



DNIT
Departamento
Nacional de
Infraestrutura
de Transportes

National Department of Transport Infrastructure Railway Infrastructure Board

PROSEFER August 4, 2014

2014 Global Level Crossing
Safety and Trespass Prevention Symposium
University of Illinois at Urbana-Champaign



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PROSEFER – National Program of Railway Safety in Urban Areas

- ☐ History
- ☐ Evolution of Railway Concessions in Brazil
- ☐ Problems to solve
- ☐ National Program of Railway Safety in Urban Areas
- ☐ Examples of Interventions

History

1957 – Law nr. 3115: creation of RFFSA – Federal Railway Network, with administrative unification of 18 railways, 37,000 km of rail lines, operating cargo, intercity and urban passenger transports.

1971 – Law nr. 10410/SP: creation of Fepasa by the fusion of 5 railways in the state of São Paulo, with 5,000 km.

1984 – Urban railway transports are transferred to CBTU.

1988 – Urban railway transports are transferred to the states.

1992 – RFFSA was included in the National Privatization Program.

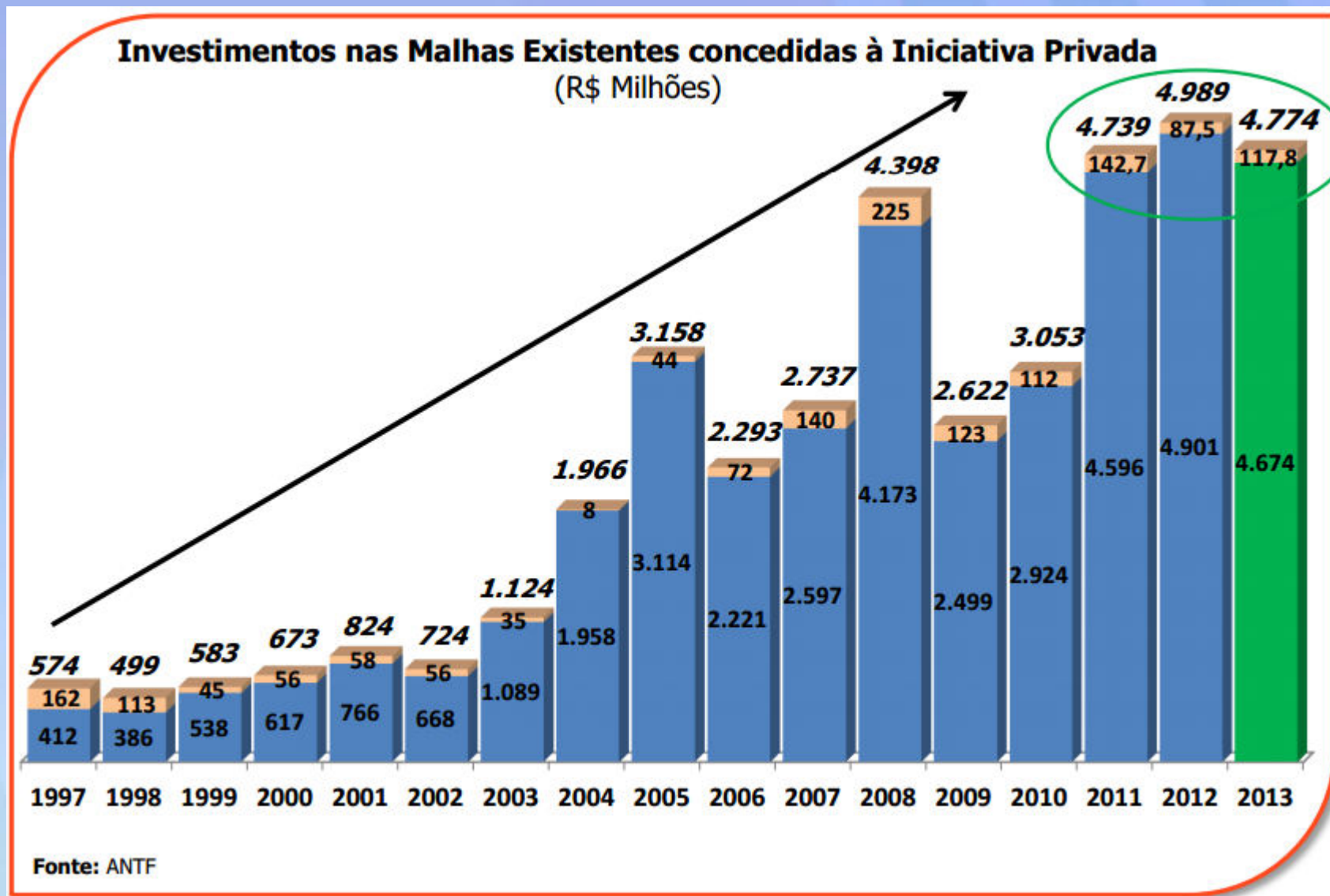
1995 – Concessions Law (Law nr. 8987).

1999 – RFFSA was closed down (Decree nr. 3277).

2007 – Extinction of RFFSA: patrimony transferred to DNIT.

Evolution of Railway Concessions

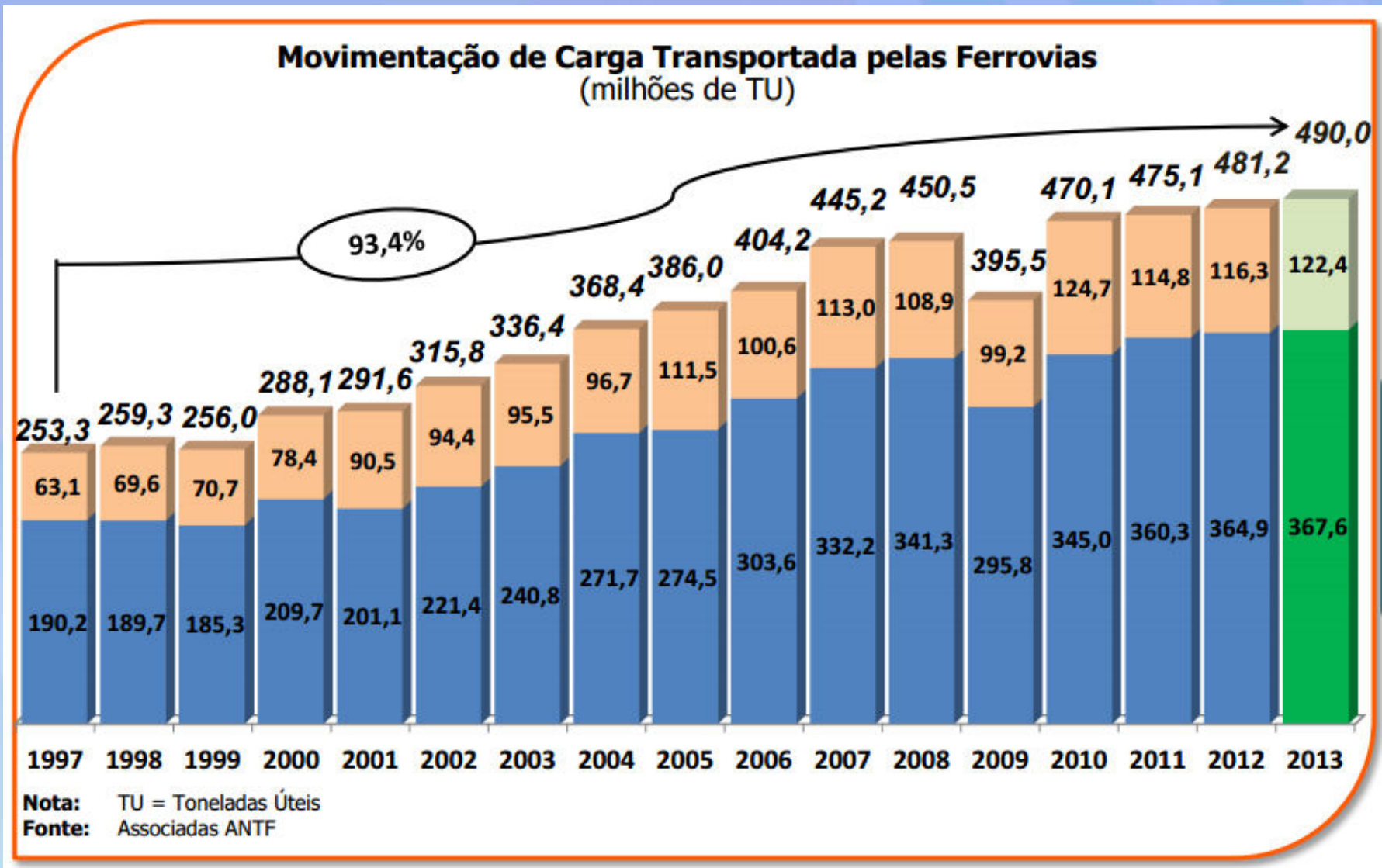
Total investments of R\$ 39.7 billions (about US\$ 18 billions) – 1997/2013



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Evolution of Railway Concessions

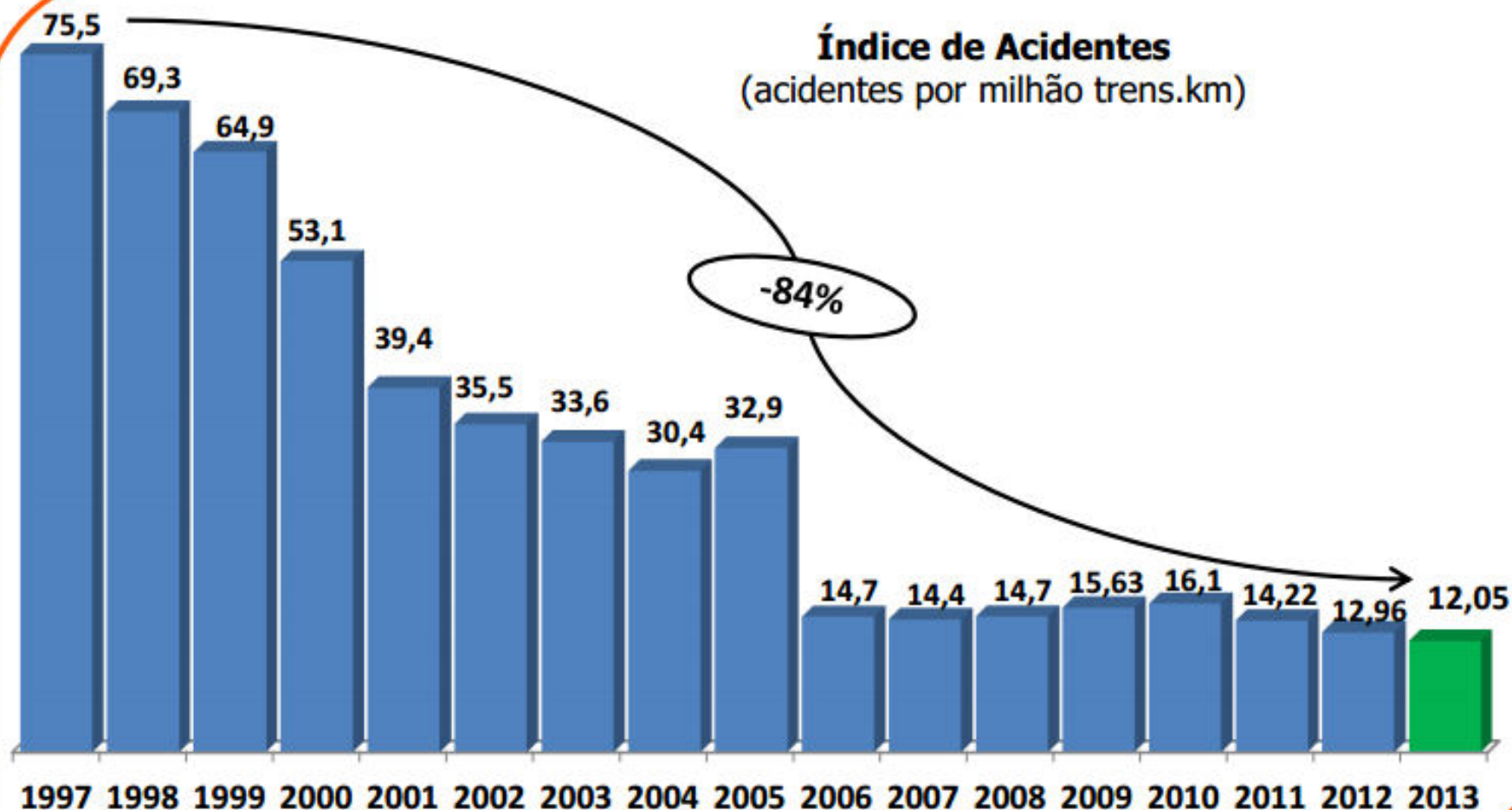
Increase in transport from 253.3 (1997) to 490 (2013) millions of net tons



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Evolution of Railway Concessions

Decrease from 75.5 to 12.05 accidents/million of trains.km

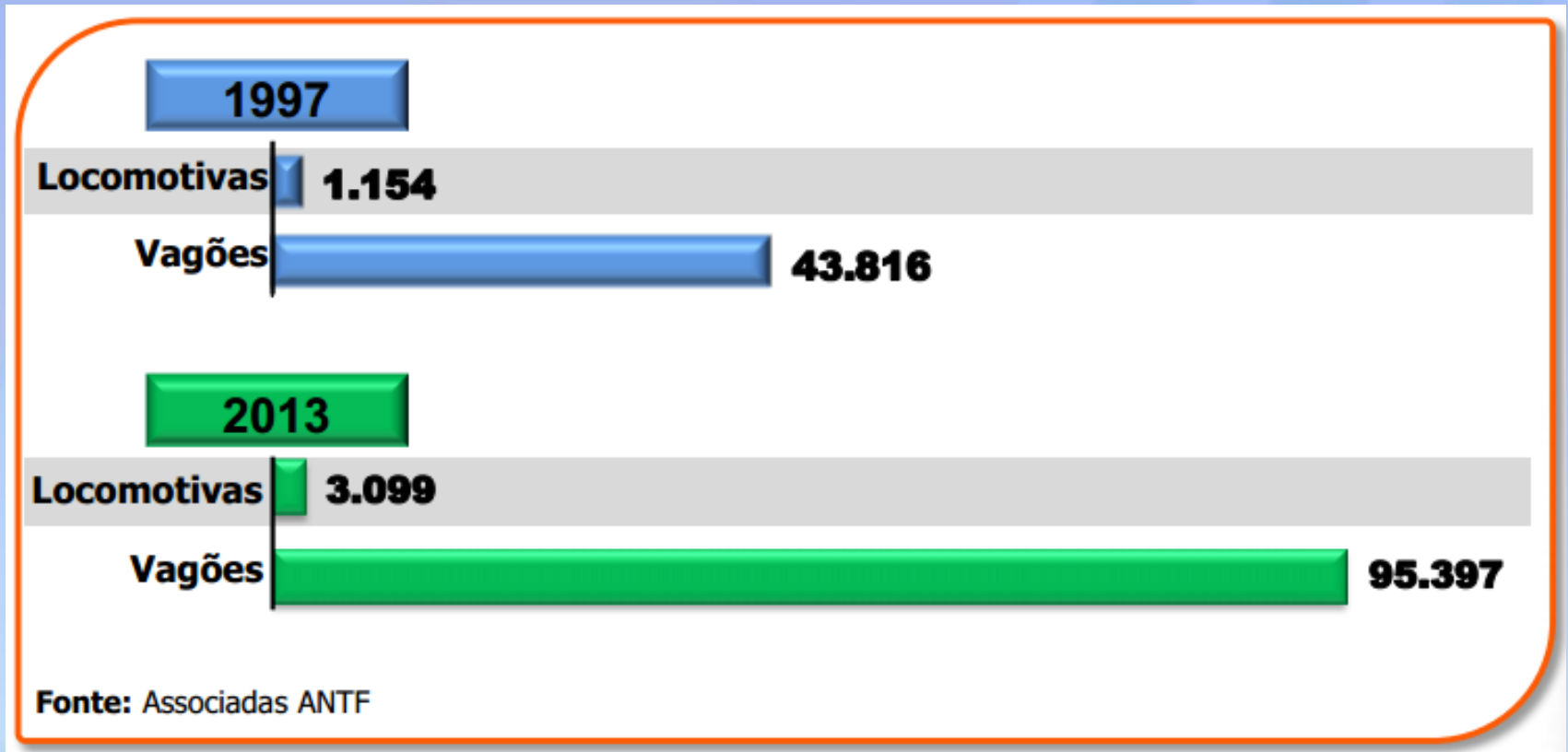


Fontes: ANTT e Associadas ANTF

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Evolution of Railway Concessions

Increase in rolling stock – locomotives and freight cars



Problems to solve

- Concessions of railways involved cargo transportation only.
- Intercity transport of passengers, gradually abandoned by RFFSA, was extinct (except Vale Company).
- Passenger stations became non-operational.
- Passage of trains through urban areas became an inconvenience (long and slow trains).
- Eg.: train 1500 m long, moving at 18 km/h (5 m/s)
Crossing time: $1500/5 = 300\text{s} = \mathbf{5\text{min}}$

People and vehicles take the risk of crossing ahead of trains!

What is PROSEFER?

- ✓ **PROSEFER is the National Program of Railway Safety in Urban Areas**
- ✓ **Scope of the study:**
 - **15,000 km of railways;**
 - **16 states;**
 - **596 municipal districts;**
 - **5,609 crossings analyzed;**
 - **355 invasions of right-of-way identified;**
 - **17 corridors where 95% of railway cargo transported in Brazil has circulated (2008).**

Objectives of PROSEFER

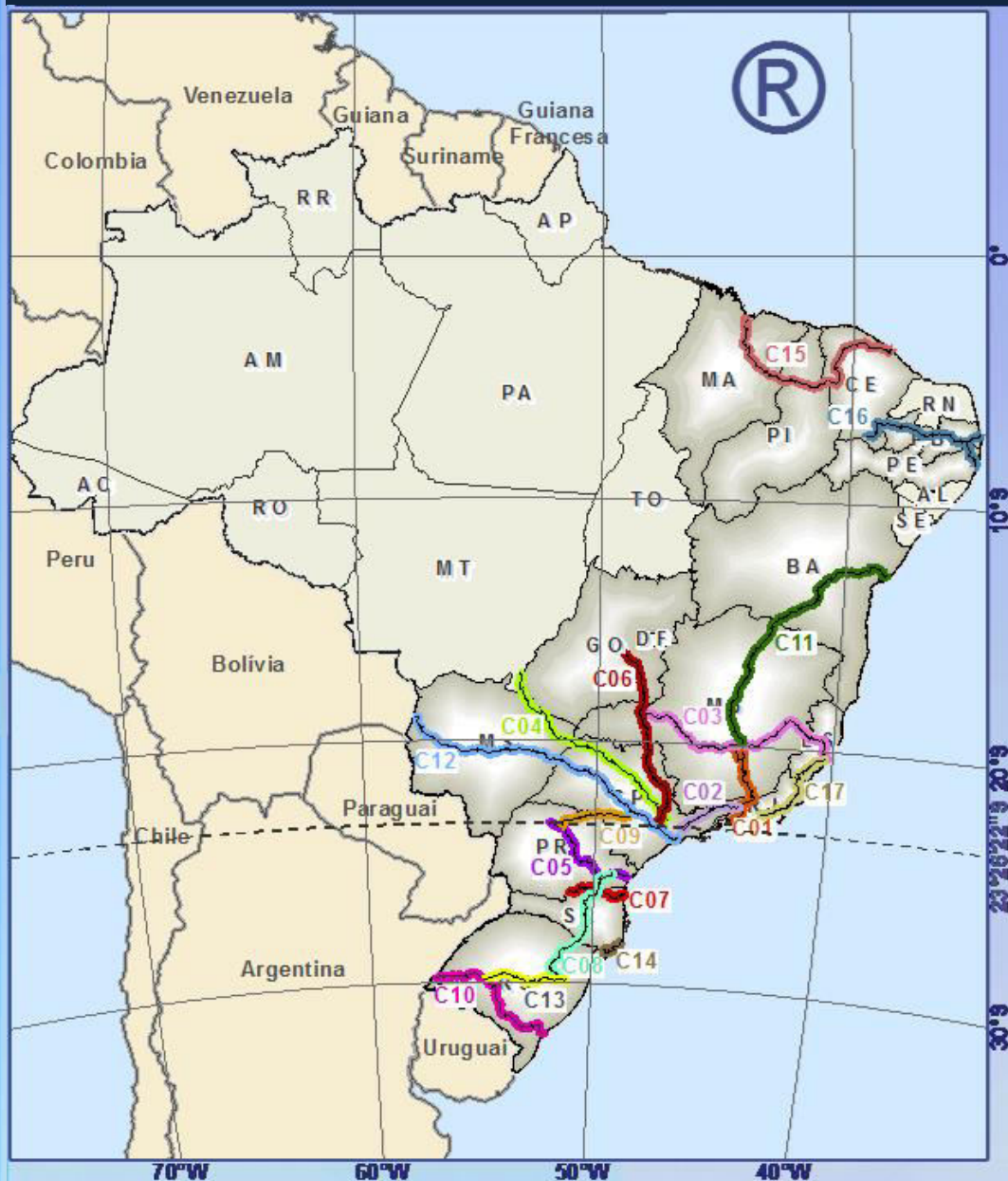
✓ For society

- Increase in urban quality of life;
- Increase on safety for the population;
- Reduction of accident risk;
- Increase in operations;
- Decrease in transports costs.


















✓ For the government

- Creation of a management tool;
- Identification of prioritary actions and works;
- Updatable database.

PROSEFER corridors

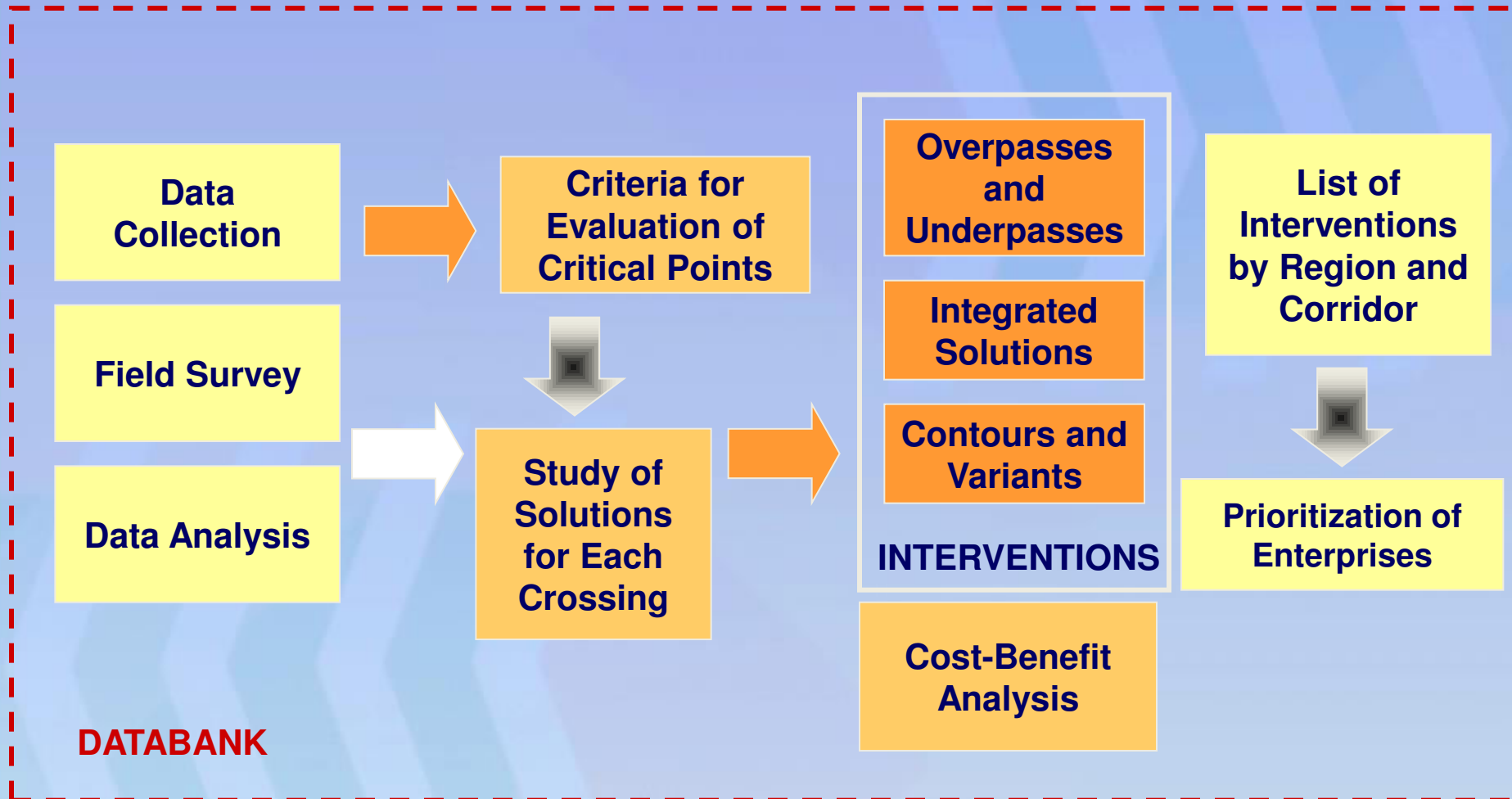


PROSEFER corridors

- | | |
|---------------------------------------------------------------------------------------|--------------------------------------------|
|  | C01 - Belo Horizonte - Sepetiba |
|  | C02 - São Paulo - Barra do Piraí |
|  | C03 - Araguari - Vitória |
|  | C04 - Alto Araguaia - Campinas - Santos |
|  | C05 - Maringá - Curitiba - Paranaguá |
|  | C06 - Anápolis - Campinas - Mairinque |
|  | C07 - Porto União - São Francisco do Sul |
|  | C08 - Porto Alegre - Lages - Curitiba |
|  | C09 - Apucarana - Ourinhos - Rubião Júnior |
|  | C10 - Uruguaiana - Pelotas - Rio Grande |
|  | C11 - Belo Horizonte - Salvador |
|  | C12 - Corumbá - Bauru - Mairinque - Santos |
|  | C13 - Cacequi - Santa Maria - Porto Alegre |
|  | C14 - Ferrovia Tereza Cristina |
|  | C15 - São Luís - Teresina - Fortaleza |
|  | C16 - Arrojado - Recife/João Pessoa |
|  | C17 - Itaboraí - Vitória |

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Developed Activities



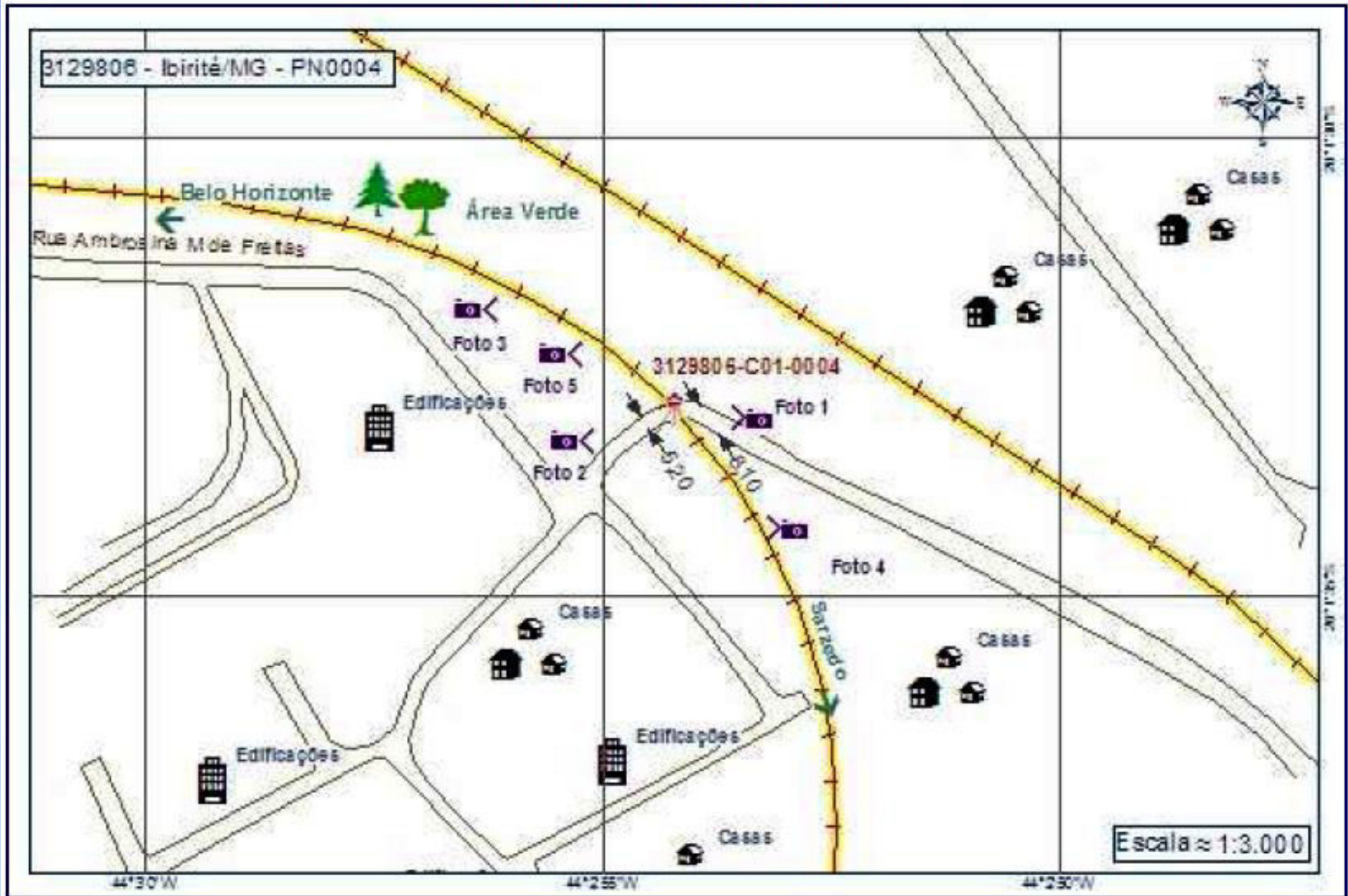
Data collection from concessionaries, National Agency of Land Transports (ANTT) , Ministry of Transports, Brazilian Institute of Geography and Statistics (IBGE) and others, related to the topics:

- **Corridors**
 - **Cargo, rails, rate of railway sleepers, grades, curve radius, operation speed.**
- **Cities**
 - **Socioeconomic data (GDP, Population, HDI, and others).**

- ☐ All extension of corridors covered.
- ☐ Field surveys based on rules, local needs and expertise of survey teams.
- ☐ Appropriate forms for each survey:
 - Level crossing form.
 - Overpass or underpass form.
 - Right-of-way invasions form.
 - Urban traffic at level crossing form.

Field Survey – level crossing diagram

Croqui da Passagem em Nível



Field Survey - photographs

Passagem em Nível (PN)

3129806_C01_0004

Município: 3129806 : Ibitité/MG



Foto 1



Foto 2



Foto 3



Foto 4

- ✓ **5,609 crossings analyzed**
 - **1,856 Urban level crossings**
 - **1,519 Rural level crossings**
 - **929 Overpasses**
 - **584 Underpasses**
 - **721 Pedestrian crossings**
- ✓ **279 level crossings were considered critical**

The characterization of critical points has considered a number of procedures that guide the decision to determine whether or not the object of analysis as critical:

- Evaluation of Transit Times**
- Momentum of Circulation and Degree of Importance**
- Distances of Visibility**
- Seasonality (eg.: harvest times)**

Evaluation criteria of level crossings

The conditions of protection and safety of a level crossing are determined by the value of:

- **Degree of Importance – Gi (NB 1238/1989)**

$$Gi = f \cdot T \cdot V$$

f = factor for conditions of visibility, location and traffic;

T = quantity of trains in both directions, per day;

V = volume of road vehicles in both directions, per day.

- **Momentum of Circulation – MC (NB 666/1989)**

$$MC (Vd \times Td + 1,4 \times Vn \times Tn) \times L$$

Vd – Daily average volume of road vehicles in day time

Td – Daily average volume of trains in day time

Vn – Daily average volume of road vehicles in night time

Tn – Daily average volume of trains in night time

L – Factor that considers the number of rail lines to cross

Number of lines	L
1	1
2	1,3
3 or more	1,5

Degree of Importance – GI (NB 1238/1989) – f factor

Characteristic of crossing			Value		Weight of importance	Final value (2x3)
1			2		3	4
01	Visibility	over 300 m	2		10	
02		150 to 300 m	3			
03		under 150 m	4			
04	Maximum grade of approach on public road	under 3 %	2		7	
05		3 to 5 %	3			
06		over 5 %	4			
07	Maximum authorized speed of fastest train	under 40 km/h	2		7	
08		40 to 80 km/h	3			
09		over 80 km/h	4			
10	Number of rail lines	single	2		6	
11		double	3			
12		triple of more	4			
13	Maximum authorized speed of road traffic	under 50 km/h	2		5	
14		50 to 80 km/h	3			
15		over 80 km/h	4			
16	Traffic of buses	under 5 %	2		5	
17		5 to 20 %	3			
18		over 20 %	4			
19	Traffic of trucks	under 5 %	2		4	
20		5 to 20 %	3			
21		over 20 %	4			
22	Unusual traffic	under 5 %	2		4	
23		5 to 20 %	3			
24		over 20 %	4			
25	Pedestrian traffic	under 5 %	2		2	
26		5 to 20 %	3			
27		over 20 %	4			
28	Total					

$$f = \frac{\sum Vi \cdot Wi}{100}$$

$$(1 \leq f \leq 2)$$

Conditions of visibility of a level crossing

The conditions of visibility of the road user, related to the train, are also given by the maximum authorized speed (VMA) to the road, divided in ranges:

1st range: $VMA < 60$ km/h (urban roads)

2nd range: $60 \leq VMA \leq 90$ km/h (rural roads)

3rd range: $VMA > 90$ km/h (highways)

Table of Solutions – MC and GI

TYPE OF VIGILANCE	SITUATION IN THE RANGE (MC E GI)	SOLUTION
Optional	1st range and $GI < 3,000$ 2nd range and $GI < 1,500$	Adequate road and rail signaling plates and satisfactory conditions of visibility.
Obligatory	1st range and $3,001 < GI < 25,000$ 2nd range and $1,501 < GI < 12,000$	Adequate road and rail signaling plates, with signaling devices operated manually and satisfactory conditions of visibility.
Automatic	1st range and $25,001 < GI < 50,000$ 2nd range and $12,001 < GI < 30,000$ 3rd range and $1,001 < GI < 25,000$	Adequate road and rail signaling plates, with signaling devices operating automatically.
	1st range and $GI > 50,000$ 2nd range and $GI > 30,000$ 3rd range and $GI > 25,000$	Construction of overpasses, underpasses or rail contours.

1. Variant or Railway Contour

- ✓ **Variant involves more than one municipality**
- ✓ **Contour develops in the same municipality**

2. Overpasses or Underpasses

- ✓ **Viaducts, footbridges, fences**
- ✓ **Underpasses for vehicles and/or pedestrians**

3. Integrated Solutions

- ✓ **Involve more than one crossing**
- ✓ **Can involve more than one type of solution (overpasses, underpasses, lowering of track, fences, footbridges)**

Programmed Interventions of PROSEFER

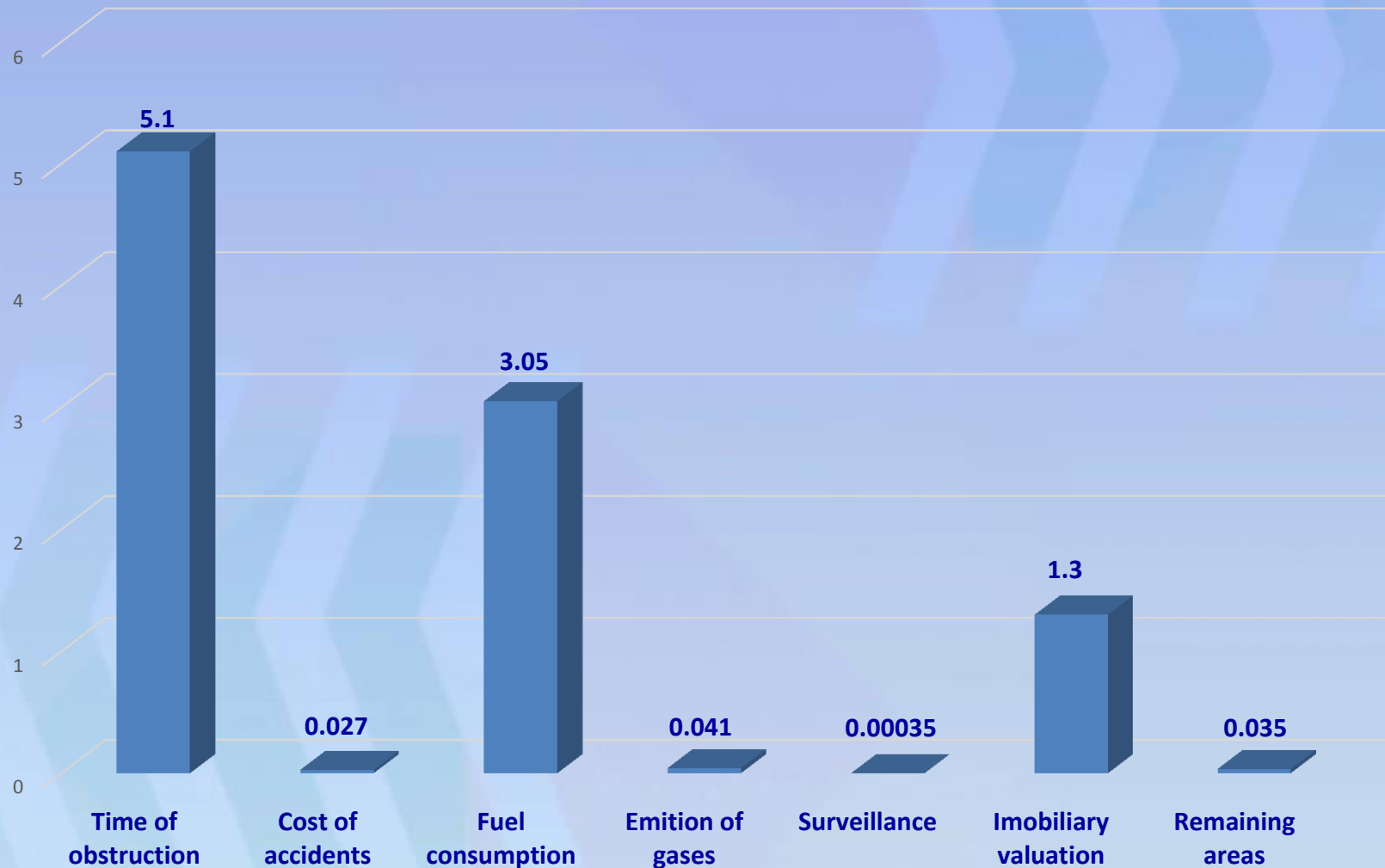
- ✓ **In 186 municipalities (from 596 studied)**
- ✓ **Investments of US\$ 3.5 billions (basis May 2009);**
 - **US\$ 1.3 billion for 28 rail contours**
 - **US\$ 1.2 billion for 6 variants**
 - **US\$ 330 millions for 158 overpasses/underpasses**
 - **US\$ 270 millions for 25 integrated solutions**

Socioeconomic Benefits

- **Reduction in fuel consumption:**
About US\$ 3 billions
2.7 billions of liters
- **Reduction in obstruction time:**
About US\$ 5 billions
- **Reduction in emission of pollutant gases to atmosphere:**
About US\$ 41 millions
Significant benefit considering the environmental component.

Socioeconomic Benefits

Total of socioeconomic benefits: US\$ 9.5 billions



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Increase in transport capacity

- ✓ **The objective of this evaluation is to calculate the increase in transport capacity of a corridor, considering operational speed. It was calculated the reduction in transit time of trains, under present and future scenarios.**
- ✓ **With the construction of proposed works, the railways affected will transport about 16.7% more net tons in relation to 2008 (basis of the study).**
- ✓ **Railways will compete in better conditions with other modals.**

Classification by order of importance of the works determined by PROSEFER, through an administrative tool that utilizes several parameters.

These indicators are divided in several subjects:

- Technical;**
- Socioeconomic;**
- Environmental;**
- Indicators of feasibility;**
- Operational; and**
- Strategic.**

IPP – Index of Prioritization PROSEFER

AREA	WEIGHT	ITEM	WEIGHT	CRITERION	WEIGHT	VALUE	RESULT
TECHNICAL	0.5	Planimetry	0.15	Doesn't meet the standard	0.00		
				Meets the standard	1.00		
		Altimetry	0.15	Doesn't meet the standard	0.00		
				Meets the standard	1.00		
		Gauge	0.20	Metric	1.00		
				Large	0.00		
		D Level Year	0.20	From 2009 to 2023			0.000000
		Level of difficulty to elaborate studies, projects and works	0.20	Low	1.00		
				Medium	0.50		
				High	0.00		
		Segregation	0.10	Yes	1.00		
				No	0.00		
Sum	1.00				0.000000		
SOCIOECONOMIC	2.5	Accidents	0.20	Yes	1.00		
				No	0.00		
				No Information	0.00		
		State Capital?	0.20	Yes	1.00		
				No	0.00		
		Railway junction	0.20	1 track	0.00		
				2 tracks	0.30		
				3 tracks	0.60		
				> 3 tracks	1.00		
		Invasions	0.20	Yes	1.00		
				No	0.00		
		Time of obstruction (min)	0.20				0.000000
Sum	1.00				0.000000		
ENVIRONMENT	0.5	Environmental Protection Area or Conservation Unit	0.20	Yes	1.00		
				No	0.00		
		Dangerous cargo	0.50	Yes	1.00		
				No	0.00		
		Native lands	0.30	Yes	1.00		
				No	0.00		
Sum	1.00				0.000000		

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IPP – Index of Prioritization PROSEFER

AREA	WEIGHT	ITEM	WEIGHT	CRITERION	WEIGHT	VALUE	RESULT
INDICATORS OF FEASIBILITY	1.5	IRR	0.30				0.000000
		B/C	0.30				0.000000
		Per capita investment	0.40				0.000000
		Sum	1.00				0.000000
OPERATIONAL	2.5	Freight volume	0.20				
		Passengers	0.10	Yes	1.00		
				No	0.00		
		Trains/day	0.20				0.000000
		Nr. of eliminated level crossings	0.20				0.000000
		Nr. of rail tracks	0.10	1 track	1.00		
				≥ 2 tracks	0.00		
		Existence of train formation yard	0.10	Yes	1.00		
				No	0.00		
		Maximum authorized speed	0.10	20 km/h	1.00		
				30 km/h	0.70		
				40 km/h	0.40		
				> 40 km/h	0.00		
		Sum	1.00				0.000000
STRATEGIC	2.5	Operational gain	0.20	From 0 to 100			0.000000
		Strategic importance	0.20	From 0 to 10			0.000000
		Port access	0.20	Yes	1.00		
				No	0.00		
		Growt Acceleration Program	0.20	Yes	1.00		
				No	0.00		
		PNLT/CNT	0.20	Yes	1.00		
				No	0.00		
		Sum	1.00				0.000000
SUM	10.0	Index of Priorization PROSEFER - IPP					0.000

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Prioritization of Solutions

Nr.	Municipality	UF	Corridor	Investment (US\$)	Type of Work
1	Curitiba	PR	05	43,000,000	Variant
2	São Francisco do Sul	SC	07	22,000,000	Contour
3	Belo Horizonte	MG	01	2,200,000	Viaduct
4	Joinville	SC	07	25,000,000	Contour
5	Barra Mansa	RJ	02	22,500,000	Integrated Sol.
6	Três Rios	RJ	01	8,300,000	Integrated Sol.
7	Candeias	BA	11	25,500,000	Contour
8	Belo Horizonte	MG	03	4,400,000	Viaduct
9	Ponta Grossa	PR	05	6,000,000	Viaduct
10	Paranaguá	PR	05	9,200,000	Viaduct

Examples of interventions – Barra Mansa/RJ



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Examples of interventions – Barra Mansa/RJ



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Examples of interventions – Barra Mansa/RJ



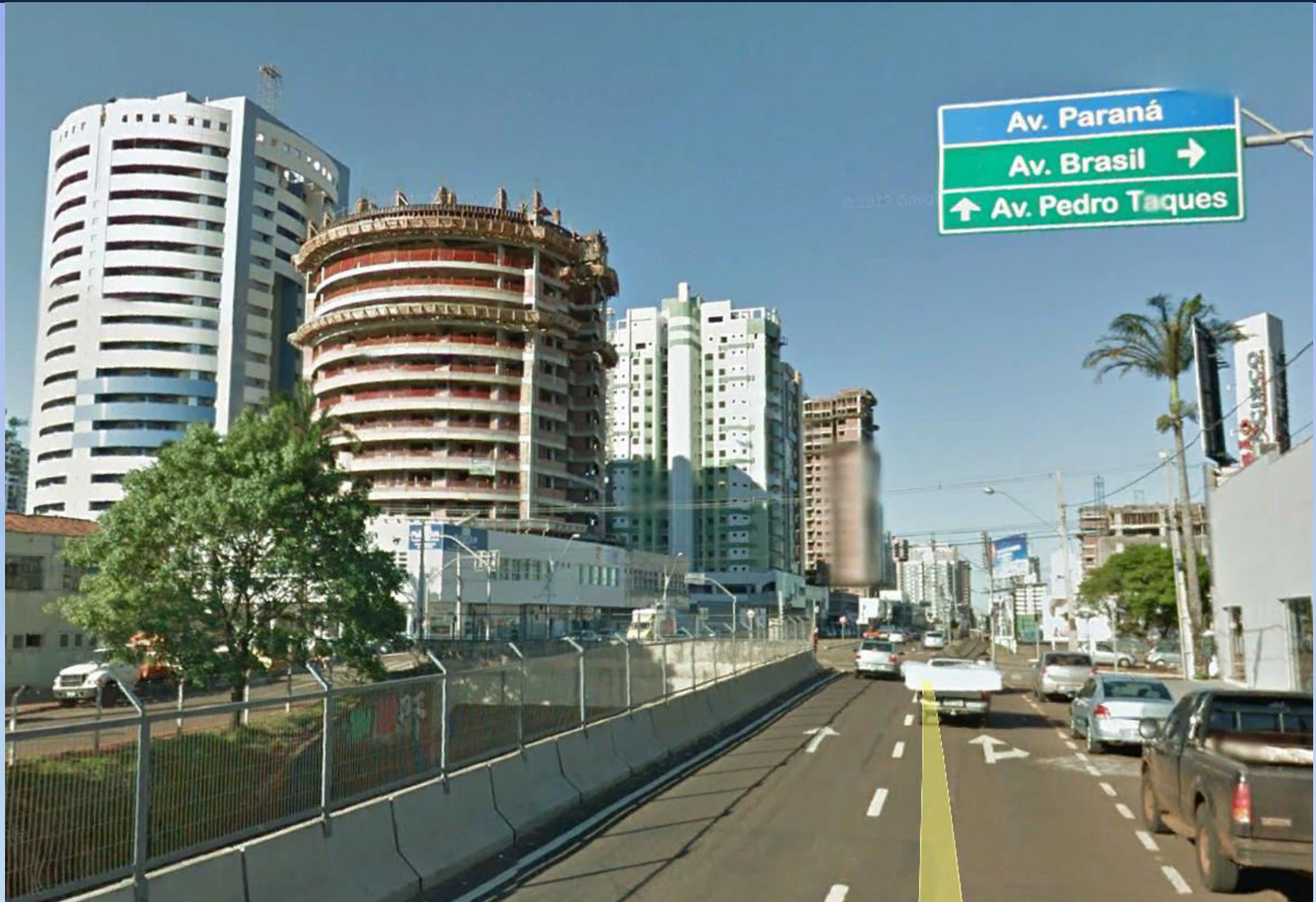
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Examples of interventions – Maringá/PR – lowering : 7.6 km



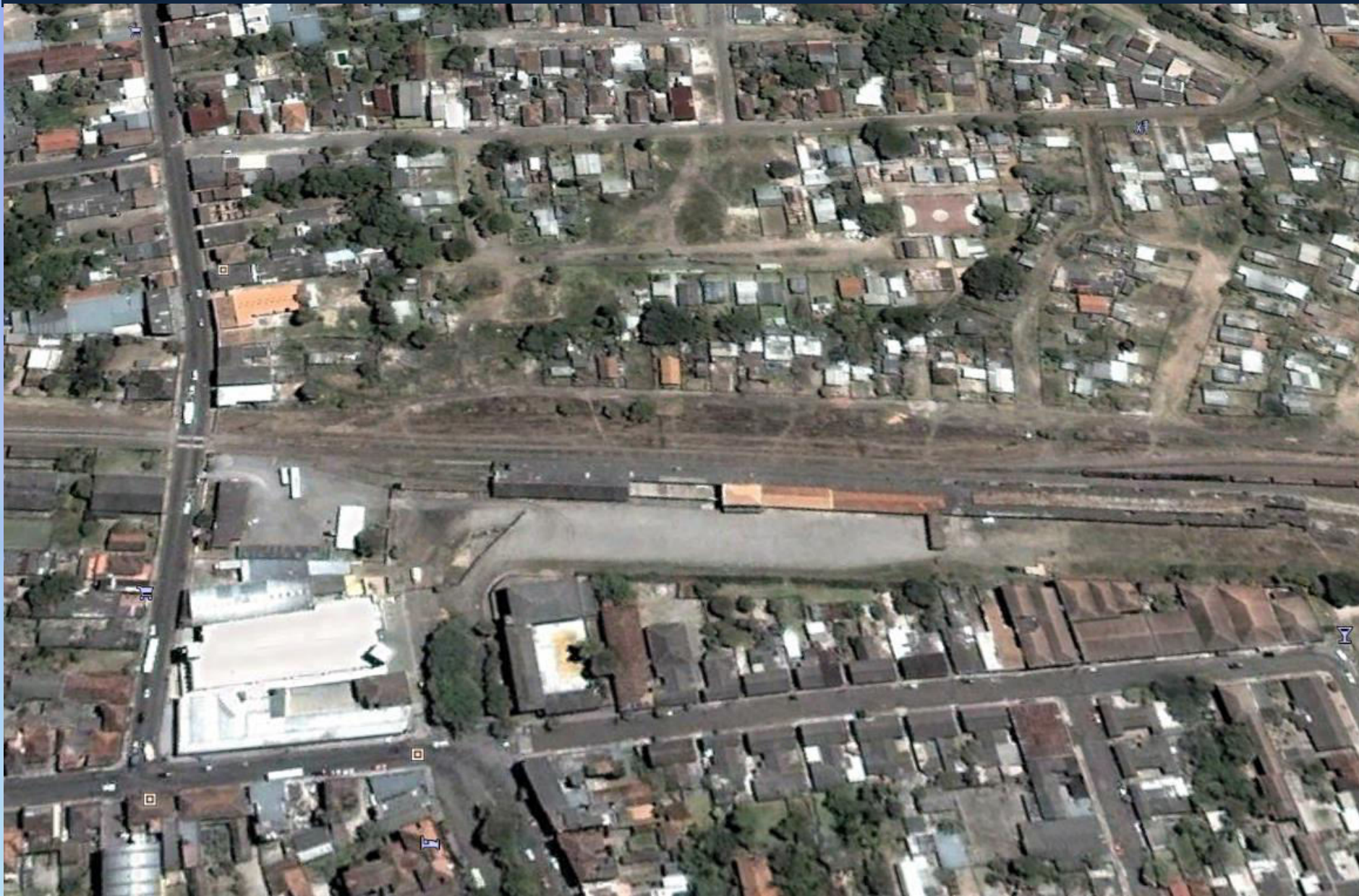
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Examples of interventions – Maringá/PR – false tunnel: 1.6 km



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Examples of interventions – Santa Maria/RS



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Examples of interventions – Santa Maria/RS



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Examples of interventions – Santa Maria/RS



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Examples of interventions – Araraquara/SP – contour: 8.65 km



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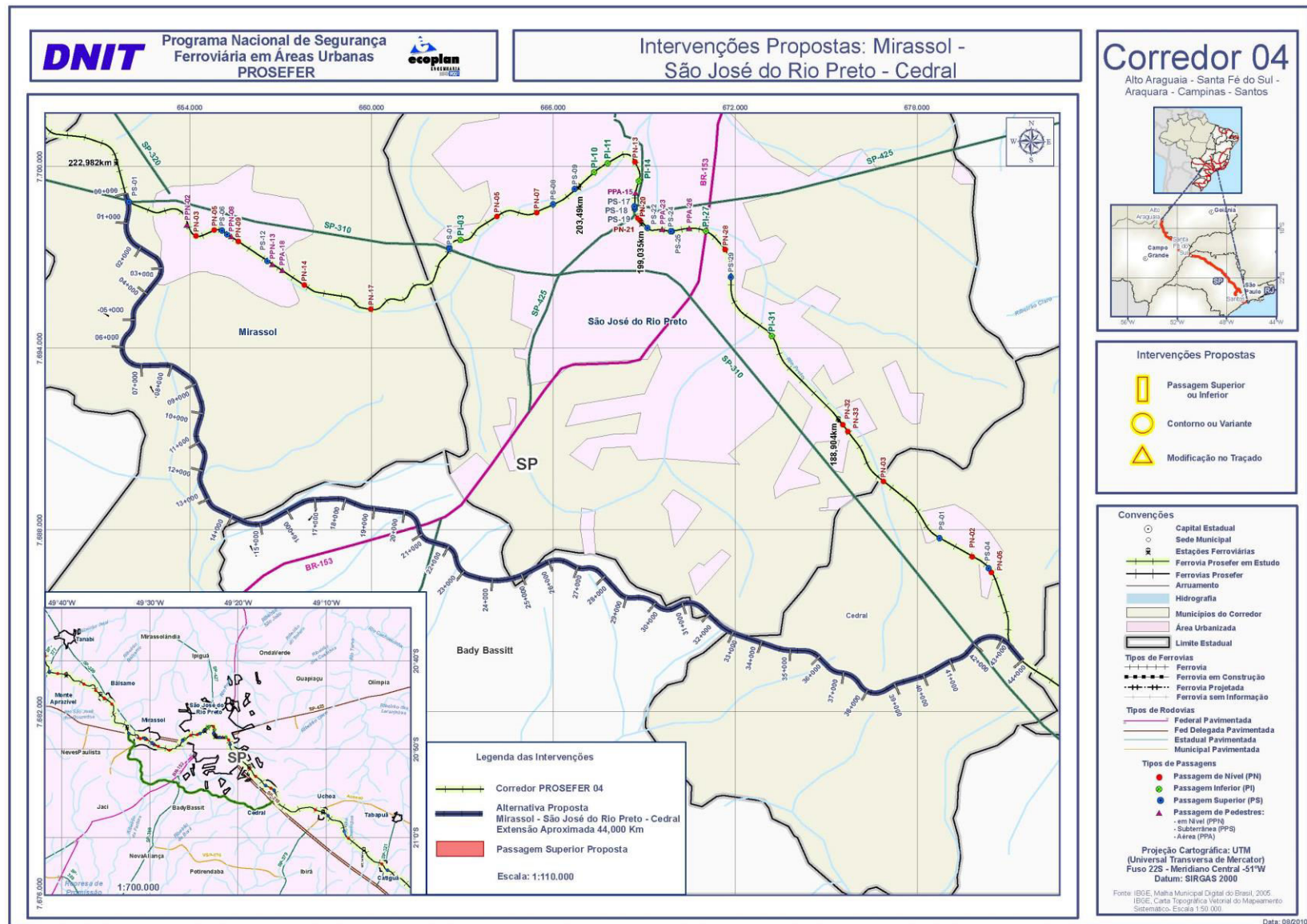
Examples of interventions – São José do Rio Preto/SP



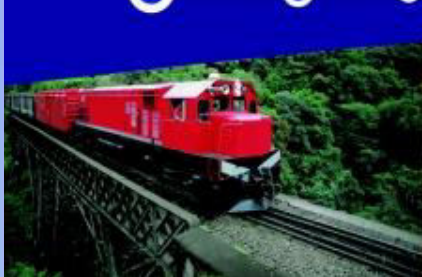
Derailment in São José do Rio Preto, Nov 24, 2013

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Examples of interventions – São José do Rio Preto/SP – variant: 44 km



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