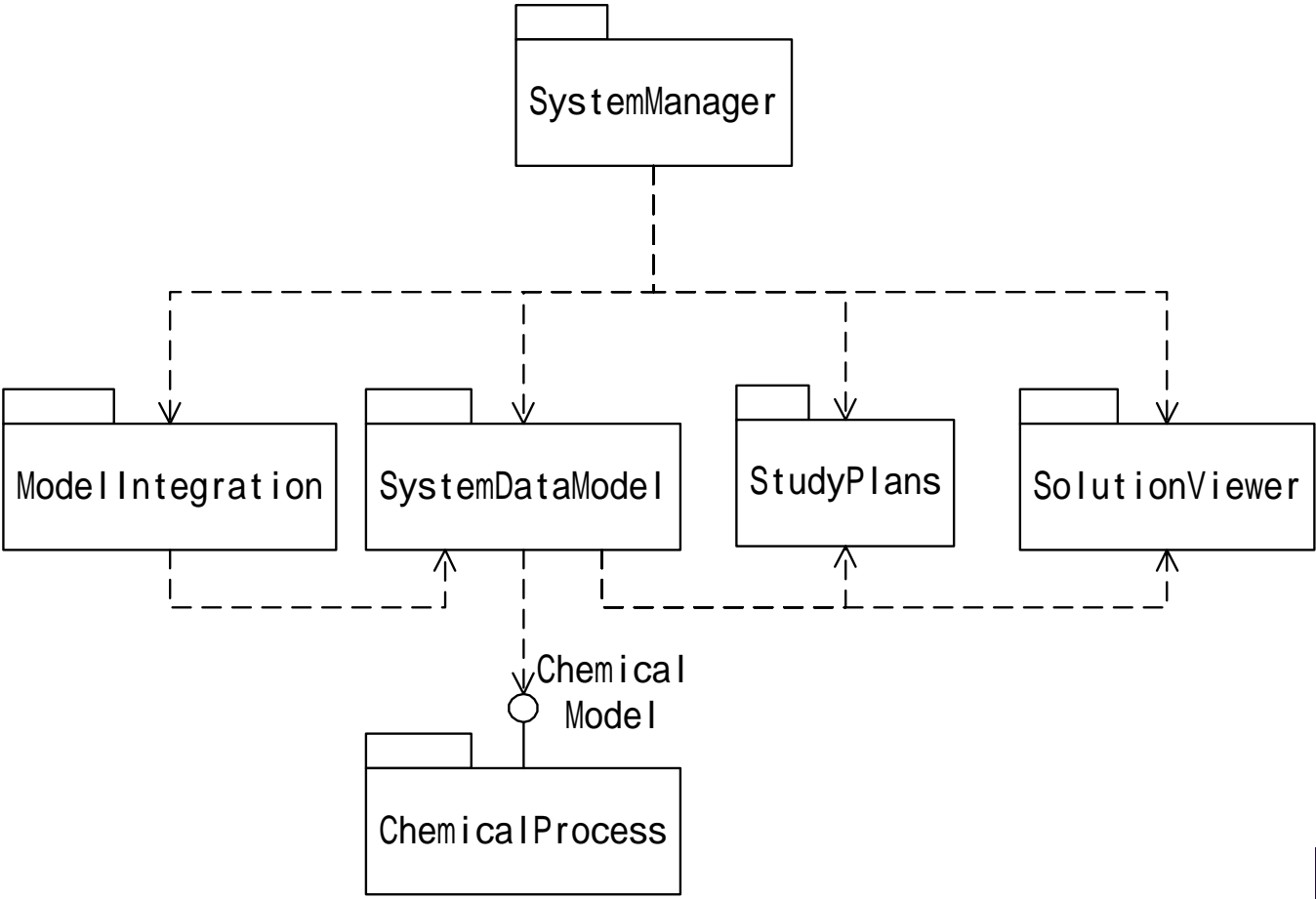




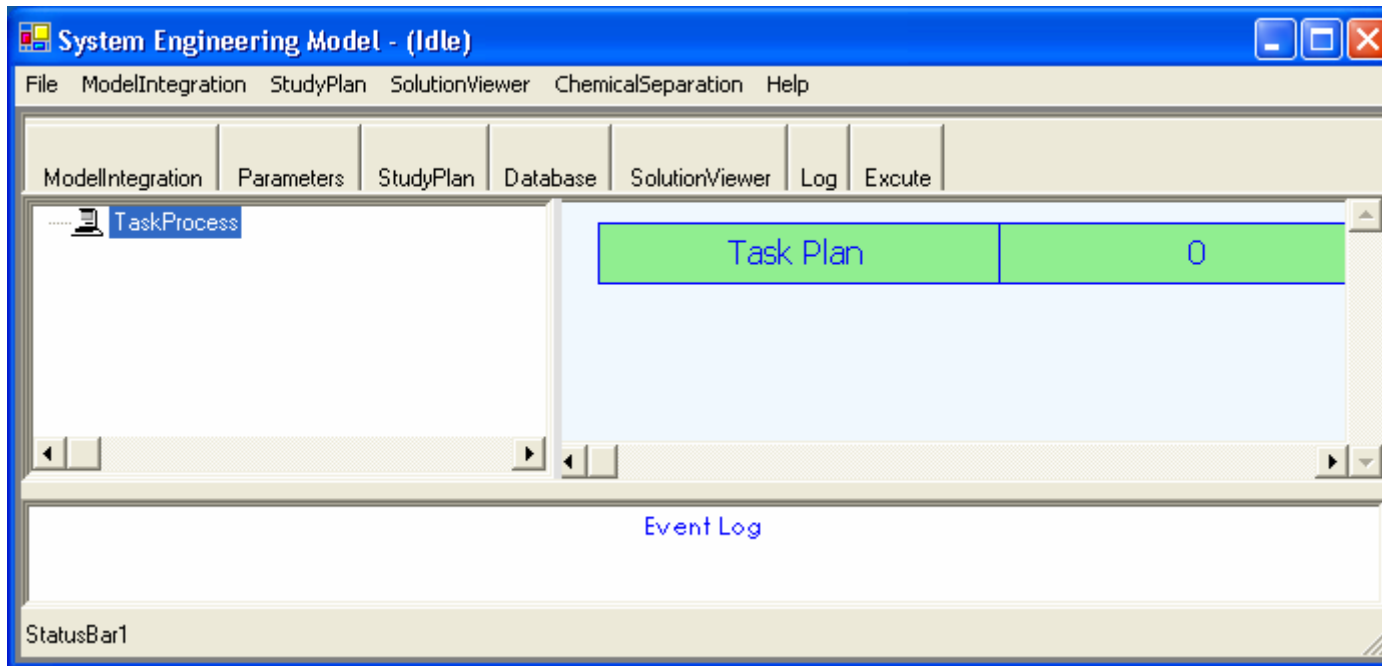
Architecture of AMUSESimulator



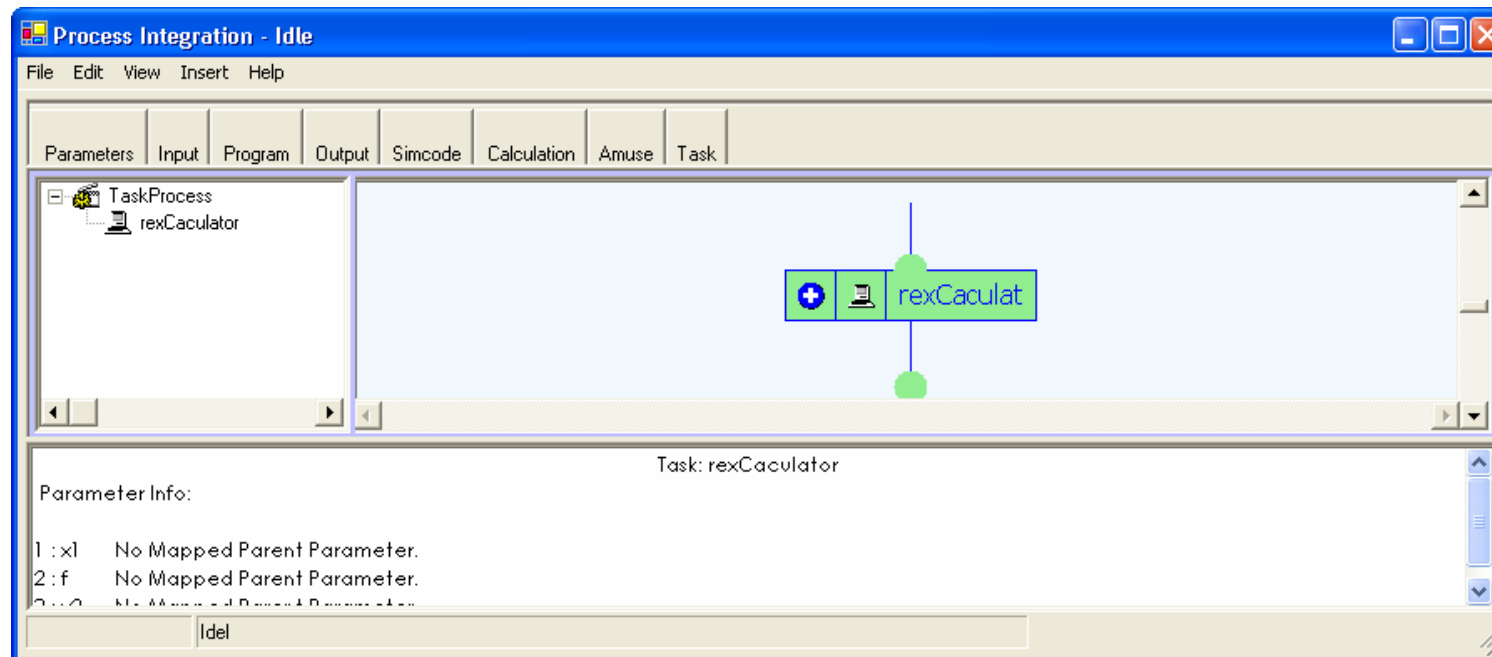
System Architectures

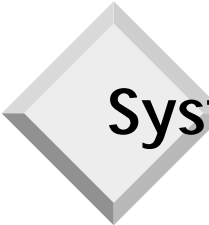


System Demonstration – Main Interface



System Demonstration - ModelIntegration





System Demonstration

- Define Design Variable, Objective and Constraint

frmMainParameters

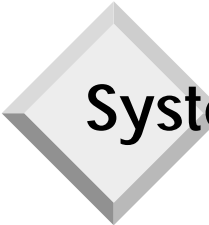
All

	Parameter	Var	Obj	Type	LBound		Current V	UBound	Description
1	x1	<input checked="" type="checkbox"/>	<input type="checkbox"/>	real	0	≤	0	≤ 5	Design Variable x1
2	x2	<input checked="" type="checkbox"/>	<input type="checkbox"/>		0	≤	0	≤ 5	Design Variable x2
3	f	<input type="checkbox"/>	<input checked="" type="checkbox"/>	real	0		0	0	Objective Function
4									
5									

OK Apply Help

Context menu for row 1:
Potential Design Var
Design Var
Not Design Var





System Demonstration – Factor Level for DOE Study

frmDOEDefinition

Study: Plan Used: Technique:

Factors | Interactions | Design Matrix | Post-Processing

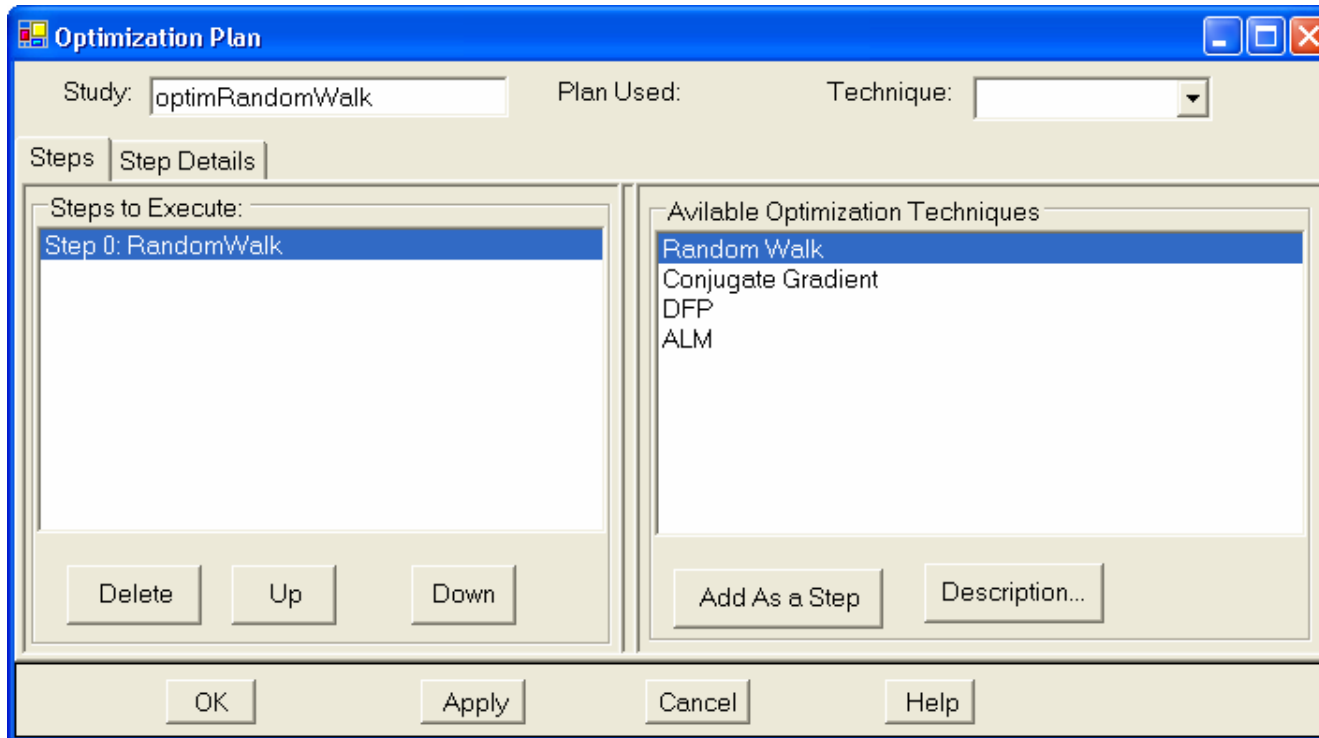
	Parameter	Fact	#Le	Levels		Baselin	Values
1	x1	<input checked="" type="checkbox"/>	2	-25 25	%	0	-25 25
2	x2	<input checked="" type="checkbox"/>	2	-25 25	%	0	-25 25
3	f	<input type="checkbox"/>	2	-25 25	%	0	-25 25

Factor
Not Factor

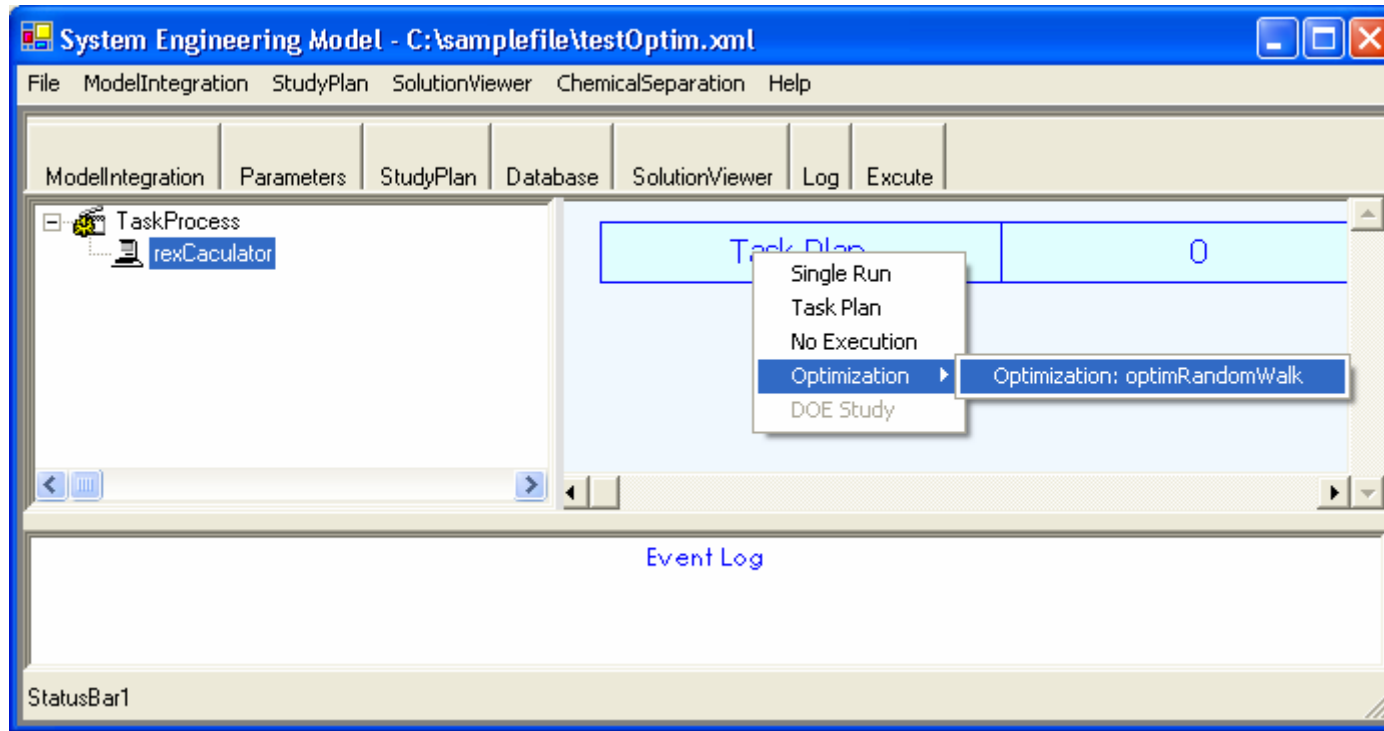
OK Apply Cancel Help



System Demonstration – Optimization Selection



System Demonstration – Choose Study Plan





System Demonstration - Database Viewer

fmDBViewer

Database

Run Case Table		
Case ID	Generate TI	Description
031019-1713	10/19/2003 5	Need modify I
031021	10/21/2003 4	Need modify I
031024-1612	10/24/2003 4	Need modify I
031024-1626	10/24/2003 4	rev01

Flowsheet Table: Case Id= 031021-160757									
case_ID	FS_ID	file_suffix	folder_name	num_sections	process_temp	diluent	solvent_extra	recycle	
031021-1607	031021-1636	rev01	reports	3	25	UREX	CC	False	
031021-1607	031021-1639	rev01	reports	3	25	UREX	CC	False	
031021-1607	031021-1642	rev01	reports	3	25	UREX	CC	False	

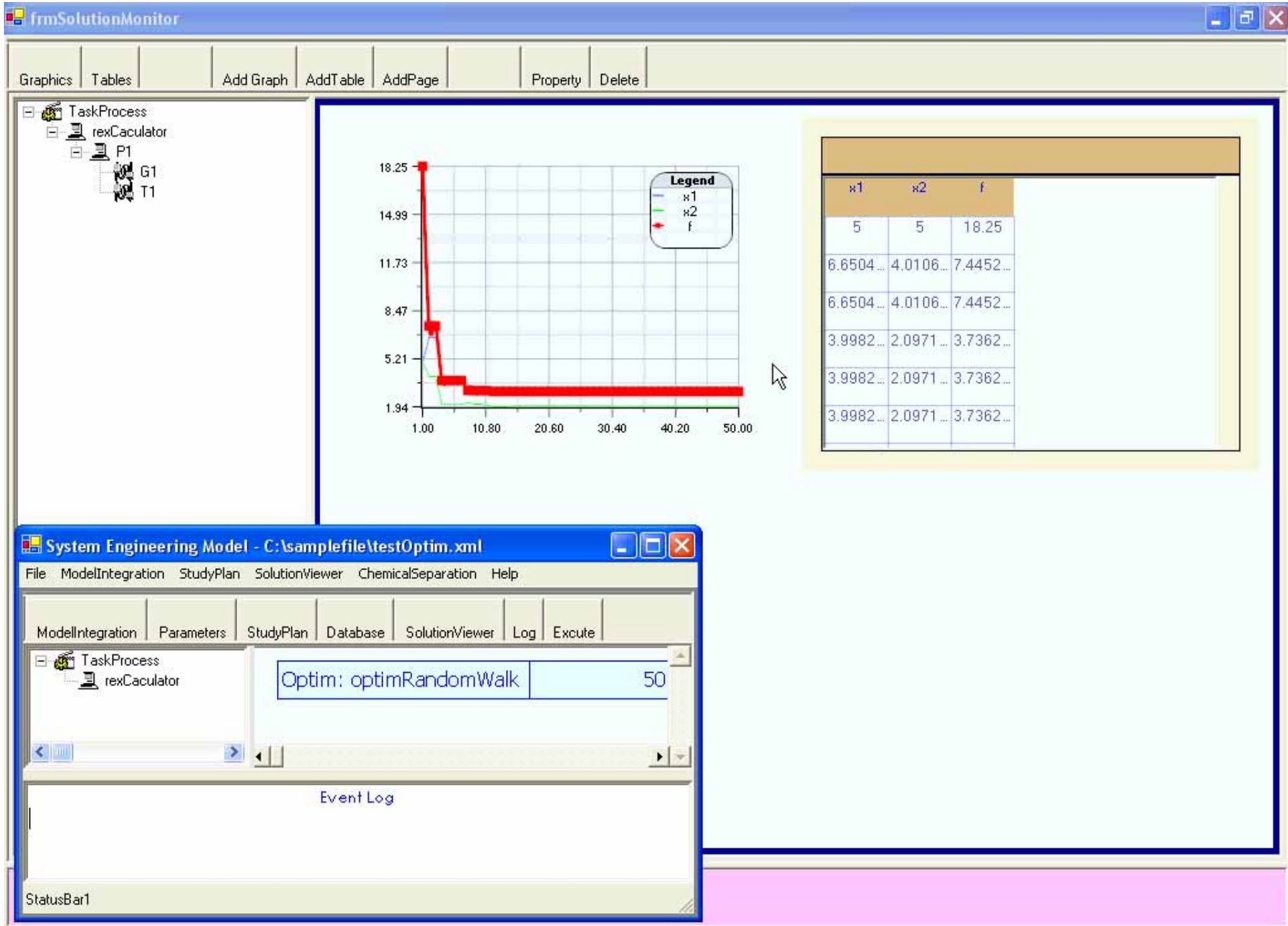
Section Table: Flowsheet Id= 031021-163624												
FS_ID	section_no	section_name	num_stages	frac_efficienc	QFAI	aq_feed_cl	QFOI	org_feed_cl	FEAI_input	aq_eff_cl	FEOI_input	org_eff_cl
031021-1636	1	extraction	8	0	200	F	250	X	1	W	0.9	P
031021-1636	2	strip	8	0	200	F	250	X	0.9	W	0.9	P
031021-1636	3	scrubf	8	0	200	S	250	X	0.9	W	1	P

Stage Table: Flowsheet Id = 031021-163624 Section No = 1				
FS_ID	section_no	stage_no	aq_sample_n	org_sample
031021-1636	1	1	DW	
031021-1636	1	2		
031021-1636	1	3		
031021-1636	1	4		
031021-1636	1	5		
031021-1636	1	6		
031021-1636	1	7		
031021-1636	1	8		DP

Stage Table: Flowsheet Id = 031021-163624 Section No = 1					
FS_ID	section_no	comp_name	aq_feed_conc	org_feed_conc	ini_DValue
031021-1636	1	A1	0.25	0.26	0
031021-1636	1	B1	0.25	0.26	0
031021-1636	1	C1	0.25	0.26	0
031021-1636	1	F1	0.25	0.26	0
031021-1636	1	H1	0.25	0.26	0

Close





System Engineering Model - C:\samplefile\testOptim.xml

File ModelIntegration StudyPlan SolutionViewer ChemicalSeparation Help

ModelIntegration Parameters StudyPlan Database SolutionViewer Log Excute

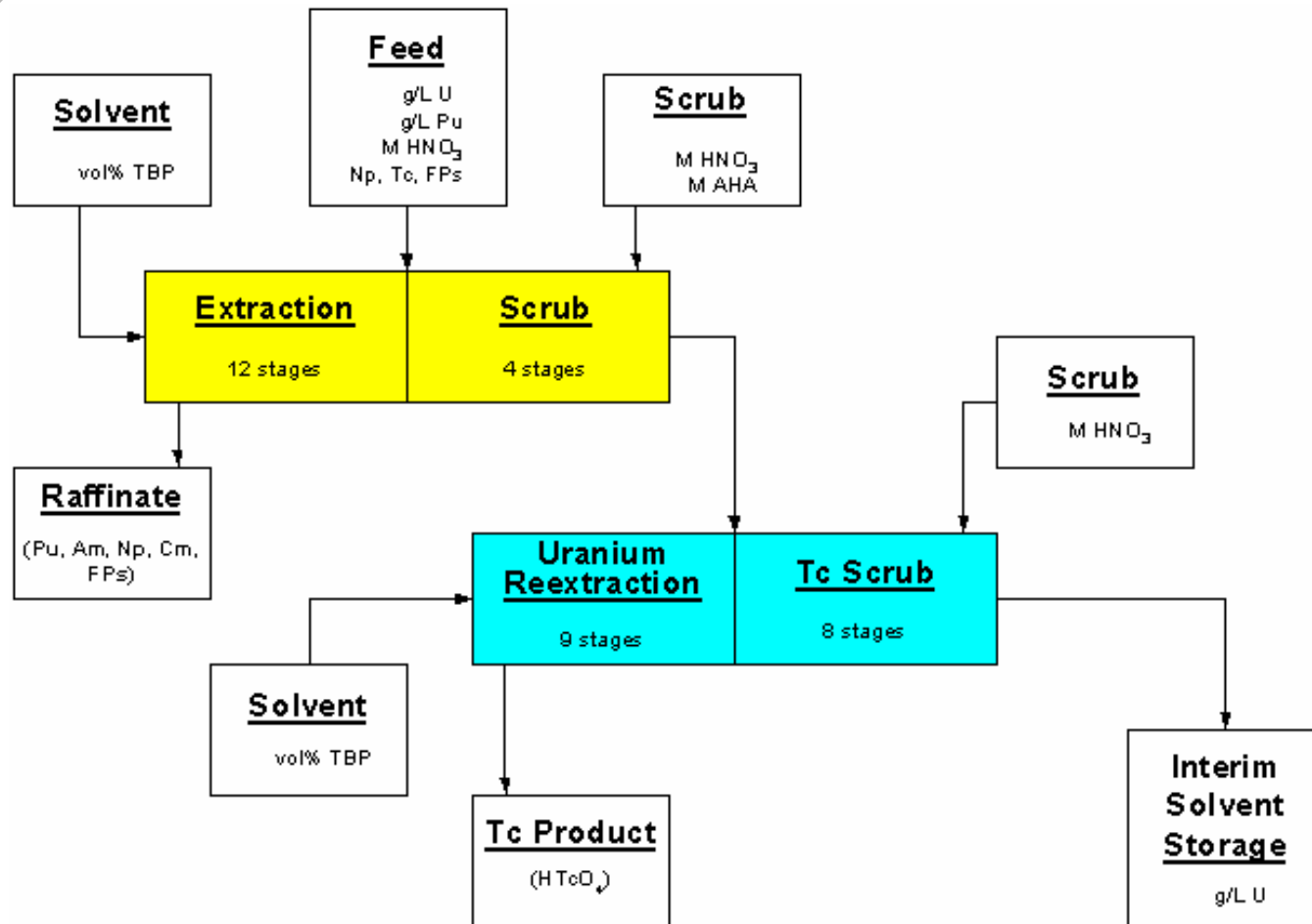
TaskProcess
 rexCalculator
 Optim: optimRandomWalk 50

Event Log

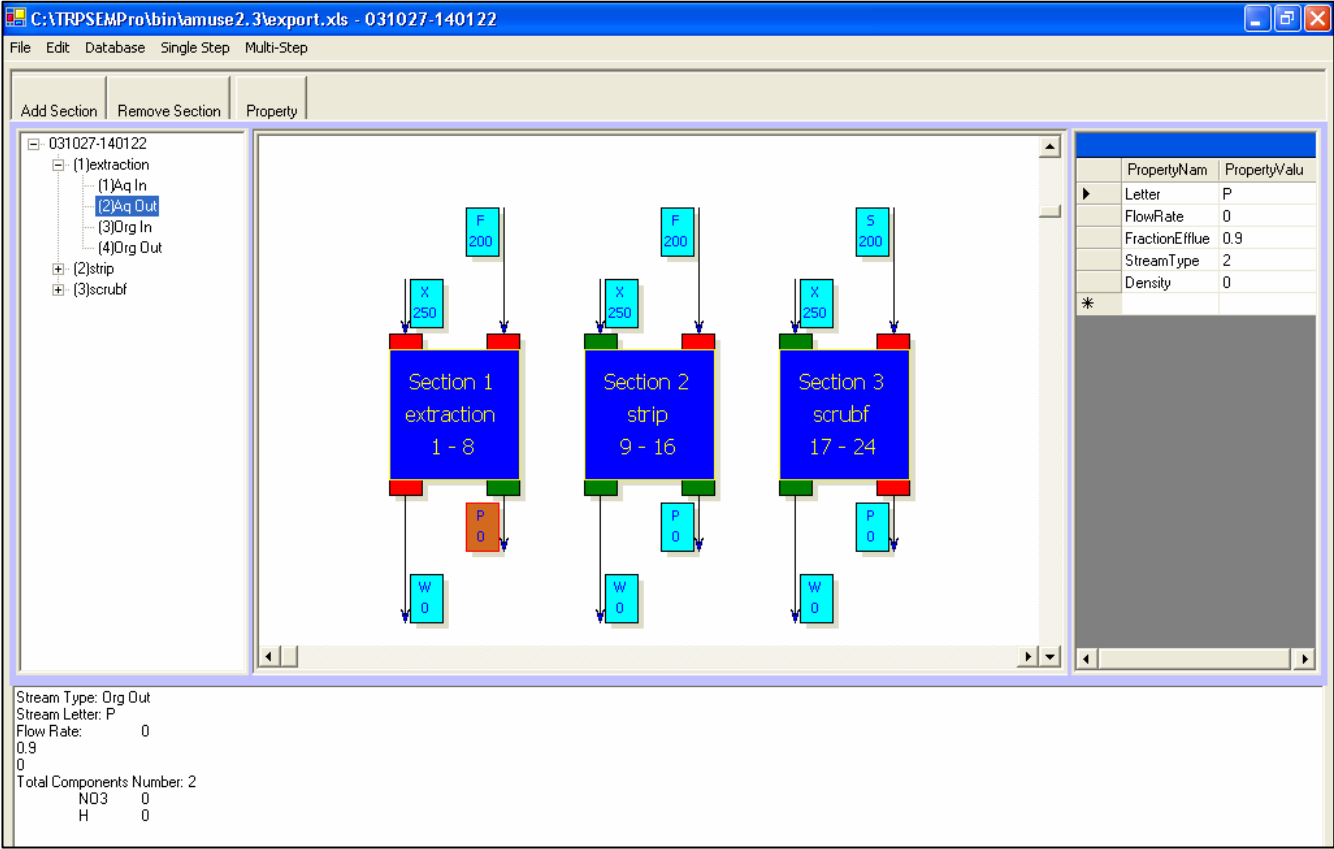
StatusBar1

System Demonstration – Chemical Separation Process Integration

-Glovebox Phase of UREX Process

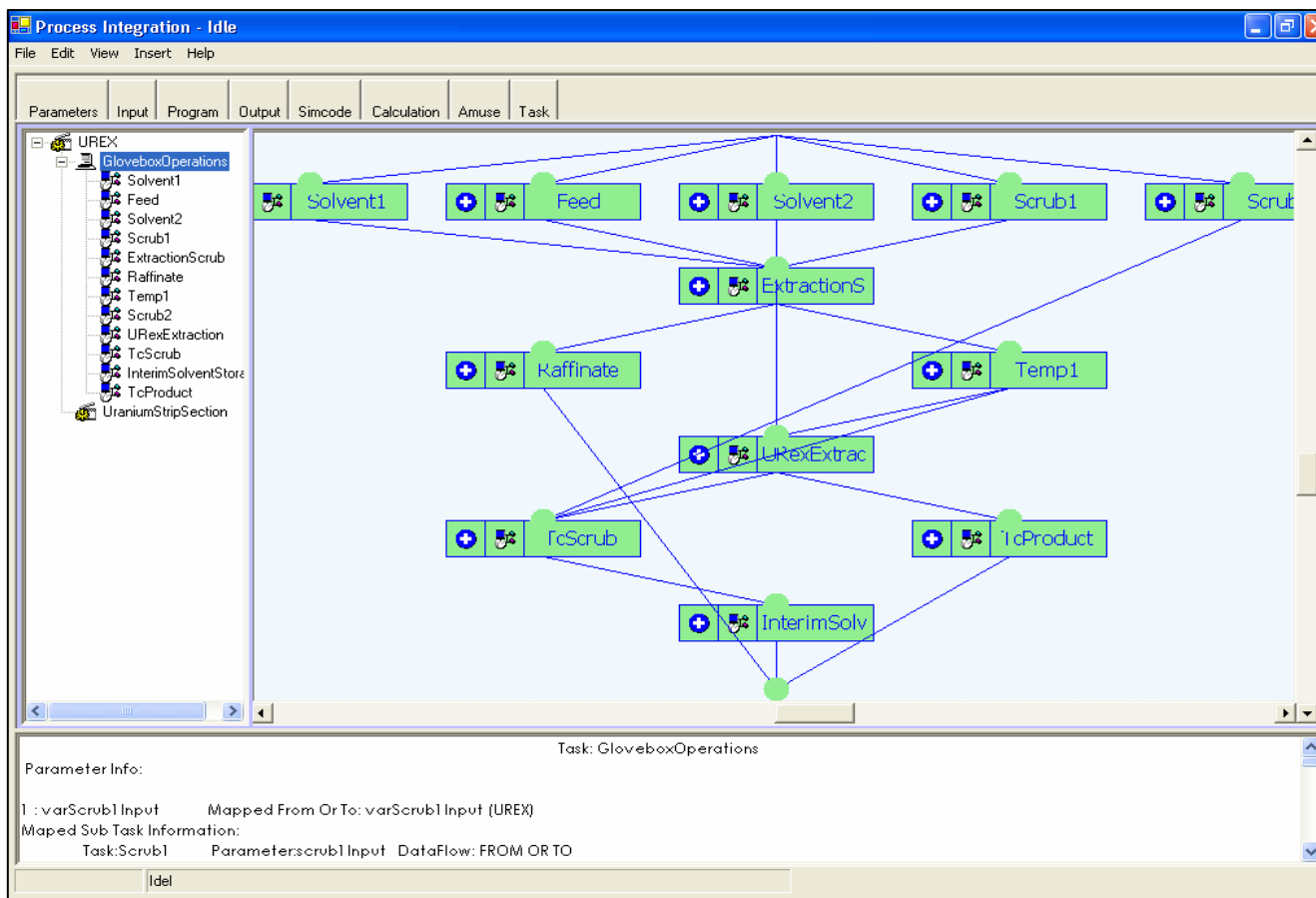


System Demonstration - AMUSESimulator



System Demonstration - Integration Result

- for Glovebox Phase of UREX Process



Conclusion and Future Work

- A general purposed systems engineering model, Transmutation Research Program System Engineering Model Project (TRPSEMPro), has been developed
- Couple simulation code from multiple disciplines
- Easy to setup design problems
- System Analysis Techniques
 - DOE (Design of Experiments) - study and explore design space
 - Optimization
- Provide Solution Viewer to view the design running results
- To study and develop more system analysis modules to strengthen the capability on solving complex chemical separation process.



Acknowledgements

Supports of this research from Transmutation Research Program - University Participation Program ([TRP-UPP](#)) /Department of Energy ([DOE](#)) and Argonne National Laboratory–East to the University of Nevada, Las Vegas are greatly appreciated.



Questions?