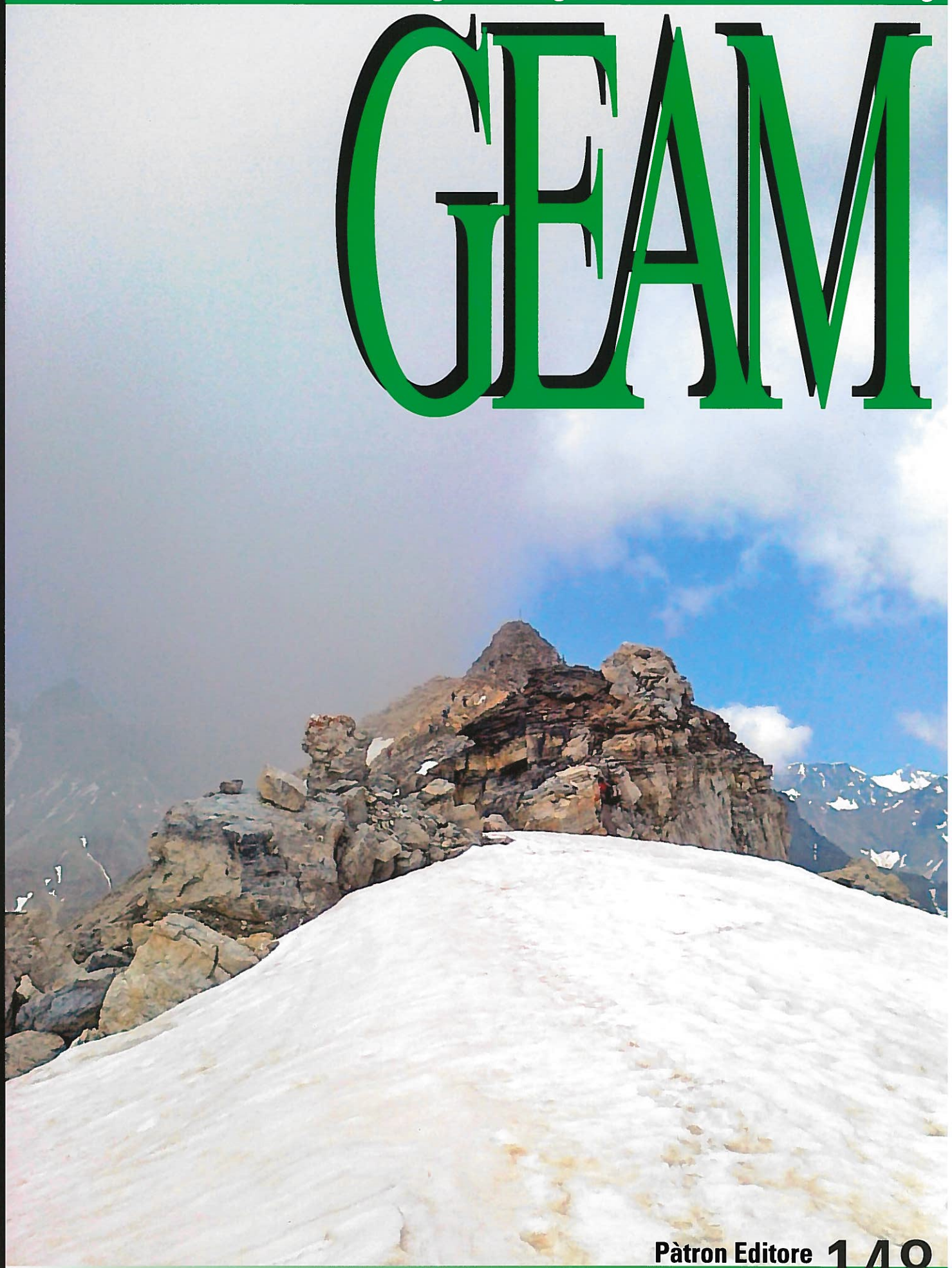
Forensic investigation techniques contribution in the occupational safety & health risk assessment and management

ISSN 1121-9041

Geoingegneria Ambientale e Mineraria

Geoengineering Environment and Mining

GEAM



GEAM - Anno LIII - n. 2 maggio-agosto 2016 - Quadrimestrale - Poste Italiane S.p.A. Sped. in Abb. Postale DL 353/2003 (conv. in Legge 27/02/2004 n. 46 Art. 1, Comma 1) - CN/BO
Pàtron Editore s.r.l. - Via Badini, 12 - Quarto Inferiore - 40057 Granarolo dell'Emilia (Bo)

Pàtron Editore 148

Rivista della **ASSOCIAZIONE GEORISORSE E AMBIENTE**

GEAM

GEAM – Geoingegneria Ambientale e Mineraria
Rivista dell'Associazione Georisorse e Ambiente
Anno LIII, n. 2, agosto 2016 (148)

Direzione e redazione
Associazione Georisorse e Ambiente
c/o DIATI – Dip. Ingegneria dell'Ambiente, del Territorio, e delle Infrastrutture - Politecnico di Torino, Corso Duca degli Abruzzi, 24 – 10129 Torino
Tel.: 011 0907681 – Fax: 011 0907689
e-mail: geam@polito.it – www.geam.org

Direttore Responsabile
Daniele Peila

Vice Direttore
Daniele Martinelli

Gestione editoriale affidata a:
Pàtron Editore – Via Badini, 12 – 40057 Quarto Inferiore – Granarolo dell'Emilia – Bologna
Tel. 051 767003 - Fax 051 768252

Singoli fascicoli: € 39,00 Italia – € 49,00 Estero
PDF articoli: € 14,00.

Per ordinare:
www.patroneditore.com
abbonamenti@patroneditore.com

Modalità di pagamento:
Versamento anticipato adottando una delle seguenti soluzioni:
- c.c.p. n. 000016141400 intestato a Pàtron editore – via Badini 12 – Quarto Inferiore – 40057 Granarolo dell'Emilia – Bologna – Italia
- bonifico bancario a CARISBO – Agenzia 68 – Via Pertini 8 – Quarto Inferiore – 40057 Granarolo dell'Emilia – Bologna – Italia – BIC IBSPIT2B; IBAN IT 03 M206385 36850 07400000782T
- carta di credito o carta prepagata a mezzo PAYPAL www.paypal.it specificando l'indirizzo e-mail: amministrazione@patroneditore.com nel modulo di compilazione per l'invio della conferma di pagamento all'Editore.

Per ricevere la rivista in abbonamento contattare:
Associazione Georisorse e Ambiente
Tel. 011/0907681 – geam@polito.it

I fascicoli cartacei, se non pervenuti, possono essere richiesti all'Editore.
Tel. 051/767003 – abbonamenti@patroneditore.com

Pubblicità
advertising@patroneditore.com

Grafica e impaginazione
Exegi Snc - Bologna

Stampa
Tipografia LI.PE. Litografia Persicetana - San Giovanni in Persiceto, Bologna, ottobre 2016

Riconosciuta dal C.N.R. quale rivista nazionale del settore Geo-Minerario, viene pubblicata sotto gli auspici del CONSIGLIO NAZIONALE DELLE RICERCHE
Anagrafe Naz. Ricerche 518915NF – ISSN 1121 - 9041
Autorizzazione del Tribunale di Torino, n. 1682 del 20-11-1964

SOMMARIO

GEAM

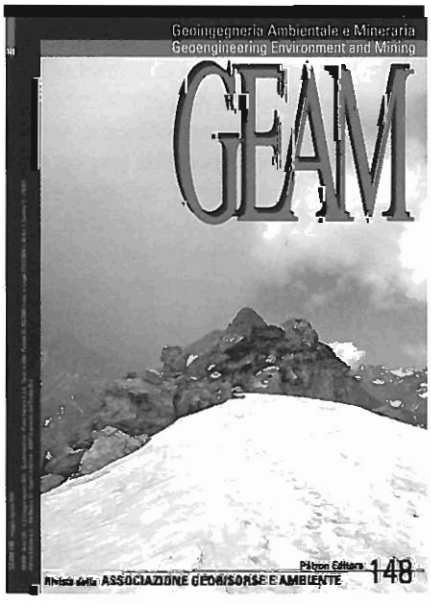
SOMMARIO

Note Tecniche

Le rubriche di GEAM

In copertina:
Cima bianca – Torgnon (AO)

Foto:
Daniele Peila



Forensic Investigation techniques contribution in the Occupational Safety & Health Risk Assessment and Management

Romano Borchiellini*
Paolo Fargione**
Luisa Maida**
Mario Patrucco**
Paolo Piantanida***
Enrico Pira****

* DENERG, Dip. Energia, Politecnico di Torino, Italia
** DIATI, Dip. Ingegneria Ambiente, Territorio e Infrastrutture, Politecnico di Torino, Italia
*** DISEG, Dip. Ingegneria Strutturale Edile e Geotecnica, Politecnico di Torino, Italia
**** DSSPP, Dip. Scienze della Sanità Pubblica e Pediatriche, Università degli Studi di Torino, Italia

Occupational Safety and Health – OS&H – Risks Assessment and Management is a particularly demanding task: the European Directives – and the derived Italian laws and regulations – stress the importance of a pro-active approach, the one able to reach effective results.
To simply focus on localized situations, and carry out a bird's-eye survey cannot ensure a systematic evaluation of the operating contexts in complex settlements such as the Large Public Facilities, where the most serious criticalities are not of direct identification.
The paper – developed within The General Safety Issues and Goals in Turin Universities *research program, funded by Politecnico di Torino, discusses a special sub-part of the well-tested Guideline set up, for Large Public Facilities, in cooperation between Politecnico di Torino and Università degli Studi di Torino, aimed to grant a sufficient detail in the aforesaid situations. The approach is based on an original development for OS&H Risk Assessment and Management of some Forensic Investigations techniques for a thorough Hazard Identification on shell, services and interior spaces of settlements containing workplaces, and on their not-operative content.*
The analysis of some case histories confirms the effectiveness of the approach in terms of completeness and repeatability, and makes possible to draw suggestions on the selection of the better investigation technique in different scenarios.
***Keywords**: Occupational Risk Assessment and Management, Occupational Safety and Health, Hazard Identification, shell, services and interior spaces analysis, Forensic Investigation techniques, Forensic Engineering, Canvassing techniques.*

Il contributo delle tecniche di investigazione forense per la valorizzazione e gestione dei rischi per la sicurezza e salute occupazionali. *La Valutazione e Gestione dei Rischi per la Sicurezza e la Salute nei luoghi di lavoro è un compito particolarmente impegnativo: le Direttive Europee – e i relativi recepimenti italiani – sottolineano l'importanza di un approccio pro-attivo, in grado di raggiungere risultati efficaci.*
Concentrare gli sforzi su situazioni localizzate, con analisi speditive non può garantire una valutazione sistematica dei contesti operativi in scenari complessi come le Grandi Strutture Pubbliche, dove le criticità più gravi non sono di immediata identificazione.
La presente nota – che si inserisce nell'ambito delle attività di ricerca inquadrate nella tematica generale di ricerca Occupational Risk Assessment e Management in coerenza con la Linea Guida Condivisa PoliTo-UniTo – supportata dal Politecnico di Torino, focalizza l'attenzione su una sotto fase applicativa della Linea Guida, messa a punto e validata per le Grandi Strutture Pubbliche in collaborazione con il Politecnico di Torino e l'Università degli Studi di Torino, in grado di conferire un adeguato approfondimento di analisi nelle situazioni suddette. L'approccio si basa su un adattamento originale di alcune tecniche di Investigazione Forense a supporto dell'individuazione dei fattori di pericolo legati a unità tecnologiche, servizi, unità ambientali ed al loro contenuto in condizioni non operative.
La disamina di una serie di casi studio mostra l'efficacia dell'approccio in termini di completezza e ripetibilità e fornisce suggerimenti sulla scelta della tecnica di investigazione più idonea nei differenti scenari.
***Parole chiave**: Valutazione e gestione dei rischi occupazionali, sicurezza e salute occupazionali, identificazione dei fattori di pericolo, analisi delle unità ambientali e tecnologiche e servizi, tecniche di investigazione forense, ingegneria forense, tecniche di canvassing.*

Foreword

OS&H Risk Analysis involves the identification of hazards in a system and the evaluation of possible scenarios leading to unwanted consequences.

The research program *The General Safety Issues and Goals in Turin Universities* – TGSIGTU –, supported by Politecnico di Torino, was established with the specific aim to support, through a rigorous scientific approach, the improvement of knowledge on OS&H, and the diffusion of the Culture of Safety.

The hazard analysis phase is a very important part of the Risk Assessment and Management process: fig. 1 summarizes step by step (1 ÷ 6) the approach proposed by *Group Ad Hoc* (EEC-GAH, 1994).

1. The importance of an effective Hazard Identification

Risk analysis relies on a structured and systematic approach, starting from the Hazard and Exposure Identification phase, characterized by the largest potential for errors due

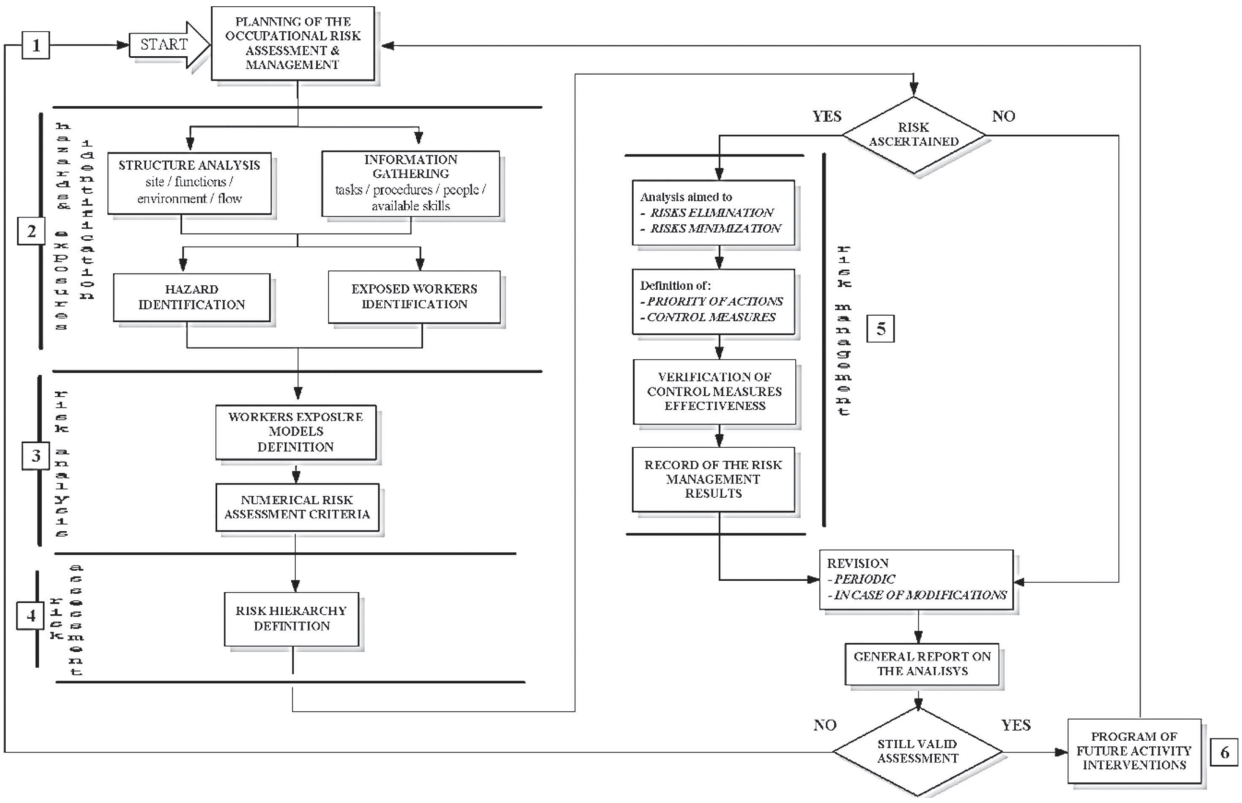


Fig. 1. Risk Assessment and Management phases according to the EC GAH document.
Fasi di Valutazione e Gestione del Rischio secondo l'approccio del EC GAH.

to a poor identification of hazardous agents/materials characterizing the process. The correct definition of the exposure model for each worker involved in the system depends firstly on a correct Hazard Identification: obviously, in the case of undetected or underestimated Hazard Factors (e.g. we identify the presence of airborne dust, but don't investigate its composition), the result is an incomplete Risk Analysis misleading the Risk Assessment and Management phases.

In order to develop an effective Hazard Identification, it is essential to investigate the following aspects:

1st: shell, services and interior spaces of settlements containing workplaces and their not-operative content, obviously pre-conditioning both the OS&H conditions, and the selection of prevention measures for normal and emergency situations;

2nd: the productive activities at the workplaces, which should be designed and organized in coherence with the above.

The target of the Hazard Identification techniques is to identify potential Hazard Factors or events related to deviation conditions potentially leading to Risk scenarios, and reduce the chance of missing possible hazardous events.

This phase is also a basic part of the Quality Management of process and systems (hence, the revision of Hazard Identification process when system changes occur should never be underestimated).

In any case, the approach adopted should comply with the basic requirements of Hazard Identification, as suggested e.g. in *Center for Chemical Process Safety, American Institute of Chemical Engineering, 2008*. In particular:

a. the analysis of the process variables and deviations should lead to design tailored solutions also including the emergency aspects;
b. an analysis based on a logic sequence of functional discretization of the system in key points minimizes the risk of missing some Hazard Factors;
c. the logical breaking up of every complex operation into a number of basic ones enables a thorough understanding of the system criticalities;
d. finally, an unbiased, systematically updated documental/technical information sharing is of pivotal importance for "historical memory" of the analysis approach and results along the time, and to satisfy the exigence of a Systemic Information System, open to the decision makers and safety staff.

Points b. and c. cover both the technological aspects (e.g. a combination of machines constituting a production line), and the total duration of productive operations aimed to complete a complex operation (e.g. Work Breakdown Struc-

ture, tasks and sub-tasks in a Gantt Chart).

Moreover, where the target is the Safety analysis of shell, services and interior spaces of settlements containing workplaces and their not-operative content, the approach suggested in point b. becomes of particular relevance.

2. Can Forensic Investigation techniques be useful for OS&H Hazards Identification?

The use of not repeatable and not formalized Risk Assessment approaches is a typical and somehow underestimated problem, the more in the present industrial and occupational context, characterized by dramatic technological and socio economic changes: even if at first glance this can appear a "simplification"[1] of the procedure, the consequences may become important in terms of:

– poor Risk Management, due to undetected leaks in the Hazard Identification completeness;
– difficulties in the comprehensiveness of the results deriving from a not systematic approach;
– impossibility to repeat and confirm the investigation, due to lack of information on the used criteria.

Moreover, this "simplification" often implies a total subjectivity in the survey, based at best on the analyst's experience and knowledge of the system, and not supported by objective data, i.e. to totally arbitrary risk matrices.

It is then clear that the only correct way to conduct an exhaustive Hazard Identification, coherent with a scientific approach, should start (fig. 2) from a thorough analysis – based on real evidences – on the Safety characteristics of shell, services and interior spaces of settlements containing workplaces and their not-operative content, in absence of production and workers, to avoid interferences with the analysis (to discuss the OS&H operative aspects in a physical context of unverified safety is simply meaningless). The procedure and final result, including the possibility to derive checklists usable for subsequent checks on the state of conservation of the achieved Safety level by personnel not particularly skilled in OS&H, are summarized in the flowchart of fig. 3. The present paper provides a contribution to the development of Box 1 of fig. 2.

The aforesaid considerations led the Authors to evaluate the possible use of the techniques typical of the Forensic Science – known as "Canvassing" techniques – to improve the completeness of the analysis in this OS&H Hazard Investigation phase.

Forensic Science (Miller, 2011) covers many different fields of science, including engineering. Generally, the purpose of a forensic tech-

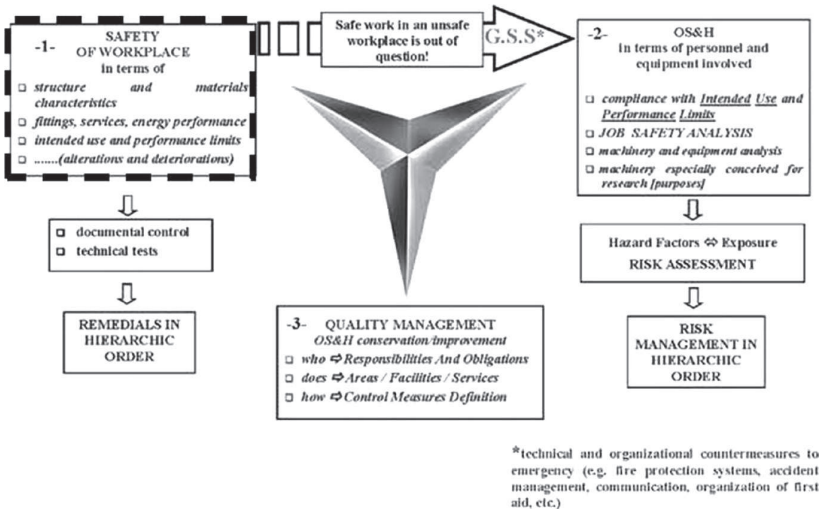


Fig. 2. A well-tested approach to the OS&H Risk Assessment and Management.
Un approccio consolidato per la valutazione e gestione dei rischi per la sicurezza e salute occupazionali.

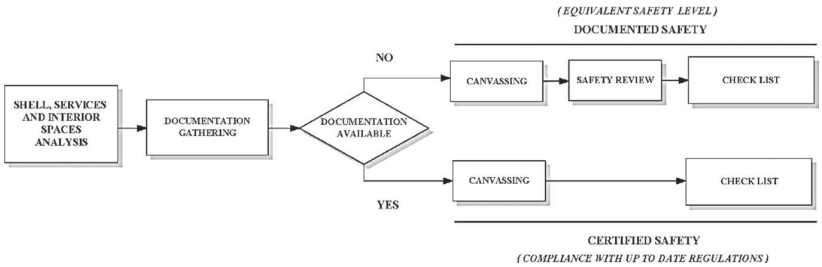


Fig. 3. Procedure and results of the analysis of shell, services and interior spaces of settlements containing workplaces and their not-operative content.
Procedura e risultati dell'analisi di unità tecnologiche, servizi, unità ambientali ed del loro contenuto in condizioni non operative.

[1] The 89/391 EEC Directive, art.9, 2, stated *"Member States shall define, in the light of the nature of the activities and size of the undertakings, the obligations to be met by the different categories of undertakings in respect of the drawing-up of the documents provided for in paragraph 1 (a) and (b) and when preparing the documents provided for in paragraph 1 (c) and (d)"*. It is an obvious simplification of bureaucracy, sometimes misinterpreted to the detriment of the OS&H Risks Assessment and Management.

nical investigation is to find out the causes of failure, or to support courts in determining the Root Causes and responsibilities of an event, through a sound reconstruction of the intermediate events path.

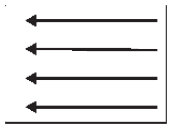
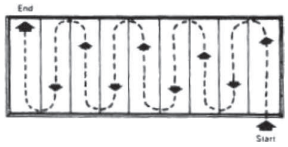
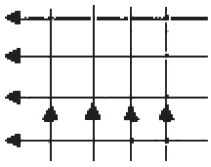
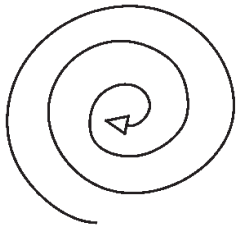
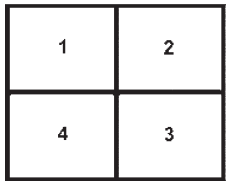
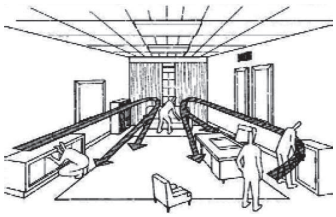
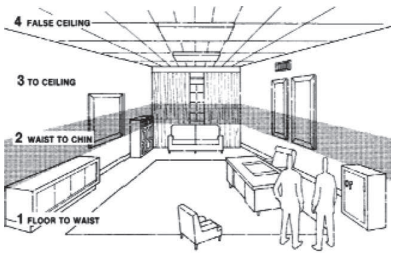
OS&H, a typically multidisciplinary science, can benefit from Forensic Science techniques to improve the workers Safety and Health conditions, through processes aimed to enhance the performance or life of critical components, or to interrupt the chain of events leading from the Root Causes to work related accidents. This obviously requires a preliminary thorough understanding of the event chain which led to the accident (Demichela *et al.*, 2011, Luzzi *et al.*, 2015 & De Cillis *et al.*, 2015).

3. Main Forensic Investigation techniques and their special evolution to support OS&H Risk Assessment

Tab. 1 summarizes the main search modes for evidence gathering typically used in the forensic investigations (International Association of Chiefs of Police and the Federal Law Enforcement Training Center, 2010). Some of the proposed techniques (lines d. and f.) suggest functional volumes discretization methods, others (lines a., b., c. and e.) provide guidance on how the site investigation should be performed: both the goals are clearly coherent with the basic requirements of Hazard Identification as afore discussed.

Having acknowledged the potential of Forensic Investigation techniques, the Authors started a preliminary study on special adjustments to make them fully fit to improve the completeness of the Hazard Identification phase on shell, services and interior spaces of settlements containing workplaces and their

Tab. 1. Main search modes for evidence gathering.
Principali metodi di ricerca per la raccolta delle prove.

technique	geometric pattern	search mode
a. lane search	 strip  wavy line	Personnel will stand in one long line and move forward together to avoid missing areas. Stakes and string can also be used to create "lanes" for which each member of the team would be responsible. When a suspected piece of evidence is located, the Team Leader is informed before any action.
b. grid search		Similar to a strip search, the investigation is conducted by completing a lane search in one direction and then completing a lane search in the perpendicular direction. This is the most thorough search technique because the same area is searched twice by a grid pattern format.
c. spiral search		Spiral search involves a spiral into (inward) or out from (outward – as in figure) a crime scene. For crime scene, a practical disadvantage with outward spiral searches is the evidence may be destroyed as the searchers move to the center of the crime scene area to begin their outward search.
d. zone search		Area to be searched is divided into zones or sectors. Each person is assigned a sector to do a thorough search. The sectors can then be searched by another team member, if necessary.
e. overlapping search		The Team Leader should observe and supervise the search, while other team members perform the investigation of the area. With an overlapping search items are unlikely to be missed.
f. zone elevation search		This type of search is used where evidence may be on the walls or in the ceiling. Only one elevation zone should be checked at a time.

not-operative content (equipment included[2]).

The original adjustments covered in particular the following aspects:

1. our target is the Hazard Identification, not the reconstruction of the dynamic of unwanted events;
2. the search should start from available documentation[3];
3. the selection of the most suitable Canvassing technique depends on the typology of working environment also in terms of spatial configuration, furniture and operative context.

In the OS&H context, special combination of volume discretization and way-of-look-for techniques, taking advantage of the most useful peculiarities of each technique, can contribute to achieve an exhaustive analysis.

This concept becomes apparent in the case of the *Zone Elevation Search*: this method could be used as reference technique in each combination, since it allows extending the search to the volume in compliance with the investigation needs.

For OS&H applications, this technique was improved to:

– ***Zone Split 3D***, essential to distinguish in the same volume sub-zones characterized by parameters that require a homogeneous approach. A *Zone Split 3D* preliminary discretization based on well-founded assumptions can simplify each volume to be searched, and avoids errors due to subjectivity, slapdash or bureaucratic decisions. Correct results are for instance:
  – the division of a large settlement in independent modules, each of them in certified or equivalent safety for fire emergencies;
  – the division of each module in floors, and not by intended use (workshops, offices, etc.), the latter neglecting the layout and conditioning of general fittings and technical-organizational countermeasures to emergency, and the possible interference criticalities.
– ***Zone Elevation Split***, used for the discretization of the volume to be searched. The use of some reference points and landmarks is strongly recommended, since it facilitates both the spatial discretization and the record of points of interest. The availability of computer assisted georeferencing image processing techniques, based on image adjustment algorithms developped for images digitizing elaborations (Cina, 2015), can be very useful both for the investigation, the results record and the sharing phases.

Finally, the selection of the most suitable method to carry out the site investigation depends on a number of factors of difficult standardization, such as the geometrical characteristics of the investigated volume, the presence of fittings, equipment, furniture, etc. In the following pages, the Authors discuss the results achieved in a number of typical sites, and provide suggestions on the most efficient techniques combination. Special care is devoted to the case of Large Public Facilities, and in particular to the case of Universities.

4. In situ tests of Forensic Investigation techniques in Large Public Facilities

Large Public Facilities show various operative contexts and a variety of different hazardous scenarios, both in terms of working environments and performed activities. Hence, it is necessary to adopt special Risk Assessment and Analysis approaches to evaluate and manage the particular criticalities of such systems.

The cooperation of experts of Politecnico di Torino and Università degli Studi di Torino made available a special Guideline for the Occupational Risk Assessment and Management of employees and students (Borchiellini *et al.*, 2015): the present research work contributes to the improvement of a sub-part of the Guideline, specially devoted to the analysis of the shell, services and interior spaces of settlements containing workplaces, and on their not-operative content (box 1 of fig. 2.).

The Authors carried out a series of tests in offices, classrooms, laboratories and workshops of Politecnico di Torino, selected as pilot sites representing typical environments, to practically verify the real user friendliness and the effectiveness of the proposed evolution of the Forensic Investigation techniques in the special case of Large Public Facilities.

Tabs. 2, 3, 4 and 5 summarize the results of the tests, and some considerations concerning the benefits/limits of each discretization and way-of-look-for technique.

5. Conclusion

The application tests of Forensic Investigation techniques to support the OS&H Hazard Identification make possible some suggestions

[2] In this particular case the term "equipment" includes any machine, apparatus, tool or system, forming complex machines, equipment and components necessary for the implementation of a production process, destined to be used at work (from the Italian enforcement of the EC Directives D.Lgs 81/08 s.m.s. art. 69 lett.a.) also including machinery specially designed and constructed for the purpose of research.

[3] In the case of settlements of old construction, for which no exhaustive documentation is available, the Hazard Identification can be supported e.g. by a Safety Review approach, in coherence with the suggestions of the PoliTo-UniTo Guideline for the Occupational Risk Assessment and Management.

Tab. 2. In situ test 1.
Test in situ 1.

Site: **Offices**

Fig. 4. Panoramic image of one of the investigated offices.
Panoramica di uno degli uffici esaminati.

Discretization: the *Zone Elevation Split* proved to be of simple application, but the *Zone Split 3D* did not give special advantages, since the reduction of an homogeneous and limited volume into sub-volumes provided no more information.
Suggested discretization: ***Zone Elevation Split.***
Search modes: the *Grid Search* results excessive: the search patterns result too dense. The same problems occur with the use of *Spiral Search*, more difficult for the presence of furniture. Hence, the best technique is the Strip Search.
Suggested search modes: ***Strip Search.***

The method at a glance

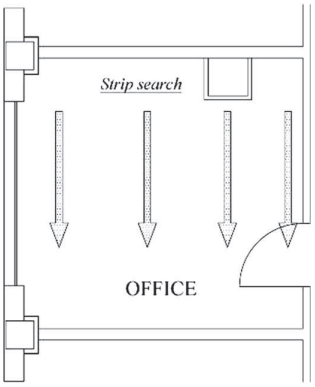


Fig. 5. Layout of the office.
Planimetria dell'ufficio.

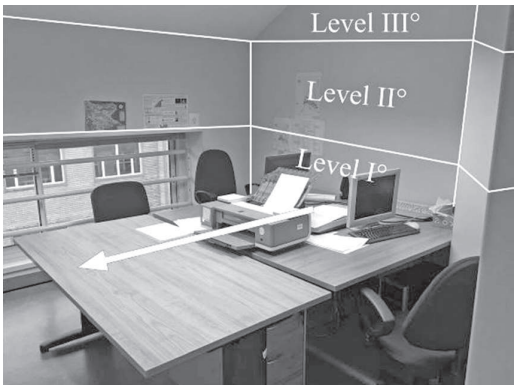


Fig. 6. Office discretization and search method.
Metodi di discretizzazione e ricerca per l'ufficio.

Special benefit of the method

Fig. 7. Point of interest.
Punto di interesse.

Considerations: the *Zone Elevation Split + Strip Search* combines simple application and in-depth analysis of the area in a systematic way. This approach permits an effective Hazard Identification of some potential hidden criticalities (fig. 7).

on their useful contribution in the workplaces Safety Analysis, and on the logistic and operative parameters somehow conditioning the selection of the most suitable technique.

Thanks to the good results achieved, these techniques can be considered effective, appreciably rigorous and useful to support the Hazard Identification activities.

The following positive aspects of the Canvassing techniques can be highlighted.

a. *for the use in OS&H field, the canvassing is essentially intended for the analysis of shell, services and interior spaces of settlements containing workplaces, and on their not-operative content in absence of production and workers, to avoid interferences and alteration of the boundary conditions;*
b. *the analysis is independent on the nature of the critical issues and their subsequent management, and therefore can be defined "aseptic";*
c. *the use of the Canvassing techniques avoids incurring errors due to the judgment subjectivity of the analyst, who may act in accordance with his own preconceived and possibly misleading Attention Index criteria;*
d. *the Canvassing techniques make possible a thorough referencing of the results, the detail depending on the quality and suitability of the storage and sharing systems available (in the case of Politecnico di Torino, which*

Tab. 3. In situ test 2.
Test in situ 2.

Site: **Research Laboratories**

Fig. 8. Panoramic image of one of the investigated laboratories.
Panoramica di uno dei laboratori esaminati.

Discretization: the application of *Zone Split 3D* is necessary to separate the zone assigned to measuring equipment preparation and results processing and archiving from the laboratory area, characterized by different intended uses and criticalities; for each sub-volume it is necessary a further discretization by means of the *Zone Elevation Split* technique.

Suggested discretization: ***Zone Split 3D + Zone Elevation Split.***

Search modes:

Zone for the measuring equipment preparation and results processing and archiving: this context results critical due to the presence of equipment, particular materials and tools. For these reasons:

– *Grid search* model is of difficult implementation due to some cramming of furniture;
– the application of *Wavy Line* search is problematic for encumbrance and tightness of the environment;
– *Overlapping Search* results too expensive also for the involved resources (the technique requires at least 3 operators).

In this context the *Spiral* or *Strip* searches allow to achieve a thorough analysis with good results.

Research Laboratory:

– the application of the *Grid* and *Strip* searches can lead to loss of important pieces of information, e.g. due to the presence of critical hidden zones behind the various equipment;
– the use of *Wavy Line* search is difficult due to encumbrance problems and the tightness of the environment;

The *Overlapping search* can be the most suitable technique in such a complex scenario, since more operators perform the investigation of the whole environment. In such a way, Hazard Factors are unlikely to be missed.

Suggested search modes: ***Spiral or Strip for the measuring equipment preparation and results processing and archiving zone; Overlapping search for laboratory.***

The method at a glance

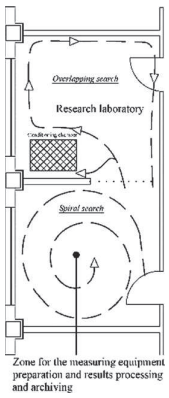


Fig. 9. Layout of the Lab.
Planimetria del laboratorio.

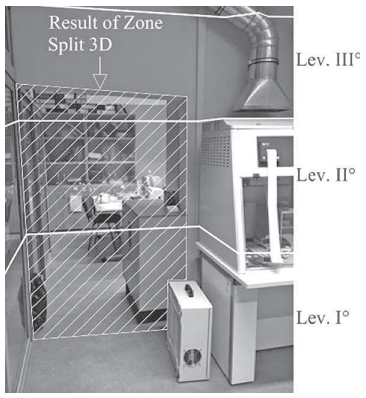


Fig. 10. Zone Split 3D result.
Risultati della Zone Split 3D.

Special benefit of the method

Fig. 11. Hidden zone.
Zona nascosta.

Fig. 12. Poor organization.
Scarsa organizzazione del lavoro.

Considerations: the combination of the *Zone Elevation Split* and the *Overlapping Search* in such a complex contest permits multiple analysis of the potential criticalities, and reduces the possibilities of incompleteness of results: e.g. to overlap the same area by more than one operator reduces the risk of skipping some Hazard Factors.

Tab. 4 In situ test 3.
Test in situ 3.

Site: **Classrooms**

Fig. 13. Layout of one of the investigated classrooms.
Panoramica di una delle aule esaminati.

Discretization: the *Zone Split 3D* results useful especially for the definition of homogenous volumes (desk zone, blackboard zone, etc.). In each identified volume the *Zone Elevation Split* is applied. This combination ensures the completeness of the analysis.
Suggested discretization: ***Zone Split 3D + Zone Elevation Split.***
Search modes:
The search method depends on the specific configuration of each sub-volume previously identified.
Students zone: the *Grid* and *Spiral* searches are poorly applicable due to particular desks layout. The *Strip Search* seems to be tailored for the students zone, thanks to its suitability to the linear layout of the desks.
Lecturer zone: as in the desk zone the *Strip Search* appears suitable. A good alternative could be the *Wavy Line Search,* due to the more complexity (in terms of devices and systems) of this volume if compared to the students one.
In order to ensure the continuity in the analysis of the fittings, a *Strip Search* in the border areas could be useful; for the devoted analysis of identified plants and fittings a special Hazard Identification technique will then be used.
Suggested search modes: ***Strip search for the students zone; Strip or Wavy Line search for the lecturer zone.***

The method at a glance

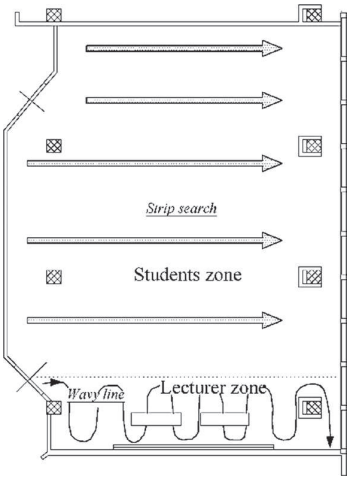


Fig. 14. Layout of the classroom.
Planimetria dell'aula.

Special benefit of the method

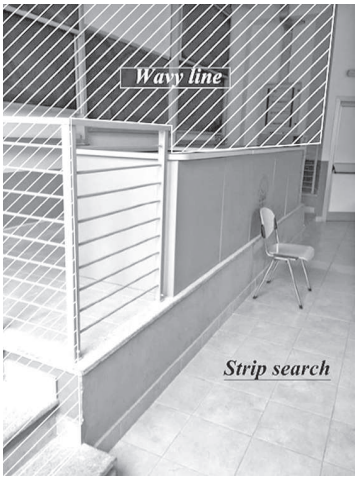


Fig. 15. Classroom discretization in different floor levels.
Discretizzazione dell'aula su livelli differenti.

Fig. 16. Point of interest.
Punto di interesse.

Considerations: the combination of *Zone Split 3D* and *Zone Elevation Split* permits to reduce the extent of the searched volume, and to select the investigation method, *Wavy line* or *Strip,* the most suitable to its characteristics.
It is of pivotal importance to consider the possible variability of the classroom in terms of dimension and configuration. These aspects could influence the choice of a technique rather than another (e.g. in a small classroom the *Wavy Line* and *Zone Split 3D* do not provide any improvement for the Hazard Identification, and the *Zone Elevation Split* results sufficient).

Tab. 5. In situ test 4.
Test in situ 4.

Site: **Workshops**

Fig. 17. Panoramic image of one of the investigated workshops.
Panoramica di una delle officine meccaniche esaminate.

Discretization: the *Zone Split 3D* results necessary both to reduce the extent of the investigation area, especially in crammed volumes, and to isolate, where possible, zone assigned to different uses (e.g. office, storage, etc.). The discretization of the search volume will be the more effective if the sub-volumes are identified according to pre-defined criteria based on their characteristics. Similarly to previous pilot sites, the analysis requires a *Zone Elevation Split.*

Suggested discretization: ***Zone Split 3D + Zone Elevation Split.***

Search modes: the well-organized layout of the different workstations suggests the application of the *Grid Search* in the machinery area and the *Strip Search* in the storage zone and in the office.

In presence of limited and clear spaces, resulting from *Zone Split 3D* application, it can become advantageous to substitute the *Grid Search*, too expensive for these situations with a *Strip Search*, simple and effective.

Suggested search modes: ***Grid and Strip searches.***

The method at a glance

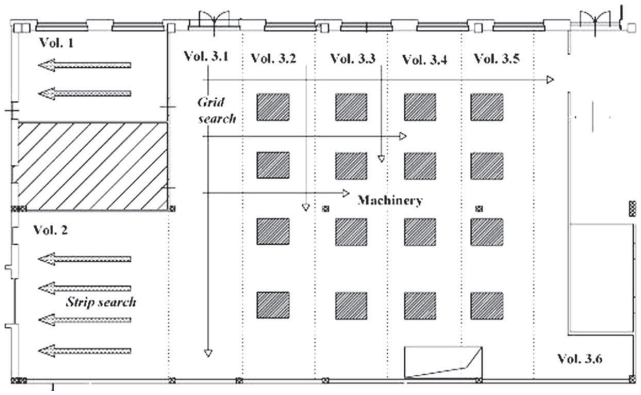


Fig. 18. Layout of the workshop.
Planimetria di un'officina.

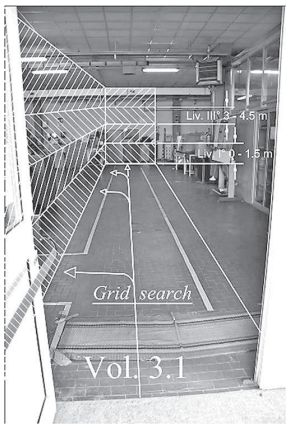
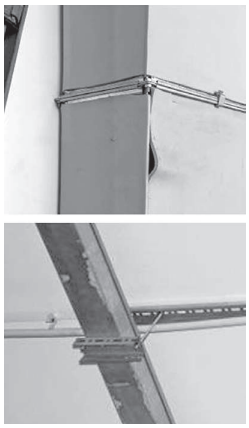


Fig. 19. Workshop discretization.
Discretizzazione dell'officina.

Special benefit of the method



Figs. 20-21. Points of interest.
Punti di interesse.

Considerations: Typically, the workshop shows a lot of criticalities related to special activities, machinery, fittings and tools, sometimes worsened if the working areas are narrow and crammed. As result of the in situ test a combination of *Zone Split 3D* and *Zone Elevation Split* becomes necessary to reduce the volume to be searched.

has efficient and constantly updated systems, this will provide a considerable advantage). Then, they ensure the repeatability of the analysis in controlled conditions.

e. *the Canvassing techniques make possible (an important economic advantage) to derive checklists usable for subsequent checks on the state of conservation of the achieved Safety level which can be carried out by not particularly expert operators (in the case of the Politecnico di Torino typically the safety advisors headed by the various Departments and Units).*

Finally, tab. 6. provides some suggestions on the most suitable Canvassing technique to be adopted in different scenarios, with reference to the main logistic and operative parameters which can condition the selection.

An interesting future research

Tab. 6. Main aspects conditioning the selection of the Canvassing technique.
Principali aspetti che condizionano la scelta della tecnica Canvassing.

Logistic Parameters		*Operative Parameters*		
Skills, Information and Resources	Tools	Working environment layout	Common services and fittings	Particular situations
– documented site layout; – skilled OS&H analysts; – analysts assistants; – experts in surveying techniques; – time spent on the analysis;	– support devices and tools (e.g. professional camera, markers, Electronic Distance Meter); – tools to delimit volumes (landmarks, stakes and strings);	– site dimensions and characteristics; – presence of machinery and furniture; – possibility of freely circulating the site;	– complex plants; – devoted fittings of machineries;	– false ceiling; – enclosures; – special volumes covered by security regulations.

study could be testing the effectiveness of the approach in special contexts where "concealed criticalities" can be present. Clearly, in these situations, a particularly detailed and accurate investigation becomes of paramount importance, and objective references are needed to assess any worsening of the situation the time passing.

The completeness and repeatability of the suggested approach contributes to enhance, from the very first step, the effectiveness of the special Guideline for the Occupational Risk Assessment and Management, providing a significant contribution to the diffusion of the Culture of Safety, in a synergic cooperation of all the involved people.

References

American Institute of Chemical Engineering – Center for Chemical Process Safety, 2008. *Guidelines for Hazard Evaluation Procedures,* New York, ISBN 0-8169-0491-X.

Borchiellini, R., Maida, L., Patrucco, M., Pira, E., 2015. *Occupational S&H in the case of large public facilities: a specially designed and well-tested approach,* in International Conference on Chemical & Process Engineering, 19-22 Maggio, Milano, AIDIC, Chemical Engineering Transactions Vol. 43, pp. 2155-2160.

Cina, A., Manzino, A.M., Manzino, G., 2015. *Recovery of cadastral boundaries with GNSS equipment.* Survey Review, pp 1-9. ISSN 0039-6265

Demichela, M., Monai, L., Patrucco, M., 2011. *La analisi approfondita degli eventi infortunistici quale essenziale strumento di prevenzione: un protocollo di indagine post-evento messo a punto a supporto dell'attività degli analisti* in Chiaia, B., Ingegneria forense: metodologie, protocolli e casi di studio, Dario Flaccovio Ed., Palermo, Ottobre 2011, ISBN 9788857901015, pp. 231-246.

De Cillis, E., Maida, L., Patrucco, M., 2015. *Computer-aided Advanced Technique for the Analysis of Occupational Accidents*, 8th edition of International Conference WOS.net Smart Prevention for Sustainable Safety – Porto, 23-25 September, University of Minho pp. 404-414.

International Association of Chiefs of Police and the Federal Law Enforcement Training Center, 2010. *Crime Scene Search Study Guide Part II.*

Luzzi, R., Passannanti, S., Patrucco, M., 2015. *Advanced Technique for the In-Depth Analysis of Occupational Accidents* in International Conference on Chemical & Process Engineering, 19-22 Maggio, Milano, AIDIC, Chemical Engineering Transactions Vol. 43, pp. 1219-1224.

Miller, M.T., 2011. *An Introduction to Crime Scene Investigation*. Aric W. Dutelle. In Investigative Sciences Journal, Vol. 3 (2).

Regulations

Council of the European Communities, 1989, Directive 89/391/EEC, – OSH "Framework Directive.

Council of the European Communities, EC Working Group Ad Hoc, 1994 – project 5196/94PA 5/7/94.

Acknowledgment

The authors are sincerely grateful to SPP and EDILOG of Politecnico di Torino for their valuable cooperation, and to the chiefs of the research laboratories and workshops who made possible the various validation phases of the original adjustments to the Forensic Investigation techniques.