



- ▶ Anticipate danger precursors through the development of a predictive function

Vianney BORDEAU, Rail Safety Expert



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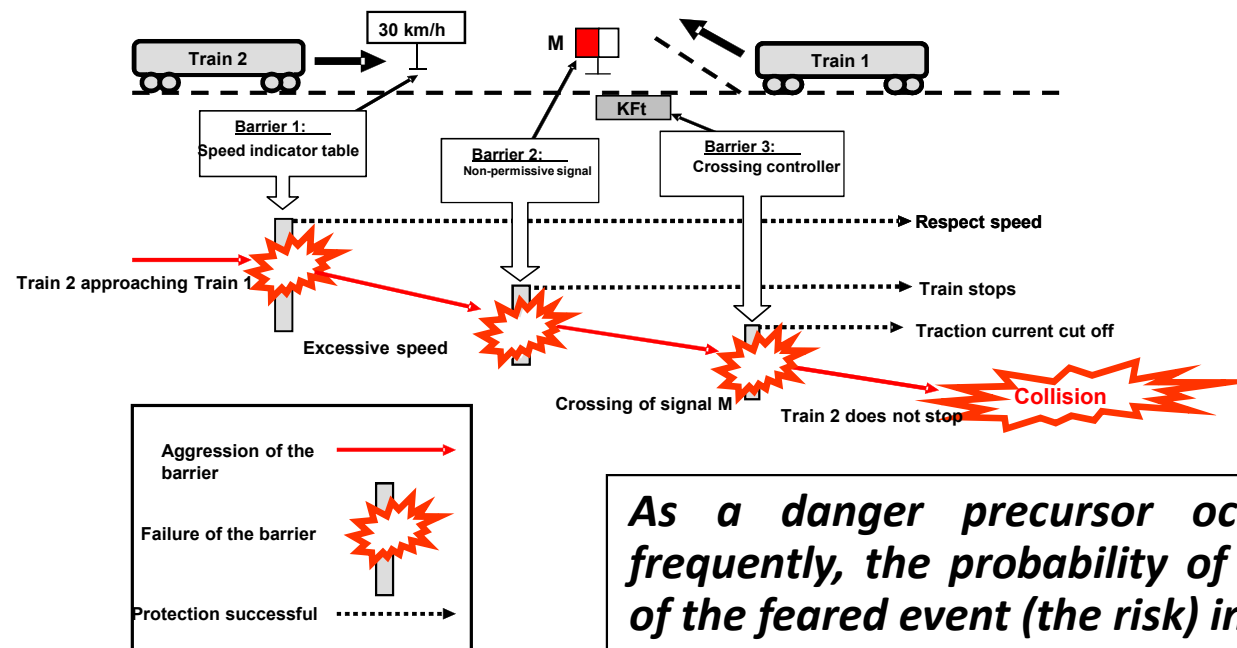
# Risk control policy at RATP

## ***Basic principle at RATP***

- “Pay attention to all precursor signs to reduce their frequency of occurrence, which is the only way of reducing the probability of the occurrence of feared events”.
- Development of a risk control policy based on the **Danger precursors** concept :
  - Application of the “**Precursors**” **Approach** over the past 10 years;
  - *More than **200 Danger precursors** are monitored on RATP’s different networks.*

# « Precursors » Approach

## Identification principle



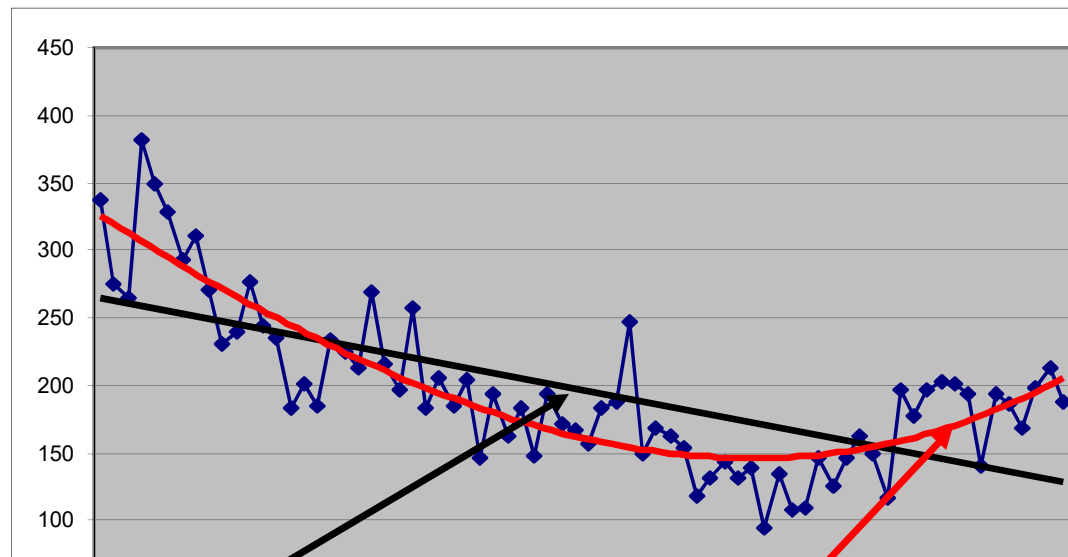
# « Precursors » Approach

## *Principle of the approach*

- Objective : to provide a steering tool giving an alert on precursor drifts in order to **React** and to be **GAME** at all times.
  - **Danger alert** Trend Charts : permanent devices for testing and evaluation of the safety level of installations.
- Implementation : analysis based on the study of several indicators representative of changes in precursors.
- Results : **Recommendations** to operators and maintenance workers (eg: **No action, Examine or React**).

# Implementation of a predictive model

*For what purpose ?*



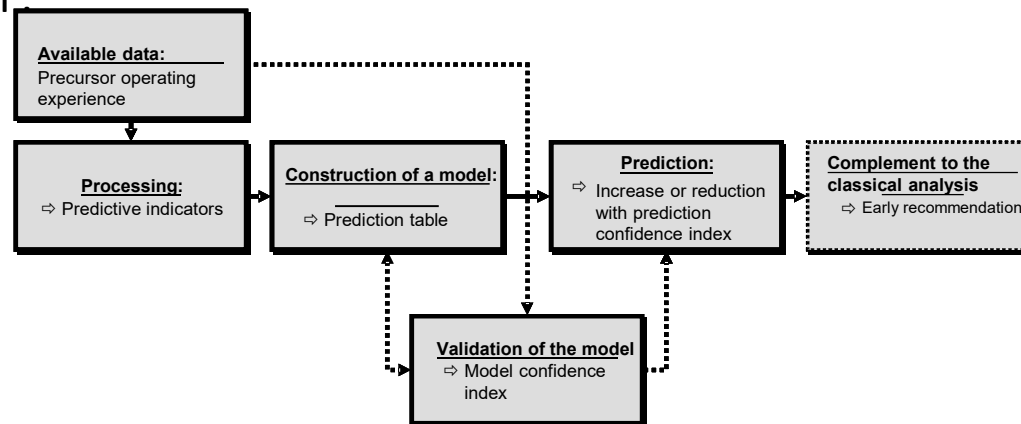
A linear trend curve suggests that the precursor is likely to change downwards in the next few months...

A second order polynomial trend curve suggests that the precursor is likely to change upwards in the next few months...

# Implementation of a predictive model

## *General principles*

- Objective : Process based on the analysis of the history of a system, the purpose of which is to evaluate the probability that this system will change in one direction or the other.
- Implementation :



- Results : **Anticipation of recommendations.**

# Implementation of a predictive model

## *Assumptions and input data*

- Model based on a **Statistical analysis** of the change of precursors based on **Incidental operating experience**.
- Purely statistical approach :
  - That anticipates how a system will change, **without considering physical or technical phenomena** ;
  - That is based on **Predictive indicators** for which the change can be **correlated to the safety level of the studied system** ;
  - That associates predictions with a **Confidence Index** (the index is higher when the law becomes more "true").



# Predictive indicators

## *Selected principles*

- Each indicator is a **Mathematical Indicator** managed through Macros using the Microsoft Excel® software.
- The adopted model is based on **3 predictive indicators** :
  - **Predictive indicator related to monthly changes** : it expresses the change in precursors in one month compared with the same calendar months during the previous 5 years.
  - **Predictive indicator for changes in the short term** : it expresses the trend of precursors during a period of 6 months.
  - **Predictive indicator for changes in the long term** : it expresses the trend of precursors, the value of which is related to its mean value, during a period of 5 years.

# Creation of the predictive model

## Precursor analysis principles

- The analysis of indicators characterises the state of system degradation according to 2 or 3 criteria **GREEN** / **ORANGE** / **RED** or **GREEN** / **RED**

*The combination of:*  
 - 3 monthly criteria,  
 - 2 short term criteria,  
 - 2 long term criteria.



**12 triplets model that summarises the various possible changes of precursors in 12 states.**

**Each state characterises the safety degree of the studied precursor.**

	Indicateur prédictif mensuel	Indicateur prédictif à court terme	Indicateur prédictif à long terme
Triplet 1	VERT mensuel	VERT court terme	VERT long terme
Triplet 2	ORANGE mensuel	VERT court terme	VERT long terme
Triplet 3	ROUGE mensuel	VERT court terme	VERT long terme
Triplet 4	VERT mensuel	ROUGE court terme	VERT long terme
Triplet 5	ORANGE mensuel	ROUGE court terme	VERT long terme
Triplet 6	ROUGE mensuel	ROUGE court terme	VERT long terme
Triplet 7	VERT mensuel	VERT court terme	ROUGE long terme
Triplet 8	ORANGE mensuel	VERT court terme	ROUGE long terme
Triplet 9	ROUGE mensuel	VERT court terme	ROUGE long terme
Triplet 10	VERT mensuel	ROUGE court terme	ROUGE long terme
Triplet 11	ORANGE mensuel	ROUGE court terme	ROUGE long terme
Triplet 12	ROUGE mensuel	ROUGE court terme	ROUGE long terme

# Creation of the predictive model

## *Statistical interpretation of results*

- Creation of a **Statistical prediction table** specific to each precursor.
- **Implementation:**
  - Identify the triplets in the history of the studied precursor
  - **Statistically identify changes (Up or Down) from month to month in the changes history as a function of identified triplets.**
- **Results :**
  - Complete the "Precursors Approach" analysis
  - **Degree of confidence in the model** : check predictions on all data in the history.

# Creation of the predictive model

## *Principe of the Statistical prediction table*

	Statistical change in month M+1			
	Observed number of increases	Observed number of reductions	Probability of change	
			Hausse	Baisse
Triplet 1	0	0	-	-
Triplet 2	0	0	-	-
Triplet 3	0	0	-	-
Triplet 4	14	25	35.9%	64.1%
Triplet 5	30	20	60.0%	40.0%
Triplet 6	23	4	85.2%	14.8%
Triplet 7	0	0	-	-
Triplet 8	0	0	-	-
Triplet 9	0	0	-	-
Triplet 10	4	6	40.0%	60.0%
Triplet 11	10	4	71.4%	28.6%
Triplet 12	3	0	100.0%	0.0%

Triplets that have never occurred

Triplet followed by an Increase in 85.2% of cases and by a Reduction in 14.8% of cases

Triplet always followed by an Increase

# Example application

PREDICTIVE INDICATORS			STATISTICAL CHANGE			
associated with the monthly indicator	associated with the short term indicator (Degrad. if 6-month slope >=0)	associated with the long term indicator	Increase or identical	Reduction	Probability of change	
					Increase or identical	Reduction
GREEN	Improvement	Positive	0	0	-	-
ORANGE	Improvement	Positive	0	0	-	-
RED	Improvement	Positive	0	0	-	-
GREEN	Degradation	Positive	2	8	20.0%	80.0%
ORANGE	Degradation	Positive	9	14	39.1%	60.9%
RED	Degradation	Positive	17	4	81.0%	19.0%
GREEN	Improvement	Negative	0	0	-	-
ORANGE	Improvement	Negative	0	0	-	-
RED	Improvement	Negative	0	0	-	-
GREEN	Degradation	Negative	18	33	35.3%	64.7%
ORANGE	Degradation	Negative	25	12	67.6%	32.4%
RED	Degradation	Negative	5	2	71.4%	28.6%

The precursor prediction table for the month of December 2013

With an 81% risk of degradation, it would have been possible to predict a degradation in December

The model is reliable for this precursor

Self-check of the model		
Correct predictions	Incorrect predictions	Confidence index valid model
102	47	6.8 / 10

CHOSEN MONTH	December 2013		Change statistics		Probability of change		
Monthly attribute	Short term attribute	Long term attribute	Increase or identical	Reduction	Increase or identical	Reduction	Confidence index Model
RED	Degradation	Positive	17	4	81.0%	19.0%	68.0%

# Salient points

- State of ongoing work
  - A reference method has been defined.
  - An Excel Macro under VBA has been produced and applied to data for RATP's various networks.
  - The results were conclusive on some precursors.
  
- Model limit
  - Evaluation made with a **purely statistical justification** :
    - Statistical results **not 100% true**
    - A **confidence index for the model** has to be identified to evaluate the statistical uncertainty

# Study approaches...

- **Define new types of indicators** (eg new mathematical models, number of indicators to be used, number of criteria considered, etc.)
- Make use of a validation process based on existing and future operating experience.
- Use other data sources available at RATP  
Use other predictive methods.
- Obtain predictions over longer periods.

***Thank you for your attention***

