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Adaptation of roads winter maintenance strategies to weather influences

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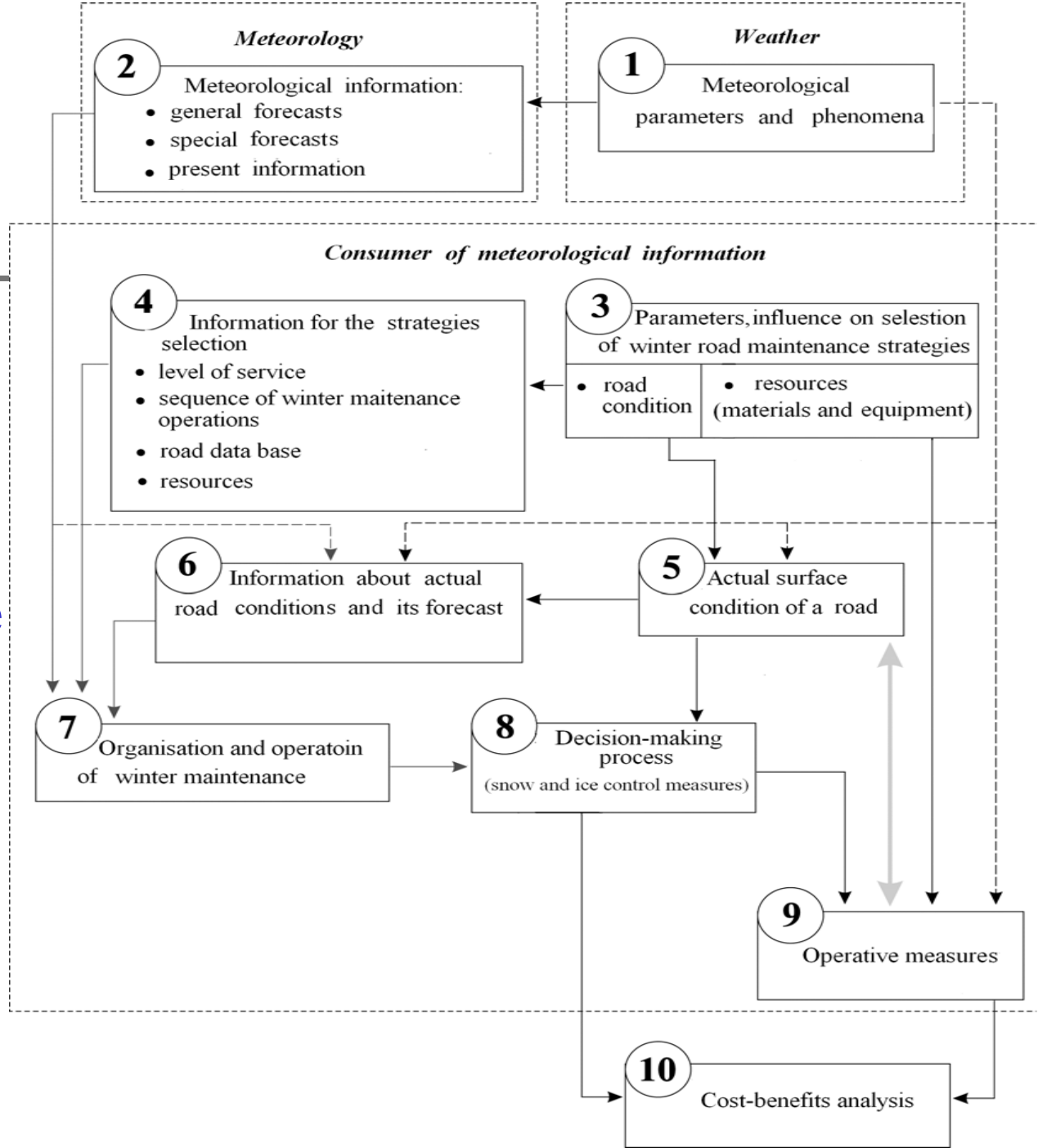
«Weather – Meteorology – Consumer» system structure



Losses which take place at complex weather conditions

$$L_{CW} = E_{RO} + L_V + L_A + L_E$$

- E_{RO} - the road organizations expenditures for the winter maintenance work
- Losses in transport complex and national economy from unsatisfactory road conditions:

L_V - Lower speed on a slippery road surface,

L_A - Cost of accident,

L_E - Damage of polluted environment.

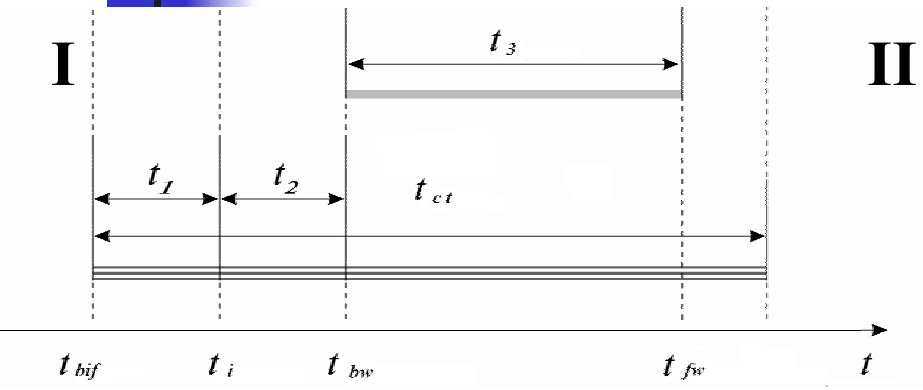
The matrix of losses

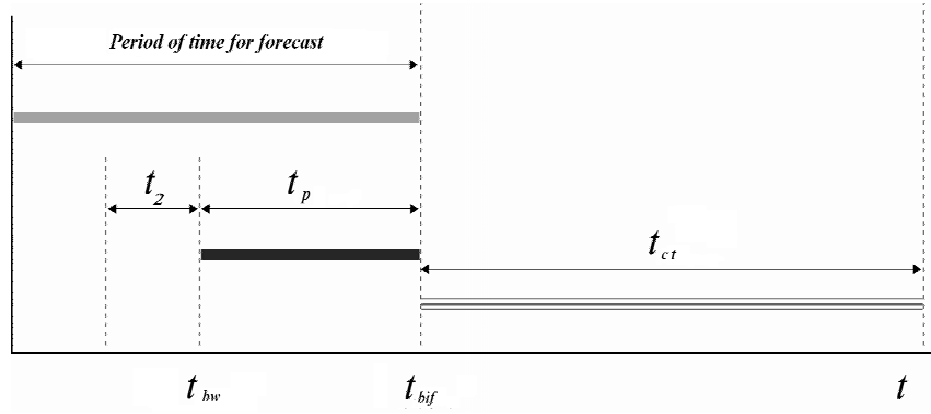
Predicted conditions ***F***	The decisions, accepted by the road organization	
	Protective measures are accepted adequately, according to weather conditions	Protective measures are inadequate to weather conditions
F_1 (ice presence)	S_{11}	S_{12}
F_2 (ice absence)	S_{21}	S_{22}

ROAD WINTER MAINTENANCE STRATEGIES

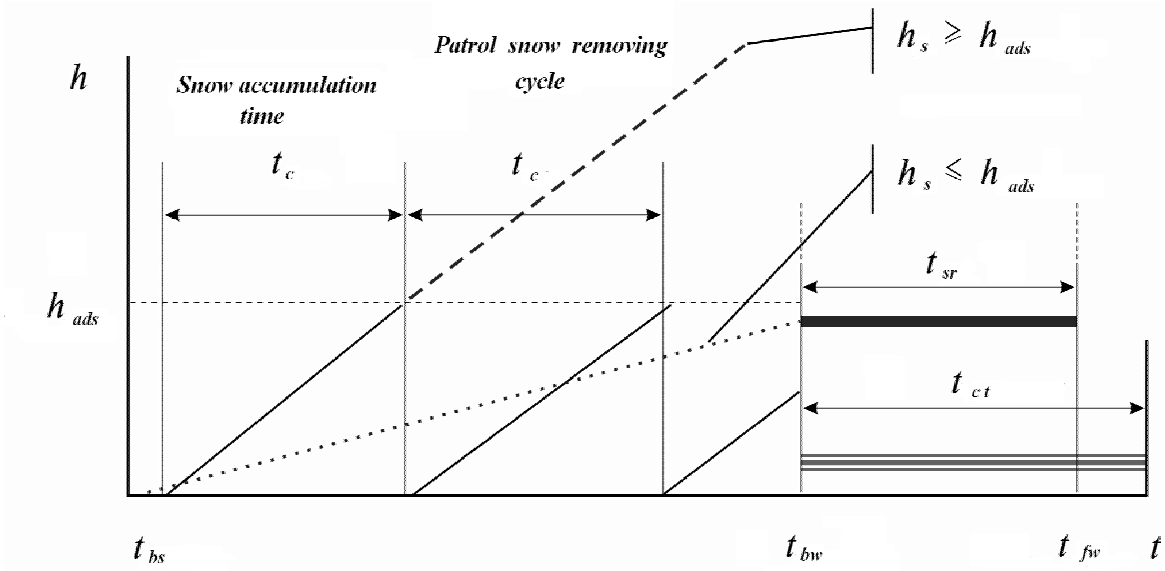
Number of strategy	The name	Type of road slipperiness
I	Post salting	Glaze, ice, black ice
II	Pre-salting	Glaze, ice, black ice
III	Mechanical clearing of snow, patrol snow removal	Fresh snow
IV	Pre-salting, mechanical clearing of snow	Compacted snow

The time diagrams



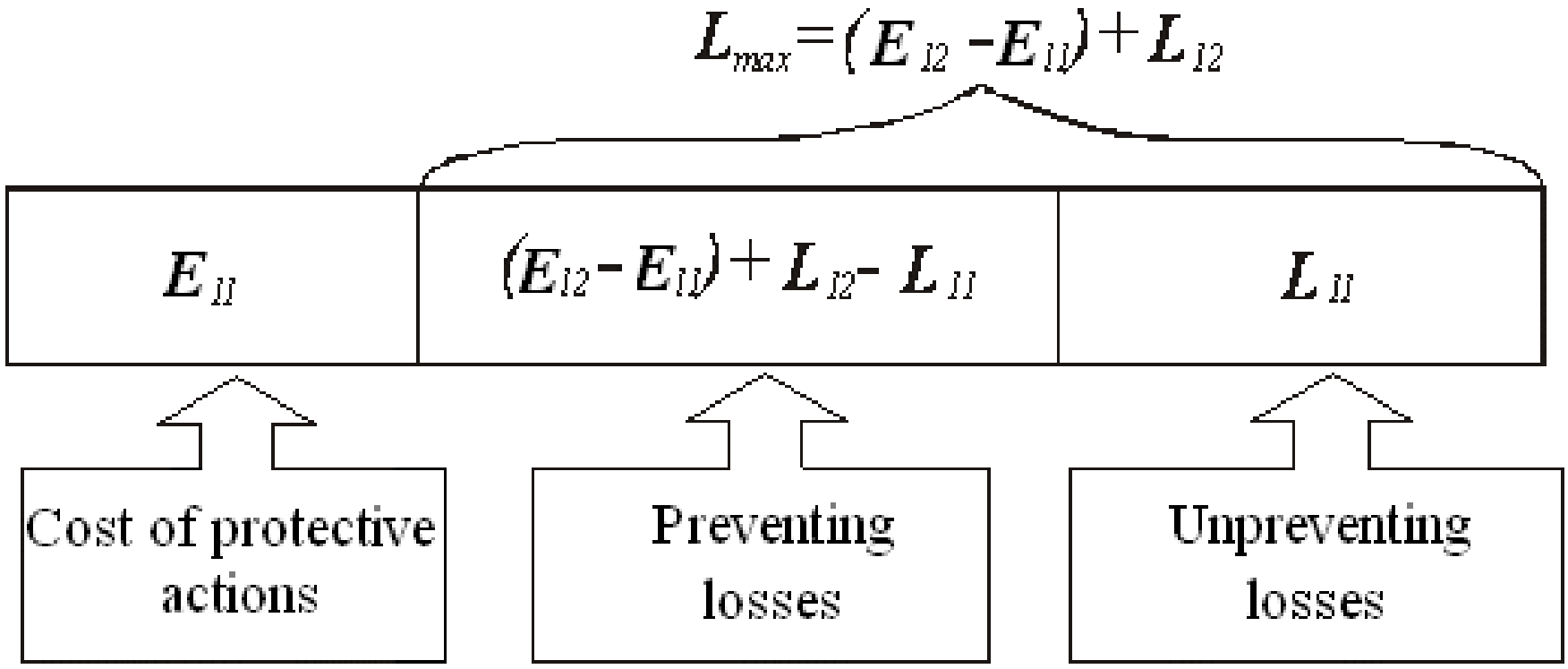


III - IV



The distribution diagram for possible losses at protective actions

$$\begin{vmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{vmatrix} = \begin{vmatrix} E_{11} & E_{12} \\ E_{21} & E_{22} \end{vmatrix} + \begin{vmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{vmatrix}$$



ADAPTATIVE PARAMETERS

- $\varepsilon = L_{11} / [(E_{12} - E_{11}) + L_{12}]$

  $\varepsilon = 0$ - *protection means are cardinal;*

  $\varepsilon = 1$ - *losses are maximal and cannot be prevented*

- $B = E_{11} / [(E_{12} - E_{11}) + L_{12} - L_{11}]$

- $\beta = (1 - B) + (1 - 2\varepsilon)/(1 - \varepsilon)$

  for $\beta < 1$ *the forecast loses economic utility*

- $F = 1 - 2\varepsilon - E_{11}/[(L_{12} - L_{11}) + E_{12}]$

  the values of this parameter should be positive

THE RESULTS OF THE COMPUTING TESTS (for roads of I class)

I	Works are spent to cycle time	$\varepsilon = 1$	*this strategy is not "meteosensible"*
	Works are spent in view of the minimal air temperature forecast	ε=0,31 β=1,06 F=0,04	*this scheme gets in a zone of adaptation. Forecasts of the minimal air temperature allow to receive the certain economic benefit*
II		ε=0,06 β=1,86 F=0,75	*at pre-icing strategies losses practically are completely prevented and protection measures are cardinal.*
III	*the parameters of adaptation are near to threshold value. The matrixes of losses were calculated for average parameters of snow intensity and intensity of movement. It is possible to assume, that there are certain combinations of weather and road factors at which parameters of adaptation will exceed threshold values. Researches for this strategy will be continued.*		
IV			