National Center for
Integrated Systems Technology
Illinois State University

A Career Path System for Integrated Systems Technology

Mapping Content in
Advanced Manufacturing Integrated Systems (AM/IST)
Program Models
to
Career Ladders and Lattices
in
High-Performance Manufacturing Workplaces

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Purpose

The purpose of this document is to report on potential career paths within manufacturing environments that depend upon integrated systems technology. It represents the first comprehensive attempt to "map back" the skills imbedded in the Advanced Manufacturing/Integrated System Technology Program (AM/IST) to potential career ladders and lattices involving integrated systems in the high-performance manufacturing workplace.

As equipment and processes become increasingly high-tech, manufacturers require highly skilled workers who can operate, troubleshoot and maintain complex, integrated production systems. Increasingly this involves knowledge, skills and abilities related to several different areas of work: electrical, electronic, mechanical and fluid power. It requires not only the ability to gain new skills that allow for vertical movement to higher levels of specialization within a given area (career ladder), but also the ability to gain new skills to support horizontal or lateral movement (career lattice) through critical cross-training among systems. Together they constitute a career path in integrated systems manufacturing.

This paper provides the rationale for why the AM/IST program is uniquely suited for application to a career path model in the 21st century manufacturing workplace. It outlines the content imbedded in the program, that is, electrical, electronic, mechanical and fluid power technical competencies, and illustrates how the program design supports individualized instruction to include both vertical and lateral progression based on each learner's personal career goals. The final report will relate the content and competencies in the AM/IST program to career opportunities in demand by manufacturers.

Application of Career Paths to the AM/IST Program

Many current workers who have gained skills in integrated systems through years of work experience and practical application are nearing retirement, and most of those remaining on the job were trained in traditional, occupationally specific programs. Even with the general decline of manufacturing jobs, positions that require knowledge of integrated systems are increasing due to rapidly advancing technology. Therefore, it is critical that both new workers to manufacturing and those incumbent workers already on the job have a visual "career map" to illustrate how the skills they currently have, coupled with additional education and training they may receive, can lead them to the new, high-demand career opportunities available in integrated systems manufacturing.

To that end, this document focuses on the design of such a career path, including career ladders and lattices, related to the skills imbedded in the Advanced Manufacturing Integrated Systems Technology (AM/IST) program. Several characteristics of the AM/IST program make it uniquely suited for application to a career ladder/career lattice model.

- The program incorporates the full set of production and maintenance competencies required to function in a high-performance manufacturing environment from entry-level up to a skilled technician on the shop floor;

- The content covers an expansive range of academic, workplace and technical competencies roughly equivalent to four semesters at a community college in terms of knowledge and skills, and inclusive of the technical skills required for an Associate of Applied Science degree;

- The curriculum was intentionally designed in a modularized format that can be easily adapted and customized to the needs of a wide variety of end users, i.e., the program can be used in parts or as a whole, depending on the needs of the business customer and individual learner; and

- Instruction is directly correlated to a set of technology-based materials and equipment that simulate real-world manufacturing challenges and provide direct hands-on learning experiences.

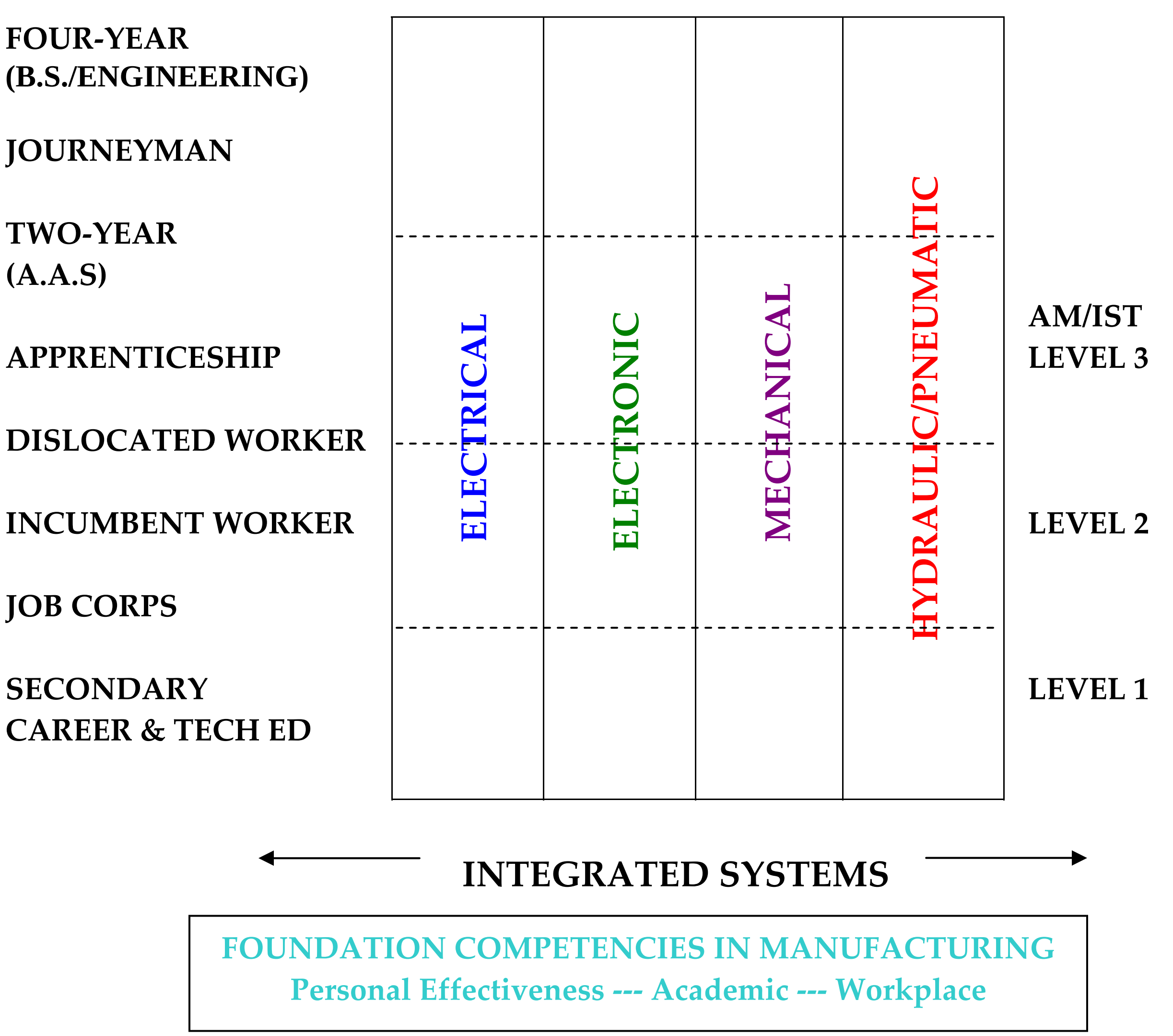
Because of this design and flexibility, the program has been used successfully with youth in career technical programs, young adults in Job Corps centers, dislocated workers identified through One Stop centers, incumbent workers engaged in skills upgrade training, apprentices completing related instruction, and populations seeking various programs and degrees at community colleges.

While the critical nature of the content of the AM/IST program stands on its own merits, it gains even greater value when individuals can see the relationship between what they are learning and the career paths available to them because of their increased knowledge and skills. That translates to career retention, advancement and – ultimately – higher wages.

AM/IST Program Model

Figure One is the visual representation of the broad content knowledge and skill areas imbedded in the AM/IST program model. It represents the vertical opportunities available to individuals to specialize in one of four key content areas: electrical, electronic, mechanical and fluid power, representing the four levels of instruction available in the complete AM/IST program. It also illustrates the powerful cross-training aspect of integrated systems in terms of the horizontal or lateral movement across content and skills that occurs at each of the four program levels.

Figure One
Advanced Manufacturing Integrated Systems Technology (AM/IST) Program Model



The four technical content areas build on a base of critical foundation skills of modern high-performance: personal effectiveness, academic competencies and workplace competencies. While not linear in terms of progression, i.e., an individual does not master all of the workplace competencies before moving on to technical competencies, the foundation skills provide the critical basis upon which technical competencies are taught. Most individuals have mastered these fundamental personal, academic and workplace competencies before beginning the AM/IST training program. For those who have not, AM/IST reinforces personal effectiveness skills and imbeds critical academic (primarily math) and workplace skills into the curriculum.

Figure One also references a timeline or progression in terms of the education and training delivery system. Beginning with some sort of career technical training that might be offered through a high school or Job Corps program up through a four-year degree in a specialty area, this framework begins to map out the progression inherent in the AM/IST program.

While the visual references the content to a time-based framework, it is merely to suggest when content might "typically" be mastered. That is to say, the content is not age-related. Many of the basic technical skills in Level 1 might be taught to young persons attending a high school vocational center or out-of-school youth attending a Job Corps center. On the other hand, they might also be taught to a 30 year-old immigrant for whom English is a second language as part of a job training program. Higher Level 3 content skills might be taught to an 18 year-old following the traditional sequence of apprenticeship training, or to a 42 year-old dislocated worker as part of a retraining program.

The visual also references the three levels of integrated learning units available within the AM/IST program. Each unit teaches industry relevant job tasks, meets international skill standards, integrates math and science skills, and covers a broad depth of content. Each unit uses a layered design consisting of 6-10 specific content areas that start with basic concepts and progress to more complex activities. Units also feature cross-connecting activities where learners apply in one unit what they have learned in other units, emphasizing a systems-approach to learning across content areas. Manufacturers rank the ability to understand and work with systems one of the five most important career skills.

Finally, Figure One illustrates the seamless articulation with continued post-secondary education beyond a formal apprenticeship program or two-year associated degree. Specializations in each of the four content areas can lead directly to a variety of four-year applied science, applied technology or engineering degrees.

A Conceptual Framework

Before launching into a review of the content and competencies within the AM/IST program and the analysis of its relationship to career opportunities, it is important to set the conceptual framework for the mapping process. That involves some background discussion on career ladders and lattices, as well as career path systems.

What are Career Ladders and How Do They Relate to AM/IST?

Career ladders are structures that relate occupations in an organization or industry based on skill progression and increased earnings. Traditionally, career ladders have been occupational frameworks used to encourage, recognize, and reward capable employee performance. They refer to the normal progression of individuals from entry-level work into higher-skill, higher-wage career opportunities. Successful on-the-job training or the acquisition of new skills through education and training programs typically prepare individuals for the next job level, or rung on the career ladder. Several different types of career ladders can be identified:

Single-Firm Career Ladders: Single-firm career ladders exist primarily in organizations large enough to have a hierarchy of related occupations, plus enough growth and turnover, to allow for upward movement. While they have declined in recent decades, as firms have shed ancillary functions and focused on their core business, some major corporations have maintained strong career ladder programs, often through strong labor management cooperation. Typically career ladders in single firms target a number of entry-level occupations, offer skill-building training leading to higher level positions, and collaborate with training providers to ensure vacancies are filled through internal promotions. Examples include the career ladders within large manufacturing corporations such as Caterpillar and General Motors.

Single-Industry/Segment Career Ladders: Over the past several decades, single-industry or segment-specific career ladders have begun to emerge as employers of all sizes face increased difficulty in finding skilled workers and in identifying successful strategies to promote workers while moving new employees into entry-level positions. Because the manufacturing industry is made up of so many diverse segments, such as food processing, chemical, plastics, etc., career ladders that function within a single-industry or single-segment of manufacturing have grown in importance. Employer demand pulls low-skilled workers up from low-wage jobs using advancement opportunities created by industry-wide career ladders. Industry-wide career ladders typically function in a local or regional economy, such as the metals industry in the greater Chicago region.

***Sector-Based Career Ladders*:** Sector-based career ladders target specific occupations or sets of occupations in a particular sector of the economy, then develop skills-training courses or programs designed to prepare workers for those positions. Rather than focusing just on meeting employer needs, sector-based strategies tend to take a broad-based, systems approach. This often includes demand-side strategies such as the development of industry skill standards and adoption of model human resource practices to support career ladder advancement opportunities. Additionally, sector-based career ladders also address supply side change by relying heavily on customized training for targeted occupations and industry sponsored skill certifications to support worker advancement. The efforts of the National Association of Manufacturers (NAM) to support effective workforce development strategies in member firms across the country represent a sector-based career ladder approach.

All three types of career ladders have numerous applications and can yield benefits for both individuals and employers:

- **Performance Incentive**: The opportunity for advancement motivates employees to produce and perform well on the job and to acquire new knowledge and skills.

- **Employee Retention**: Career ladders provide an incentive for employees to stay with an organization or in an industry when they see opportunities to advance.

- **Cost Savings**: Employers save on costly turnover, recruitment and training expenses.

- **Succession Planning**: Career ladders enable organizations to plan for and develop the skills, knowledge and abilities they need now and in their future workforce.

The important point to emphasize is that the AM/IST program has direct application to all types of career ladders: single-firm, single-industry, and sector-based as relates to high performance manufacturing. Because it encompasses a broad range of content relating to both production and maintenance functions with manufacturing, the AM/IST program has relevance to and is supportive of vertical career ladder progression in single firms, for groups of firms in single industries within manufacturing such as electronic equipment manufacturers, and across the entire manufacturing sector. In fact, the AM/IST program content has even had relevance to a cross-sector career ladder effort in the construction industry because of the transferability of skills between the two industry areas.

What are Career Lattices and How Do They Relate to AM/IST?

In recent years, corporate flattening, downsizing, rightsizing, and outsourcing have curtailed the number of rungs on career ladders, both in individual organizations, industry- and sector-wide, significantly altering the once powerful image of "climbing the ladder of success." Such flattened organizational structures, the changing nature of work, and the blurring of boundaries across traditional occupations are causing workers to move laterally to pursue fresh challenges, develop new skills, and/or seek opportunities to move up. While the vertical promotion inherent in all types of career ladders still occurs, the term "career lattices" may more accurately reflect the type of movement that often occurs in the workplace today.

Up is Not the Only Way: A Guide to Developing Workforce Talent by Kaye, suggests: "Once considered a way of shelving "dead wood," lateral moves have become a way for employees to broaden existing skills, learn about other areas of the organization, develop new talents, demonstrate versatility, and prepare for future vertical moves."

Moreover, as the modern workplace continues to shift from an occupationally-based framework to a skills-based framework, the neat lines or boundaries that have historically defined most vertical career path systems have begun to blur. For example, most production operators perform some level of routine preventive maintenance on their machines to keep them performing at top efficiency.

As technology increases and machines get more sophisticated, that same worker may need to increase his or her maintenance skills and possibly take on some of the preventive maintenance or diagnostic maintenance typically associated with a general maintenance mechanic. Or, that new piece of equipment may now have some functions that are electronically driven, requiring yet an additional set of skills by the workers in a totally new systems area.

Implicit in a career lattice model is the need for cross-training among sets of skills traditionally associated with discrete areas of knowledge and skills, and typically discrete occupational titles. In terms of a visual model for mapping in today's dynamic workplace, such a scenario creates more of a career "web" than it does a neat vertical or horizontal chart. Such career webs have begun to emerge in the business technology, information technology and health care industries, where a strong set of cross-cutting foundation skills can lead to a multitude of both vertical and lateral career options.

The AM/IST program inherently incorporates a career lattice model because it is grounded in the basic premise of cross-training among systems critical to high-performance manufacturing environments: electrical, electronic, and mechanical. Advancing technology and the dynamic manufacturing workplace continually require workers to gain new sets of skills that may cross over into what traditionally has been associated with a different occupational area.

The AM/IST program begins with that assumption, and proactively trains workers with the increasingly broad, cross-cutting skill sets they will need to be effective in the modern manufacturing environment. Every current worker who completes the short-term incumbent worker AM/IST training expands his/her skill base to include electrical systems, programmable logic controllers, mechanical systems, as well as hydraulic and pneumatic systems – which expands future career opportunities.

What is a Career Path System and How Does It Relate to AM/IST?

Broadly defined, a career path system includes both career ladders (vertical progression) and career lattices (lateral movement) within firms, within an industry segment, and across the sector, as well as the education, training, labor and government programs and partners needed to effectively implement skills development programs in the workplace.

A career path system:

- groups job and skill clusters that facilitate both vertical and lateral career moves;
- relates to and incorporates nationally recognized skill standards and industry-based credentials;
- establishes requirements for education and training curricula including academic, workplace and technical competencies; and
- relies on a partnership of business, labor, government and educators to develop all aspects of the system.

There is growing national consensus that organizing workforce development around industry sectors, such as manufacturing, helps organize both the needs of employers for skills workers (the demand) and the needs of individuals for skills training (the supply). A successful workforce *system* must be able to serve the full spectrum of individuals seeking training – those with few skills and no experience in the workplace, those currently employed in low skill jobs who want to improve their earnings position, those dislocated from the labor market who may need "gap" training to reenter, and those in need of upgrade training to advance their careers.

Again, **the AM/IST program is well positioned to serve as a career path system for manufacturing workforce development at the local, state and national level to provide cross-cutting skills acquisition and support both vertical and lateral career moves for individuals at all ages and stages of work history.** The AM/IST program meets all of the criteria for a career path system in that it:

- provides a sequential set of instructional modules keyed to successive levels of skill requirements in four particular job families or clusters within manufacturing: electrical, electronic, mechanical and hydraulic/pneumatic;

- incorporates the requirements of national skills standards and several industry-based certifications such as the Manufacturing Skills Standards Council, the National Institute of Metalforming Skills, ETA International Electronic Association, the International Fluid Power Association, and others;

- builds on and reinforces the personal effectiveness, academic, and workplace competencies needed for success in the modern manufacturing workplace, while focusing on the technical competencies essential to career retention and advancement; and

- is based on partnership with key stakeholders in business, labor, education and workforce development, including, but not limited to: public technical schools, Job Corps manufacturing programs, community colleges, One Stop Centers, registered apprenticeship programs support by various labor organizations, and hundreds of individual companies engaged in incumbent worker training.

One of the primary criteria for a career path system is that it provides multiple entry and exit points, enabling individuals of all levels and abilities to access the system and providing both short-and long-term education and training experiences that can build an individual's skill base. The AM/IST program meets that criteria in that it has been configured to address multiple customer groups, as discussed in the following section, and that it offers a variety of learning packages customized to the needs of critical target audiences.

Career Ladders and Lattices for the Five AM/IST Program Models

The Advanced Manufacturing/Integrated Systems Technology Program, a modularized instructional system, has been configured as five basic curricula that target different learner groups:

- **High School Career & Technical Education/Job Corps Program**, an 800 hour program which focuses on building foundation skills in applied academics, technology applications, safety, workplace competencies, and cross-cutting, industry-wide technical skills in manufacturing processes, quality assurance, and design processes. The program also introduces the basic concepts in electrical, electronic, mechanical, and hydraulic/pneumatic systems.

- **Dislocated Worker Program**, a 200 hour curriculum designed to help individuals with previous work histories build on their existing skill base and re-enter the marketplace on a manufacturing career path.

- **Incumbent Worker Program,** a short-term technical skills program for current workers to provide them cross-training experience in the areas of electrical systems, programmable logic control, mechanical systems and hydraulic/ pneumatic systems.

- **Integrated Systems Technology Apprenticeship Program,** a comprehensive 8,000 program of in-depth related instruction to complement an on-the-job experience in integrated systems technology.

- **Associate of Applied Science Program: Advanced Integrated Manufacturing Systems Technologies Degree:** a two-year degree program offered at the community college level.

Each of these AM/IST program models was designed to address the needs of a particular customer group, and so they vary considerably in terms of depth and breadth of content. However, they share many of the same basic structural features in terms of competency-based underpinnings, modularized design, technology-based delivery, and individualized instruction.

Each of the five program models is discussed below, including a visual for each model that outlines the general program content and "maps back" to relevant manufacturing career paths and occupations. In each case an identified content area represents a unit or module of instruction.

Secondary Career Technical/Job Corps

The AM/IST program at the most basic level is appropriate for high school students in a career technology education (CTE) or Manufacturing Academy program, as well as out-of-school youth at Job Corps Centers and other short-term Workforce Investment Act (WIA) funded programs. It could also be used as the basis for a short-term training program for out of work adults recruited through a One Stop Center and operated by any number of community providers or a local community college.

The basic program as it relates to the overall AM/IST model includes several modules in foundation academic and workplace competency areas, as well as numerous modules related to industry-wide technical competencies, which is the emphasis of the program. Finally, it covers the basic knowledge and skills related to all four of the content specific units covered in integrated systems technology, including electrical, electronic, mechanical, and fluid power.

The program was designed to address the growing need among small and medium sized manufacturing firms for entry-level workers who possess a broad set of foundation or "core" competencies in manufacturing skills and are able to perform multiple tasks in the constantly changing manufacturing workplace. The competency-based program was intentionally designed to provide new workers a broad base of skills – what every worker in the industry should know and be able to do - rather than preparing them for specific occupations. As a result, graduates are able to:

- Demonstrate good work habits and employability skills
- Function as safe, productive workers immediately
- Perform multiple tasks in production, maintenance and quality assurance
- Demonstrate entry-level skills with mechanical, electrical and fluid power systems

Students spend approximately 800-hours in a technology-driven classroom that combines self-paced, computer-based instruction with hands-on application through use of both manufacturing equipment and simulators. Classrooms operate as shops, with students work in pairs and small teams to complete Learning Activity Packages (LAPs) and problem-based learning exercises. The instructional content correlates to Level One of the total AM/IST Curriculum

The program, which was intentionally designed to be cross-cutting and not occupationally specific, prepares graduates to enter manufacturing through a wide variety of occupational doors. Performance data collected from several Job Corps centers that operate the program illustrate the range of opportunity created, as illustrated by the following visual, which links the program content to the career pathways.

Figure Two
Secondary Career & Technical Education/Job Corps Model and Related Career Paths

Entry-Level Career Pathways/Occupational Areas for AM/IST

(Actual job titles of student placements, which reflect primarily industry-wide competencies, the emphasis of this short-term training program)

- Production Worker
- Fork Lift Operator
- Inventory Clerk
- Machine Operator
- Lathe Operator
- Package Handler
- Material Handler
- Quality Control Inspector
- Stacker
- General Laborer
- Maintenance Assistant
- Engineering Assistant

Electrical	**Electronic**	**Mechanical**	**Hydraulic/Pneumatic**
Electrical Systems Level 1 Electrical Control Wiring	Mechanical Systems Level 1	Programmable Controllers Introduction to Robotics	Fluid Power Systems Level 1

Cross-Cutting, Industry-Wide Competencies

- Safety
- Manufacturing Processes – Levels 1 and 2
- Quality Assurance – Level 1
- Design Processes – Levels 1 and 2

Foundation Competency Modules

- Workplace Skills for Success
- Applied Mathematics/Precision Measurement
- Information Technology Skills
- Business and Manufacturing Principles

Dislocated Worker Program

While the Dislocated Worker Program is actually shorter in hours, at 200, than the High School Career & Technical Education/Job Corps model described above, it is intended for a very different target audience. It is designed to help individuals with previous work histories build on their existing skill base and re-enter the marketplace on a manufacturing career path. As a result, it presumes fundamental workplace and industry-wide technical skills have already been mastered and focuses exclusively on building or enhancing the technical skill sets of individuals with previous work histories.

The program is designed as a series of fourteen modules ranging from five to thirty-nine hours in length. The intent is to provide a standardized set of instructional units which, for some, may serve as a review to sharpen existing skills and, for others, may introduce new knowledge and skills into their existing competency base.

A critical feature of the program is that the modules cut across and include all four of the major content areas: electrical, electronic, mechanical and hydraulic/pneumatic systems (although some versions of materials show the last two grouped together under a "mechanical" heading). This feature makes the program truly unique, in that most short-term dislocated worker programs tend to focus on only one or two of those areas, and are typically shorter in duration, aiming for immediate reemployment. The AM/IST program provides a broad cross section of skills so trainees can see the interrelationships of content areas as they apply to many advanced technologies on the shop floor.

Additionally, many dislocated workers involved in the program have been employed in a narrow occupational area related to only one of the four areas or have had exposure to selected cross-cutting skill sets only through on-the-job training or particular hobbies they may have had. For many trainees, this curriculum offers a first time, formal learning experience that shows the intersection of content and skill areas.

The AM/IST Dislocated Worker Program content is outlined in Figure Three, along with **sample job titles of actual employed program participants**. It illustrates both the vertical progression that is possible through the AM/IST curriculum into career pathways associated with each of the four specific content areas (boxes directly above content areas), and the cross-cutting nature of the curriculum that would support lateral movement (career lattices) between and across pathway areas (top box). It is important to point out that of the twenty actual occupational titles, none of them has the words "Integrated Systems" in them, even though the need for cross-cutting skills in implied in each and every one. The terminology, while widely recognized, is so new it has not as yet moved into the common occupational titles used in the workplace.

Figure Three: Dislocated Worker Program and Related Career Paths

- Assembly
- Assembler/Special Machine
- CNC Machining
- Field Service Technician
- Industrial Technician
- Machine Maint. Operator
- Machine Repairman
- Maintenance Assistant
- Maintenance Engineer
- Maintenance Machinist
- Maintenance Mechanic
- Maintenance Supervisor
- Maintenance Technician
- Plant Operator
- Production Supervisor
- Quality Consultant
- Quality Control
- Quality Supervisor
- Senior Technician
- Utility Technician

Apprentice – Electrical Electrician

ELECTRICAL

A/C Electrical Control Systems

Basic Electrical Circuits
Electrical Measurements
Circuit Analysis
Inductance and Capacitance
Combination Circuits

Electrical Motor Control

Intro to Electrical Motor Control
Manual Motor Control
Control Transformers
Control Ladder Logic
Control Relays and Motor Starters
Introduction to Troubleshooting
Systems Troubleshooting
Reversing Motor Control
Automatic Input Devices
Basic Timer Control

Industrial Electrical Wiring

Intro to Electrical Control Wiring
Electrical Control System Wiring

Industrial Power Distribution

Introduction to Raceways
Basic Conduit Bending
Advanced Conduit Bending
Conductors & Overload Protection
Conduit Sizing & Wire Pulling

Installer Technician Electronic Technician

ELECTRONIC

Programmable Controllers

Introduction to Programmable Controllers
Basic PLC Programming
PLC Motor Control
Discrete I/O Interfacing
Introduction to PLC Troubleshooting
PLC Systems Troubleshooting
Event Sequencing
Application Development
PLC Timer Instructions
PLC Counter Instructions

Mechanic Mechanical Technician

MECHANICAL

Mechanical Systems I

Introduction to Mechanical Drive Systems
Key Fasteners
Power Transmission Systems
Introduction to V-Belt Drives
Introduction to Chain Drives

Mechanical Systems II

Heavy Duty V-Belt Drives
V-Belt Selection and Maintenance
Heavy Duty Chain Drives

Piping Systems

Metal Piping Systems
Metal Piping Installation
Metal Tubing Systems
Hoses

Hydraulic Troubleshooting

Introduction to Pressure Compensated Pumps
Troubleshooting Hydraulic Activators
Troubleshooting Hydraulic DCVS
Troubleshooting Flow Valves
Troubleshooting Pressure Valves
Troubleshooting Hydraulic Systems

Apprentice Plumber/Pipefitter Refrigeration Technician

HYDRAULICS/PNEUMATICS

Basic Hydraulics

Hydraulic Power Systems
Basic Hydraulic Circuits
Principles of Hydraulic Pressure/ Flow
Hydraulic Speed Control
Pressure Control Circuits

Intermediate Hydraulics

Hydraulic DCV Applications
Hydraulic Cylinder Applications
Hydraulic Relief Valve Operation
Hydraulic Relief Valve Applications

Basic Pneumatics

Pneumatic Power Supply
Basic Pneumatic Circuits
Principles of Pneumatic Pressure/Flow
Pneumatic Speed Control Circuits

Intermediate Pneumatics

Pneumatic Maintenance
Introduction to the Pneumatic Construction System

Electro-Fluid Power

Power Devices
Control Relays
Sequencing Control

Incumbent Worker Program

In order to cover the broad range of technical skills associated with integrated systems in advanced manufacturing workplaces, the AM/IST Incumbent Worker Training Program model offers employers thirty modules of training in the four primary content areas, distributed as follows: electrical(10), electronic(5), mechanical(5) and hydraulics/pneumatics(10). The list of content, as summarized below, is too exhaustive to be visually portrayed in the same format as other examples shown earlier.

ELECTRICAL

A/C Electrical Control Systems

Basic Electrical Circuits
Electrical Measurements
Circuit Analysis
Inductance and Capacitance
Combination Circuits
Transformers

Electrical Motor Control

Intro to Electrical Motor Control
Manual Motor Control
Control Transformers
Control Ladder Logic
Control Relays and Motor Starters
Introduction to Troubleshooting
Systems Troubleshooting
Reversing Motor Control
Automatic Input Devices
Basic Timer Control

Industrial Electrical Wiring

Intro to Electrical Control Wiring
Electrical Control System Wiring

Industrial Power Distribution Systems

Introduction to Raceways
Basic Conduit Bending
Advanced Conduit Bending
Conductors & Overload Protection
Conduit Sizing & Wire Pulling

Process Control Systems

Introduction to Process Control
Instrument Tags
Piping and Instrument Diagrams
Loop Controllers
Final Control Elements
Level Measurement
Liquid Level Control
Methods of Automatic Control
Basic Flow Measurement and Control
Control Loop Performance

Thermal Process Control Systems

Introduction to Temperature Measurement and Control
Instrument Tags
Piping and Instrumentation Diagrams
Thermal Energy and Heat Transfer
Basic Temperature Control Elements
Loop Controllers
Final Control Elements
Temperature Sensors and Transmitters
Basic Temperature Control
Methods of Automatic Control
Control Loop Performance

A/C Electronic Drive Systems

Introduction to AC Motion Control
AC Vector (Spindle) Drives
AC Axis Drives
General Purpose AC Drives
AC Drive Troubleshooting

D/C Electronic Drive Systems

Introduction to DC Motion Control
Basic DC Drives – SCR Control
DC Spindle Drives
Basic DC Axis Drives
DC Pulse Width Modulation Drives
DC Drive Troubleshooting

CNC Troubleshooting and Maintenance Systems

Introduction to CNC Systems
CNC Operator Controls
Basic CNC Part Programming
CNC/PMC Interface and Operation
CNC Controller Functions
Introduction to CNC System Troubleshooting
CNC Servo System Troubleshooting
CNC Controller and Operator Interface Troubleshooting

Mechatronics

Automation Operations
Basic Component Adjustments
Pick and Placement Feeding
Gauging
Indexing
Sorting/Queuing
Robotic Pick and Place Assembly
Torqueing/Assembly

ELECTRONIC

Programmable Logic Controllers (Basic)

Introduction to Programmable Controllers
Basic PLC Programming
PLC Motor Control
Discrete I/O Interfacing
Introduction to PLC Troubleshooting
PLC Systems Troubleshooting
Event Sequencing
Application Development
PLC Timer Instructions
PLC Counter Instructions
Program Control Instructions
Math and Data Move Instructions

Programmable Logic Controllers (Applications)

Analog Input Modules
Analog Output Modules
Analog Scaling

Programmable Logic Controllers (Panelview)

Introduction to Panelview
Panelview Application/Editing
Panelview Application Editing II

Programmable Logic Controllers (Data Highway)

Introduction

Programmable Logic Controllers (Remote IO)

Introduction to Rio

MECHANICAL

Mechanical Systems I

Introduction to Mechanical Drive Systems
Key Fasteners
Power Transmission Systems
Introduction to V-Belt Drives
Introduction to Chain Drives
Spur Gear Drives
Multiple Shaft Drives

Mechanical Systems II

Heavy Duty V-Belt Drives
V-Belt Selection and Maintenance
Synchronous Belt Drives
Lubrication Concepts
Lubrication Concepts
Precision Shaft Alignment
Couplings
Heavy Duty Chain Drives

Mechanical Systems III

Solid Plain Bearings
Ball Bearings
Roller Bearings
Antifriction Bearing Selection and Maintenance
Caskets and Seals
Advanced Gear Drives
Gear Drive Selection and Maintenance

Vibration Analysis

Introduction to Vibration Analysis
Vibration Condition Monitoring
Vibration Analysis

Piping Systems

Metal Piping Systems
Metal Piping Installation
Plastic Piping Systems
Metal Tubing Systems
Hoses
2-Way Valves
Check Valves and Steam Traps
Relief Valves and Regulators

HYDRAULICS/PNEUMATICS

Basic Hydraulics

Hydraulic Power Systems
Basic Hydraulic Circuits
Principles of Hydraulic Pressure/ Flow
Hydraulic Speed Control
Pressure Control Circuits

Intermediate Hydraulics

Hydraulic DCV Applications
Hydraulic Cylinder Applications
Hydraulic Relief Valve Operation
Hydraulic Relief Valve Applications
Accumulator Applications

Advanced Hydraulics

Hydraulic Motor Applications
Hydraulic Pump and Motor Performance
Fluids and Conditioning

Hydraulic Troubleshooting

Introduction to Pressure-Compensated Pumps
Pressure-Compensated Pump Performance
Troubleshooting Hydraulic Actuators
Troubleshooting Hydraulic DCVs
Troubleshooting Flow Control Valves
Troubleshooting Pressure Control Valves
Troubleshooting Unloader and Counterbalance Valves
Troubleshooting Hydraulic Systems

Electro-Fluid Power

Introduction to Electrical Control Systems
Basic Control Devices
Power Devices
Control Relays
Sequencing Control
Pressure Control Applications

Basic Pneumatics
Pneumatic Power Supply
Basic Pneumatic Circuits
Principles of Pneumatic Pressure/Flow
Pneumatic Speed Control Circuits
Intermediate Pneumatics
Pneumatic DCV Applications
Air Logic
Pneumatic Maintenance
Advanced Pneumatics
Moving Loads Pneumatically
Air Compressors
Vacuum Systems
Pneumatic Troubleshooting
Introduction to Pneumatic Troubleshooting
Air Preparation Troubleshooting
Troubleshooting Pneumatic Cylinders
Motor and Rotary Actuator Troubleshooting
Troubleshooting DCV's and Flow Control Valves
Troubleshooting Vacuum Systems
Troubleshooting Pneumatic Systems
Pneumatic Construction System
Introduction to the Pneumatic Construction System

This content is relevant across a broad range of over forty occupational areas related to maintenance functions within the advanced manufacturing environment. To determine this list, a scan was conducted using the Department of Labor online O*NET system. A review was conducted of the over 350 occupations within the O*NET database that met the following criteria:

- First-line supervisor or below (the focus of AM/IST program), not managerial and professional positions such as engineers;
- Those maintenance, repair and installation functions performed within the manufacturing facility, not those at end-user sites such as washing machine repairman; and
- Only production and production-support occupations, not business services occupations such as accounting that may also occur within a manufacturing enterprise.

That resulted in the identification of 86 occupations that fell into the general category of Maintenance, Installation and Repair, the targeted "occupational family of AM/IST." These 86 were then reviewed in terms of skill requirements, and a general crosswalk was conducted between the skills required of the identified occupations and the general content imbedded in the AM/IST Incumbent Worker Training Program.

The visual on the next page illustrates the relationship between the incumbent worker program model and various occupations that could be positively impacted by the AM/IST Incumbent Worker Program. Directly above the program content are examples of occupations that tend to reflect the specialty skills of that particular discipline, such as Circuit Board Repairer for Electronics and Pipe Fitter for Hydraulics. Hovering above the content areas, however, is a much larger grouping of over forty occupations that require some element of cross-cutting skill sets and cross walk directly to the content imbedded in the AM/IST program. The list includes such occupational titles as Electronic Mechanic and Electromechanical Technician, clearly reflective of the growing trend towards interdisciplinary technology requirements and skill sets.

Figure Four: Incumbent Worker Program and Related Career Paths

Sample Occupations Requiring Cross-Cutting Skills:

All Other Electrical and Electronic Equipment Mechanics
All other Mechanics, Installers and Repairers
Calibration and Instrumentation Technicians
Control Technicians
Diesel Engine Erectors and Fitters
Electric Motor and Switch Assemblers and Repairers
Electrical Repairman
Electrical Mechanics
Electrical and Electronic Inspectors and Testers
Electromechanical Technicians
First-Line Supervisors - Mechanics, Installers and Repairers
Helpers- Electricians and Powerline Transmission Installers
Helpers- Mechanics and Repairers
Helpers- Plumbers, Pipefitters and Steamfitters
Hydraulic Repairman
Hydro Maintenance Technicians
Industrial Technicians
Instrument and Electrical Technicians
Machinery Maintenance Mechanics
Machinery Maintenance Repairers
Machinery Maintenance Servicers
Maintenance Repairers
Materials Inspectors Mechanical Door Repairers
Mechanical Inspectors
Meter Mechanics
Millwrights
Multi-skilled Maintenance Worker
Precision Devices Inspectors and Testers
Precision Instrument Repairers
Programmers- Numerical, Tool and Process Control
Pump Installers and Servicers
Refrigeration Mechanics
Transportation Maintenance Clerks

20

Aircraft Electricians
Electricians
Powerhouse, Substation and Relay Electricians

Electronics Engineering Techs
Electronics Mechanics & Techs
Test Card and Circuit Board Repairers

Diesel Engine Mechanics
Heating and Air Conditioning Mechanics
Mechanics

Pipe Fitters
Plumbers
Valve and Regulator Repairers

Electrical

A/C Electrical Control Systems
Electrical Motor Control
Industrial Electrical Wiring
Industrial Power Distribution
Process Control Systems
Thermal Control Systems
A/C Electronic Drive Systems
D/C Electronic Drive Systems
CNC Troubleshooting
Mechatronics

Electronic

Programmable Logic Controllers:

- **Basic**
- **Applications**
- **Panelview**
- **Data Highway**
- **Remote IO**

Mechanical

Mechanical Systems I
Mechanical Systems II
Mechanical Systems III
Vibration Analysis
Piping Systems

Hydraulics/Pneumatics

Basic Hydraulics
Intermediate Hydraulics
Advanced Hydraulics
Hydraulic Troubleshooting
Electro-Fluid Power
Basic Pneumatics
Intermediate Pneumatics
Advanced Pneumatics
Pneumatic Troubleshooting
Pneumatic Construction System

Integrated Systems Technology Apprenticeship Program

The Integrated Systems Technology program has the depth and breadth of content to link with and support over fifty existing apprenticeship programs registered with the Department of Labor. A comprehensive report on linkages between the AM/IST program and existing registered apprenticeship programs in discrete occupational areas including electrical, electronic, mechanical and hydraulic/pneumatic is being prepared as a separate document from this Career Pathways piece and will be submitted as part of the final NCIST report.

Another approach to linking the AM/IST program with the registered apprenticeship system is the development of apprenticeship programs that integrate the various AM/IST content disciplines **within** a given registered apprenticeship program. Since no such programs existed, they had to be developed and approved. One such program, developed by Cuyahoga Community College, was used for this career pathways analysis.

That program is the Apprenticeship Training for Maintenance Repairer, Building – DOT Code: 899.381-010 – Healthcare Facility Maintenance and Management Apprenticeship Program. While developed for application in a health care setting, this program, with slight modifications, has the potential to eventually be applied in a much broader context to maintenance related settings across a broad range of different industries.

The program focuses on the unique skills required in the healthcare sector to repair, service, and install facility systems. Students receive training in electricity, motors and motor controls, programmable logic controllers (PLCs), HVAC/R, and boilers. This is a recognized apprenticeship registered with the Department of Labor.

This program is targeted for:

- those already in a maintenance department of a hospital looking to upgrade their skills,
- people with maintenance skills looking for advanced training in electrical concepts, HVAC/R, and boiler systems,
- people seeking CFC (refrigerant) and 3rd Class Stationary Engineer certifications,
- individuals with general skills looking to become more marketable.

Requirements for Completion, Healthcare and Institutional Courses

To earn the Facility Maintenance and Management Apprenticeship Certificate in Healthcare, the individual must successfully complete all of the required courses below totaling 192 hours and choose at least 88 hours of the 120 hours of elective classes to satisfy the 280 hour requirement for completion. On-the-job training is also required to complete the apprenticeship program.

Required Courses	Hours	Electives (88 Hours Required)	Hours
Maintenance Fundamentals	16	Programmable Logic Controllers	16
National Electric Code (NEC)	16	Fluid Power Fundamentals	8
NEC for Hospitals	16	Motor Controls	8
Nurse Paging Systems	16	Commercial Wiring	16
Institutional Cabling	24	High Pressure Boiler	24
Safety-ILSM Procedures	24	Mechanical Power Transmission	8
Carpentry, flooring, paint, drywall repair	24	Industrial Piping	8
HVAC/R I	32	Electronics for Electricians	8
Fire and Police Alarm Systems	8	Low Pressure Boiler	16
Refrigeration Systems I	16	Refrigeration Systems II	8
Total Required Hours	**192**	**Total Electives Available**	**120**

Both the required courses and electives of this newly developed apprenticeship program reflect the cross-occupational, cross-content premise of the AM/IST program. The required courses include broad-based maintenance and safety fundamentals, as well as covering basic electrical, electronic and HVAC systems content. Similarly, the menu of electives reflects a smattering of all four Integrated Systems content areas.

This approach is groundbreaking in that, historically, apprenticeship programs have been developed to include depth of content in a particular occupational area. Electives may provide some breadth, but the focus of content in most programs is narrow and deep in a given occupational area. This newly developed Facility Maintenance and Management Apprenticeship program reflects a broader approach that cuts across traditional occupational areas and incorporates content typically associated with four areas of specialization. As opposed to narrow and deep, this approach is broad and wide. This new registered apprenticeship program reflects the growing need to have skilled workers trained in several disciplines and able to deal with emerging technology that cuts across and integrates various systems. While developed for a healthcare setting, it has potential application, with minor modifications, to many other industries.

Associate of Applied Science Program: Advanced Integrated Manufacturing Systems Technologies Degree

This two-year degree program, to be offered at the community college level, is the most comprehensive and extensive of the program models. It includes four semesters of both required college level academic preparation, such as Composition and Introduction to College Algebra and Trigonometry, as well as a cross-cutting technical program of study.

This AAS Degree Program is highly unique in that it incorporates the Integrated Systems concepts across electrical, electronic, mechanical and hydraulic/pneumatic systems. Typically, AAS degree programs at community colleges focus on a particular occupational specialization or "major", such as electronics. At most, colleges will offer a "minor" and/or electives in other disciplines, in order to provide exposure to other related disciplines. This program, however, breaks the traditional mold by intentionally offering a balance of various technical disciplines to achieve the "integrated systems" concept. As such, it provides the student both depth and breadth in terms of learner outcomes.

This program also provides a strong basis for potential transfer to a four-year institution, for B.S. degrees in a variety of related engineering programs, such as electrical engineering, electronic engineering, mechanical engineering and others. It could also potentially serve as a model for the related instruction component of the registered apprenticeship program under development. An "integrated systems" apprentice simultaneous completing both the requirements for the registered apprenticeship and this two year program would emerge with both a journeyman certificate and an A.A.S degree – a formidable combination.

As illustrated in Figure Five, the comprehensive content covered in the two-year Advanced Integrated Manufacturing Systems Technology Program can lead to a variety of technician level occupations, as well as lay the foundation for advancement to engineering level occupations, assuming additional education at the college or university level. Not surprisingly, all of the advanced engineering degree programs noted are highly specialized, focusing on specific content areas. University educators suggest that students who enter such specialty degree programs with a broad base of understanding such as would be offered through the AM/IST Two Year AAS Program, will be very successful because of their broad knowledge base across numerous content areas.

Figure Five: Advanced Integrated Manufacturing Systems Technology Two Year AAS Program

Sample Engineering Areas: Electrical Engineers, Electronic Engineers, Environmental Engineers, Industrial Engineers, Mechanical Engineers, and Nuclear Engineers.

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Sample Technician Level Occupations Requiring Cross-Cutting Skills:

Calibration and Instrumentation Technicians
Control Technicians
Electrical and Electronic Engineering Technicians
Electromechanical Technicians
Hydro Maintenance Technicians
Industrial Technicians
Instrument and Control Technicians
Instrument and Electrical Technicians
Machinery Maintenance Technicians
Mechanical Drafters
Multi-skilled Maintenance Technicians
Precision Devices Inspectors and Testers
Precision Instrument Technicians

↑

Associate of Applied Science in Integrated Systems Technology (Technical Content)

1st Semester Core Course Sequence

- **Principles of Mechanical Systems**
- **Applied Electricity** and **Electronics**
- **Fundamentals of Fluid Power Systems**
- Blueprint Reading and Drafting

2nd Semester Core Course Sequence

- **Power Distribution and Control Systems**
- **Machining Fundamentals**
- **Advanced Principles of Mechanical Systems**

3rd Semester Core Course Sequence

- **Programmable Logic Control**
- **Advanced Fluid Power Systems**
- Program Electives

4th Semester Core Course Sequence - Electives:

Electrical Maintenance

- **Electrical Blueprint Reading and Drafting**
- **Electrical Motor Control**
- **Variable Speed Drives**
- **National Electrical Code Principles**
- **Industrial Controls**

Programmable Logic Control

- **Electrical Blueprint Reading and Drafting**
- **Variable Speed Drives**
- **Advanced Programmable Logic Control**
- Process Control and Instrumentation

Mechanical Systems Maintenance Electives

- **Mechanical Blueprint Reading and Drafting**
- **Fluid Power Pumps and Systems**
- **Conveyors and System**
- **Machine Moving and Repair**

Facility Maintenance Electives

Facility Blueprint Reading and Drafting
Sheet Metal Fabrication and Layout
Gas Heating Principles
Refrigeration and Air Conditioning
HVAC Troubleshooting

Fluid Power Specialist Electives

Piping Systems
Pipefitting and Plumbing Concepts
Fluid Power Pumps and Systems
Process Control and Instrumentation

A Career Path System for Integrated Systems Technology

The purpose of this document is to report on potential career paths within manufacturing environments that depend upon integrated systems technology, "mapping back" the skills imbedded in the Advanced Manufacturing/Integrated System Technology Program (AM/IST) to potential career ladders and lattices involving integrated systems in the high-performance manufacturing workplace.

Earlier sections of this paper reported on each of the five areas or models that currently make up the AM/IST program: High School Career & Technical Education/Job Corps Program, Dislocated Worker Program, Incumbent Worker Program, Apprenticeship Program and Associate of Applied Science Program. For each particular model and customer group, a general program overview and visual were presented reflecting the content and relevant manufacturing career paths and occupations associated with that model.

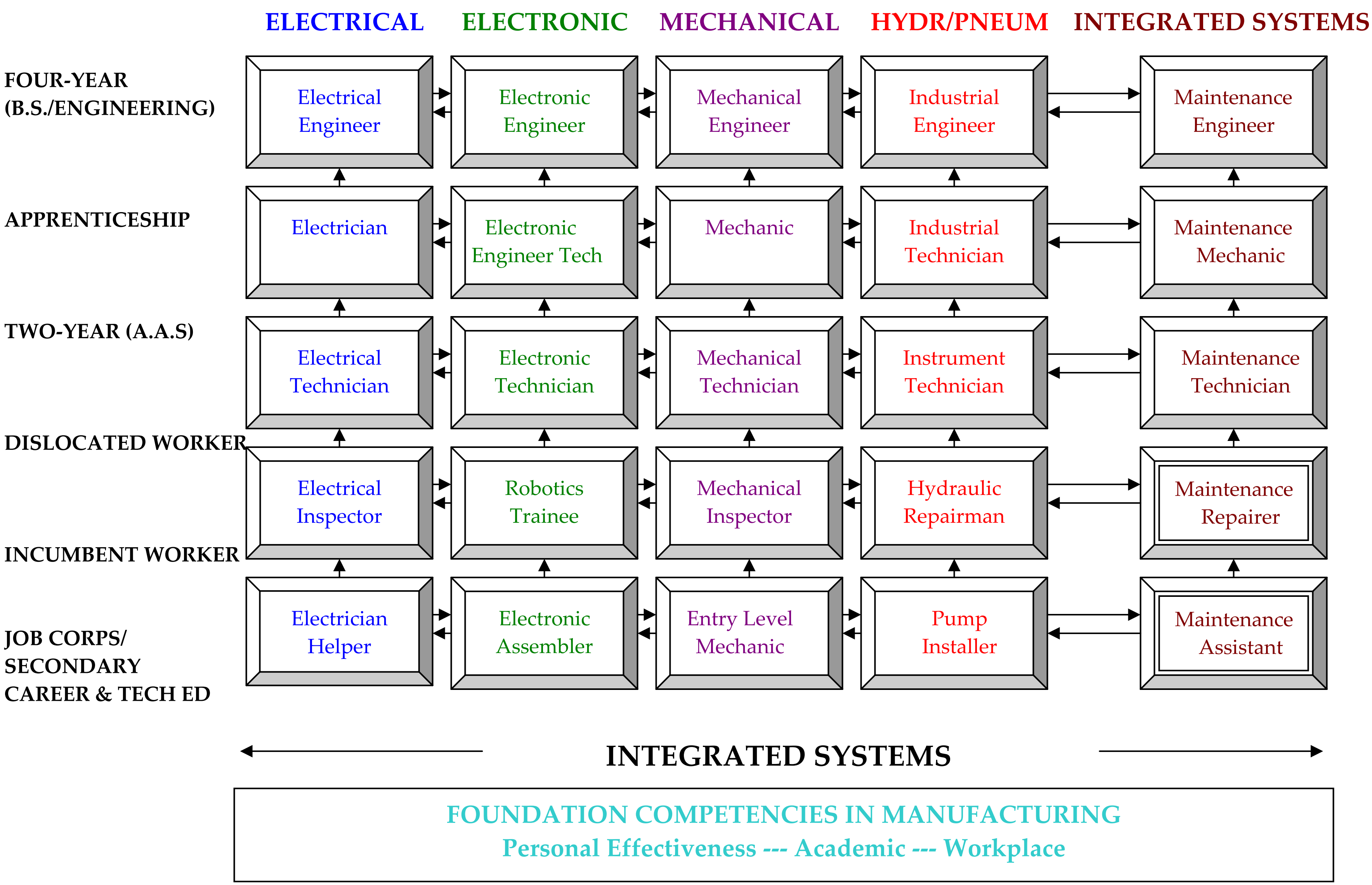
This section ties the five models together to offer the "gestalt" or whole picture of the career path system within the Advanced Manufacturing/Integrated Systems Technology program. It attempts to illustrate visually the underlying premises of the Integrated Systems approach. That is, that as equipment and processes become increasingly high-tech, manufacturing workers must operate, troubleshoot and maintain complex, integrated production systems involving knowledge, skills and abilities related to several different areas of work: electrical, electronic, mechanical and fluid power. New skill acquisition must allow not only for vertical movement to higher levels of specialization within a given area (career ladder), but also to support horizontal or lateral movement (career lattice) through critical cross-training among systems. Together they constitute the career path in integrated systems manufacturing.

Given the number of occupational areas in each of the four content areas, as well as the growing number of general maintenance-related areas, a visual attempting to show every possible occupation in the AM/IST career path is virtually impossible. The occupations most relevant to the mastery of content in each of the program models are listed in Figures 2 through 5.

Figure 6 illustrates **sample career paths** that might be associated with the AM/IST program, as follows:

- Vertical career ladders (depth), whereby individual advances based on mastery of ever more complex knowledge and skills **in a given content area.**

Figure Six: Sample (AM/IST) Career Paths: Ladders (Vertical) and Lattices (Horizontal)



- Horizontal career lattices (breadth), which allow individuals to move horizontally by mastering knowledge and skills **across content areas**.

  NOTE: Traditionally, such vertical movement both vertically and laterally would require enrollment in a separate program of study, so the individual could acquire the needed skills. However, the integrated systems approach, which is modularized, technology-based and individualized, supports another option.

- Integrated systems approach (depth and breadth), which allows individuals to master knowledge and skills **across content areas within a single program of study**.

Implicit in a career path model is the need for vertical progression as well as cross-training among sets of skills traditionally associated with discrete areas of knowledge and skills, and typically discrete occupational titles. In terms of a visual model for mapping in today's dynamic workplace, such a scenario creates more of a **career "web"** than it does a neat vertical or horizontal chart. Such career webs have begun to emerge in the business technology, information technology and health care industries, where a strong set of cross-cutting foundation skills can lead to a multitude of both vertical and lateral career options.

The integrated systems approach brings that concept to advanced manufacturing because it is grounded in the basic premise of cross-training among systems critical to high-performance manufacturing environments: electrical, electronic, and mechanical. Advancing technology and the dynamic manufacturing workplace continually require workers to gain new sets of skills that may cross over into what traditionally has been associated with a different occupational area.

The AM/IST program begins with that assumption, and proactively trains workers with the increasingly broad, cross-cutting skill sets they will need to be effective in the modern manufacturing environment. Every current worker who completes the short-term incumbent worker training program through AM/IST expands his/her skill base to include electrical systems, mechanical systems, programmable logic controllers, as well as hydraulic and pneumatic systems – which expands future career opportunities.

It is also important to note that a given individual completing and enrolled in an AM/IST program may acquire knowledge and skills in a new content area, but maintain the same job title with added new responsibilities. That is why occupational titles are beginning to lose their meaning on the shop floor, and new "hybrid" job titles, such as Electromechanical Technician and Hydro Maintenance Technician have begun to emerge.

Additionally, the AM/IST program design expand placement options into a variety of areas. For example, a secondary high school student completing an electrical training program might get a job as an electrician helper and ultimately be enrolled in an electrical apprenticeship program. On the other hand, a Job Corps student completing the Integrated Systems Technology training could be placed as an Electrician Helper, but also be placed as an Electronic Assembler, Entry-Level Mechanic, Pump Installer or more generic Maintenance Assistant. The industry-wide competencies incorporated into the curriculum such as safety, manufacturing processes and quality assurance assure the strong foundation needed by workers in all high-performance manufacturing environments, and that the cross-cutting technical skills provide the generic entry to a wide variety of entry-level positions (see Figure Two for details of program content).

The same high school student might go on to take a traditional course of study at the local community college and graduate with a two-year degree as an Electrical Technician. While the student would likely take a few electives related to other content areas, the focus of the program would be to develop a depth of knowledge and skills in the electrical area.
On the other hand, the Job Corps student might go on to enroll in an AM/IST program at a community college and would be exposed to a broad range of core courses that cut across all four content areas (see Figure Five for details). That student would master knowledge and skills that applied to a broad range of occupational areas, increasing the likelihood of employment and the ability to compete for the growing number of positions that require mastery of multiple content areas.

To that point, Figure Seven provides one last perspective on the AM/IST system. It reflects the many occupational areas that students completing the program might access, depending on the number and level of program modules completed. In essence, occupations listed at the various levels could be substituted for those on the current Figure Seven visual, reflecting the vast myriad of combinations and opportunities available within integrated systems manufacturing.

Figure Seven: Cross-Cutting Occupations in the AM/IST Career Path

Professional/Managerial ($62K+)

Engineers - Managers - Executives

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Skilled Technician/Journeyman ($37K+ per year)

Calibration and Instrument Technicians	Industrial Technicians	Programmers – Numerical, Tool and Process
Control Technicians	Instrument and Electrical Technicians	Refrigeration Mechanics
Diesel Engine Erectors and Fitters	Machinery Maintenance Mechanics	Transportation Maintenance Mechanics
Electrical Mechanics	Meter Mechanics	Electronic Engineering Technician
Electromechanical Technicians	Millwrights	Hydro Maintenance Technicians
Hydraulic Repairman	Precision Device Inspectors	Multi-Skilled Maintenance Technicians

↑

Entry-Level Technician/Apprentice ($26K+ year)

Industrial Technician	Maintenance Technician	Quality Control	Utility Technician
Machine Maintenance Operator	Maintenance Machinist	Plant Operator	Quality Supervisor
CNC Machining	Machine Repairman	Maintenance Mechanic	Production Supervisor
Field Service Technician	Maintenance Supervisor	Quality Consultant	Senior Technician

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Entry-Level Skilled Jobs ($9.00 - $14.00)

Production Worker	Machinist Trainee	Electrician Helper	Robotics Trainee
Inspector	Quality Control Inspector	Pump Installer	Entry-level Welder
Inventory Clerk	Engineering Assistant	Lathe Operator	Basic Electronic Tech

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Entry-Level Semi-Skilled Jobs ($7.50 – $9.00)

Assembler	Material Handler	Inventory Clerk
Fork Lift Operator	Packer	Shipping Clerk

Conclusion

Today's high cost of production equipment and facilities make maintenance more critical to the bottom line of manufacturing than ever before. Employers must protect their investments and assure their capital assets are well maintained. Well-trained maintenance workers are critical in helping businesses save both time and money.

The AM/IST training can serve as a career path system for maintenance workers in advanced manufacturing workplaces in that it provides cross-cutting skills acquisition and supports both vertical and lateral career moves for individuals at all ages and stages of work history**.** It meets all of the criteria for a career path system in that it provides a sequential set of instructional modules keyed to successive levels of skill requirements in four particular job families or clusters within manufacturing; builds on and reinforces the personal effectiveness, academic, and workplace competencies needed for success in the modern manufacturing workplace, while focusing on the technical competencies essential to career retention and advancement; and is based on partnership with key stakeholders in business, labor, education and workforce development. Moreover, AM/IST provides multiple entry and exit points, enabling individuals of all levels and abilities to access the system and providing both short-and long-term education and training experiences that can build an individual's skill base.

This document provides the maps linking skills in the Advanced Manufacturing/ Integrated Systems Technology (AM/IST) program content to career ladders and lattices in high-performance manufacturing workplaces for five different program models: High School Career & Technical Education/ Job Corps Model, Dislocated Worker Model, Incumbent Worker Model, Apprenticeship and A.A.S. in Integrated Systems Technology. Mapping the state-of-the art curricula and content areas back to career paths allow students to see the relationship between what they are learning and the career paths available to them because of their increased knowledge and skills.

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