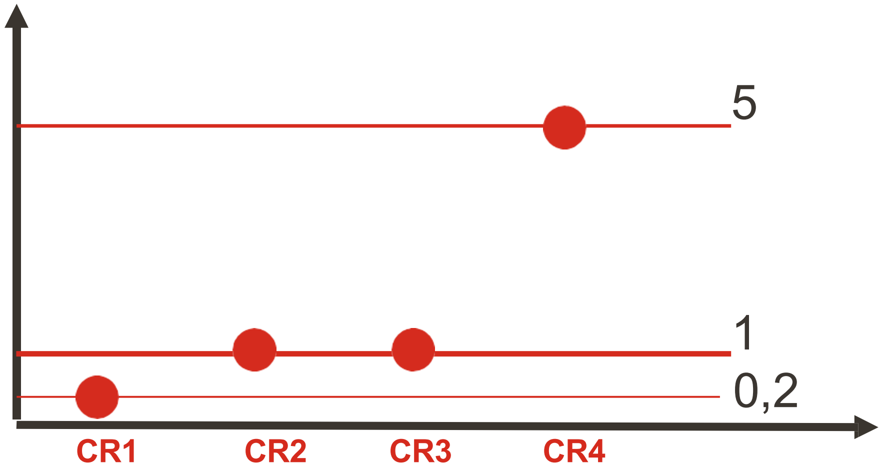
Risk analysis methodology prioritization of safety investments

METHOD, ACCIDENTOLOGY & STATEMENTS
USE CASE ON CROSSING LEVEL

SNCF SÉCURITÉ FREDERIC HENON – IRSC 2019

FIRST STEP : METHOD




CR1


CR2


CR3


CR4

CR1: risks with a low level of liability from the railway undertaking are weighted by a factor of Y = 0,2

CR2: safety at work (and road drivers safety) are equally weighted: Y = 1 (SNCF choice)

CR3: risks of rail transport passenger is also weighted Y = 1

CR4: risks of "uninvolved" third parties are weighted by a factor of Y = 5

AVERSION TO RISK

- Accidents with very large damage are perceived more strongly than several small accidents, although resulting the same number of victims : 1 accident x 10 victims ≠ 10 accidents x 1 victim
- It is therefore justified to give more “weight” to these accidents. **Risk aversion** is characterized by a stronger weighting of serious consequences as these accidents are less well accepted.
- Operational application use an aversion factor Z : $Z = \sqrt{c}$, c being the number of victims.

Example: c = 5 Victims, Aversion factor $\varphi = 2.23$,
Risk-averse weighted consequences = 11.2 weighted victims

Characterization of accidents (according to "EBP" method):

- Equivalent victims (EV) =
  Nbr killed + 0.1 serious injured + 0.01 lightly injured
- Catégories of victims:
  factor Y (0.2 for suicides, 1 for others victims)
- Risk aversion weighting: $Z = \sqrt{VE}$ (for VE > 1)

Weighted Victims : WV = VE * Y* Z

OBJECTIVES OF THE "USE CASE » ON LEVEL CROSSINGS

THE STUDY WAS LED ON 2060 ACCIDENTS WITHIN 11 YEARS, CONCERNING 12500 PUBLIC LC (PASSIVE AND ACTIVE) OF THE FRENCH NETWORK

THREE STEPS

1. Define a method to enlarge the notion of victim (Weighted Victims WV)

2. Analyze the characteristics of these accidents

3. Propose a cost-effective method and argumentation for the implementation of risk control measures on level crossings (LC)

- Sources :
  SNCF Réseau ISCHIA base (accidents) 2007-2018, SNCF Réseau descriptive base of infrastructure ARMEN (LC Park)

SECOND PART : ACCIDENTOLOGY & STATEMENTS

PASSIVE LC

2 BARRIERS LC

4 BARRIERS LC

2 BARRIERS LC WITH TRAFFIC ISLAND SEPARATOR

ACCIDENTOLOGY & STATEMENTS

- 3 types of accidents on LC:
  Clashes against people, 9% of accidents, 0,75 killed/accident
  Collisions against vehicles, 52% of accidents, 0,2 killed/accident
  Suicides, 39% of accidents, 0,9 killed/accident

- Collision accidents are spread as :
  40% inattention of the car driver, lack of visibility, surprise …
  40% non compliance of the road traffic signage: forcing, zig zaging passage …
  20% vehicule blocked on the LC: vehicule that stalls, which blocks behind a raw …

- Statistical repartition of accidents (without suicides)

LC type	1 acc. every	WV aver./acc.	WV/LC/y
Passive LC	188 ys	0,28	1,5.E-03
2 barriers LC	109 ys	0,33	3,0. E-03
2 barriers LC with traffic island separator	43 ys	0,32	7,6. E-03
4 barriers LC	40 ys	0,32	8,0. E-03

IMPACT OF MOMENTUM

- Accidentology increases with the “momentum” of the LC (momentum = rail traffic X road traffic / day)
- 23% of highest momentum LC are causing 68% of victims.
- Global accidentology (Aver. Nbr WV/LC/year) is spread as :

WITHOUT SUICIDES	MOMENTUM RANGES					
	1-100	101-1 000	1 001- 5 000	5 001- 25 000	25 001- 125 000	> 125 000
2 BARRIERS LC	4,32E-05	4,77E-04	1,08E-03	2,15E-03	8,19E-03	**1,32E-02**
2 BARRIERS LC WHIT ISLAND SEPARATOR	---	0	0	2,67E-05	3,67E-03	**1,39E-02**
4 BARRIERS LC	---	0	6,49E-05	6,25E-04	5,75E-03	**1,11E-02**
PASSIVE LC	1,43E-03	2,21E-03	4,09E-03	0	---	---
AVERAGE	9,60E-04	7,48E-04	1,11E-03	2,09E-03	7,71E-03	**1,25E-02**

For the highest momentum, for one LC, they may be one Weighted Victim every 70 years

THIRD PART : EVALUATION OF MEASURES

IDENTIFIED MEASURES

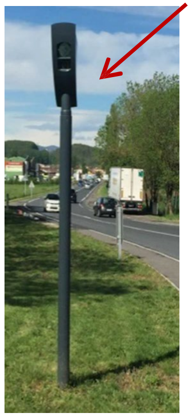
- Passive LC :
  - Simple deletion of LC (ie without bridge)
  - Transformation to active LC

- ACTIVE LC :
  - Deletion of 2-barrier LC
  - Transformation 2 to 4-barrier LC
  - Equipment with OD (obstacle detection)
  - Equipment with crossing radar
  - 4-barrier stickers (“BRAKABLE BARRIER”)
  - Flashing red lamps with LED’s + on-ground signaling
  - LED lighting barriers
  - Video-protection with prosecution or not
  - Traffic separator Island (2-barrier)

ILLUSTRATIONS

OBSTACLE DETECTOR

CROSSING RADAR



VIDEO PROTECTION

FLASHING LED LIGHT

CALCULATION METHOD

Coasts : equivalent annual costs (per LC)

- initial cost of allocated investment based on duration of use and inflation rate
- Costs for operatiING and maintenance (of the measure)
- Potential revenues provided by the measure

Efficiency (per LC)

- Estimation of weighted victims (WV) “saved” per year, thanks to the measure per LC

Coast-efficiency ratio :

- **Annual expense to save 1 WV per LC (per year)**

Nota: "Interesting" investment if ratio < 10 M€/WV/year, "rationnable" investment if ratio < 20 M€/WV/year

PASSIVE LC RESULTS

PASSIVE LC (momentums)	Cost- Efficiency (M€/WV/LC/Y)		
	1-100	101-1 000	1 001- 5 000
NUMBER OF LC	**1341**	**363**	**26**
SIMPLE DELETION	**5,1**	**3,1**	**1,6**
TRANSFORMATION INTO 2 BARRIERS LC	18	14,4	**8,3**

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TWO-BARRIERS LC RESULTS

TWO BARRIERS LC (ranked with momentum)	101-1000	1001-5000	5001-25000	25001-125000	>125000
NUMBER of LC	**1915**	**2047**	**2108**	**1516**	**489**
NUMBER LC WITH ISLAND TRAFFIC SEPARATOR	**7**	**7**	**34**	**77**	**108**
DELETION (BRIDGE)	495	314	183	62,8	40,6
TRANSFORMATION INTO 4-B		47,3	31,5	19,7	22,9
OBSTACLE DETECTION	481	230	119	34,1	20,5
CROSSING RADAR	596	263	108,4	**3,4**	**2,1**
OBSTACLE DETECTION + RADAR	606	285	138	28,5	17,3
LED BARRIERS	98,6	43,6	21,9	**5,7**	**3,6**
LED SIGN LIGHTS + ON- GROUND SIGNALING	123	54,1	27,2	**7,1**	**4,4**
LED SIGN LIGHTS + GROUND SIGNALING + LED BARRIERS	117	51,7	26,0	**6,8**	**4,2**
VIDEOPROTECTION WITHOUT PROSECUTION	210	92,9	46,7	12,3	**7,6**
VIDEOPROTECTION WITH PROSECUTION	335	148	63,3	**2,1**	**1,3**
TRAFFIC SEPARATOR ISLANDS				**7,0**	

FOUR-BARRIERS LC RESULTS

TWO BARRIERS LC	COST / EFFICIENCY (M€/WV/LC/Y)			
	1001-5000	5001-25000	25001-125000	>125000
NUMBER of LC	**14**	**32**	**214**	**340**
STICKERS on exit barriers	49,7	**5,2**	**0,6**	**0,3**
OBSTACLE DETECTION	4 579	426	51,0	26,2
CROSSING RADAR	5 844	497	**6,5**	**3,4**
LED BARRIERS	725	75,3	**8,2**	**4,2**
LED SIGN LIGHTS WITH GROUND SIGNALING	901	93,5	10,2	**5,3**
LED LIGHTS SIGNS + GROUND SIGNALING + LED BARRIERS	860	89,3	**9,7**	**5,1**
VIDÉOPROTECTION WITHOUT PROSECUTION	1 894	197	21,4	11,1
VIDÉOPROTECTION WITH PROSECUTION	3 043	269	**3,7**	**1,9**

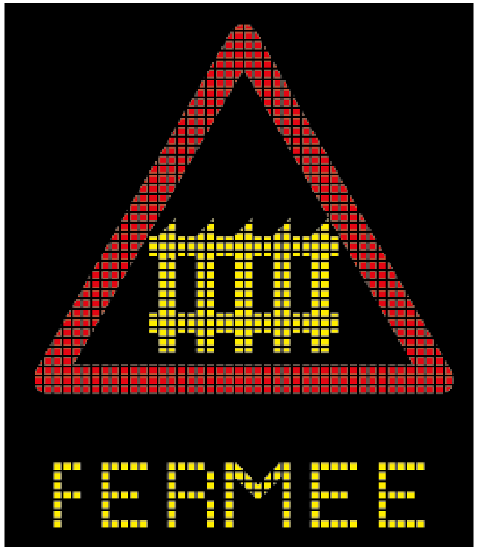
SUMMARY

- Cost/efficiency is high even excessive for low-momentum's level crossings.
- Some low-cost investments improve road drivers visibility and are cost-efficient.
- Deletion of LC eliminates the risk, but low cost-efficiency.
- Obstacle detectors has a low cost-efficiency (expensive and prevents 40% of collisions only).
- Crossing radars are expensive and have limited efficiency.
- Videoprotection is
  - Affordable and efficient, especially in the case of prosecution
  - Offers extensive features: fight vandalism, better knowledge on road traffic, detection of near-accidents and help enquiries upon an accident.

NEXT STEPS ON THE USE CASE

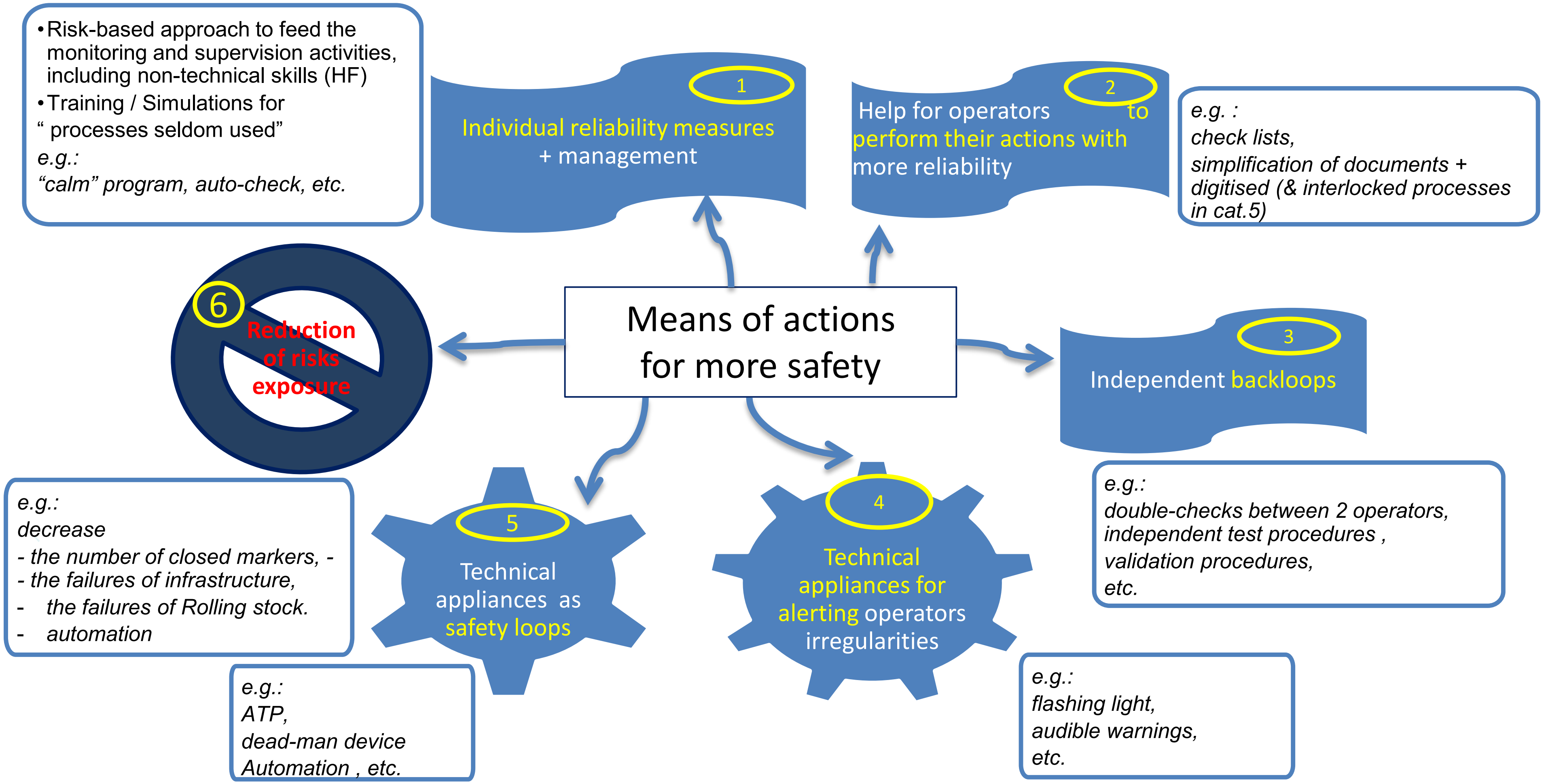
Evaluate cost/efficiency of road traffic equipment, to provide a global decision-making guide for risks managers

Exemple: lighting warning road sign (approximatively located 300 m ahead of the crossing)



NEXT STEPS FOR DECISION MAKERS

Evaluate cost/efficiency for all « means of actions for more safety »



NEXT STEPS FOR DECISION MAKERS

Example for SNCF NETWORK PROGRAM « SAFETY TO SYSTEM INVESTMENTS »

Programme	Nr	Mesure	RCE [Mio.€/vp]
P8 PN	P8.17	SAL2, Ilot séparateur "dur" / M 25001-125000	10
P4 Clôture	P4	Clôture: Gare	11
P3 STEM	P3.3	Contrôle du Chargement et des Roues (CCR)	11
P8 PN	P8.14	SAL4, Vidéo protection / M > 125000	11
P8 PN	P8.18	SAL2, Ilot séparateur "souple" / M 25001-125000	11
P7 Quai	P7.2	Annonces cycliques: gares cat. 2/3	13
P1 Déshuntage	P1.4c	Temporisation (45") gare moyenne	17
P8 PN	P8.9	SAL2, DO PN + Radar de franchissement / M > 125000	17
P7 Quai	P7.3	Annonces précis: gares cat. 0/1	18
P7 Quai	P7.5	Barrières quais: gares cat. 0/1	18
P8 PN	P8.4	SAL2 --> SAL4 / M ≥ 25001-125000	20
P4 Clôture	P4	Clôture: Urbain	21
P7 Quai	P7.4	Clôtures quais; gares cat. 2/3	21
P8 PN	P8.5	SAL2, DO PN / M > 125000	21
P5 Sites MD	P5.5	Locaux de confinement (sites MD cat. A)	25
P8 PN	P8.6	SAL4, DO PN / M > 125000	26
P6 TVP	P6.3	Signaux lumineux	38
P7 Quai	P7.5	Barrières quais: gares cat. 2/3	42
P1 Déshuntage	P1.9	Sentinelles automatiques, pédale d'assistance	42
P7 Quai	P7.3	Annonces précis: gares cat. 2/3	44
P8 PN	P8.3	Suppression PN SAL2 / M > 125000	48
P6 TVP	P6.4	Passerelle	56
P6 TVP	P6.5	Souterrain	56
P5 Sites MD	P5.4	Système d'alerte riverains (sites MD cat. A)	58
P3 STEM	P3.2	Vidéo STEM	60
P2 KVB	P2.1	KVB – Protection des trains origines	66
P2 KVB	P2.2	KVB - Dépassement vitesse limite UIC 3-6	66
P5 Sites MD	P5.3	Deux réservoirs d'eau (sites MD cat. A)	68

THANK YOU FOR YOUR ATTENTION !