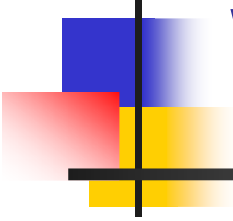


The Use of Simulation in the Management of Logistics in Large Scale Inventory Systems to Support Weapon System Maintenance



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and

Hank Grant, U of Oklahoma





Summary

- 400,000 bins of material
- Multiple Sites
- Varying part size
 - Rivets to wings
- Difficult to monitor and forecast
 - No “production” plan
 - Demand forecast based on approximation of inventory level
 - Empty – partial - full





Summary

- General autonomous bin simulation
- Agent based approach
- Data (File) Driven
- Interface with external software
- Bins simulated over 50 years of operation





Summary

- Underlying Simulation Technology
 - V1: GPSS model
 - V2: SLAM/AWESIM
- Simulation technology is transparent to the user





Integration of SLAM and SCOPTIMA™

- Automatically run simulation of Bin Q,r strategy to verify results
- Support SCOPTIMA decision making using simulation
 - Verification of Q,r changes when bin agent determines need for change
- “Agent” based approach
- Automated



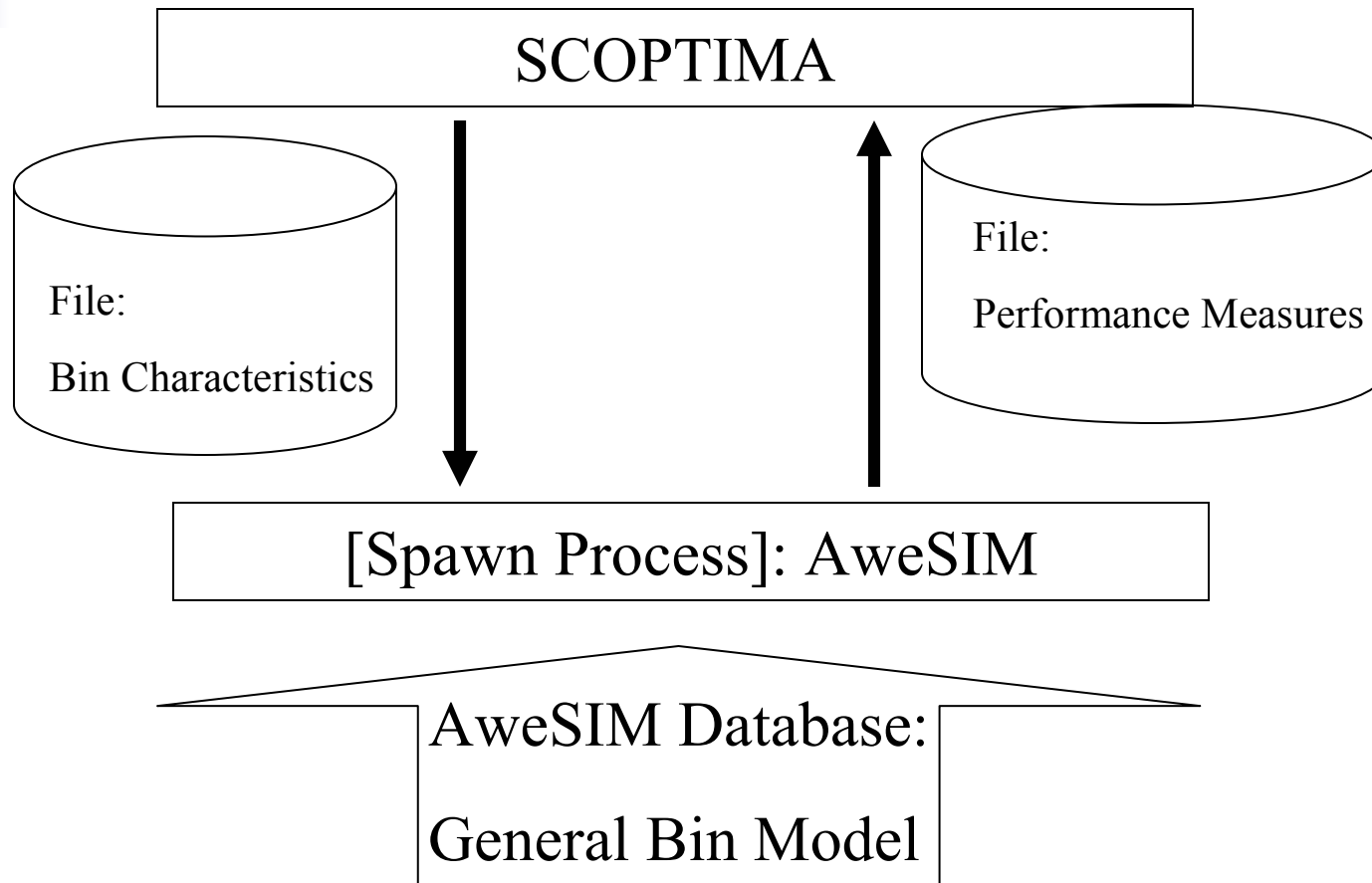


Integration

- Spawn process from SCOPTIMA to invoke AweSIM model
- Interface via Data Files or Database
- Results returned to SCOPTIMA via Data Files or Database



Architecture



Summary of Simulator Capabilities



- Individual Bins
- Multiple Bins
- Sensitivity Analysis
 - Demand Rate
 - Reorder Quantity and Reorder Point
 - Automatically runs multiple analyses



Summary of Simulator Capabilities



- Bin Transfer Evaluation
 - Evaluate best bin to use for transfer
- Demand Rate Profile
 - Demand Rate varies over time
 - Surge modeling





Inputs

- Text file
- Simulates any number of bins with any varying, or the same, attributes
- Uses Q, r values from optimization





Inputs

- Example data file

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	210	C069	88.00	95.00	7.60	22.80	0.55	3.28	3.12	1.00	50.00	150.00
5305003383288	150	A071	159.00	222.00	7.60	22.80	0.15	0.88	3.12	1.00	100.00	300.00

- This will automatically simulate two bins



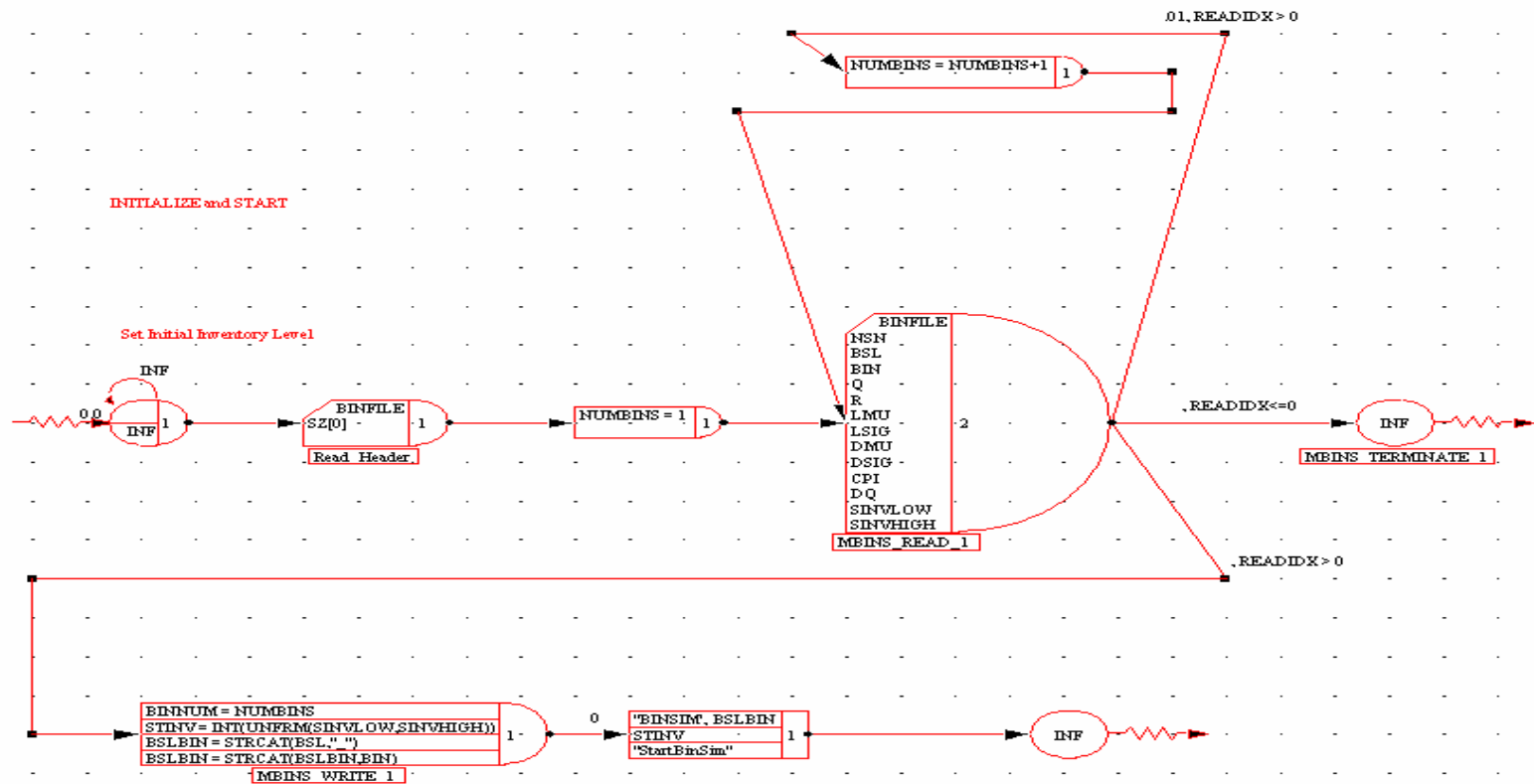


Models

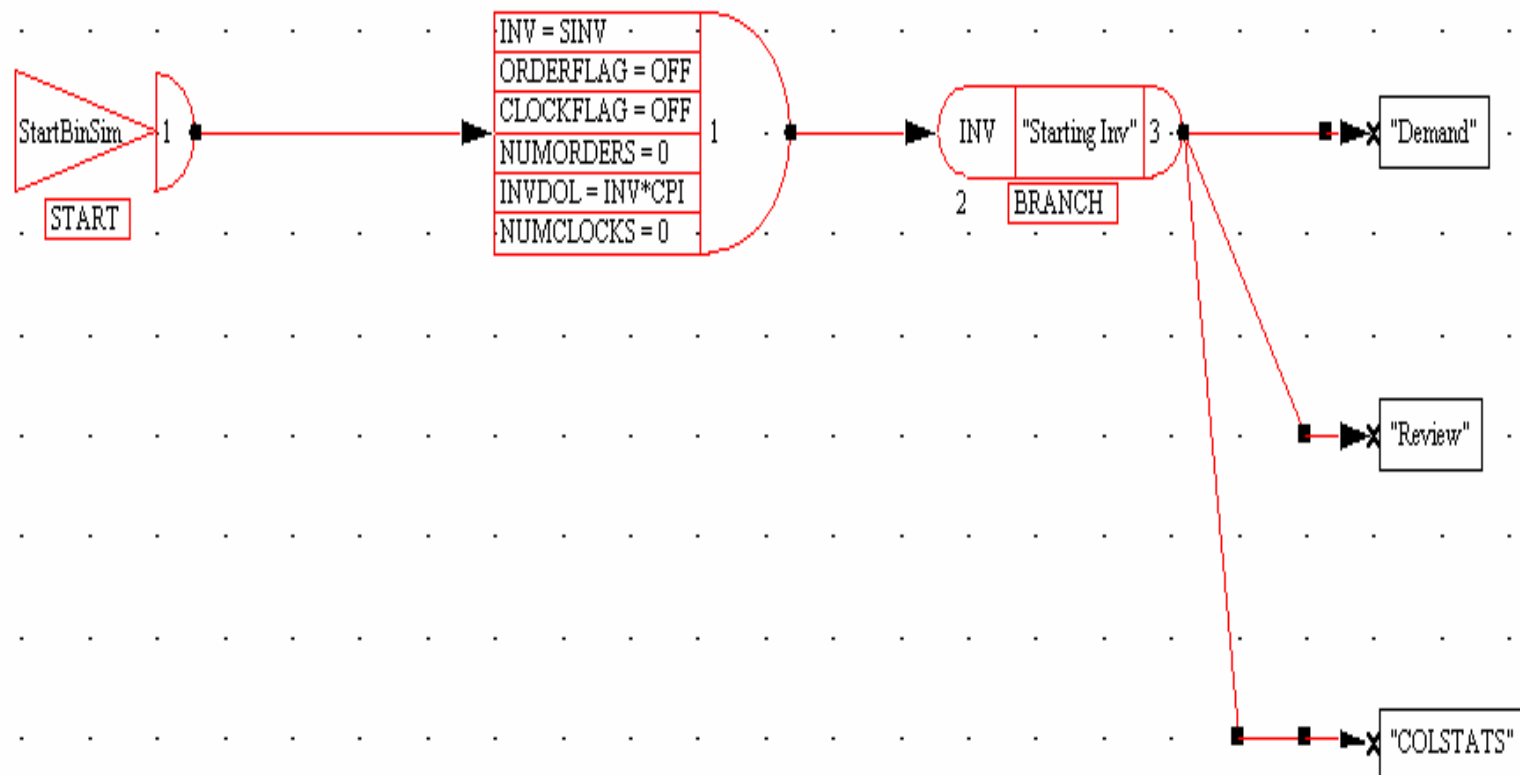
- Stage I
 - Read input and invoke bin agent to simulate operation
- Stage II
 - Simulate bin operation for each bin defined
 - Stage II replicated automatically for each bin



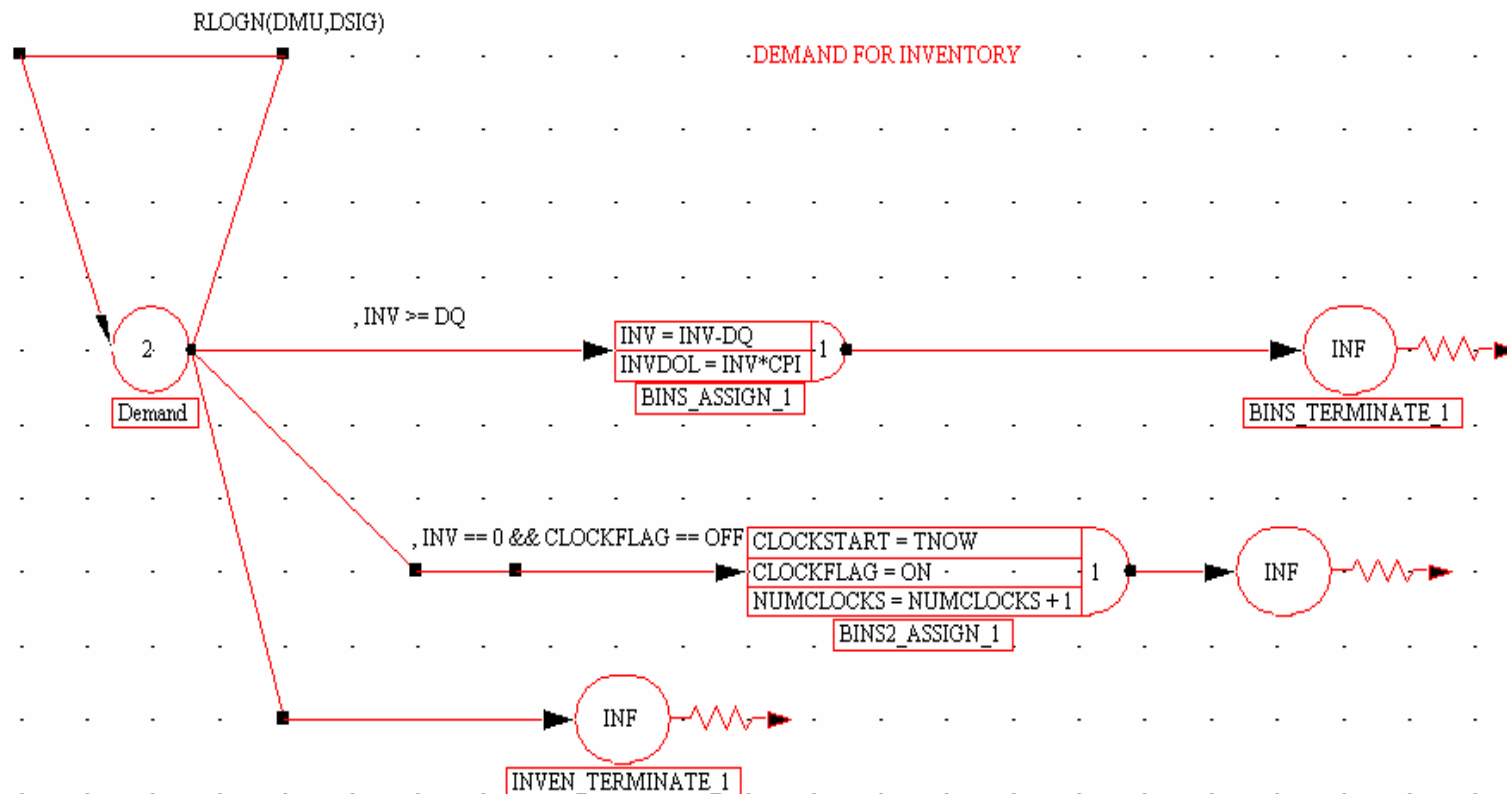
Models - Read Data and invoke bin agent/simulation (Stage I)



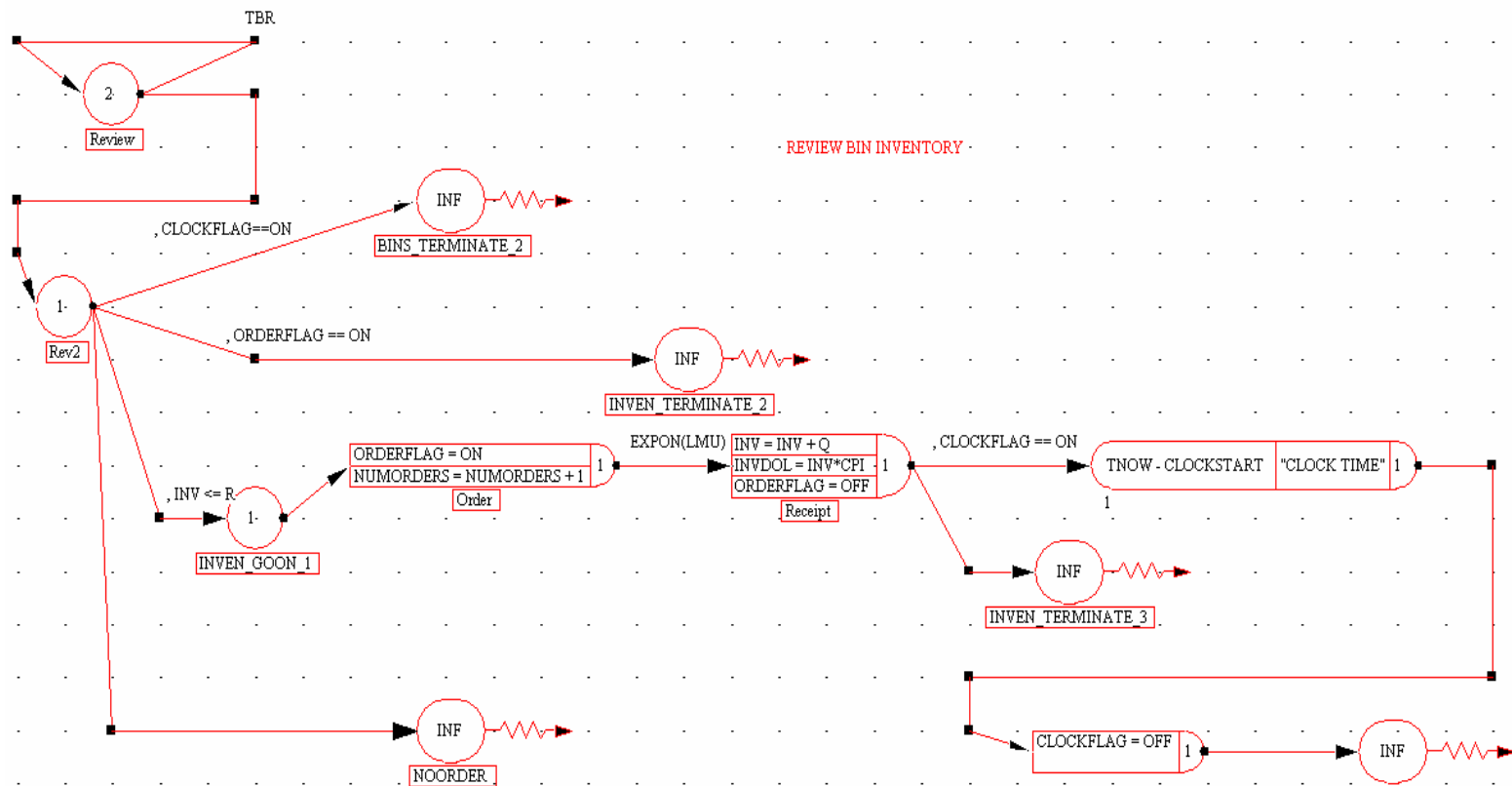
Models – Initialize Bin Agent(Stage II)



Models – Demand Agent(Stage II)

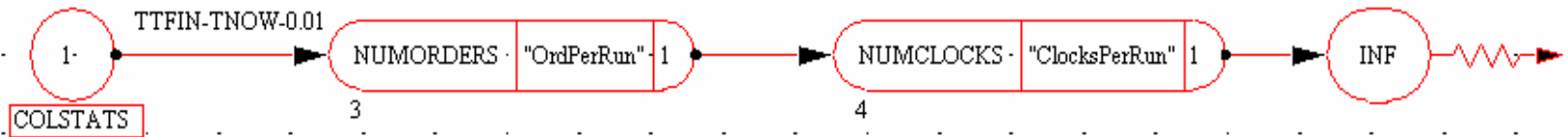


Models – Review Bin Agent(Stage II)



Models – Stat Collection Agent (Stage II)

Collect Stats on number of orders per run and clocks per run





Outputs

- Statistical collection for all Bin based performance measures
- Includes:
 - Clock Time
 - Orders per Run
 - Clocks per Run
 - Inventory
 - Inventory Cost
 - Service Level



Outputs – Example Report

(Produced for each Bin)

** AweSim! MULTIPLE RUN SUMMARY REPORT **

Subnetwork : BINSIM

Instance : 175_Y676

** OBSERVED STATISTICS for BINSIM 175_Y676 **

Label	Mean Value	Standard Deviation	Standard Error	Minimum Average Value	Maximum Average Value
CLOCK TIME	3.380	5.844	0.826	0.000	21.402
Starting Inv	386.020	240.490	34.010	3.000	691.000
OrdPerRun	15.200	0.670	0.095	14.000	17.000
ClocksPerRun	0.400	0.571	0.081	0.000	2.000

** TIME-PERSISTENT STATISTICS for BINSIM 175_Y676 **

Label	Mean Value	Standard Deviation	Standard Error	Minimum Value	Maximum Value
Bin Inventory	735.897	39.500	5.586	622.568	805.929
Service Rate	0.990	0.017	0.002	0.941	1.000
Inventory Value	1103.846	59.250	8.379	933.852	1208.894





Virtual Bin Consolidation

- Combine demand for groups of bins with the same NSN and calculate Q,r for group using optimization spreadsheet.
- Combines and reduces variance of multiple bin processes
- Calculate new demand parameters based on number of bins and bin details
- Simulated over 50 years of operation





Bin Consolidation – Case I

- Two Bins - Identical
- Separate:
 - $Q = 281$
 - $R = 303$
- Combined
 - $Q = 490$
 - $R = 557$



Bin Consolidation – Case I

Data Files

- Separate

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	176	Y677	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00

- Combined

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	490.00	557.00	7.67	10.58	0.05	0.14	1.50	1.00	0.00	700.00



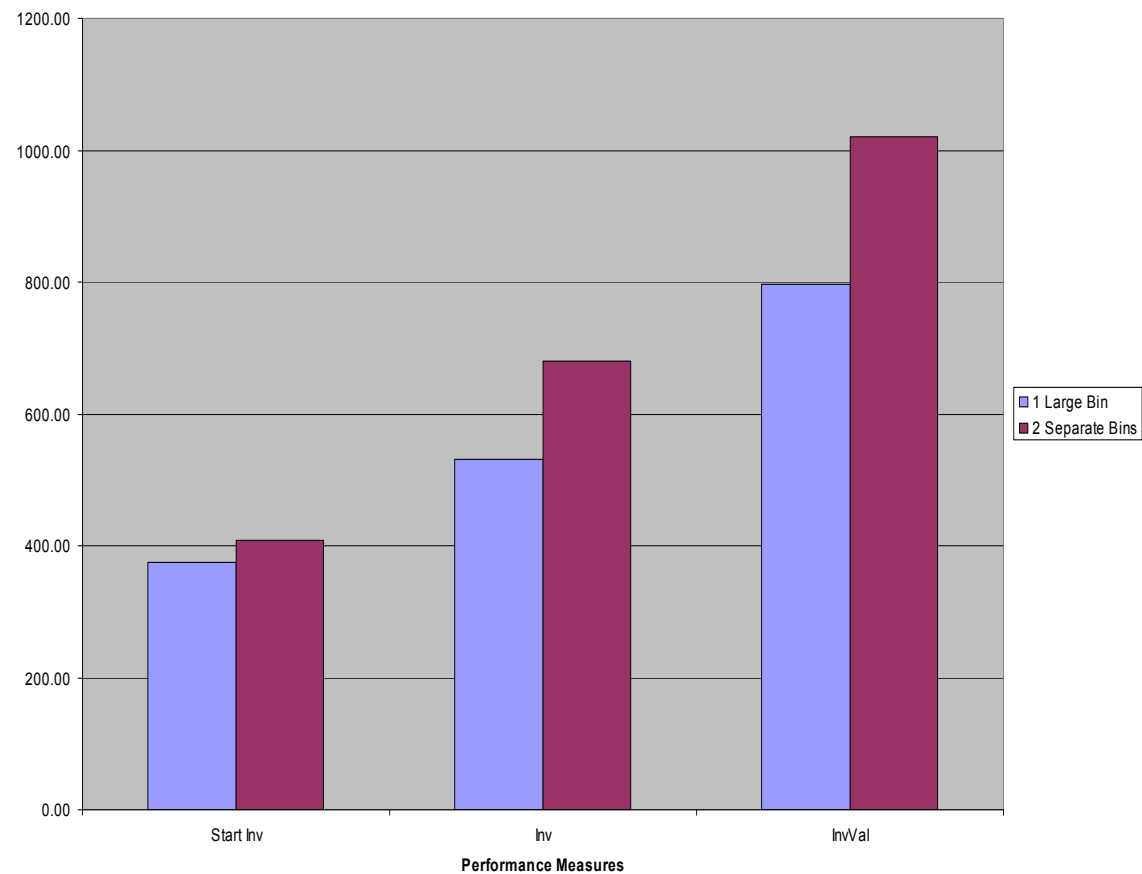


Results – Case I

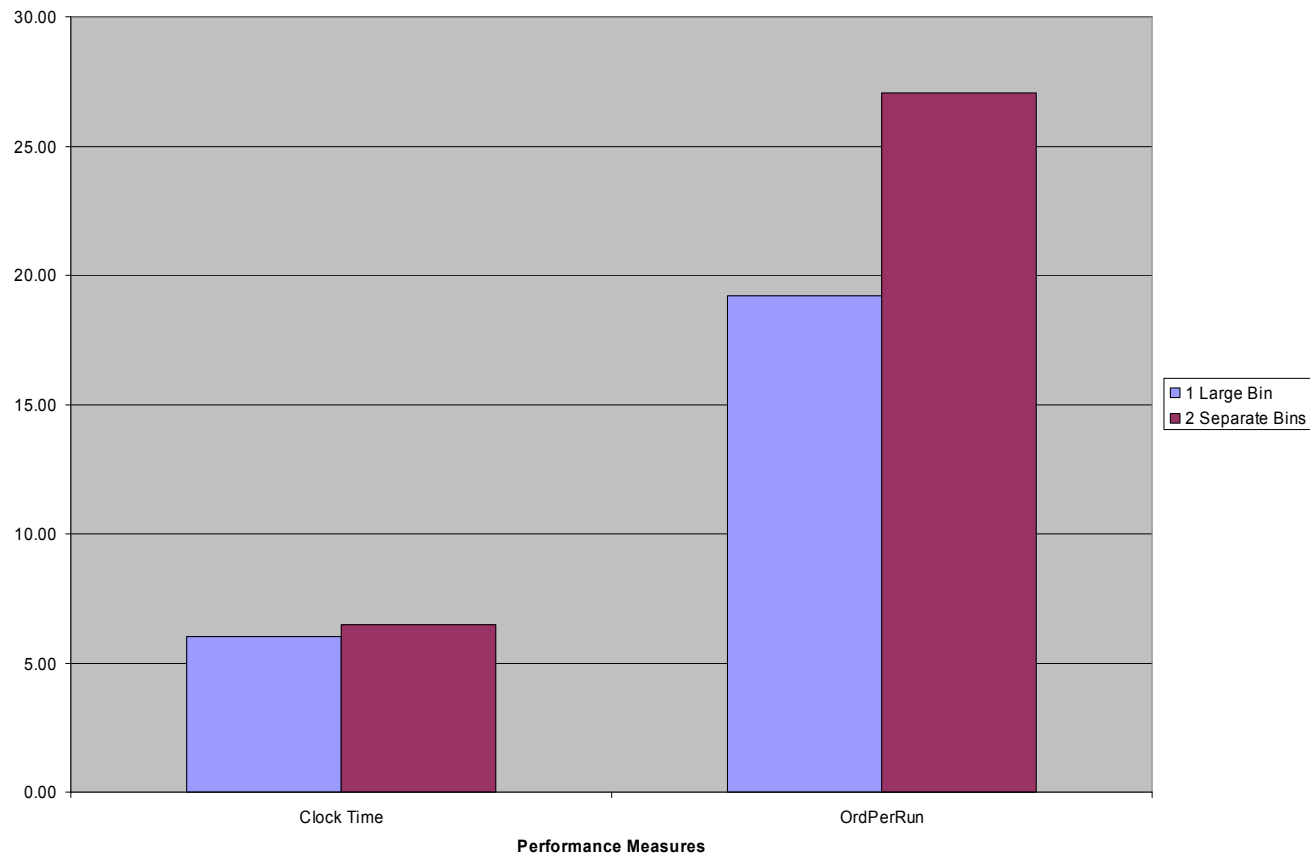
	1 Large Bin	2BINA	2BINB	2 Separate Bins
Start Inv	374.78	214.00	193.80	407.80
Inv	530.90	343.46	337.40	680.86
InvVal	796.35	515.19	506.11	1021.30
Clock Time	6.03	3.20	3.29	6.49
OrdPerRun	19.22	13.54	13.52	27.06
CLocksPerRun	0.96	0.54	0.46	1.00
Service Rate	0.98	0.99	0.97	0.98



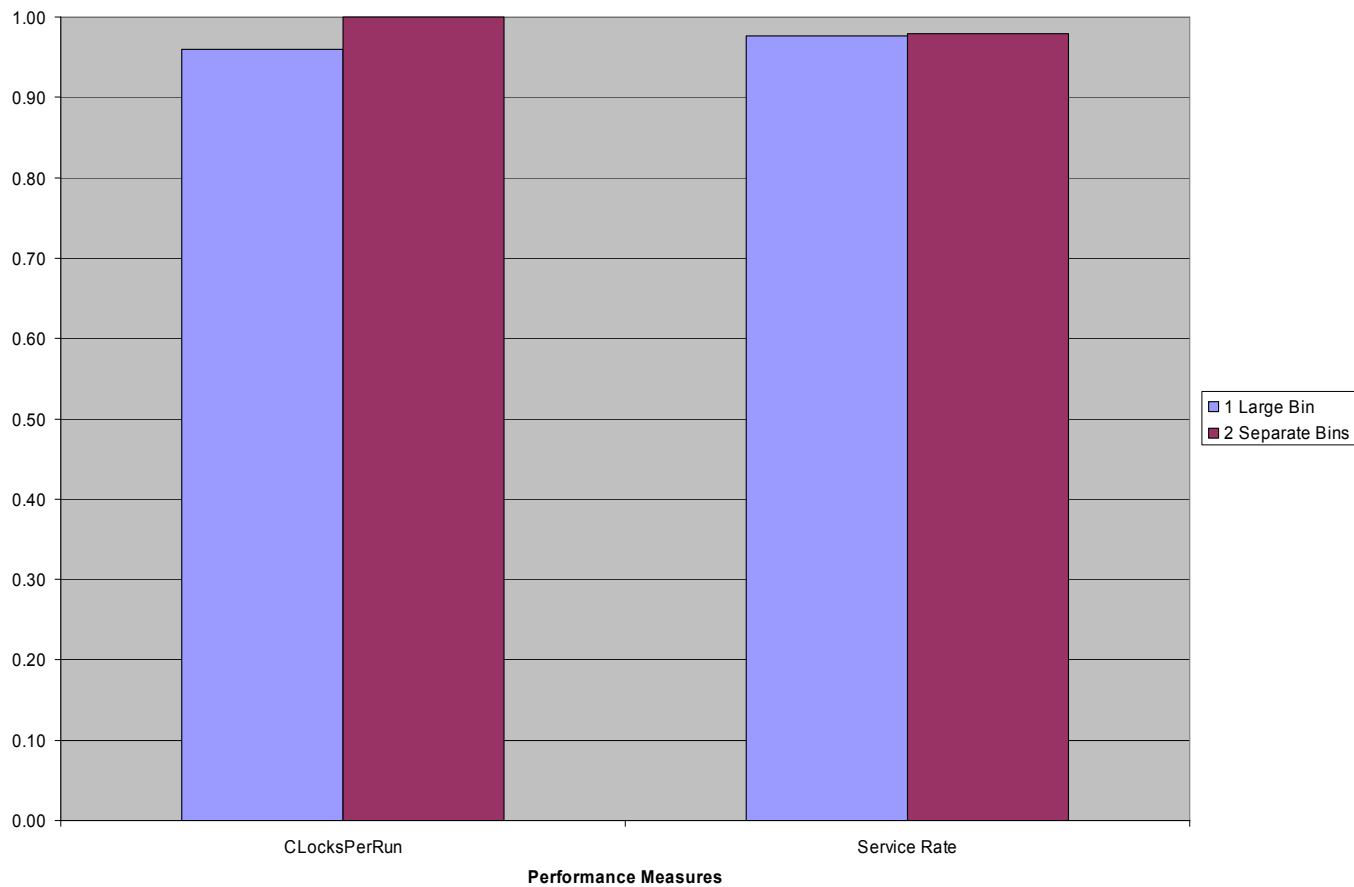
Results – Case I



Results – Case I



Results – Case I





Results – Case I

- Ordering over two bins reduces number of orders, inventory and costs, while increasing performance
- Even simple procedure is effective (managing group of bins as single bin)





Bin Consolidation – Case II

- Four Bins - Identical
- Separate:
 - $Q = 281$
 - $R = 303$
- Combined
 - $Q = 543$
 - $R = 1086$



Bin Consolidation – Case II Data Files

- Separate:

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	176	Y677	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	177	Y678	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00
5305003383288	178	Y679	281.00	303.00	7.67	10.58	0.10	0.20	1.50	1.00	0.00	427.00

- Combined

NSN	BSL	BIN	Q	R	LMU	LSIG	DMU	DSIG	CPI	DQ	SINVLOW	SINVHIGH
5305003383288	175	Y676	543.00	1086.00	7.67	10.58	0.03	0.04	1.50	1.00	0.00	1500.00

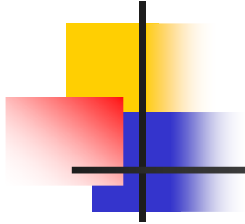




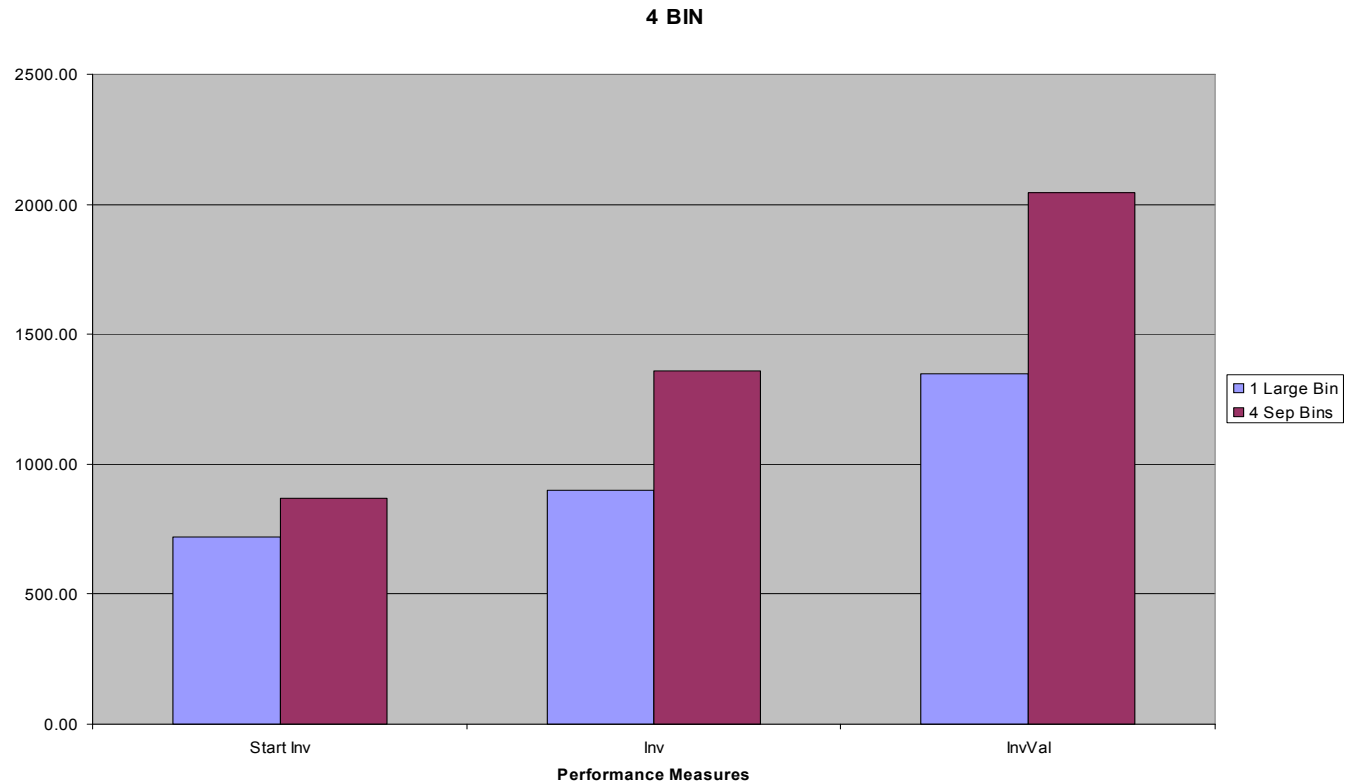
Results – Case II

	1 Large Bin	4BINA	4BINB	4BINC	4BIND	4 Sep Bins
Start Inv	719.00	200.000	231.000	221.000	217.000	869.000
Inv	898.00	340.000	344.000	336.000	341.000	1361.000
InWal	1348.00	511.000	516.000	504.000	512.000	2043.000
Clock Time	6.00	4.600	2.600	2.700	2.700	12.600
OrdPerRun	27.00	13.500	13.600	13.400	13.600	54.100
CLocksPerRun	1.40	0.560	0.058	0.520	0.660	1.798
Service Rate	0.968	0.986	0.991	0.971	0.989	0.984



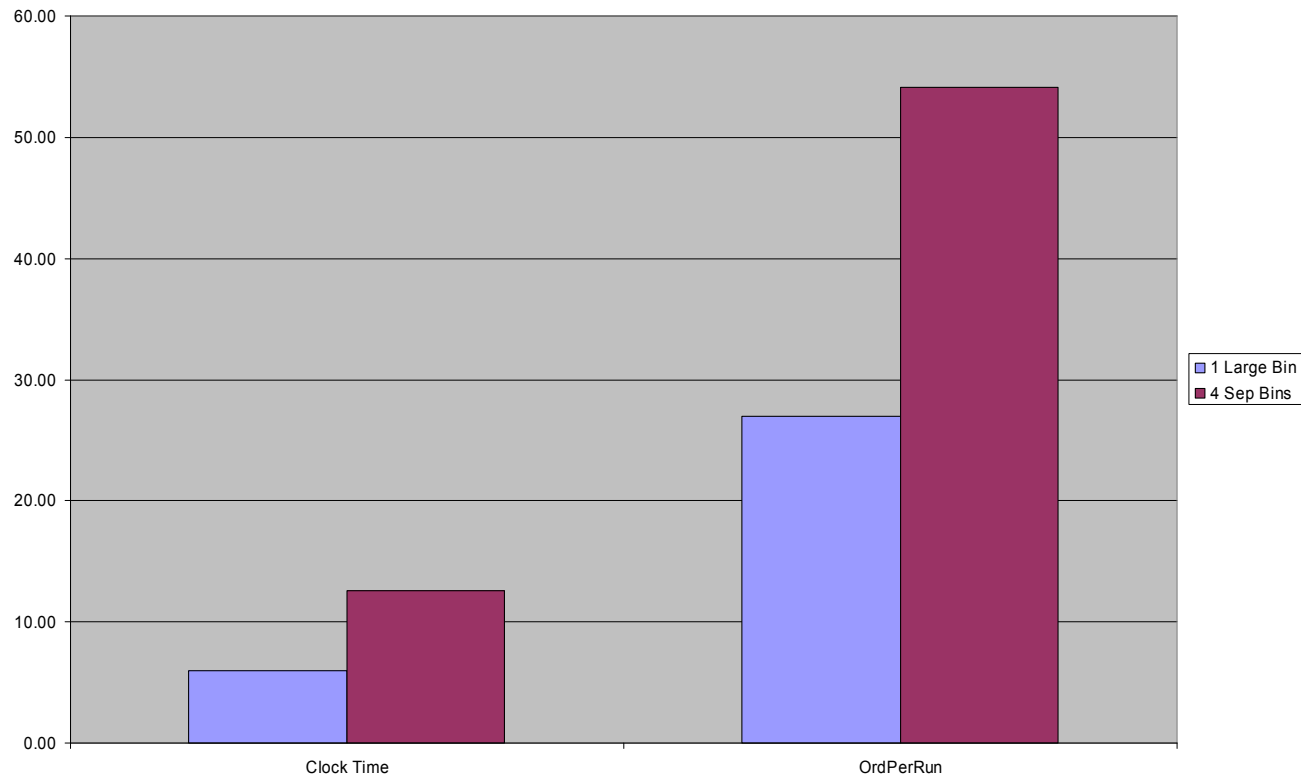


Results – Case II



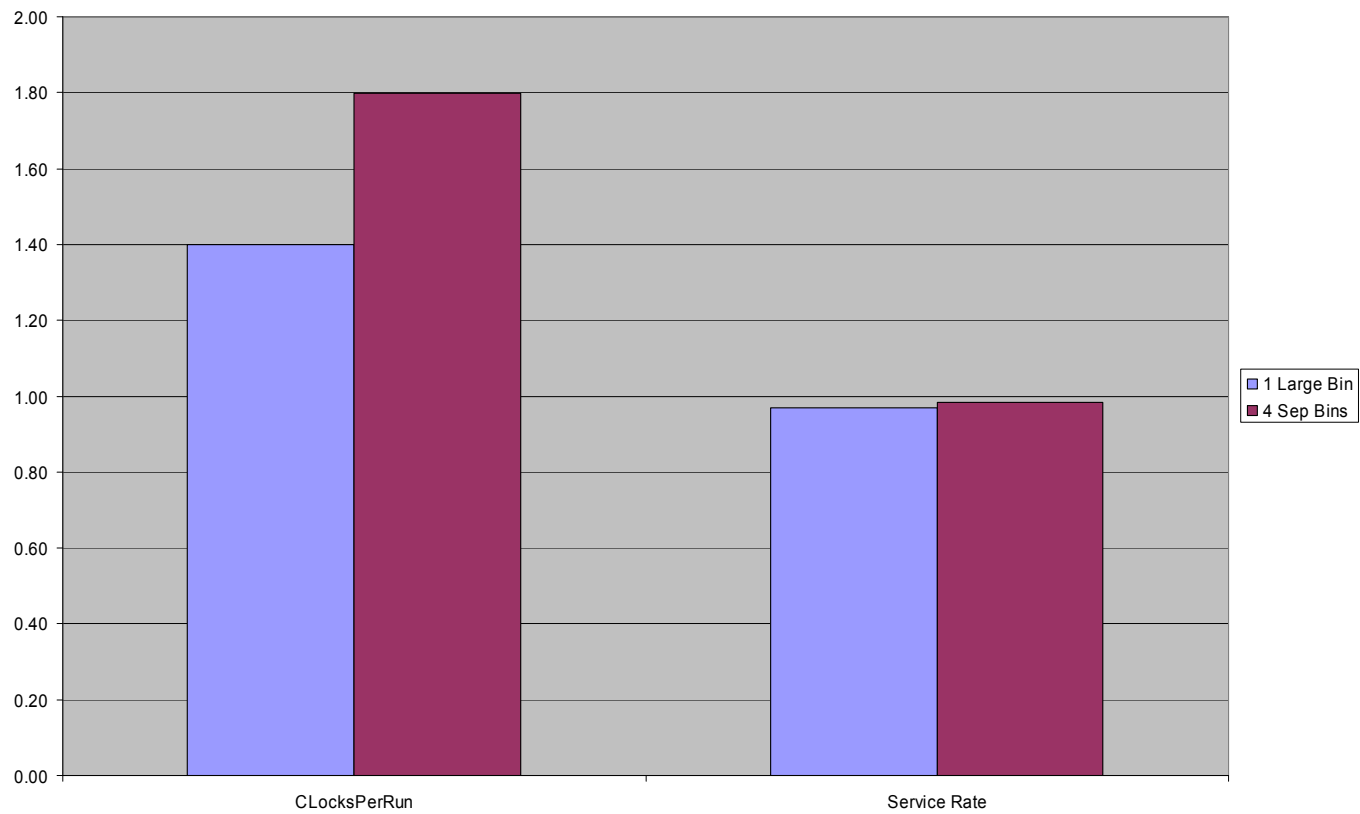
Results – Case II

4 BIN



Results – Case II

4 BIN



Bin Consolidation – Case I I- Results

- Ordering over 4 bins is even more effective in reducing variance of bin management process and reducing inventory/increasing service rate





Conclusions

- Simulation has proved to be an effective tool in managing large scale inventory systems
 - Good Forecasting tool
 - Good analysis tool
 - Can be made transparent to non-technical users





Dr. Hank Grant

Dr. Grant joined the faculty at the University of Oklahoma in December of 1993 as Director of the School of Industrial Engineering and Southwestern Bell Professor. He is currently Director of the Center for the Study of Wireless Electromagnetic Compatibility and Dugan Professor of Industrial Engineering. Prior to joining the University of Oklahoma, he was with the National Science Foundation in Washington, DC, where he directed programs in Production Systems, Engineering Design, and Operations Research. Dr. Grant was instrumental in the startup and development of two Industrial Engineering software companies: Pritsker Corporation and FACTROL. Dr. Grant is a Fellow of the Institute of Industrial Engineers and is a member of the following societies: INFORMS, Tau Beta Pi and The Institute of American Entrepreneurs. Dr. Grant received his Ph.D. from Purdue University in Industrial Engineering in 1980.





Eugene Beardslee

Eugene Beardslee is the software system architect of the Industrial Prime Vendor (IPV) project's enterprise system: SCOPTIMA Supply Chain Software. For the past five years, Mr. Beardslee has managed and directed the design, development, implementation and maintenance of all aspects of this logistics support software. Recipient of the 2003 SAIC Achievement Award for Excellence in Program Performance: Technology Development and Analysis, he has guided three successful Manufacturing Production and Engineering research projects focused on improved inventory and replenishment process performance. Mr. Beardslee has over 18 years experience in the production of software systems with over 12 years designing Oracle software systems. He is a member of the IEEE Computer Society, the Association for Computing Machinery and the Institute of Industrial Engineers. Mr. Beardslee received his Bachelor of Science degree in Computer Science in 1988, and his Master of Arts in Computer Resources and Information Management in 1997.

