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Maintenance Management Newsletter


# Nonlinearity in Maintenance


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When leadership makes the decision to defer maintenance it is usually made on the belief that the problem being deferred will follow the logical condition path toward failure of:

***Good > Not So Good > Worse > A Problem > A Real Problem > Bad > Breakdown***

This **linear** path allows the decision-maker the time to ***define*** the maintenance need, ***measure*** the seriousness of the problem, ***analyze*** the options, choose an optimum solution of ***improvement***, initiate the maintenance needed, and ***control*** the machine in the future to prevent a recurrence. There is the belief that the progression will allow continued production and have adequate time to recognize the final stages of failure and act to prevent a breakdown. This **deterministic** and scientific method of management that works so well in every other linear aspect of business will not work in the maintenance arena because:

***The Function of Maintenance is Nonlinear***

**Nonlinear** functions can but do not have to follow the straight line failure progression mentioned above. Nonlinear functions can flip from performing to nonperforming without following a logical failure progression. Nonlinear functions can jump from *Not So Good* to *Breakdown* without going through all the middle steps.

Scientific methods of management cannot measure and predict nonlinear maintenance breakdown events because of the number of variables that cannot be controlled by a maintenance manager are almost infinite. It is impossible to quantify just ten of these variables such as (1) engineering design, (2) manufacturing quality, (3) replacement parts quality and availability, (4) unpredictable weather, (5) operational support for preventive maintenance, (6) the quality of repair mechanics and technicians, (7) management commitment to predictive and preemptive maintenance, (8) the quality of energy (Electricity or fuel) used, (9) the operating conditions, and (10) the training level and commitment of the asset operator .

***Therefore, if it is impossible to predict any of these variables then it is impossible to predict the sum of these variables. This is Hard Science.***

The infinite number of possible initial conditions that will define the destiny of a machine toward a breakdown event simply cannot be predicted no matter how many ACCURATE data points are measured. This is what defines the problems associated with dynamic and nonlinear systems. The hard science of this statement can be verified in any major university by contacting their Department of Nonlinear Studies. It is being said that the $20^{th}$ Century will be remembered for relativity, quantum mechanics, and the **Chaos Theory**.

It is important to understand that the study of chaos (Dynamic and nonlinear systems) is the study of finding hidden order in apparently chaotic systems such as turbulence, weather, biology, and the performance of machines. **Dr. Edward Norton Lorenz** of MIT is considered to be the father of the Chaos Theory due to his discoveries in weather prediction. In the early days of computing, his nonlinear weather model formulas with only 10 feed-back variables proved that small changes in **initial conditions** can amplify over time in such a way that long-range weather prediction would be impossible.

His work proved the sensitive dependency on initial conditions was so powerful that the very smallest of errors in measurement (Thousandths of a unit) of the initial starting condition of any of the variables could result in very large differences in the later state. This sensitivity to initial conditions was later called **The Butterfly Effect**. The mathematical engine that drives his discovery is a strange attractor called **The Lorenz Attractor**.

***The Lorenz Attractor describes a system that never succeeds but never fails.***
***It flails along between an apparent upper and lower boundary***
***but the frequency and amplitude are unpredictable.***

***I have never heard a better definition of a maintenance budget better than that!***

With just the smallest of differences in initial conditions (By the flap of a butterfly's wings.) in a nonlinear feedback formula, a system can flip between performing and nonperforming without having to go through the linear sequence of *Good > Not So Good > Worse > A Problem > A Real Problem > Bad > Breakdown*. One machine might offer advanced warning of a failure over a long time and there is plenty of time to defer maintenance and choose an optimum solution for competitive bids and continued production without a breakdown event. However, an identical machine sitting beside it under the exact same operating conditions might breakdown with little or no warning at all and when this happens the **True Risk/Reward Ratio for Deferred Maintenance** may exceed 60:1 in repair dollars and 15:1 in downtime compared to an early intervention maintenance event. The cost associated with the breakdown event will be the **square of the primary failure part** and will square again with each cascading level of failure.

So, if you come to believe that the function of maintenance is nonlinear and unpredictable, how can you as an leader use this information to better support the operational needs of your organization?

1. When a machine is known to need repairs, do not expect it to follow the logical and linear sequence to failure. There is no guarantee of time to resolve the issue before failure.

2. When a machine is known to need repairs, do not demand or expect a prediction of failure by your maintenance manager because this is not possible. The variables are too infinite to calculate. Approximations will be all that can offered as to time of failure, downtime, or money.

3. Remember, nothing you will spend during an early intervention will be as much as a breakdown event. Offer your maintenance manager all the direct support needed in funding and downtime to create an early intervention event to repair the machine as soon as practical. The less time between detection and early intervention the less likely to incur the 60-times penalty in money and 15-times more in downtime.

4. Understand that machines cannot be motivated by human standards. Money and downtime must be made available when the machine demands it, not when the budget demands it if you want to avoid exponentially escalating breakdown costs.

Just because a maintenance manager can't predict future maintenance costs doesn't mean they are bad managers. The problem is simply unpredictable. If allowed early intervention, they can produce the lowest maintenance cost per unit of production possible even though they cannot tell you what that cost will be.

**The author:**

David Geaslin is a graduate of The University of Texas at Austin with degrees in Industrial Management & Marketing; a former Marine Corps Aviator and Aircraft Maintenance Officer (1968-1975); the CEO of his maintenance service company for 15 years; and has consulted offering coaching and seminars in the management of maintenance since 1990. He lives in Gonzales, TX and travels offering his services wherever needed.