Stowarzyszenie Inżynierów i Techników Pożarnictwa Oddział w Olsztynie

Live Fire Training as Simulation

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Fighting fires inside buildings (compartment fires) is a low frequency/high hazard activity for firefighters around the world. Effective training develops the knowledge to make appropriate strategic and tactical decisions as well as proficiency in the skills necessary to mitigate or reduce hazards and provide a safer operating environment. However, the question of what makes fire training effective is often unasked and even more often unanswered.

Understanding & Application

Safe and effective structural firefighting operations require a solid understanding of fire dynamics and skill in task and tactical activity. However, while necessary, this knowledge and skill is not sufficient. Firefighters and fire officers must effectively apply this knowledge on the fireground. Facilitating this transfer from training to operational context is a significant challenge.

Figure 1. Training Transfer to Operational Incidents

It is reasonable to expect that firefighters and fire officers develop critical skills before being called upon to use them under emergency conditions. However, as Aristotle observed; "for the things we have to learn before we can do, we learn by doing" (Aristotle, 1984, p. 1738). Training in a realistic context not only provides an opportunity to develop a practical understanding of fire dynamics and proficiency in firefighting skills, but is also a means for learners to recognize cues and conditions that are critical to effective decision-making.

In emergency operations, firefighters are often faced with limited information about the building, occupants, contents, and fire conditions. This lack of information increases firefighters' risk. However, in the training environment, conditions are controlled to provide a safer environment for the participants. Speaking at the 2009 International Fire Instructors Workshop in Sydney, Australia Dr. Stefan Svensson of the Swedish Civil Contingencies Agency posed the question: "How do we get learners to understand the differences between training fires and 'real fires'". This is an interesting question in that training conducted in a container, burn building, or acquired structure is in fact a "real fire", but has considerably different characteristics than a fire occurring in a house, apartment, or commercial building. Improperly designed training may provide the learner with an inaccurate perspective on the fire environment which can lead to disastrous consequences.

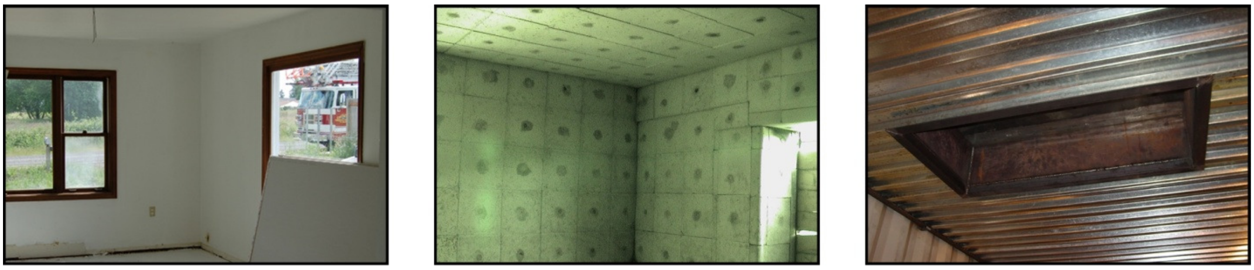
Recognizing the differences between the training and operational environment is critical to learners, trainers, and training program managers. Training must not present unreasonable risk to the participants, but must result in development of knowledge and skill that effectively transfers to the operational environment.

What is the Difference?

Compartment fires in the training environment differ from those encountered during emergency operations on the basis of compartment characteristics, fuel, ventilation profile, heat release rate, and time scale. In addition to differences related to fire dynamics, firefighters and fire officers also encounter psychological stress resulting from a sense of urgency and societal expectations of immediate action (particularly in situations where persons are reported to be trapped in the building).

Other than acquired buildings, structures used for fire training are generally designed and built for repetitive use and not for regular human habitation. Structural characteristics that make a durable live fire training facility are considerably different than most if not all other structures in the built environment. Density, thermal conductivity, and specific heat of training structures can be considerably different than a dwelling or commercial structure, which has a significant impact on fire behavior.

Figure 2. Variations in Structural Characteristics Influence Fire Behavior



Note: From left to right, these photos illustrate an acquired structure with gypsum board compartment linings, a purpose built masonry burn building with high temperature ceramic lining, and steel container based prop with corrugated sheet steel lining.

A purpose built prop or burn building is also likely to have significantly different compartmentation and ventilation profile than a typical residential or commercial structure. Live fire training facilities often (but not always) are designed with small burn compartments. This speeds fire development and minimizes both initial and ongoing cost. However, fire behavior and the impact of fire control tactics can be considerably different in a large area and/or high ceiling compartment. Many modern structures are designed with open floor plans that are challenging to duplicate in the training environment. Energy efficient structures limit ventilation (air exchange), while training structures are often quite leaky, particularly after extensive use. This can have a significant influence on development of a ventilation controlled burning regime and influence of ventilation on the concentration of gas phase fuel in smoke. Failure of glass windows in ordinary structures should be anticipated, as this changes the ventilation profile and resulting fire behavior. Training structures on the other hand provide a more consistent ventilation profile as durable (e.g., metal) windows do not present the same potential for failure.

While structural characteristics, compartmentation, and ventilation differ between typical structures in the built environment and those used for live fire training, one of the most significant differences lies in the types, quantity, and configuration of fuel.

Occupational safety and environmental considerations are the two major influences on the type and amount of fuel used for compartment fire behavior training (CFBT)[1]. In the United States, the impact of environmental regulations on live fire training varies with location. In general, requirements related to emission of smoke are more stringent in urban areas. National Fire Protection Association (NFPA) 1403 Standard on Live Fire Training (NFPA, 2007) is fairly explicit regarding fuel characteristics and loading for live fire training evolutions, prohibiting the use of treated wood, plastic, rubber, and flammable liquids (unless a purpose built prop is specifically designed for use of liquid fuel). Fuel loading must also be limited to preclude the occurrence of uncontrolled flashover or backdraft. Fuel used for CFBT generally falls into two categories, Class A fuels such as wood or straw and Class B gas fuels such as propane.

Differences in structural characteristics, ventilation profile, and fuel load provide considerably different fire dynamics between the training and operational environments. How much and in what ways does this impact on the effectiveness of training in compartment firefighting?

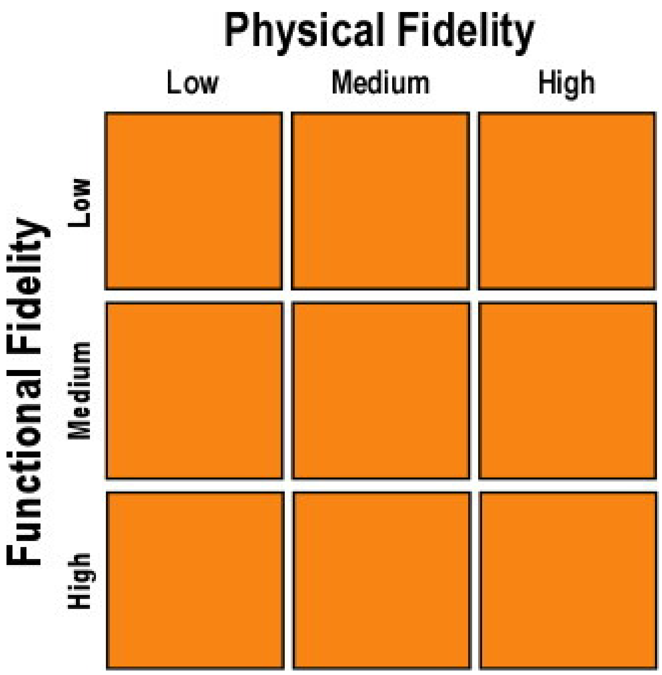
Fidelity

CFBT does not completely replicate fire conditions encountered in an operational context. All live fire training involves simulation. The extent to which a simulation reflects reality is referred to as fidelity:

> The degree to which a model or simulation reproduces the state and behavior of a real world object or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation; faithfulness… 2. The methods, metrics, and descriptions of models or simulations used to compare those models or simulations to their real world referents or to other simulations in such terms as accuracy, scope, resolution, level of detail, level of abstraction and repeatability. (Northam, n.d.)

[1] CFBT is used here as a generic term for training in practical fire dynamics and compartment firefighting and is inclusive of classroom instruction, laboratory demonstrations, live fire training in fire behavior, and live fire tactical training.

Figure 3. Two-Dimensional Fidelity Matrix



Note: Adapted from *Fidelity Versus Cost and its Effect on Modeling & Simulation* (Duncan, 2007)

Fidelity can be described in a number of different ways. One fairly simple approach is to examine physical and functional fidelity (see Figure 3). Physical fidelity is the extent to which the simulation looks and feels real. Functional fidelity is based on the extent to which the simulation works and reacts realistically.

Describing fidelity of a simulation as low, moderate, or high, is unlikely to provide adequate clarity. A more useful description of fidelity includes both qualitative and quantitative measures on multiple dimensions. But what measures and dimensions? In a compartment firefighting simulation, key elements of physical fidelity will likely include fire behavior indicators such as Building, Smoke, Air Track, Heat, and Flame (B-SAHF). Important aspects of fidelity would include the characteristics of doors and windows (e.g., opening mechanism), hose and nozzles, and influence of tactics such as gas and surface cooling on fire behavior. Replicating conditions encountered during emergency operations using an acquired structure would likely provide the most realistic context and correspondingly the greatest risk to participants.

On the surface it makes sense that increased fidelity would result in increased effectiveness and transfer of knowledge and skill. However, it is important to remember that simulations are a model of reality and "all models are wrong, but some models are useful" (Box & Draper, 1987, p. 424). The importance of the various aspects of fidelity depend on the intended learning outcome of the simulation. In fact, a simulation that focuses on critical contextual elements may be more effective than one that more fully replicates reality. However, at this point, we simply have unsupported opinion and in some cases anecdotal evidence of the effectiveness or lack of effectiveness of current training practices. The key to this puzzle is to clearly define the intended learning outcomes and identify the critical elements of context that are required.

Questions to be Answered

Key questions for trainers and training program managers responsible for CFBT include:

- What degree of simulation fidelity is necessary to develop the knowledge and skills necessary for safe and effective operation on the fireground?
- What are the key elements of fidelity for various learning outcomes such as 1) developing understanding of fire development in a compartment, 2) dynamic risk assessment, inclusive of recognizing critical fire behavior indicators, 3) selecting appropriate fire control techniques, 4) developing competence and confidence when operating in a hazardous environment, 5) developing skill in nozzle operation and technique, 6) evaluating the effect of tactical operations.
- Is live fire training the only or most effective simulation method for achieving these learning outcomes? If so, what type of simulation will safely provide the required degree of fidelity? If not, what other simulation method may be used in place of, or in addition to live fire training to provide the required degree of fidelity?

Effective performance under stressful conditions such as those encountered during firefighting operations requires substantial training in a realistic context. However, effective training in this context presents considerable challenges.

> Training effective task performance in stressful situations requires that the following conditions be met: (a) Trainees should be exposed to and familiarized with stressors characteristic of the criterion situation; such stressors should be introduced into the training process in a manner that (b) prevents the build-up of anxiety and (c) minimizes interference with acquisition of skills that the training is designed to promote (Friedland & Keinan, 1992, 157)

Examining the various dimensions of fidelity provides a starting point for a more substantive discussion of live fire training as simulation and critical elements of context for safe and effective fire training programs.

References

Aristotle (1984) Nicomachaen ethics. In *The complete works of Aristotle*, (J. Barnes, Ed.). Princeton, NJ: Princeton University Press

Box, G. & Draper, N. (1987). Empirical model-building and response surfaces. San Francisco: Wiley.

Duncan, J. (2007). *Fidelity versus cost and its effect on modeling & simulation*. Paper presented at Twelfth International Command and Control Research and Technology Symposium (12th ICCRTS), 19-21 June 2007, Newport, RI.

Friedland, N. & Keinan, G. (1992) Training effective performance in stressful situations: Three approaches and implications for combat training. Military Psychology, 4 (3), 157-174.

National Fire Protection Association (NFPA). (2007) *NFPA 1403 Standard on Live Fire Training Evolutions*. Quincy, MA: Author.

Northam, G. (n.d.). *Simulation fidelity – Getting in touch with reality*. Retrieved May 2, 2009 from http://www.siaa.asn.au/get/2395365095.pdf