APPENDIX I

SIGNIFICANCE OF CERTAIN IMPORTANT STATISTICAL RESULTS

A railway is usually said to manufacture and sell transportation and like every other manufacturer requires to know the cost of what it sells in order to measure its efficiency and to gauge the adequacy or otherwise of the rates and fares charged. As the main function of a railway is to transport passengers and freight between two points cheaply and expeditiously, everything which helps to decrease the cost of transportation will benefit both the railway and the trader and at the same time increase the prosperity of the country.

2. It is, therefore, essential to obtain efficiency with economy and so railway officers must be supplied with accurate and up-to-date information of what is happening at all points of the railway to enable them to decide what steps are necessary to maintain and improve the efficiency of the undertaking.

3. Statistics, however comprehensive, will not in themselves run a railway but they will supply the necessary data with the help of which the various problems that arise from day to day can be assessed and solved. Without statistics, officers have to base their decisions on surmises and not on facts. No railway can afford to grope in the dark and take risks of mistakes arising from incomplete and inadequate information.

4. The averages connected with the results of operation arrived at by dividing one set of fundamental units by another related set of fundamental units help the officers to ascertain their relationship to one another.

5. It is, therefore, useful to know the significance of the various figures arrived at in statistics. Accordingly, certain important results are dealt with below:—

(*a*) **Engines available for use.**—The daily average number of engines employed on each class of work i. e., service during the month can be simply and readily worked out. From the totals of these figures, the following important results can be worked out:—

(*i*) Engine kilometres per passenger, goods, etc., engine per day.

(*ii*) Engine kilometres per day per engine in use.

(*iii*) Engine kilometers per day per engine on line.

With the help of such figures, it is possible to ensure that as much use as possible is being made of the engines available for use and to see the effect of any improved methods introduced. It is also advisable to analyse at fixed intervals exactly how an engine spends each hour of the 24 hours in a day. In case, there is a wide variation between items (*ii*) and (*iii*) above, further analysis is necessary to find out if a railway/division has stocked more engines than its requirement and also the engines actually employed in service are being utilised to the full.

In making comparisons between railways on the basis of engine kilometres per engine per day, allowance must be made for such factors as :—

extent of local or short distance goods service ;

extent of suburban service/through goods and van and shunting good services.

extent of business offering ;

average length of haul ;

gradients and curvature ;

proportion of single line.

(*b*) **Net tonne kilometres per goods locomotive day.**—This result is arrived at by dividing the net tonne kilometres of revenue earning and non-revenue traffic (less the net tonne kilometres of traffic carried in departmental trains other than coal) by the product of the number of goods locomotives during the year and the number of days in that year.

A decrease in the figure of net tonne kilometres per goods locomotive day may be due to:—

(*i*) less traffic offering ;

(*ii*) shunting hours not being cut down in proportion to the decrease in traffic offering ;

(*iii*) increase in departmental, assisting required, assisting not required and light engine kilometres ;

(*iv*) decrease in the amount of work obtained from an engine daily either in the number of kilometres run per day or in the loads hauled ; and

(*v*) increase in the number of engines under or awaiting repairs.

Over a series of years, this figure should show a steady increase due to improvements in the design of engines and a consequent increase in the tractive effort. This figure is also valuable for comparing the work obtained from engines during two busy periods.

(*c*) **Average wagon load.**—This result is arrived at by dividing the total net tonne kilometrage by the loaded wagon kilometrage.

A decrease in the average wagon load may be due to :—

(*i*) a change in the type of commodities offering;

(*ii*) the supply of smaller wagons; and

(*iii*) inefficient working of the station staff.

The average wagon load that can be secured on a railway depends on :—

(*i*) the type of traffic dealt with ; it is, for example, possible to obtain a higher wagon load when the majority of traffic is coal, mineral ores etc.

(*ii*) whether traffic is retail or wholesale i.e., traffic is booked in full wagon loads or smalls; it is possible to obtain a higher average wagon load where traffic is booked in large quantities.

(*d*) **Wagon kilometres per wagon day.**—The numerator is wagon kilometres and the denominator is wagon days.

The term wagon includes both covered and open goods wagons.

The wagon kilometrage includes the kilometrage made during the month by loaded and empty wagons run on goods and mixed trains, but excludes empty brake wagons and empty departmental oil tanks, gas holders, water trucks and inspection carriages. etc.,

Wagon days are arrived at by multiplying the daily average number of wagons on the line, in terms of 4-wheelers, by the number of days in the month.

This figure is much lower during the slack season than during the busy season owing to the fact that wagons are more fully used during the latter period. The difference between these two figures is generally the measure of the stock lying idle on the line during the slack season. This unit will give an idea of th efficient and economical use of the wagon stock available.

A decrease in the wagon kilometres per wagon day may be due to :—

(*i*) delays in marshalling yards;

(*ii*) delays at stations when loading or unloading :

(*iii*) decrease in the average speed of goods trains ;

(*iv*) increase in the number of wagons under or awaiting repairs ; and

(*v*) less traffic offering.

(*e*) **Net tonne kilometres per wagon day.**—This unit is one of efficiency in wagon-user. This result is the product of mobility and loading. A decrease in the net tonne kilometres per wagon day may be due to any of the causes which affect the figure of wagon kilometres per wagon day. This figure also takes into consideration the proportion of loaded to total wagon kilometrage, the average load of a loaded wagon and the relative proportion of heavy and light merchandise carried.

(*f*) **Loads of goods trains.**—The load of a goods train is measured in :

(*i*) net or freight tonnes ;

(*ii*) gross tonnes including the weight of engine ; and

(*iii*) gross tonnes excluding the weight of engine.

A decrease in the net or freight load may be due to :

(*i*) less traffic offering ;

(*ii*) a decrease in the average starting wagon load ;

(*iii*) a decrease in the wagon loads of wagons received at junctions ;

(*iv*) unbalanced traffic and the necessity for working back at large number of empties: and

(*v*) bad working.

The above factors may explain a decrease or an increase in the average net or freight train load but there are at the same time various factors which affect the average train load. These include :—

(*i*) the class of traffic dealt with, i. e., whether it is likely to give a high average wagon load such as coal, mineral ores, etc.

(*ii*) whether traffic is retail or wholesale; it is possible to obtain a higher average wagon load when traffic is booked in large quantities;

(*iii*) the diffusion of traffic ; it is possible to obtain better loads as a rule if the majority of traffic is long distance traffic as it is then profitable for a railway to increase the strength of the track and bridges, to buy a stronger locomotive, etc.;

(*iv*) the physical characteristics of the railway, such as gradient, curvature, strength of the bridges and track, length of sidings, terminal arrangements, marshalling yards, etc., and

(*v*) the class of rolling stock used, specially as regards the capacity of locomotives and wagons.

The net or freight train load of a railway should show a steady increase every year due to such factors as:—

(*i*) the use of more powerful locomotives ; and

(*ii*) the use of larger and better designed wagons.

The gross train load depends to a great extent on the net or freight train load. It sometimes happens that when there is a large number of empty or lightly loaded wagons on a train, the gross load of the train is limited by its length rather than by the capacity of the locomotives.

(*g*) **Average speed of passenger and goods trains.**—The average speed of trains–train kilometres per train engine hour–is not the average running speed but the average time taken over the division or section, including all stops at stations.

If the average speed of trains on a section is low, the running of trains should be carefully analysed and it will generally be found that the low average is due to delays on certain block sections or at one or more stations and that it is possible to increase the average speed by:—

(*i*) changing the timings of the trains ; and/or

(*ii*) providing extra loops or other facilities.

The stations at which the heaviest delays take place should be dealt with first until by a process of elimination there is no specially bad station.

(*h*) **Gross tonne kilometres per engine hour.**—A figure of gross tonne kilometres per engine hour is more suitable for judging departmental efficiency than a figure of net tonne kilometres per engine hour, as sometimes the net tonne kilometres go down with no decrease in gross tonne kilometres due to such causes as an increase in the proportion of unbalanced traffic and so an increased running of empties.

(*i*) **Grosstonne kilometres per train engine hour.**—A figure of gross tonne kilometres per train engine hour is valuable as a check on the efficiency of the running of goods trains. A decrease in the gross tonne kilometres per train engine hour may be due to a decrease in either the gross loads or the speeds of trains. A figure of gross tonne kilometres per train engine hour is better than either the train load or the speed separately but gives an undue importance to speed. The aim of transportation officers is to get as high a figure of gross tonne kilometres per train engine hour as possible and this can be done by either increasing the load or increasing the speed. The final check is the cost per tonne kilometre and it is necessary to avoid increases in the gross tonne kilometres per train engine hour if they involve an increase in the cost of working one tonne one kilometre.

(*j*) **Net tonne kilometres per engine hour.**—A figure of net tonne kilometres per engine hour is probably the best individual figure to take for watching the efficiency of freight working on a division. Net tonne kilometres indicate the amount of revenue earning work done while engine hours measure the cost of doing it. A decrease in net tonne kilometres per engine hour may be due to :—

(*i*) less traffic offering ;

(*ii*) shunting engine hours not being cut down in proportion to the decrease in traffic offering ;

(*iii*) increase in departmental, assisting required, assisting not required and light engine running ;

(*iv*) decrease in the average load or the average speed of goods trains;

(*v*) decrease in the average starting wagon load or in the wagon loads of wagons received from other divisions ; and

(*vi*) increase in the proportion of unbalanced traffic.

(*k*) **Average haul.**—A knowledge of the average distance hauled is of great importance in all questions of the stock of wagons required, the rates charged and the cost of working.

With a short average haul, a lower average number of kilometres per day is generally obtained out of each wagon, as the shunting necessary is greater and it is not possible to arrange for the running of long distance through trains. This results in increased coal consumption and increased cost of working.

(*l*) **Shunting kilometres per 100 train kilometres.**—Shunting is essential for operational purposes, because carriages and wagons lying at different points have to be collected to form a train and marshalled properly. But it does not directly earn any revenue and is, therefore, treated as an unproductive service.

Shunting engine hours arise in two ways : (1) from whole or part time shunting engines employed at the larger stations and yards and (2) from train engines shunting at road-side stations during the run, as also before the booked departure and after the actual arrival of trains at terminals.

Shunting engine hours are converted into shunting engine kilometres at an arbitrary equivalent of 8 kilometres per hour for steam engines and 12 kilometres for electric and diesel electric engines.

This derivative result is not of much value when employed for comparison between railways but has value only when used for comparing results from month to month and year to year on the same railway.

Unless shunting kilometres are cut down when traffic measured in train kilometres decreases, figures of shunting kilometres per 100 train kilometres will go up. If there is, however, an increase in the shunting kilometres per 100 train kilometres this may be due to the fact that better train loads are being obtained with a decrease in the train kilometres run and no decrease in the work done.

(*m*) **Density.**—The density of traffic has a very great effect on the results obtained in the working of a railway and it is important to know on what sections the density is the highest. Increased density of traffic per kilometre of a railway brings about a reduced cost of working per revenue unit as long as heavy capital expenditure on such works as doubling the line, is not necessary to enable the railway to carry the traffic offering. In such cases, the cost per revenue unit goes up temporarily until such time as there are further increases in the density of traffic when the costs will go down until the increased capacity of the line has been worked upto. Maintenance costs and costs of working terminals, engine power, etc., do not increase so fast relatively as the earnings with an increased density and for this reason the cost of working per revenue unit goes down.

Density is best measured in different units for different purposes such as :—

(*i*) gross tonne kilometres per running track kilometre for purposes of deciding on the best weight of rail ;

(*ii*) net tonne kilometres and passenger kilometres per running track kilometre for all questions relating to earnings and to loads of trains ; and

(*iii*) train kilometres per running track kilometre per day for the capacity of a section.

(*n*) **Coal consumption.**—Coal is one of the largest individual items of expenditure and the importance of efficient methods of checking the amounts of coal consumed is obvious. The actual amount of coal consumed on each class of service must be first obtained and then it is possible to compare this with the work done. Figures should, therefore, be kept separately for passenger, mixed, goods, shunting, departmental and miscellaneous services and the amount consumed compared with various units of work such as, engine kilometres, 1,000 gross tonne kilometres.

The engine kilometre is the unit of work which is probably most commonly used, as it is a figure which is, readily available and which the Locomotive department can obtain for themselves. This figure has, however dtisnct limitations as it takes no account of the speed or the load of the train. It is of use when comparing the working of engines on the same link and is often employed as a check on the working of the engine crew ot find out which crews are heavy on coal.

One of the main factors which influence the consumption of coal is the load and for this reason the figure of *kilograms of coal consumed per* 1,000 *gross tonne kilometres* is generally considered the best unit for checking the consumption. This figure does not, however, take into account the effect of the speed of a train on coal consumption.

(*o*) **Operating ratio.**—The Operating ratio is, broadly speaking, the ratio between working expenses and gross earnings and, as such, is an important figure in the estimation of a Railway's efficiency. This ratio is not always a good criterion of the relative efficiency of different railways where the conditions of working vary considerably, and this is particulary so in India where differences in climate, topography and commercial and agricultural activity show so little uniformity.

In comparing the ratio of one year with another, however, great care must be taken to see that the terms "Working Expenses" and "Gross Earnings" are clearly defined and that the figures have been compiled on the same basis. The object of a railway administration is to keep this ratio as low as possible, consistent with efficient working and good maintenance ; it will tend to fall with efficient working, increase of traffic and fall in the expenditure. This will also fall or rise with variations in the rates charged to the public for movement of passengers and goods ; other things being equal, it will fall or rise with an increase or a decrease in rates charged.

(*p*) **Turn round of a wagon.**—This is equal to the effective wagon holdings divided by wagon loadings, where the effective wagon holdings represent wagons owned by a railway less the daily average number of wagons out of service modified by the daily average wagon balance. Wagon loadings in this context include (1) average daily loading, (2) average number of wagons received loaded from other railways daily, (3) average daily number of wagons carrying military traffic and (4) daily average number of wagons into which goods are transhipped from wagons of the same gauge.

The wagon turn round figure as between railways can only be of general interest. No useful purpose is served in comparing the turn-round between different railways as a number of factors influence the figure and these factors differ on different railways. The principal factors governing wagon turn round are the average lead, traffic density, ruling gradients affecting speed and line facilities, such as, double or single line and main and branch line connections at junctions. As between different periods on the same railway, however, the figure is a useful indicator of efficiency.