The Kornati Island Accident

A Preliminary Analysis

by

D. X. Viegas, L. Ribeiro, L. Pita

and C. Rossa

ADAI, Department of Mechanical Engineering
University of Coimbra, Portugal

Contents

Introduction

- The accident of Kornati Island was very unfortunate for the loss of 13 lives.
- Our aim in studying this and other accidents is not to find guilties or to blame anyone but rather to find what happened and to extract lessons, to avoid future accidents.

- We had access to some data that was provided to us by Dr. Darko Stipanichev and his team. Part of this material was in Croatian language and also the time that we had available to analyse this case was not enough.
- Therefore only a preliminary analysis shall be presented here. This work is open to debate and to be improved by further data and research.

Methodology

- In the analysis of similar accidents we try to get as much information as possible. If it is practical we visit the site, speak with intervenients, survivors, and try to reconstruct the accident.
- Our goal is to understand the movement and behaviour of both Personnel and of fire.
- The final objective is to extract lessons to avoid similar accidents.

Initial fire spread

- It is known that the fire started at Vrulja Bay at 11.40h on the 30th August 2007 and the accident occurred at Sipnate canyon at 15.26h.
- The distance between these two points is around 6.6km.
- The average ROS was therefore of the order of 1.97 km/h (54 cm/s).

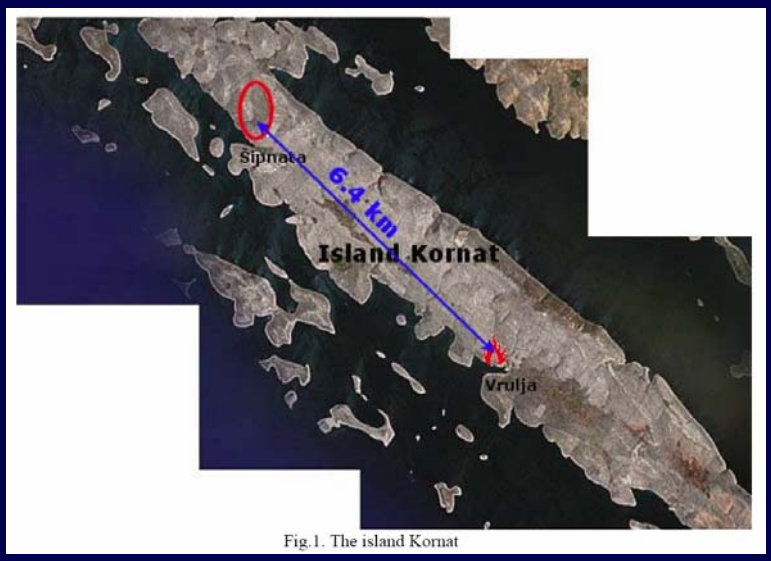

Fig.1. The island Kornat

Typical vegetation cover in Kornati


Fig.38 Island Kornat – 10 km to the south

Fig.32 Unburned canyon part (West part second half to top).

Fig.33 Unburned canyon part (West part second half to top).

Fig.20 On bushes with wooden parts only leaveson all of them were burned. Wooden parts were burned only on bushes located on south side but not all. On some of them only the surface was burned.

- Most vegetation can be considered as herbaceous with some mixture of small shrubs, with discontinuities due to rocks.
- Dr.Darko and his Group estimated an average fuel load value of Mc=0.6 kg/m2.

Fig.34 Island Kornat – the same day – the same fire – 3 km south

Fig.36 Island Kornat – the same day – the same fire – 3 km south

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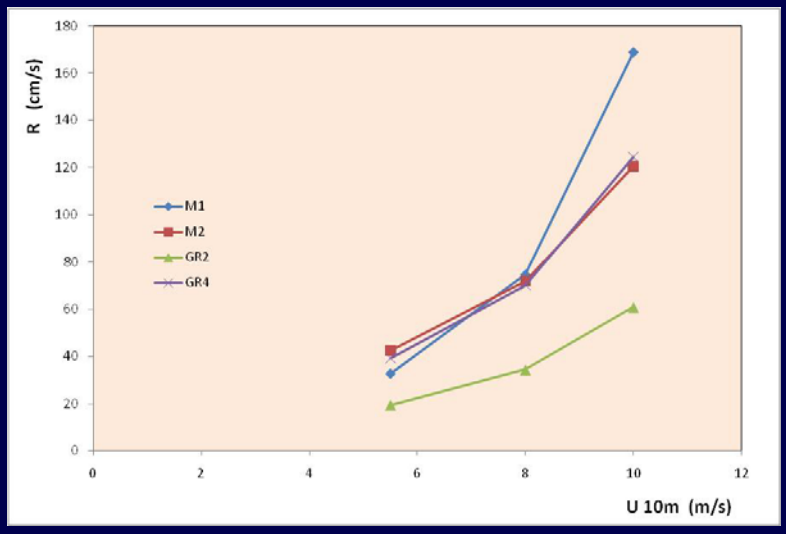
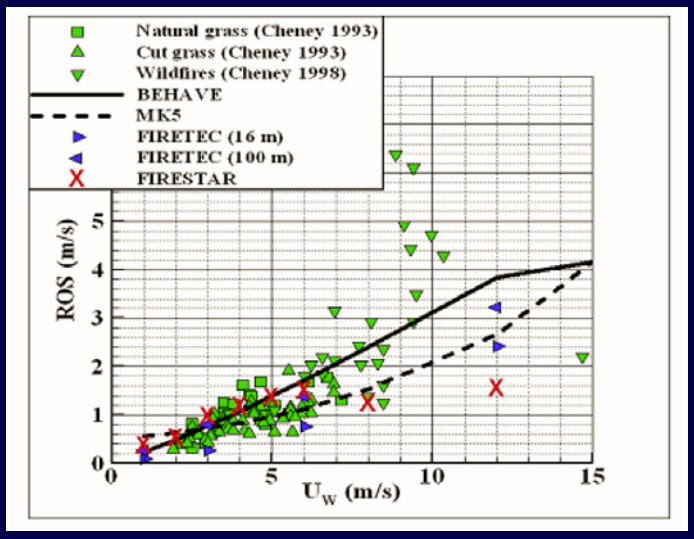
Behave model simulation



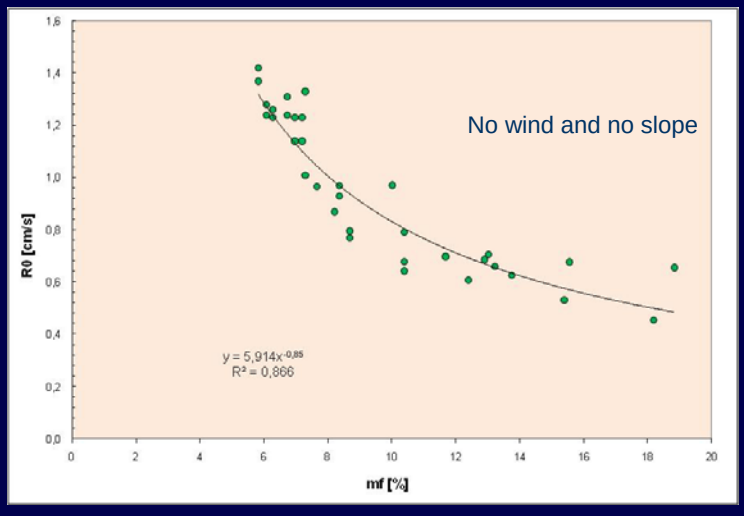
Comparison between different models and experimental data



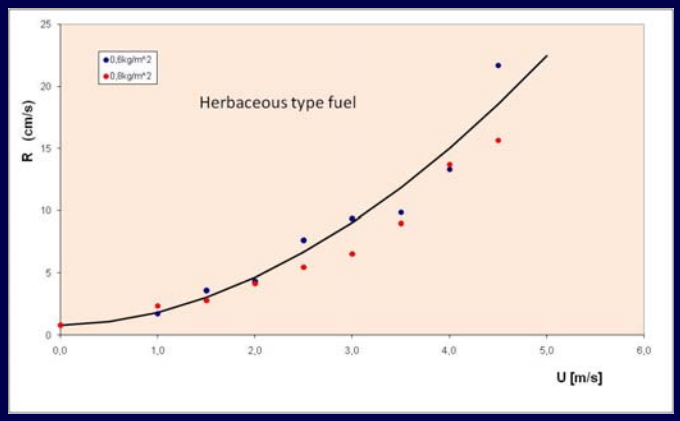
Laboratory analysis at Coimbra

- We performed an extensive research of wind effect on herbaceous type of fuel.
- In our experiments we use straw as a fuel because it is obtained from a herbaceous type of plant.

Moisture content effect on the ROS



Velocidade de Propagação para uma dada Velocidade do Vento



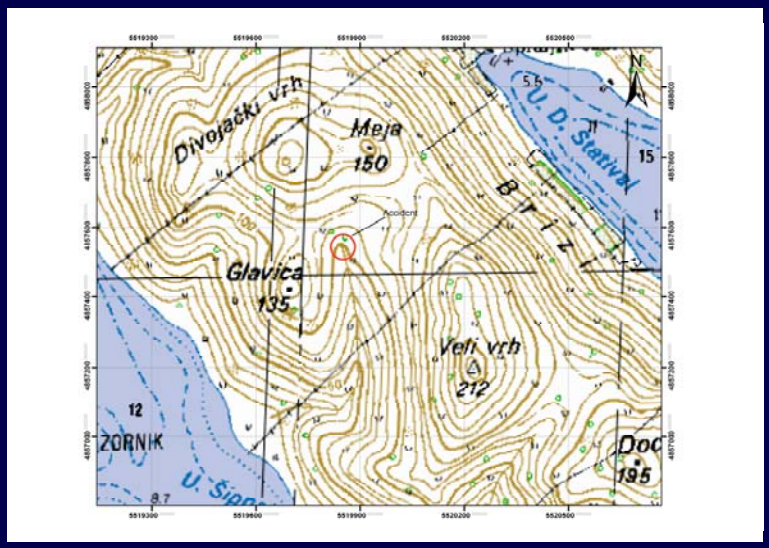
- Extrapolating this regression to larger wind velocity values we should need a reference wind velocity of 9 m/s to have an average ROS of the order of 50 cm/s.

Law velocity for straw

$$R = R_o(1+1.3U_{REF}^{1.88})$$

Canyon Geometry and simulation

- The canyon of Sipnate is rather complex. It has a “water line” that is not a straight line. Its faces are not planar and besides it is closed by a second slope: “box canyon”.
- In our analysis we shall consider a simplified for of the canyon.



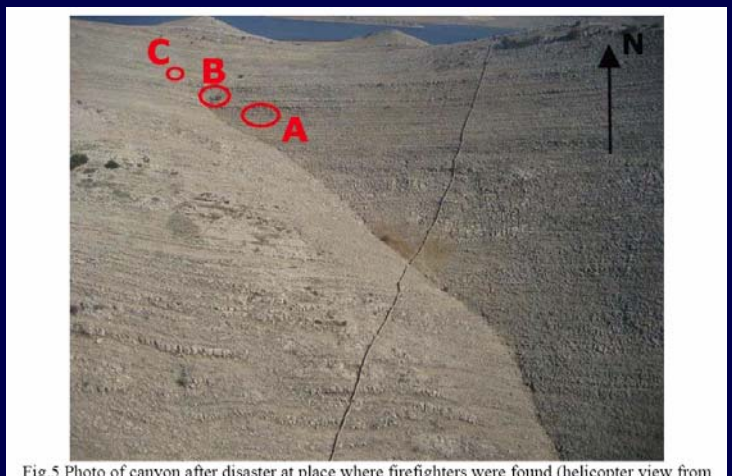


Fig.5 Photo of canyon after disaster at place where firefighters were found (helicopter view from south part)

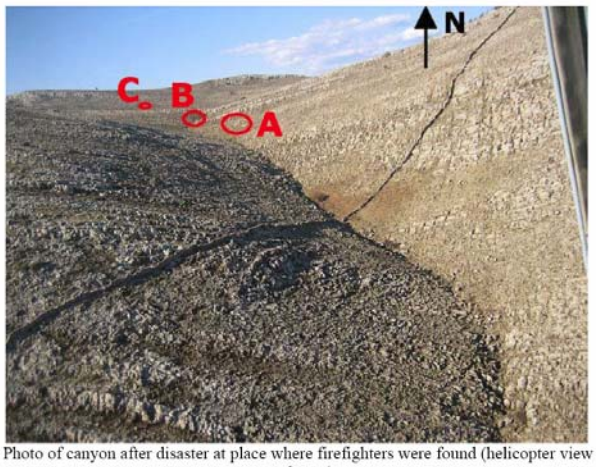
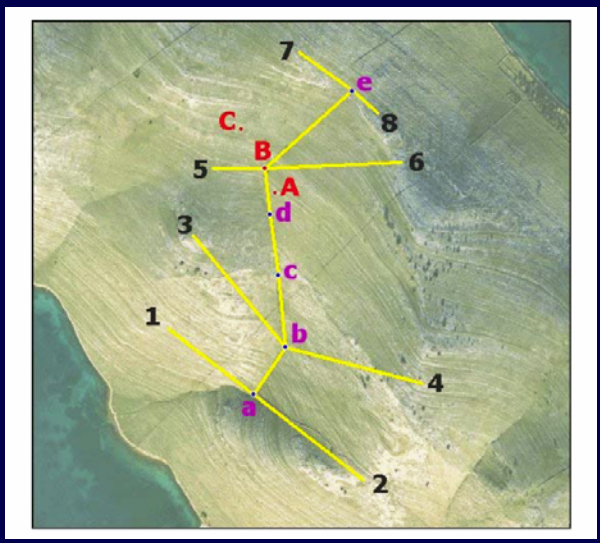
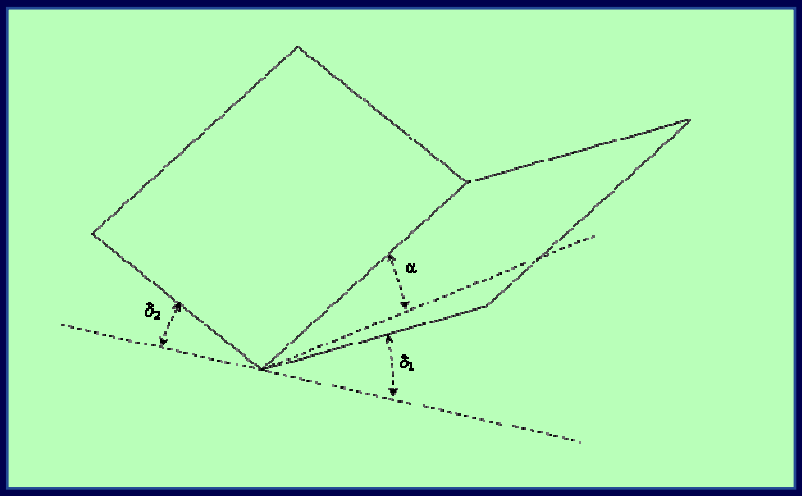


Fig.6 Photo of canyon after disaster at place where firefighters were found (helicopter view from south part)



Canyon geometry definition



Laboratory simulation of fire

- We performed a series of experiments with the general geometry of the Kornati canyon.
- The fuel was straw with a load of 0.60 kg/m^2

- Ignition was made at a point in the symmetry line of the canyon.
- We did not consider wind in the tests.
- Frames at 10 and 20 second intervals will be shown.

Profile 1

- Tests in the small table

Profile	α	$\delta 1$	$\delta 2$
1	7.2	7.9	8
2		15.9	11.3
3		22.7	9.5

- Profile 2

(10 seconds between frames)

- Other tests on the Large Table with a larger value of the angles to take into account the effect of wind.

- Alfa=17º
- Delta 1 = 14º
- Delta 2 = 10º

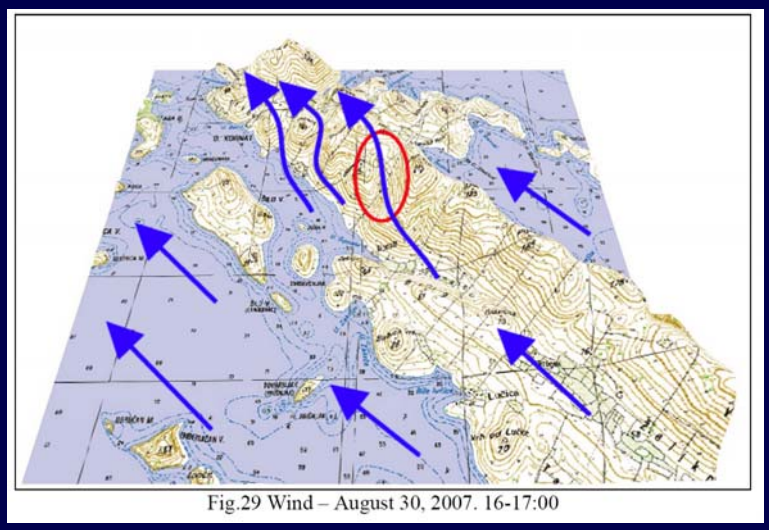


Fig.29 Wind – August 30, 2007. 16-17:00

Fuel was straw

Fuel load was 0.6 kg/m^2

Setting of angles δ_1 and δ_2

Setting of angle α

Setting the ignition point

Digital video and

Infra Red cameras

- Sequence of video images taken at 10 sec time steps.


00m 00s


00m 10s


00m 20s


00m 30s


00m 40s


00m 50s


01m 00s


01m 10s


01m 20s


01m 30s


01m 40s


01m 50s


02m 00s


02m 10s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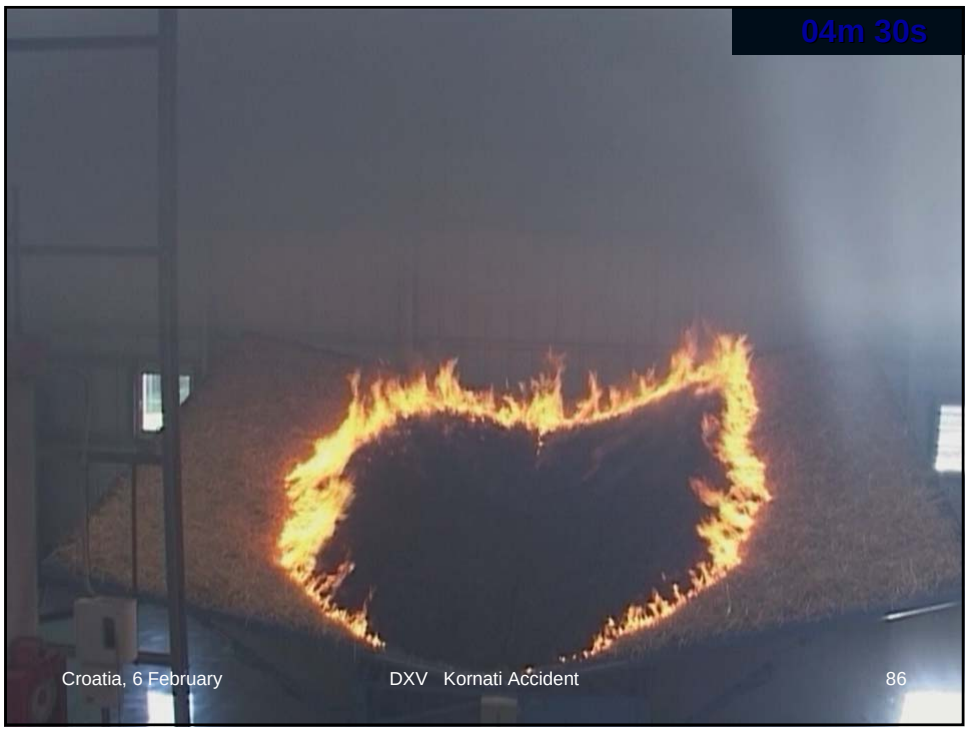
04m 10s


04m 20s


04m 30s


04m 40s


04m 50s


05m 00s


05m 10s


05m 20s


05m 30s

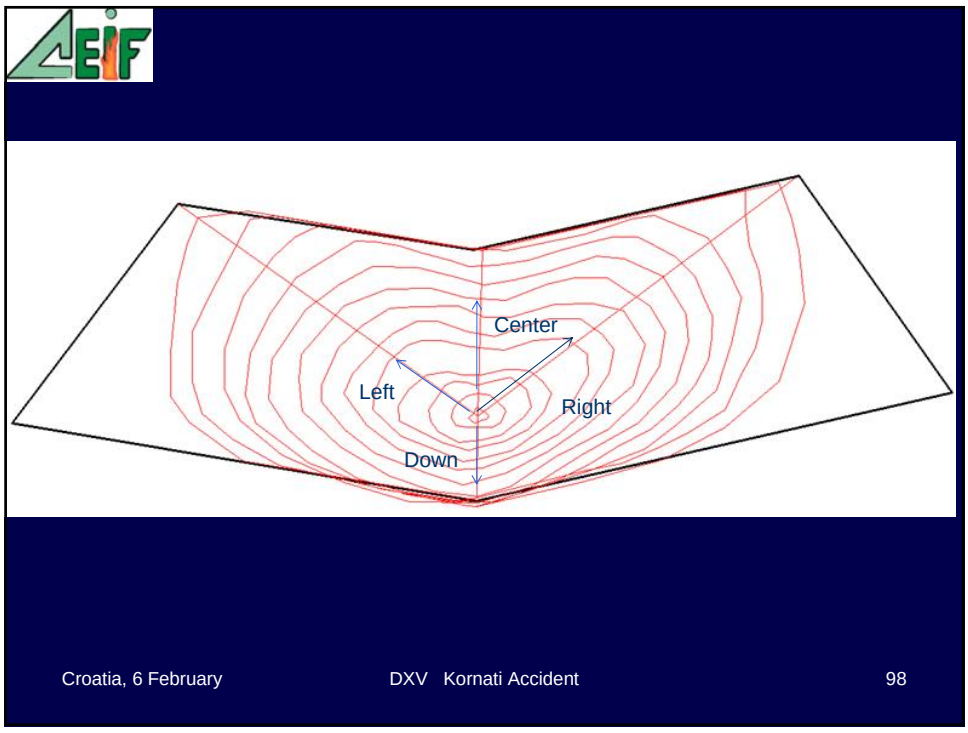

05m 40s

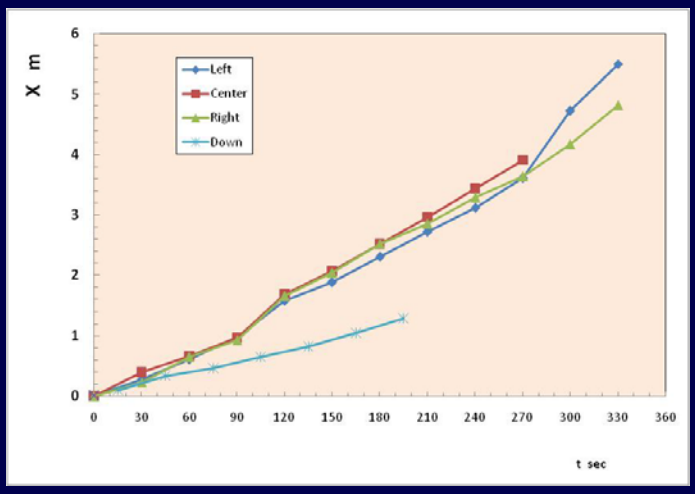

05m 50s


06m 00s


06m 10s


06m 20s

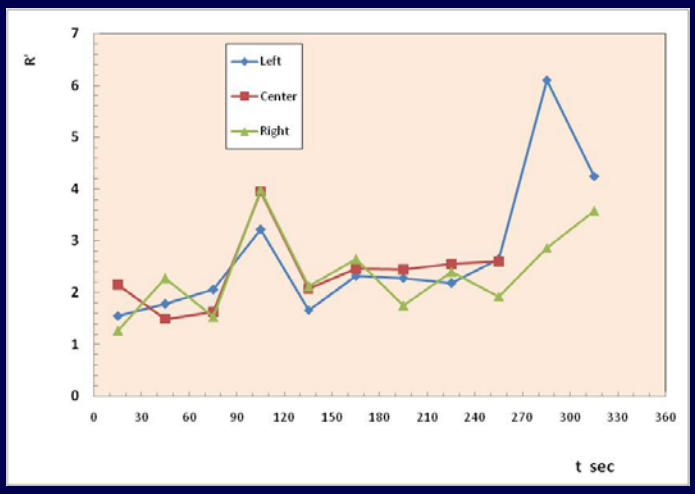

Center
Left
Right
Down



The experimental value of Ro in this case was:

Ro=0.61 cm/s

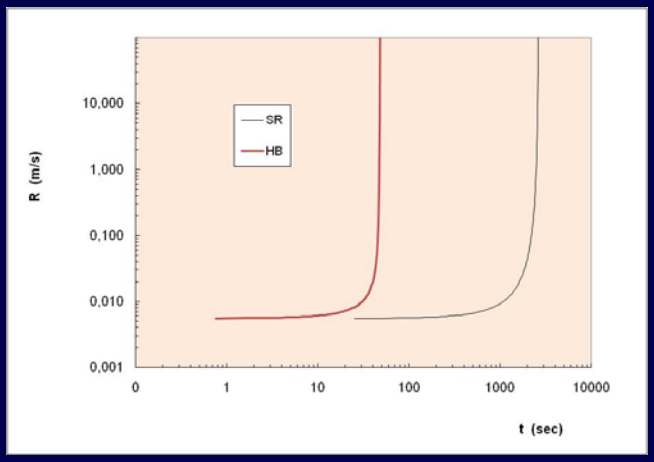
Non-dimensional ROS in the canyon



Application of the Mathematical Model

- We applied the mathematical model for eruptive fire behaviour to the present case.
- The parameters of the fuel have to be determined more carefully as we do not have sufficient experience with herbaceous fuels.
- The influence of the canyon configuration on the model parameters has to be better developed.

Application of standard model with average values of the parameters



- In the present case we have a less steep and less closed canyon. It is reasonable to assume that the induced flow parameters are smmaler than for the standard case of α=25º and δ=25º.
- We need to study better the dependance of a_2 and b_2 on α and δ.

Test of the Eruptive Fire Behaviour Model

Model parameters:

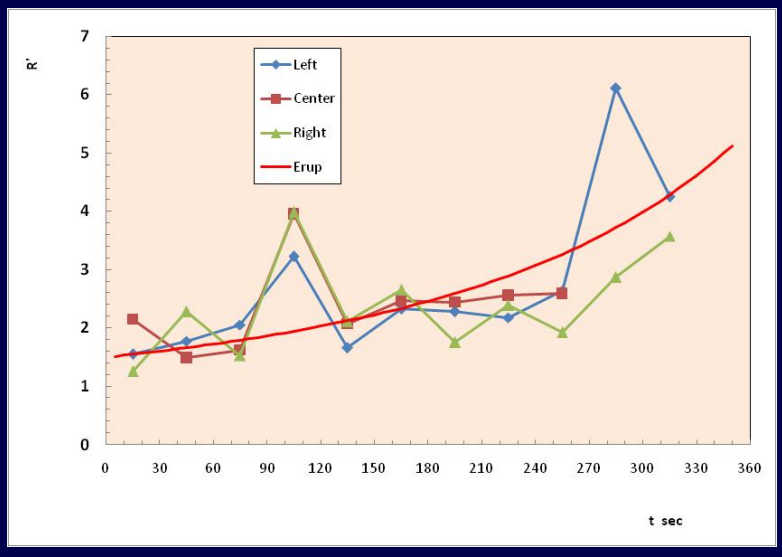
a'_1=0.2 — These values were measured in the wind tunnel or this particular fuel

b_1=1.8

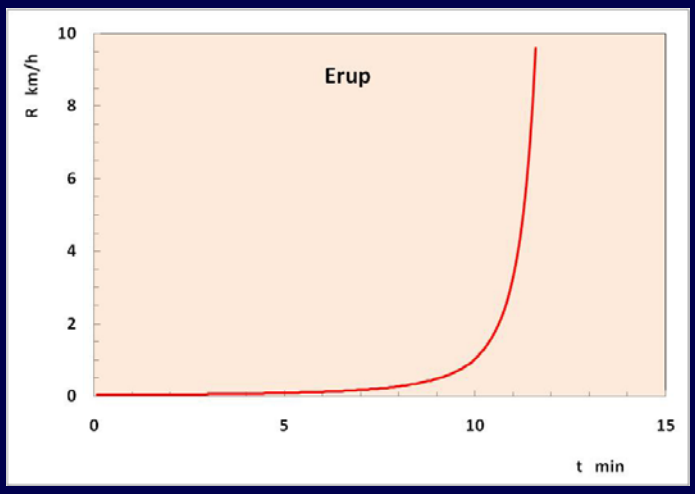
a'_1=0.2 — Adapted to take into account the geometry of the canyon

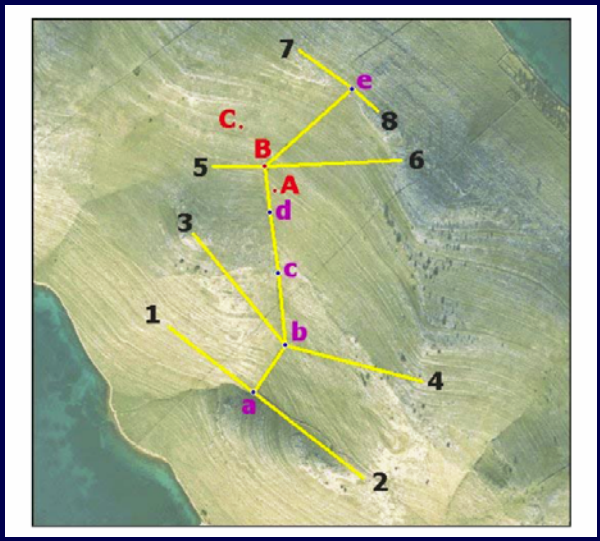
b_2=1.0

t_o=50 sec

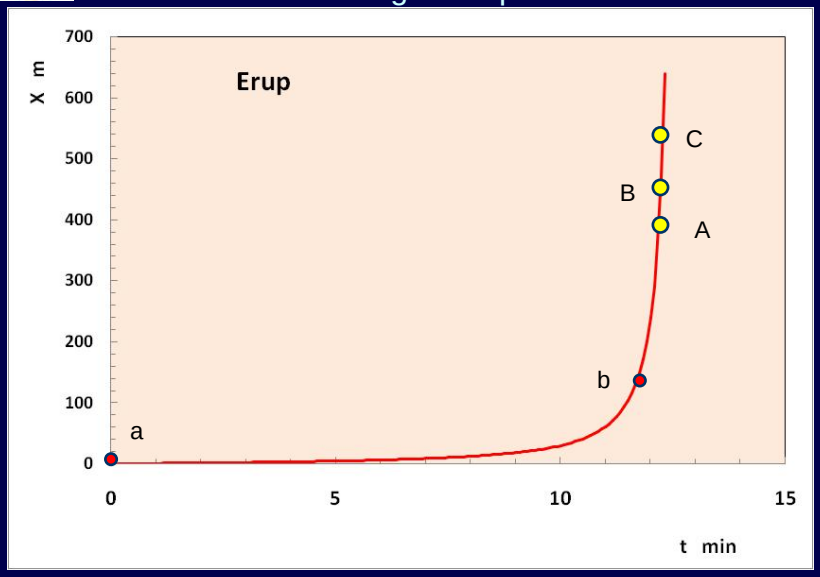


Full size conditions

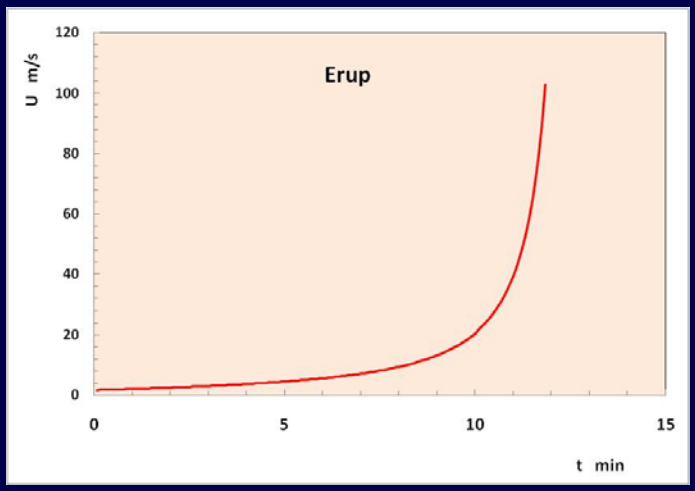




Distance run by the fire in herbaceous vegetation according to eruptive model



Induced wind velocity at the fire front



Travel distances and times on the terrain

From:	To:	Distance	Elevation	Travel time (min)		
				Velocity (km/h)		
		m	m	2	4	6
a	**b**	131	20	3,9	2,0	1,3
b	**c**	163	26	4,9	2,4	1,6
c	**d**	137	19	4,1	2,1	1,4
d	**B**	103	12	3,1	1,5	1,0
a	**B**	534	77	16,0	8,0	5,3

Travel distances and times for personnel

- We are dealing with distances of the order of 150 to 300m for personnel travel and of the order of 300 to 500m for the fire.
- The range of velocities for personnel travel seems to be adequate given the difficulty of the terrain. It is reasonable to assume na average velocity of 3km/h going up and perhaps 4km/h going down.

From this site Point A can not be seen

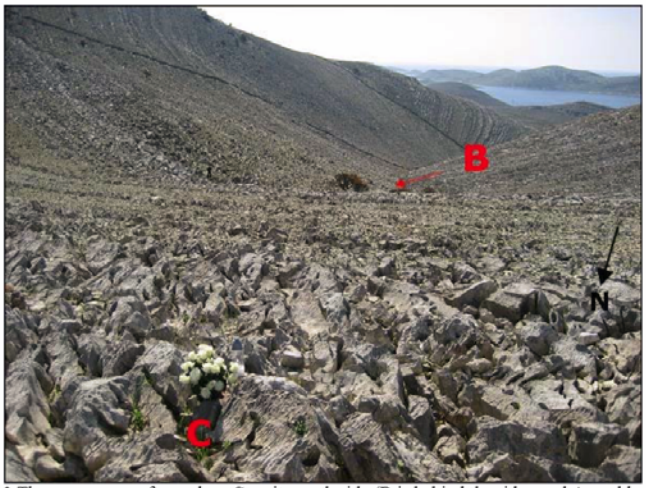


Fig.13 The canyon seen from place C on its north side (B is behind the ridge and A could not be seen)

From this point the bottom of the canyon can not be seen.

Fig.16 The canyon seen from place behind A (west side)

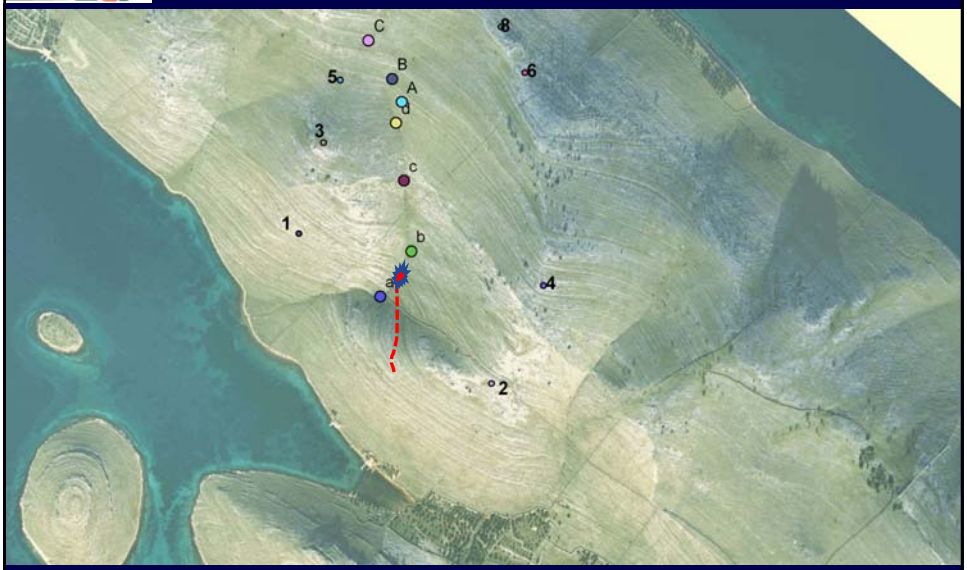
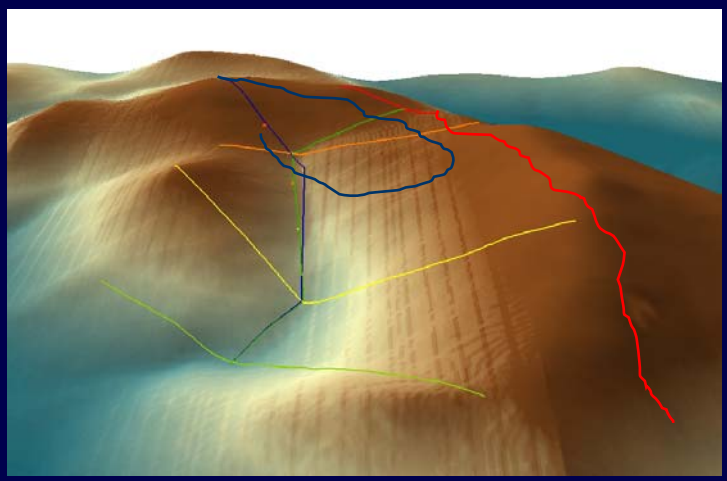
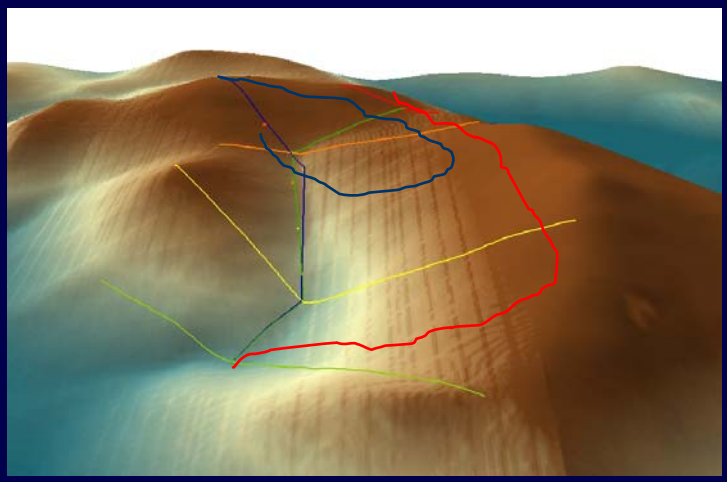
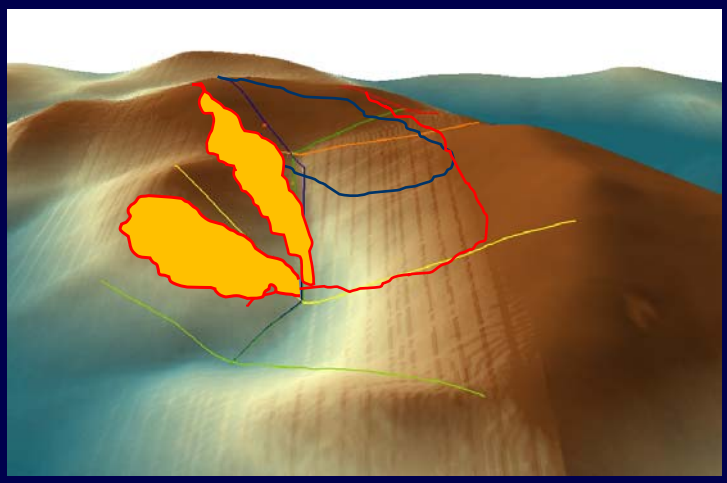


Fig.34 Island Kornat – the same day – the same fire – 3 km south


N
Accident





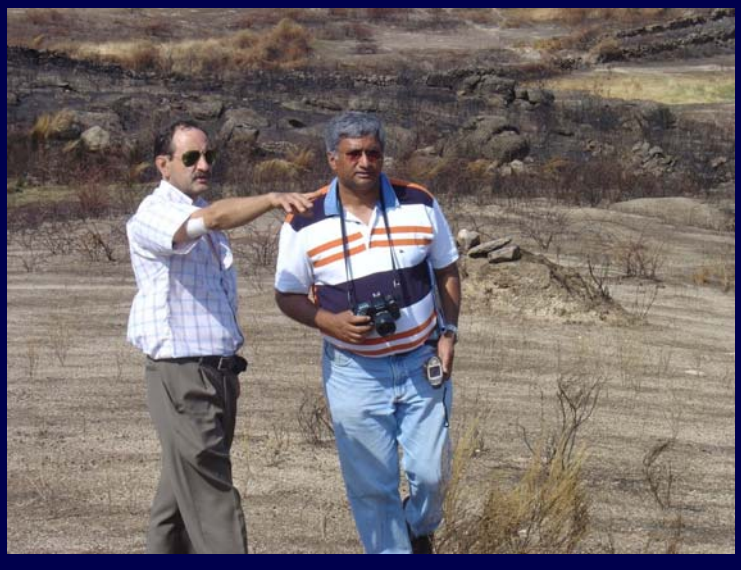


Similar cases

- When you deal with a large number of cases it is not difficult to find comonalities between cases that occurred in very different places.
- It is important to compare these cases, to extract the lessons and to consolidate our assumptions.
- Two cases:
  - Castelo de Vide Accident (Portugal, August, 2003)
  - Palasca Accident, (Corsica, France, September, 200)

Castelo de Vide Accident

- In 2003 among the 18 accidents with 22 fatalities that we investigated in Portugal there was one in which a fire fighter was killed by a grass fire. Two other were wounded.
- They had a fire truck full of water but decided to run away because teh fire was encircling them.
- One that was left behind did not escape the burn injuries.




CASTELO DE VIDE 1
8
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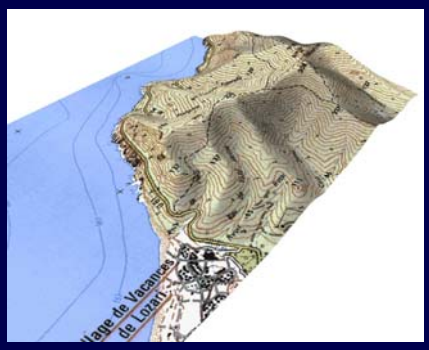
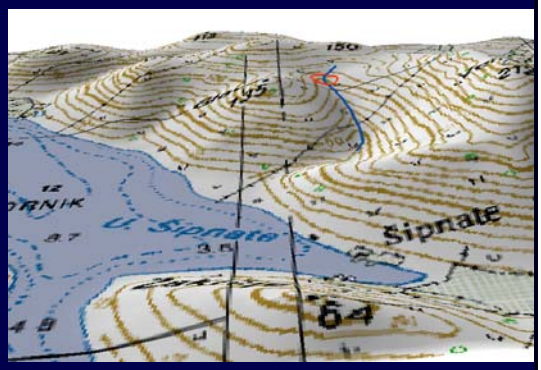
Palasca Accident

- This accident occurred in the North of the Island of Corsica on the 7th September 2000.
- Two fire fighters were killed by a fire eruption.
- An amateur video of this fire exists.


Village de Vacances
de Lozari

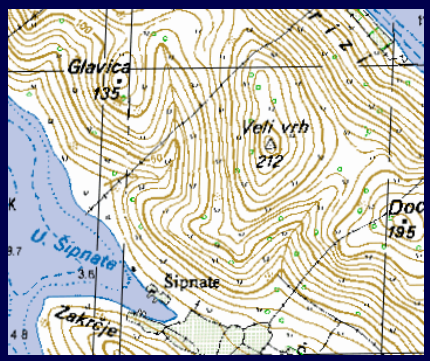
Configuration of the two canyons

Palasca



Kornati

Palasca



Kornati

Amateur video

Conclusion

- According to our preliminary analysis the existence of a fire eruption is most likely in Sipnate canyon during the accident.
- The simulation show that the fire must have bifurcated in both slopes, cutting the possibility of escape to the Fire Fighters.
- We do not exclude other possibilities of explanation of this accident but would like to stress that the ambient conditions of this fire were very favourable to such na event.

- Even if it did not occur in this case, we consider that the concept of eruptive fire behaviour should be introduced to all the personnel dealing with forest fires in Croatia.
- The danger associated to this type of fire behaviour should be known to everybody, especially when dealing with fires in complex topography and/or with strong wind.