ANALYSIS OF SOURCING AND DISASTER PLANNING

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Summary

Industrial Engineers at IBM's Systems Manufacturing Division plant in Kingston, N. Y. are using a GPSS model to simulate the effect of a disruption in supplier delivery resulting from a disaster at his facility. Run on an IBM System/360, Model 65, the model contains some 1900 instructions, uses about 150K bytes of core storage and has an exceptionally fast run time of 1. 75 minutes.

Introduction

In many corporations today there is a trend toward divisional product line responsibility. When this is the case, it's the mission of individual plants to produce and/or procure one or more of the many subassemblies or components for the entire corporation. Such a concept offers obvious cost advantages and the ability to maintain controls over technology and engineering changes. There can, however, be an exposure relative to the procurement of the various materials required to support volume production.

When it becomes necessary to procure subassemblies by means of multi-sourcing, management must include as a part of its sourcing strategy the possibility of a loss, either complete or temporary, of one or more of the major sources. Therefore, planning should include the effects of a disruption of the supplier's production due to disasters such as a flood, fire, hurricane or other natural calamities.

Aided by GPSS Model

At IBM's Systems Manufacturing Division plant in Kingston, N. Y., the development of sourcing strategy has recently been aided by the use of a GPSS model. Now we have an opportunity to simulate the effect of a disruption in supplier delivery resulting from some kind of disaster to his facility. This model has been designed by the Industrial Engineering Planning Group and utilizes the inputs from those functional areas throughout the plant that are concerned with sourcing decisions.

Former Method Lengthy and Cumbersome

Because of the many factors that must be combined to determine sourcing strategy, the previous methods of manual analysis were both cumbersome and lengthy. Generally, a plan, based on the available manpower, was formulated two or three times a year and was often obsolete by the time it was completed. Adjustment of production requirements, while the study was in progress, resulted in an inaccurate assessment of the effect of a disaster. The interaction of those variables effecting tooling and test capacity, manpower availability, and lead times, made the analysis arduous and extremely time consuming. In addition, only one "typical" potential disaster was reviewed, often with some disagreement as to how representative it might be to a "real world" situation. All of these factors confirmed the need for a means to simulate many types of potential disasters, no matter how remote the possibility of their occurrence.

Objectives and Scope

The objectives of the simulation and the scope of the model are illustrated in Figure 1. Components are being procured from four sources (A - D), each with varying production capability depending on tooling and test capacity, manpower, facility allocations and general technical "know-how."

The cross-hatched area represents the amount of capacity being utilized by current sourcing demands, with "open cap" indicating the open capacity or the ability to produce additional units beyond present demands.

Each source has varying lead times, based on distance, proximity to transportation facilities and particular legal or import constraints.

As deliveries are received, components are placed in stock locations until they are needed in the manufacturing area.

The Impact of a Disaster

In Figure 2 we see the impact of a disaster. Let's say, for example, that a fire at Source D heavily damages the facility. The result is a 90% loss of the building, 50% loss of tooling and 100% loss of test capability. Another building is located, renovated and equipped in three months, tooling and test equipment are replaced in four months, and 75% of the manpower is returned, requiring only a minimum of retraining. Five months later the source is again delivering on a limited basis. Seven months after the disaster the source has reached its maximum recovery at 85% of its previous capacity.

When the disaster occurs the other sources are asked to deliver at total capacity. Additional open capacity is reached by each source in the following amount of time from the point of the disaster:

	First Delivery	Maximum Capacity Attained
Source A	4 weeks	12 weeks
Source B	15 weeks	24 weeks
Source C	6 weeks	16 weeks

As the simulation progresses, the model will monitor: the components in the inventory as it is impacted by requirements being greater than deliveries.

As the other sources begin to provide relief, the rate of loss begins to decrease. The inventory level, however, will continue to decline until monthly deliveries are equal to monthly requirements.

Once Source D has started to recover and other sources are at maximum, monthly deliveries start to exceed monthly requirements, and inventory begins to increase. Eventually, the inventory level will reach the desired level and sourcing can return to a more normal pattern.

Normal Sourcing Strategy

A graphical representation of a normal sourcing strategy, designed to protect a given amount of future requirements is illustrated in Figure 3. The solid line is the number of units in the inventory at the end of each month, while the dotted line indicates the amount of units that will be required for a given period of time in the future. This future requirement is sometimes referred to as "buffer."

In an ideal sourcing plan, the two lines will remain parallel, or may fluctuate slightly, with the level of the inventory being slightly above or below the future requirements.

When a disaster occurs, (Figure 4) the inventory level begins to decline. The slope of the curve is a function of:

1. The amount of units previously supplied by the affected source.
2. The number of other sources available to provide relief.
3. The amount of open capacity available at each source.
4. The response time required by each source to added demands, based on the ability to increase production.
5. Lead time from the source to the final delivery to stock.

As noted previously, inventory losses will continue to decline until monthly source deliveries and production requirements are equal. As the other sources increase deliveries and the affected source begins to recover, deliveries will exceed requirements and inventory levels will then begin to increase until a normal (pre-disaster) situation is attained.

Evaluating Sourcing Strategy

As a result of the simulation, sourcing strategy can be evaluated in terms of the following questions:

1. Will there be a sufficient number of units in the inventory to protect against a disaster?
2. Will the inventory deplete to zero, and if so, for what length of time?
3. During a zero period, what will be the extent of inventory loss, i.e., in terms of production, how many shipments will be lost?
4. How far will the inventory drop? What is the lowest point or "bottom-out" point?
5. How long will we be affected by the disaster, and when will we be back in control with inventory at pre-disaster levels?
6. How many units can be obtained from each of the other sources, and what will be the rate of delivery?
7. What is the total amount of relief beyond current deliveries that can be expected?
8. Will the relief from other sources be sufficient to keep the inventory above zero?
9. How much inventory will be lost prior to the recovery of the affected source?

The two major tasks of the model are dynamic development of open capacity at each source and monitoring inventory as it is impacted by deliveries and production requirements.

Developing Open Capacity

Open capacity is developed by means of a matrix save value (Figure 5), containing those factors effecting the open capacity (rows) and the various sources delivering the components (columns). Each transaction represents a new week. Thus, as transactions are generated, those factors determining open capacity are updated and the model calculates a new open capacity, by component, for each source.

Weekly Updating

In Figure 6, we see those factors which can be updated weekly (updating is optional). These include:

1. Delivery schedule - in units.
2. Capacity of any automated equipment - in units.
3. Unit hours based upon automated production.
4. Unit hours based upon manual production.
5. The maximum manpower that can be obtained in the event of a disaster.
6. Capacity of test equipment - in units.

From these factors (Figure 7) the model will calculate the number of units to be produced by automated and manual methods. This data, together with unit hours, is extended to determine the total man-hours expended, (Figure 8) and the amount of available man-hours remaining to be applied to open capacity.

Based on the delivery schedule, test capacity and automated capacity, the model determines excess test capacity and excess automated capacity.

Finally, net hours are evaluated in terms of excess capacity (Figure 9) to determine the open capacity at each source for each component.

After computing the open capacity, the model takes up its second task of inventory monitoring.

Inventory Monitoring-Establishing Functions

The delivery schedules from each source and the production requirements of each component are placed into FUNCTIONS, which have as a dependent argument the C1, clock time of the model. Savevalues are established for each component inventory.

As each transaction is generated (weekly) the inventory is updated by a VARIABLE, based on the accumulated source deliveries, less the production requirements.

VARIABLE FN1 + FN2 + FN3 - FN4 (1)

where functions 1 through 3 are deliveries from sources A, B and C and function 4 is the weekly requirement for the component.

When a disaster occurs, let's say at Source B, the inventory is updated by a new variable:

VARIABLE FN1 + FN3 - FN4 (2)

(actually .... V1 - FN2)

thus, simulating the disruption in the delivery from Source B.

Functions are also established relating to the ability of each source to increase production beyond pre-disaster deliveries. These functions are based on the clock time of the model, adjusted to the simulated start of the disaster.

For example, in order to increase production, Souce C requires:

4 weeks to obtain additional manpower and expand facilities.
3 weeks to manufacture additional components.
1 week to deliver from source to stock.

Because of learning, only 60% of the open capacity can be obtained initially and this gradually increases each week. Thus, a function might be constructed based upon:

Weeks	Delivery Percentage
0 to 8	0
8 to 10	60
10 to 12	70
12 to 14	80
16 to 18	85
18 to 20	90
20 to 22	95
22 to (n)	100

(n as long as they might be needed)

When the disaster occurs, the inventory of each component is increased by the open capacity of each source, as adjusted by that source's function governing its ability to provide relief.

Accumulating Costs

In conjunction with inventory tracking, the model determines the cost of delivery from each source and accumulates these costs, by source, by product.

At the start of the disaster, data is maintained relating to the amount of additional "relief" units and related premium costs by source and product. These costs are also accumulated and included in cost-to-date data.

Also, those premium costs associated with the recovery of the source affected by the disaster are maintained and included with all costs-to-date according to:

	Cost This Week	Cost to Date
Cost prior to disaster	XXX	XXX
Relief costs	XXX	XXX
Recovery costs	XXX	XXX
Total program costs	XXXX	XXXX

Inventory carrying costs are computed by the model, based on the weighted average total cost (material, labor and burden) of each component. A similar evaluation is made of the cost to carry a given number of future weeks' production requirements. (See Figure 3 - solid vs. dotted line.) This analysis places inventory carrying costs into a "what will be" vs. "what should be" perspective. A run can be made without a simulated disaster to provide an analysis of inventory carrying costs resulting from a proposed sourcing strategy, contrasted by costs to carry a given number of weeks' production requirements.

Thus far, we have seen in broad terms the objectives of the model. Let's take a look now at the inputs required to meet these objectives.

Required Inputs

The majority of the inputs required are used in the initial development of source open capacity. Included for each source are:

1. Weekly delivery schedule.
2. Total unit hours for each component by manual and automated production processes.
3. Amount of automated equipment, and associated unit hours.
4. Percent down time of automated equipment.
5. Amount of test equipment and associated unit hours.
6. Average number of tests per component.
7. Percent down time of test equipment.
8. Maximum available manpower that could be obtained if necessary.
9. Number of working days per month (holidays and vacation shut downs).
10. Number of shifts normally worked.
11. Response time to added demands.
12. Learning curve for increased production.
13. Unit cost (labor and procurement burden).

14. Premium cost learning curve.

For monitoring inventory the inputs include:

1. Initial stock quantity at the start of the simulation.
2. Weekly production requirements for each component.
3. Various sources delivering to each inventory.
4. Material cost for each component.
5. Average total unit cost.
6. Annual inventory carrying cost percentage.
7. Start of disaster.

Comprehensive Monthly Output

Through the use of the Output Editor feature of GPSS, weekly data is summarized for monthly output. (See Figure 10.) This includes data contrasting monthly delivery against monthly production requirements for each component and the level of inventory at the end of that month. This inventory is compared to a given amount of future requirements to determine a plus/minus status. Cumulative delivery and requirements to date are also available.

Open capacity of each source is also included as part of this output. Once the disaster occurs, this output will incorporate the total amount of relief units and recovery units delivered during the last week. In addition, the model has a matrix savevalue that contains the amount of relief and recovery units by source and in total, as delivered each week of the simulation.

Cost data for each component (Figure 11) is also generated on a monthly basis, reflecting:

1. Normal delivery cost in accordance with each source's pre-disaster delivery schedule.
2. Premium costs for relief and recovery delivery.
3. Total component cost - normal plus premium.

Conclusion

The model contains some 1900 instructions, and utilizes approximately 150K bytes of core storage. Total run time averages about 1.75 minutes. It is presently being run on an IBM System/360, Model 65. This exceptionally fast run time is due in part to the fact that the model does not contain any FACILITIES, QUEUES, and ADVANCE TIMES. Data is accumulated and/or manipulated through Savevalues, Matrix Savevalues, and Transaction Parameters. As a result, GPSS scan time is minimized.

Thus far the model has been used at least once a month to analyze current sourcing strategy in light of changes in production requirements.