CHAPTER 1
INTRODUCTION

Among the most important of the different experiments and surveys carried out by the *Research on the Interrelationships Between Costs of Highway Construction, Maintenance and Utilization* (ICR Research) are the surveys on the free speed of the vehicle population and the fuel consumption experiments conducted with the Project's vehicle test fleet.

The results of these experiments, carried out in various Brazilian States during a period of nearly five years, made it possible to produce, for computer use, a mathematical algorithm that predicts the free speed and the fuel consumption of a given fleet of vehicles trafficking on a road of known characteristics.

This algorithm - initially designed just to generate aggregate equations to be used in speed and fuel consumption predictions for global models of highway-investments evaluation - showed, after conclusion of its initial version, a potential for isolated and independent use not foreseen in its initial conception. Consequently, though still used to perform auxiliary functions in the elaboration of the aforementioned models of highway-investments evaluation, it came to be considered as a final product of the *ICR Research,* and was designated the *Model of Time and Fuel Consumption* (MTC).

Therefore, correct evaluation of the MTC, whether as an independent model, or an auxiliary model for developing the *Model of the Interrelation of Highway Costs* (MICR), requires familiarization with the project, including its implementation and the analysis of the experiments which originated it. Only then will the reader be able to evaluate both the potentialities of the model, derived from its solid experimental foundation, and its limitations, the latter being, to a certain extent, transitory consequences of the new applications envisioned for the MTC.

Such familiarity with the speed and fuel consumption experiments should be gained through the reading of other volumes of this series of *ICR Research* publications, particularly Volume 6. The present Volume, which has the purpose of describing and explaining the basic conceptions and the logic of the Model, contains only a simplified presentation as to how the results of those experiments were organized and utilized in designing the MTC. Figures 1.1 to 1.4, presented below, were conceived with this objective in mind.

Figure 1.1 illustrates that, once the horizontal geometry of the road is known, the MTC, based on the results of Experiment TB-4 (Free Speed·on Curves), defines and limits the free speed on all curves of a given road on the basis of radius, roughness, class of vehicle, and so forth. Once this is done, the MTC program considers the road as if it were entirely straight, with sections in which the speed is limited.

Figure 1.2 does not refer to any experiment but illustrates, just as the previous figure, sections of the road where (for legal or safety reasons) speed is also limited. These sections were called *speed-control sections*, and represent stretches where vehicles should travel at a restricted speed that is probably below its capacity. Such stretches include those passing through villages or by Highway Patrol or Inspection Stations, etc. When a speed-control section coincides with a curve, either the curve itself or the restriction imposed by legal or safety reasons may limit speed. In this case, maximum speed will be the lowest of the two, whether imposed legally or by the existence of the curve.

In those road locations where speed is limited neither by speed limits, nor by the curvature itself (Experiment TB-4), the MTC uses a *default* speed limit of 150 km/h. Consequently, the Model then works with one speed-limit profile for the entire road.

Figure 1.3 shows how Experiments TB-1 (Free Speed on Positive Grades), TB-2 (Free Speed on Negative Grades), TB-3 (Acceleration), TBS-3 (Deceleration) and TB-6 (Calibration) were utilized to determine the performance of vehicles in highly varied grade situations, roughness, speed mode (constant/acceleration/deceleration), etc. It should be noted that the final free-speed profile of Figure 1.3 was established after having taken the speed-limit profile into consideration.

Figure 1.4 shows how Experiments FC-1 (Consumption at Constant Speed), FC-2 (Consumption During Deceleration by Gravity), FC-3 (Consumption on Curves), FCS-4 (Consumption During Acceleration), TBS-6 (Consumption During Deceleration by Braking) and FC-4 (Calibration) were utilized to determine fuel consumption in highly varied situations of grade, roughness, speed mode, etc. One should note that the variable *fuel consumption* has volume and time as its units (ml/sec).
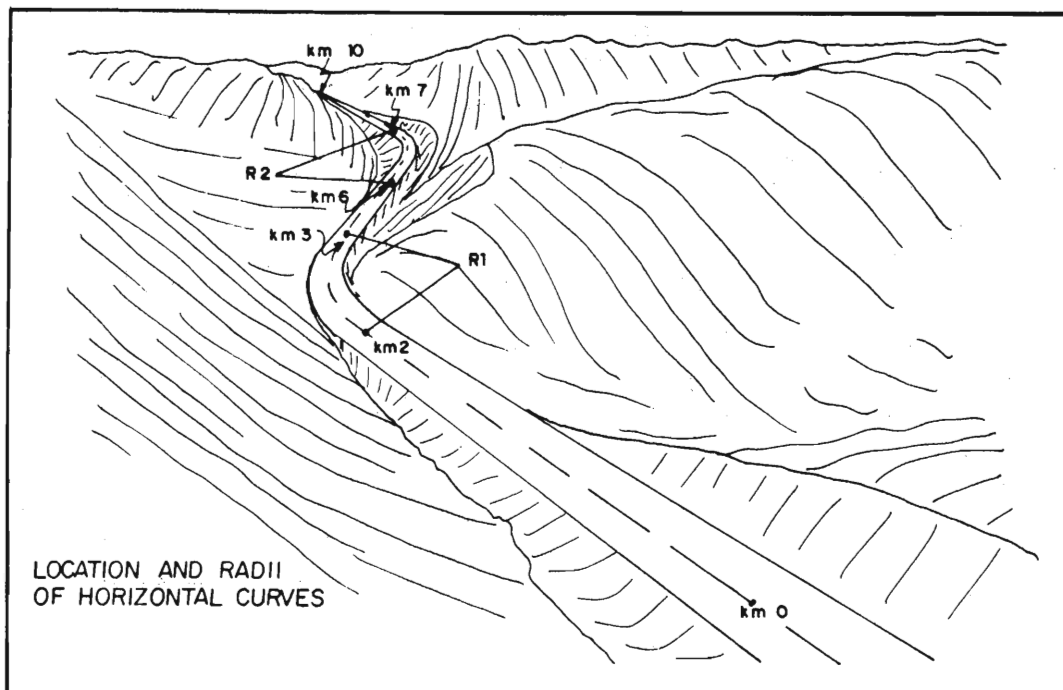
EXPERIMENT TB 4

$V_c = F(R, I^{rr}, etc.)$

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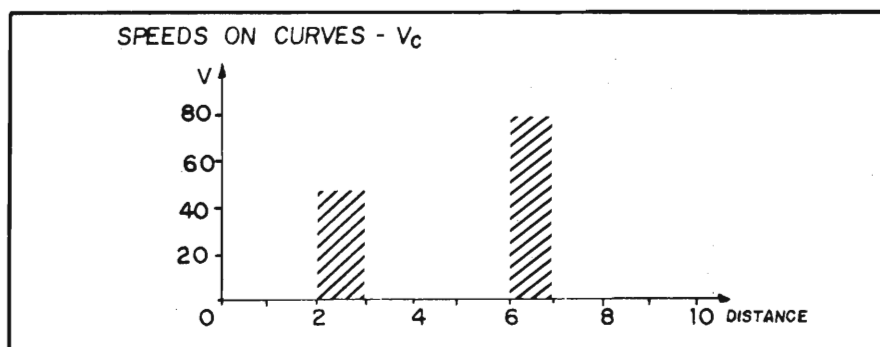$V_c = F(R, I^{rr}, etc.)$

SPEEDS ON CURVES - V_c

Figure 1.1 - INTEGRATION OF SPEED AND FUEL CONSUMPTION EXPERIMENTS IN MTC DESIGN. DETERMINATION OF SPEED ON CURVES.

SPEED - CONTROL SECTION - V_{max}.

SPEED ON CURVES - V_c

SPEED LIMIT PROFILE
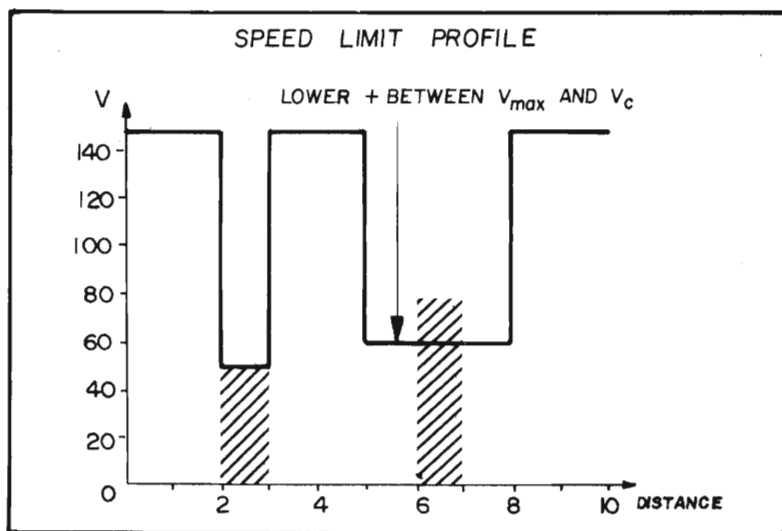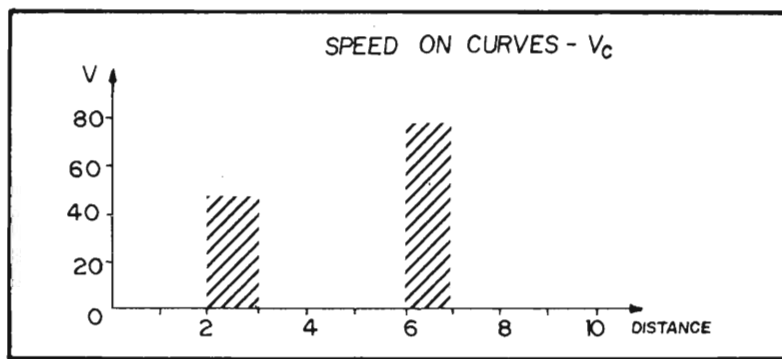
LOWER + BETWEEN V_{max} AND V_c

Figure 1.2 – INTEGRATION OF SPEED AND FUEL CONSUMPTION EXPERIMENTS IN MTC DESIGN. DETERMINATION OF SPEED LIMIT PROFILE.

EXPERIMENTS

TB - 1

TB - 2

TB - 3

TBS - 3

TB - 6

$+ i\%$

V_0

FREE S

FREE S $= F (V_0, i\%, Irr, etc.)$

V_0

FREE S

$- i\%$

LOCATION OF POSITIVE AN NEGATIVE GRADES

0% $+3\%$ -6% $+2\%$ -1%

km   0   1   3   6   8   10

SPEED - LIMIT PROFILE

V

140

120

100

80

60

40

20

0   2   4   6   8   10   DISTANCE

FREE - SPEED PROFILE

V

80

60

40

20

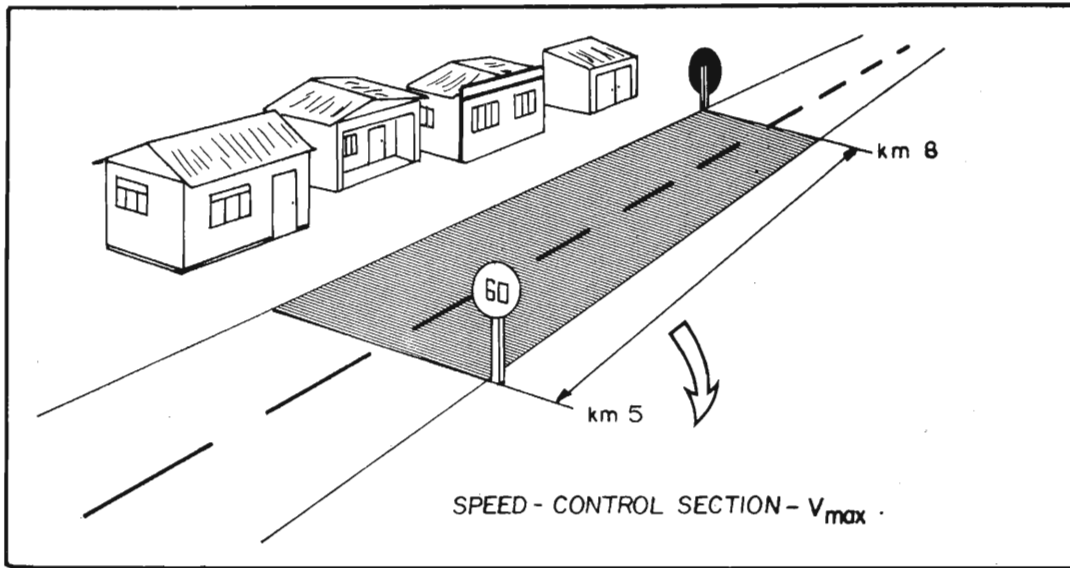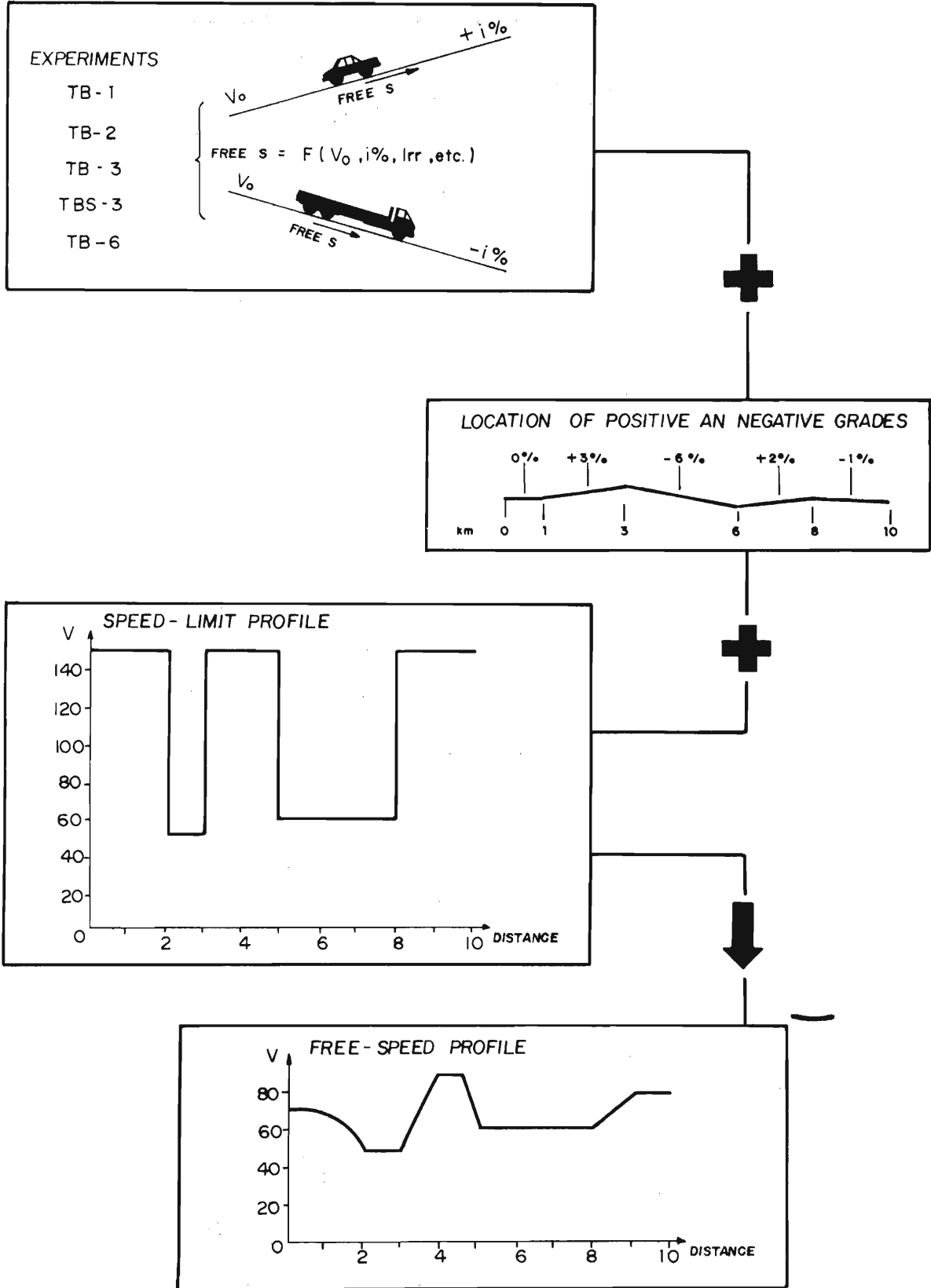0   2   4   6   8   10   DISTANCE

Figure : 1.3 - INTEGRATION OF SPEED AND FUEL CONSUMPTION EXPERIMENTS IN MTC DESIGN.
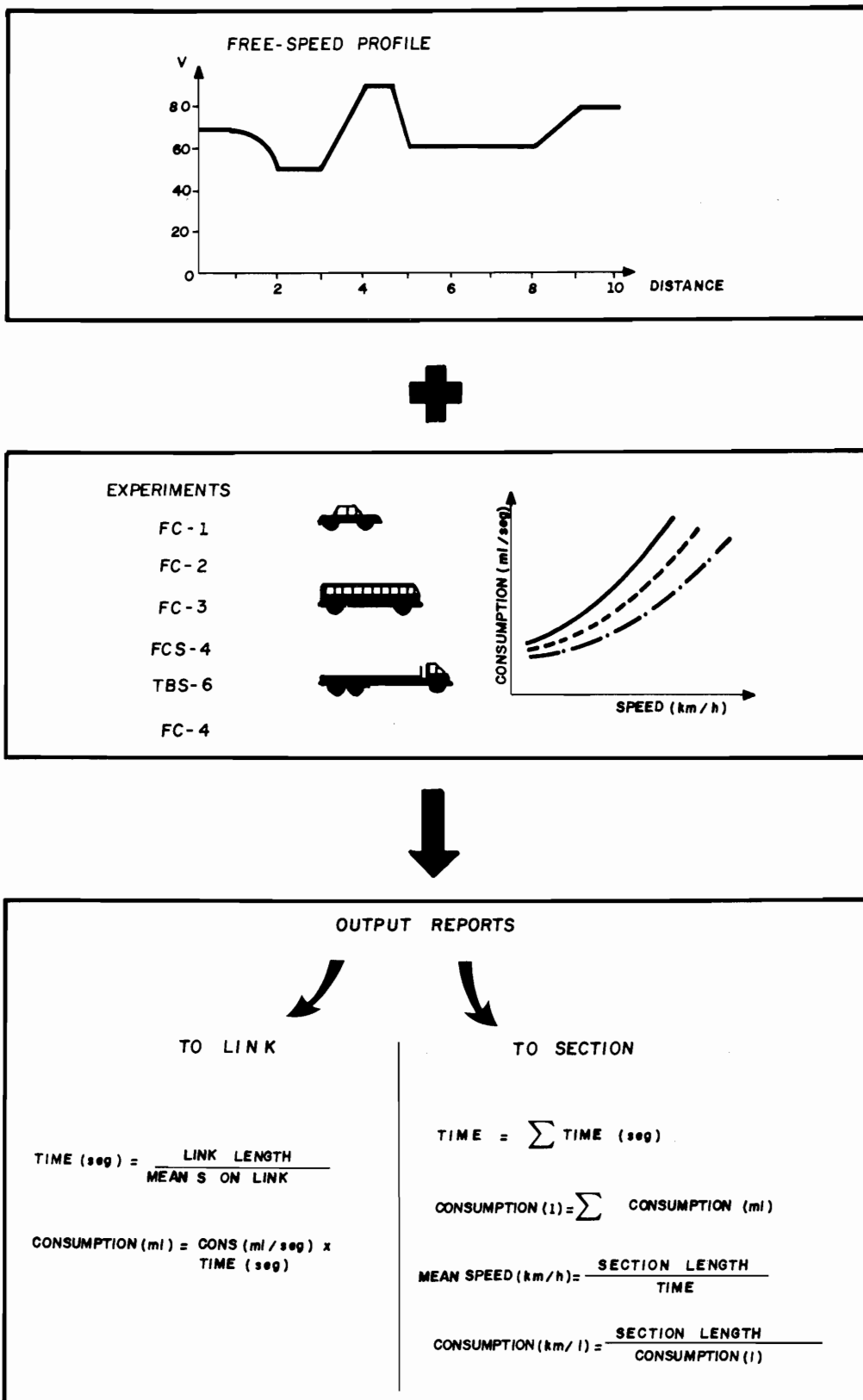DETERMINATION OF FREE-SPEED PROFILE.

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Figure 1.4 - INTEGRATION OF SPEED AND FUEL CONSUMPTION EXPERIMENTS IN MTC DESIGN. OBTAINING OF OUTPUT REPORTS.

Consumption on a link (subdivision of the section) is calcu-
lated by multiplying the time spent to cover its length by the rate of
consumption. The consumption on the section will be the sum of that
on the links which compose it.

The user should note that the result indicated in Figure 1.1
(Speed on Curves) is used in Figure 1.2, with the additional in-
formation on sections with speed control, to produce the speed-limit
profile in Figure 1.2.

The speed-limit profile in Figure 1.2 is then used in
Figure 1.3, together with additional information on the locations of
positive and negative grades, to produce the free-speed profile, through
the utilization of equations derived from Experiments TB-1, TB-2, TBS-3
and TB-6.

As shown in Figure 1.4, the free-speed profile is associated
to the fuel-consumption experiments (FC-1, FC-2, FC-3, FCS-4, TBS-6 and
FC-4), to produce the output reports of the model at two levels: de-
tailed report, which will include results of fuel consumption and tra-
vel time for each link, and the summarized report, containing the same
results for the section as a whole.

This overall view of the utilization of experiments re-
sults by the Model, permits detailing the process by which the
MTC calculates free speed and fuel consumption for each link and for
each section of the road under analysis.