Systems Engineering and Industrial Engineering

From SEBoK
Systems Engineering and Industrial Engineering

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*Industrial Engineering is concerned with the design, improvement and installation of integrated systems of people, materials, information, equipment and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems. (IIE 1992)*

Industrial engineering (IE) encompasses several aspects of systems engineering (SE) (i.e., production planning and analysis, continuous process improvement, etc.) and also many elements of the engineered systems domain (production control, supply chain management, operations planning and preparation, operations management, etc.), as depicted in Figure 3 of the article Scope and Context of the SEBoK.

This knowledge area covers the overarching aspects of industrial engineering and describes the synergies between IE and SE.

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Overview of Industrial Engineering

Industrial engineers are trained to design and analyze the components of which man-machine systems are composed. They bring together individual elements that are designed via other engineering disciplines and properly synergize these subsystems together with the people components for a completely integrated man-machine system. Industrial engineers are focused on the improvement of any system that is being designed or evaluated. They make individual human tasks more productive and efficient by optimizing flow, eliminating unnecessary motions, utilizing alternate materials to improve manufacturing, improving the flow of product through processes, and optimizing the configuration of work spaces. Fundamentally, the industrial engineer is charged with reducing costs and increasing profitability through ensuring the efficient use of human, material, physical, and/or financial resources (Salvendy 2001).

A systems engineer leverages industrial engineering knowledge to provide:

- production planning and analysis
- systems integration
- lifecycle planning and estimating
- change analysis and management
- continuous process improvement
- quality assurance
- business case analysis / return on investment
- engineering management
- systems integration

Industrial engineers complement systems engineers with knowledge in:

- supply chain management
- budgeting and economic analysis
- production line preparation
- production
- production control
- testing
- staffing, organizing, directing
- cost, schedule, and performance monitoring
- risk monitoring and control
- operations planning and preparation
- operations management

Industrial Engineering Body of Knowledge

The current overview of the industrial engineering body of knowledge is provided in the *Handbook of Industrial Engineering* (Salvendy 2001) and *Maynard's Industrial Engineering Handbook* (Zandin
The Institute of Industrial Engineers (IIE 1992) is currently in the process of developing a specific industrial engineering body of knowledge. Additionally, industrial engineering terminology defines specific terms related to the industrial engineering profession. Definitions used in this section are from this reference. Turner et al. (1992) provide an overview of industrial and systems engineering.

The elements of IE include the following:

**Operations Engineering**

Operations engineering involves the management and control aspects of IE and works to ensure that all the necessary requirements are in place to effectively execute a business. Key areas of knowledge in this field include: product and process life cycles, forecasting, project scheduling, production scheduling, inventory management, capacity management, supply chain, distribution, and logistics. Concepts such as materials requirements planning and enterprise resource planning find their roots in this domain.

**Operations Research**

Operations research is the organized and systematic analysis of complex situations, such as if there is a spike in the activities of organizations of people and resources. The analysis makes use of certain specific disciplinary methods, such as probability, statistics, mathematical programming, and queuing theory. The purpose of operations research is to provide a more complete and explicit understanding of complex situations, to promote optimal performance utilizing the all the resources available. Models are developed that describe deterministic and probabilistic systems and these models are employed to aid the decision maker. Knowledge areas in operations research include linear programming, network optimization, dynamic programming, integer programming, nonlinear programming, metaheuristics, decision analysis and game theory, queuing systems, and simulation. Classic applications include the transportation problem and the assignment problem.

**Production Engineering / Work Design**

Production engineering is the design of a production or manufacturing process for the efficient and effective creation of a product. Included in this knowledge area is classic tool and fixture design, selection of machines to produce product, and machine design. Closely related to production engineering, work design involves such activities as process, procedural and work area design, which are geared toward supporting the efficient creation of goods and services. Knowledge in work simplification and work measurement are crucial to work design. These elements form a key foundation, along with other knowledge areas in IE, for lean principles.

**Facilities Engineering and Energy Management**

Facilities engineering involves attempting to achieve the optimal organization in factories, buildings, and offices. In addition to addressing the aspects of the layout inside a facility, individuals in this field also possess knowledge of material and equipment handling as well as storage and warehousing. This area also involves the optimal placement and sizing of facilities according to the activities they are required to contain. An understanding of code compliance and use of standards is incorporated. The energy management aspect of this area encompasses atmospheric systems and lighting and electrical systems. Through the development of responsible management of resources in the energy management domain, industrial engineers have established a basis in sustainability.

**Ergonomics**

Ergonomics is the application of knowledge in the life sciences, physical sciences, social sciences, and engineering that studies the interactions between the human and the total working environment, such as atmosphere, heat, light and sound, as well as the interactions of all tools and equipment in the workplace. Ergonomics is sometimes referred to as human factors. Individuals in
this field have a specialized knowledge in areas such as: anthropometric principles, standing/sitting, repetitive task analysis, work capacity and fatigue, vision and lighting, hearing, sound, noise, vibration, human information processing, displays and controls, and human-machine interaction. Members in this field also consider the organizational and social aspects of a project.

**Engineering Economic Analysis**

Engineering economic analysis concerns techniques and methods that estimate output and evaluate the worth of commodities and services relative to their costs. Engineering economic analysis is used to evaluate system affordability. Fundamental to this knowledge area are value and utility, classification of cost, time value of money and depreciation. These are used to perform cash flow analysis, financial decision making, replacement analysis, break-even and minimum cost analysis, accounting and cost accounting. Additionally, this area involves decision making involving risk and uncertainty and estimating economic elements. Economic analysis also addresses any tax implications.

**Quality and Reliability**

Quality is the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs. Reliability is the ability of an item to perform a required function under stated conditions for a stated period of time. The understanding of probability and statistics form a key foundation to these concepts. Knowledge areas in quality and reliability include: quality concepts, control charts, lot acceptance sampling, rectifying inspection and auditing, design of experiments, and maintainability. Six sigma has its roots in the quality domain; however, its applicability has grown to encompass a total business management strategy.

**Engineering Management**

Engineering management refers to the systematic organization, allocation, and application of economic and human resources in conjunction with engineering and business practices. Knowledge areas include: organization, people, teamwork, customer focus, shared knowledge systems, business processes, resource responsibility, and external influences.

**Supply Chain Management**

Supply chain management deals with the management of the input of goods and services from outside sources that are required for a business to produce its own goods and services. Information is also included as a form of input. Knowledge areas include: building competitive operations, planning and logistics, managing customer and supplier relationships, and leveraging information technology to enable the supply chain.

**References**

**Works Cited**


Primary References


Additional References

Operations Engineering


Operations Research


Production Engineering / Work Design


Facilities Engineering and Energy Management


Ergonomics


Engineering Economic Analysis


Quality & Reliability


Engineering Management


Supply Chain Management


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SEBoK v. 2.1, released 31 October 2019

Retrieved from


- This page was last edited on 28 October 2019, at 08:47.