# Learning Curve

The concept of the learning curve was introduced to the aircraft industry in 1936 when T. P. Wright published an article in the February 1936 *Journal of the Aeronautical Science*. Wright described a basic theory for obtaining cost estimates based on repetitive production of airplane assemblies. Since then, learning curves (also known as progress functions) have been applied to all types of work from simple tasks to complex jobs like manufacturing a Space Shuttle.

The theory of learning is simple. It is recognized that repetition of the same operation results in less time or effort expended on that operation. For the Wright learning curve, the underlying hypothesis is that the direct labor man-hours necessary to complete a unit of production will decrease by a constant percentage each time the production quantity is doubled. If the rate of improvement is 20% between doubled quantities, then the **learning percent** would be 80% (100-20=80). While the learning curve emphasizes time, it can be easily extended to cost as well.

The learning percent is usually determined by statistical analysis of actual cost data for similar products. Lacking that, you may use the following guidelines from "Cost Estimator's Reference Manual- 2nd Ed.," by Rodney Stewart:

- 75% hand assembly/25% machining = 80% learning
- 50% hand assembly/50% machining = 85%
- 25% hand assembly/75% machining = 90%

or

1. Aerospace 85%
2. Shipbuilding 80-85%
3. Complex machine tools for new models 75-85%
4. Repetitive electronics manufacturing 90-95%
5. Repetitive machining or punch-press operations 90-95%
6. repetitive electrical operations 75-85%
7. Repetitive welding operations 90%
8. Raw materials 93-96%
9. Purchased Parts 85-88%

The calculator uses the learning curve to estimate the unit, average, and total effort required to produce a given number of units. Effort can be expressed in terms of cost, man-hours, or any other measure of effort. The calculator can be set to compute the Wright learning curve or the Crawford learning curve. The user is required to enter the effort (in terms of cost, man-hours, etc.) required to produce the first unit, the total number of units, and the learning percent.

A detailed explanation of the methods used to compute learning curve values is contained in the textbook "Engineering Cost Estimating," by Phillip F. Ostwald. This book is currently out of print. You can also find information in "Statistical Methods for Learning Curves and Cost Analysis," by Matthew S. Goldberg and Anduin E. Touw.

# Learning Curve Models

There are several models of learning curves in use in business and industry. The log-linear is, perhaps, the most extensively used. The log-linear model states that the improvement in productivity is constant (i.e., it has a constant slope) as output increases. There are two basic forms of the log-linear model: the average cost function and the unit cost function.

## Average Cost Model

The average cost model is used more that the unit cost model. It specifies the relationship between the cumulative average cost per unit and cumulative production. The relationship indicates that cumulative average cost per unit will decrease by a constant percentage as the cumulative production volume doubles.

## Unit Cost Model

The unit cost model is expressed in terms of the specific cost of producing the xth unit. The unit cost formula specifies that the individual cost per unit will decrease by a constant percentage as cumulative production doubles.