Simulation analyses subdivide themselves conveniently into two major categories: discrete-event simulation and continuous simulation (Zeigler, Praehofer, and Kim 2000). Continuous simulation studies processes amenable to analysis using differential and difference equations, such as stability of ecological systems, chemical synthesis, oil refining, and aerodynamic design. Discrete-event simulation studies processes in which many of the most important variables are integer values, and hence not amenable to examination by continuous equations. Such processes almost invariably involve queuing, and the variables of high interest include current and maximum queue lengths, number of items in inventory, and number of items processed by the system. Many of the integer values are binary; for example, a machine is in working order or down, a worker is present or absent, a freight elevator is occupied or vacant. Processes with these characteristics are common in manufacturing, warehousing, transport, health care, retailing, and service industries.

3.1 Manufacturing Simulation

Historically, one of the first major application areas of discrete-event process simulation was within the manufacturing sector of the economy (Miller and Pegden 2000). Strategically minded managers, not to mention industrial and process engineers, quickly learned that simulation is a delightfully quick, inexpensive, and non-disruptive alternative to the potential purchase, installation, and integration of expensive machines or material-handling equipment “because it ought to improve productivity. Simulation permits “trial by proxy” of such proposals, often involving high capital expenditure and risk, before undertaking them on the manufacturing plant floor.

3.2 Automotive Industry Simulation

The automotive industry involves not only complex and variegated manufacturing contexts but also large and complex supply chains. At the apex of the supply chain
lies the final assembly plant – no matter how many subsidiary plants, both those of the vehicle manufacturer and those of its suppliers, contribute to the manufacture of the vehicle, the manufacturing process must culminate with the integration of all the parts (engine, powertrain, body panels, interior trim, exterior trim….) into a vehicle. Underscoring the complexity of vehicle manufacturing and supply chain operations, automotive industry suppliers are routinely classified as Tier I (supply vehicle components to the final manufacturer), Tier II (supply components to a Tier I company), Tier III (recursively). Conceptually, the automotive company itself can be considered Tier Zero, although this term is seldom used. Accordingly, managers and engineers in the automotive industry, whether their employer is a vehicle manufacturer or a supplier thereto, have been eager and vigorous users of simulation for many years (Ülgen and Gunal 1998). As early as the 1970s, long before the advent of modern simulation software and animation tools, when GPSS [General Purpose Simulation System] (Gordon 1975) and GASP [General Activity Simulation Program] were relatively new special-purpose languages (GASP was FORTRAN-based), pioneers in automotive-industry simulation sought to accommodate increasingly frequent requests for simulation analyses. One of these early efforts, in use for many years, was GENTLE [GENeral Transfer Line Emulation] (Ülgen 1983).

3.2.1 Overview of Automobile Manufacturing

Historically and etymologically, the very word “automobile” reflects astonishment: a vehicle, unlike a wagon, cart, or buggy, which can move [“mobile”] by itself [“auto”], without need of an ox, donkey, horse, or mule. Automotive manufacture was an early pioneer of the assembly line, in which the work piece is brought to the worker, instead of the reverse. Over several generations, as vehicles (not just automobiles!) became more complex and diversified their manufacture naturally became subdivided into stages. At a very broad, overview level, these stages are (Hounshell 1995):

1. Press shop, in which sheet steel is stamped into recognizable vehicle components, such as roofs, doors, hoods, trunk lids, etc.
2. Weld shop, in which these components are joined; at this stage, the structural form or silhouette of a vehicle becomes readily visible and is called a “body in white [BIW].”
3. Paint shop, in which, under strict conditions of cleanliness, the BIW is pre-treated, sealed, and painted; the coat of paint is then baked dry, and perhaps waxed and polished.
4. Engine shop, in which the vehicle’s motive components – engine and powertrain – are installed into the painted vehicle body.
5. Trim shop, in which components such as windshields, interior trim and seats, steering column, electronics, and tires are fitted to the vehicle; after final test in this shop, the vehicle is driven away under its own power.