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A COMPREHENSIVE COMPUTERIZED INVESTIGATIVE PROTOCOL FOR CONFINED FIRE INVESTIGATIONS (STRUFIS)



Marcello Mangione [1] Franco Bontempi [2] Alessandro Marasco [3]

ABSTRACT

The numerous fires that damage structures make it necessary to reconsider many procedures on prevention through the implementation of more efficient managing methodologies improving the investigative techniques.
For these reasons, resorting to new technics and Information Technology (IT) systems in order to improve the investigative activity is very important.
From this point of view, there is an effort to create a software that could guide the operator in a coded investigative activity of confined fires to avoid the risk of losing data and giving him the possibility to gather all the evidence in the best way possible: this is the starting point for the creation of a comprehensive investigative protocol.
Structural Fire Investigation Software (whose acronym is Stru.F.I.S.) can be considered a new IT tool for the Fire Investigation, a reference point for the engineer who, as an investigator, wants to improve the research for useful data to enable a better understanding of the origin and causes of the fire. [1]

1 INTRODUCTION

The Fire Investigation, framed within the investigation of accidents, concerns the examination of the effects of the fire for the purpose of mainly determine its origin and causes.
It is a real discipline that requires a firm understanding of the thermodynamic principles of a fire and a proven track record in the investigative field.
NFPA 921: *Guide for Fire and Explosion Investigations* and NFPA 1033: *Standard for professional qualifications for fire investigator* are the main references for the investigations on fires.

[1] Engineer, Ph.D Candidate. Department of Structures and Geotechnical - Engineering University of Rome *La Sapienza*. Italy- e-mail: marcello.mangione@uniroma1.it. **Corresponding Author**.
[2] Prof. of Structural Analysis and Design Department of Structures and Geotechnical - Engineering University of Rome *La Sapienza*. Italy - e-mail: franco.bontempi@uniroma1.it.
[3] Engineer Azienda Intellitronika, Viale Asia, 3 Roma, Italy - http://www.intellitronika.com/.II.; e- mail: alessandro.marasco@intellitronika.com

2 FIRE INVESTIGATION

The Structural Fire Investigation, unlike classical investigative activity, can be defined as that conduct investigative discipline on fire purely from a structural engineering perspective.
It will, contrary to what happens in common investigations, is based on the semiotic for fire damage on the structural elements and the materials that make up the scene internally and externally.
The point of origin of the fire and the path is then searched by reading such damages taking into account the thermal and structural characteristics of construction materials and conditions to the existing boundary at the time of the event (fire load, ventilation stage, etc.). [2]
A correct reading of the scene is obtained by a meticulous survey of the effects that the fire produced on the structural elements (Fig. 1).

Fig. 1. Photos of investigative scenes

The carefully scanning the damage is the basis of the initial evidence. [3]
These deductions and the compatibility can be achieved with the help of thermo-fluid-dynamic and structural calculation codes available on the market, such as FDS-Smokeview (*the National Institute of Standards and Technology*) and SAFIR (*Franssen, Jean-Marc - Université de Liège*). [4]
The total compatibility can be obtained through the use of techniques of back-analysis of Structural Fire Engineering, starting from the detected damage and collapse.
Such work, if properly planned and computerized, leads to identify significant structural and forensic data as illustrated in the article Causal models for the forensic investigation of structural failures.
The Fire Investigation structural engineering becomes a real discipline if the engineer-investigator, is a pivotal figure of the investigative team, especially in major fire investigations.
The ability to analyze the damage and their genesis is material to reconstruct the route that the fire has followed during its evolution.

The census of the damage and the collapse mechanisms which suffered the structure must be complete in order to reconstruct realistically both the fire scenario that a structural model justifying the evidence gathered.

The type of collapse that has suffered the structure (*Pancake, zipper, domino, etc*.). [5]
Sets priorities in the evidence collection operations, where often the clues are hidden in the bottom of the layer of rubble.
Once the investigator is able to produce an adequate connection between structural modeling and scene of a fire, it may be assumed to achieve satisfactory results with a reasonable margin of error in order to obtain the necessary compatibility due to the creation of the causative link in the legal field.[6]

3 COMPUTERIZE THE INVESTIGATION

Computerization purpose
In order to improve and streamline of the investigative work, in carrying out professional activities of the investigator, the use of technology and tools, is playing an increasingly important role.

Through appropriate software it's possible to minimize the time, to avoid errors and to make available a decision support tool that can guide the investigator in their actions.
Considering this background, it's arising the need to create a software that guides the operator in forensic activity on the confined fires.
Often during the evidence collection operations problems arise concerning the degree of accuracy with which the tests are collected (for example too many hours after the event, clues not found in it, etc.)
And for the creation of reports, in some cases mixed with each other , issued by different operators (Firefighters, engineer, consultants, etc.).
In this respect, it is appropriate to consolidate, in the same language, a common understanding of the investigative activity.

If the evidence was collected and examined with a single standardized protocol, then these could be reused and integrated to represent possible variants.
So the use of technology and new IT tools in order to improve and streamline the investigative work, plays a fundamental role.
With this background comes the need to create a software that guides the operator in coded forensic activity on the confined fires. [7]

Software functions
The main purpose of the application Structural Fire Investigation Software**,** whose acronym is Stru.F.I.S**.** (See images shown in Fig. 2) are the following:

- To define a line computerized guide line to simplify the operations of evidence collection, reducing the time of the survey;
- To have a easy to use tool in the collaboration of a wide assortment of investigators (police staff, fire brigades staff, freelancer, etc.), with a single flow chart, than can link theory to investigative practice;
- To allow to run, in situ, immediate calculations (fire-term orientation, etc.) of a given volume of investigation (confined structure);
- To create a Unique Investigative Protocol (UIP);
- To synchronize all data collected with a server (through a safe and secure channel), thus ensuring a backup of the acquired information and the ability to share them with other devices in the sector.

Fig. 2. Graphic interface of StruFIS.

An important aspect of the software is to made up the sync with a central database, which will collect and catalog all the information from the various devices.
The transfer system will be based on an encryption protocol capable of ensuring the inalterability of the data transmitted to the server.

This synchronization will have as its primary function to ensure a backup of information stored by StruFIS, in order to perform a restore on other devices or data recovery on the same device used.
The second function will be represented by the realization of a web based interface able to perform searches and analysis on the data collected and transferred by each device.

The main functions are:
- Access to information on the single Fire Investigation session;
- Geographical and historical research of expert reports;
- Advanced search on metadata.

Form for the comparison of Fire Investigation sessions.

StruFIS will be built on the Android platform and it will be compatible with versions 5.1 and later. Regarding the use of mobile devices, for better use, we recommend the installation of tablet not less than 8 ".

The main functions available to the user are:
- **User management**
  The software will be conceived as a multi-user one; this means that multiple users can be registered and each of them will have the ability to manage their information and investigation activities separately.

- **User registry**
  The software will give the opportunity to note down a series of background information, useful to the compilation of the final report.

- **History display**
  This section will display all carried out Fire Investigation activities, allowing the user to consult the collected previous information and possible amendment.

– **Synchronization with remote server**
  This function will give the ability to synchronize all information stored on a remote server.
  The transfer system will be based on an encrypted protocol, thus giving the necessary security of a transfer of all the information in a safe way.

The information exchange system will be bidirectional, which means that may be used possibly as a backup and as a restore system giving the possibility to synchronize on other mobile devices of the Fire Investigation sessions.

– **Management of the Fire Investigation session**

  - **The type selection**
    The step at the time of a new investigation will be to select the type; through this selection, the software will be structured automatically, providing the operator the tools that he need to step through the evidence collection activities and to add the information.

    The type will eventually be changed during construction; at this point the software will propose the steps to follow and the tools associated to the performance of activities.

  - **Information boards consultation**
    The software will be provided with information tables able to help the operator entering information (*melting temperatures of the materials, explanatory images on the kinds of collapses of structures, etc.).*
    An important tool for the investigations will be represented by the blackboard for freehand drawing.

    Through this tool map of the building can be easily drawn, selecting the reference scale and associated notes, videos or photos.
    A preset library will be made available, to add to the design elements that can be defined in more detail in the survey area (*sofas, beds, tables, etc*.).

  - **Image capture/video/audio**
    The software will provide multimedia functions such as the ability to capture images or video through the device camera, record audio, and associate that information to a specific step of the investigation session.

  - **Annotations**
    An easy to use text editor, will be made available to be used to describe in more detail an evidence.

  - **Timeline**
    This function allows the automatic display of the collected evidences, placing them on a timeline and categorizing the event type.
    That function will give an overview both of the findings and his investigations.

  - **Final report**
    The final report will be generated basing it predefined templates and containing all the information entered during the evidence collection.
    The report will be sent by synchronizing the server and creating its PDF document.

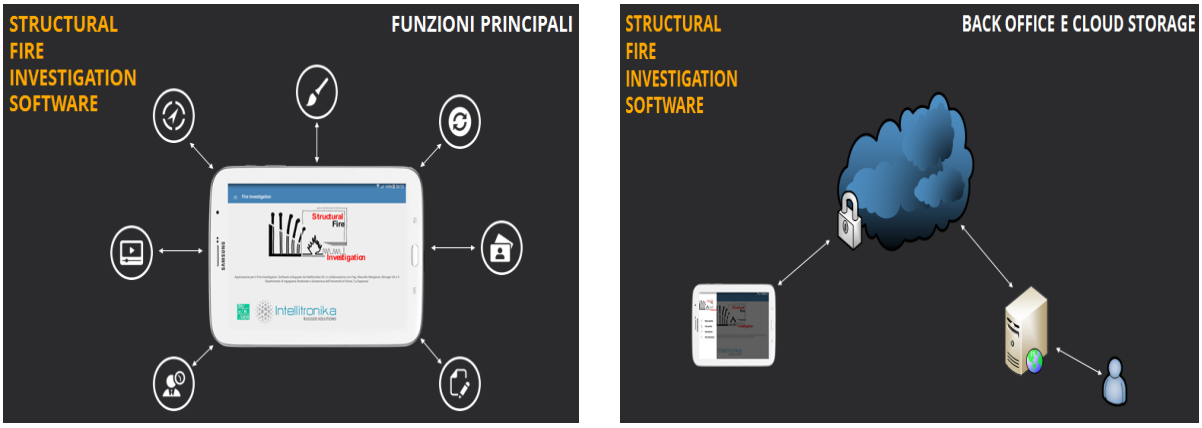

Fig. 3. Main functions and Back office e cloud storage StruFIS

Software features

As described in the previous section, the software will assist the operator in all of the artifacts collection, following the guidelines defined by the procedure and avoiding making mistakes and allow you to make a proper examination of the fire scene. To use the software the first action to take is that of user registration.

The software uses Multi-user, this means that for every use of the software you will have to enter a user name and password to view your entered data.

The main features of the software are:

– Multi users;
– Encryption of data;
– Ability to store photos, video and any audio;
– Multi platform (Android, iOS, Windows Phone).

Once logged into the software will be available to the operator various sections such as:

– **Main Menu**
  - New expertise;

– Archive expertise
  - Surveys in progress;
  - he concluded Appraisals.

– Settings
  - Change Password;
  - Personal data user;
  - Master collaborators;
  - Personal data customers;
  - Synchronization;
  - Software Update.

La first step will be to fill the own registry, this operation will be necessary in order to avoid that at each session of expertise to be inserted in the information regarding the operator who is performing the collection of artifacts.
Depending on the type of expertise, they may be generated as the collaborating users that will help the expert in the development of expertise.

4 UNIQUE INVESTIGATIVE PROTOCOL

Often during the evidence collection operations there are problems concerning the degree of accuracy of the tests (for example evidences collected too many hours after the incident, clues not found in it, etc).
All this leads to the same survey, to have many documents, often competing with each other, issued by different operators (*Firefighters, Police, etc*.).
However, there isn't a glue that defines common investigative criteria.
By the mere fact that the timeline varies undergoing the scene and also by the different skills of the operators it should be consolidated, a common understanding of the investigative activity in the same language.

If the evidence would be collected and examined with a single protocol, then these could be used using the same language even in the FDS or other model, to represent different possible variants of carrying out the scenario.
The software has the purpose to reduce the risk of data leakage and then allowing the uniform collection, of countless tests. Therefore it can be used as a starting basis for the creation of a Unique Protocol Investigation (UIP).
For this reason the purpose of the given UIP of StruFIS is to seek a coded method that avoids underestimating some evidence or making errors in the assessments of the happened fire scenario.
In the investigative context, the solution must be perfectly superimposed to the real after-fire scenario, otherwise it is not precise enough to perform calculations or it is not sufficiently exhaustive on evidence collection.
The real innovation is to choose a unique computational tool and more convenient for that case, defining a UIP.

The UIP allow 'to have several advantages better illustrated in Figure 4.

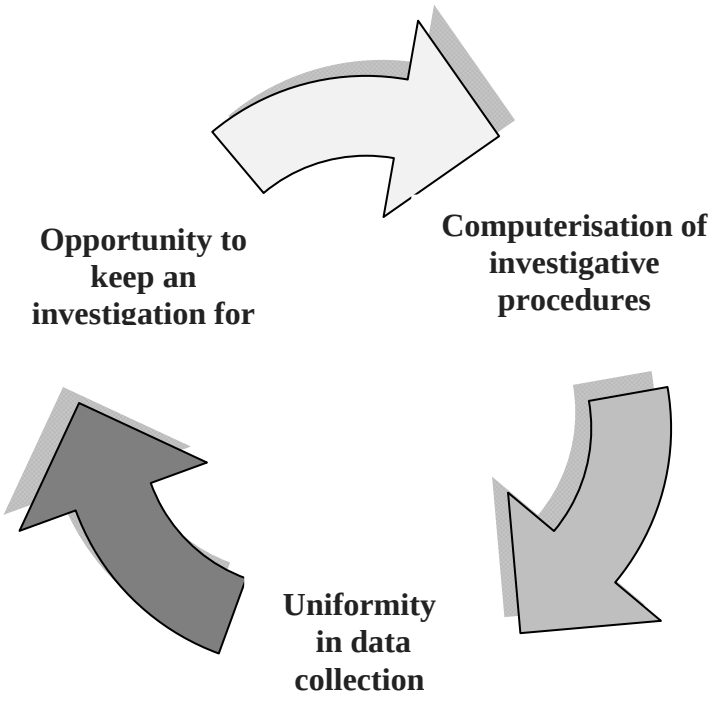

Fig. 4. Advantages of UIP.

With this protocol the same method can be always used both for additional evidences collected or received by the defense and/or accusation (single model of investigative expertise), and for the same method of representation (*FDS, CFAST, PyroSim, etc*.)
Through the use of the StruFIS, the operator will have a system capable of driving him in a simple and effective way in the evidence collection session, suggesting what should be the steps to follow to optimize all the activities of investigations
The software will be structured following the guidelines of the PhD and by providing user functions such as: location of the finds, photo shots, audio or video recordings, notes, freehand drawing by associating photos /videos or notes, creating an automatic timeline on a time basis and based on their findings. [7]

5 CONCLUSIONS

The purpose of StruFIS is therefore to seek a coded method that avoids underestimating some evidence in the fire scenario evaluations. Investigative part, the solution must be perfectly superimposed to reperted scenario, otherwise it is not precise enough to calculate duct or is not sufficiently exhaustive on evidence collection.
The consequence is that of not having rebuilt a clear causative link and deliver in court, an inaccurate report of departure.
The real innovation of StruFIS is to standardize the procedures of investigations, defining a PUI to use both of further evidence collected (single model of investigative expertise) and is to always have the same mode of representation (FDS, CFAST, PyroSim, etc.).
In conclusion, trying to improve, as in any scientific field, including the investigative field trying to create new tools that keep pace with the times.

REFERENCES

[1] Bontempi F., Crosti C., Mangione M., *L'investigazione antincendio sugli aspetti strutturali: una proposta di codifica*, Rivista di prevenzione incendi, Antincendio, ottobre 2015;

[2] Mangione M, Bontempi F., Crosti C.,*Structural Fire Investigation e Ingegneria Forense*, Atti del Convegno IF CRASC '15 Ingegneria Forense, Facoltà di Ingegneria Civile e Industriale La Sapienza, Roma, maggio 2015;

[3] Augenti N., Chiaia B. M. *Ingegneria Forense*, Dario Flaccovio Editore, 2011;

[4] Tzu-Sheng Shen, Yu-Hsiang Huang, Shen-Wen Chien - *Using fire dynamic simulation (FDS) to reconstruct an arson fire scene* - Building and Environment 43 Elsevier, 2008.

[5] Bontempi F.: *Ingegneria forense strutturale: basi del progetto e ricostruzione dei collassi* - Relazione generale, Atti del convegno IF CRASC'15, 14-16 maggio 2015 – Università La Sapienza – Roma.

[6] D'Errico F., Dalla Casa M., *Oltre il ragionevole dubbio* - Edizioni ETS.

[7] Mangione M, Crosti C., Marasco A. "*L'informatizzazione dell'attività di Fire Investigation sulle strutture*", Atti del Convegno Valutazione e Gestione del Rischio VGR 2016, Istituto Superiore Antincendi ISA Roma, 13-15 settembre 2016.