Line of Balance

The Line Of Balance (LOB) process is employed when a repetitive process exists within the contract's work scope. The manufacturing of parts and the assembly of units in the factory are two candidates for the use of LOB.

Exhibit 1

Line Of Balance (LOB) is a management control process for collecting, measuring and presenting facts relating to time, cost and accomplishment - all measured against a specific plan. It shows the process, status, background, timing and phasing of the project activities, thus providing management with measuring tools that help:

1. Comparing actual progress with a formal objective plan.
2. Examining only the deviations from established plans, and gauging their degree of severity with respect to the remainder of the project.
3. Receiving timely information concerning trouble areas and indicating areas where appropriate corrective action is required.
4. Forecasting future performance.

The "Line of Balance" itself is a graphic device that enables a manager to see at a single glance which of many activities comprising a complex operation are "in balance" - i.e., whether those which should have been completed at the time of the review actually are completed and whether any activities scheduled for future completion are lagging behind schedule. The Line of Balance chart comprises only one feature of the whole philosophy which includes numerous danger signal controls for all the various levels of management concerned.

History: LOB was devised by the members of a group headed by George E. Fouch. During 1941, the Goodyear Tire & Rubber Company monitored production with LOB. It was successfully applied to the production planning and scheduling of the huge Navy mobilization program of World War ll. LOB proved to be a valuable tool for expediting production visibility during the Korean hostilities. During this period, defense suppliers used LOB.

LOB application has been further expanded, making it suitable now across a whole spectrum of activities ranging from research and development through job shop and process flow operations.

Specific forms and reports will be found to differ in detail, but the basic pattern and symbology are quite uniform throughout industry.

Standard Symbols: All LOB chart use standard symbols, as shown in the lower right hand corner of Exhibit 1. They identify the "sensors" (milestones), i.e., readily identifiable stages of development or control point in the process designating completion of specific activities or clusters of activities.

Application to Production: Exhibit 1 is a simplified example of a LOB Chart for a hypothetical fabrication and assembly operation and demonstrates the original application in monitoring and controlling production. The finished LOB chart displays first, the OBJECTIVE (the required delivery schedule), as shown in the upper left hand portion. Second, there is a clearly defined PLAN for meeting that objective, indicating interrelationships, and how each part of component fits into the assembly process, as well as the exact point in the cycle when each one is required to be available. This is shown in the graphing of sensors, using standard symbols, in the lower half of the chart. The bottom scale is the number of working periods (in this case, the measure is in days), counting backwards from total completion, when each component shall be finished. Third, there is an appraisal of the progress that has been achieved, given by the vertical bars in the PROGRESS chart in the upper right hand portion. Finally, also in the upper right hand portion, there is the LINE OF BALANCE, (i.e., a measure of the level of progress that shall have been reached if the objective is to be met on schedule, according to the established plan). These four basic elements are vital ingredients of any effective management system. Together they will provide for the continuous exercise of authority and create a balanced and integrated operation out of a large number of individual and uncoordinated transactions.

The Objective curve is a plot of schedule cumulative deliveries against calendar dates. In this instance, the curve tells us that a total of ninety units are scheduled for delivery between November 1 and June 30. The dotted curve indicates that actual deliveries have fallen below the required number, reaching only thirty-eight units by May 10, whereas forty-eight had been planned.

The Operating (manufacturing) Plan is represented by the series of interconnecting horizontal lines, seen in the lower portion of the Line of Balance Chart. Along these lines are the sensors indicating identifiable stages of development and control points. These control point are numbered consecutively from left to right across the schematic diagram, and from top to bottom wherever two or more points have a common position along the horizontal axis. As will be seen later, each of these control sensors is keyed by a corresponding number to a bar graph in the Progress portion of the LOB chart. The Operation Plan illustrated has an established cycle of twenty-four days per unit. It indicates the manner in which the several types and kinds of parts and components are joined to form the completed product.

To restrict the number of sensor points to a minimum (no more than fifty), certain conventions have been introduced. One convention is to develop a separate chart for each of two or more categories of parts (such as, purchased, company made, major components, customer furnished parts, etc.). In any case, there always remains the requirement for summary of the whole to indicate the overall program state. A Summary Chart generally is made by selecting key control points from each of the supporting charts, and having each such point represent a number of subordinate sensors.

A similar device frequently is adopted in the treatment of complex products consisting of a large number of parts. This expedient calls for each sensor to represent an association of parts (for example, a so called "family group" of items on an indented parts list). Under such conditions the symbol should be positioned for the earliest required part. All other related data (such as stock status) should be representative of the least favorable condition obtaining within the particular family group at the time of the survey.

The next step in our example is to cause a visual combination of the data displayed in the Objective and the Plan portions of the chart. This will be used to establish a gauge for measuring the performance requirements that will be necessary to meet the prescribed delivery goal under operating conditions established by the Manufacturing Plan. This combination of elements is known as the LINE OF BALANCE, the feature that gives its name to the technique.

Deriving the Line Of Balance Referring to Exhibit 1, note that the date of the progress review is May 10. This now becomes the date for all reference purposes. The delivery requirements at any time will be found by erecting a perpendicular at the point corresponding to the date in question, and extending it to intersect the cumulative delivery curve. The value of the ordinate at that point represents the required TOTAL DELIVERIES for that time. In the case illustrated, the curve shows that by May 10 a total of 48 units should have been shipped. In the Line Of Balance, the 48 units relate to sensors 24 and 25, the events that take place at the time of delivery.

For CURRENT needs to insure FUTURE deliveries, consider sensors Numbers 1 and 2. These actions indicate initiation of the manufacturing cycle and are slated for accomplishment 24 days prior to delivery of the finished unit. On May 10, we shall have completed not only the 48 end items sets of items 1 and 2 required for delivery on that date, but shall also have completed an additional quantity sufficient to meet the shipping needs 24 working days later. The precise level of this requirement can be found by erecting a perpendicular at the calendar date that is 24 working days after May 10, that is, June 13. The cumulative delivery curve at that point calls for 78 finished units, showing that a total of 78 end item sets of items 1 and 2 should have been completed (or have been available for use on May 10). The Line of Balance is drawn at this level in the Progress Chart. Similarly, sensor 3, which is slated for 23 days prior to the delivery date, shall provide for requirements for June 12, namely, 76 units, which is its Line of Balance.

Now, consider sensors numbers 4, 5, and 6, all of which are required 21 working days in advance of shipment. The May 10 level of requirements for these items is represented by the value of the ordinate at the point corresponding to June 10, 72 units. For sensor number 7, scheduled for accomplishment 18 working days in advance of shipment, a requirement for 66 end item sets is shown by the Objective curve value for June 5.

By following the same principle of construction, requirement levels for all other elements are established, culminating in a 48 unit delivery schedule by May 10, the date of the study, and providing for planned future deliveries.

The end result is the characteristic step down contour of a Line of Balance. Properly constructed, this invariably will step downward from a high point on the left to the level indicated for cumulative deliveries on the date of the study. By comparing the Line of Balance with the record of completed sensors of each item, management is afforded a graphic portrayal of program status and an accurate forecast of shipping capability.

The vertical bars in the Progress chart are typical LOB representation of the progress being made on a program. As was mentioned earlier, each sensor in the Operating Plan is keyed by an identifying number to a bar graph display.

The length of this bar represents the number of end item sets that have been completed or are available for use, as read off the vertical scale used for the Objective curve. It will be noted that because of the manner in which the chart was constructed, the bar graphs with the lowest numbers relate to the events that occur earliest. This automatically points out the priority of corrective action. Also, because progress is reported in terms of END ITEM SETS, the inventory count is translated into the capability of delivery of finished units. That is to say, if the end product is a bicycle, the bar graph for wheels will be on a length that is equivalent to the total number of wheels that have been completed (or are available for use) divided by two. The results show how many finished bicycles can be delivered out of the current stock level of wheels.

All the sensor that are behind schedule are indicated by bar graphs that fail to meet the Line of Balance. The first of these is sensor number 8, complete fabrication of part "D". Sensor number 8 is a "make" assembly which is manufactured relatively early in the factory cycle. To the extent that supporting sensors 5 and 6 are on schedule, evidently some problem exists in the fabrication process. The effects of this difficulty have been transmitted throughout subsequent operations as may be seen by the bar graphs for 10, 15, 16, 18, 19, 21, 22, 23, 24, and 25. It may be concluded that the fault for shipping only 38 instead of 48 units lies almost entirely with the failure to complete the required quantity of part "D". The chart also reveals the presence of a problem area in the operation represented by sensor 13 and 15. Even if the troubles with part D were cleared up, the deliveries would be limited to only 51 units as shown by the height of bar graph 15.

This rudimentary example serves to illustrate the application of this technique to a simple process of fabrication and assembly. Line of Balance can be applied to all other manufacturing or production operations, whether they are job shop or flow shop. Although more than some fifty years have elapsed since Line of Balance was first introduced, it is still considered to be most effective for control of production.