**Crash Scene Hazard Management: An Updated Approach**

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DFS has developed an updated approach to crash scene hazard management and welcomes the opportunity to collaborate with other organizations to share best practices and lessons learned.

On 21 January 2016, an updated approach to crash scene hazard management was presented to representatives of the major air investigator communities in Canada: the Canadian Society of Air Safety Investigators (CSASI), Transport Canada (TC), the Transportation Safety Board (TSB), and DFS. The updated approach is rooted in the risk management process recommended by the International Civil Aviation Organization (ICAO) and is designed as a comprehensive yet straight-forward evidence-based approach to managing crash scene hazards.

**Background**

From the early 2000’s, crash scene hazard management in Canada focused largely on biohazard protection. This was the logical consequence of changes in the late 1990’s to workplace health and safety guidelines aimed at protecting the worker from exposure to infectious diseases such as Human Immunodeficiency Virus (HIV), Hepatitis B, and Hepatitis C. To emphasize the perceived risk, the annual “Personal Protection” training for aviation accident investigators was specifically called “Blood Borne Pathogen (BBP) training.”

Unfortunately, the emphasis on biohazard protection sometimes overshadowed other potential hazards at aviation crash scenes. Anecdotally, there was concern at DFS (the independent investigator of CAF aircraft accidents), that some CAF flight safety personnel were emerging from training with the impression that infectious diseases were the primary hazards at a crash scene. Over time, DFS attempted to supplement BBP training with instruction on other hazards - such as chemical, explosive and radiological hazards – but this led to ever-growing “shopping lists” of specific hazards, which were difficult to remember and not contextualized in terms of the actual risks they posed.

In 2015, DFS began a review of its crash scene hazard training package, ultimately leading to this updated approach that is believed to benefit not only Canadian air investigators but also international air investigators.

**Method**

DFS reviewed the ICAO guidance provided in Circular 315 “Hazards at Aircraft Accident Sites,” which discusses specific crash scene hazards and groups them into categories. DFS adopted this consolidated hazard categorical approach, but made slight modifications to the individual ICAO categories after broad consultation with DFS accident investigators, and CAF aviation medicine and occupational medicine experts. Thus, the previous “shopping lists” of hazards were reorganized into five easy-to-remember categories: 1) Physical, 2) Chemical, 3) Environmental, 4) Psychological, and 5) Biological.

DFS then conducted a risk analysis of the five hazard categories using a Risk Management (RM) process. ICAO Circular 315 recommends applying a RM process to crash scene hazards involving the cycle of: 1) identifying hazards, 2) identifying exposure routes, 3) assessing risk, 4) introducing controls, and 5) reviewing and revising the risk assessment. Rather than applying RM at the time of a crash, DFS decided to take the ICAO recommendations one step further and *pre-assess* the likely hazards. With primary focus on CAF aircraft fleets, DFS gathered evidence from scientific and medical literature, hazardous material safety data, and expert consensus to assess the overall risk of each hazard category. The pre-assessment was intended to give investigators a “head-start” when confronting a crash scene, allowing faster and more accurate risk assessment, safer scene hand-over, and improved safety measures.

Applying this RM process, DFS ultimately assessed that there was a low risk associated with biohazards (i.e. Human Immunodeficiency Virus (HIV), Hepatitis B, and Hepatitis C) at a crash site. This assessment was based on reassuring information from the US Centers for Disease Control, the Public Health Agency of Canada, and a thorough literature search for documented cases of disease transmission from aircraft accident sites. Moreover, consideration was given to advances in medical science since the creation of health and safety guidelines in the 1990’s. For instance, Hep B transmission can be prevented with vaccination, HIV transmission can be prevented with post-exposure prophylactic treatment, and Hepatitis C can now be medically cured. Thus, the relatively low risk of biohazards can be put in proper context for accident investigators.

**Crash Scene Hazard Matrix (CraSH Matrix)**

In the end, DFS produced the following matrix describing the *minimum* expected risk level of each of the five crash scene hazard categories. The CraSH Matrix is intended to serve as a quick-reference and simple starting point for crash scene hazard management. At the same time, investigators remain free to modify the risk levels when necessary based on specific crash site circumstances. DFS has rewritten the chapter on Crash Scene Hazard Management (previously entitled “Blood Borne Pathogens”) in its Airworthiness Investigation Manual (the investigation standards manual for the CAF). The new approach is being taught on the CAF Flight Safety course for aircraft accident investigators and the medical course for Aviation Medicine providers.

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| **Crash Scene Hazard (CraSH) Matrix** | | | | |
| **Hazard** | | **Exposure Route** | **Risk** | **Control** |
| **Physical** | * Broken structures * Composite fibre (CF) * Stored energy * Explosives * Radiological† | * Cuts * Punctures * Crush * Inhalation / Ingestion * Contact/proximity | **High**  Likely Probability  Critical Severity   * Severe injury and/or * Significantly degraded operational capability | * Control access * Avoid/cordon * Disarm * Apply Fixant (CF) * Decontaminate * No eating on site * Wear PPE |
| **Chemical** | * Petroleum, Oil, Lubricants/fluids * Metals/oxides * Viton (rubber) | * Inhalation * Ingestion * Contact | **Medium**  Likely Probability  Moderate Severity   * Minor injury and/or * Degraded operational capability | * Control access * Avoid/cordon * Neutralize * Decontaminate * No eating on site * Wear PPE |
| **Environmental** | * Cold/heat * Fatigue * Insects/wildlife * Enemy/Security * Political Situation | Variable | **Medium**  Likely Probability  Moderate Severity   * Minor injury and/or * Degraded operational capability | * Control access * Implement site security * Apply work/rest cycles * Feeding/hydration * Insect repellent/sunscreen/ tick removal * Wear clothing appropriate for the weather * Wear PPE |
| **Psychological** | Traumatic exposure†† | * Direct exposure * Indirect exposure (vicarious trauma, narratives) | **Medium**  Likely Probability  Moderate Severity   * Minor injury and/or * Degraded operational capability | * Control access * Apply work/rest cycles * Monitoring * Limit exposure and control information release * Wear PPE |
| **Biological** | Blood Borne Pathogens   * HIV * Hepatitis B/C | * Cuts * Punctures * Via mucous membranes | **Low**  Unlikely Probability  Critical Severity   * Severe injury | * Vaccinate††† * Control access * Decontaminate * Wear PPE |

† Although the injury sustained from Radiological hazards could be severe, the probability of exposure is considered improbable and therefore the risk is considered LOW.

†† The potential for severe traumatic exposure may increase the assessed risk level to HIGH in certain circumstances

††† Advance vaccination is encouraged and could be mandatory for all personnel who attend a crash scene

**Practical Application**

DFS has now moved beyond the conceptual stage of this initiative and has had opportunities to practically apply the CraSH Matrix in the field.

The first practical application of the CraSH Matrix occurred in November 2016 as a result of a CF188 Hornet crash in an unpopulated area near Cold Lake, Alberta, where the pilot sustained fatal injuries. Based on reported conditions, the accident investigation team used the CraSH Matrix while enroute to the crash scene to pre-assess the hazards. The resulting assessment indicated a probable high risk level due to the type and quantity of physical hazards and required the investigators to adopt the wearing of full PPE. Upon arrival, it was determined that conditions were not as initially reported and the physical risk was downgraded to a medium level. This re-assessment resulted in the investigators having to wear less PPE thereby increasing their manoeuverability and efficiency and easing the level of difficulty in conducting their on-scene investigation. As the investigation progressed, the level of risk had to be adjusted due to environmental hazards (e.g. changing weather), physical hazards (e.g. unexploded ordnance), and psychological hazards (e.g. human remains).

Overall, awareness of hazards, their associated risks and the application of control measures was simplified and enhanced by use of the CraSH Matrix. As a practical tool, the CraSH Matrix allowed the team to keep up with changes in risk levels, anticipate and modify plans, and successfully complete the on-scene investigation. In addition, the CraSH Matrix served as a vital tool when handing over responsibility of the crash scene to the Aircraft Recovery and Salvage Team. Crash Scene Hazard Management for this case also included the first-ever follow-up medical screening for all 109 personnel who worked on the crash site, a process that was well-received by personnel and their supervisors. Screening took place for potential injuries from all five hazard categories in the CraSH Matrix, with particular attention to potential psychological injuries.

The second practical application of the CraSH Matrix occurred due to an engine failure of a CT156 Harvard II trainer in January 2017, which forced both occupants to carry out a controlled ejection and caused the aircraft to crash in a farmer’s field. Again, the aircraft accident investigators used the CraSH Matrix tool to pre-assess the expected risks and, as a result of the analysis, made the decision to wear minimal PPE. Deteriorating weather forced a re-assessment of the hazards and associated risks, resulting in a change of control measures to enhance PPE, modify the recovery plan and ultimately resulted in the move of the wreckage to an indoor location.

In both cases, the CraSH Matrix allowed the accident investigation teams to pre-brief and safely prepare their crews on the anticipated hazards and associated risks of the crash scenes, then allowed for rapid yet comprehensive re-assessments of the crash scenes upon their arrival. The matrix proved to be an excellent tool for briefing off-site supervisors on local conditions and increased the effectiveness of the crash scene handover to new personnel arriving on-site.

**Projected Future Development**

DFS will continue to use the CraSH Matrix when investigating accidents; however, its use has highlighted areas that need to be strengthened and updated particularly in the application of controls measures.

The first area needing review is the rationalization of appropriate PPE. DFS’ current process involves the provision of items including (but not limited to) coveralls, gloves, respiratory and visual protection to CAF flight safety units located across Canada. The challenge is aligning the available standardized equipment to the actual requirements of the crash scene. This alignment requires an understanding of the environment in which the equipment is to be used and knowledge of the limitations and capabilities of the equipment. For example, aircraft accident investigators often wear protective coveralls over their environmental clothing. While coveralls provide a physical barrier against contaminating particles, they are challenging to wear in an outdoor setting because they rarely fit properly and hinder movement. Coveralls are susceptible to tearing which decreases the protective nature of the suit and their lack of breathability can cause discomfort. Although wearing coveralls may be recommended as a proper procedure at a crash scene, it should be recognized that coveralls may also introduce hazards and increase the associated risks to their wearers.

The provision of PPE does not mean that every crash site will require the investigator to wear all the items for proper protection. Rather the crash scene investigators need to know and understand the hazards to which they are being exposed and then they need to be able to pick the appropriate protective items from a menu of available resources. Understanding that flight safety investigators have limited time to deal with the intricacies of PPE at the time of an accident, DFS personnel are refining the selection of available PPE to better protect against known hazards (e.g. type of respiratory filter to prevent the inhalation of composite fibres) and are developing a visual PPE pocket-card to compliment the CraSH Matrix tool.

Another area for review is the need to develop education and training products that complement the updated approach to Crash Scene Hazard Management. For instance, the effective use of a PPE pocket-card relies on flight safety investigators understanding the hazards that they might encounter at a crash scene and knowing the limitations and capabilities of their equipment. To promote this understanding and knowledge, DFS is in the process of developing short training videos that can be accessed via the internet. The intent of these videos is to provide accurate, standardized, current and accessible information to flight safety personnel so that they can easily educate themselves at the time and place that is convenient to them.

Finally, the Canadian Forces Health Services Group (CF H Svcs Gp) has developed a cross-platform mobile application called the “Div Surg App” that features resource material and online tools to meet the needs of the aerospace medicine and flight safety communities. The CraSH Matrix is available for download from this app, both as a read-only “pocket-card” quick-reference and as a modifiable “worksheet” document which can be shared via email. DFS intends to continue to collaborate with CF H Svcs Gp to extend the features within this app to support Crash Scene Hazard Management.

**Collaboration**

A key factor attributing to the success of this updated approach has been the collaboration between members of the Canadian air investigative community. Coincidentally, CSASI, TC and the TSB were considering a periodic review of their own crash scene hazard management and BBP training packages and the meeting with DFS in January 2016 identified that there was a great deal of consensus on the suggested way forward. Each group subsequently agreed to collaborate with DFS to further develop the CraSH Matrix and to determine how to best incorporate it as the basis for crash scene hazard management within their respective organizations. This common approach was expected to enhance interoperability and allow collaboration on future work, such as the rationalization of PPE.

After the DFS article on Crash Scene Hazard Management was published in the October-December 2016 *International Society for Air Safety Investigators (ISASI) Forum* magazine, conversation was generated with other air accident investigation agencies, notably the United States National Transportation Safety Board and the United Kingdom Air Accidents Investigation Branch. These conversations are indicative of a growing trend towards supporting this updated approach and demonstrate the importance of collaborating with other organisations to promote a greater understanding of crash scene hazard management.

**Conclusion**

Hopefully our shared knowledge will give our accident investigators a better idea of the actual hazards and associated risks that may be encountered at a crash scene. This knowledge will result in the application of more effective control measures and will ultimately increase the health protection of our personnel working at a crash site.

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