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**EUFIRELAB:**  
**Euro-Mediterranean Wildland Fire Laboratory,**  
**a “wall-less” Laboratory**  
**for Wildland Fire Sciences and Technologies**  
**in the Euro-Mediterranean Region**

**Deliverable D-09-03**

**How to improve the safety and the efficiency of the fire  
fighters**

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## SUMMARY

The study on forest fire accidents has led to the conclusion that they do not merely occur during big fires and that the global vegetation state (drought years) is not a determining factor: these two parameters worsen the situation. On the other hand, we were able to classify all these accidents into three categories: **lack of training, change in the weather conditions** (change of wind direction and strength) and **exceptional phenomena**. Action on the first two causes is feasible or has already been taken, in the case of European countries, on the other hand, the third cause requires a thorough study of these phenomena (studies are being carried out by the CEREN and ADAI).

Following this assessment of the forest fire accidents observed in Europe, this document was elaborated to collect safer training procedures and fighting techniques. It is in this context that the French Minister of the Interior, Mr Sarkozy created in 2003 work groups on the forest fire accident theme (the Pourny mission). The CEREN has actively taken part in setting objectives to improve safety. There are 11 objectives: (modernise the commandment organisation procedures, ensure sanitary support and emergency aid for interveners, decrease risks linked to aerial means,...).

This document is divided into two parts:

- Assessment of the French objectives,
- From analysing accidents to creating "objective" cards

## 1 ASSESSMENT OF THE OBJECTIVES DEFINED BY THE FRENCH WORK GROUP:

### 1.1 STUDY AND OCCURRENCE OF THE "FIRE" PHENOMENON

Safety problems during forest and vegetation fires require a thorough study of fire behaviour.

Four very interesting studies on this theme are submitted:

- « Thermic accidents » – Colonel Claude MARET,
- « Safety during forest fires » – CEREN – Nicolas RAFFALLI,
- « Fire strength –thermal radiance» – Robert CHEVROU,
- « The H method» - Roger HUCHERON and Christian MAURIN.

Nevertheless, interveners must be able to visually assess a situation : estimate the evolution and quickly determine and ask for means and additional support. The following elements have to be considered:

Smoke : smoke color, smoke wreaths (white or black, volume, direction and angle are important indicators to visually evaluate fire strength, its spreading capacity and speed.

Fire spread : The main elements: wind, landscape and drought must be analysed because fire has its own logistic in front of it.

Spot fires: they generally come from the fire front and are transported by the wind and hot gazes issued by incandescent fuels.

Fire front: the head or front, generally the part exposed to the wind, quickly spreading and forming the most important radiant panel.

Radiance : proportional to the distance between the interveners and the radiant panel of the fire.

#### 1.1.1 Specific phenomena

Gas-layer fires: for this category we will refer to the conclusions reached by the thermic accidents work group, managed by Colonel Claude MARET.

Tornadoes, fire storms, flare-up of the distillate layers are aggravating factors and are not always predictable. They are very often very local phenomena having a very short life-span and during which danger is rarely felt.

Nevertheless, forewarning signs do exist:

- Preceding silence and wind drop
- Noises and successive gas explosions
- Important darkening due to the smoke
- Generally an effect caused by the landscape: in talwegs or hollows not exposed to the wind and thus favouring gas accumulation, after a rather slow spreading phase there is a flare-up in the tree stratum fuel which is often homogeneous, well-ventilated and continuous.

#### Definitions of the different fires:

-*Fire Origins*: initial starts, indicated and attacked with the first means.

- *Small Fires* : on which ground or aerial means are used.

- *Fires* : fires requiring in addition to the fighting means: headquarters and a structured organisation.

- *Big fires* : their strength goes beyond relief means and certain parts are in wild spreading range.

- *Tactic fires* : widening of an existing firewall, anchor area or path by generating a backing fire. It is an active fighting method which consists in burning before the arrival of the fire in order to weaken its intensity, help suppress it or canalise the spreading. Counter fires lit using landscape and aerology also fit into this category.

-*Controlled burnings*: fires lit outside risk prone periods and fight to create grazing and cleared areas.

- *Control line* : means positioned on a infrastructure to control fire spread by using water, moisturisers, foams or ground retardants. This is generally a static method but it can change into a dynamic one.

### 1.2 SAFETY :

#### 1.2.1 Experience feedback:

In order to systematically establish an experience feedback on accidents and on avoided accidents, it is

necessary to set up a procedure which keeps the actors anonymous while largely disseminating the knowledge of the mechanism having led to the incident or accident.

The opening of conclusions, today subjected to taboos because of the judiciary impact linked to accidents, must be done, even in their "above norm" aspects when they exist.

Consequently, it is necessary to:

- make sure the conclusions are easily accessible
- establish fact reports
- declare all situations through an anonymous questionnaire
- keep a history track of the accidents, avoided accidents, incidents, dysfunctions
- systematically report any accident and avoided accident according to an analyse method, (still to be defined), essentially mentioning the technical aspects:
  - accident analysis (H method.) –theory from James Reason,
  - Incidents –incident card,
  - Dysfunctions –comment card,
  - Vigilance,

### 1.2.2 Experience feedback communication:

Before and after the forest fire increase season, an assessment of all the accidents and incidents must be done and afterwards, it has to be compared to the evolution of safety means and to the means/result scale. The validated proposals after these meetings will be immediately integrated to training referentials in order to improve operation orders

### 1.2.3 International aspects:

The experience feedback dimension must largely go beyond the national framework so observations and experiences from other countries can also be taken into account. Will have to be studied, not only the content but also the shape, disseminating level and aspects influencing responsibility. This is how, in the context of European contacts or those established with the C.D.F (California), a large opening of experience feedbacks will be established?

### 1.3 HUMAN FACTOR:

The analysis of the human factor is essential to safety both at an individual and collective level.

- Authority, especially the notion of the chief, discipline and understanding of the responsibility level, influences interveners' behaviour.

- Infallibility, failure to act, navel-gazing and non communication are to be banished.

- If the vulnerability level of a simple relief plan is permanently known, it will be possible to immediately take into consideration the necessary safety dimension.

### 1.4 VULNERABILITY :

This notion of vulnerability helps the chief of a unit to measure the human and material aspects that will condition the operational capacity of his unit. A questionnaire defining the vulnerability level of the unit is proposed. This way, the vulnerability level of a unit can be considered by a chief of relief operations (COS) or a chief of intervention group (GI) for local interveners, and the same procedure should also be done for reinforcement troops coming from the outside.

Furthermore, during an intervention, for a risk to be acceptable it always has to be compared to immediate stakes. Acceptable Stakes/Risks is a permanent relation which will guide decisions.

#### 1.4.1 Stress :

Intervener's experience, excess in self-assurance or escape, knowledge of technical and terrain constraints, training and maintaining experience through frequent practice are all factors that influence stress level and at what moment its appearance is not compatible anymore with intervention conditions.

Solving this problem will imply more training and most of all, at each level, an excellent experience maintaining through regular practice for the units.

**The realization of a simulator of real fires** would reach these objectives and test men, the equipment and material.

#### 1.4.2 Training at the recruitment and continuous training :

Training in this area must be carried out immediately after recruiting and continue all through out the career, according to the responsibilities. It has to be organised around three aspects: training (initial and continuous), instruction (acquire know-how) and practice (maintain know-how). It has to be given to risk-prone departmental personnel and to potential reinforcement personnel.

Even if recruiting at the age of 16 is not incompatible with the operational aspect, for forest fires, it is better to establish a tutoring period-accompanying procedure till the age of 18. During this period, individual development and training must be linked with well managed interventions in order to obtain not only trained staff, but also experienced ones.

The notion of "doubling", team notion, physical and mental capacities, experience and vigilance during all the phases of a fire, especially suppression but also drenching and monitoring have to be considered.

Training applied to individuals and to the whole relief plan has to be a means to:

- Establish a limit to the action of each one.
- Identify each one's position and role.
- Provide a complementarity among the team and group.
- Recognise the Chief and put oneself under his authority.
- Guaranty group cohesion and efficiency.
  - Measure vulnerability and consequently the safety level of the Intervention Group.
  - Understand manoeuvre changes due to tactical or safety reasons.

It is also important to frequently practise on the terrain, to test fuel breaks thus enabling the knowledge of the access points, different paths, resources and map updating.

#### 1.4.3 Interveners :

The comprehension of the different actions taken at all levels must take into consideration fire, environment and terrain knowledge. As there are less and less big fires, experience has to be acquired through brush or urban/ wildland interface fires which are also dangerous.

In the fight plan framework, other interveners can potentially take part to measure an immediate action (population civic sense) or provide a support plan (authorised labour association, Defence of the Forest against Fire, County Committee for Forest Fires). It would be a mistake to integrate these actions to the relief plan, on the contrary, the complementarity of the missions must be maintained and the limits must be perfectly known to avoid accidents. Spontaneous

or organised civic action must stop as soon as aerial means and a structured plan are in place.

#### 1.4.4 Medical Aspects :

The fight against forest fires implies rapidity, mobility and interveners' sturdiness, especially in difficult terrain, as well as a previous excellent physical condition and medical support during the intervention.

Physical examination, adapted capacities, healthy diet and frequent water consumption along with physical development will help avoid incidents and accidents.

Furthermore, a Medical Support and Intervention plan (AMI) is needed among the rescue parties as a reinforcement, and also on sites where several rescue parties are in. This medical support would be given upon request of the Zonal Operation Centre (COZ) to the asking departments and provided by the departments having this capacity.

Composed by an ambulance (Relief and Assistance to Victims Vehicle- VSAV) and a medical vehicle (Medical radio Vehicle-VRM), a doctor and a nurse, the Medical Support and Intervention plan provides curative and prevention treatment as well as an immediate care of serious cases.

#### 1.4.5 Safety and Vigilance :

Developing the safety and training functions in this area is the basis to improve the safety of the interveners. So, all the departmental fire and relief services will have to develop this function to the benefit of their own personnel.

The safety function during a big operation is essential and it must be under the responsibility of a trained officer. A safety perimeter with regulated entering conditions must be set up and an Intervention Zone where only relief means are present will be under the responsibility of the police, gendarmerie and County Committee for Forest Fires (CCFF). When aerial means are engaged, this perimeter changes to a 3<sup>rd</sup> dimension to become a safety volume.

During some dangerous operations, the safety function requires monitoring certain manoeuvres with a "bell", a watcher having no other task.

The "Safety" officer, perfectly identifiable, must be the permanent counsellor of the Chief of Relief Operations (COS). He will have an inter-

administration authority during big relief operations, this is essential in order to put in place a homogenous and coherent plan for the safety of the interveners from all administrations and for others.

Furthermore, among every Local Fire and Relief Service (SDIS) a safety officer will make sure the different procedures and instructions are applied. He will also check their evolution and experience feedback. ..His participation to the Hygiene and Safety Committee (CHS) seems to be necessary as well as acquiring an official expertise level so he can take part in the inquiries and research for fire causes.

He must also animate the safety function in the Local Fire and Relief Service (SDIS).

## 1.5 EQUIPMENT :

An equipment research department at a national and zone level, according to the risk basin and to technical specificities, would favour a quick consideration of the recommended evolutions, in relation with the industrialists.

Based on experience feedbacks, the following studies and questions, without being exhaustive, highlight the needed evolution in the equipment and procedures.

### 1.5.1 Individual equipment :

- when must it be worn or not?
- the norm has to be adapted to mobility and to velocity
- obligation to equip all personnel according to the different operational phases and to the risks.
- The colour of Individual Equipment must enable :
  - spotting and visibility (orange-yellow)
  - regulate internal heat
  - provide good thermic protection without isolating from sensations.

- The escape breathing protection device must complete this equipment.

The practise of safety procedures and survival equipment use in stressful situations will free personnel from the psychological impact and generate safety behaviour automatisms.

### 1.5.2 Ground vehicles :

On the basis of the same general technical specifications, two norms have to be developed, one specific for forest fires and the other for rural vehicles.

- normalised and protected, the cabin of a fire tank truck (CCF) is the refuge for the survival of the unit.
- notion of crew: 4 people → What mission? Why?
- condition-age-reliability and adaptation of the fire tank trucks to the intervention sectors (Mediterranean-Aquitaine).
- equipment → defining the minima – maximal for the canons - spraying
- use of additives (wetting agents-foams-retardants..)
- thermic protection for the windows
- safety procedures and personnel behaviour automatisms
- locating units in difficulty (fire-rockets – fire hoses pointing towards the air...) –"rocket launching" pen
- colour of the lateral and top part of the vehicles.
- The behaviour of the drivers taking part in the fight against forest fires must be conditioned by a specific training to movements on uneven terrain but also on roads or convoy.
- Avoiding road accidents implies a certain type of behaviour from drivers and vehicle chiefs, acquired during these trainings.

### 1.5.3 Aerial means:

Safety constraints for aerial means are perfectly codified for the aeronautical field and for pilots by texts that are still evolving. The use of planes in the fight against fires highlights three worrying phases in terms of safety:

- droppings (on the personnel)
- Retardant stations (personnel training)
- scooping (safety measures for scooping water points and crew)

Droppings: the problem mainly lies in locating human and equipment means on the ground, under the vegetation, among the smoke... Thus a non authorised drop is not conceivable, unless the plane is the first to arrive and has received clearing from

the Departmental Operation Center for Fire and Relief (CODIS) and Zone Operation Center (COZ).

Safety dropping: this consists in dropping on a group and on equipment being in a critical situation. It is quite difficult to do as the drop height is essential and the localisation of men and vehicles is rarely perfect.

In order to improve these conditions, several means such as smoke apparatus on the vehicles , "pen" activating a distress beacon at a 30-40 meter distance, flasher...even if they do not have the expected results, have to be tested.

The colour of the clothes and more generally speaking of the intervention means has to be improved. Fluorescent pipes and fluorescent yellow and orange clothes are easily seen.

Intervenors have to be visible (F2 helmets, orange and yellow jackets are spotted more easily).

A reflective strip (white or yellow + gray) is the norm in terms of signalling. This norm has to evolve in order to obtain a forest fire outfit that would be as polyvalent as possible, very different from the other administrations and solving vertical and horizontal identification problems.

Furthermore, the top part of the vehicles and equipment (pipes) will help through their visualisation on the ground to indicate the location of personnel in case of doubt.

The rapid attack philosophy causes an important concentration of means during the first ten minutes. Around a fire origin, there is not enough space for everyone and upon the arrival of aerial means, only the relief means need to remain, the others must return to their original monitoring or reinforcement missions.

Priority must be given to airplane missions because they are often decisive regarding spreading. Ground means then complete fire suppression..

We must take note that modern planes, equipped with turbines, are less noisy than before (the CL215 is noisier than the CL415).

**To summarize: it is the visibility of the means on the ground (fire tank trucks + hoses + firemen)**

**that still remains a problem for the planes, it is also this that we will have to improve.**

Concerning helicopters: all landing and take-off movements are phases during which safety measures have to be perfectly respected. On the "landing/take-off" zone the less people as possible must be present. It has to be positioned close to the commanding headquarters and cleared (no trucks manoeuvring in the area) .

The helicopter, because of its stationary flight, observation, visualisation and personnel extraction capacity is an excellent safety means during fires. The helicopter division of the Civil Protection has tested recovery nets (to recover 2 people at the same time, or by rotation, a fire tank truck crew).

Generally speaking, all the planes have to be able to communicate with each other and with a responsible officer on the ground.

This measure has to be extended to all the planes present on a site regardless that they belong to the Civil Protection or that they have been hired from local public authorities. For water dropping helicopters, sometimes this communication problem cannot exist (they are not equipped with a wide range frequency radio), when other planes are present, the exclusion of the aerial safety volume must be considered.

#### Risks on a retardant station

Safety measures for plane filling on the ground are part of a training, thanks to which no major accident or incident has been reported. This training must be continued and continuously adapted to plane standards.

- approach a plane in difficult conditions (noise, heat, wind...)
- maintenance problems on the retardant stations. Who? (conventions between the Local fire and relief services and the owner...)
- modernize the stations (reduce the number of people intervening on the planes)
- if the pilot notices a problem, he must stop the engines and do a briefing.
- no radio contact, no full tank
- the chief of the retardant station must keep a thorough vigilance with the plane and check the frequency.

For permanent tracking and consistency reasons, it is important that the maintenance of the different

platforms is done by the same entity. Currently, some platforms are not well maintained, not knowing who is in charge of them.

Information dissemination:

A structure has to be put in place to diffuse the documents.

Risks during scooping:

Safety on scooping areas and for the crew in case of a problem must be considered in a study and by a change in the navigation regulations. A technical work group can submit propositions in the context of training for interveners in the nautical field.

**1.5.4 Transmission and Locating :**

- T/R (transmitter/receptor) : all the vehicles must at least be equipped with a mobile T/R.
- equipment for individuals and groups: it will be compulsory for the Chief of the unit and for the assistant to be equipped.
- T/R for the fire-hose carrier, at term for unit members (earphone type),
- localisation of the vehicles – rockets – small balloons
- GPS : can translate a geographical position into azimuth/distance
- Localisation of mobile units by the CODIS and planes,
- Alert plan with map positioning
- Safety mode shift (load speakers, whistles, two tones)
- warning on portative T/R
- GPS indicator actionning on numerical map

**1.5.5 Transmission equipment :**

Transmission procedures and organisation are adapted to the fire fighting field, to improve safety conditions, the following points could be considered:

- safety/reception frequency: channel 8 - FQ 85 600 double use
  - priority access, also for aerial means (planes and helicopters)
  - The "fire origin phase" should be supervised by the Departmental Operational Fire and Relief Center (CODIS)

- Priority must be given to the one who is in a difficult position, the other means must adapt to his position.

- A SOS type procedure applied to personnel in difficult position.

In the same way, equipment must change in order to match norms, be more simple to put in place and be ergonomically adapted to the mission. For example, it has to have:

- a safety function through a simple button or switch
- recognizable keys
- no legibility needed when in a difficult position

**1.5.6 The weather factor:**

The presence of an antenna on big disaster sites along with a weather engineer to analyse aerology and weather factors does not bring anything more than what the engineer at the Departmental Center can do with his computers, and it would cause problems regarding the accuracy of his forecasts.

Thus, the anticipation function of the headquarters, by the use of existing means, the weather antenna in VALABRE and those from other departmental centers for example, has to establish a permanent weather watch.

The knowledge of situations having caused accidents on fires:

- problems linked to landscape
- problems linked to wind direction changes
- spot fires from crests to crest due to strong winds
- spotting in dominant wind direction
- possible gas accumulation
- fire climbing from a valley
- fire coming from a crest and going down towards the valley
- fire on a the hill side exposed to the wind coming from the bottom of a thalweg
- research of the situations where the presence of distillate layers have been detected, they will have to be analysed and listed.

Generally, local aerology phenomena are known, but it is important to compare them with the forecasts and observations on the terrain.

- vigilance to permanently follow the forecasts.
- predictable weather front and refer to Météo France to have the information

- breeze effects (originating from the Littoral)
- maritime breeze scheme
- mountain sun/shade breeze scheme
- forecast of storm situations.

We must consider generalizing weather networks to provide the Departmental Fire and Relief Center for Operations with real time weather reports.

Finally, it has to be specified that beyond the permanent presence of the Valabre and Aquitaine weather units during the summer, the regional centers are open 24H/24H.

An executive must be in charge of the weather, we have several possibilities

- Information Officer,
- Safety Officer,
- Measures and observations on Intervention Zones (IZ) : they can be done by a mini weather station, all the departments of the South have been provided with one.

### 1.6 ORGANISATION :

The organisation of the fight against forest fires is the object of a national doctrine, embodied by a National Forest Fire Organisation, a user guide for aerial means and a training manual.

Also, depending on the implementation of the existing procedures in the context of elaborating a forest fire order per department along with a good coordination, fight operations are generally well managed.

But simultaneous disasters cause organisation problems in the relief plan.

It is thus necessary to remind the what the conditions are to activate first level plans in the departments prone to forest fires; and to the Zone Headquarters, the reinforcement transporting procedures.

Several regulation supports have to be considered:

- Operation order per department articulated around a common guideline.
- known state of the art,
- Adapting texts in the middle,

- knowledge of the legal aspect, especially assistance failure, obstacle to relief arrival, precaution duty , ...
- perfect implementation of the existing procedures
- identification and visualisation of managers and chiefs : Commander of relief operations / sector chief / Safety Officer / aero / sub-sector chief / Centre for the Gathering of Means / transit areas...

As it has been done in the department of Gironde, the identification of the different commanding functions, safety officers, implemented functions headquarters +reception area+ transit area, aero, must be permanent and systematic to all the personnel, authorities and eventually to actors from the outside.

A thorough management of the changes per headquarters / CODIS with the different Relief Centres by previously elaborating cycles is absolutely necessary:

=> reinforcements with included change turns / rescue party of three groups:

- 2 active
- 1 at rest

=> big lines 1<sup>st</sup> day 24H (8H of rest)

Morning 12H

Evening 12H

=> change turns for reinforcement troops – avoid night

=> reinforcements (Headquarters) pre-formatted Zone Headquarters.

### 1.7 INTERVENTION ZONE, ENVIRONMENT AND RESOURCES :

In the forecasting frame, a detailed study of the forest sectors must be organized according to the criteria of the tactical reasoning.

This study would help elaborate "reflex" documents that would improve initial attack, but also highlight specific features of the sites (sensitive areas, access, wildland/urban interface areas...), risk prone areas (gas accumulation..)

It would also favor a prior study in order to position prevention zones (vegetation breaks, clearing, agriculture areas), determine prevision means (hydrant networks, tanks, water points..) and complementary prevision means and ensure monitoring in order to have an early detection of fire origins.

Human resources coming from actors complementary to the relief services, authorities and internal and external communication capacity will also be analyzed.

**1.8 COMMUNICATION ON THE SAFETY THEME :**

It will be necessary to communicate on the safety theme to representatives and interveners.

The concerned local representatives would become the essential communication vector and the Departmental Services for fire and Relief (SDIS) the best means to brief interveners.

Training and all its supports are also an essential point for information dissemination through modern communication means.

Furthermore, in order to have a universal message, comic strips and more generally speaking any visual aid are to be preferred.

**Consequently, 11 cards have been elaborated, they correspond to the same number of objectives to achieve.**

**1.9 DEFINED OBJECTIVES :**

**Objective n° 1 : study the forest fire phenomenon**

Acknowledgement :

The knowledge of the phenomenon is not complete. No organization can today say it possesses all the elements.

Propositions :

Dispose of a unified documentation, accessible to everyone, easy to refer to.

Carry out a scientific study on the fire mechanisms and behavior, trying to obtain knowledge on unusual phenomena.

Consider on the terrain fire spreading and behavior, distillates and smoke.

Expected Improvements:

Improvement in knowledge and in training.

Anticipation of dangerous phenomena.

Improve fight.

Improve appropriate tactic level by creating a national technical guide.

Reinforce the protection for interveners.

Effects:

Formalize operationals' expectancies and answer them.

Collectively finance research.

Have institutions and researchers work on identified themes.

Observations :

Institutions such as ENSOSP, INRA, CEREN, CEMAGREF, big schools, researchers are able to produce in this field.

They essentially carry out applied research, system engineering and experiments.

Create documentation and an internet site (ENSOSP).

**Objective n° 2 : Modernize existing commandment procedures during interventions.**

Acknowledgement :

Globally, the procedures are good but their interpretation and application varies from one department to the other.

Propositions :

Organize commandment according to forest fire training and operational management and commandment (rescue party headquarter and site headquarter).

Integrate new decision aid systems.

Identification of the operational functions with color jackets (COS, aero, safety officer, sector chief...).

Standardize at a zonal level the guidelines for the different operational documents.

Expected improvements :

Pre-format the command chain according to strength increase.

Establish an organization plan and a thorough management of changing turns.

Reinforcement rescue parties: in-situ pre-positioning of rescue parties coming from outside the

department, equip personnel according to the mission (forest or urban fire) and to standards (rescue party headquarters and sanitary support).

Taking in charge the engaged workforce implies a commandment level along with the adapted training.

Perfect legibility of the operational and commandment functions (jackets).

Organize maneuvers and practice exercises for executives having a zonal and national implication (it has been done for local and departmental levels, now it has to be put in place for zonal and national levels).

Develop anticipation tools, especially for modeling. Once more, we would like to draw attention to the fact that in the context of a specific project, knowledge and skills should be gathered in a unique place.

Effects :

Coordination and animation of all commandment levels.

Pre-form tactical and commandment reinforcement.

Perpetuation (calm years or not).

Validate fire modeling experiences.

Observations :

Defining a clearly asserted and legible policy in the commandment organization will really improve the safety of the interveners.

**Objective n° 3 : Put in place a safety policy for interveners based on experience feedback**

Acknowledgement :

Experience feedback is not done systematically.

Many taboos remain.

Propositions :

Set up a systematical experience feedback procedure for accidents and avoided accidents.

Compulsory dissemination of experience feedbacks, anonymously and with no censor.

Turn safety into an essential and permanent culture in all Fire and Relief Services.

Expected Improvements :

Identify dysfunctions.

Improve knowledge.

Share instruction.

Propose corrective measures.

Make sure they are concretely applied.

Secure intervention area.

Effects :

Create a safety chain under the authority of a departmental safety Officer, in charge of animating the chain and counseling the Center for Relief Organization (COS).

List at each hierarchical level safety considerations.

Create a National Reference Guide for "command functions" (COS, safety officer, aero, headquarter chief...)

Create a National Reference Guide (GNR) for "logistic functions" (food, lodging, sanitary support, transmission support, mechanical support...).

Elaborate general and specific safety directives, according to risk basins and to specializations.

Set up a training referential on safety with a value scale corresponding to the forest fire scale.

Set up a controlled safety line and volume around the intervention area.

Organize national and zonal exchanges.

Observations :

Create a permanent Safety Officer position.

Provide safety training at each level:

Team member

Unit Chief

Vehicle Chief

Group Chief or assistant

Rescue team Chief or assistant

As soon as the site headquarters is set up, the safety function is given to a trained and experimented executive who will supervise it during all the intervention.

**Objective n° 4 : Provide sanitary support and emergency care to firemen during forest fires through a Medical Intervention Unit (MIU)**

Acknowledgement :

The installation of a MIU is still not systematic on big sites. It would be a good thing to do so. The departments not having the means for it can ask for outside help, the same way as they do for other operational means.

Propositions :

Dispose in each department of at least one executive from the Medical Health and Relief Services (SSSM), always on call.

Position a medical team with the adapted intervention vehicles (light medical all terrain type vehicle- VLMTT and relief and assistance to victims vehicle- VSAV) on every intervention site as soon as a headquarter is set up; integrated to each rescue party.

Adapt this plan according to the evolution of the event.

Give technical advice to the Center for Relief Organization (COS) in terms of hygiene, food and personnel surveillance.

Expected Improvements :

Immediate treatment of wounded firemen.

Preventive taking in charge with treatments adapted to forest fires.

Improvement of the physical and psychological condition.

Reduction of the frequency of accidents at work.

Effects :

Dispose of enough specialized personnel.

Mutualize at a zonal level and plan medical reinforcements.

Observations :

A Medical Health and Relief Services (SSSM) structure is operational in each department.

**Objective n° 5 : Reduce risks linked to aerial means in order to deal with accident-prone situations during drops, retardant station filling, scoopings and helicopter maneuvers.**

Acknowledgements :

Aerial means can intervene only when ground personnel is out of the drop areas. Aerial means can be used as a safety measure on groups in emergency situations.

The training that has been given to the personnel affected to retardant stations, has helped to avoid accidents, up to today we have had no accident.

Up to now, maritime regulations have nothing on scooting.

Propositions :

Droppings :

Visually insure the location of ground personnel and equipment.

Carefully follow existing procedures (radio air/ground – aero)

Systematically put in place a aerial coordination when different types of planes are used.

Know at all times the position of personnel and equipment.

Equip ground means with autonomous signaling and emergency positioning devices.

Inform population of the dangers linked to droppings.

Retardant stations :

Provide training to all the personnel;

Improve maintenance on the retardant station surface and name the institutions in charge of it.

Reinforce the mesh around the installations.

Scooping:

Guarantee safety on scooping areas for the public and for the plane, as well as help in case of problem.

Set up maritime regulations for scooping.

Helicopter carryings :

Only to be done with trained personnel.

Commandment :

Systematically establish a commandment helicopter.

Create a guide for "maneuvers with aerial means" (planes, helicopters).

Expected Improvements :

Adopt vivid color clothes and equipment that will offer a strong contrast with the environment and will be visible by aerial vectors.

Posses human and equipment means to ensure coordination.

Ensure good radio contact.

Develop GPS use.

Equip interveners with individual location devices (rocket-launching pens..)

Continue the driving action in the aeronautical field in order to keep an optimal aeronautical safety level.

Effects :

Revise Personnel Protective Equipment (PPE) and equipment regulations.

Develop integrated systems for localization, linked to cartography.

Take into account safety needs in the air and manage plane intrusions (coordination – commandment helicopters).

Observations :

The above mentioned measure (especially locating) encounters many other work groups.

**Objective n° 6 : Considering risk factors in order to establish a vulnerability/ stake relation.**

Acknowledgement :

Vulnerability level of personnel and equipment must be evaluated before the intervention.

The place and moment of the intervention can be changed if there is no immediate protection in order to match a better vulnerability/stakes relation.

Propositions :

Systematically analyze human, equipment, organization, human and natural environment vulnerability to compare them to stakes.

Expected improvements :

Better adequacy between risk taking and real stakes (equipment gains versus human risks).

Knowledge of the commitment capacity of the group.

Effects :

Dispose of a means to evaluate team performance (personnel and equipment) (cf: application of thermic accidents work group calculation ).

Define vulnerability evaluation means (method).

Observations :

Include relief services in the conception and decision phases of environment management to limit vulnerability (access, u-turn areas, water points, habitats, clearing, anchor areas, vegetation type..)

**Objective n° 7 : Modernize and make transmissions more reliable.**

Acknowledgement :

Transmission networks must be improved in order to establish communication between each intervener.

Propositions :

Make sure the network(s) used for operations is/are independent (non dependent from the GSM, widen band...) but capable of being inter-operable for the different actors.

Make it possible to increase the strength to adapt it to the volume, transmission hierarchy and data transportation.

Ensure intervener localization.

Make communication in extreme situations easier.

Equip each intervener with a communication device.

Expected improvements :

Priority must be given to the one in a difficult situation, the others means must adapt to his situation (human aspect and/or equipment).

"SOS type" procedure for personnel in emergency situations.

Improve the ergonomics and the reliability of the devices to the mission: easiness of use.

"SOS" function (identification-localization) with a simple button.

Effects :

Equip Civil Protection with modern equipment (spatial, numeric) adapted to the missions (volume, localization, image and data transmission).

Observations :

Forest Fires impose upgrading the means in an organized way. (several thousand men in a few hours for combined actions air/ground and in a narrow, mobile and dynamic geographic area.)

**Objective n° 8 : Permanent observation of weather and aerology on the intervention area.**

Acknowledgement :

We have to be able to observe micro-weather phenomena and aerology having an influence on fire behavior in order to take the according measures.

Propositions :

Collect, analyze and use by the site headquarters (anticipation function) observations and weather data.

Improve the prevision network (realism, division into risk areas)

Uniform at a national level conversion procedures of weather risk into forest fire risk.

Expected improvements :

Improve dialogue between terrain actors and weather forecasters.

Real-time follow up of predictable weather evolutions by the site headquarters, and adapt them to terrain context (integration of fire thermic, aerology, landscape: fluid mechanism)

Be able to anticipate weather changes and fluctuations as well as their effects on fire spread.

Set up a training program for weather and forest engineers on forest fire risk level prediction and on the induced phenomena.

Set up a training program for fire fighter executives to "popularize" knowledge of weather and aerology phenomena.

Effects:

Improve the measure network with a coverage adapted to all risk prone sectors and to their specificities(all defense zones are concerned).

Make use of the data from the network (associated expertise) in order to convert them into a risk scale.

Observations :

Even if it is still difficult to draw conclusions between the south and the south-east zones, procedures must be standardized in order to gain efficiency.

**Objective n° 9 : The vehicle must become the best survival vector for the interveners**

Acknowledgement :

The policy which has been started must be continued.

Propositions :

The combination: cabin-chassis must be treated so as to form a survival place.

The vital organs of the vehicle must stay functional in extreme situations.

Expected improvements : (passive and active protection)

Make the mechanical functioning of the vehicle more reliable in complex and extreme thermic environments (flux, temperature, particles..).

Reduce the vulnerability of essential safety organs and accessories.

Consider the cabin as the last survival space (self-protection, air, airtightness..)

Ensure mechanical resistance and protection if upside down or/and accident.

Equip seats with seatbelts.

Ensure visibility for aerial means (fluorescent color hoses, top of the vehicles in white with an identification mark).

Signal door handles.

Improve equipment ergonomics and simplify tasks linked to safety in order to decrease weariness.

Effects :

Create a forest fire norm.

Integrate the objectives to the norms.

Validate through tests and controls (training and test centers).

Training to vehicle driving for operations on and off roads.

Instruction and real-life situations (practice in extreme conditions by simulating real fires, including stress level).

Observations :

Strongly support at a national level an equipment program and/or level compensating (state of the art, adaptation possibilities and choice).

The study and elaboration of the objectives and norms must undergo a systems analysis.

Adapt the mission to the protection level of the vehicles (cf: objective n°6: vulnerability)

**Objective n° 10 : Personal Protective Equipment (PPE)**

Acknowledgement :

It is possible to conceive personal protective protection equipment (PPE) which is at the same time multipurpose, protective, visible and light.

Propositions :

Choose a protection level integrating mission and man.

Train personnel in real-life situations (practice in extreme conditions by simulating real fires, including stress level).

Expected improvements :

Offer an acceptable clothes safety level presenting a lower physiological constraint level and integrating:

Thermic efficiency

Free movements (ergonomic, weight)

No physiological constraint

Visibility

Dispose of an individual rescue breathing protection device (escape mask), compatible with the mission.

Individually equip interveners with measuring and alarm devices for dangerous situations (temperature, fluxes, gas, smoke...)

Communication capacity

Effects :

Improve knowledge of the fire environment (see objective n°1: study of the phenomenon)

Observations :

The atmosphere around forest fires presents a certain toxicity level but its composition and quantity level still has to be determined.

Labor laws which can be applied to some of these gases would imply wearing permanent breathing protection devices and/or reducing exposition time. This seems to be incompatible with the fight mission (special dispensations or adaptations of the protection regulations to the specificity of the mission?).

**Objective n° 11 : Organize terrain in order to improve the fight, reduce risks for interveners and protect population**

Acknowledgement :

A regulation exists but is not, or little respected. Nevertheless, it has to be improved.

Propositions :

Apply the existing regulation.

Improve the texts regarding fire use, movements inside the forests and clearing.

Create wild land/urban interface areas for leisure that would also be fuel breaks.

Control clearings and warn infractions just before and during risk increase periods.

Give notice to proceed to the clearings or organize them at the charge of breachers.

Create accessible protection areas not merely reserved to fire fighting but also to agriculture, grazing, tourism, leisure...

Create safety missions for forest massifs in the forest fire sub-commissions (CCDPCSA)

Expected improvements :

Fight against forest fires will be facilitated because of fuel reduction.

Access will be possible for the vehicles.

Hydraulic resources positioning in wild land/urban interface areas.

Improved safety for interveners.

It will be possible to use urban means to protect houses in wild land/urban interface areas.

Combined action with the forest fire committees for house self-protection.

Better coordination and action rapidity of the other public means.

Reinforce technical counseling to town halls in terms of prevention.

Effects :

Obligation for insurance companies to establish bills or controls for clearings once a year.

Financial interest of the equipment to other ends than only for forest fires (cross financing).

Police and forest services warn than take disciplinary actions.

Economic development for companies specialized in clearing vegetation.

Work for community benefit: hire prisoners to work outside jails

Observations :

The protection of sensitive areas with fuel breaks also having other uses such as agriculture, tourism, grazing...will help maintain them.

Actions carried out by pilot programs serve as examples for the population.

In the Gironde department, firemen executives are commissioned by the Prefect and authorized to list infractions to the forest code.

## 2 FROM ANALYZING ACCIDENTS TO CREATING OBJECTIVE CARDS

In this last part, some case studies show how a French work group defined these 11 objectives. Not all the accidents and avoided accidents will be analyzed here, some of them have been the object of a study in the D451 "Analysis of previous accidents". Furthermore, all the elements we used to define the objectives will not be exposed here and we will not redefine all the objectives.

### 2.1 OBJECTIVE 1 : STUDY OF THE FOREST FIRE PHENOMENON

Many studies have shown atypical behaviors since many years. Here are some accidents having taken place in France:

- In 1949, a fire tornado killed 82 people in the area of Bordeaux,
- In 1982, an explosion at the bottom of a valley seriously burns 2 people in the Var region,
- In 1989, when the fire seems to be extinguishing, a sudden flare-up in a valley kills 1 person and seriously burns another one, Bouches du Rhône department.
- In 1990, 4 people are killed and 2 others seriously burned after a flare-up in a thalweg on the right side of a fire.
- In 2000, a rescue team is suppressing a small fire (less than 7 hectares) when an explosion occurs setting fire to a hydrocarbon layer. Two firemen were killed and 5 others seriously burned.

Through these French examples (which do not reflect all accidents having occurred during atypical phenomena), it is impossible to define in a simple way fire behavior. Many institutions and laboratories, at a national and international level, are working to better understand it. Much progress has been done (study of the physics-chemical composition of gas

layers, slope effect, simulations by using semi-empirical or physics models, use of satellite data...) but this does not necessarily have a direct impact on the interveners.

This is why it is urgent to develop for the users (foresters and firemen) a simple, clear and easy to use database. The progress done by researchers will help save lives on the terrain but only if the results are better communicated.

### 2.2 OBJECTIVE N°3 : PUT IN PLACE A SAFETY POLICY FOR INTERVENERS BASED ON EXPERIENCE FEEDBACK:

Whereas in the industrial field experience feedback on accidents, incidents and avoided accidents is systematically done (in house), it is still not the case among the French Civil Protection.

Indeed, even if experience feedback is done at a local level (intervention unit), it is not passed on to people outside. Because of the "hunt for poor elements" and the judiciary pressure which focuses on responsibility, no feedback collecting system has been put in place. Some elements such as the number of fires, distance, etc are accessible (Promethee web site for example) but these elements only help to go through the process to do "your experience feedback".

When we compare the different accidents having occurred in France in the past years, we notice similarities. Furthermore, studies are rarely done on incidents and on avoided accidents. Following this proposition, several actions have been taken, including the creation, at a national level, of an accident prevention and inquiry bureau. Studies have been carried out on the last accidents (2003 and 2004), and the results have been communicated to the different actors.

### 2.3 OBJECTIVE N°5 : REDUCE RISKS LINKED TO AERIAL MEANS (...):

Since the beginning of the 1960s, tests on the use of aerial means against forest fires have been done in France and supported by the Entente. What has appeared right from the first tests is the complementarity existing between aerial and ground means.

Unfortunately, accidents have blemished this much too positive assessment. Because of the lack of visibility, strong turbulences, strong winds, plane mass loss after drop, precarious communication with ground forces, the risk for all interveners is at the highest.

We number several plane crashes (in 2004 2 killed and 1 seriously wounded during a practice flight, 2 killed after a helicopter crash; in 2000 after a "big water bomber" crash 2 killed and 1 seriously injured),

accidents during the filling of Trackers (in the "retardant stations") and finally during droppings (1 injured in 2003, 2 killed in 1989..).

The efficiency of these planes and helicopters is known by all but it is essential to be informed on the risks in order to minimize these accidents. During fires, firemen officers are commissioned to be the unique interface between air and ground troops; in the same way, during big fires, a counterpart (fireman or personnel from the airbase) is in charge of the same mission for aerial means.

As a result, accidents have decreased throughout the years, but the risks still remain and efforts must be maintained in order to keep the risk level as low as possible.

**2.4 OBJECTIVE N° 7 : MODERNIZE AND MAKE TRANSMISSIONS MORE RELIABLE:**

Interventions on forest fires have a distinctive feature compared to other interventions: the geographical area and the exchanges between it and the different elements of a fire (kinetics, volume, stakes..). Interveners find themselves on big geographical spaces. A division into sectors of the fire has to be done to reduce the impact on operational management. (see figure 1)

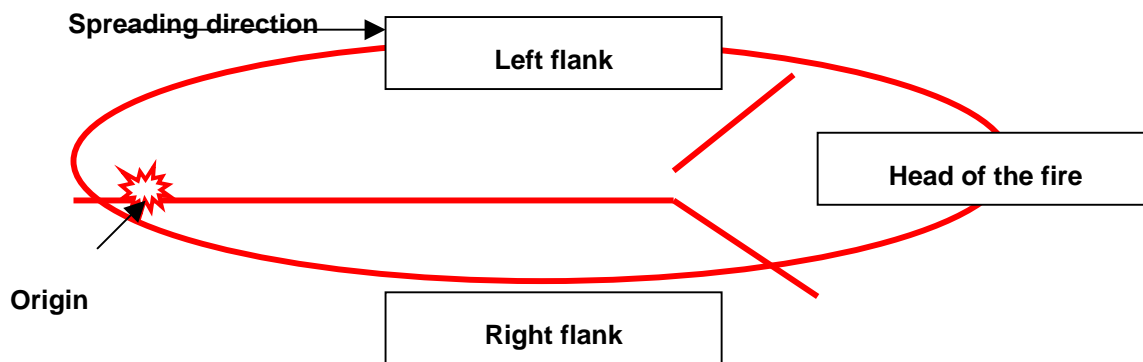


Figure 1 : Division into sectors of a forest fire

In the same way, the radio frequencies used by interveners are divided into sectors. But up to today, only 2 radios (at the best) or only 1 is available per vehicle and information transmission to personnel on the terrain is very difficult: is done by voice in a very noisy environment with low visibility. For example, in 2003 during a fire in the county of Lambesc (department of the Bouches du Rhone) a truck group was in a difficult position. The order to retreat was

given to them when someone noticed the danger of the situation. Unfortunately, between the time when the order was given and the time when they retreated it was too late: a gas explosion occurred, 2 were seriously burned and 1 of them died two months later as a result of his injuries.

If all the interveners are equipped with a portative communication device (as for police forces) they could all stay tuned and information transmission would be optimized.

The CEREN has unfortunately noticed that you still have interveners who do not use the same radio frequency (accident of June 18<sup>th</sup> 2003 where a military firemen group could not communicate with the other groups, this accident caused no victims but only equipment loss). A standardization of the radio frequencies would limit this type of accidents.

Finally, there is an emergency procedure used when a firemen group is surrounded by flames to reduce the thermic ambient with safety droppings. It clearly appears that the pilots have the information quickly but that it is very difficult for them to localize the group (smoke, no precise geographical data...). By using a GPS type equipment (Global Positioning System), this could be improved but it needs to be developed..

**2.5 OBJECTIVE N° 10 : PERSONAL PROTECTIVE (PPE) :**

All the services intervening on forest fires have realized the risks taken when being in this type of environment. Indeed, burn risks, intoxication...is very high. To face this, norms and user guides (NIT) have been developed so EVERY intervener can have the adapted protective equipment.

Developing PPE is essential. Too many accidents occur because the equipment was not well adapted: in certain situations, for specific tasks, the intervener had to undress and the accident happened at that moment.

Another problem lies in the toxicity of the environment of the interveners: studies have suggested that in specific situations (including a high stress level) experienced people took decisions that were not adapted to the situation, putting in danger all the team (reptilian reaction, navel-gazing..).

Today several personal protective equipment have been tested to resist to an external aggression but not always considering the man inside it. We have to rethink personal protective equipment so it integrates the mission and the man. Furthermore, much pressure exists to have values and norms not match a need, but a discrimination between supplier know-how. It is thus very important for scientists and users to make sure these norms are according to their expectancies (mission of the Miroir group in France).

## 2.6 OBJECTIVE N°11 : ORGANIZE TERRAIN (...):

A fire is the result of 3 elements: fuel (vegetation for forest fires) combustive (oxygen in the air) and activation energy (ignition, natural or artificial). Up to now, we have been considering safety in a "passive" way: indeed, in all the above points, we have been focusing on the couple fire-man, the fire element being always present. The theme of this last objective is territory management.

Two work lines are possible:

- contain urban growth
- forest management ( Forest Defence Equipment against Forest Fires )

In 1974 a fire started in the surroundings of Marseille (Bouches du Rhone department). Firemen (who were using a urban type vehicle) were surrounded by the fire and 2 of them died. It is thus essential to use adapted equipment as much as possible and to act on these areas before fires occur in order to create spaces where the fight is facilitated. Much progress has been made in the last thirty years but there are still too many difficult areas.

In 2001, 2002, 2003 and 2004, to mention only these last four years, fires have threatened wild land / urban interface areas and at each time, incidents, avoided accidents and accidents have been listed.

Furthermore, due to the low economic value of the Mediterranean forest (the value is environmental and touristic), this area deteriorates year after year. Fuel loads have increased so much that interventions are more and more dangerous. With no land management, firemen cannot enter into the massifs anymore or if they have to, with very high risks.

As powerful computers are becoming common, the use of simulators is possible as a decision aid tool (Firetactic© from Intergraph Public Safety©, for example), or as a massif management tool (position fuel breaks...). Many research laboratories (CNRS : IUSTI, LEMTA....) are developing multi-phase physics models to get closed to reality. These models will soon be ready to use for operationals.

With the development of all these tools, management efforts will be optimised, especially in terms of fuel breaks and water resource availability (artificial and natural). **If there is no concerted massif management and an important communication of their condition to the different services** (the fires in the Var region in 2003 occurred in managed areas but intervention forces had not been informed about this before the fire...), **the insecurity level of the interveners will be very high.**

## CONCLUSIONS :

This document summarizes the European problematic, even if only the French case is examined. Two different types of actions can be considered:

- those that will eliminated risk situations (massif management, permanent weather observation...), or "active" safety.
- Those that will during an event, ensure better protection for the interveners (individual protection equipment, truck equipment...), or "passive " safety.

During the past years, many initiatives have been carried out at a European level to optimise safety and efficiency of the interveners. It is a fundamental work which requires time to see the evolution but it is one of the priorities of all the interveners and at all levels.

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