The Industrial Base Analysis Model (IBAM)

Louis Edward Alfeld
Robert M. Sholtes

INTRODUCTION

IBAM is a production chain simulator. IBAM simulates the flow of orders and products among the many suppliers and subcontractors that combine to produce an end item. The U.S. Department of Defense has used IBAM to analyze the erosion of its critical manufacturing base in an era of declining defense budgets and to identify potential bottlenecks in the event of renewed defense acquisition requirements. IBAM can also provide support for analyzing industrial competitiveness, planning regional economies, and building "virtual" manufacturing organizations. The model identifies key manufacturers, assesses labor needs, forecasts technology impacts and prioritizes policy options, all with little effort. The model benefits users by pinpointing potential bottlenecks and quantifying the relative costs and benefits of alternative solutions.

A production chain may contain as many suppliers as desired. Figure 1 provides an example of a production chain developed by DoD to explore the dynamics of helicopter manufacturing. Each of the boxes in Figure 1 contains the name of a producer and a product, joined together to form a production map. Each box is actually a simulation model in itself. During simulation, each box manufactures an end item (or items) for shipment to the next fabricator up the chain. Although every model on the map contains the same generic structure, their parameter values all differ. These different values define the individual manufacturing processes and products that make up the chain.

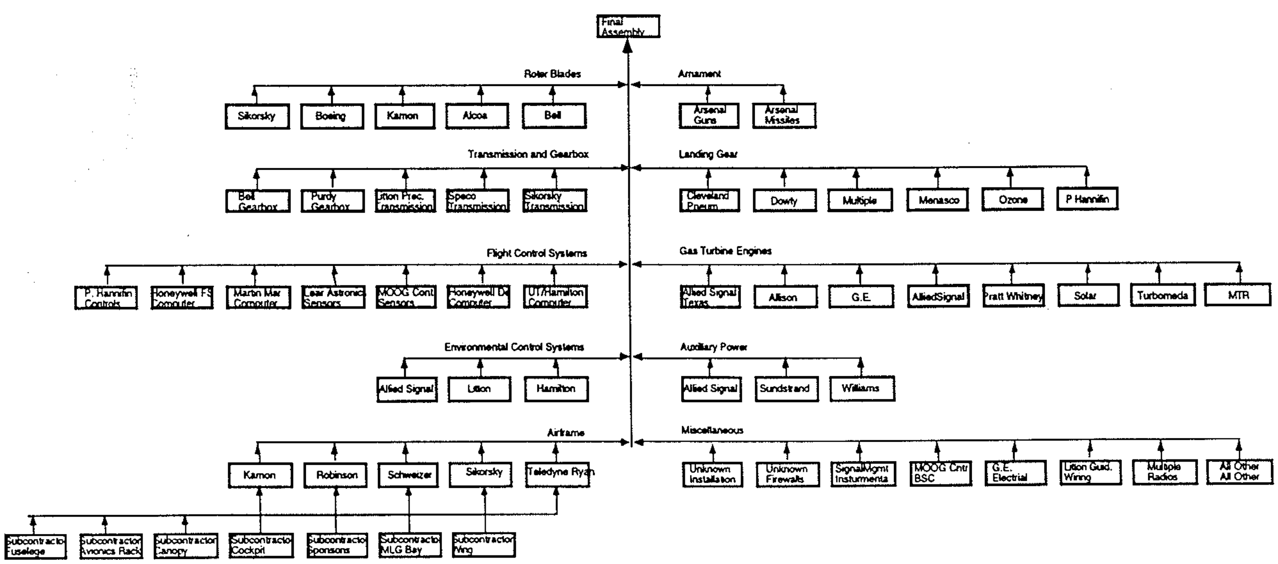

Figure 1: An Aggregate Helicopter Production Map

ORDERBOOK

The program user must define a projected orderbook profile for the end item. An example of an orderbook profile is shown in Figure 2. The orderbook profile may contain historical data as well as future projections or assumptions concerning product demand. More than one orderbook may be defined to reflect multiple demand sources. Orderbooks may also be defined for any or all of the suppliers and subcontractors in the chain. At a minimum, IBAM needs only a single, top-level orderbook to run a simulation. If only one orderbook is defined, IBAM will automatically set the orderbooks for the sub-tier industries to establish an initial equilibrium. (During simulation, actual orders for sub-tier suppliers will depend upon demand from higher-tier producers.)

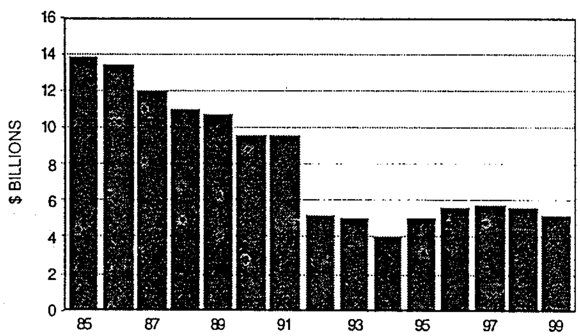

Figure 2: Orderbook profile for tactical missiles

Having defined a production chain and a top-level product orderbook, IBAM then quantifies the impact of changes in demand on all of the supplier production capabilities. The model simulates the flow of orders and shipments for each supplier in the production chain. Figure 3 reproduces a representative IBAM output graph based on torpedo production.

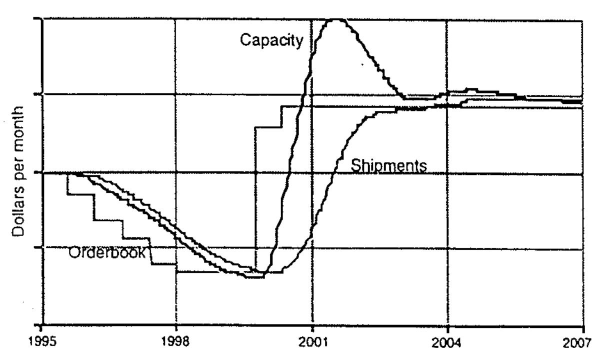

Figure 3: Capacity and shipments response to orderbook

During simulation, production capacity across the supplier chain adjusts to changes in orderbook demands. In Figure 3, the initial drop in orders to the prime contractor triggers a downsizing in manufacturing capacity. In addition, every supplier in the production chain adjusts their operations to the new market conditions defined by the orderbook. The hypothetical scenario shown in Figure 3 includes a sudden new demand for torpedoes during 1999. This jump in production demand causes suppliers to expand capacity as each company acquires new capital, hires and trains additional workers, and increases demands on its own sub-tier suppliers.

MODEL ORGANIZATION

Figure 4 illustrates the primary feedback structure of IBAM. Feedback acts to match shipments to orders by altering production capacity. The model uses incoming orders, average past demand and current backlog to calculate a desired production rate. Capacity is calculated using a Cobb-Douglas function that depends upon both capital and labor. Actual production is the lesser of either desired production or capacity. Delays in perceptions of the average incoming order rate coupled with varying delays in adjusting capital, labor and materials generate the dynamic transients typical of disequlibrium economic systems.

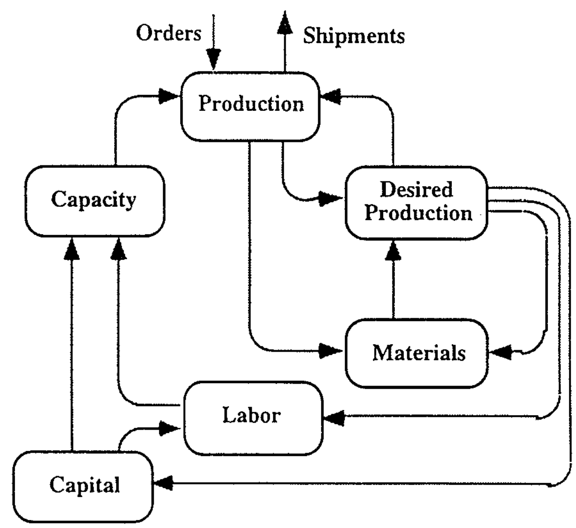

Figure 4: IBAM feedback structure

IBAM was specifically designed to operate in the data-poor environment of industrial production. Starting with whatever data is on hand, the user can immediately build a production chain and run simulations. As better data becomes available, the model can be refined and extended to better satisfy user needs.

IBAM contains an internal database with four-digit SIC code data for 56 of the most common defense manufacturing industries. By entering the appropriate SIC code, IBAM will automatically supply the data for an industry, interpolating values for capital and labor based on the ratio of user-defined shipments to total SIC industry shipments and inserting the industry average for shifts and utilization. The user may, of course, override any of the program-supplied data values with different values that reflect better or more detailed data.

The second input required of the user is the amount of materials every manufacturer purchases from each of its sub-tier suppliers. If this number is not known, the user may "guestimate" the percentage distribution instead. Given only this marginal information, IBAM will provide a first approximation of the production chain dynamics.

USER INTERFACE

Model users may build a production chain utilizing a graphic toolbox that contains industry icons and connector arrows. As each industry icon is placed on the production map, it automatically creates an instance of the generic simulation model. Double-clicking on the icon then opens the data interface to that industry. Figure 5 shows a sample data interface window.

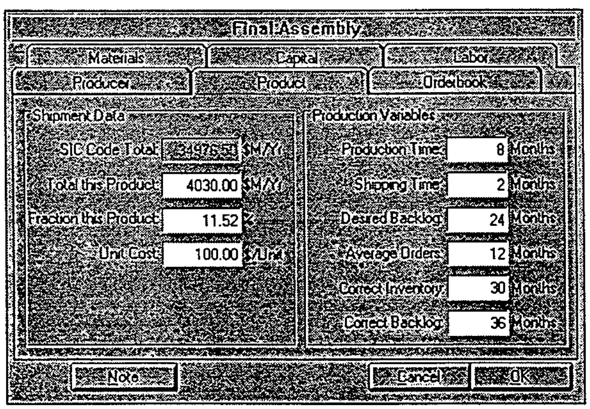

Figure 5: Defining the Product

Data is organized on six tabbed displays. Figure 5 shows the display for the product variables. The left side contains shipment data, including the SIC code total for the industry. The right side shows the parameters that define the production process.

IBAM is capable of using data at many different levels of aggregation, from a single production line to an entire industry. For some applications, the user may wish to develop a detailed diagram of individual production lines for critical components while aggregating less critical material flows at much higher levels.

"WHAT-IF?" SCENARIOS

IBAM "what-if?" simulations may be used to test alternative parameter values and different intervention actions. "What-if?" scenarios may also analyze imagined products, proposed production chains and even new process technologies about which there is little or no historical production data. One model application, for example, developed a hypothetical production chain for the flat-panel display industry, which has yet to develop. Making assumptions about production parameters for each sub-tier supplier allowed analysts to simulate flat-panel display production under a variety of orderbook assumptions that combined both defense and commercial demand. The results showed relative rates of industry growth under alternative DoD development and acquisition scenarios.

IBAM includes a built-in "what-if?" technology scenario generator, illustrated in Figure 6. The five tabbed displays contain access to all model parameters that reflect possible changes in product or process technology.

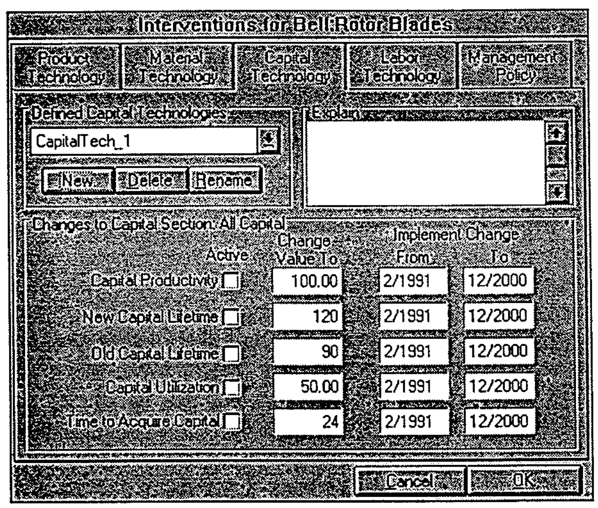

Figure 6: Capital Technology

Figure 6 shows the capital technology display. The user may alter any of five parameter values from their baseline value, ramping the change over time, if desired, to reflect the time required to implement a specific change. Increasing capital productivity and lowering new capital lifetime, for example, might reflect the acquisition of a new computer technology.

Simulating these changes against a baseline scenario will show the relative impact of the new technology in response to an orderbook. Assessing the cost of the technology upgrade against gains in capacity or shortened delivery times allows industrial planners to judge the relative value of alternative investment options.

For example, Figure 7 plots model output for two "what-if?" scenarios for helicopter production based on a hypothetical jump in orderbook demand. In this instance, only one helicopter, the RAH-66 Comanche, was simulated by altering the parameter values used to define the companies in the production chain.

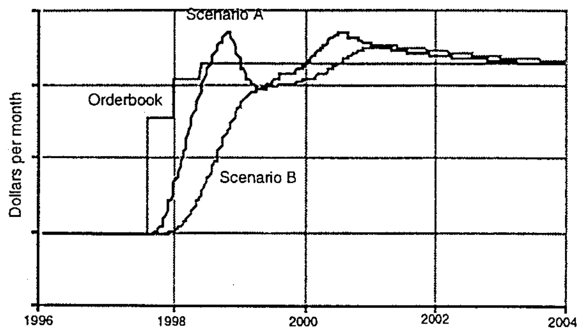

Figure 7: Relative production curves for two simulations

In addition to its DoD aplications, the ability of IBAM to create models for hypothetical industrial chains affords users the ability to assess the dynamic behavior of "virtual" manufacturing entities as well as to study how to best nurture regional and local manufacturing expansion. Economic planners may "flight test" alternative industrial relationships to determine which types of expansion best satisfy regional and local employment, resource and environmental goals.

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