

## **Developing Product and Manufacturing Integration Engineers: Integrating Graduate Education, Training, and Managed Job Assignments into a Strategic Career Path**

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### Abstract

This paper describes two separate but interrelated learning programs that integrate advanced education and training into a twelve-year experiential learning process. One program is in integrated product (vehicle) engineering and another in integrated manufacturing engineering. The objective of these programs is to develop and prepare engineers for positions as technical leaders in each of these mission-critical areas.

Both programs contain four critical elements that are designed to instill in the learner the capability to execute advanced but clearly defined job requirements within a prescribed set of time and budget constraints. The components also develop the ability to achieve these objectives within a dynamic matrix of rapidly advancing technology and organizations. These four components include:

1. a master's degree in engineering with a plan of study that is interdisciplinary and includes a highly specialized job assignment unique to each learner;
2. over 1600 contact hours of specific and proprietary training to complement the plan of study in the degree program;
3. a scheduled and well-coordinated set of job assignments ranging sequentially over twelve years and performed concurrently with the successful completion of both the education and the training; and
4. a project-based course, culminating in a certificate, that applies the body of knowledge to management decisions for improvements and innovations.

This formal certification prepares graduates for high-level management responsibilities and positions in both vehicle and manufacturing integration engineering.

The programs emphasize the importance of globalization, systems engineering, and manufacturing processes in the context of a multi-variable, multi-cultural academic-industrial environment. Both programs are described concurrently in this paper as effective and efficient

components of General Motors' operational plan, which calls for the two to complement one another and to be organized to lead to increasingly successful car programs.

## I. Introduction

### The GM Technical Education Program

The General Motors Technical Education Program (TEP) represents a strategic weapon for the GM Strategy Board because it provides a competitive, multi-university, global network of first tier universities that offer media enhanced distance learning to the company's technical community throughout the world.

Courses from these institutions are selected and offered to GM employees through a formal bid process to ensure that the curriculum is aligned with corporate strategies and objectives. The courses are for the most part existing ones, however TEP often provides resources and input on the development and modification of courses offered by its university partners. The primary issues considered in the course selection process are consistency with GM's goals and needs, cost, distance learning capability and long-term curriculum planning horizons.

In some cases, degree programs are developed and implemented for global delivery, with the plan of study providing for a substantial component of multi-university cooperation.

Two such university partners have a long and mutually beneficial relationship with GM: Purdue University and the University of Michigan-Ann Arbor. Each offers the GM technical community a distance-learning, global master's degree program that is based on unique attributes of the institution.

### Purdue University and Continuing Engineering Education

The Purdue University faculty began the process of offering a complete off-campus program leading to a Master of Science in Engineering (MSE) or a master of science (MS) in 1957. This program did "not cover the finer and finer points of smaller and smaller matters but the encompassing science and mathematics that pertained generally to engineering... Here was none of the fragmentation of curricula that... had been a plague to engineering for generations"<sup>1</sup> (Knoll, 1963).

This interdisciplinary degree, tailored for the practicing engineer, was utilized as the foundation for the education component in the Integrated Vehicle Engineering (IVE) learning program. The IVE plan of study illustrates the academic power of a tier 1 university operating within a multi-university partnership format to service the needs of a global, multi-cultured manufacturing company. This plan of study coupled with properly timed training and sequentially appointed work assignments within a planned career path learning program provides the necessary construct to develop sophisticated, highly proficient vehicle integration engineers.

The basic MSE/MS degree requires 30-semester hours or 10 3-hour courses. Eighteen of these hours must be Purdue University coursework. The IVE program outlines 9 hours of Purdue courses (IE 545, IE577, and ME 571) plus 9 hours of selective Purdue University graduate Coursework in Integration/Systems Engineering. These 9 hours need to be approved by the student's advisory committee. The additional 12 hours may be taken from pre-approved courses from the University of Michigan, Stanford University, Rensselaer Polytechnic Institute, University of Illinois at Urbana-Champaign, The Massachusetts Institute of Technology, and Cranfield University, England.

Since the IVE learning program requires an extra 9 hours to complete, Purdue University tracks these additional hours as part of the plan of study that is required for the MSE./MS degree.

As evidenced by the program outline below, nine participating universities, including a course and certificate from Stanford University, form the necessary academic alliance to provide a world class integrated vehicle engineering learning program.

### Integrated Vehicle Engineering (IVE) Learning Program

#### Component I

Purdue University Master of Science in Engineering with an IVE plan of study

#### Coursework

- Automotive Engineering - The University of Michigan-Ann Arbor
- Design for Manufacturability I and II - Stanford University
- Engineering Economic Analysis - Purdue University
- Human Factors in Engineering - Purdue University
- Managing New Product Development - Rensselaer Polytechnic Institute
- Property and Selection of Engineering Materials - University of Illinois at Urbana-Champaign
- Reliability Based Design - Purdue University
- Systems Engineering - Virginia Polytechnic Institute & State University
- Vehicle Structures - Cranfield University, England
- Minimum of nine hours of GM approved Purdue University graduate coursework in Integration/Systems Engineering
- Plus seminars in Automotive Noise, Vibration, and Harshness Control - The Ohio State University; Lean Engineering - Lehigh University; Powertrain Dynamics and Control - The Ohio State University; and Strategic Product and Manufacturing System Development - The University of Michigan.

#### Component II

GM Specific training, totaling 1600 contact hours

#### Component III

GM selected job assignments accumulating over a period of 12 years

#### Component IV

Stanford University capstone project and certificate of completion in Integrated Vehicle Engineering

The University of Michigan College of Engineering

The University of Michigan-Ann Arbor currently offers a Master of Engineering in Manufacturing degree program to GM worldwide, and this program provided the foundation for the education component in the Integrated Manufacturing Engineering (IME) learning program.

The IME plan of study again illustrates the academic power of another first tier university operating in a multi-university environment to serve the needs of a global, multi-cultural manufacturing company. The University of Michigan Program in Manufacturing (PIM) plan of study is coupled with properly timed training and sequentially appointed work assignments. This process is part of a planned career-path learning program that provides the body of knowledge to develop sophisticated, highly proficient manufacturing integration engineers.

As evidenced by the program outline below, Six universities participate in the context of a University of Michigan Master's degree, including an additional project based course to certify the graduates' capacity to provide manufacturing leadership and technical expertise.

Integrated Manufacturing Engineering (IME) Learning Program

#### Component I

The University of Michigan Master of Engineering in Manufacturing with a GM IME plan of study

#### Coursework

- Advanced Quality Control - The University of Michigan
- Agile Manufacturing Systems - Lehigh University
- Engineering Economic Analysis- Purdue University
- Lean Manufacturing - The University of Michigan
- Manufacturing Systems Management - Rensselaer Polytechnic Institute
- Materials in Manufacturing and Design - The University of Michigan
- Product Realization I and II - University of Illinois at Urbana-Champaign
- Systems Engineering - Virginia Polytechnic Institute & State University
- Technologies and Strategies in Manufacturing - The University of Michigan
- A minimum of nine hours of GM approved University of Michigan Graduate coursework in manufacturing systems/integration, including MFG 503-Manufacturing Project (IME).

#### Component II

GM specific training and workshops totaling 1600 contact hours

#### Component III

GM selected job assignments, sequentially accumulating to 12 years

## Component IV

### The University of Michigan-Ann Arbor Certificate of Completion in Integrated Manufacturing Engineering

#### Other Participating Universities

As evidenced by the program outlines above, seven universities support this program with courses and modules that were selected based on the unique competencies of each institution: Cranfield University (England), University of Illinois at Urbana-Champaign, Lehigh University, the Ohio State University, Rensselaer Polytechnic Institute, Stanford University and Virginia Polytechnic Institute and State University. These universities complement the curriculum with courses whose faculty were selected on the basis of their research and teaching in areas of specific importance to the IVE and IME programs.

This diverse group of outstanding institutions reflects the broad scope of the programs, but it also represents an increasing recognition among faculty that partnerships of this kind strengthen their programs and lead to new opportunities.

#### II. Career Pathways and the Future

The learning programs outlined here are early attempts by General Motors and its university partners to accomplish three main objectives:

- to develop a common process for education and professional development;
- to realize a common body of knowledge for core disciplines; and,
- to reduce the length of time needed for academic achievement.

Speed and knowledge will continue to provide significant competitive advantages to both industrial and academic organizations. We believe learning programs such as the IVE and the IME will form the basis for competition and survival into the next millennium.

#### Bibliography

1. Knoll, H. B. (1963) "The story of Purdue engineering," West Lafayette, IN: Purdue University Studies.

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Ed Alef is the founder and Dean for Curriculum Development of the GM Technical Education Program. Before joining GM, Alef was Dean of the Walsh College of Business in Michigan, where he also taught Statistics.

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Mary Bonhomme is associate director of Continuing Engineering Education (CEE) at Purdue University in West Lafayette, Indiana, where she develops and markets credit courses and noncredit education/training programs for practicing engineers. She also manages CEE's Instructional Technologies Facility, from which a broad array of credit and noncredit courses are delivered via distance learning technology to a network of industrial and educational sites. Adept in both industry and academe, she served as manager of information and communication for Cabot Corporation and for Indiana University, Kokomo. She serves in an executive capacity on the boards of numerous professional engineering educational associations and is active in a variety of community organizations.

#### EDWARD G. BORBELY

Ed Borbely is Director of the Center for Professional Development at the University of Michigan College of Engineering. He has lead responsibility for graduate professional degree programs, continuing education programs, off-campus education, and technology enhanced learning. Previously, he was Director of Off-Campus Education in the School of Engineering and Applied Science, at Columbia University in New York, NY. He has also served as a Faculty Fellow at the New Jersey Department of Higher Education, and has consulted on variety of projects dealing with telecommunications, instructional technology and methodology, and distance learning. He is a member of several professional organizations, is Chair-Elect of the Executive Board of the Continuing Professional Development Division of ASEE, and serves on the Governing Council of the International Association of Continuing Engineering Education. He has several publications to his credit on the subject of continuing education and technology enhanced learning.