The road to true reliability-based asset

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Reliability Improvement requires more than an investment in technology and three day training sessions for the workforce. We believe that most reliability efforts do not understand and address the significant cultural and behavioral issues that are critical to a successful program. We believe that it is essential that organizations recognize this aspect of reliability improvement.

In addition, staff reductions and downsizing have limited the resources that can be assigned to develop and lead reliability improvement within most organizations.These staff reductions have also depleted some of the experienced subject matter experts that traditionally support other employees within the workforce. Fewer resources are available within the organization that can mentor and support employees with reliability program implementation tasks as they are applied in the workplace.

Reliability Support Services believes that reliability improvement programs are successful when employees are given mentoring and support **in addition** to training. This mentoring process allows employees to develop confidence in the new work processes and builds the "critical mass" of organizational acceptance that supports new work processes. Our 30 years of experience in manufacturing and industrial improvement efforts has determined this aspect to be **essential for success**.

Reliability Support Services Business Purpose is to provide organizations a resource that can bring the knowledge and experience required to address these issues, and provide support for the successful implementation of improvement initiatives.

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Our Philosophy is based on our belief that organizations can be successful if they recognize that Technology, Tools, Techniques and PEOPLE are the elements of a reliability improvement program

The road to true reliability-based asset care has numerous twists and turns. For many, a drive down that road ends in disaster because data is missing, inaccurate or misinterpreted. Described below are ten steps on how to stay the course.

1. Take a proper inventory of all assets to provide a baseline.

For all equipment and component parts, log all relevant tombstone data such as unique asset number, parent-child relationships, asset specifications and warranty information. Many CMMS packages allow the user to prepare a graphics parts book that stores a CAD drawing for each piece of equipment. Some of these packages allow drill-down capability to zoom in on drawings of components and even spare parts. A hot key link is usually available to jump back and forth between the graphics and equipment master. For infrastructure assets such as roads and parks, or facilities such as fire equipment, some CMMS packages may allow a reference to a GIS locator as well as the graphics link.

2. Perform a critical path analysis to determine criticality, as well as reactive, preventive & predictive maintenance requirements.

By carefully examining the end-to-end processes within operations, one can determine the criticality of each piece of equipment and its component parts. Critical inputs and outputs to the system should be identified, as well as its sub-systems. Then answer the following questions:

What does this component do?
Identify the points where a potential component or part failure would disrupt critical inputs/outputs.

What happens if it fails?
The answer will range from "catastrophic" to "negligible impact" and numerous choices in between such as "major safety, environmental or operational impact", "reduced efficiency" or "other financial loss (eg. quality problems)".

What maintenance program is required for this component?
If the impact of failure is negligible, then a reactive or "run to failure" program will most likely be cost-effective. On the other hand, a catastrophic impact may cost-justify the more expensive predictive maintenance program. For all other impacts, a cost/benefit analysis will determine the most economical maintenance program to adopt, ie, reactive, preventive or predictive.

Preventive and predictive tasks can then be defined to avoid or detect a failure. As well, the user can record corrective tasks required in the event of mechanical breakdown.

3. Define options for problem, cause, action and delay codes.

Coded fields greatly simplify data collection and force consistent reporting of failures by narrowing the choices. Descriptive fields are still available on the CMMS for more detailed explanations.

A problem code refers to how a breakdown is reported. For example, in a facilities operation, a tenant might report that a room is excessively hot or cold. A cause code is determined by the maintenance worker upon investigation of the problem. In the example above, possible causes may be: failed thermostat, blown circuit breaker, inoperative fan, and so on. The action taken

can be codified in this example as repaired fan, reset circuit breaker or replaced thermostat.

A delay code explains why operations have temporarily ceased, such as awaiting raw materials, operator break, or product changeover.

4. Define options for work order and equipment status fields.

Status fields can be used to track the cycle time of various activities and delays. Work order status field options could be pending approval, waiting for arrival of parts, assigned to maintenance worker, etc. The equipment or component status field options might include commissioning, warranty repair, third party repair, and others.

5. Define performance measures linking operations and maintenance.

One effective way to focus the attention of both operations and maintenance departments on asset care is to show the relationship between equipment reliability and operations productivity. This can be accomplished through simple measures such as maintenance cost per unit of output, or operations cost per minute of equipment downtime. More important than the actual value of each measure is the trend over time.

6.Monitor the condition of the assets.

Condition monitoring is becoming an important feature of every CMMS. The simplest packages allow users to manually input data such as equipment usage for triggering PM routines. The more sophisticated CMMS is connected on-line to PLC's for automated data collection. The software then analyzes incoming data to ensure that trends are within user-defined control limits. When data strays outside the control limit, users are "alarmed" and/or action is taken such as issuing a work order or paging the maintenance planner.

7. Conduct statistical analysis to indentify recurring problems.

Failures can be prioritized in terms of impact on safety, operations output, and cost. Use statistical analysis of equipment history to determine the high-frequency, high-impact problems and their underlying causes. Pareto analysis is one such tool.

Fishbone Diagramming or Cause & Effect Diagramming is then used to find the root cause. The CMMS can help link coded problem and cause occurrences with corrective action required. Various predictive and preventive maintenance tasks should be explored to prevent a problem from occurring in the first place. The analysis could also highlight the need for focused training of maintenance workers and/or operations personnel.

Studying the history of status codes may also provide valuable insight into how to improve asset reliability. Problems such as long lead times and inadequate authorization may suggest obvious corrective action. Additionally, the difference between cycle time (ie, elapsed time including delays) and touch time (actual hands-on productive time) highlights problems with the responsiveness of the maintenance department.

8. Perform repair/replace analysis.

Suppose in my earlier example that the problem "insufficient heat" has been caused by a failed thermostat in say, 80 percent of the cases reported in the equipment history file. The average cost of repairing the unit may have been $225 for parts and labour. Further analysis reveals that to replace all of the thermostats would cost only $125/unit.

Moreover, preventing failure would ensure that tenants are not left in the cold especially during extended cold spells. Thus, repair/replace decisions can be justified based on statistical analysis of equipment history.

9. Examine asset history to determine appropriate adjustments to user-defined variables.

The CMMS must be kept current and accurate. Some of the high-end packages analyze actuals compared with user-defined variables such as spare part lead times and safety stock level. Suppose, for example, a user had input a lead time of two days for a given spare part.

The system monitors this measure and reports an actual lead time of say, 10.5 days. The user could then adjust the lead time accordingly. Other variables that may require adjustment include PM frequency, control limits on equipment usage, equipment/component criticality, and so on.

10.Establish rules-based diagnostics.

The most advanced CMMS packages use coded history to develop a knowledge or rules-based troubleshooting system for identifying the best course of action for a given problem. If, for example, a motor fails in a given piece of equipment, the diagnostic tool determines the statistical likelihood of each cause and suggests corresponding actions to consider.

Such a knowledge-based diagnostic tool could also be used for predicting failures in similar parts, components and equipment, once a pattern is determined. This would lead to monitoring the condition of key components that had not yet failed but were deemed statistically likely to do so, in order to catch a problem before it happens.

where Trait Variance refers to the unobservable, hence fictional, "true" variance of the persons on the underlying trait. Observed Variance compounds trait variance, measurement error, data misfit and other anomalies. Reliability indicates the stability of person measures or scores under hypothetical replications of equivalent tests.

Zero and Perfect Extreme Scores
In True-Score theory, perfect and zero scores are modelled to be exact. They have no error variance. Consequently including extreme scores lowers the average score error and inflates RT. In Rasch theory, an extreme score is recognized as containing little information about that person's location on the infinite latent trait. Any arbitrary "measure" set to correspond to such a score has an infinitely large standard error. Thus, including persons with extreme scores increases the average measurement error and lowers RR.

Statistical Validity
Statistical "validity" is the correlation between the person measures or scores on a test and those persons' unobservable, and hence fictional, exact trait measures. Clearly, if we are interested in estimating a person's math ability, we are more concerned about locating that person on the trait (statistical validity) than in having that person obtain a stable measure or raw score (reliability).

At first glance, better reliability must lead to better validity. In fact, one might predict that
Reliability coefficient = (Validity coefficient)^2
But this is true only up to a point. When better reliability means worse validity, we have the famous "Attenuation Paradox" (RMT 6:4, p. 257).

Figure 1 depicts the attenuation paradox. In a simulation study, a test was constructed containing 40 dichotomous items uniformly distributed across a two logit range. This was administered to 1000 normally distributed, on-target samples of 114 persons with trait S.D.'s uniformly distributed from 0 to 9.99 logits under Rasch model conditions. True-Score reliability and validity coefficients were calculated for each sample and plotted. In this case, validity is the correlation between the simulated person scores and their generating logit ability values. In Figure 1, validity and reliability follow their predicted relationship over most of their range. For high reliability values, however, validity drops! (For the same result using a normal ogive model, see Sitgreaves, 1961).

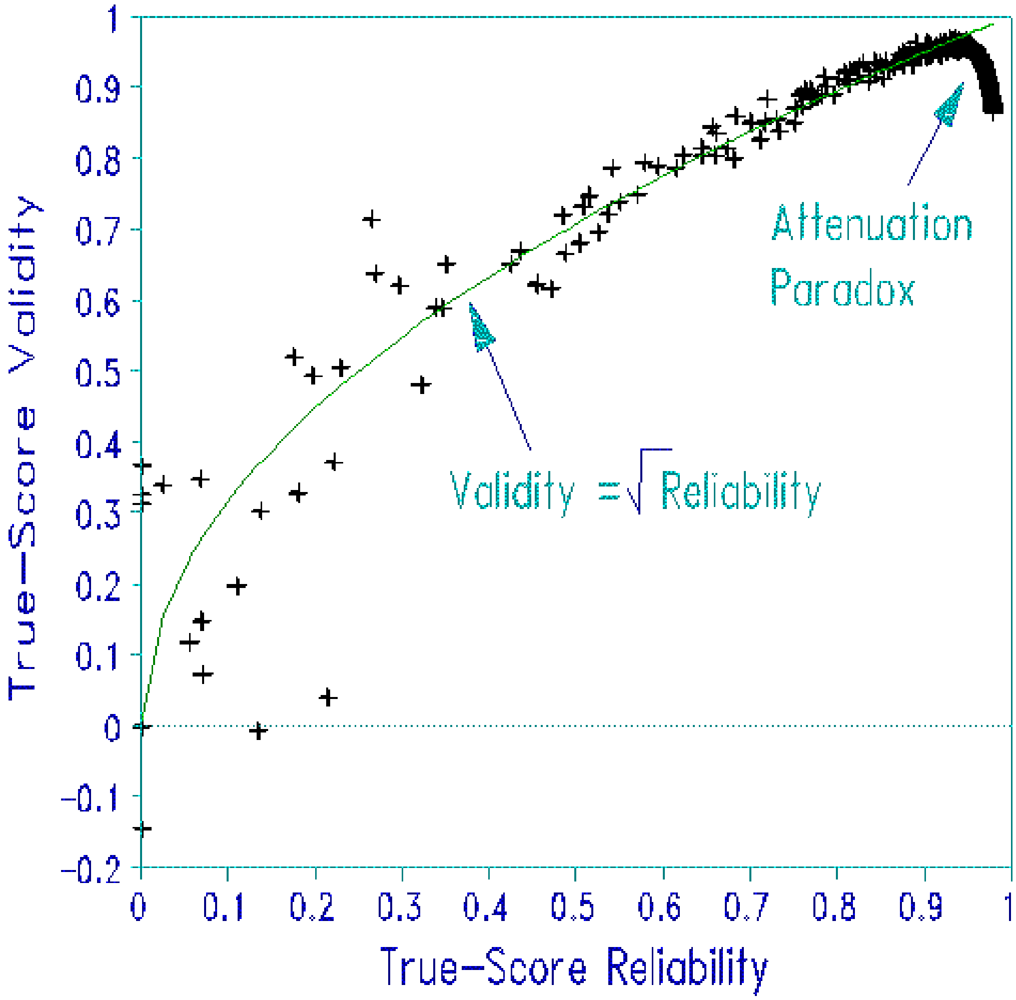

Figure 1. The Attenuation Paradox

Rasch reliability and validity coefficients were also computed. For zero and perfect scores, Rasch measures corresponding to 0.5 score-points from the extreme were estimated. The Rasch validity coefficient for each sample is the correlation between generating and estimated persons measures. The reported Rasch reliability coefficient is the misfit-attenuated "real" version.

Figure 2 shows the trend lines. Corresponding Rasch and True-Score coefficients are almost identical for samples up to 1 logit S.D. This is to be expected, because, when all scores are central, the ogival relationship between scores and measures is close to linear. Beyond this point, however, results differ markedly.

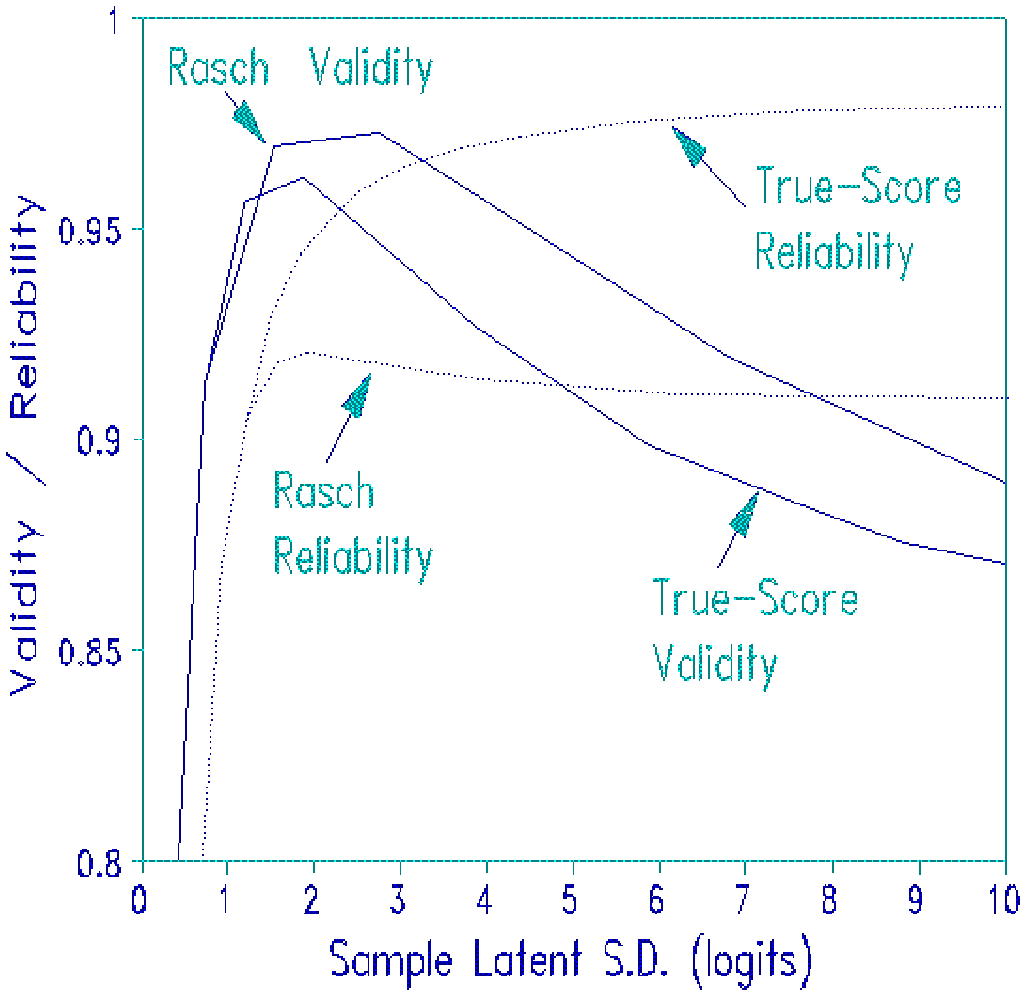

Figure 2. Reliability or Validity?

True-Score validity levels off and then starts dropping after 2.0 logits S.D. As the ability range becomes wider, the non-linear compression of the widening range of abilities into a narrow range of scores lowers the correlation between scores and trait location, and so lowers the True-Score validity. Rasch validity continues to increase until the sample S.D. is 3.0 logits. Beyond this, the test becomes too easy or too hard. It cannot locate many persons on the trait, so validity drops. Since Rasch validity is generally higher than True-Score validity, Rasch is more effective than raw scores at locating persons on the underlying trait.

<u>Results :</u>

The Attenuation Paradox

Rasch person separation reliability also increases up to 2.0 logits S.D., then drops off slowly. The person ability range is now very wide, so that persons at the ends of the range are measured very imprecisely by the test. The increase in the underlying ability range is counteracted by the increasing imprecision in the outlying measures so that Rasch reliability decreases slowly.

True-Score reliability, however, increases monotonically with person trait variance. This indicates that as sample dispersion becomes greater, individual raw scores become more stable (i.e., the data become more Guttman-like). But the decrease in True- Score validity means that these scores are less useful for locating persons on the latent trait. We know more and more about less and less. Perfect True-Score reliability is obtained when all items are perfectly correlated, i.e., acting like one item. Such a test has the statistical validity of a one item test, i.e., almost none.

Reliability or Validity?

Contrary to popular belief, the conventional True-Score reliability coefficient does not always summarize the measurement effectiveness of a test. Regardless of the relative sizes of the reliability coefficients, Rasch measures are more useful than raw scores for locating persons on an underlying trait.

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