# Roads Maintenance Management
# Evaluation of traffic load distribution with Automatic Vehicle Location (AVL)

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**Abstract:**

Load carrying capacity measurements provide information on the bearing capacity of individual road sections at each given time, i.e. we calculate for the road section concerned how much traffic load and axle load it can support for instance for the next 20 years. Special frost dept measuring devices also give supplementary information on the variable bearing capacity of each stretch of road from time to time.

It is important to be able to collect without undue complication better traffic load distribution data on the road system in order to support improved targeted planning in new construction, maintenance and service projects, as well as for better management of weight restrictions where these are needed during periods of thaw.

A system has been set up whereby heavy traffic is analysed and classified through the use of activity analysing and digital mapping techniques in order to evaluate and calculate the traffic load on the road system. The work consists in the analysis of collected data (data bases), the drawing up of work and calculation processes, the handling and interpretation of data, data transmission and storage and other aspects which come under the general execution of the project/task in question.

## 1. Project background:

The following methodology is essentially intended for roads with limited load bearing capacity and with relatively little traffic ("Low Volume Roads") .There is an increased need for information on the load bearing requirements and structural degradation due to traffic on the road system. Data from traffic counters and traffic classifiers provide certain information on the traffic load on certain parts of the road system.

It is important to be able to collect good and reliable traffic load distribution data for the road system easily and automatically, without undue complications. Collected data is then compared with measured load bearing capacity to figure out the lifetime for the corresponding road or road section for project prioritisation in order to support improved targeted planning in new construction, maintenance and service projects, as well as for better management of weight restrictions where these are needed during periods of thaw.

## 2. The project:

The plan is to base Road User Charges, at least for heavy vehicles, on both Odometer readings for the distance travelled and GPS-locationing for time and position. In order to respect the rules of privacy it is important to distinguish between information needed for the collection of taxes, which should be charged for driving at this time and on this stretch of road and the tax-amount on one hand, and on the other hand the information needed for the road authority, i.e. knowledge about the actual strain on the road and where and when this occurs.

A system has been developed whereby heavy traffic is analysed and classified through the use of activity analysing and digital mapping techniques in order to evaluate and calculate the road burden. The model consists of the analysis of collected data (data bases), analysing and calculation processes, the handling and interpretation of data, data transmission and storage and other aspects which come under the general execution of the project/task in question.

## 3. **Projects implementation**:

### 3.1. Data collection from AVL:

Apart from electronic toll collection for the distance traveled, installation of activity monitoring equipment (AVL - Automatic Vehicle Location equipment) in the vehicles concerned opens new possibilities for the calculation of road traffic loads and the breakdown effects on all road sections used by these vehicles. Larger vehicles such as trucks are the most important and have the greatest impact here and will without any doubt supply the bulk of such data.

In a trial project the Icelandic Roads Administration (ICERA) is using an on-board unit in a vehicle to solve these needs together by in-vehicle processing of road user charges and actual road burden evaluation.
Tracking technology with topological applications provides an opportunity to calculate user charges, road burden and estimate the breakdown rate for every road. The challenge is to build the data collection and processing into a single unit, omitting central collection of vehicle tracking – and thus preserving personal rights.

The relevant information for taxation and structural degradation is based on axle-equivalents (10-tons axle equivalents) and maximum total load. This evaluation is based on how road-friendly each vehicle or vehicle group is.
The combined model design concept for the on-board unit (OBU): data collection for road user charging, actual road burden and mileage without curtailing personal rights. The concept is topological with mileage data processing inside the OBU.

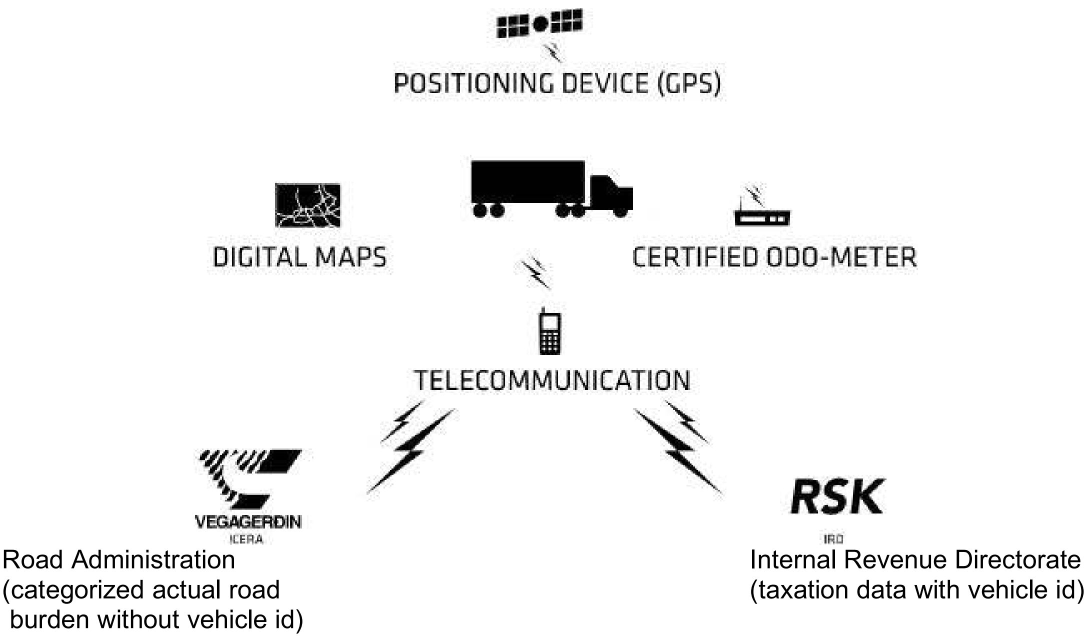


Figure 1 – Road user charging and actual road burden evaluation [1]

Every day summations and readings are portioned out where one is sent to the Internal Revenue Directorate (to which we send taxation data with vehicle identification) and another sent to the Icelandic Road Administration (containing categorized actual road burden data but without vehicle id) – anonymous data. Further development ideas and calculations include possible supplementary levies, subject to time and location, vehicle size and vehicle pollution.

The diagram shows the ideology behind the data collection concept, how data flow and data handling is conceived in an automatic road use taxation scheme and a road strain

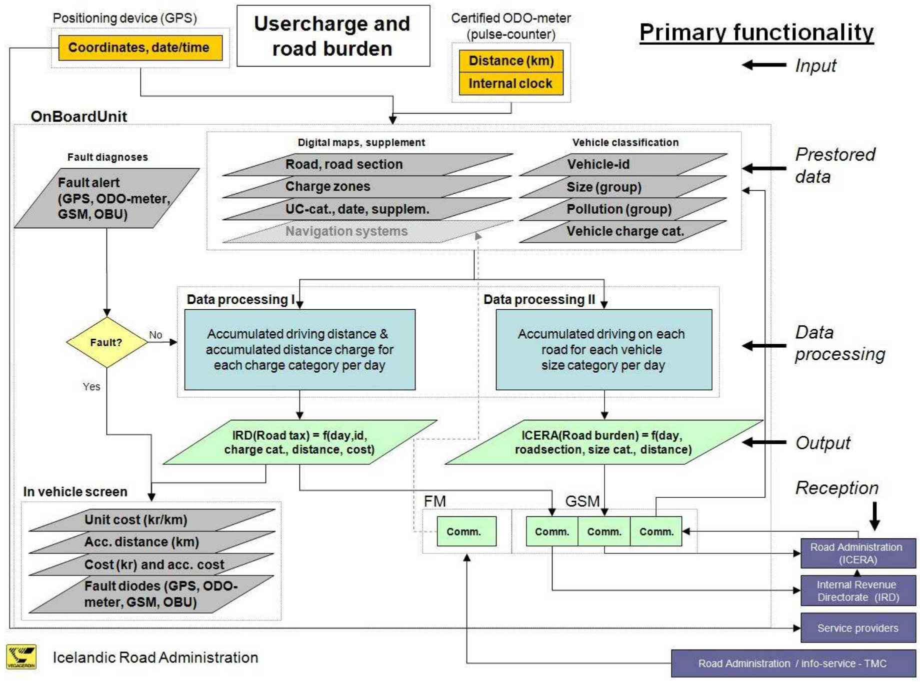


Figure 2 – Data collection concept [1]

3.2. Road burden:

From the Fourth Power Law we have the Load Equivalency Factor (LEF). [3, 2]:

$LEF = (k_{at} \times k_{as} \times k_{wt} \times k_{tp} \times k_{st} \times P/10)^4$
$k_{at}$ : Effect of axle type (single axles = 1,00, tandem axles = 0,60, triple axles = 0,45)
$k_{as}$ : Effect of axle spacing (space between axles > 1,3 >>single axle, $k_{as}$ = 1,0)
$k_{wt}$ : Effect of wheel type (dual tyre =1,00, normal single tyre =1,30)
$k_{tp}$ : Effect of tire pressure (8 bar, 116 psi pressure, even load distribution, $k_{tp}$= 1)
$k_{st}$ : Effect of suspension type (Traditional = 1,0. Improver/air = 0,95)

The 10-ton axle equivalent (Euro-class classification, EUR 13) is calculated for different vehicle classes with different axle load, axle configuration and axle spacing.

# Road burden

| Vehicle Classification Table GR03-EUR13 | | | 10 t ekv.*1 axleload trad/air suspension. | Max total weight t. |
|---|---|---|---|---|
| 1 | Car, Light Van | | 0,0002 | |
| | Light Goods Vehicle (LGV) | | 0,0052 | |
| | Car/LGV & 1-Axle Caravan/Trailer | | 0,0032 | |
| | Car/LGV & 2-Axle Caravan/Trailer | | 0,016 | |
| 2 | Rigid 2-Axle Truck (HGV) | 8 10 | 2,1/1,8 | 18 t. |
| 3 | Rigid 3-Axle Truck (HGV) | 7 7 7 | 1,6/1,3 | 21 t. |
| | Rigid 3-Axle Truck (HGV) | 8 18 | 2,5/2,1 | 26 t. |
| 4 | Rigid 4-Axle Truck (HGV) | 7 7 18 | 2,7/2,2 | 32 t. |
| | Rigid 4-Axle Truck (HGV) | 8 24 | 2,5/2,1 | 32 t. |
| 5 | Rigid 2-Axle Truck & 2-Axle Drawbar Trailer | 8 10 8 10 | 3,6/2,9 | 36 t. |
| | Rigid 2-Axle Truck & 3-Axle Drawbar Trailer | 8 10 8 18 | 3,9/3,2 | 44 t. |
| | Rigid 2-Axle Truck & 1-Axle Caravan/Trailer | 8 10 10 | 3,2/2,6 | 28 t. |
| | Rigid 2-Axle Truck & 2-Axle Caravan/Trailer | 9 11 10 10 | 5,3/4,4 | 40 t. |

| Vehicle Classification Table GR03-EUR13 | | | 10 t ekv.*1 axleload trad/air suspension. | Max total weight t. |
|---|---|---|---|---|
| 6 | Ragid 3-Axle HGV & 2-Axle Drawbar Trailer | 8 18 9 9 | 3,8/3,1 | 44 t. |
| | Ragid 3-Axle HGV & 3-Axle Drawbar Trailer | 8 16 9 16 | 3,5/2,9 | 49 t. |
| 7 | Artic, 2-Axle Tractor & 1-Axle Semi-Trailer | 8 10 10 | 3,2/2,6 | 28 t. |
| 8 | Artic, 2-Axle Tractor & 2-Axle Semi-Trailer | 8 10 20 | 4,2/3,5 | 38 t. |
| 9 | Artic, 2-Axle Tractor & 3-Axle Semi-Trailer | 7 10 23 | 2,8/2,3 | 40 t. |
| 10 | Artic, 3-Axle Tractor & 1-Axle Semi-Trailer | 8 18 10 | 3,5/2,9 | 36 t. |
| | Artic, 3-Axle Tractor & 2-Axle Semi-Trailer | 8 18 18 | 3,9/3,2 | 44 t. |
| 11 | Artic, 3-Axle Tractor & 3-Axle Semi-Trailer | 8 18 23 | 3,7/3,0 | 49 t. |
| 12 | Bus or Coach 2-Axles | 8 10 | 2,2/1,8 | 18 t. |
| | Bus or Coach 3-Axles | 8 18 | 2,5/2,1 | 26 t. |
| 13 | Vehicle With 7 or more Axles | | | |
| | Vehicle not Classified above | | | |

Figure 3 – Vehicle classification and road burden.

*1 Load Equivalency Factor from publ. no. 66, Distress and damage factors for flexible pavements, Norwegian Road Research Laboratory 1992. [3]
Single axles, dual tyre, traditional/air suspension, 8 bar pressure, even load distribution, OECD Road Research Group 1983

Each vehicle of a certain type with a definite axle combination and axle spacings with a calculated 10-ton axle equivalent (Euro-class classification) using a defined road section automatically delivers data on its itinerary through a telecommunications system and thus information is collected/accumulated on the total 10-tons axle equivalents which pass the road over a defined period of time.

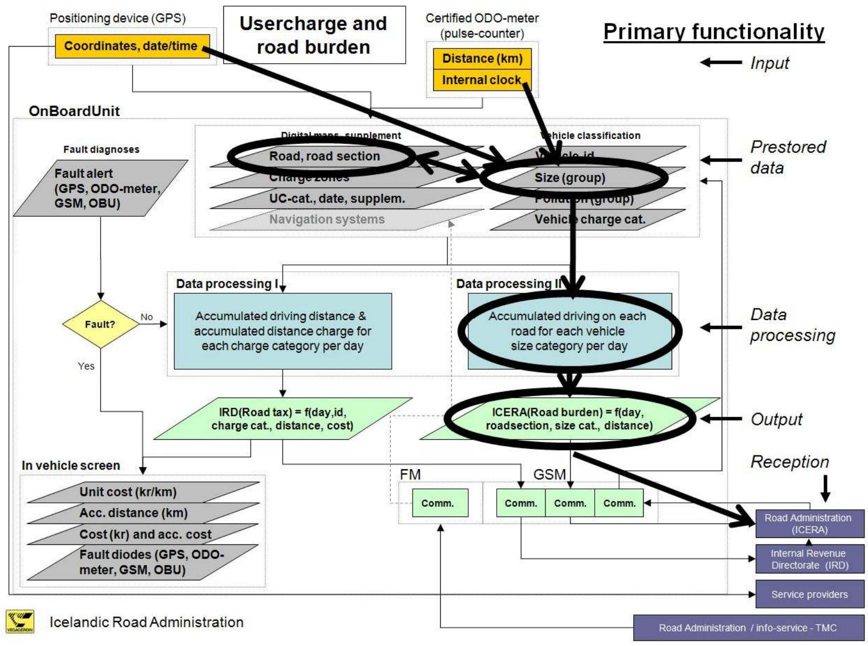


Figure 4 – Road burden, data collection and data flow [1]

### 3.3. Load carrying capacity measurements from FWD

Load carrying capacity measurements from FWD (Falling Weight Deflectometer) provide information on the bearing capacity of individual road sections at each given time, i.e. we calculate for the road section concerned how much traffic load and axle load it can support, for instance for the next 20 years.

Special frost dept measuring devices also give supplementary information on the variable bearing capacity of each stretch of road from time to time.

Calculation criteria are as following:
$E_{dim}(Mpa) = 110p/(f_0 x(f_0 - f_{20}))^{0,5}$

p = load pressure from FWD
$f_0$ = in middle of stress area
$f_{20}$ = deflection 20 cm from center of stress area

Bearing capacity (ton) = $11x(E_{dim}/200)^{0,6}x(50/\ AADT\text{-}hv)^{0,072}$
(AADT–hv = Annual Average Daily Traffic of heavy vechicles in both directions in the opening year)

For AADT–hv = 200:
Bearing capacity (ton) = $11x(E_{dim}/200)^{0,6}x0,25^{0,072}$
= $11*(110p/(f_0x(f_0\text{-}f_{20})^{0,5}/200)^{0,6}x0,25^{0,072} = 7*p^{0,6}/(f_0\text{-}(f_0\text{-}f_{20}))^{0,03}$

By joint evaluation of the load capacity of individual sections of the road system and the traffic load on the same sections we can, with calculations, obtain approximate figures on the remaining lifetime of the road sections concerned.

## 4. Calculation:

There exist numerous methods for the structural design of roads, and this project is based on the Norwegian methodology where the number of heavy vehicles is described by N-values, i.e. the number of 10-t axle equivalents over a defined design period.
The following shows the approximate calculated lifetime of the road in question based on falling weight deflectometer measurements and the Norwegian methodology:
The falling weight deflectometer frame of reference is 200 heavy vehicles per day, two lanes and 4% growth of traffic during the design time.

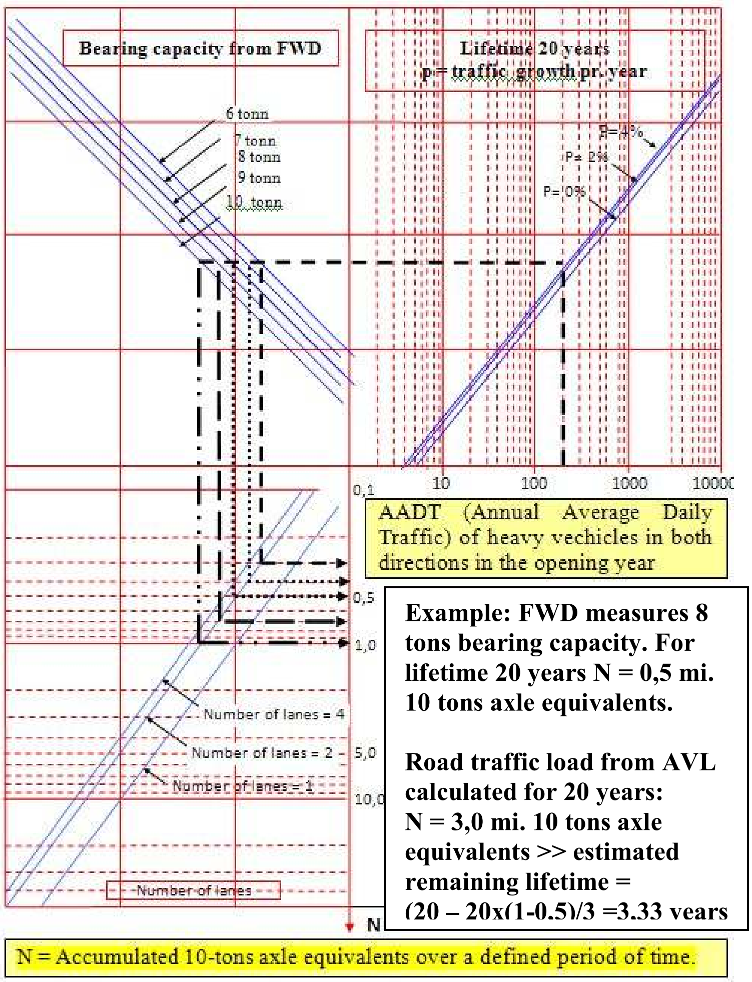


Figure 5 - Number of 10 t axle equivalents over a design period.[4]

If this is summarised for different FWD measurements and different traffic load, we obtain an integral chart for different road service life or time until road reconstruction.

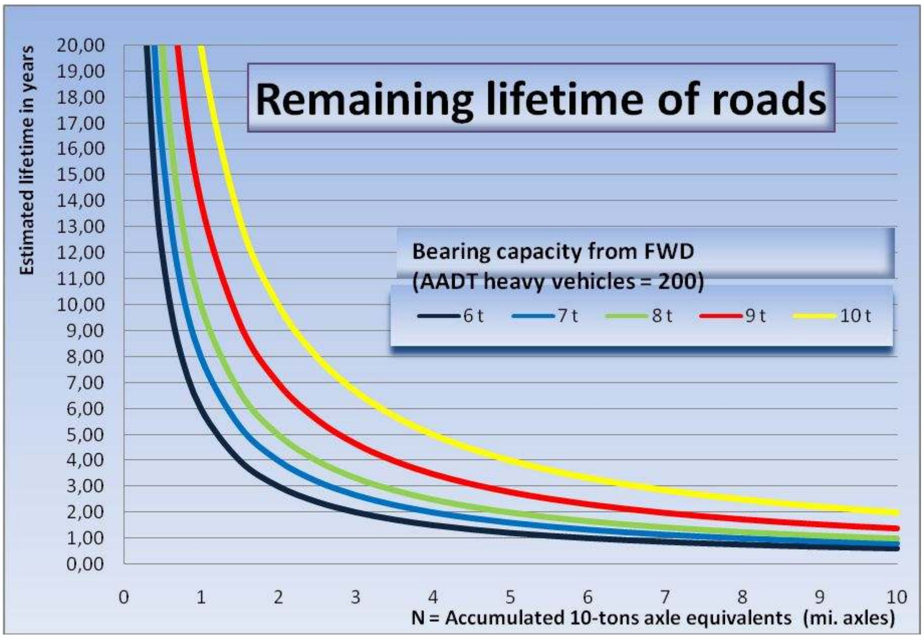


Figure 6 – Remaining lifetime of roads.

Information on this estimated lifetime and the projected road traffic load for particular road sections, provides a better foundation for decision-making on the priority order of projects and organised planning for the operation, maintenance and/or renewal requirements of the road system.

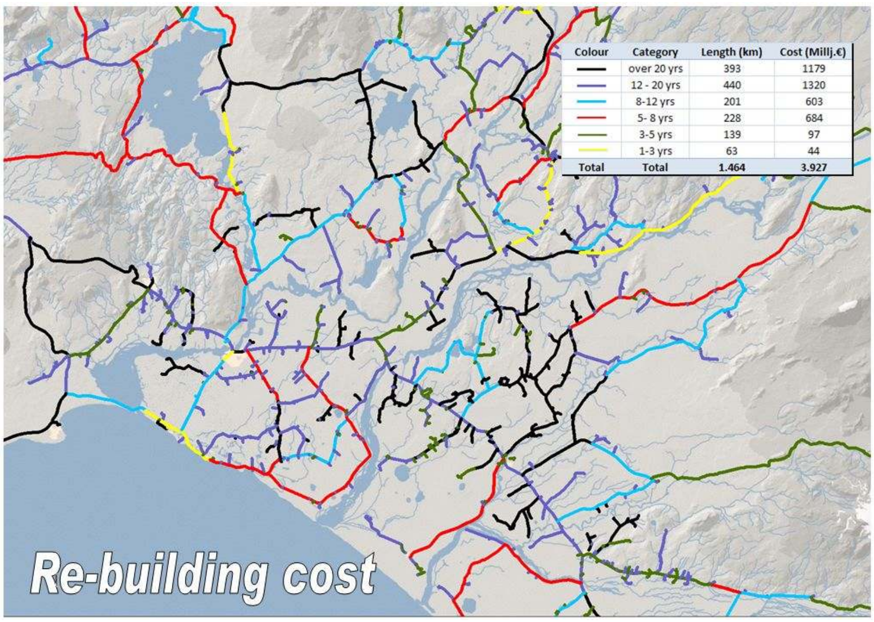


Figure 7 – Re-building cost.

## 5. Summation:

It is planned to levy Road User Charges, at least for heavy vehicles, for the distance travelled, based on the distance measured with an odometer and on the GPS location technology that defines position /charge zone and time. Part of the information received from the same heavy vehicles can be used by the Road Authority without infringing the rules of privacy, i.e. it can collect anonymous data on the driving pattern of heavy vehicles on any road at any time.
By processing the collected anonymous data, received automatically from the heavy vehicles, and assimilating it with the measured road-bearing capacity, we can roughly derive the remaining service life of the road or road sections concerned. Through this data processing we can at the same time attain better project prioritization and improved planning of construction, maintenance and service projects for all roads.

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4. Handbok 018, Vegdirektoratet, Norge 2005.