

# cantene'

# ARTU, a new tool for the risk assessment of existing and new road tunnels

Michele Fronterre – Project Manager  
Rugiada Scozzari – Fire Safety Engineer

**Innovation in Tunnels, 6th edition**

## Who we are



**Cantene** is a Torino Politecnico spin-off (Energy Dept.) specialized in **numerical modelling&simulations**.

### Intervention areas:

- metro and tunnel ventilation system design;
- high complexity sites fire protection projects (fire safety engineering);
- crowd management and large urban events.

## Our portfolio (tunnel and subways)

Fluid-dynamic (1D, 3D) and egress analysis of:

- road tunnels (including Frejus, Gronda di Genova);
- subways (including Copenhagen Cityringen, Riyadh line 3, Glasgow line 1).



*Planisphere designed by Freepik*

# Why risk assessment of road tunnels

Compliance with European Directive **2004/54/EC**



Decision-making during the **planning and design** of new infrastructures

Balance risks VS costs during **refurbishment** of existing infrastructures



# ARTU

- Cantene developed an **in-house tool** that implements a methodology for the **assessment of risk in tunnels**;
- The tool is called **ARTU**, which is the acronym for the Italian “**A**nalisi di **R**ischio **T**unnel” (Tunnel Risk Analysis).

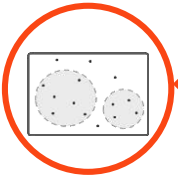
# ARTU aim and objectives



Focus on life safeguard (**societal risk**)



Focus on the occurrence of a **fire**



Large number of **possible scenarios**



Reduced **computational cost**

# ARTU methodology

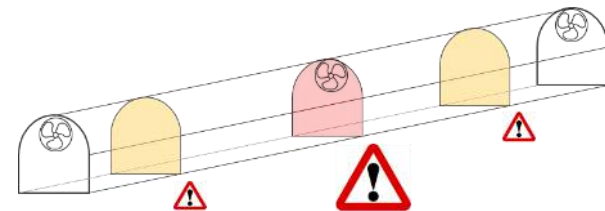
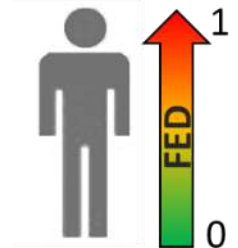
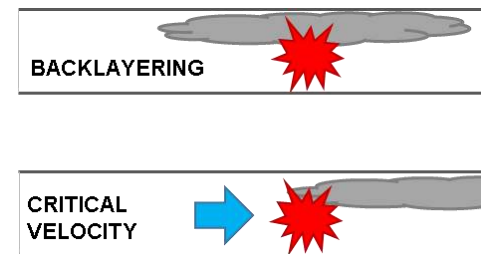
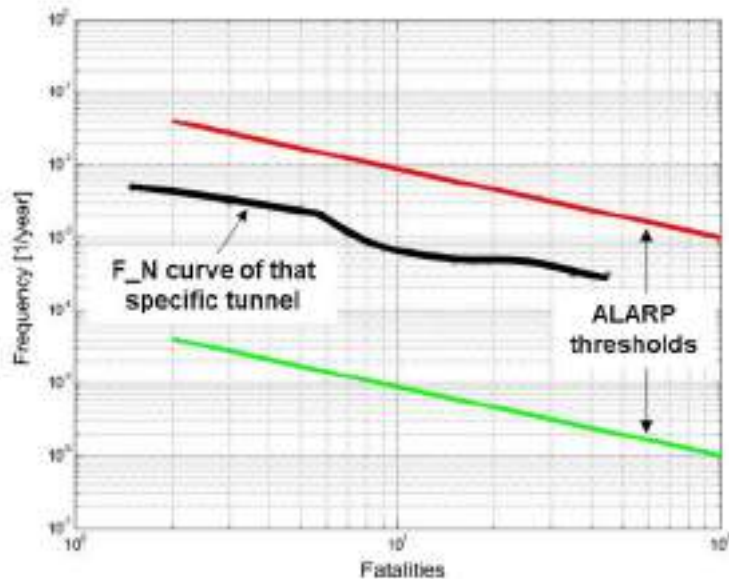
- Random sampling from statistical distributions is used to define **hundreds of fire/egress scenarios**;
- Smoke propagation inside the tunnel is modelled by means of **1D fluid-dynamics**;
- Evacuation simulation takes into account **environmental conditions**;
- **FED** (Fractional Effective Dose) is calculated for each agent at each time-step.





# ARTU output: FN curve and detailed results

- **FN-curve** expresses the risk associated to that tunnel and can be compared to an ALARP diagram accordingly to the regulations.
- **In addition** to the F-N curve, **ARTU provides**:
  - air velocity upstream the fire (comparison with critical velocity);
  - detailed description of damage (FED parameter);
  - presence of weak points in the tunnel.



# ARTU verification and validation

- **GOAL:** to verify if the calculation method is accurate enough, and equations are implemented correctly.
- **WHO:** **Lund University**, Division of Fire Safety Engineering.
- **RESULTS:** **ARTU provides conservative results for risk analyses in road tunnel.**

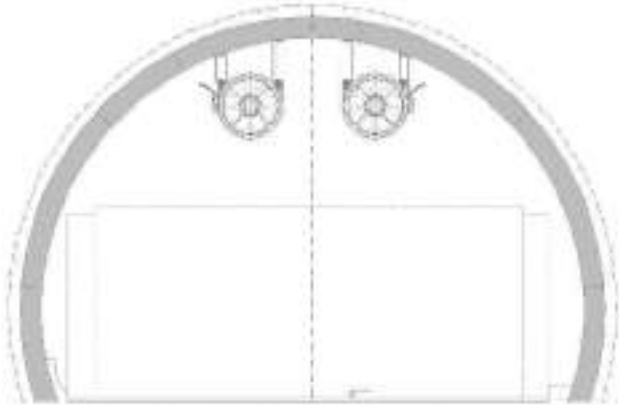


*Designed by iconicbestiary / Freepik*

ARTU has been validated for the following applications:

- ✓ longitudinal or natural ventilation;
- ✓ Fire starting in a vehicle, no fire spread between vehicles;
- ✓ no fire suppression system,
- ✓ no BLEVE or other explosions;
- ✓ no analysis of technical systems malfunctioning.

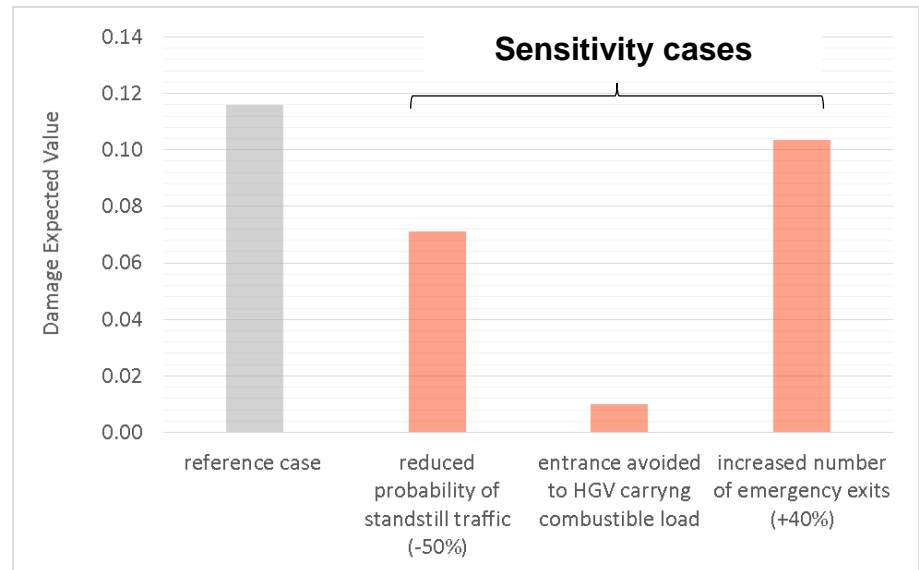
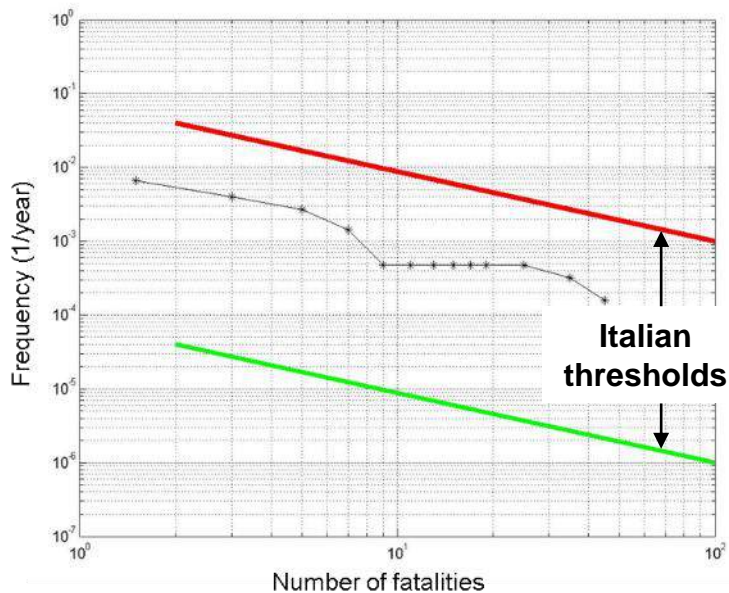
## Case study



Typology	<b>Highway tunnel</b>
Length	7.7 km
Cross sectional area	94m <sup>2</sup>
Slope	-2.5%
Number of emergency exit	30
Traffic direction	Unidirectional
Average annual daily traffic	30.000 veh/day
% of heavy goods vehicle	18%
Ventilation system	Longitudinal
Fixed-fire extinguishing system	None

## Case study – ARTU results

- ARTU returns a **FN-curve**, that can be compared with the threshold set by the **country regulation**.
- ARTU returns a FN-curve for each sensitivity case, different cases are compared using **Expected Value**.



# Conclusion

- **Risk assessment** has become an integral part of tunnel documentation both for new and existing tunnels (**2004/54/EC** Directive).
- Cantene developed an in-house tool for the assessment of risk in tunnels, called **ARTU**.
- ARTU has been **validated** by the Division of Fire Safety Engineering of Lund University.
- Validation process and a case study presented here show that ARTU gives **conservative results, with a limited computational cost**.

**To know more about ARTU please visit  
<http://www.cantene.it/products/artu/>**

## **Cantene - FSE and tunnel ventilation**

**Cantene S.r.l.**

VAT Number: IT09645800013

Address: Via Marco Polo, 24 - 10129 Turin - Italy

Phone: +39 011.19707165

**E-mail: [info@cantene.it](mailto:info@cantene.it)**

**[www.cantene.it](http://www.cantene.it)**

