P1.3 EVALUATION OF WINTER WEATHER CONDITIONS FROM THE WINTER ROAD MAINTENANCE POINT OF VIEW – PRINCIPLES AND EXPERIENCES

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1. INTRODUCTION

The beginnings of the issuing of the so called winter index date back to year 2002, when Directory of Roads and Highways called for winter conditions evaluation on Czech roads and highways. According to examples of foreign winter road maintenance indexes and watched maintenance parameters, general winter index was created by V.Kveton and M.Zak. Further, based on meteorological, climatological, statistical and maintenance data the concrete winter index was constructed based on data of winter road maintenance (for period 1997-2003) from Mr. Ing. Havránek in spring 2004 by V.Kveton.
During winter season 2004-2005, routine application was issued for Zlin district, and 12-parts-scale of winter road maintenance severity was used (see Tab. 1 for details). In this season only one general index was issued, since season 2005-2006 also partly indexes of ploughing and scattering have been computed and evaluated as well.
This routine application has been used since that up to now, with increasing numbers of regions and roads/highways in next seasons and with partly improvements.

2. BASIC PRINCIPLES OF WINTER ROAD MAINTENANCE INDEX AND ITS POSSIBLE FORMS

Winter road maintenance index is based on the following meteorological parameters: snow, icy road conditions (black ice, glaze, frost deposit) and snow drifts. Since the construction of the winter index is not the focus of this paper, we will not discuss concrete composition here any more. But we will focus on the performance interpretation of this winter index.

First of all, it has to be mentioned that index enables very exact evaluation of seasonal winter maintenance severity. It also enables mutual comparison, including planning of winter road maintenance under various climate conditions.

Running supervision of maintenance output data is possible with this index, of course the shorter evaluated time, the worse preciseness. The winter index has been used in two possible ways, either as numeric data, when increasing values mean also increasing winter road maintenance requirement, or as the 12-parts-scale, when winter road maintenance severity was used (with 0 meaning no or minimal requirement for winter maintenance and 11 total calamity on the roads, see Tab. 1). For both forms, interpretation based on performance analyses is needed. The first way is not easily understandable for the governments and road maintenance staff, the second one enables to pronounce extraordinariness of the winter season or of it parts (days, weeks, months) **and** is user friendly **and** easily understandable.

It has to be stressed, that often there is tendency to precisely evaluate on daily bases and/or short parts of roads, but this approach leads to loss of statistical benefit of working with large numbers (even small mistakes of interpolation can lead to large impreciseness).

Course of winter meteorological conditions based on 12-parts scale of road maintenance severity is given on Fig. 1.

Degree	Frequence (probability) of occurence	Road maintenance severity
0	WI=0	No or minimal requirements
1	WI>0 and p>=0.8	Very small requirements
2	0.8>p>=0.7	Small requirements
3	0.7>p>=0.6	Medium requirements
4	0.6>p>=0.5	Normal, a bit decreased requirements
5	0.6>p>=0.5	Normal, a bit increased requirements
6	0.5>p>=0.3	Increased severity
7	0.3>p>=0.2	Strongly increased severity
8	0.2>p>=0.1	High severity
9	0.1>p>=0.05	Very high severity
10	0.05>p>=0.01	Calamity
11	p<=0.01	Total calamity

Table 1. Scale of winter road maintenance index (WI).

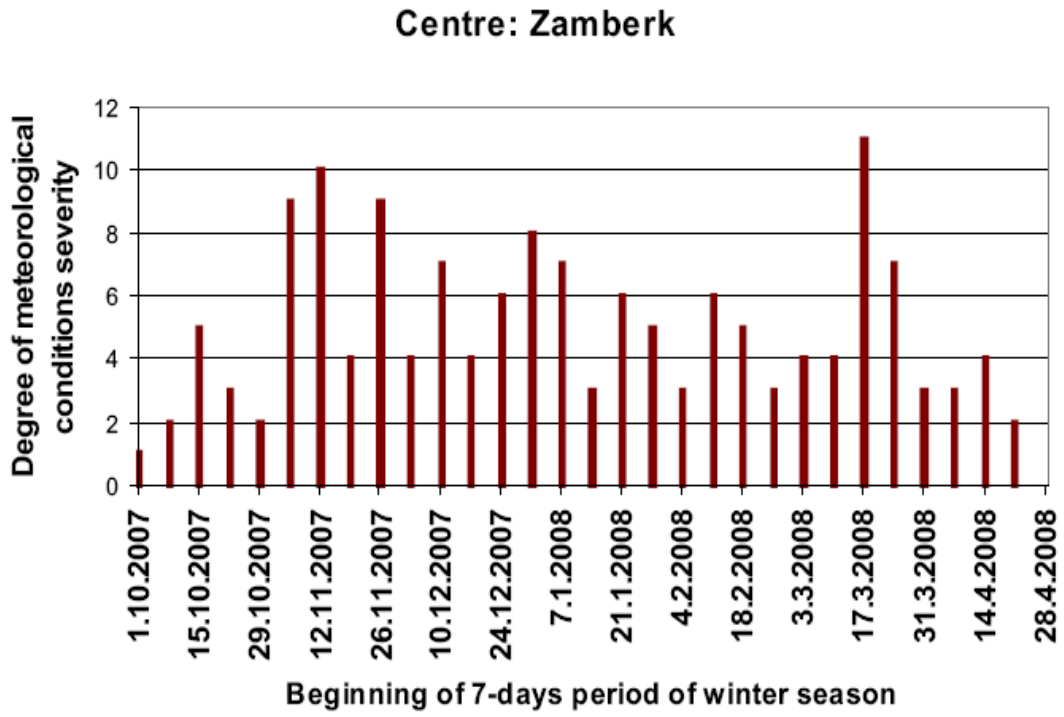

Fig. 1: Course of winter meteorological conditions based on 12-parts scale of road maintenance severity in winter season 2007–2008.

3. PERFORMANCE INTERPRETATION OF WINTER INDEX

Using of winter index in road maintenance praxis needs corresponding interpretation based on results of statistical analysis of winter index related to winter maintenance data (performance, cost of maintenance etc). Example of this is shown on Fig. 2. Straight lines and relevant regression equations represent two examples of linear regression dependence of some type of maintenance performance on winter index. The values lying on

straight lines are named as expected values and represent requested performance interpretation of winter index for given maintenance parameter. Expected value is average value of maintenance (e.g. some performance parameter) based on regression statistical analysis. Real (observed) values are depicted as point (circles, triangles). The tighter dependence (R^2 higher) the more exact is the performance interpretation of winter index or (if you like) the better validation of performance data can be done by using this winter index. On this place, it should be said there was a good agreement between expected and real values when testing this winter index, so one can assume good quality (and ability of winter index) for evaluation of winter severity performance, or of the selected performance parameter. For example, for highways coefficient of determination for most evaluated parameters oscillates between 95 and 99 % for the whole season (scattering, ploughing, amount of used scatter materials). Values on straight lines are very useful for long-term maintenance planning, deviation of real performance value from expected value should be analysed from a view point road maintenance quality and effectiveness.

Performance analysis of winter index is related to unit of maintained road area. It enables to compare maintenance between different centres and in different years (changes in road network/area size).

This interpretation depends on the way of using of index like ***running issuing of index***, ***back-evaluation*** for month, season, more years, long-term planning etc.

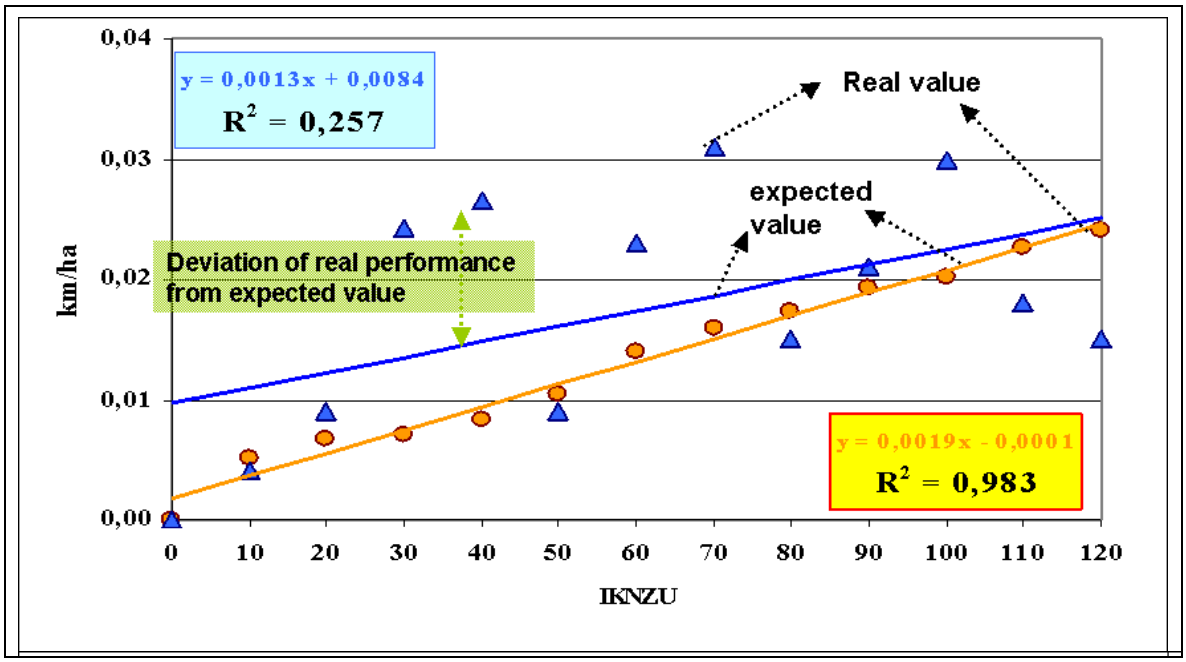

Fig. 2: The performance interpretation. X-axis: cumulative winter index, y-axis: parameter of road maintenance performance (e.g. road ploughing in km/ha). Regression straight lines represent the winter severity maintenance for given maintenance parameter. Circles and triangles represents real (observed) values of performance. Red colour depicts very good (close) dependence of maintenance relate to winter index (high determination coefficient R^2, blue colour represents very bad dependence (low determination).

3.1 *Running issuing of index*

It is designated for preliminary evaluation of winter maintenance severity from the distinguished maintenance centres point of view. It enables basic current analysis of reasons of outlier values of maintenance parameters, e.g. too small/large maintenance, mistakes in maintenance data evidence etc. When evaluating it has to be taken into account greater disperse of maintenance values to expected average for given meteorological conditions, smaller stability of meteorological values (more rough data, less count of used station, less interpolation preciseness and less statistical stability) and last but not least time shift between meteorological conditions and maintenance action.

3.2 *Seasonally/monthly evaluation*

Back-evaluation enables finer and more exact analysis. It is based on more stations, better checked data, more stable statistical approach and enables to use cumulative processing which prevents short time shifts between meteorological

and maintenance data. It is usable for evaluation of performance of centres and for long-term planning. Finally, it is possible to evaluate winter extremity of different seasons from the winter road maintenance point of views.

4. HOW TO INTERPRET THE RESULTS

In the following paragraphs, we would like to point out some specifics that need to be taken into account when doing results interpretation. Following aspects should be accounted:

a) good or bad reaction on weather conditions
b) determination of optimal maintenance performance

4.1 *Good or bad reaction on weather conditions*

Closeness or relationship between winter index and some maintenance parameter could be express by determination coefficient (square of correlation coefficient, see Fig. 2). Scattering of observed values around average (expected) value can by depicted by "scattering figure" or "shooting target" (see Fig. 3). The target on the left corresponds to low determination (blue colour on Fig. 2), target on the right to high determination (orange on Fig. 2). The middle target represent very close relationship in single maintenance centres, but huge different between centres. Middle and right target represent an excellent reaction to weather. Differences between centres (middle target) can be caused by

a) constant different properties by that time not yet accounted in maintenance versus winter index analyses, e.g. traffic density, maintenance priority, special terrain conditions, different shape of maintained region etc.,
b) different efficiency of maintenance,
c) bad comparability of used performance parameter etc..

In the case of different staffs working in the same centre only point b) has to be taken into account.

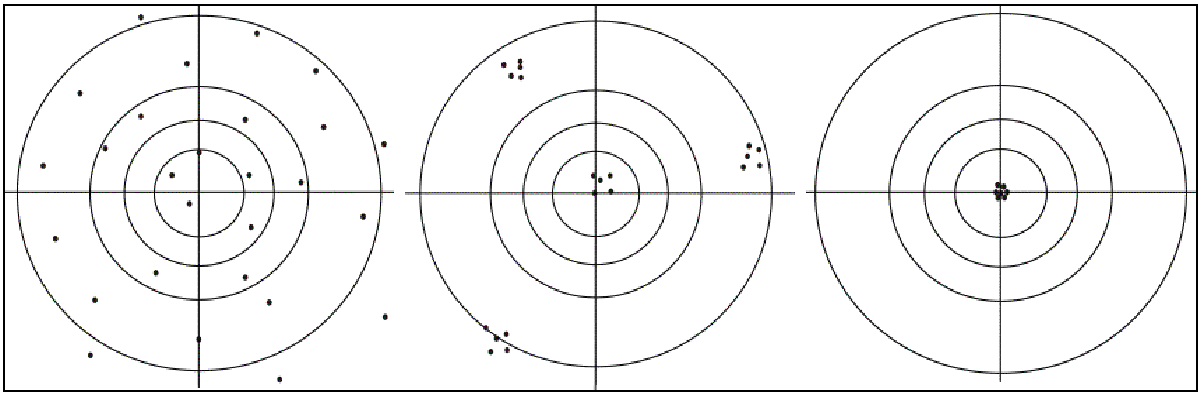

Fig. 3: Types of maintenance centres reaction for winter conditions. (left: chaotic reaction; middle: excellent, but different reaction in different centres; right: excellent and same reaction in all centres).

4.2 *Assessment of optimal maintenance performance,*

Deciding, if the road is optimally maintained regarding traffic safety, must be done independently on winter index (e.g. by independent checking persons, by number of traffic accidents and traffic fluency etc.). Average (more precisely named "***expected*** (theoretical) value" of maintenance performance represent not optimal maintenance, but average maintenance computed from statistical analyses between given maintenance parameter and winter index based on older "training" data sample.

Examples of reactions on weather conditions are shown ion figures 4-7 by cumulative values from the beginning of winter season 2007/2008. The green line represents expected (optimal) performance, blue line is the real performance.

Fig. 4 represents case of bad reaction with real performance higher than the optimum (can be caused by fixed specific road properties of given centre or bad maintenance (too high values of ploughing). Fig. 5 shows example of bad reaction with ploughing lower than expected (probably no performance data were filed or insufficient maintenance between 10th and 31st March). On Fig. 6, excellent reaction of maintenance on weather can be seen. Fig. 7 shows systematically lower performance than optimum (either the scattering was more effective or smaller then needed).

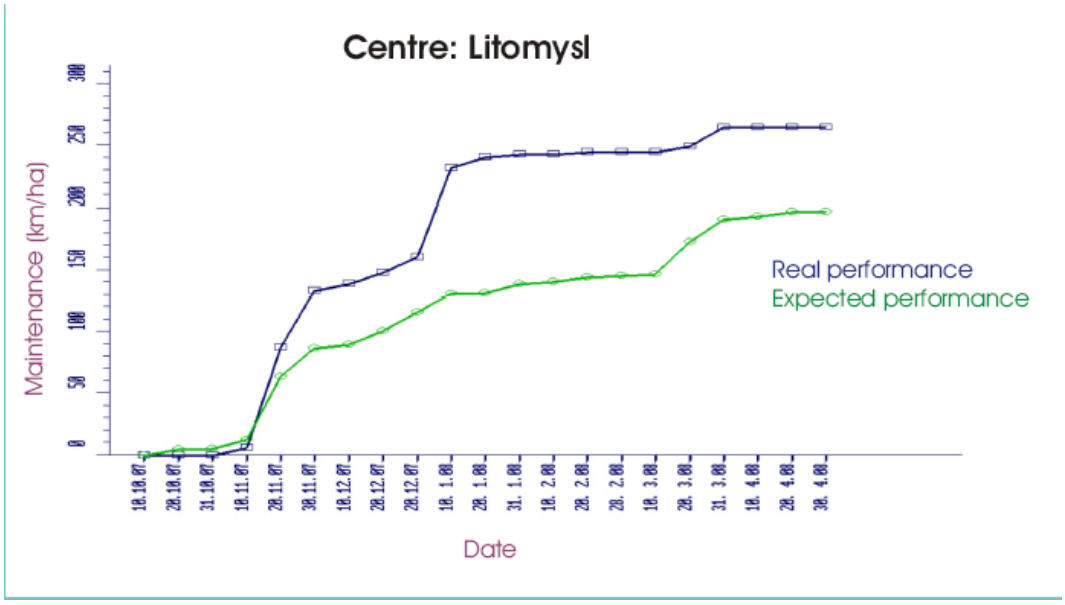

Fig. 4: Course of real and expected performance for ploughing. Bad reaction on weather conditions.

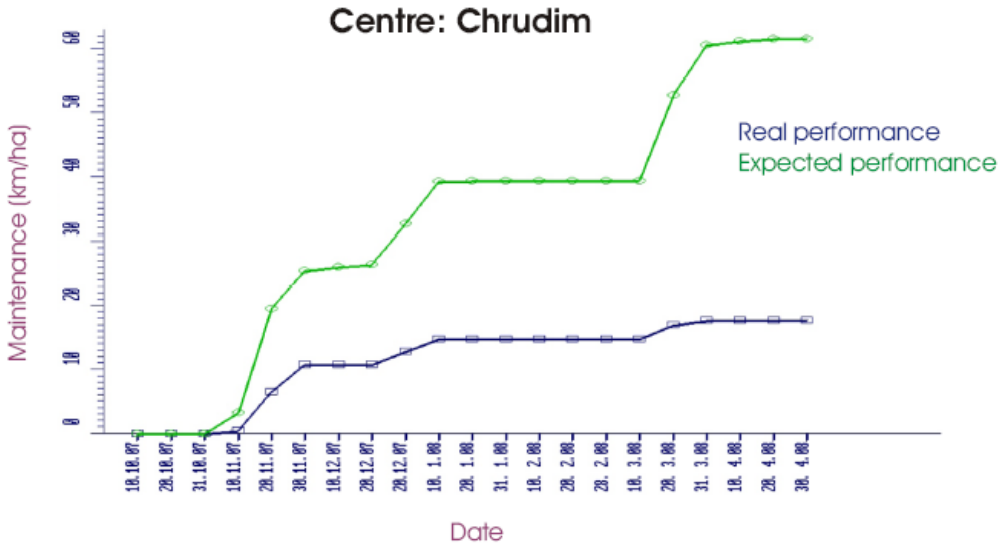

Fig. 5: Course of real and expected performance for ploughing. Bad reaction on weather conditions.

5. CONCLUSION

This winter index evaluates very well winter severity from the maintenance point of view. It enables mutually comparison of maintenance centres. Also, it enables to make inter-seasonal comparison in given centre and find out inter-seasonal variations in performance of some region caused by different work efficiency.

The longer part of season is evaluated the more fine results and more exact analysis can be obtained. The index is suitable for maintenance severity planning of winter road maintenance under various climate conditions.

Sometimes, there can be special conditions causing differences between expected and real performances (caused by slant of terrain, maintenance priority, shape of maintained region, position of the maintenance centre in the region etc.). But it has to be stressed here, that not always these conditions are known when computing the index and we don't have such data available. When doing more years-comparison between centres it is possible to pronounce specific features of centres by distance between separate clusters on the middle

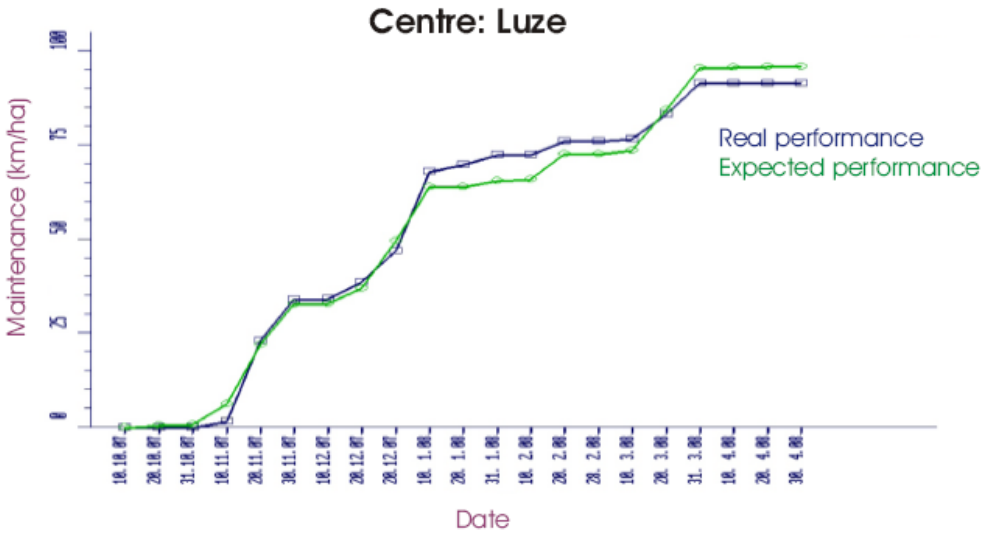

Fig. 6: Course of real and expected performance for road scattering. Good reaction on weather conditions.

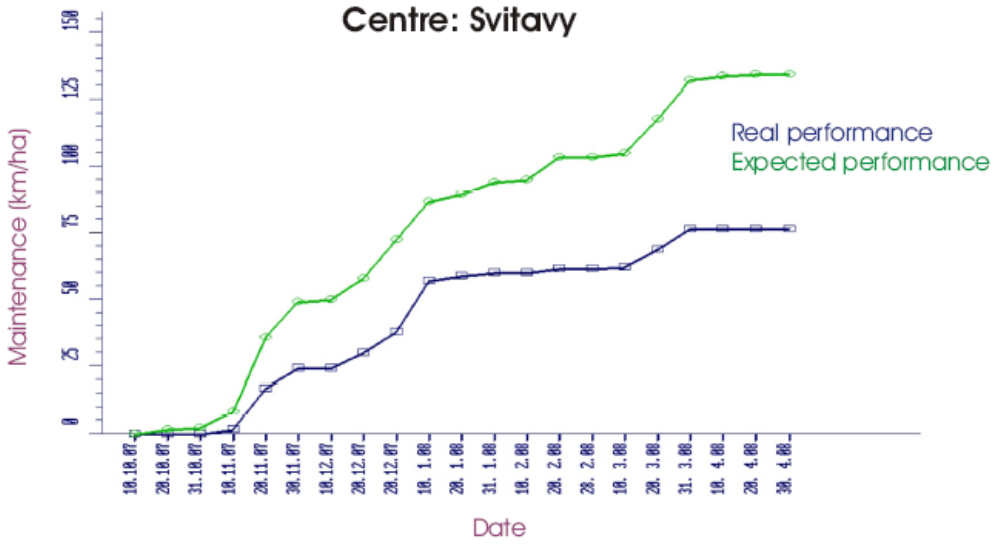

Fig. 7: Course of real and expected performance for road scattering. Bad reaction on weather conditions.

target (Fig. 2) and this distance use as a correct factor when comparing performances of single centres and of maintenance operators (firms). Of course, it is important to stress that this is possible only if there are no or little changes of borders between maintenance possible to make inter-seasonal comparison in given centre and find out inter-seasonal variations in performance of some region caused by different work efficiency.

This index doesn't replace road meteorology center forecasts, because these forecasts are keys for effective maintenance – the more maintenance centers act up to forecasts the better agreement with seasonal winter index.

Regarding using of road meteorological stations some data from these stations are influenced by the way and quality of maintenance. They are very good help for issuing forecasts and for operative organizing of maintenance, they are not suitable for evaluating of maintenance efficiency and severity.

The winter index in the CHMI is issued every season from 1st November to 31st March, if not later needed. The output values are discussed with customers in some cases. And we have already 4th season of routine issuing without any failure.

In the following seasons, further development and improvement of winter index is planned, as well as further automatization.