# THE PHILOSOPHY BEHIND COST EFFICIENT TRACK MAINTENANCE

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## 1. INTRODUCTION

In the big picture, the railway is a mode of transport competing with a number of other modes of transport for business which is the sustenance of any business' existence. Whether the business receives an adequate share of the market depends on a number of factors of which competitiveness is a major contributor.

In very simplified terms the cost of transporting goods will be calculated by adding up all the business expenses such as labour, energy, maintenance, depreciation (the construction costs divided by the functional life of the track) and profit, and divide that by the total expected load to be carried per year to get to a rand per ton rate.

As maintainers of track we control the maintenance and depreciation aspects of the calculation and can contribute towards competitiveness by a reduction in those costs. However, studies[3] have shown that maintenance only accounts for 17% of the total costs as opposed to a minimum of 50% for depreciation costs. Savings on maintenance cost by doing less maintenance will prove to be very uneconomical as this will reduce the service life of the track and increase the depreciation cost.

The objective should therefore be to lower the track geometry deterioration rate and preserve the service life of the track by employing optimised maintenance strategies.

This paper will use hypothetical examples to illustrate how the maintenance strategy can be optimised, measured over the life of the track. The examples will be supported by relatively new research results by Prof Peter Veit from the Technical University of Gratz in Austria, in his paper 'Outsourcing In Track Maintenance' as read at the OVG conference in September 2004. His paper is based on a major project, "Track Strategy", by the Austrian Railway since 1996 that concentrated on the optimisation of track maintenance.

## 2. THE EFFECT OF MAINTENANCE ON TRACK LIFE

Figure 1 schematically shows a hypothetical track deterioration curve and the influence of maintenance on track life.

An increase in track roughness will result in an increase in dynamic loads, which will accelerate the rate of deterioration. The curve AC represents deterioration of an asset with no maintenance intervention. If the deterioration is left unattended, the functionality of the asset will reduce until it can no longer be used. This can be compared with a motorcar that is bought new and over distance travelled, deteriorates in condition and wear to a point where it becomes unsafe to drive.

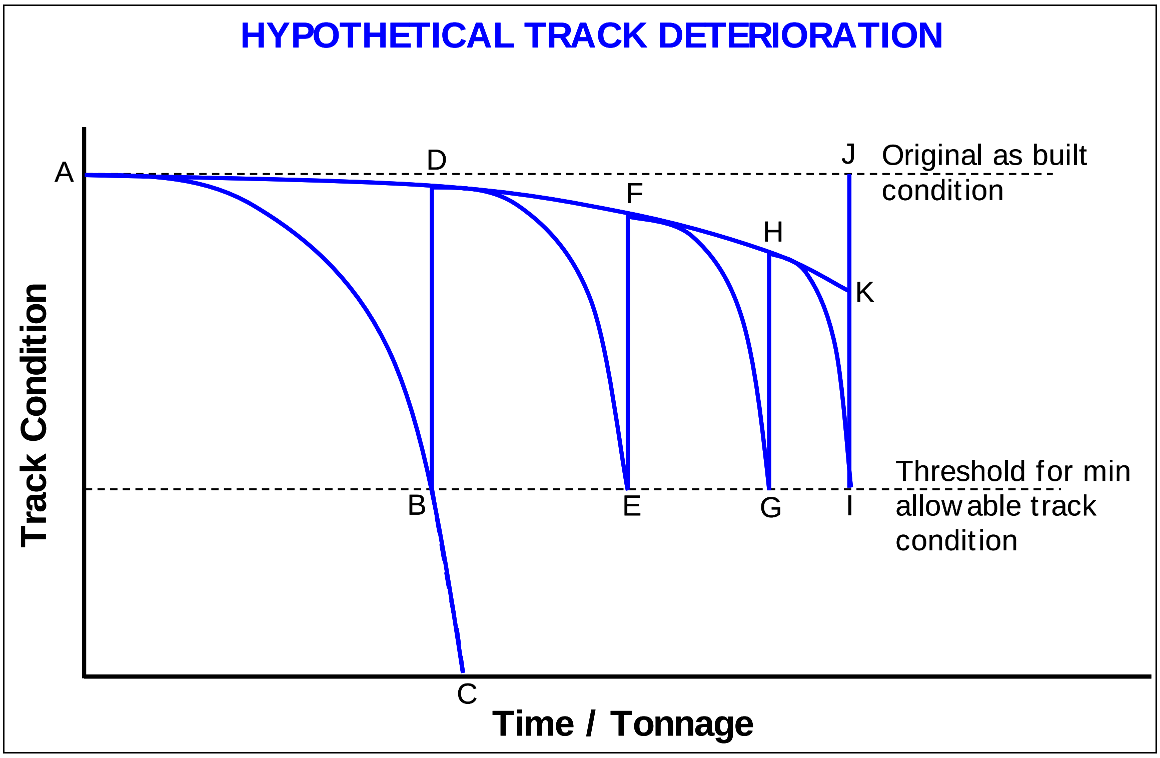


*Figure 1 :The Effect Of Maintenance On Track Life*

The same applies to the track. For the safe passage of traffic, the track cannot be allowed to deteriorate beyond the threshold for minimum allowable track condition.

Similar to the motorcar, the deterioration rate of the track can be slowed down through planned maintenance actions which are executed on time. However, the original as built functional condition cannot be regained by typical maintenance input (as depicted by BD) due to the wear of the track components.

After maintenance input the track will continue to deteriorate (DE). Once again, as the deterioration approaches the threshold for minimum allowable track condition, maintenance input is required (EF) and, as before, the condition as achieved after the previous maintenance input cannot be regained.

This process continues with each maintenance input achieving a lower track condition than before and the interval between maintenance inputs reducing exponentially. This produces a new deterioration curve (curve AK) which is much longer than the curve AC without maintenance input. The life of the track has therefore been extended.

This process will continue until the period between required maintenance inputs becomes uneconomically short (compare distance GI with BE). Complete track renewal e.g. formation rehabilitation, replacement of sleepers, rails, fastenings, ballast or any combination of these components will then be required (IJ). The whole process will repeat itself.

## 3. THE EFFECT OF INADEQUATE FINANCIAL INPUT OR POOR MAINTENANCE STRATEGIES ON TRACK LIFE

Track maintenance comprises a large percentage of any Railway's operational expenditure. When financial difficulty is experienced, the maintenance budget will usually be reduced first. The graph in figure 1 was based on the hypothesis that the necessary maintenance input in financial terms has been allowed for. The question arises what the case will be if the maintenance input is inadequate i.e. both in terms of maintenance intervention at a point below the maintenance threshold (too late) and/or insufficient input (too little) to achieve the highest possible condition.

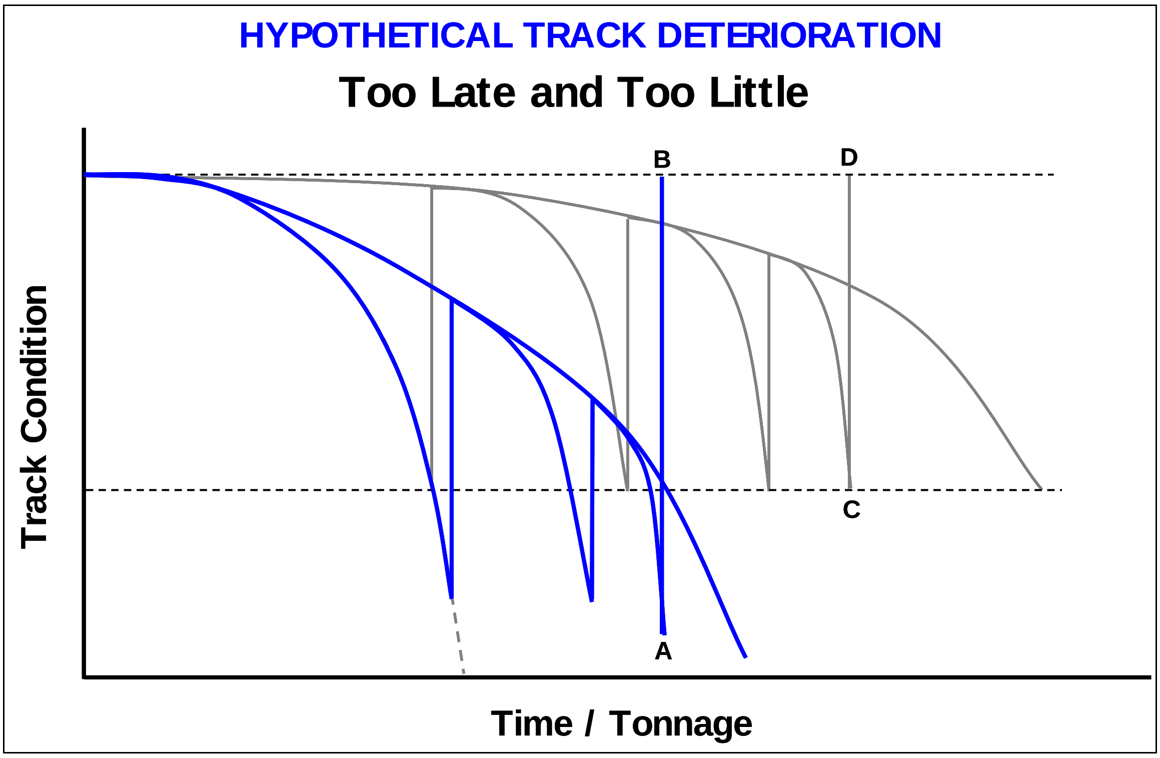


*Figure 2 : Track Deterioration Curve With Inadequate Financial Investment*

Figure 2 illustrates how the deterioration curve will be much shorter than what the potential is if timeous and sufficient maintenance was carried out. The life expectancy of the track has been drastically reduced. In addition, the input required to renew the track (line AB) will greatly exceed the input that would have been required if timeous and sufficient maintenance was carried out (line CD).

## 4. THE EFFECT OF INITIAL QUALITY ON TRACK LIFE

The influence of the initial quality of the track also needs mentioning. Decisions made during the planning, design and construction phases of the track have far reaching consequences for expenditure later in the life of the track structure. The use, for example, of lower standard track components, or lower standards of formation or drainage construction, may save money in construction costs, but the extra track maintenance cost and train delay times that result from this lower standard of work will consume these savings several times over. The higher the initial quality of the track, the greater the quality reserve, and the longer it will take before the next maintenance intervention becomes necessary, as illustrated in figure 3. The Tazara line is a very good example of how a high initial quality with well constructed cuttings and drains allowed a very long service life from the track despite limited maintenance being carried out.

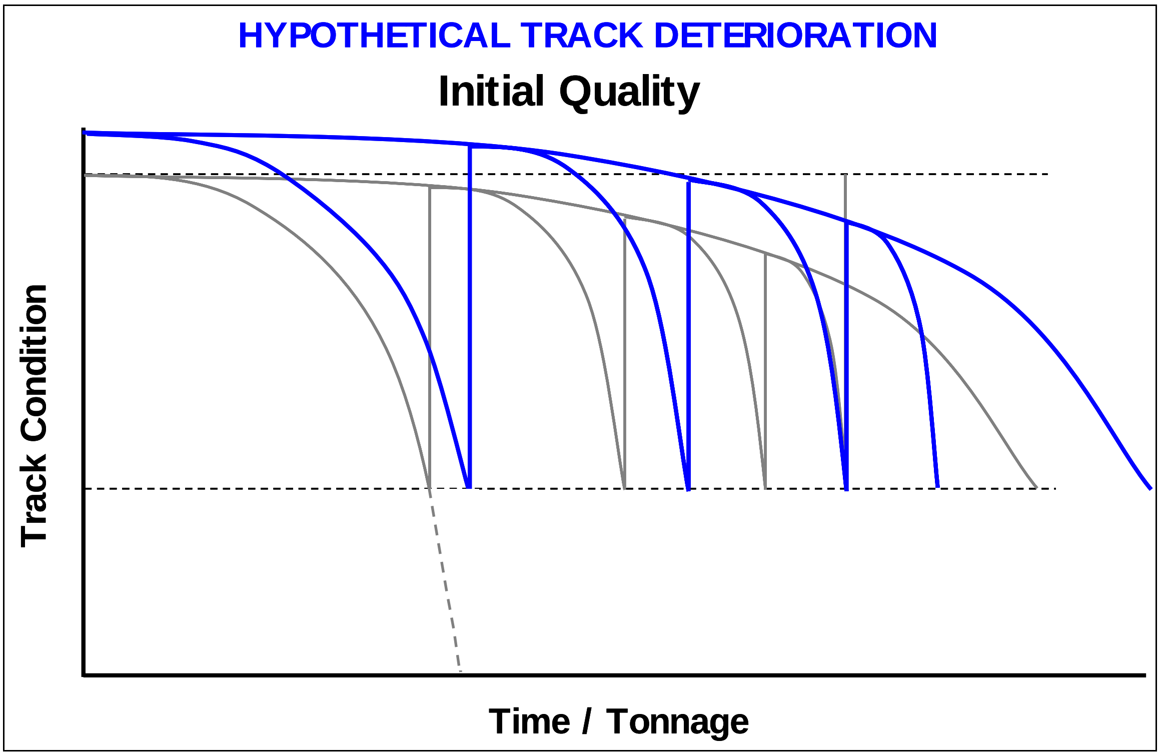


*Figure 3 : The Effect Of High Initial Quality On Track Life*

Therefore, the selection of initial construction standards for new lines should be aimed at achieving high initial quality of track and the subsequent maintenance input should be aimed at activities which will lower the track geometry deterioration rate such as clean ballast, good drainage, profiled rails, lubrication etc., which will extend the service life of the track.

These decisions must of course be taken with due consideration given to traffic density, speed and axle loads that will be carried by the track.

If the above mentioned principle is applied correctly, the lifecycle cost of the track will remain at affordable levels without having to undermine the service life of the track.

A few more assumptions, though proven in practice, can be made.

- A system should be in place to establish when the deterioration is approaching the threshold where maintenance is required. This requires the measuring of the track parameters and footplate inspections to establish the ***track information*** required for calculated decision making.

- Every maintenance input should aim to reduce the deterioration rate, i.e. durability of maintenance should be aimed for. Maximum durability can be achieved if appropriate and proven mechanised ***maintenance machinery*** is used. This is also aimed at achieving high initial quality, something that is difficult to achieve with hand labour.

- Whether or not mechanised methods are utilised, any track maintenance department needs a well managed, trained and motivated ***labour*** force. The extent to which the employees' motivation, needs, skills, experience and values are properly aligned with the company's objectives, needs, values and norms will directly influence the quality and durability of track work performed.

- Resources will invariably be limited and proper ***planning*** becomes crucial to utilise the resources effectively and economically. This can only be achieved if a maintenance management system is employed.

- The length of the deterioration curve will depend on how close the maintenance input brings the track condition back to the level before, taking into consideration the wear and tear in the track components. This implies that proven ***maintenance practices*** and ***maintenance strategies*** should be applied at all times.

## 6. RESEARCH THAT SUPPORTS THE ABOVE HYPOTHETICAL EXAMPLES

The paper presented by Prof Peter Veit from the Technical University of Graz, 'Outsourcing In Track Maintenance', provides some of the vital technical and economical correlations of the track which supports the hypothetical example used above. The paper was based on the Austrian project which concentrates on the optimisation of track maintenance by implementing strategies that take the total cost of the track into account from initial construction to the next complete renewal. An understanding of the research results should be carefully considered by us in South Africa in an effort to optimise our maintenance strategies. The following are extracts from the paper by Prof Veit.

The evaluations and analysis of the Track Strategy project highlighted a number of facts (see figure 4) including :

- When the traffic decreases, the life cycle costs for the track also decrease.

- The total lifecycle cost comprises depreciation (the construction costs divided by the functional life of the track in years / tonnage / number of axle passes), running or operational costs and maintenance costs.

- The additional operational costs as a result of maintenance (impact on traffic, occupations etc) can exceed the maintenance costs.

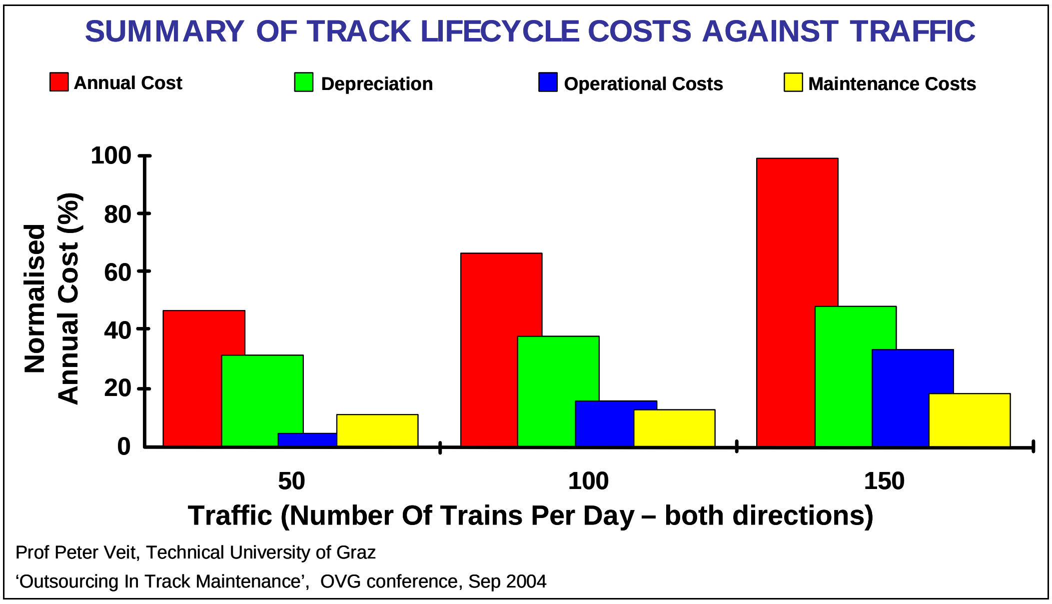


*Figure 4 : Summary Of Track Lifecycle Costs Against Traffic*

The main conclusion of the analysis was that the optimisation of track costs, i.e. reduction of the lifecycle costs, is only possible through a reduction of depreciation through the extension of the service life of the track. On the other hand the analysis showed that there is little room for savings on maintenance costs since when maintenance is reduced, the life expectancy of the track will decrease sharply which will increase the depreciation costs. The result is very uneconomical which is likely to have the opposite effect – an increase in lifecycle cost. The analysis was therefore summarised as follows : Adequate maintenance from the start will lead to a long service life, optimising the track economics.

The paper also addressed the effect that maintenance has on the lifecycle of the track. It refers to actual results which are almost identical to the hypothetical example used in figure 1. Quality improvements are said to be dependent on, inter alia, the threshold for minimum allowable track condition (see figure 5).

If the threshold for maintenance intervention is set at point 1 (low threshold), the effect of too little maintenance will be hardly noticeable at first but the service life can already have been reduced due to the knock on effect of the first track defect. For example, if the track roughness index is set to low before tamping takes place, the roughness will cause higher dynamic loading of the track which will cause crushing of the ballast, which in turn will result in fines in the ballast bed retaining moisture, etc.; eventually resulting in damage to the permanent way material. When the maintenance measures are set for a low quality threshold, the evaluation showed relatively high initial improvements in quality values, however, this level is not sustainable and the deterioration will rise. The quality level achieved after maintenance will be lower than if measures had been implemented sooner. Intensive maintenance efforts at a later stage to extend the service life once more proved uneconomical.

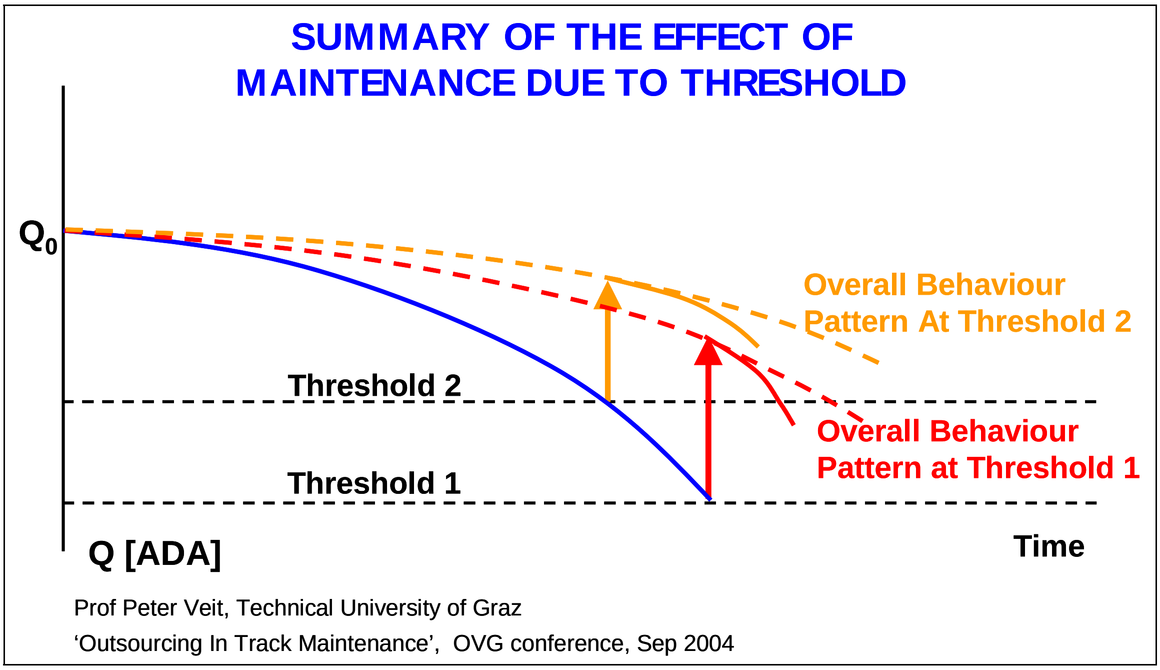


*Figure 5 : Summary Of The Effect Of Maintenance Due To Threshold*

The level at which the threshold is set is therefore of significant economic importance. Furthermore, calculations have shown that the threshold from an economic point of view should not be set at a fixed value but it should rather be linked to the age of the track. It can be proven that this type of threshold leads to a longer service life and is generally more economical.

The general tendency by maintenance managers is to maintain a constant threshold for maintenance intervention throughout the life of the track. In a practical example, the track Quality Index (TQI), as measured by the track recording car, is set on 1.6 for the coal line before tamping takes place. The research analysis of the Austrian project however provides a different approach. Starting from the bottom of figure 6. An increasing threshold means that while the track is new, the threshold is set very low and investment in maintenance is limited. Initially the effect thereof cannot be seen. As the track ages, the threshold has to increase due to the increasing wear of the other track components, to maintain a reasonable availability and track life. However, the knock on effect referred to earlier has already taken its toll and will negatively impact on the life of the track. This is probably not a maintenance strategy but rather the result of financial constraints or neglect.

With a constant threshold, maintenance intervention will always take place when the track condition has reached a predetermined level, irrespective of the age of the track such as the coal line example. From the hypothetical figures provided, it can be seen that to maintain this quality level, the period between interventions will become shorter due to the wear of the track components.

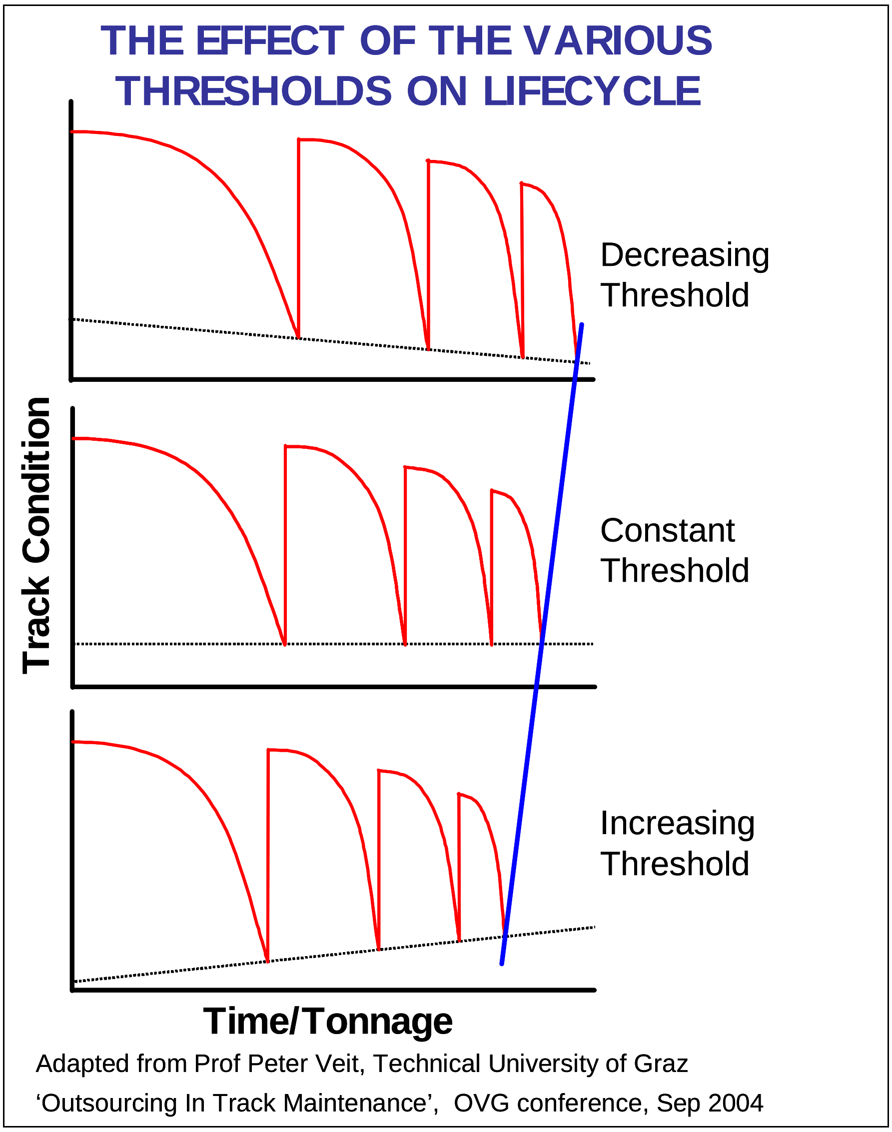


*Figure 6 : The Effect Of The Various Thresholds On Lifecycle*

The most economical approach to track maintenance was proved by the Austrians to be when money is invested in a high level of quality initially with corresponding maintenance which leads to a long service life, i.e. economic advantages in the future. In other words, a long service life and lowest lifecycle cost can be expected when a high initial quality has been achieved during construction and when the threshold for maintenance intervention is at its highest while the track is still new. The threshold is then gradually reduced towards the end of the track life.

## 8. CONCLUSION

In South Africa where the railways are not subsidised, they must pay out of profits for their ‘road’, unlike the trucking industry which uses public funded roads. As maintainers we play a crucial role in making the railway competitive through the application of scientific maintenance strategies and practices which extends the life of the track and in so doing reduces the depreciation cost. This can be achieved through :

- Having a long term approach and considering every effort in terms of the lifecycle cost. The worst approach will be to reduce maintenance in the short term to save on costs as this will have a detrimental long term effect and may very well put the railway out of business.

- The position / value of the maintenance threshold must receive careful consideration. The Austrian project confirms this philosophy by providing evidence that if maintenance intervention takes place too late or is inadequate, the depreciation value will increase which will make the railway uncompetitive.

- Implementing a decreasing threshold which will see track defects and preventive maintenance being addressed early during the life of the track. This is especially applicable to all the new turnouts that are currently being installed.

Wisely planned and implemented maintenance at regular intervals will extend the life of the track to remain economically viable for many years to the benefit of economic growth of our country, to the benefit of the environment from an energy consumption point of view and to the benefit of road users through reduced traffic congestion and fatal accidents.

**REFERENCES**

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