ICELAND

1 Demographics and Roads

1.1 Information about the country

Area	103,000 km².
Latitude	64°08´N
Population	320,000
Density	3.1 per km²

Iceland is situated in the middle of the North Atlantic Ocean, approximately 290 km east of Greenland and 970 km west of Norway. Consisting mainly of a plateau, Iceland's average height above sea level is 500 m, the highest point being 2,110 m. Only one quarter of the country lies below the 200 m contour line. The island is mountainous, surrounded by coastal lowlands, fjords and valleys shaped by marine abrasion and glacier erosion.

The economy depends mainly on export of products from power intensive manufacturing (24%), fishing industry (27%) and tourism (20%). The road network plays an important role in local transport of marine products for processing and export and for the increasing tourism.

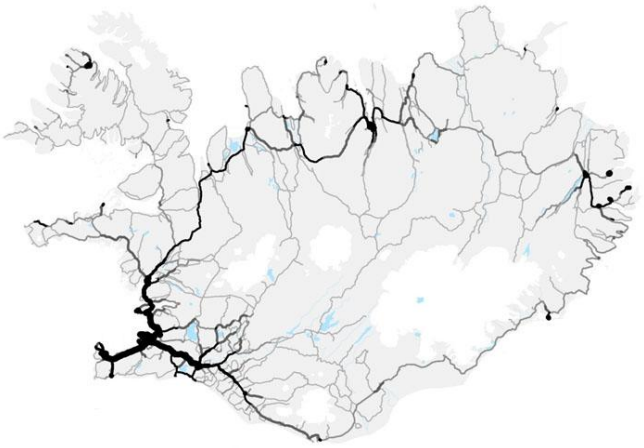
1.2 Road network and traffic

The Icelandic Road Administration, ICERA, is responsible for the road network, whereas the municipalities take care of roads within populated areas. The ICEARA road network includes 12,898 km, thereof 5,252 km of paved roads. The road network is divided into:

Road type	Length of road
Total ICERA road network	12,898 km
Primary roads	4,425 km
Local access roads	3,091 km
Primary highland roads	505 km
Highland roads	1,921 km

Primary roads connect areas of 100 or more inhabitants, *secondary roads* interconnect primary roads or connect primary roads to mountain roads, smaller villages and popular tourist destinations, *local access roads* connect farms or public places outside of populated areas to secondary and primary roads, and finally *primary highland roads* and *highland roads,* across mountains and moors, with limited service and often closed in winter.

Most of the traffic finds place in a 40 km circumference around the capital area in the southwest, where approximately half of the population is living. This map shows the traffic distribution on the road network:



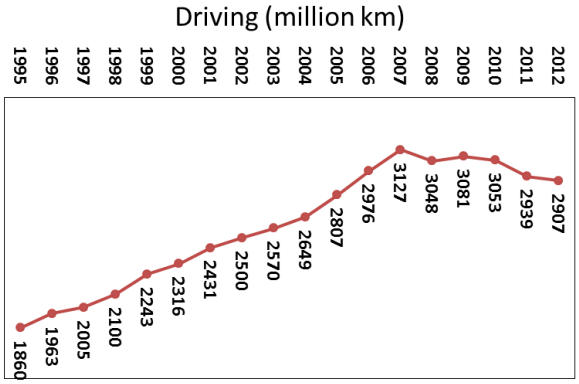
Number of vehicles by December 31st 2012:

242,500 vehicles total, thereof

210,000 passenger cars

32,500 commercial vehicles

Heavy vehicle commercial traffic has increased considerably since sea transport along the coast ceased by the end of year 2004. However, traffic growth has ceased following the economic recession. The following diagram shows estimated total traffic on the Icelandic road network.



2 Climate

2.1 Overview of climatic areas, main winter events to be mastered

Iceland has an oceanic climate and doesn't undergo the extreme temperature conditions of continental climates. The winters are mild, but the summer is cool. There is a considerable difference between respectively the coastal lowland climate, the climate of the main highland plateau and the climate of the highest mountain areas.

There is also some difference between the north and south. Temperature decreases and precipitation increases with height above sea level. The north of Iceland is generally cooler than the south in wintertime and has more snowfall while mid-winter rainy periods are more frequent in the south.

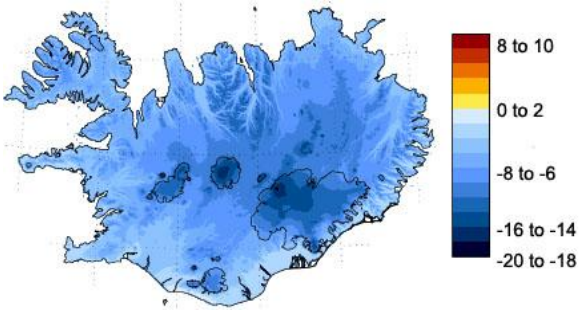
Strong winds occur frequently, especially during the winter. Road service is challenged by icing, snowfall and drifting snow, which due to sparse vegetation and absence of forest is acting on the whole road network. Snow avalanches threaten a few low-traffic volume roads in rural areas. Reduced bearing capacity and road damage during thaw periods in wintertime is a growing concern on old roads.

2.2 Statistics on temperatures, icing and precipitation

According to experience, snow is covering the ground during most of the mid-and late winter in areas where the mean temperature of the coldest month is below -4 °C. At the station of Reykjahlíð in the northeastern inland the snow is covering the ground completely for 135 days per year. In Reykjavík in the southwest this number is 55 on the average.

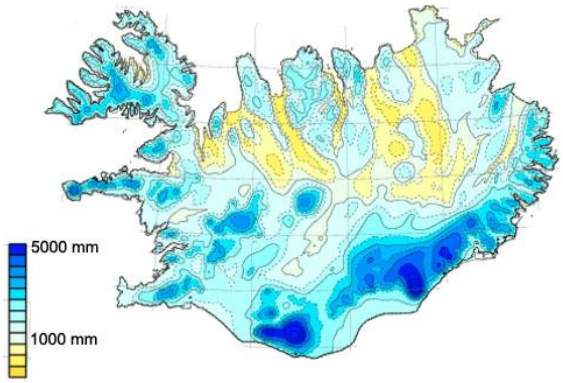
The temperature minimum drops below 0.0 °C on 123 days per year on the average in Reykjavík, 161 days in Akureyri in the north. These are typical lowland values.

Mean minimum January temperature:



The north is on the average drier than the south, although significant exceptions can be found locally. Usually the precipitation is light. Reykjavík thus has some precipitation on 221 days per year, but on 148 of these the precipitation exceeds or equals 1mm. In Akureyri the corresponding numbers are 171 and 103.

Mean annual precipitation:



Snow or sleet is recorded on 82 days per year in Reykjavík, but 96 in Akureyri. Freezing rain occurs, circa once per year, per location. Blowing snow is a significant traffic problem, especially outside the main towns.

The conditions outlined above are only valid for the lowlands. The winter problems increase considerably with height above sea level. In the vicinity of Reykavík the frequency of total snow cover days thus e.g., increases from 55 in Reykjavík (52m a.s.l.) to 91 at Stardalur (a few km to the East, at 185 m a.s.l.). Mean annual precipitation in Reykjavik for the period 1961-1990 is 800 mm, for Akureyri it is 490 mm and for Eyrarbakki on the south coast the mean annual precipitation is 1,370 mm.

2.3 Winter index

A winter index was developed by ICERA for distributing winter budget between the different

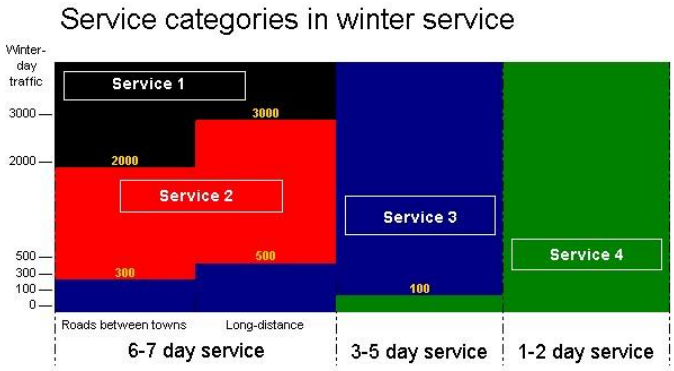
regions. The index reflects critical values and trends in temperature, humidity, and wind.

3 Winter Road Management

3.1 Standards and rules

Snow and ice control, traffic information and winter road management is carried out by ICERA according to rules set by the Ministry of The Interior. Operation of the winter service is outsourced to private entrepreneurs. ICERA is financed by state budget and road-user taxes.

There are four service categories/classes considering road function and traffic volume.



Quality requirements for winter services concern the following factors:

- Service aims;
- Service level/category;
- Timing of actions;
- Maximum snow depth and road surface evenness criteria;
- Ice conditions/friction;
- Visibility at intersections and levelling of snow banks.

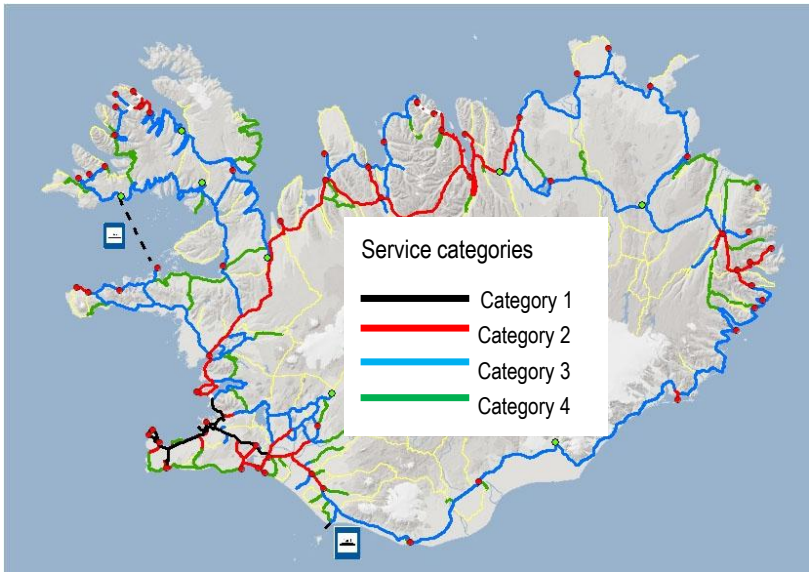
Besides the service class categorisation, roads in the lower service classes are subject to different number of service days pr. week.

Service class 1 implies a "bare road" strategy and relies on continuous use of de-icing chemicals, only NaCl is used. Pre-wet salt is the main application method.

Summary of the service requirements for roads in service categories 1 and 2 is as follows;

Summary of Winter Service Quality Standards		Service Class	
		1	2
Service hours	In town	24 / 7 service	06:00 - 22:30
	60 km from town		08:15 - 22:00
	120 km from town		10:30 - 21:30
Critical snow depth for service		2 cm	4 cm
After snowfall, ploughing		2 hours	3 hours
After road closure, snow removal is completed within		-	3 hours
Max. service cycle duration		2 hours	
Max. service route pr. vehicle		50 km	
Maximum snow depth		5 cm	12 cm
Maximum track depth		1 cm	2 cm
Min. friction coefficient	Generally	μ >0.25	μ >0.15
	Curves and slopes	μ >0.25	μ >0.25

Service classes 2, 3 and 4 allow a certain amount of packet snow and ice with minimum friction criteria. Salt is used in these lower classes only when reasonable due to the weather conditions e.g. in autumn and spring.



3.2 Organization and operation of winter maintenance

- **Management and organisation**

ICERA runs two control and surveillance centres that share the overall organisation of the winter service, and monitor weather and road conditions on a 24/7 basis from October 15th until April 30th. Countrywide there are 18 regional service centres co-ordinating the force of contractors responsible for the operational tasks and the on-site road condition assessment are carried out by contractors.

In larger towns the ICERA is serving the major roads according to the ICERA standards based on contracts with the local municipal authorities.

The service equipment fleet is mainly trucks with snowploughs and salt spreaders, pay loaders and graders. Rotary blowers are very important in winter service on mountain roads and exposed primary roads. Grader works, such as removal of hard snow and ice are increasingly overtaken by plough-trucks with under-body blades. Graders are, however, still important to level snow banks on the road shoulder in exposed areas.

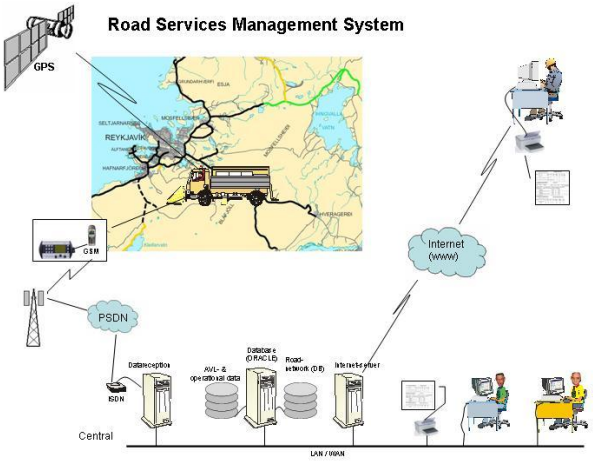
Depending on the service category, the service route per vehicle is 50-120 km. Usually there are 1 or 2 men per truck.

The ICERA´s internal codes define the responsibility for different tasks concerning winter services:

Unit	Tasks / Responsibility
ICERA Management Service Department	Overall service procurer Central planning and organisation Service standards and rules Assign service category to roads Operation of RWIS and other information systems Training and education
Control and Surveillance Centre 2 centres countrywide	Monitor weather and road conditions Planning and coordination Registration and information processing Service assessment
Regional Service Centre 18 centres countrywide	Inventory Daily operation management Control: - Road condition in-situ - Service quality - Budget
Contractors	Operational tasks - Snow ploughing - De-icing, sanding

Road closures are enforced by the police under adverse weather conditions according to the ICERA´s evaluation. Snow-Avalanche hazard, flooding, etc., may also lead to road closure.

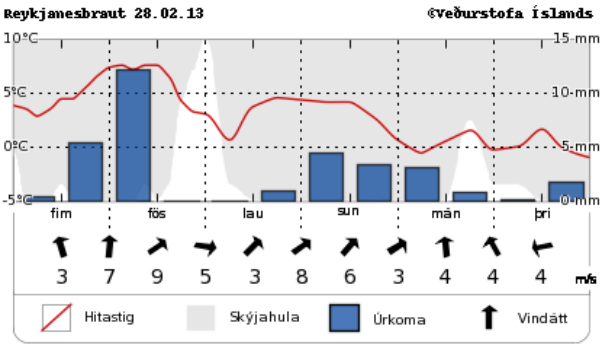
Automatic vehicle location and activity registration is used for settlement of winter services and as well as for quality control. AVL equipment, consisting of a telecommunications device (GSM) and sensors, is installed in snow removal equipment with a salt and brine spreader as well as front and under-body blades to automatically collect information about location, activities, speed, distance and time.



Upon receipt of data from a device, the grid position is plotted into the road system, along with information on salt/sand use, length of road cleared, etc.

- **Road weather information**

ICERA has contracts with the Icelandic Meteorological Office. In the current information system for the ICERA, data is gathered into a central database. Forecast period up to six days is used. There are approximately 100 road weather stations (approx. 100 RWIS stations countrywide). For 19 road stations, a six day forecast meteogram is issued:



Operators in the two control centres monitor weather forecast and observations as well as the approximately 100 camera-points on the roads.

3.3 Assessment of the snow and ice control measures

- **Cost & benefits of winter maintenance activities**

The annual cost of the winter maintenance in 2011-2012 on the road network (excluding highland roads) is:

Road network open for winter service	10,472 km
Total winter service costs 2011-2012	1,200 EUR/km/year
Road network treated with salt, ∑(2-lane kilometres)	1854 km
Amount of salt used	27,600 t/year 14,9 t/km/year 2,3 kg/m2/year

The winter index mentioned in previous chapter turns out to reflect the actual annual cost reasonably well each winter.

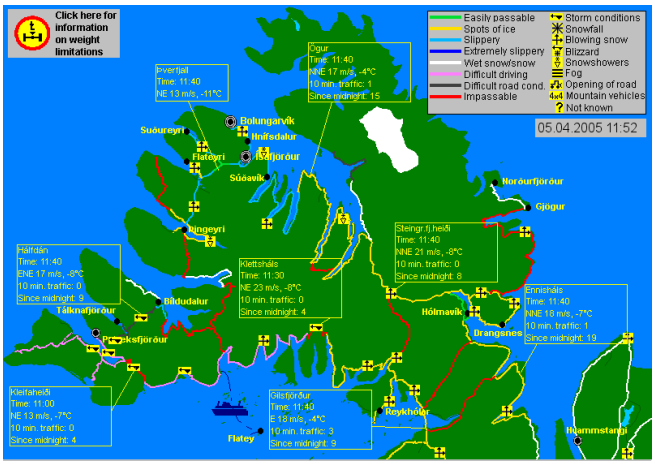
- **Methods to decrease use of salt while maintaining the service levels**

Through observations of water amount, residual salt and road surface temperature, and considering the weather outlook, salt dosage for concurrent actions is defined. The use of automatic sensors and manual measurements for this purpose is in a development phase.

3.4 Traffic safety and information

- **Information provision to the road user**

Information is provided through various media. Information provided is; condition of road (slipperiness), weather (wind speed, gust and wind direction, temperature), road temperature, humidity and dew-point, traffic (last 10 minutes, traffic from midnight), estimated time of opening if road is closed, maintenance works, axle-load restrictions, ferry schedules etc. The one hundred camera-points are available to the general public through internet.



- **Use of weather related road sensors and variable road signs**

Most of the ICERA´s weather stations have temperature sensors in the road surface, and some have road surface humidity sensors for management use only. Frost depth sensors are used to determine weight restrictions on roads. Variable message signs are used to show wind speed, wind direction, temperature and in extremely exposed areas wind gust. Variable roads signs are also used to show if a road is closed.

- **Use of information technologies for efficient management and for avoidance of danger by providing information to road users**

Information and warnings are provided through radio, internet, text-TV, phone service and message signs.

4 On-going research and studies to improve winter management

4.1 New technology

ICERA is developing different models and instruments to enhance the availability of road weather information. Among the systems that have been developed and are under validation are;

Wind gust forecast, for chosen sites. The model utilizes historical statistics on the relationship between measured wind gust on road weather stations and the forecast for atmospheric conditions. The model indicates the probability of wind gust over a certain threshold for the particular site the next 28 hours.

Frost depth forecast, for freeze-thaw conditions in the road sub-base. The model takes readings from the frost depth monitoring system previously developed for ICERA, as an initial condition and extends the five day weather forecast through the road sub-base to indicate when axle load restrictions are necessary for the low-bearing capacity roads.

Road surface temperature and icing forecast is under development. The model gives accurate prognosis for road temperatures under the most critical conditions for sudden icing on the road network. This prognosis is important e.g. when road temperatures drop below the freezing point due to long wave emission from the surface due clear sky, even when air temperatures are still significantly above the freezing point.

Residual salt and ice detection sensor has been developed. The sensor indicates the road surface temperature, the freezing of liquid present on the surface and gives estimate on the residual salt left on the pavement surface.

Customizing salt dosage. A new procedure for defining dosage for salt spreading is under trial at the control and surveillance centre for the capital area. The aim is to use available information on road condition, including residual salt, weather and traffic pattern to define the salt dosage. The goal is to use less salt without compromising service quality.

Modelling Residual Salt (MORS-project). ICERA participates in the NordFoU MORS project. The aim is to develop a model which is capable of predicting the residual salt development on the road, taking traffic, road and weather parameters into consideration.

4.2 New management and organization approaches

The hierarchy describes in chapter 3.2 describes a new organisational approach adopted by ICERA in 2012. The new structure facilitates a more centralized management in order to harmonize practise in the regions and enable a more flexible use of the workforce without administrative boundaries. Centralizing surveillance and call-out has economic benefits and is believed to be more reliable.

Training. Since autumn 2012, it is decided that all staff engaged in winter management and operations shall undergo a training course.

5 References

Traffic and weather information in English on ICERA's internet site:

http://www.vegagerdin.is/english/

Statistics Iceland: http://www.statice.is/

The Road Traffic Directorate:

http://www.us.is/umferdarstofa/english