



52nd Annual Convention and Transport Trade Show of the Association Québécoise des Transports

Road Tunnels Refurbishment
Important ongoing or completed abroad projects

The Italian approach in road tunnels refurbishment and safety implementation

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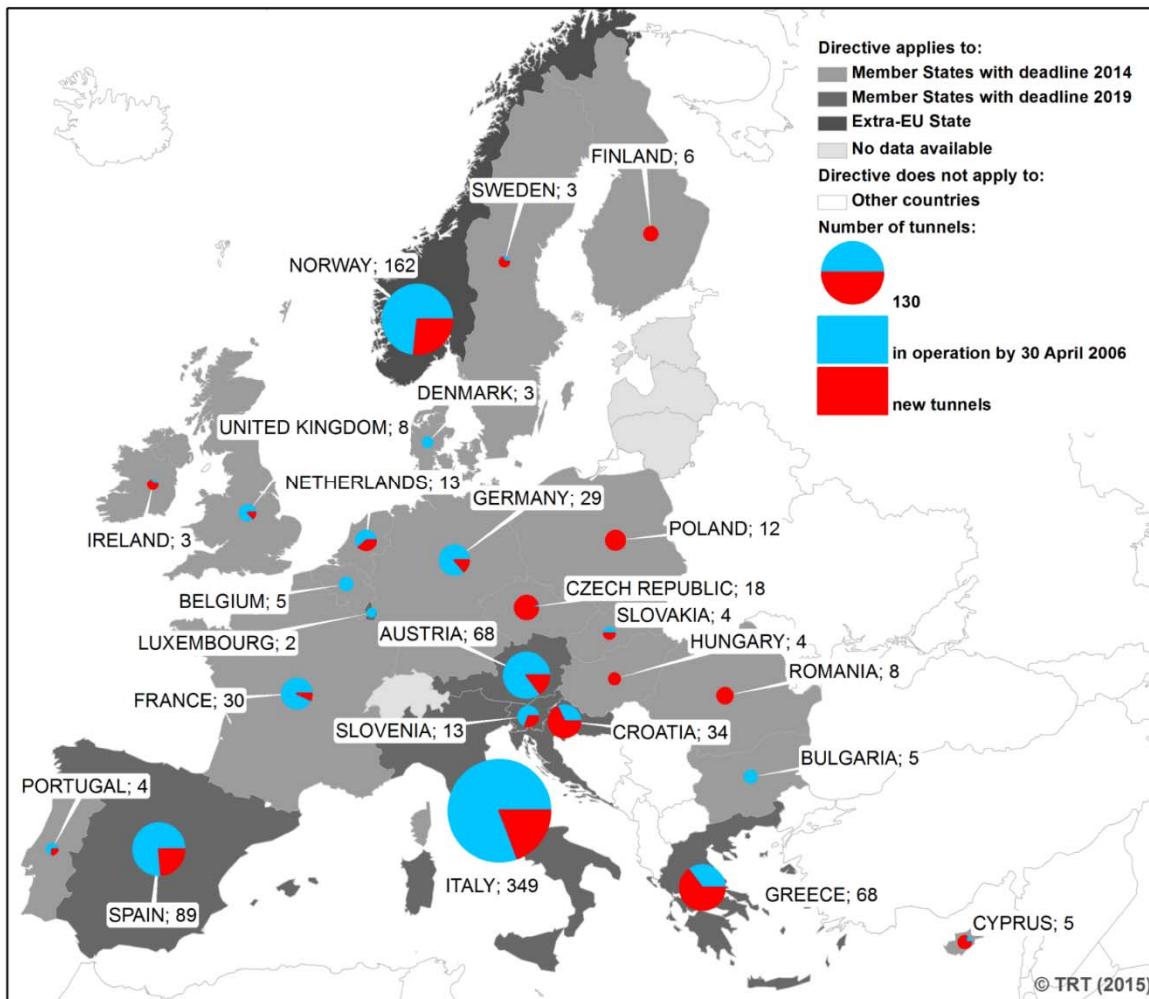
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 - ✓ Cima di Rovere Tunnel
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Number of tunnels in the scope of the Directive by country



ANAS SpA

NATIONAL ROADS AND
HIGHWAYS



26.000
km

About 1.300 km
of highways

1.300
Tunnels

800
km

101 Tunnels
in TEN-T Network
to update

89 one-way tunnels
12 two-way tunnels
190 tubes

EC Directive 2004/54

of the European Parliament and of the Council of 29 April 2004 on
minimum safety requirements for tunnels in the
Trans-European Road Network

Legislative Decree n. 264/06

- Structural measures
- MEP systems measures
- Management / Organizational measures as
 - ✓ maintenance plan
 - ✓ plan for emergency management
 - ✓ mode of acquisition of knowledge framework



Technical requirements

Structural measures



- n° of tubes and lanes
- Slope
- Emergency walkway
- Emergency exits
- Turning bay
- Lay-by
- Drainage of dangerous liquids
- Structural fire resistance

MEP systems measures



- Lighting
- Ventilation
- Emergency stations
- Fire-fighting
- Road signs
- Control center
- TVcc system
- Tunnel closing devices
- Communication systems
- Power supply
- Fire resistance material

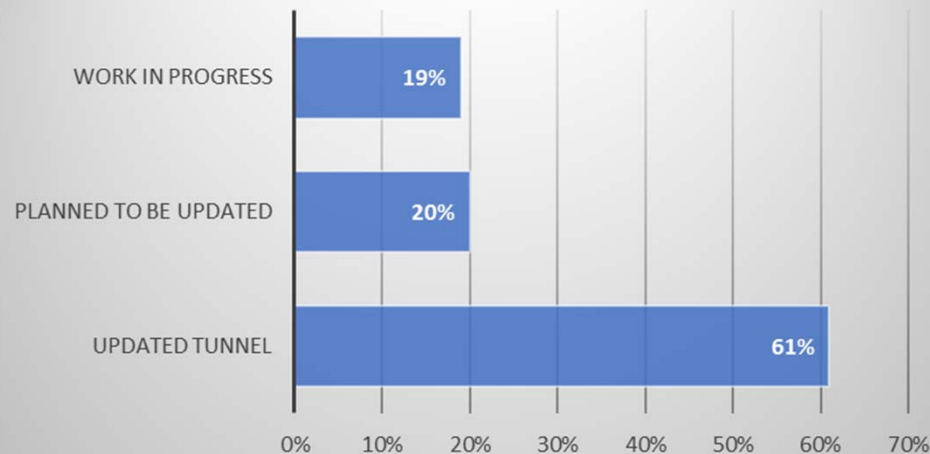
Organizational measures



- Contingency plan
- Maintenance operations
- Risk management
- Tunnel closure
- Transport of dangerous goods
- Overtaking control
- Safe distance control
- Information campaign



Updating of ANAS tunnels



Case histories

Cima di Rovere Tunnel



Appia Tunnel

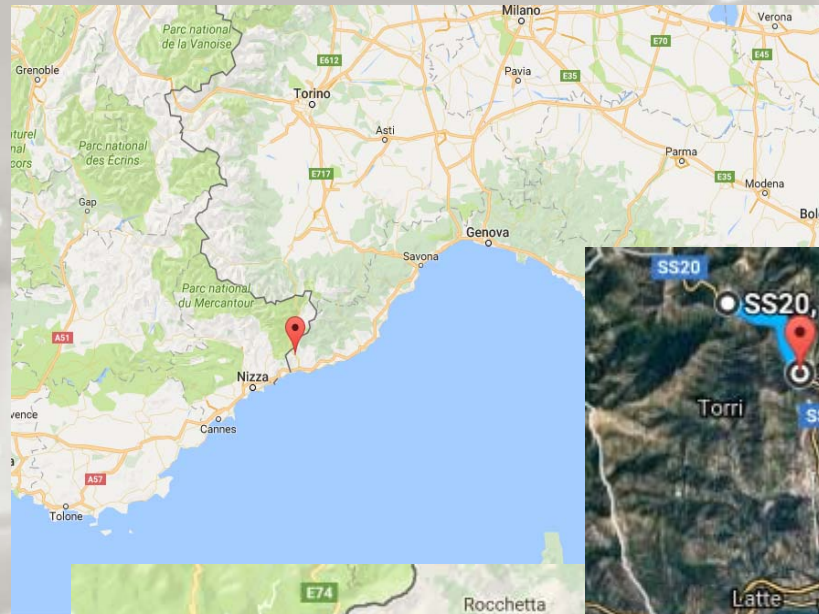
di Rovere Tunnel

ed along SS 20 close to
y of Airole (IM), in the
west of the Italy close
French border.

pen to traffic in 1996
2361m long.

affic is bi-directional
ngitudinally ventilated.
mergency exits.

al update investment:
12.000.000 €



Cima di Rovere Tunnel

Tunnel has 3 different cross sections: 3 circular and one, that is a rockfall protection too, is rectangular with windows.

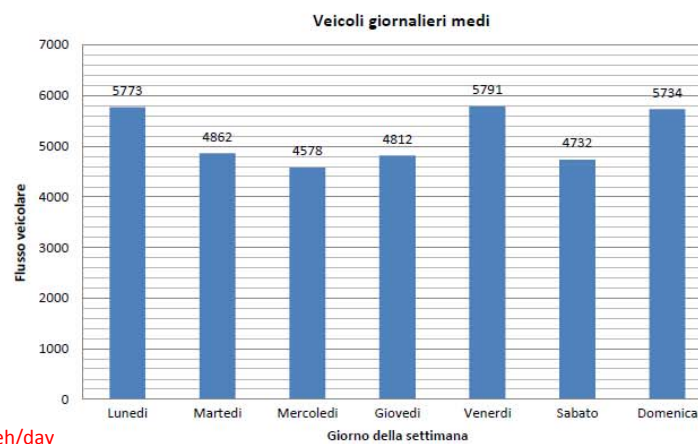
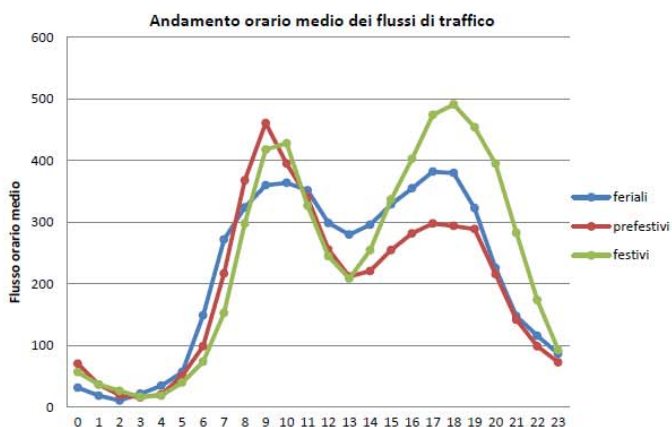
Each carriageway has one lane 4m large in each direction.



Cima di Rovere Tunnel - TGM

Tratta n. 350: SS20, Km 143.050, Ventimiglia(IM)

Direzione del Flusso	Consistenza Dati Pervenuti/Attesi	Veicoli Leggeri Volumi medi negli intervalli			Veicoli Pesanti Volumi medi negli intervalli			Velocità medie nei periodi tutte le classi		
		06:00-20:00	20:00-22:00	22:00-06:00	06:00-20:00	20:00-22:00	22:00-06:00	06:00-20:00	20:00-22:00	22:00-06:00
		flusso ascendente	50,00%	1504	198	181	60	5	8	67
flusso discendente	50,00%	2753	257	215	42	1	5	66	70	70



Giorno di punta del periodo: **domenica 31 luglio 2016**
Volume giornaliero di punta: **8229 [veicoli/giorno]**

4.100veh/day
per lane

Ora di punta: **domenica 24 luglio 2016 ore 18:00-19:00**
Flusso dell'ora di punta: **794 [veicoli/ora]**

Giornate con rilevamenti completi: **46**

di Rovere Tunnel

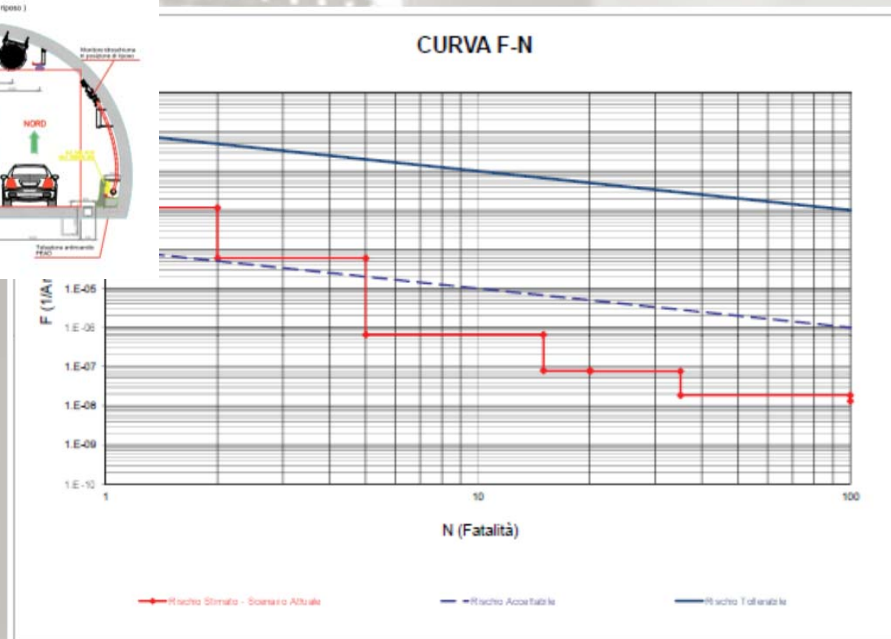
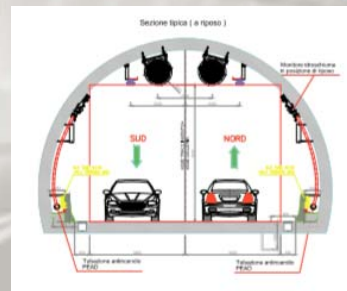
Quantitative Risk Analysis was performed and showed that some interventions of risk mitigation are needed:

MEP systems measures

- Lighting
- Automatic Fire-fighting
- TVcc system
- Tunnel closing devices
- Communication systems
- Power supply
- Fire resistance material

Structural measures

- Drainage of dangerous liquids
- Structural fire resistance



Appia Tunnel



Open to traffic in 2000, it is located along the Rome Ring Road, is a 1150m long tunnel, monodirectional traffic, 3 lanes each 3.75m wide.

It's longitudinally ventilated.

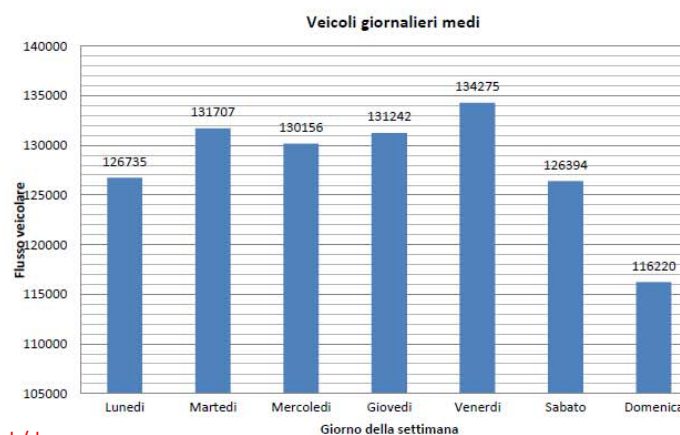
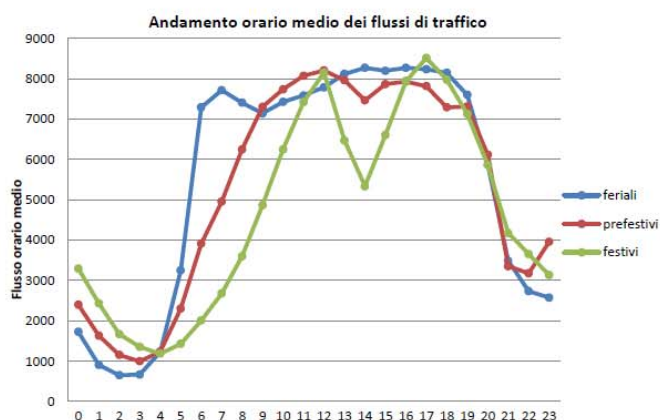
No emergency exits.



Appia Tunnel - TGM

Tratta n. 920004: A90, Km 42.100, Roma(RM)

Direzione del Flusso	Consistenza Dati Pervenuti/Attesi	Veicoli Leggeri Volumi medi negli intervalli			Veicoli Pesanti Volumi medi negli intervalli			Velocità medie nei periodi tutte le classi		
		06:00-20:00	20:00-22:00	22:00-06:00	06:00-20:00	20:00-22:00	22:00-06:00	06:00-20:00	20:00-22:00	22:00-06:00
flusso ascendente	100.00%	52175	4560	7718	2731	153	682	73	80	91
flusso discendente	100.00%	46277	4580	5972	2646	193	555	84	95	103



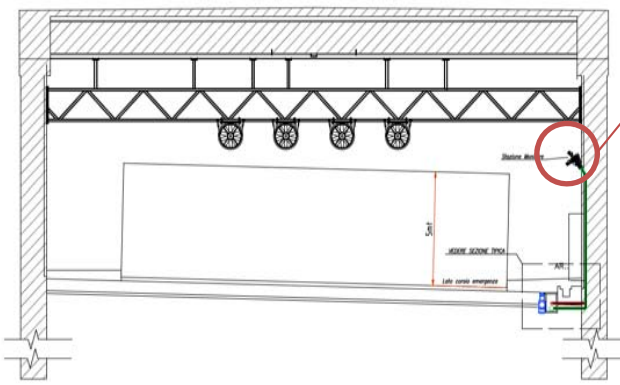
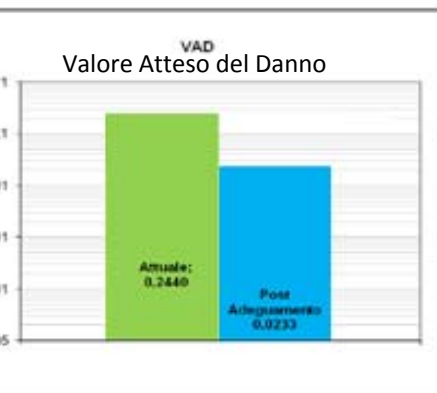
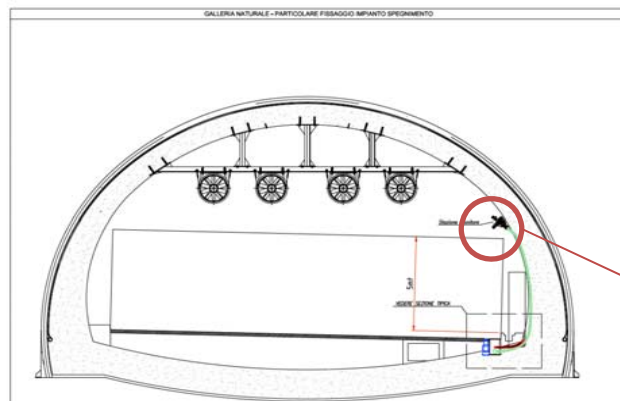
Giorno di punta del periodo: **martedì 29 marzo 2016**
Volume giornaliero di punta: **145878** [veicoli/giorno]

24.300veh/day
per lane

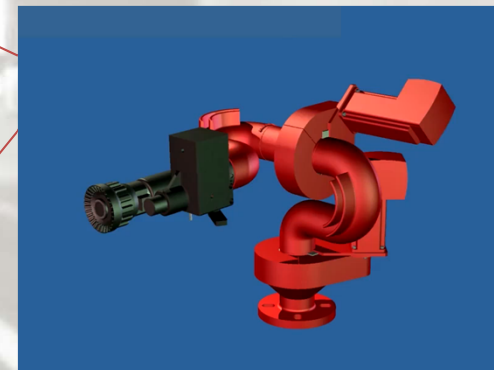
Ora di punta: **domenica 27 marzo 2016 ore 11:00-12:00**
Flusso dell'ora di punta: **10119** [veicoli/ora]

Giornate con rilevamenti completi: **90**

Appia Tunnel



Automatic extinguishing system, which use infrared cameras as a guidance.





Authomatic fire-fighting system



Updating old tunnels (construction and operation pre EU Directive)



Technical difficulties and excessive cost (financial and social)



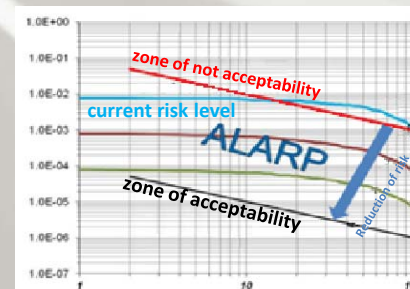
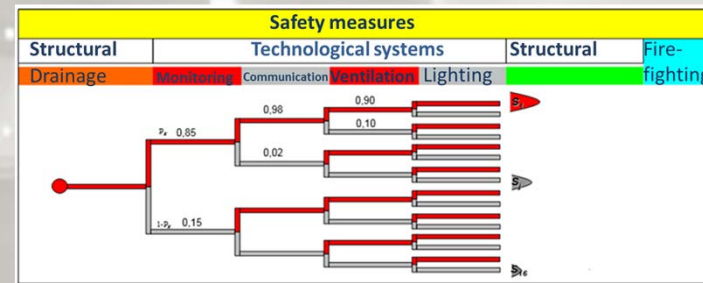
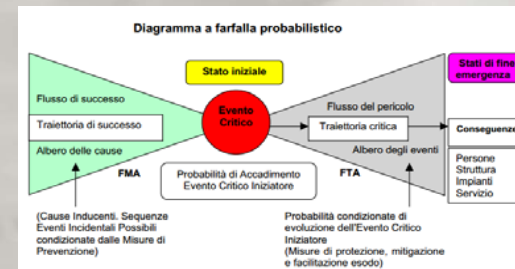
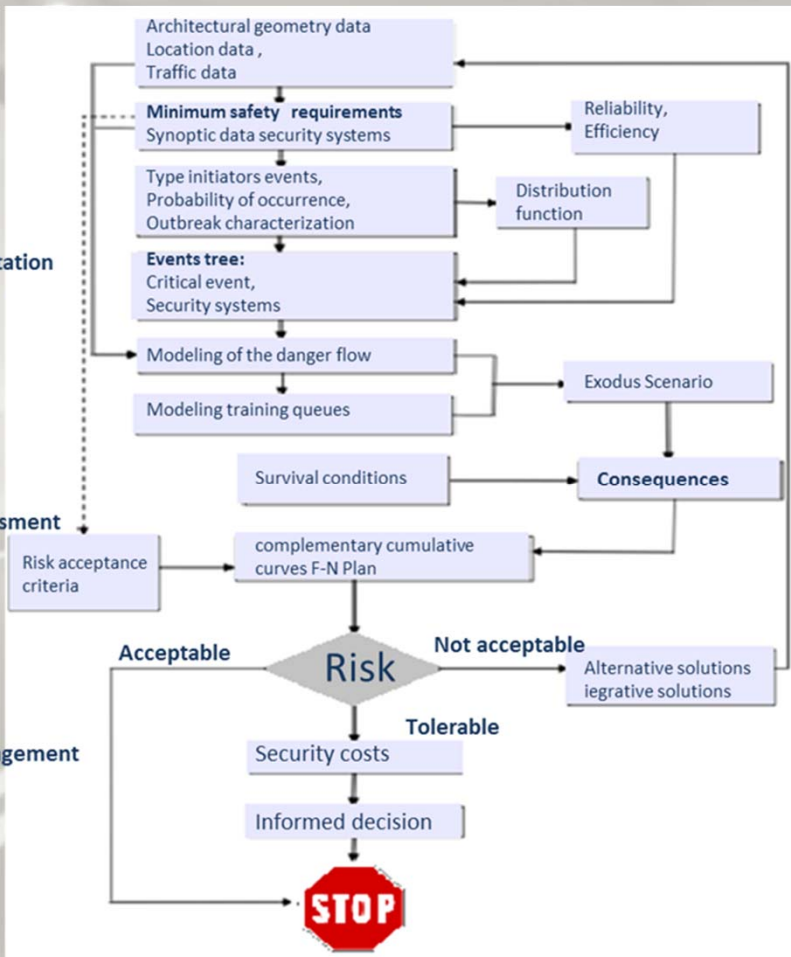
Operational measures and alternative measures



Quantitative Risk Assessment



Risk Analysis - Quantitative Method



$$R = F \otimes N$$

↑ Risk ↑ Frequency ↑ Consequences

Quantitative Risk Assessment



Smart Tunnel



Dynamic Risk Assessment

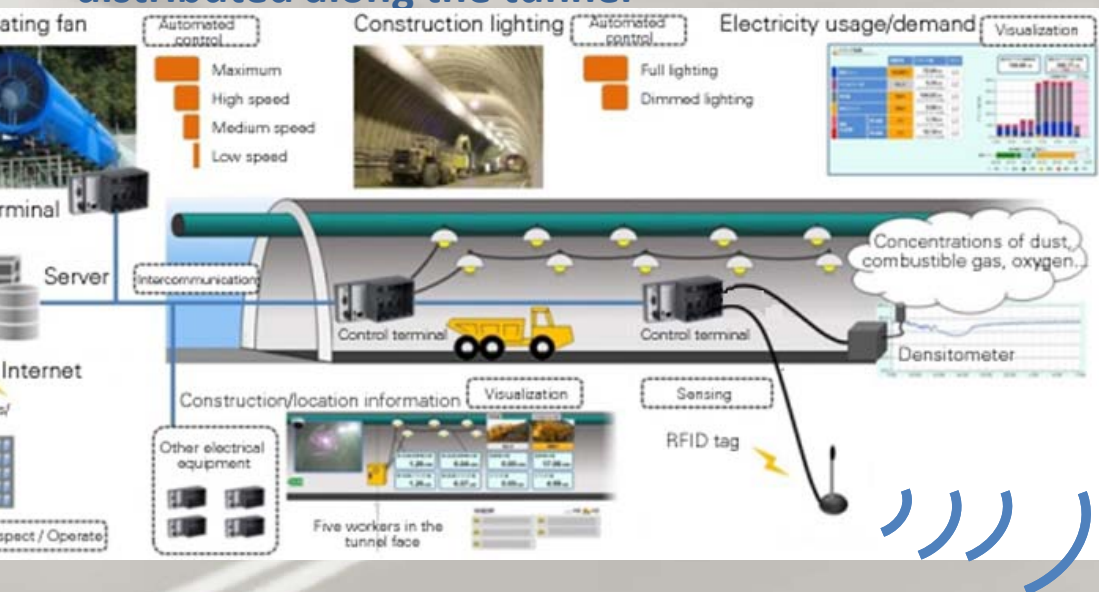
Smart Tunnel



- Developing and implementing solutions that improve safety aspects
- Developing management systems that help to prevent and control dangerous situations
- Constantly monitoring operating conditions
- Optimizing maintenance
- Having a predictive system of hazards

Smart Tunnel

IoT sensors sustainable redundant and distributed along the tunnel



Risk Calculation



Acoustic sensors: average speed, flow, congestion

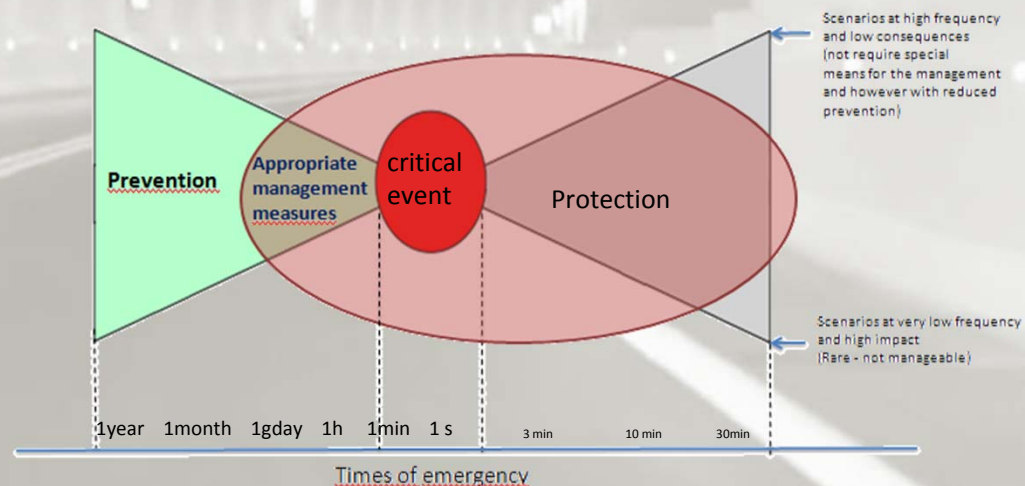
Environmental sensors: weather, air velocity, pressure, pollution, lighting

Detection: smoke, temperature, dangerous goods.

Dynamic risk analysis

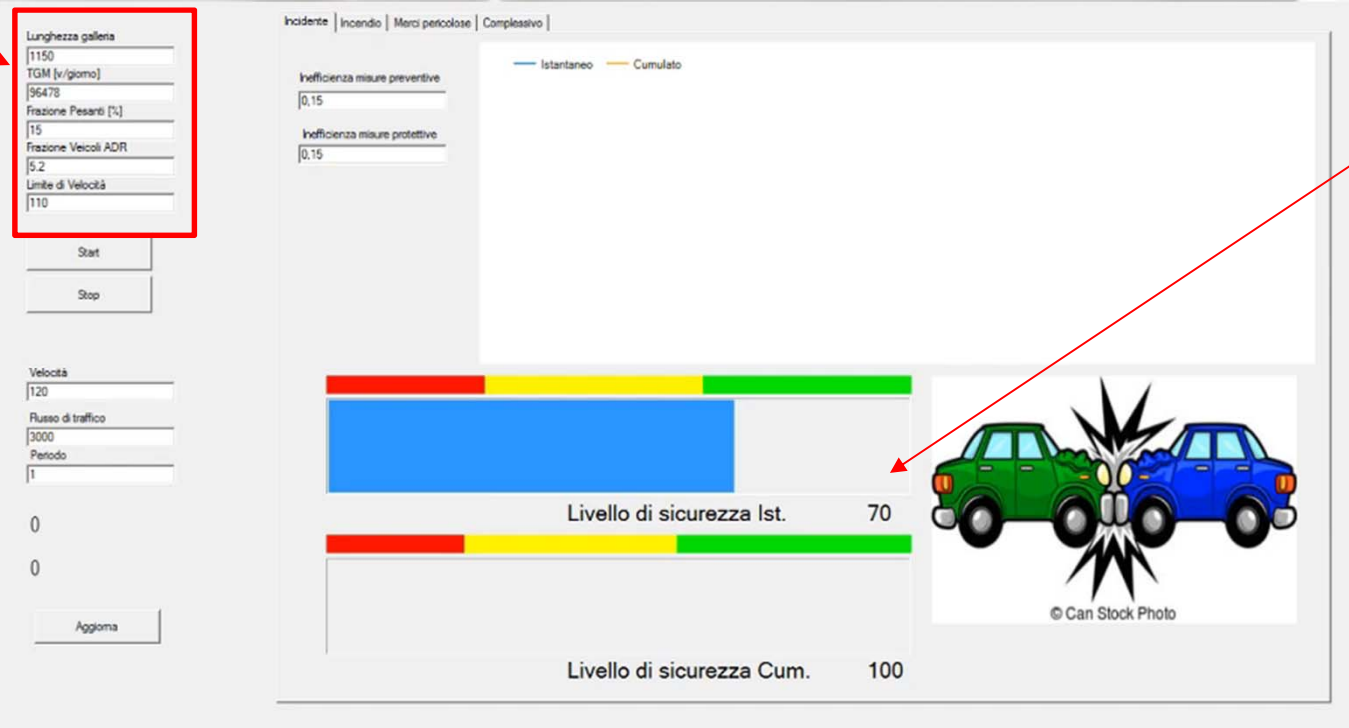
Dynamic risk analysis is a new tool that allows to:

- define the risk framework / safety level of a tunnel under operating conditions
- have a survey of the state of operation of MEP systems or the presence of any faults
- plan interventions of adjustment or maintenance
- work or emergency, when there is a malfunction of the systems or decreases the safety record
- assess if the safety level is acceptable (ALARP) or if it is necessary to introduce additional measures to mitigate the risk



Dynamic Risk - Analysis Simulation

Parameter



Real team
safety level

Conclusion

- ◆ Old tunnel often presents difficulties in upgrading to the new level of safety request by the users
- ◆ Difficulties can be originated by consequence on traffic condition (high social cost) or on the excessive cost to sustain (financial cost)
- ◆ The operational and alternative measure that respect high level of safety can be successfully applied thanks to new technologies and web based application (Internet of Things, IoT)
- ◆ The tunnel monitoring devices can be used to continuously monitoring the risk
- ◆ Dynamic Risk Assessment permit to decide how and when close the tunnel to keep low the risk level

**Thank you
for your patient and
attention !**