

**DEPARTAMENTO DE SISTEMAS INFORMÁTICOS Y
COMPUTACIÓN**

UNIVERSIDAD POLITÉCNICA DE VALENCIA

P.O. Box: 22012 E-46071 Valencia (SPAIN)



Informe Técnico / Technical Report

Technical Report of an Extended Manufacturing Simulation Survey

Nancy Ruiz, Adriana Giret, Vicent Botti,
Department of Informatics Systems and Computing
Polytechnic University of Valencia
Valencia 46022, Spain
nruiz@dsic.upv.es, agiret@dsic.upv.es, vbotti@dsic.upv.es

Abstract

1. Figures

List of Figures

1	Discrete Event Simulation Tools (1)	6
2	Discrete Event Simulation Tools (1a)	7
3	Discrete Event Simulation Tools (2)	8
4	Discrete Event Simulation Tools (2a)	9
5	Discrete Event Simulation Tools (3)	10
6	Discrete Event Simulation Tools (3a)	11
7	Discrete Event Simulation Tools (4)	12
8	Discrete Event Simulation Tools (4a)	13
9	Geometrical Simulation Tools (1)	14
10	Geometrical Simulation Tools (2)	15

2. Introduction

Simulation Tools are useful to introduce "what if" event suddenly appear into the system and observe system reaction from different points of view. The observation allows the user detect problems and possible opportunities areas to improve the system operation at areas such as cost reduction, better product quality, and resources utilization without any risk.

Strategic manufacturing is a topic introduced by Steve Brown in [9] that is described as "*viewing production operations capabilities as a core competence, having a long term view of the business, being fully aware of all market opportunities, planning strategies to outperform competitors by targeting sectors in which it can compete while deliberately avoiding those in which it cannot, and engage in horizontal and vertical partnerships*". Based on characteristics of Strategic manufacturing such as product innovations, materials managements, process technology, and human resources, some researches [20] contend that manufacturing simulation should be treated as a key component of strategic manufacturing.

The goal of this report is update a existing survey of simulation tools for computer-aided production engineering and incorporate additional basic information that be useful to know which of them are according the requirements of "new manufacturing". Our hypothesis is that the simulation tools that provide more functionalities related to requirements of "new manufacturing" will be better options to improve simulation of manufacturing environment instead tools that not offer them.

3. Manufacturing and Simulation

Due to there are no standard features that allows the user select the better manufacturing simulation tool according its needs, in this report we collect key information detected by some researchers to study current simulation tools and was taken into account that manufacturing simulation applications include [20]: modeling and verification of discrete and continuous manufacturing process, offline programming of robots and other machinery, site selection, layout planning, process and system visualizations, ergonomic analysis of manual tasks and work area layout, evaluation of scheduling algorithm and dispatching rules, and business process engineering.

Then, we take into account to the evaluation two applications related to a high level of abstraction: modeling and physical topics such as: modeling and verification of discrete and continuous manufacturing process, and offline programming of robots and other machinery. According to this applications, the survey is based mainly on an established criteria by Klingstam et al in [16] to evaluate manufacturing process and physical elements programming, that means that we evaluate Discrete Event, Geometrical separately; we include Continuous Event Simulation tools at a new classification. Due to our goal is identified simulation tools focused at its application on manufacturing, we include into the survey, the criteria of requirements for next generation manufacturing systems presented by Shen in [22] such as: Enterprise Integration, Distributed Organization, Heterogeneous Environments, Interoperability, Open and Dynamic Structure, Cooperation, Integration of humans with software and hardware, Agility, Scalability, and Fault Tolerant.

Moreover, there are variety of criteria applied to evaluate features of simulation software. Thus, some researchers like Banks in [4, 6, 5, 7], Breedam in [8], Davis in [10], Holder in [15], Kochlar in [17], Law in [1, 2, 3], Mackulak in [19], Hlupic in [12, 13, 14], Kuljis in [18], and Nikoukaran in [21] have proposed a list of features to evaluate simulation software, from different points of view.

Our survey extension was performed based on the following steps:

- a) **Spreadsheet Construction:** Incorporate next generation manufacturing requirements to Klingstam evaluation spreadsheet.
- b) **Information Update:** Update information about current tools of the base survey.
- c) **Tools Addition:** Search current available manufacturing simulation tools and incorporate them into the spreadsheet.
- d) **Tools Evaluation:** Evaluate new tools according Klingstam features and manufacturing requirements.

The evaluation includes some of the most representative simulation tools that are offered at market.

4. Evaluation of Manufacturing Simulation Tools

Following defined steps at Section 3 are detailed as follows:

a) *Spreadsheet Construction*

Due to associated features to Discrete and Continuous Event, and Geometrical simulation tools are different. The evaluation are divided into three different tables. Due to the Continuous simulation tools include continuous, discrete and can include geometrical simulation, we have called this new type as Mixed Simulation Tools.

Then, due the related features to each one of the types of Simulation Tools are different, the features that we have take into account to the evaluation are shown in Table 1:

b) *Information Update*

The information of simulation tools included at original survey of Kligstam was updated by verifying features on their web internet pages as well as by their vendor contact electronical address. Some of them have been bought by other companies, has changed their name, or have been incorporated into other simulation tool has an extramodule. For example [11], Flexsim was founded in 1993 by Bill Nordgren (Co-Founder Promodel Corporation, 1988), Roger Hullinger, and Cliff King. Initially the company was named F&H Simulations, Inc. and sold, supported, and conducted training courses for Taylor II simulation software in North America. In 1998, F&H Simulation B.V. in Holland developed the first generation 3D object oriented simulation engine called Taylor ED (Enterprise Dynamics). F&H Simulations, Inc. assisted in this development by developing robust objects for use in Taylor ED, and continued to sell, consult, and train in the new software. In 2000, F&H

<i>Features</i>	<i>Tools Classification</i>		
	Discrete Event	Geometrical Event	Mixed
Extramodules	Yes	No	
Specific Application modules	No	Yes	
Manufacturing Application	Yes	Yes	
Hardware platform	Yes	Yes	
Software platform	Yes	Yes	
User Interface	Yes	Yes	
Integration Interface	Yes	Yes	
Programming Language	Yes	Yes	
Shop-floor integration	Yes	Yes	
Reporting possibilities	Yes	Yes	
Ling GS software	Yes	No	
Robot language support	No	Yes	
Other features	Yes	Yes	
Enterprise Integration	Yes	No	
Distributed Organization	Yes	No	
Application at Heterogeneous Environments	Yes	No	
Interoperativity	Yes	No	
Open and Dynamic Structure	Yes	No	
Cooperation	Yes	No	
Integration of humans	Yes	No	
Agility	Yes	No	
Scalability	Yes	No	
Fault tolerant	Yes	No	
Vendor contact	Yes	Yes	
Home page	Yes	Yes	

Table 1. Features to Evaluate

Simulations B.V. was purchased by a Dutch consulting company. At this time F&H Simulations, Inc. became independent. Dr. Eamonn Lavery was brought on to oversee product architecture and begin development of a new, second generation, 3D object oriented simulation software called Flexsim. F&H Simulations, Inc. changed its name to Flexsim Software Products Inc. Flexsim simulation software was released in February 2003. Simple++ is a tool of Aesop company that was acquired by Tecnomatrix[23] (a comprehensive portfolio of digital manufacturing solutions, is built on an open product lifecycle management (PLM) foundation called the Teamcenter) of UGS company and its name was changed to eM-Plant. There are no available any information related to Robot Simulations Company manufacturer of Workspace4. Factor/Aim information can not be updated because Wintek company do not provide information about it. The web address Rosl company owner of Workspace4 is not available today, so we can not update its information.

The final results of the initial list of simulation tools updating are incorporated into the detailed tables of step (d).

c) Tools Addition

After our searching the found some additional representative related to each type of tools, as follows:

Discrete Event simulation tools: Dosimis3, Taylor ED(Enterprise Dynamics), GPSS/H, G2-Rethink, MMS, Scheduling, Ses/Workbech, ShowFlow, SIMASII, SimBax, SimFlex, SimProcess, SIMUL8, SLX, and Spar.

Geometrical simulation tools: AMESim, Delmia, FoCs, HCADWin, ITI-SIM, ProDyn, Simplorer, Softmachines and UniversalMechanism.

Mixed Event simulation tools: AweSim, MLDesigner, SimcriptII.5, 3DCreate, and gProms.

d) Tools Evaluation

According available information related to the simulation tools identified, we extract and relate the information to the specified features. Due some information was no available or was incomplete, some of the features rows still in blank. The detailed information related to Discrete Event, Geometrical and Mixed Simulation tools is shown according list of figures in Section 1.

5. Conclusion

6 Acknowledges

We send our gratitude to every owner of each tool who have contributed with information to the simulation tools survey.

References

- [1] A.M.Law and S. Haider. Selecting simulation software for manufacturing applications:practical guidelines and software survey. *Industrial Engineering*, 34, 1989.
- [2] A.M.Law and W. Kelton. *Simulation Modelling Analysis*. McGraw-Hill, 1991.
- [3] A.M.Law and M. McGomas. How to select simulation software for manufacturing applications. *Industrial Engineering*, 24(7):29–35, 1992.
- [4] J. Banks. Selecting simulation software. In *The 1991 Winter Simulation Conference*, pages 15–20, 1991.
- [5] J. Banks. Interpreting simulation software checklist. *ORMS Today*, 22(3):74–78, 1996.
- [6] J. Banks and et. al. The simulator: new member of the simulation family. *Interfaces*, 21(2):76–86, 1991.
- [7] J. Banks and J.S.Carson. *Discrete Event System Simulation*. Prentice-Hall,Englewood Cliffs,N.J., 1996.
- [8] A. Breedam, J. Raes, and K. Velde. Segmenting the simulation software market. *OR Insight*, 3(2):9–12, 1990.
- [9] S. Brown. *Strategic Manufacturing for Competitiveness Advantage, Transforming Operations From Shop Floor to Strategy*. Prentice Hall, London, 1996.
- [10] L. Davis and G. Williams. Evaluation and selecting simulation software using the analitic hierarchy process. *Integrating Manufacturing Systems*, 5(1):23–32, 1994.
- [11] I. Flexim Software Products. <http://flexsim.com/company/about/>, supervised by march 2006.
- [12] V. Hlupic. Simulation software selection using simselect. *Simulation*, 69(4):231–239, 1997.
- [13] V. Hlupic and R. Paul. A critical evaluation of four manufatcuring simulators. *International Journal of Production Research*, 33(10):2757–2766, 1995.
- [14] V. Hlupic and R. Paul. Simulation software in manufacturing environments: a users’ survey. *Journal of Computing and Information Technology - CIT*, 1(3):205–212, 1995.
- [15] K. Holder. Selecting simulation software. *OR Insight*, 3(4):19–24, 1990.
- [16] P. Klingstam and P. Gullander. Overview simulation tools for computer-aided product engineering. 38, 1999.
- [17] A. Kochhar. Computer simulation of manufacturing systems - 3 decades of progress. In *Proc. of the third European Simulation Congress*, pages 3–9, Edinburgh,UK, 1989.
- [18] J. Kuljis. Hci and simulation packages. In *Proc. of the 1996 Winter Simulation Conference*, pages 687–694, California,USA, 1996.
- [19] G. Mackulak, P. Savory, and J. Cochran. Aserntaining important features for industrial simulation environments. *Simulation*, 63, 1994.
- [20] C. MCLean and S. Leong. The expanding role of simulation in future manufacturing. 2002.
- [21] J. Nikoukaran, V. Hulpic, and R. J. Paul. A hierachical framework for evaluating simulation software. *Simulation Practice and Theory*, 7(3):219–231, May 1999.
- [22] W. Shen and D. H. Norrie. Agent-based systems for intelligent manufacturing: A state-of-art survey. 1(2):139–156, 1999.
- [23] UGS. <http://www.ugs.com/products/tecnomatix/>, supervised by march 2006.

Overview of discrete event simulation software tools					
	Extend	Factor/Min	MicroSaint	ProModel	Quest
<p>Atena</p> <p>MPsim: manufacturing, Preactor: finite capacity scheduling, BPSimulator: BPR, Extend+Manufacturing Extend+BPR, Grapher, Gantt Charts</p>					
Extramodules		Executive: Batch simulator, Reporter & Grapher, Gantt Charts	Action View: 2D animation tool	Shifts: work and break schedules SimRunner: optimisation software StatFit	Derebergo human modelling and simulation Witness Optimizer: Witness VR
Manufacturing Application	Material Flow analysis, Information flow analysis	Manufacturing Decision support	Material flow analysis Manufacturing systems analysis	Material Flow analysis, Manufacturing system analysis	Material flow analysis, Manufacturing system analysis
Hardware platform	PC	PC	SGI/Sun, Macintosh, PC	PC	DEC, HP, IBM, Inetgraph, SGI, Sun, PC
Software platform	Windows	Windows	UNIX, MacOS, Windows, OS/2	Windows98 SE, XP, 2000	UNIX, Windows
User Interface	Menu bars, icon panels, dialog boxes, 2-D animation	Windows Style, icon toolbars, dialog boxes, 2D animation	Menu bars, icon panels, dialog boxes, 2-D animation	Menu bars, icon panels, dialog boxes, 2D animation, -D perspective animation	Menu bars, icon panels, dialog boxes, 2-D animation
Integration Interface	ODBC, OLE, Visual Basic, DXF import	IPC Functions, ODBC, Active X, OLE, DLL, Excel	Data file transfer	OLE	OLE, Prosim: process mapping tool from knowledge based Systems Inc. ProIngriner, Unigraphics Possible to execute C Programs
Programming Language	SIMAN: Simulation language Cinema: Modl: script simulation language animation language	Process flow language, C	The "parser", converts mathematical and/or logical expressions into computer code	Script simulation language: including if-then-else, Logic, boolean expression	SCL: Simulation control language: simulation language BCL: Batch control language: send and receive signals from PLC: robotclassmail: Oy products Action Language: BASIC-like simulation language
Shop-floor integration	Online communications with external applications like SFC and PLC	Factor applications: capacity, logistics and production scheduling, online status of the shop floor			
Reporting possibilities	Automatic standard output statistics, Input analyzer, data fitting, Output analyzer, enhanced statistics	Automatic standard output statistics	Automatic standard output statistics	Automatic standard output statistics Parameter estimates, graphical analysis	Automatic standard output statistics, Enhanced statistics 2D draw world: generation of CAD drawings
<p>Eng. GS software</p> <p>logip: Simulates continuous motions</p>					
Other features	Possible to run continuous simulations for DES input values	Cost modelling and simulation (ABC), Online help	Task network modelling, activity model with sequence	RTI- runtime interface: design of schedules SimRunner optimisation software	Cost modeling and simulation (ABC) Recording of animation Witness SDX, Witness Visio, Witness Miner, Witness Documenter, Witness OEM

Figure 1. Discrete Event Simulation Tools (1)

Enterprise Integration	Yes	Yes, it include capacity engineering, planning and scheduling, and costing	Let model purchase, material flow, integrate supplier, schedule personal/production process	Capable of rigorous analysis of multiple business internal and external scenarios/supplier, flow material, logistics)	
Distributed Organization	Posses a Network Version		Distribute models to other divisions and departments with run-time licensing		
Application at Heterogeneous Environments	Yes, Business Process, Customer Service, Military, Healthcare, Manufacturing, SupplyChain, CallCenters, etc.	Manufacturing, service industries, bussines, reengineering, communications, logistics, healthcare, environmental studies.	Manufacturing, Pharmaceuticals, Logistics, Government, Planning, Healthcare, Financial services, bussines reengineering	discrete manufacture, process industries, BPR, e-commerce, call centers, health, finance and government	
Interoperability	Yes, VBA Visual Basic, Active X, ADO/ODBC Access, etc	IPC Functions, ODBC, Active X, OLE, DLL, Excel	File Data Transfer	ORACLE, SQL Server, Access, etc, direct spreadsheet links in/out, XML from partner BPM and CAD applications	
Open and Dynamic Structure	No, to adjust is necessary stop simulation.	Its parameters and model logic can be changed on the fly	Have an open database structure by storing model data in Microsoft Access	Open Architecture approach to modeling by distributed logic associate with resources	
Cooperation	Just if all have arena licenses	Because of its integrated development environment, it has proven to be simulation engine of choice for more third party applications		By it analysis of scenarios is possible involve suppliers, logistics and internal processes	
Integration of humans	Yes with limited attributes	Yes, it considers humans as an element			
Agility	Yes, if its necessary adjust model	Because its Hierarchical modelling structure	Code reuse, model merging, and submodel capabilities	Incorporating intelligent algorithms, it quickly calculates the optimum solution	
Scalability	Yes, its necessary stop simulation	Apply its Hierarchical modelling	Yes its possible add/change new elements	Modular and hierarchical structure	
Fault tolerant	No			Using Six Sigma Algorithms—An adaptation of the SA algorithm to ensure that the nature of change from a defined AS-IS situation is	
Home page	www.arenasimulation.com	www.magnethalric.com	www.promodel.com	www.delmia.com	www.banner.com

Figure 2. Discrete Event Simulation Tools (1a)

Overview of discrete event simulation software tools		Enterprise Dynamics (Taylor ED)		Flexsim (Taylor II)	
AutoMod		DOSIMIS 3		em-Plant(Simple++)	
DE3		Grasp2000		Modeling Assistant	
Extramodules	3D Modeller/ Optical Conveyor Design Module Simulation, Intel Process Communication	CAD data exchange, Conveyor Design module, Module for discrete event simulation, Intel Process Communication	eD-Suite(Falcon, Studio, Economy)	Experimenter tool to simulate 'what-if' scenarios, ACS3D	
Manufacturing Application	Warehousing and Distribution, Factory capacity and throughput, material flow analysis, manufacturing systems	Robotics systems and automated processes	Assembly operators, Body In White or Painting lines and Continuous Process applications, Workflow material flow analysis, manufacturing system analysis	Planning & scheduling, incident management, process control, full VR visualization or network operations	Manufacturing, material handling, and logistics
Hardware platform	HP, SGI, Sun, PC	PC	PC(DEC, HP, IBM, SGI, Sun)	PC	PC
Software platform	UNIX, Windows	Windows 95/98 or Windows NT	Windows NT/4/2000 or Windows 95/98/Me/XP	Windows2000/UNIX	Windows 2000, XP (Home/ Pro)
User Interface	Menu bars, icon panels, dialog boxes, 3-D animation	Windows Style, icon toolbars, dialog boxes, 3D graphics	Windows Style, icon toolbars, dialog boxes	Windows Style, icon toolbars, dialog boxes, 2D animation, 3D visualization	Windows Style, icon toolbars, dialog boxes, 3-D animation, AVI recorder
Integration Interface	IGES, Cimat technologies Corp products (factory-FLOW, PLAN and CAD)	Data file transfer IGES, STEP, VRML, avi	DXF	ActiveX, ASCII files, Socket and DDE, CAD, PPS System, Oracle, SQL, ODBC, XML	OpenGL, 3DS, DXF, WRL, STL objects, ODBC
Programming Language	English like scripting language, if-then-else logic, while loops	Simulation language, i.e. repeat, goto, and wait commands	native robot languages	CC++, SimTalk, Simulation Language	C++, Flexscript
Shop-floor integration	AutoSched: finite capacity planning and scheduling, integrating MRP and shop-floor control	Trough GRASP	native robot languages	DDE or RPC connections to shop-floor systems (operating system dependent: UNIX or Windows NT), Material Flow	Manufacturing, Warehouse and Distribution
Reporting possibilities	Automatic estándar output statistics, Gant charts, AutoStat, design of experiments, enhanced statistics	Statistical output as dynamic on-screen graphs and tables and data output in spreadsheet compatible formats	Diagram, Graphic, Histogram	Automatic 3D Model Generation, Video Recording (avi and mpeg) and Camera Control, User Defined and Controlled Viewpoints, Camera Attachment to Objects and Camera Animation along Paths, True to Scale Objects, Additional Modeling Tools, Snap Objects to Grid, Placement Toolbox, Graphic Primitives	Statistical tables, charts and graphs, Histograms
Lang. GS software	Use GRASP2000	native robot languages			
Other features	Users can create real-time interactive simulations, using DE3's accurate 3D geometry, library of materials handling equipment, and real process data (e.g. order profiles and shift patterns).	General kinematic modeller and library of industrial robots	Application object templates: conveyors, GVS	2D- and 3D modeling capabilities of new objects Powerful process visualization	ExpertFit, OptiQuest and Viso are also compiled into the application. Virtually any hardware device can be connected to a PC. The software is oper for the user to customize

Figure 3. Discrete Event Simulation Tools (2)

Enterprise Integration	Yes	Yes	Yes	Throughput analysis, staffing, bottleneck recognition, machine utilization, WIP analysis, and scheduling
Distributed Organization	Support multiple robots	Yes	Yes	
Application at Heterogeneous Environments	Warehousing and Distribution, Factory capacity and throughput, Conveyor systems	Yes	Yes	Simulation and animation of systems and business processes Manufacturing, Logistics, Airports, Business Process, Hospitals Transportation, Movement of visitor into a place, Handling patients of food in a hospital, Handling checks at bank
Interoperability	native robot languages		Active X, IP, OLE, ODBC	OpenGL, 3DS, DXF, WRL, STL objects, ODBC, DDE, OLE
Open and Dynamic Structure				The extensive information processing with SimTalk allows to change it during simulation run Openess and interconnectivity are hallmarks of its architecture
Cooperation	Integrated support for conveyor systems including layout and design	Yes		Supporting major industry standards and can be easily connected or integrated with other software systems and components
Integration of humans				
Agility		Yes		Changes possible during the simulation run
Scalability	It uses accurate robot and work-cell collaboration techniques with no external measuring equipment required.			Through the interconnection of model objects the desired hierarchy and the step-by-step refining or roughening of eM-Plant models comes into being dynamically The system consists of a powerful Enterprise Dynamics (e.D.)-engine® and many building blocks grouped into eD-Suites
Fault tolerant	Robot reach validation and configuration checks			
Home page	www.automod.com	www.bvysimulation.com	www.szcz.de	www.emplant.de incontrol.nl flexsim.com

Figure 4. Discrete Event Simulation Tools (2a)

Overview of discrete event simulation software tools		SLX (Language)	MMS	Schedula	SES/Workbench	ShowFlow	SIMASII
GFSSHT (Language)							
Extramodules		Prime: For fitting Bézier-curve-based probability functions to data observations	MMS Graphical Model Builder, MMS Comp-Cen		WB Animated Simulator, WB System Requirements Workbook Library, CNF(Common Modeling Framework)		SIMASII Report Wizard
Manufacturing Application	Manufacturing, transportation, distribution	Simulation engine in a proprietary assembly line	Analysis, evaluation and modification of plant performance		Business process re-engineering	Analysis process in logistics, manufacturing and material handling	Manufacturing process, flow control, automated assembly
Hardware platform	PC, Sun Sparc workstations	PC	PC	PC	PC	PC	PC
Software platform	Windows 98/Me/NT/4/2000/XP, OS/2, Unix	Windows	Windows	Windows	Windows	Windows	Windows 95/98/NT4
User Interface	Text files and text entry directly by keyboard	Windows Style, Text files	Windows Style	Menu Tree Style, botons	Windows Style	Windows Style, icon toolbars, dialog boxes, 2D and 3D animation	Windows Style
Integration Interface	ASCII file I/O	DLL, C/C++	Microsoft Visual C++	Import-Export services to Files	Open interface for creating and extracting model data	Text Files	Word/Excel Files
Programming Language	GFSSHT, Expert Fil, C, Fortran	SLX	Microsoft Visual C++		C		C
Shop-floor integration	Manufacturing, transportation, distribution		Power plants and process chemical plants			Analysis process in logistics, manufacturing and material handling	Analysis process manufacturing and Flow control at Assembly
Reporting possibilities	Basic simulation data, queueing statistics, Custom formatted text and data file to a file	Basic simulation data, queueing statistics, Custom formatted text and data file to a file		Summary reports, Logfile of events, Time series by batch, activity or resource into a plain Files	Report writer integrated with Framemaker, Statistics browsing	Automatic model documentation, Customize documentation	Standard Statistics, Customize reports using Excel and Word
Lang. GS software							
Other features	Manage (en conceptual flexibility to model systems		It is implemented as a menu system that guides you in every phase and avoids inconsistent		Hardware architecture and design software requirements, analysis and design, distributed system performance analysis, networks performance analysis and design, computer systems and network capacity planning, database performance planning		

Figure 5. Discrete Event Simulation Tools (3)

Enterprise Integration	Training, evaluation of plant performance, modifications, control system design, and check-out and plant analysis	It does not attempt to optimize a single parameter; instead it helps to find a working point that is acceptable from all points of views	Evaluate designs during any phase of the development process	Analysis process in logistics, manufacturing and material handling	It is easily follow the production flows since you can name the successive production stages.
Distributed Organization	Apply RTI of HLA(DoD) High level architecture for distributed simulations		It can be applied at distributed systems		
Application at Heterogeneous Environments	Manufacturing, transportation, distribution, telecommunications, hospitals, computers, logistics, mining	Simulation engine in a proprietary assembly line: Air Traffic, Government, Move of Pedestrians, Logistic	Transient analysis of plant systems	Hardware, software and networking performance and resource allocation problems	Industrial mass-production installations in the fields of automated assembly and food packaging, Line manufacturer, flow control design
Interoperability	ASCII file I/O	GPSSH-like language, C-like Kernel	Microsoft Visual C++ to autoperametrization	Supports collaborative simulation using the IEEE Standard for Modeling and Simulation (IEEE 1516) High Level Architecture (HLA).	
Open and Dynamic Structure	Model code can be generated "on-the-fly" every time that the model parameters are modified by a user		Open interface		
Cooperation					
Integration of humans					It possible give a priority to a task and operators decide, it possible to define efficiency.
Agility	It takes a layered approach to simulation modeling. You can choose the layer that offers the programming detail you need to solve your problem.		Let change some answers and variables on-fly		Use the switching rule to modify decision taken in real time. It is possible to pick product on-fly and placed on another conveyor.
Scalability	It is able to handle very large models and model validation and debugging	Is an extensive tool beyond its built-in feature set	MMS Comp-Gen permits maximum user flexibility for customizing the MMS to meet specific requirements	Very extensible with embedded C code	Extensive thanks to use of object-oriented programming
Fault tolerant					When a program runtime error occurs, it automatically saves the current model. It possible revert to an earlier version
Home page	www.wolverine.com	www.nhancestech.com	www.codewerx-ll.com	www.hyperformak.com	www.showflow.co.uk
	www.wolverine.com	www.nhancestech.com	www.codewerx-ll.com	www.hyperformak.com	www.showflow.co.uk
	www.wolverine.com	www.nhancestech.com	www.codewerx-ll.com	www.hyperformak.com	www.showflow.co.uk

Figure 6. Discrete Event Simulation Tools (3a)

Overview of discrete event simulation software tools		SimFlex	SimProcess	Simu8	Spar	gPromsModelBuilder	Task ResourceSIM (Presimulator)
Extramodules			Simu8 Planner, OpQuest for Simu8, Simu8 Templates, Simu8 Components, VR environment	SparOpt		gOCAPE-OPEN, go-Simulink, goMatlab, goCPD, goRun	DistributionSIM, SupplyChainSIM
Manufacturing Application	Material flow	Supply chain	Logistics / supply chain	Material handling, Robot Assembly line, Develop PLC control rules, Capacity planning	Manufacturing process, flow control	Design and operation of process plant	It is designed to integrate tasks and resources for improved customer service.
Hardware platform	PC	PC	PC	PC	PC	PC	PC
Software platform	Windows 98/NT 2000, XP, UNIX, APPLE Macintosh	Windows	Windows	Windows 95,98,2000,NT and XP	Windows	Windows, XP 2000, NT4, Linux	Windows
User Interface	Windows Style, dialog boxes	Windows Style	Windows Style	Windows Style	Windows Style	Windows Style	Windows Style
Integration Interface			XML files, SQL, Access Databases, UML	OLE, SQL, Excel/VB, COM, SDX/Factory CAD, XML, BPM and flowcharting software, Command Script			gOCAPE-OPEN: to run models with ASPEN Plus or SimScr's PROII, Simulink to link to a Mathworks Modeler, go-Matlab: Use models of Modeler builds as M-function within the Mathworks MATLAB, goCFD: To use CFD within Fluent Inc, or CD Adapco's Star CD, go-Run: is a "runtime engine" to be executed behind Excel.
Programming Language			MODSIM, JII, XML	Visuallogic Programming, e.gemplo: if, elseif, else, while, until, set			
Shop-floor integration	Material flow		supply chain	supply chain	manufacturing process, material flow	process industries	Model an entire system of tasks and resources
Reporting possibilities		Standard Statistics related to time, service, material, Financial, resource utilization	Standard estadistics	Histograms an Time graphs, Gantt char. It is possible to customize reports by Visual Logic or VBA.	Standard estadistics of time, averages, distributions, sensitivities and user-defined metrics		By its Data Validation Reports, allows to detect error or anomalies, which allows customize reports
Eng. GS software							
Other features		It combines both optimization and simulation technologies. Transportation, customs, trends, supplier relationship, cost and operational time analysis	Business Activity Monitoring (BAM) that include DSS, CRM, ERP capabilities. Apply Six Sigma Technology	It use SPAR (Monte Carlo probabilistic simulation techniques) to optimize the life-cycle behavior of industrial systems			It allows to predict the resulting performance in service level.
							Used to enhance design and operation of continuous and batch processes.

Figure 7. Discrete Event Simulation Tools (4)

Enterprise Integration	Analyze and understand complex and dynamic global supply chains	Analyze supply chain	Apply its extramodules is possible to cover simulation of the whole supply chain.
Distributed Organization	Apply, multi-segment, multi-customer, multi-company and multi-product analysis	Remote Plot Capability, External Application call, Remote Application Call, External Entity Schedules	Focused on plant process
Application at Heterogeneous Environments	Electronics, Automotive, Pharmaceuticals, Chemical, 3PL Providers, Distribution and Transportation	Business Process, Health care, Human resources, Call center, Logistics / Supply chain	Chemical, Petrochemical, Refining, Pharmaceutical, Food and mineral sectors, oil & gas, power, fuel cell, industrial gases, consumer products.
Interoperativity		Healthcare, Transport and Logistics, Manufacturing, Services, Supply chain, Energy, Government	Due its open architecture it can be linked to virtually and external software running on any platform. Via GSERVER engine, itself can be embedded in external software. It can run side by side with other packages exchanging data as required.
Open and Dynamic Structure		Is compatible with VBA in Excel, Access, Word and Visio. Stat:Fit data and inputs to SIMUL8/SOL (Oracle, Sybase, Access)	Its open architecture allows to use a single, evolving model for all the applications across the process design and operational lifecycle.
Cooperation		XML, Java, C++	It is possible using its extramodules
Integration of humans		It is applied as simulation service in a SOA (SOA (Oriented Architecture and On Demand)	
Agility		meta-objects	It uses "meta-objects" to modify its structure
Scalability		Is possible to customize models, even on a remote way, due to its hierarchical integrated process	During simulation is possible use Dynamic optimization at critical decision points
Fault tolerant			Facilities to hierarchical modeling
Home page	www.alicos.com	www.flextronics.com	www.simulationdynamics.com
	www.atcos.com	www.simp/ocess.com	www.pseinterprise.com
	www.clockwork-solutions.com	www.simul8.com	www.simulationdynamics.com

Figure 8. Discrete Event Simulation Tools (4a)

Overview of geometrical simulation software tools		em-Workplace PC (RobCad)	Workspace4	AMESim	Formal Checkers(FoCS)
Specific Application modules	CimStation Robotics(CSR E-Hub)	GRASP2000	Igrp	Workspace4	AMESim
ArcWeld, SpotWeld Paint, Polishing	ArcWelding, Spray painting, Robotic	ArcWelding, Spot, Arc, Paint, Gun, Finishing, Painting, Realistic Fixtures, OLP, Drill, Laser, Robotic	DELMAErgo, SpotWelding, Arc Welding, Spot, Arc, Paint, Gun, Finishing, Painting, Realistic Fixtures, OLP, Drill, Laser, Robotic	Robotrak for calibration	AMESet, AMECustom, AMERun
Manufacturing application simulation, OLP, Collision detection	3D visualisation, Geometric manufacturing system simulation, OLP, Collision detection	3D visualisation, Geometric manufacturing system simulation, OLP, Collision detection	3D visualisation, Geometric manufacturing system simulation, OLP, Collision detection, SOP Polishing	It offers both a structured multipoint approach for the modeling of physical systems and a block diagram approach for control systems	Automatic generation of simulation monitors
Hardware platform	HP, IBM, SGI, Sun	HP, IBM, SGI, Sun	DEC, HP, IBM, Intergraph, SGI, Sun, PC	PC	PC
Software platform	Unix, Windows	Unix, Windows	Unix	Windows	AIX, Linux, Solaris
User interface	Menu bars, icon panels, dialog boxes-3D animation	Menu bars, icon panels, dialog boxes-3D animation	Menu bars, icon panels, dialog boxes-3D animation	Menu bars, icon panels, dialog boxes-2D animation	Menu bars
Integration interface	CADD5, Catia, Pro/Engineer, Unigraphics, IGES, STEP, IRL, DES, CAD files	AutoCad, Catia, Intergraph, Unigraphics, AutoCad, Catia, IGES, STEP, IRL, DES, CAD files	AutoCad, Catia, Intergraph, Unigraphics, AutoCad, Catia, IGES, STEP, IRL, DES, CAD files	CAE Software (Matlab, Simulink, Flux or inhouse code), C Code generation	PSU/Sugar, Verilog, C++, VHDL
Programming language	SIL-LISP like language, complex C	GRASP simulation language: eg. Repeat, goto	GSL - Graphical Simulation language	TDL - Task Description language	PSU/Sugar
Shop/Floor integration	Direct download of program to target robot	Direct download of program to target robot	Direct download of program to target robot	Direct download of program to target robot	Direct download of program to monitors
Reporting possibilities	Output drawings 3-D visualisation recording, VRML	3-D visualisation recording, VRML	3-D visualisation recording, VRML	3-D visualisation recording, VRML	HTML report generator, 2D animation
Robot language support	AIM, ARIA, Karel, Nachi, ROPS, Panasonic Rail, VAL2	Alfa, Carola, ROM3, RRL, VAL2	Acma, ARIA, Cimple, Cloos, Comau, Cybolech, GMF-RC/RG, Graco, GM, Karel, MOT-ERC/MRC, Nanchi, Rapid, RJ-KAREL/TPE, Robtalk, ROPS, ROPS2, VAL2	Karel2, Karel3, Aria, TL-1, Rapid, Slim, AS, PDL2, KPAS, Kawasaki, Modicon, Na AMLZ, nchi, INCPainter, RCM, S1, S7, Parf, Fara, ACL, RTP, Vall, V all, V/V-Hform, 1 and 2, RobTalk2, MMEBasic	
Other features	Calibration Tool, Robot library	Calibration Tool, Robot library	Calibration Tool, Robot library	Calibration Tool, Robot library	Used for modeling, simulation and analysis of dynamic engineering systems. Cross Platform: Windows, UNIX and Linux. Multi-domain system design
Homepage Vendor	http://www.acei.co.uk/	www.bygsimulation.com	www.delmia.com	www.rosi.com	www.amesim.com

Figure 9. Geometrical Simulation Tools (1)

Overview of geometrical simulation software tools						
	HCADWin	ITI-SIM	ProDyn	Simplorer	Universal Mechanism	Softmachine
Specific Application modules	Drawing, Printing, Simulation, Import/Export, Project revisions	ITI-Vis3D, ITI-ORD, ITI-STAT	Pro-Online		UM-Optimization, Module of Linear Analysis, Railway module (UM Loco), Subsystem module, UM FEM module, UM Automotive, Matlab/simulink interface	
Manufacturing application	Design logic of controls	It is used for modeling and simulation of dynamical behavior of technical components and systems (Conveying, material handling)	DCS/logic testing, develop and test plant procedures	Design of High-Performance Electromechanical System	It is intended for simulation of kinematics and dynamics of planar and spatial mechanical systems	Simulate a machine tool, collision detection
Hardware platform	PC	PC	PC	PC	PC	workstation
Software platform	Windows	Windows NT4	Windows	Windows 2000/XP	Windows NT, 2000, XP	Windows, Linux, UNIX
User interface	Menu bars, icon panels, dialog boxes-2D animation	Menu bars, icon panels, dialog boxes, 1D animation		Windows Style	Windows Style	Menu bars, icon panels, dialog boxes, 2D and 3D animation
Integration interface	ACAD dBase, DDE, VBA, DLL, Pascal, DWG, DXF, HUP	DLL for user objects, Templates (C/C++, Delphi), FEM interface, Code Exports, MATLAB/Simulink interface, COM interface (VBScript, Jscript, VB, DDE to DAdem)	Conexion with DCS Systems, SCADA/HMI interfaces, reactor algorithms synchronization	Unit handling with automatic unit	Import: 3DS, ASC files, Solidworks, Matlab models. Export: BMP, GIF or AVI files, Foramtet text file, Tables and graphs to MS Work and MS Excel	Import: CAD databases
Programming language	HSL (HCAD Simulation language)			Wizards (C, VHDL-AMS, and component models)	MS Visual C++ 5.0-6.0, Borland C++ Builder 5.0, Borland Delphi 4.0-6.0	
ShopFloor integration			It allows the user to connect to the model as an operator from any location by simply having an internet connection			
Reporting possibilities	GIF, WMF Files					
Robot language support						
Other features	It uses IEC1131 look-alike symbols	Co-simulation with ADAMS, SIMPACK and MSC, VisualNastran4D	It is Web Enabled and OPC compliant. It offers standard process models (tank model, heat exchanger, ion exchange, pH Control, Reformer, Turbine, Hydrogen Plant, Hydrocracker, etc.)	It offers statistical analysis capability and adherence to IEEE standards	Online animation of motion and plots of dynamical performances are available during simulation.	
Homepage Vendor	http://home.quicknet.nl/qn/prive/hyvatheun/index.htm	www.iti.de	www.ingenious.cc	www.ansoft.com	umlab.ru	www.acel.co.uk

Figure 10. Geometrical Simulation Tools (2)