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Guidelines to Design a Laboratory of Production Management Using Enterprise Modeling and Enterprise Games

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Abstract

Enterprises games are important tools for simulation and learning of processes that involve typical management decisions in a company. With these games, it is interesting to also use a business process model providing the players knowledge related to decision making. Information systems, like ERP, may be adapted to support, facilitate and improve game decisions. It is a way for researchers and students to learn, test and evaluate both the business processes and information systems. This article aims to describe guidelines for designing a Laboratory of Production Management. The laboratory is designed with two major components: a simulated enterprise and an enterprise game. Techniques of enterprise modeling are used to define business processes and adapt information systems of support. The methodological elements for engineering and modeling these components are based on GERAM (Generalized Enterprise Reference Architecture and Methodology).

Keywords: Enterprise games, Simulation, Enterprise Modeling, Information System.

1 – Introduction

Like the scientific areas that develop with the appearance of new technologies, new teaching-learning methods are being developed to accompany growth and new realities imposed by society. One of the main indicators for this growth is the expanded use of computers and consequent easy access to data transmission made possible by the Internet. Since computers are increasingly more common in our daily lives, it is necessary to develop the most varied software for diverse purposes, such as education, used as support tools for the teaching-learning process (BERNARD, 2006; SAUAIA, 2008).

The creation and use of research and teaching laboratories in some academic areas like Mechanical Engineering and Electrical Engineering are common. However, some areas, like Production Management lack laboratories that allow teachers and students to teach and research their theories, techniques or related tools, for example, to decision making processes related.

The business game is a type of simulation in which a sequential decision-making exercise is performed, thus looking at the systematic training of a team or all the teams, and working on the model of a business operation in which the participants assume definite positions as if they were in a enterprise.

Experience shows that enterprise games are an important tool in simulating processes that involve typical company management decisions, but they can be used jointly with other components to increase benefits and help teaching and research.

For example, an information system can be adapted to support decision making by enterprise game players.

Another possibility is the simulation of production operation processes using simulation software or even creating a mini-factory physically simulating the production of products at the supposed company. This can permit a more integrated and holistic vision and also a better understanding of the consequences of typical events that occur in a manufacturing system.

Also, rather than making a manual that only focuses on showing the steps to be taken to play the game, it is possible to use models that explain knowledge related to the possible rules of the game's enterprise processes. Besides that, enterprise models (about processes, information systems, organization,…) should be used not only to serve as a guide and support for decision making during the system operation, but also throughout the system development cycle, from the definition of enterprise strategies and requirements to design and implementation of related systems. Thus, company systems can be developed using enterprise engineering architecture.

This article presents some guidelines for designing a teaching and research laboratory in Production Management, considering a enterprise game integrated with: a production management reference model; a infrastructure for integration and support decisions; and a simulated enterprise environment. The project development is based on company engineering architecture.

2 – Enterprise Games

Enterprise game is a type of simulation in which a sequential decision-making exercise is performed, thus looking at the systematic training of a player, team or many teams. It works on the model of a business operation in which the participants assume definite positions as if they were in a enterprise. Its main current utilization takes place in the business training. However, one of the difficulties is to approach the model to the reality, as much as possible. It is an excellent teaching tool, being based on mathematical models that simulate the economic, business and organizational behavior.

Simulation through enterprise games is a means to try ideas and concepts under conditions that would be beyond the possibility of being tested in practice due to cost, delay and/or risks involved (DAVIS, 1997; MARTINELLI, 1987; ORNELLAS; CAMPOS, 2003).

With the games participants can experience and test conditions simulated from reality and later analyzing the consequences. This creates the possibility to be able to virtually err and

change course of decisions in a competitive market that punishes mistakes ever more severely (ORNELLAS; CAMPOS, 2003).

Simulation uses models to study real and complex problems through computational experimentation. Thus, its use implies constructing a model that replicates the operation of a real or idealized system and conducting computational experiments with this model, aimed at: better understanding of the problem in question, testing different alternatives for operations and thus propose better ways to execute them (SALIBY, 2000).

For better decision making, like some companies generally do in reality, it is important to use information systems to support decision making in a game aimed at production management in a fictitious company.

3 - Management and Integration of Enterprises

The need to think and change company operations due to needs generated by globalization and competition among countries has been clear for some time (HAMMER; CHAMPY, 1992). Information Technology became essential in this change process making it possible to automate and integrate its processes (DAVENPORT, 1994; VERNADAT, 2002). More specifically, information technology provided alternatives for improvement in company operations, making work projects more agile, less onerous and more effective, enabling a large number of new procedures and techniques or administrative methodologies (RODRIGUES, 1999). It plays a fundamental role in enterprise management and integration.

Enterprise production management needs could initially be satisfied in part by isolated systems, like the MRP. MRPII systems were created as an evolution of MRP. They integrated the main functions and information related to Production Planning and Control through a single information system (SCHEER, 1989; CORRÊA et al., 2000). Due to the need for integrating the entire company, the ERP (Enterprise Resources Management) concept emerged, and integrated enterprise management systems. They allowed companies to integrate every area, achieving

overall management of the company through a single database that consolidates all business operations in a single environment (CHUNG; SNYDER, 2000).

Nevertheless, despite the huge leap in terms of integration provided by these companies, some issues still need to be handled. This integration mainly occurred at the IT level (physical integration and applications), which does not ensure that company business processes are being performed the best way and that the information systems are truly integrating and correctly meeting business process requirements.

One way to better analyze, design and integrate enterprise process activities as well as provide support for decision making during production management is to use enterprise models. In other words, enterprise modeling can provide support to the entire life cycle in developing company systems from the definition of enterprise strategies and requirements to design and implementation of the systems. It can also thus provide support to the life cycle for developing this laboratory being proposed.

4 - Enterprise Modeling and Integration

According to Vernadat (1996), enterprise modeling, among other definitions, is a set of activities or processes used to develop parts of an enterprise model to get to some desired purpose. The author states the enterprise modeling proposals can be: better represent and understand how the company operates; capitalize knowledge for future use; improve the information flow; design or improve company systems (operations, information, organization); analyze and simulate part of the company; and control, coordinate or monitor company processes.

According to Kalpic and Bernus (2002), the formalization of knowledge involved in the enterprise business processes contribute towards competitiveness and provide the basis for organization development and survival.

Several formalities have been proposed to represent aspects of companies

(CARNAGHAN, 2006; ERIKSSON; PENKER,2000). Business Integration deals with the enterprise's complete integration, that is, coordination of business processes and sharing knowledge. In order to obtain it, it is necessary to make a detailed analysis of enterprise operations, rules and structure in terms of functions, information systems, resources, applications and organization units. Therefore, to achieve this integration, it is necessary to incorporate the level of enterprise knowledge, that is, understand its organization and how business processes should be conducted, modeling and integrating them (VERNADAT, 1996). Several enterprise modeling and integration projects were carried out by programs financed by governmental entities in the USA and Europe (KOSANKE; NELL, 1999; CIMOSA, 1996; IFIP-IFAC, 1999; SCHEER, 2000).

CIMOSA (Computer Integrated Manufacturing Open System Architecture) is an architecture for enterprise engineering that provides, among other concepts and components, a language and a modeling process that defines activities for modeling enterprise aspects (KOSANKE; ZELM, 1999).

GERAM – *Generalized Enterprise Reference Architecture and Methodology* architecture (IFIP-IFAC, 1999; NORAN, 2003) is a generalization of architectures proposed by GIM, PERA and CIMOSA, using the best parts of the latter ones in order to serve as a reference for all those involved in enterprise engineering and integration.

It provides a description of all elements recommended in enterprise engineering and integration and thus prepare the standard for a collection of tools and methods with which any company would benefit with greater success by taking care of the integration process, or change (or improvement) process that could happen during the enterprise's operational life time. Its methodology does not impose a collection of tools or methods in particular, but it defines criteria to be met by any collection of selected tools and methods. GERAM considers enterprise models essential for enterprise integration and engineering. This includes various formal techniques for project description – such as computer, text and graphic models for project representations. It is

comprised of components considered essential and complementary for company integration, and are shown below (Figure 1) (IFIP-IFAC, 1999):

- GERA (*Generic Reference Architecture*)
- EEMs (*Enterprise Engineering Methodology*)
- EMLs (*Enterprise Modeling Languages*)
- EMs (*Enterprise Models*)
- EOSs (*Enterprise Operational Systems*)
- EETs (*Enterprise Engineering Tools*).
- GEMCs (*Generic Enterprise Modeling Concepts*)
- PEMs (*Partial Enterprise Models*)
- EMOS (*Enterprise Modules*)
- EOSs (*Enterprise Operational Systems*)

GERA provides an analysis and modeling structure based on the life cycle concept and it identifies three dimensions to define scope and content of enterprise modeling, similar to CIMOSA:

- ***Life cycle dimension:*** sustaining the controlled process of enterprise modeling according to life cycle activities;
- ***Generality dimension:*** sustaining the controlled process of particularization (instantaneousness) from the generic to partial and from partial to the particular;
- ***View dimension:*** sustaining the controlled visualization of specific views of the enterprise.

In this paper it is proposed the use of GERAM architecture as reference in the guidelines for developing a production management laboratory, as described below.

5 – Guidelines for Laboratory Development

This section shows some guidelines for developing a research and teaching laboratory in enterprise (processes) management and integration with a focus on production management.

First, steps are shown to define a particular architecture for enterprise engineering, including the enterprise model (EM) that will be used to build the laboratory. Then, guidelines are presented for developing the enterprise's simulated environment. Finally, some considerations are provided about the Enterprise Game, as a tool to be used in an integrated manner and that provides dynamics to use the laboratory components.

5.1 – Development of a Particular Architecture

Among other architectures and modeling, GERAM will be studied and used to define the main concepts and methodological components for reaching the Simulated Environment of the Enterprise (including process, information, resource and organization aspects). Thus, based on GERAM, it is necessary to define a particular architecture (Figure 1):

- EEMs (*Enterprise Engineering Methodology*) - a methodology for developing enterprise systems (as information systems), specifically adapted to needs. In order to get to the methodology (or development process), it is proposed adapt the UP, RUP and/or CIMOSA methodologies, depending of the system to be developed;
- EMLs (*Enterprise Modeling Languages*) – a modeling language must be defined, then it is proposed considering the CIMOSA, UEML, ISO/DIS 19440 languages, and/or Eriksson and Penker extensions to be implemented through UML;
- EETs (*Enterprise Engineering Tools*) – a support tool for modeling must be developed or adapted in a manner compatible with the methodology and defined language;
- EMs (*Enterprise Models*) – processes, information, resources and organization models related to Enterprise Game and related to Simulated Enterprise Environment to the considered in the laboratory must be defined;
- GEMCs (*Generic Enterprise Modeling Concepts*) – may be used to help define the models

(EMs);

- PEMs (*Partial Enterprise Models*) – models found in literature may be be used as a reference to help define the models (EMs);
- EMOS (*Enterprise Modules*) – They may be ERP modules adapted to the system in question, as well a computers and automated components for designing an assembly system simulating production, found in the market, and that can be configured and adapted to defined models (EMs), for obtaining a Simulated Enterprise Environment (in this case, the *Enterprise Operational Systems* - EOS).

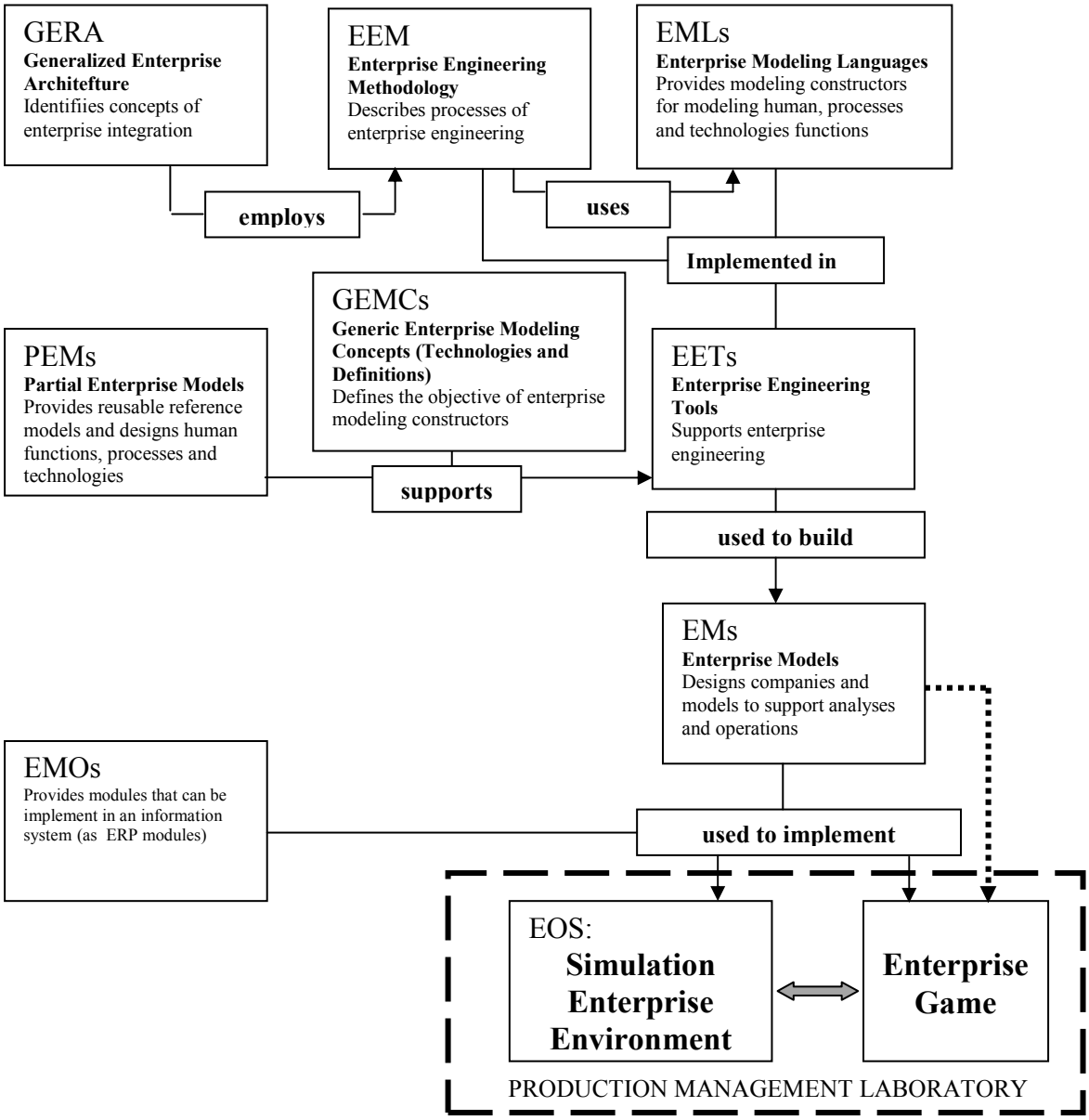

Figure 1 – Relationships between research project components (adapted from IFAC-IFIP, 1999).

5.2 – The Simulated Enterprise Environment

The Simulated Enterprise Environment will be based on defined enterprise models (EMs) and should provide conditions and resources to study, research and develop new knowledge and technologies of enterprise management and integration as well permit system testing (for example free of commercial software). It can be divided into three major components: integration infrastructure, physical assembly system and reference model for enterprise management (Figure 2). This environment should also foresee resources permitting not only internal integration, but also integration of supposedly external elements (simulation of suppliers and clients).

The reference model for enterprise management refers to knowledge and rules needed for procedures related to management processes (decision process models, also related to enterprise models – EMs) to be defined as per a previous section in this paper. They should be implemented and simulated in the enterprise game, permitting study and research in the simulated enterprise environment.

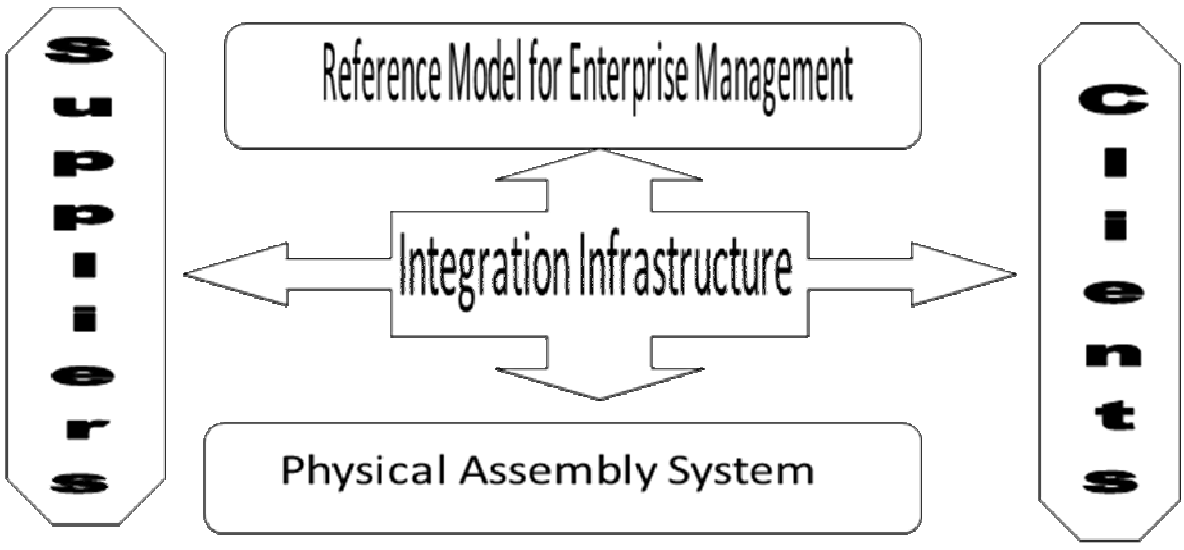

Figure 2 – Structure for the Simulated Enterprise Environment

Integration infrastructure must be comprised of hardware and software like ERP systems and Advanced Planning Systems (APS). In this environment, it is possible to adapt and use

proprietary. Or a free open code ERP, which could reduce costs and create the opportunity to more easily adapt the system's operating mode. It is also possible consider using APS (like Preactor) and simulation software (like ProModel or ARENA) to support decision making inherent to production. Computers can be dedicated to a typical company function/area (production planning, production control, purchases, sales, stock control, accounting and costs).

The physical assembly system should simulate the assembly of fictitious products (consider the use of standard pieces - LEGO). Work positions must be made for real electro-pneumatic elements of small dimensions, and the work stations for movement must be modular to simulate different production processes (with continuous or intermittent process characteristics) and types of configurations (like the cell layout, by product,...). Thus, it is possible to simulate customized orders for these fictitious products made by virtual clients as a result of pre-determined or probabilistic demand. Different products and processes (or work stations) can be simulated according to positions in which LEGO cubes can be assembled. The use of standard LEGO pieces permits the simulation of a real problem while also making it easy to disassembly and reuse, so this system does not have expenses on inputs.

We then have some complexity related to product, equipment and process management, creating a proper scenario for applying concepts and tools in the production management.

5.3 – The Enterprise Game

The Enterprise Game must be designed taking into consideration the Enterprise Management Model, which are processes related to enterprise model (EM) decisions such as Demand Projection, Production Control and Planning, Stock control and other possible processes. Thus, this environment will be able to create diverse situations that allow the students to study, research and compare these different Production Management techniques and tools. For example, in Production Planning it is possible to implement and test techniques like Just-in-Time, MRPII and the Restrictions Theory, in different scenarios.

The supposed enterprise processes are related and a decision may interfere in others, permitting a holistic view of an organization. The Enterprise Game must permit the simulation of several months (and even years) of an enterprise simulated operation and its market in the interval of a few hours. The researcher or student can thus exercise decision making skills faster than in actual reality.

6 – Final Considerations

This paper presented some guidelines for developing a Production Management Laboratory, an area that is lacking in practical teaching and research tools, especially compared to other areas as mechanical or electrical engineering.

Thus, starting with an enterprise game, an attempt was made to integrate the use of: information systems to support decisions; simulate operational processes in a simulated enterprise environment; and use models developed based on reference architecture for enterprise engineering.

Using the structure set up for this laboratory it will be possible to provide a new dynamic to research and teaching activities, creating an environment of developing and simulating of typical enterprise business processes. It will be possible to research or explore many aspects of reality more easily than using traditional research and teaching techniques.

It is thus expected that research and teaching in enterprise games, enterprise modeling, production management and information systems, like ERPs, can be strengthened and integrated with the use of a laboratory with this structure.

References

BERNARD, Ricardo. Métodos de Jogos de Empresa/Simulação Gerencial. In: MARION, José Carlos; MARION, Arnaldo Luis Costa. Metodologias de Ensino na Área de Negócios. São Paulo: Atlas, 2006. p. 83-114.

CARNAGHAN, C. Business process modeling approaches in the context of process level audit risk assessment: An analysis and comparison. International Journal of Accounting Information Systems. n. 7. Elsevier, 2006.

CHUNG, S. H.; SNYDER, C. A. ERP Adoption: a technological evolution approach, International journal of Agile Management Systems. Vol. 2, n. 1, pg 24-32, 2000.

CORRÊA, H. L., GIANESI, I. G. N., CAON, M. Planejamento, Programação e Controle da Produção - MRPII/ERP: Conceitos, Uso e Implantação, São Paulo, Ed. Atlas, 2000.

DAVENPORT, T. H. Reengenharia de Processos: como inovar a empresa através da Tecnologia de Informação, Rio de Janeiro, Editora Campus, 1994.

ERIKSSON, H. e PENKER, M. Business Modeling with UML. Estados Unidos: Wiley & Sons, 2000. 459p.

HAMMER, M., CHAMPY, J., Reengenharia: revolucionando a empresa em função dos clientes, da concorrência e das grandes. Rio de Janeiro, Editora Campus, 1992.

IFIP – IFAC Task Force on Architectures for Enterprise Integration GERAM: Generalised Enterprise Reference Architecture and Methodology – Version 1.6.3, Março 1999.

KALPIC, B. e BERNUS, P. *Business process modelling in industry - the powerful tool in enterprise management,* Computers in Industry, v. 47, p. 299-318, 2002.

KOSANKE, K.; ZELM, M. CIMOSA modelling processes. Computers in Industry – Volume 40, Pages 141-153, 1999.

KOSANKE, K., NELL, J. G. Standardisation in ISO for Enterprise Engineering and Integration, Computers in Industry, v.40, p. 311-319, 1999.

MARTINELLI, Dante Pinheiro. A utilização de jogos de empresas no ensino de administração. 1987. Dissertação (Mestrado em Administração) – Programa de Pós-Graduação em Administração, FEA/USP, São Paulo, 1987.

NORAN, O. An analysis of the Zachman framework for enterprise architecture from Geram perspective, Annual Reviews in Control, v. 27, p. 163-183, 2003.

ORNELLAS, A.; CAMPOS, R. O projeto Unified Enterprise Modelling Language e a necessidade de integração entre metodologias em modelagem de processos de negócio, Ouro Preto – MG, ENEGEP 23, 2003; UFOP, 2003.

RODRIGUES, M. V. Processo de Melhoria nas Organizações Brasileiras, Rio de Janeiro, Qualymark Ed., 1999.

SALIBY, Eduardo. Tecnologia de informação: uso da simulação para obtenção de melhorias em operações logísticas. In: FLEURY, Paulo Fernando et al. Logística empresarial: a perspectiva brasileira. São Paulo: Atlas, 2000.

SAUAIA, Antonio Carlos Aidar. Laboratório de Gestão: simulador organizacional, jogo de empresas e pesquisa aplicada. São Paulo: Manole, 2008.

SCHEER, A. W. *Enterprise-Wide Data Modeling - Information System in Industry*, Springer-Verlag,

1989.

SCHEER, A. ARIS – Business Process Modeling. 3ª. ed. Berlim: Springer-Verlag, 2000.

VERNADAT F. B. *Enterprise modeling and integration, Principles and Applications,* Chapman & Hall, 1996.

VERNADAT, F. B. Enterprise Modeling and Integration (EMI): current status and research perspectives, Annual Reviews in Control, v. 26, pg 15-25, 2002.