Asheville Fire Department Faciliated Debrief Report

Asheville Fire Department

Facilitated Debrief Report

In review of:

Incident #: 11-009303

July 28, 2011

445 Biltmore Avenue

Asheville, North Carolina

This report was completed under the direction of:

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EXECUTIVE SUMMARY

On July 28, 2011, the Asheville Fire Department suffered a catastrophic loss when Rescue 3 Captain, Jeff Bowen, a thirteen-year veteran of the department died in the line of duty. At the time of his death, Captain Bowen, along with 66 fellow members of the Asheville Fire Department, were engaged in a structural firefight at a six-story commercial building located at 445 Biltmore Avenue.

The department cooperatively participated in several reviews by the state and federal agencies including the Occupational Safety and Health Administration (O.S.H.A.), the National Institute of Occupational Safety and Health (N.I.O.S.H.), the North Carolina State Bureau of Investigation (S.B.I.) and the Federal Bureau of Alcohol, Tobacco and Firearms (A.T.F.). The findings of these inquiries are pending and the facilitated debrief conducted by the Gasaway Consulting Group was performed after, and independent of, these inquiries.

The facilitated debrief was a voluntary review made at the invitation of Fire Chief Scott Burnette and reflects highly on Chief Burnette's desire to glean the lessons of the tragedy and to use them for the betterment of his organization and the safety of his members. It takes great courage and commitment from an organization, it's leaders, and it's members to participate in a review that most certainly will identify areas for improvement.

The facilitation process was conducted over a period of four days (September 18-21, 2011) in Asheville. The facilitation team was provided with a guided tour of 445 Biltmore Avenue led by Fire Chief Scott Burnette and Training and Safety Division Chief Barry Hendren.

To ensure a non-biased review and rendering of recommendations, the facilitation team members prepared independent reports. The content of the two documents, while completed independently are dynamically complimentary.

FACILITATED DEBRIEFING

The purpose of the facilitated debrief was to assist the Asheville Fire Department in identifying areas of strength, successes, challenges and opportunities for improvement based on the department's performance at the 445 Biltmore Avenue incident on July 28, 2011. Two forms of debrief sessions were held: Individual/small group session and a large group session.

A facilitated debrief is not an investigation. Rather, it was an opportunity for those involved to recount their first-hand experiences in a non-threatening, learning environment. The debrief is not designed to find fault. The contents of this report should be used for identifying organizational strengths and opportunities to

improve future performance through enhancements to policies, operations, training, and equipment.

The individual/small group sessions afforded an opportunity to recount the events on July 28, 2011 from the participant's perspective. Sessions lasted from fifty minutes to nearly three hours. The facilitation team used the Socratic method of questioning to elicit responses. Visual prompts were also used to focus discussions to specific topical areas of workload management, teamwork/crew coordination, standard operating guidelines, decision making, communications, training, and other (an open discussion category to capture feedback not addressed previously in the debrief). Each participant was asked to identify what he or she did well at the incident and what he or she could improve upon in their future performance.

Time constraints and scheduling limited the ability to interview all participants in the incident so the facilitation team selected a representative group of participants that included five chief officers and twelve company officers/firefighters.

The large group session provided the first opportunity for the entire shift to be assembled in a single location at the same time for the purpose of discussing and sharing their various perspectives on the event. While participants were passionate about matters they felt needed to be addressed, they were amazingly professional and respectful of each other. The demeanor of the group impressed the facilitation team for an event that results in the loss of a fellow firefighter can often elicit strong emotional responses as some members may perceive the loss to have been preventable.

The large group process involved a facilitated discussion on the same topical areas as the small group sessions (i.e., workload management, teamwork/crew coordination, standard operating guidelines, decision making, communications, training, and open discussion). Participants were asked to identify what went well at the incident and what could be improved. During the discussion of improvements the participants also offered numerous recommendations, some specifically focused on issues related to the 445 Biltmore Avenue fire and other more generalized in nature. All were captured and considered in this review.

Several cautionary notes should be made with regard to the recommendations arising from this debrief, including:

1. The debrief was conducted 54 days after the fire. While there were a variety of reasons for the delay, including the need to facilitate other formal investigations and scheduling, the passage of time following a critical incident, coupled with numerous recounts of the event in the days and weeks following can impact the quality and accuracy of recall. There were a few instances where participants noted they could not recall certain details of the event.
2. As time passes and details are shared among participants there is also a risk that event details that were not experienced by certain individuals will

be adopted and recounted as if they were. These human factor traits are difficult to control yet it is important to acknowledge such possibilities do exist and may have been present, even if undetected.

3. The facilitation process was voluntary and some members of the department elected not to participate in the debriefings. Seventeen members of the department were interviewed either one-on-one or in small group sessions. During those interviews the participation and sharing of information was nothing short of extraordinary. A large group facilitation was also conducted where members involved in the Biltmore Avenue incident voluntarily participated. Again, the contributions and sharing of ideas/perspectives during this session was extraordinary and contributed significantly to the recommendations contained within this report.
4. It is relatively easy for any subject matter expert to review an event, after the fact, and see all the things that could or should have been done. Such evaluations, including this one, are devoid of all context of the real-life, real-time, real-stress environment in which responders were operating in at the time. It is important for everyone who reviews this or any report resulting from such a review to be mindful that whatever tasks someone performed, or did not perform, made sense to them at the time and that all responders hold sacred the goal to ensure everyone returns home after every call.

INCIDENT SUMMARY

On July 28, 2011 at 12:26pm, the Asheville Fire Department responded to a reported fire alarm in a six-story medical office building located at 445 Biltmore Avenue. From CAD records, the initial dispatch at 12:28 included Engine 2 (E2), Engine 1 (E1), Ladder 1 (L1) and Squad 1 (S1).

Immediately on the approach of E2 the officer reported a working fire on the top floor with heavy smoke and fire visible and immediately requested a second alarm. By department protocol, this request should have resulted in the completion of a full first alarm assignment for a working structure fire. At 12:32 dispatch toned FM10, CAR3, Rescue 3 (R3), Battalion Chief 1 (BC1) and Engine 6 (E6). At 12:55 a third alarm was requested. However, at that time, it was the second alarm resources that were dispatched: Engine 8 (E8), Engine 10 (E10), Quint 5 (Q5), and Battalion Chief 2 (BC2). For reasons that were not explored in this debrief process, the dispatcher only fulfilled the balance of the first alarm assignment when the second alarm was requested and did not dispatch the second alarm companies until the third alarm was requested. At 13:32, Engine 9 (E9), Engine 7 (E7) and Ladder 8 (L8) were dispatched. At 13:43, Ladder 10 (L10) and Engine 4 (E4) were dispatched.

By procedure, an operational channel (Fire 2) was assigned for the working fire and responding units were instructed to switch their radios to Fire 2. By switching their radios to Fire 2, responding units no longer monitor the main fire dispatch channel. Thus, it was not until later into the incident that it was realized the second

alarm was not transmitted as requested by E2. This oversight, both in not dispatching a second alarm and in command not realizing second alarm companies were not responding (or arriving) caused a critical personnel shortage at a complex, labor intensive incident. Compounding the staffing shortage was exceptionally warm and humid weather conditions contributing to multiple firefighter heat-related illnesses during the incident.

Operational personnel, following standard procedures, secured a water supply with a fire hydrant on Biltmore Avenue and connected to the fire department standpipe intake on the Biltmore Avenue side of the building. Concurrently, first arriving companies were entering the building as occupants were still in the process of evacuating. Initial crews performed primary searches of all floors and ushered occupants from the structure. At the same time, crews were advancing with high-rise hose bundles up the north stairwell to the fire floor.

The six-story building has two stairwells (North and South). It was decided that the North stairwell (closest to the fire) would be used for fire department operations and the South stairwell (furthest from the fire) would be preserved for civilian evacuations. The above-grade, bottom-most floor of the building is identified as "Ground." The story above "Ground" while actually the second story of the building, is labeled "First Floor." This resulted in the fire being on the "Fifth Floor" while it was physically located six stories above grade. While it might be thought that such a configuration might lead to confusion, the fire department did exceptionally well with identifying the floor where the fire was located as "Fifth Floor" or, in some cases, as the "fire floor." Regardless of the nomenclature, there were no indications that personnel were confused as to their orientation of which floor they were on throughout the fire.

However, there was one element of the building's construction that did have a significant impact on the situational awareness of the interior operational crews. In the north stairwell the orientation of the exit doors on to each floor (1-4) was facing west. For reference, the room of the fire's origin faced north. Thus, when crews exited the stairwell facing west, they would have turned to their right (North) to proceed to the fire. Unfortunately, the orientation of the doorway on the fifth floor was inconsistent with that of all other floors as its opening faced North. Multiple crews overlooked the difference in the door orientation and upon exiting the stairwell on to the fifth floor turned right (which they thought was North – in the direction of the fire). In actuality, the crews were heading East. Due to the configuration of the building, which included a plethora of hallways, small examination rooms, and locked doors, it would prove to be very challenging for crews to locate the fire.

Crew performance was also challenged because of problems reported with the standpipe system and the failure of the system to produce a patent water supply for firefighting crews. The exact cause of this failure is under investigation and, while noted that it complicated the operations, the failure of the water system was not a subject for review during this debrief.

MEMBER IDENTIFIED STRENGTHS & SUCCESSES

One of the most valuable outcomes of the facilitated debrief is the offering of recommendations that come from those with first-hand experience from the incident. The small group and large group sessions produced a significant list of recommendations that are extremely valuable. This list summarizes the recommendations. The list is not offered in priority order. The decision of the priority of the recommendations rests with the Asheville Fire Department.

QUICK WATER SUPPLY – HYDRANT

A water supply connection to a hydrant on Biltmore Avenue happened expeditiously and the engineer promptly secured a line to the fire department standpipe connection and supplied the standpipe with water. The quality and timeliness of this operation reflects well on both the training and experience of the operator with hydrant/standpipe operations.

ACCURATE INITIAL SIZE-UP

The officer on E2 did an exceptional job of providing an accurate size-up. This reflects well on this officer and the department's practice of ensuring all personnel develop a shared situational awareness by providing an accurate size-up.

RAPID CALL FOR ADDITIONAL RESOURCES

The officer on E2 was very astute in his request for dispatch to transmit a second alarm based on the potential complexity of this fire.

AGGRESSIVE INITIAL OPERATIONS

First-due companies arrived ahead of a chief officer and engaged aggressively in the advancement of advancing hose lines to the fifth floor and in the completion of a primary search for victims.

HIGH RISE PACKS DEPLOYED QUICKLY

The first arriving companies advanced and deployed high-rise packs efficiently. Despite challenges with securing water from the standpipe, the availability of attack lines was not an issue.

EVACUATION COMPLETED QUICKLY

First arriving crews encountered occupants exiting the building and also encountered occupants in the building. Personnel did an excellent job of ensuring

the safety of evacuees, knowing there was a significant possibility of occupants being overcome by smoke.

RIT EVACUATION WAS TIMELY

The misplacement of two of R3's portable radios challenged the rapid intervention team (RIT) because it was difficult to secure an accurate location of the distressed firefighters. It was believed the distressed firefighters were on the fifth floor and personnel were assigned to perform rescue operations. The distressed firefighters eventually made their way to the south stairwell and egressed to a position in the stairwell between the third and fourth floor where they were located and promptly removed from the structure for evaluation and treatment.

CREWS WORKED BEYOND EXPECTATIONS

The incident, for reasons discussed elsewhere in this report, was understaffed. This left the remaining personnel with an exceptionally high workload under extreme weather conditions. When the mayday was transmitted at 13:24 (58 minutes into the incident) many of the firefighters had already been deployed multiple times in the firefight and were showing signs of significant physical and mental fatigue.

Notwithstanding concerns for their own safety or physical limitations, the transmission of the mayday resulted in many firefighters performing valiantly beyond what would be considered acceptable limitations. At the time of the mayday, these firefighters realized the short staffing and the gravity of the situation and despite their exhaustion, engaged without hesitation.

REPOSITION OF L1

On the arrival of L1, the apparatus was positioned on the north side of the building. However, the positioning of the apparatus restricted the use of the aerial ladder for personnel/hose line advancements to the fifth floor. This challenge was identified and the apparatus was repositioned and firefighting crews were deployed through a window on the fifth floor, allowing them to control the fire with a hose line advanced from the platform of L1. Despite the relative infrequency in which Asheville would engage in this form of tactical hose line advancement the operation was conducted smoothly and effectively.

GOOD CROSS FUNCTION UTILIZED

Firefighting personnel assigned to positions on various types of apparatus typically have pre-established assignments. At this fire, personnel were quick to perform numerous cross-functional duties efficiently and effectively.

OFF DUTY RESPONSE

Despite challenges identified elsewhere in this report, the Asheville Fire Department experienced an exceptionally robust turnout of off-duty personnel for this incident. While these resources were mustered after the completion of the RIT operations, they were nonetheless essential to the continuity of operations as many of the shift personnel involved in the incident were unable to effectively continue their duty.

RESCUE EFFORTS

The exceptional rescue efforts of Firefighter Jay Bettencourt cannot be understated. Firefighter Bettencourt was operating in a gravely hazardous environment without the benefit of fresh air supplied by a self-contained breathing apparatus. His working conditions were exceptionally hot, held zero visibility and were extremely hazardous. His efforts to rescue Captain Jeff Bowen were truly an act of heroism and bravery beyond comparison.

At one point in his attempt to rescue Captain Bowen, Firefighter Bettencourt located the south stairwell and found it to be free of products of combustion. At that point, he found himself in fresh air, low heat and good visibility. He could have exited the building by descending the south stairs. However, this would have meant leaving Captain Bowen behind in the tenuous environment that Firefighter Bettencourt had successfully escaped.

Despite being free and clear of danger, Firefighter Bettencourt chose to re-enter the intensely smoke and heat filled corridor without the benefit of a self-contained breathing apparatus for the sole purpose of removing Captain Bowen to the safety of the south stairwell.

Upon entering the stairwell, Firefighter Bettencourt realized neither he nor Captain Bowen were in possession of a portable radio and there was no way to alert rescuers to their location. Under Firefighter Bettencourt's power, the two rolled down several flights of stairs where Captain Bowen's foot became entangled in a stair railing. Completely exhausted, Firefighter Bettencourt lost consciousness and it is in that position the two were found by rescue personnel.

NO FREELANCING

During the debrief, members identified no freelancing as a successful attribute. Some crews did engage in independent action as a result of not receiving assignments from command. Where assignments were given, personnel performed as instructed.

MEMBER IDENTIFIED CHALLENGES AND OPPORTUNITIES

AUTOMATIC ALARM UPGRADES

Working high-rise fires should trigger an automatic second or third alarm and not be a decision driven by the incident commander. The workload of the commander during the initial moments of a major fire can cause the need for additional staffing to be overlooked. While the number of personnel needed for a working high-rise incident may vary, the department could discuss and agree, in advance, on the minimum number needed to commence labor intensive operations and pre-load the response with the minimum required resources.

MONITORING CAD

The incident commander, or their assigned designee, should monitor the CAD to ensure the resources requested (manually or automatically) were actually dispatched. This would also aid the accountability officer in knowing which resources are on the scene or are responding but may not have yet arrived. This can be especially beneficial for multi-alarm incidents and at venues where the building is so large that it is difficult to maintain a visual fix on the arrival and physical location of apparatus. It is reasonable to expect the incident commander will have a good understanding of the apparatus that is actively engaged (e.g., hose lines or ladders deployed). However, staged apparatus are far more difficult to track and consequently so are their personnel unless they report to a staging location.

DISPATCH STAFFING

A second dispatcher should be assigned and dedicated to the fire department on all multiple alarm incidents. As much as the workload on personnel increases exponentially during a working multiple alarm incident, so does the workload of the dispatcher. A second committed dispatcher would create a "dispatch team" concept and allow for shared workload and situational awareness among the dispatchers about scene operations.

If the primary dispatcher is supported by multiple other dispatchers (i.e., absent a second dedicated dispatcher) there is the potential that all the other dispatchers floating in and out of the incident will not comprehend the big picture of the event.

This puts more stress and workload on the primary dispatcher as they may find themselves spending valuable time explaining things to other dispatchers who, even with the brief explanations, will likely not develop a shared situational awareness with the main dispatcher.

INCIDENT SUPPORT PERSONNEL

Once the department identifies the staffing needs for complex incidents, there is an opportunity to utilize non-firefighting personnel to fill support roles (e.g., fire marshals, light-duty personnel, trainees). Those personnel could be trained, in advance, on how to perform support functions (e.g., staging, accountability, rehab, air support, logistics, liaison, etc.) so as they arrive and report to command for their assignment, the incident commander is free of having to do any on-the-spot teaching of the job expectations. It is critically important to ensure that at all times the proper number of personnel are responding to perform support duties. Thus, after business hours, additional companies should be dispatched to fill these roles.

CHECKLISTS

It can be very beneficial for command vehicles to be equipped with clipboards that have checklists attached to them that itemize the duties of every command role (including the duties of the incident commander). While incident commanders and those who support the incident commander may be well versed on their duties for the types of incidents they see frequently, they may not be as able to readily recall (under stress) all the duties to be performed at uncommon incidents (e.g., a multiple alarm, working high rise fire).

Realizing duties may vary somewhat based on the type and complex of the incident, it would be advantageous to have several checklists for various types of emergencies. The checklists help to ensure all aspects of assignments are being performed. This can be very helpful for incidents that are complex, occur infrequently, or where duties are performed by someone who may not be well-practiced in the assigned role. Under stress, some of the duties that need to be performed can be inadvertently overlooked. If the incident commander is expecting those duties to be performed by the designee and they are not (or vice versa), this can create failed shared situational awareness between the commander and those in command support roles.

SOG REVIEW & REVISIONS

The department has an inclusive process for the development of standard operating guidelines (SOGs). However, despite the development and approval process, it appears that some SOGs may not be functionally appropriate for Asheville.

Observations made during the debrief indicated some SOGs may have been fashioned after model SOGs from other departments, contributing to some not being applicable based on Asheville's staffing and/or operations. The use of model SOGs is both a best practice and is encouraged. However, while still in the draft form, SOGs should undergo a practical testing process to ensure they meet two tests: Are they Asheville appropriate? And, are they Asheville achievable?

SOGs can be created with the very best of intentions and with the belief they are both appropriate and achievable. It is not until they are tested (preferably as part of an approval process and not at an actual emergency scene) that anomalies are identified. It can be beneficial to put each operational SOG through the rigors of testing to avoid over confidence that can arise when the creators/reviewers mentally visualize an SOG's success versus validation through testing.

It was noted during the debriefs that staffing levels available at the 445 Biltmore Avenue incident did not allow for the successful completion of all duties identified in the SOGs. It was recommended that the SOGs be reviewed to ensure they can be accomplished with available staffing, or alternatively, staffing levels be adjusted to meet the requirements of the SOGs. Regardless of which approach is taken, the outcome will be the realistic alignment of the SOGs and staffing, which can improve the success of incident operations.

SOG COMMUNICATION

Following approval, SOGs are posted on the city's intranet site and a broadcast email is sent out to all members instructing them to review the SOGs. Some members stated (and demonstrated) unfamiliarity with some of the SOGs. During the small group facilitation session some members noted they had not read every SOG and also admitted that some SOGs had changed and they were not as familiar with the latest changes as they should be.

This was also discussed and demonstrated during the large group facilitation where some members made confident statements about what the SOGs stated, only to have another member in the room read the actual SOG, refuting what was thought to be in the SOG. There is an opportunity to ensure all members have read and understand the complete list of the most up-to-date SOGs, especially those impacting operational readiness.

SOG TRAINING

While there is an opportunity to improve how SOGs are communicated and the accountability for reading them, the greater opportunity may lie with ensuring personnel are provided consistent training on SOGs by members who have been trained on the scope, purpose and expectations of performance contained within the SOG. It is an unrealistic expectation that an SOG can be distributed to shift commanders and that each of them will understand the document the same way

and train all personnel in a consistent fashion. Train-the-trainer sessions should be standard practice for SOGs. That session may be as simple as a review and opportunity for questions.

However, for more complex SOGs, the process may include hands-on training for those persons responsible for sharing the SOGs down the organization. Otherwise there is a risk of multiple interpretations of the scope, purpose and expectation for some operational SOGs. This can have a significant impact on multiple crew coordination and erode situational awareness between the commander and crews as well as between crews. Mission-critical operational SOGs should be distributed with (1) A teaching outline, (2) A practical scenario, and (3) A test or discussion questions facilitated by the trainer. Where operational crews apply the SOG and encounter breakdowns (i.e., the SOG doesn't work) the discrepancy should be noted and the SOG should undergo additional review.

During the debriefs personnel also acknowledged an opportunity to accept greater personal responsibility for knowing and understanding the SOGs.

COMMAND SUPPORT ROLES

Command support roles should be identified for incidents with significant mental workload. This should include, by practice, commanding multiple company working incidents (not to be confused with multiple alarm incidents) with a two-person (minimum) command team. Commanders who practice using a support person (e.g., aide, scribe) at smaller working incidents are far more likely to find success in using a support person at larger incidents.

The practice at smaller incidents will allow the commander and their support person to work out nuances in their styles and expectations and contribute to greater success during heavy workload multiple alarm incidents. While it may be criticized as "overkill" to have a two-person command team at single alarm incidents, the practice will prove its value in the coordination that will be critical at more complex incidents. Two-person (minimum) command teams should be a standard practice.

To clarify the context of the command team, the second person working with the commander is NOT the Operations officer or the Safety Officer. The second person is adjoined to the commander and serves as a scribe (managing worksheets, checklists and documentation) or a radio monitor (listening to the operations channel or monitoring the dispatch channel and talk-around channel) to alleviate the commander's need to listen to potentially non-stop (and non-critical) radio communications while trying to think through what is happening currently and while trying to think ahead of the incident to the potentially that lies on the horizon.

TALK AROUND RADIO CHANNEL

During the debrief, a general observation was made (unrelated to the 445 Biltmore Avenue incident) that the radio communications system has areas of unreliability (no repeater coverage) and that personnel operating inside an IDLH environment may not have contact with supervisors outside the IDLH environment. If a radio is off-line (i.e., not in contact with the repeater), when keyed-up the radio will emit a tone to indicate the it is off-line. This is often a location-dependent variable and does not indicate a catastrophic failure of the entire radio system. Rather, the portable radios simply cannot reach the repeater.

When operating in an IDLH environment, personnel who receive the tone indicating the radio is off-line should first reposition and if the problem persists, exit the structure. However, that solution resolves part of the challenge as personnel operating in an IDLH environment may be unaware their radio is off-line because they have not attempted to transmit a message.

It is possible the first message a crew transmits is a distress call and if the radio emits the tone indicating the radio is off-line, that crew will be in an imperiled situation. Fortunately the radio system used in Asheville has a "talk-around" feature that allows a radio to be set on an alternate channel and transmit a message (within a limited geographic distance) without having to connect to the repeater.

It would be beneficial for the commander (or their designee) to have a second radio turned to the alternate "talk-around" channel for the sole purpose of monitoring emergency radio traffic from crews operating in an IDLH environment if their radios cannot reach the repeater. An SOG should be developed to identify the talk-around procedures and all personnel should be trained and practiced on how to use the feature.

RADIO USAGE

By standard practice responding personnel are assigned to an operational channel for working fires. This is a common practice to ensure those working in hazardous environments do not have to compete with dispatch traffic. Unless the incident commander or their designee continues to monitor the dispatch channel they have no way to know, with certainty, that additional alarms were actually transmitted.

This was the case for 445 Biltmore Avenue. It is a reasonable assumption that when a dispatcher is instructed to transmit a second alarm that the order will be carried out. Redundancy built into the process would help ensure requests for additional staffing are fulfilled. This could be done in several ways. First, once additional resources are dispatched, the dispatcher could provide the commander with an update, prompt or reminder of the incoming companies on the second alarm.

This would serve two purposes. First, it would provide piece of mind for the commander that the proper resources have been dispatched. Second, it would serve as an audible cue for the commander to be thinking about what resources are coming in, their staffing levels, their anticipated arrival times and the work assignments that will be given to them once they do arrive.

Alternatively, as the incident commander has ready access to mobile data computers which, notwithstanding an equipment malfunction, will provide a visual prompt (versus an audible prompt from the dispatcher) as to what companies have been dispatched. Access to a visual display of companies on-scene and responding can be a very valuable tool to help a commander and the safety officer manage workload and accountability.

The standard practice for the Asheville Fire Department during a mayday operation is for the distressed crew to remain on the operating channel and all other personnel to switch to another channel. This is a logical practice as it gives exclusive use of an operating channel to the distressed crew and allows all other personnel to be coordinated on an alternate channel.

There were some inherent challenges that occurred at 445 Biltmore Avenue resulting from this practice. First, the commander was using a single portable radio to monitor incident communications. Switching the operating crews from Fire 2 to Fire 3, while good in concept, increased the commander's workload and stress as he was using a single portable radio to communicate (listen and transmit) critical radio traffic on two channels.

This required the commander to physically switch his portable radio back and forth between two channels. Whether operating the portable radio with the scan feature on or the scan feature disengaged, the potential for the commander to miss critical radio traffic while using a single portable radio while personnel are operating on two channels is very high. Add the stress of the mayday and the commander could find himself unable to keep track of communications.

Complicating the situation at 445 Biltmore Avenue was an unexpected situation where one of the portable radios used by the distressed crew, unknowingly to the user, had been (prior to the incident) turned to the alternate radio channel (Fire 3) and was on that channel for the entire incident. Thus, the initial mayday was called on Fire 2 and a subsequent mayday was called, unknowingly, on Fire 3. This led to some confusion among personnel as to which channel the mayday was called on and likely added to the stress of the commander from not knowing which channel to use for operations and which to use for the distressed crew.

The configuration of portable radios in Asheville accommodates a user being able to turn the channel selection dial all the way to the end to a channel that comes up "Mayday" on the display. At one time it was the mayday procedure that a distressed crew would turn their radios to this end position. This practice was changed in an effort to avoid requiring a distressed crew to make any radio position changes.

As the Asheville Fire Department frequently uses Fire 2 and Fire 3 for working fires, it may be possible to consider using the last radio channel as the default channel for all non-distressed personnel to operate on during a mayday event. It is important to note the practice of changing radio channels while operating in full gear, gloves, and limited visibility will present challenges and if continued as a procedure, it should be well-practiced in environments that closely replicate the actual working environment during fires.

As a rule of thumb, the more radio channels in use at an incident, the greater the possibility for communications challenges to occur. That noted, it is always a good idea to provide a dedicated radio channel to a distressed crew and it is a good idea for that crew to avoid changing channels.

It is very challenging for a commander to monitor and comprehend the radio traffic on two channels simultaneously. Anyone who has ever tried to talk on the telephone while attempting to carry on a conversation with someone else in the room can attest to the challenges it can bring to comprehending either conversation. Thus, anytime personnel are going to be operating on more than one channel, the commander should have additional personnel assigned whose sole purpose is to monitor the traffic on that channel and to report to the commander summaries of the most essential communications.

Ideally, an incident commander would always have an aide to monitor radio communications during a working incident, even if the incident is operating on a single radio channel. Given the cognitive workload of commanding an incident with multiple companies working and the possibility of the commander having to carry on face-to-face communications with others, the potential for the commander to miss critical radio traffic, or misunderstand critical radio traffic, is significant.

The Asheville Fire Department's standard practice for how portable radios are carried and used by line personnel has been left to personal preference of the user. Some use lapel microphones while others do not. Some clip the radio on to a strap while others keep them in a pocket. Some pull their radios out of their pockets when they transmit. Others leave the radio in their pockets while they transmit messages.

Quality, coherent radio communications from interior crews was a challenge at the 445 Biltmore Avenue fire as well as other fire incidents. Personnel noted the "clamshell" radio microphone extensions have proven to be unreliable and therefore many of them are not used. Recommendations from members included a variety of ideas including VOX microphones installed inside face pieces.

It is difficult to say which solution will work for Asheville without conducting trials of available technology. However, this is not an issue unique to Asheville and it may be beneficial to research the solutions that are already in use by other similar-sized fire departments.

One observation noted from the 445 Biltmore Avenue incident was two portable radios from distressed firefighters were lost, displaced, misplaced or abandoned leaving those firefighters with no way to communicate their location to rescue crews. One of the distressed firefighters noted he removed his radio from his pocket to transmit a message after which he engaged in an effort to physically extricate his incapacitated colleague. The radio, in-hand, complicated his efforts to secure a hold on his colleague's SCBA harness so he abandoned the radio.

The department will benefit from a radio storage and usage solution that allows firefighters to avoid physically handling their radios in IDLH environments.

CALLBACK PROCEDURES

The department would benefit from having a structured and practiced process for calling back off-duty personnel to backfill when major incidents draw down Asheville's on-duty resources. The goal is to have a process that is timely and not labor intensive. Several automated technologies exist to assist in achieving this objective.

AUTOMATIC MUTUAL AID

On occasion, the department may find itself with a shortfall of personnel due to multiple simultaneous incidents, multiple alarm incidents, or events that occur during extreme weather (hot or cold) that impact personnel performance and increase demand. Under such circumstances the department would benefit from the aforementioned callback system.

Additionally, the department could benefit from a regional response system where resources from neighboring jurisdictions are set-up, in advance, to respond into the city. Those resources could be used at the incident scene or to provide coverage for the city while Asheville personnel are tied up. This system would help the department improve ready access to additional personnel. That, in turn, might alleviate concerns from command about keeping city resources uncommitted for the potential (next) incident at the detriment of the actual (existing) incident.

COMMAND LOCATION

The department should consider the advantages of having incident commanders (and their aide) operate inside a vehicle. This practice would be applied at all multiple company working incidents (not to be confused with multiple alarm incidents). After the size-up, the commander and aide would be located in a fixed, secure, quiet location that provides many advantages including:

1. The ability to limit distractions and interruptions (a major contributing factor to lost situational awareness).

2. The ability to wear radio headsets (with VOX intercom between the headsets). This reduces environmental noise and provides the commander and the aide with improved clarity of radio traffic (including radio traffic that may be distorted from SCBA noise).
3. The ability to monitor a mobile radio assigned to a talk-around channel for emergencies.
4. The ability to monitor CAD data on responding and arriving units.
5. The ability to access pre-plan information on the mobile data computers (as available).
6. The ability to readily use worksheets to record incident events and crew activities.
7. The ability to readily use checklists to ensure all tasks are being performed.
8. The ability to use crew a resource tracking (accountability) system, whether that be paper or automated.
9. The ability to control ambient light and temperature to ensure the commander and aide remain physically comfortable and avoid environmental distractions.

There are some challenges that can arise from fixing a commander and aid in a vehicle as well, including:

1. After completing the size-up, the commander's physical view of the incident may be limited.
2. Those with extensive experience commanding outside of a vehicle may feel their awareness is eroded because of their fixed location and limited view.
3. Commanders may feel they are more effective providing face-to-face communications versus radio communications.
4. Commanders may feel being remotely located would increase radio traffic and contribute to an already existing problem of too much radio traffic.

These challenges can be overcome with training and practice. Commanding from a vehicle has been demonstrated to be effective in helping to improve workload management, decision making, communications, situational awareness and accountability.

RADIO TRAFFIC

The quantity and quality of radio communications during high-stress, fast paced incidents is challenging. This is complicated when personnel are operating in self-contained breathing apparatus and/or they are fatigued. Organizations often struggle with how to find the right balance in the volume of communications. For some, their challenge is too much radio communications while for others their challenge is not enough radio communications. For all, the goal is to find the right balance of the most appropriate and essential radio communications.

At the 445 Biltmore Avenue incident, personnel noted both a presence of what they thought to be excessive and unnecessary communications while, at the same

time, acknowledged the absence of certain critical radio communications (e.g., update reports of interior conditions). It is important to note that challenging interior conditions were reported to command, along with a recommendation to consider switching to defensive tactics. Some crews noted during the debrief their desire to report their conditions but were frustrated by the quantity of radio traffic and gave up trying to get airtime.

Several opportunities to improve the flow of radio communications were observed. The first is for the transmitter to identify themselves every time they communicate. At complex incidents where noise is high, stress is high and personnel are trying to communicate through SCBA, it is unrealistic to think that someone will be able to recognize the transmitter by the sound of their voice, especially if the speaker's voice is stressed. It is even more unrealistic to think that one person would be able to connect a voice to a specific crew and their assignment. Thus, implementing a practice where each and every transmission requires the transmitter to identify him or her self is a best practice that will improve communications and situational awareness.

Second, the cadence (order) of radio communications should follow a consistent and predictable pattern where the person being called is transmitted first (to get their attention), followed by the identification of the caller, followed by the message. For example: "Engine 1 from command" or "Command from Engine 1."

There were times during the 445 Biltmore Avenue incident where personnel were talking on the radio without identifying themselves and identifying who the message was intended for. This contributed to requests to repeat radio traffic and it contributed to confusion among personnel.

While it may seem like a radio communications protocol that achieves these objectives would increase radio traffic, it can contribute to a reduction in repeated traffic and a better understanding among all who are listening to the radio (including those who were not part of the conversation). This improvement in communications will contribute to better radio discipline and it will improve team situational awareness.

It would be beneficial to use these radio best practices at all incidents, not just complex incidents with multiple companies working. Practice does not make perfect. Practice makes permanent and whatever crews do on their day in and day out operations will be reflected in how they perform at novel, complex incidents. Stated another way: That which has been turned into a habit will be performed automatically under stress.

THERMAL IMAGER USAGE

While some Asheville Fire Department apparatus are equipped with thermal imaging cameras (TIC) they were not utilized to their full potential at the 445 Biltmore Avenue incident. Several firefighters who participated in the debrief

acknowledged an oversight in bringing a TIC along with them. One firefighter noted that while his apparatus has a TIC, he was unaware it was his responsibility to bring it along.

Members recommended the purchase of additional TICs to ensure their ready access by interior crews. When taken in and properly used the TIC can be a valuable tool to improve orientation, situational awareness and in assisting with locating heat, fire, and victims in smoke obstructed environments.

While interior crews did a phenomenal job of ensuring forcible entry tools and hoses were taken on entry, the TICs were not. The department could benefit from increasing TIC usage during all incidents where smoke obstructs visibility if, for no other reason, than to get personnel into the mindset and habit of utilizing TICs.

During the facilitation team visit, as fate would have it, there was a fire alarm activation at the hotel where the team was staying. This gave members of the facilitation team a first-hand opportunity to view the department's personnel deployment of tools and equipment in a fashion that was covert. It was readily noted that all crews entered the hotel with a proper ensemble of safety equipment and with compliments of forcible entry tools and a TIC. Notwithstanding the fact that a fire alarm activation with nothing showing (as was the case at our hotel) does not elicit the same stress response as an incident like 445 Biltmore. This challenge may have been an isolated occurrence and not systemic. Nonetheless, the opportunity to improving the use of this valuable tool remains.

ACCOUNTABILITY SYSTEM

The fire department has an accountability SOG and uses a passport system where accountability tags are secured to a board in the apparatus and the board is then to be delivered to the incident commander by the apparatus engineer. The incident commander, or his/her designee, also accounts for personnel using an "eStatus" report, a printed form that lists all personnel on duty and their riding assignments for the shift.

While the department also has an accountability kit that allows for tracking of personnel, a request to see a kit prompted a visit to the on-duty safety officer's vehicle where a kit could not be found. Ready access to this resource and regular use (practice) might improve the effectiveness of accountability.

For the 445 Biltmore Avenue incident the safety officer did not use the accountability kit. Additionally, the property configuration, size of the structure, location of apparatus and workload of apparatus engineers contributed to a problem with personnel accountability boards not being delivered to the commander or safety officer.

While the eStatus sheet may accurately represent personnel assignments at the start of the shift, it does not effectively track dynamic changes in personnel

availability and special assignments during the shift. For example, one firefighter was tasked to another location for apparatus operator training and his removal from his company was mentally noted by the battalion chief when the assignment was made, but was not readily recalled at the fire scene.

Tracking personnel – crew sizes, assignments, location and progress – are among the core purposes for an accountability system. The accountability system used at the 445 Biltmore Avenue incident did not accomplish those objectives.

The consistent and regular usage of a functional, accessible accountability board or worksheet could improve the situational awareness of the commander and safety officer.

Examples of how such a system might work include:

1. Personnel entering a structure identify their crew size and assignment upon entering the structure (e.g., "Command, Engine 1 with three, entering the west side, enroute to the fifth floor for fire attack."
2. Command would acknowledge the traffic with a readback (parrot of the traffic) and the crew, size, destination, and assignment would be written on the worksheet.
3. Significant crew movements or changes in assignments would also be noted by radio transmission and tracked on the worksheet.
4. During accountability reports, command or their designee would conduct a roll call during which each company would acknowledge their unit designation, crew size, location, task and, when appropriate, a conditions/progress report (e.g., Engine 1 from command, PAR check. Command from Engine 1, we have PAR, crew of 3, in the stairwell on the fifth floor preparing for attack. Command would acknowledge the PAR and only repeat the progress portion of the report.) The PAR would then be compared to the tracking on the worksheet to ensure there is an accurate accounting of each unit's crew size, location, task and progress.

PAR roll calls would be conducted on regular timed benchmarks (e.g., 15 or 20 minute increments). A heavy workload or complex incident conditions should not be used as an excuse to not complete a PAR. Some organizations have found it beneficial to call the roll in a descending order, starting with the crews perceived to be in the greatest potential for risk.

This system of accountability could improve the situational awareness of the commander, safety officer, and all other personnel working at an incident as the radio reports ensure a continual updating of mental models and keeps everyone dialed into team performance and big picture progression of the incident.

Crew sizes may change during an incident, as they did often at the 445 Biltmore Avenue incident. The officer in charge of accountability would have a dynamically updated system for knowing unit crew sizes, locations/destinations, assignments and progress.

In the event of a mayday, non-distressed personnel could be assigned to an alternate radio channel and a PAR roll call would quickly identify units, crew sizes, locations, assignments and conditions. This can be especially helpful during a mayday if the event results in multiple crews placing distress calls.

COMMAND STAFF/COMPANY TRAINING

It was noted during the debrief that command staff are often notably absent during training sessions where companies are practicing high-risk, high-consequence, team-oriented skills – the very skills that would be used during incidents that require strong command and control of personnel and tactical operations. The success of coordinating team activities will improve when command staff participate in the training evolutions and practice the coordination of tactics, communications and accountability. Participation goes beyond passive observation by commanders. Actively practicing command duties will improve command performance and improve self-confidence and crew confidence in command capabilities.

A second benefit of command staff participation in company level training is it provides a direct opportunity for commanders to make first-hand observations on the abilities of personnel, including assessments of competencies and physical abilities. As commanders improve their knowledge of crew capabilities, it will help them understand and manage expectations of personnel. As commanders improve their understanding of crew abilities and limitations, it will directly result in improved situational awareness as commanders will be able to predict outcomes with greater accuracy.

LARGE BUILDING FIRE & SMOKE BEHAVIOR

Many of the personnel operating at this scene indicated their initial assessment led them to believe the smoke/fire conditions were not significant. This may be due, in part, to an unknowing mental comparison of the smoke and fire conditions to what is seen most often when arriving at working house fires. As departments most often respond to residential dwelling fires, that can become the standard (subconscious) mindset for working incidents and set a standard for visual cue expectation.

Unfortunately, the smoke and fire conditions at 445 Biltmore Avenue did not provide an indication of how serious the fire was. This may be due to the low volume of smoke emitting from the structure. Unlike residential dwelling fires, this building had a massive volume of interior void space for the smoke to occupy, vastly reducing the visible smoke emitting from the building for arriving companies to visualize.

TRAINING FOR COMPLEX AND UNPREDICTABLE OUTCOMES

The department has SOGs for rapid intervention and mayday and has conducted training on each of them. When training on these skills there may be an opportunity to increase the complexity of the evolutions to ensure drills do not always result in the desired/expected outcomes.

For example, after training and practicing successful outcomes, there may be benefits in conducting additional drills that increase in complexity, ensuring personnel are given the opportunity to design creative solutions to challenging problems that are not covered in the SOGs. Encouraging personnel to construct novel solutions to unexpected and complex problems can improve creative problem solving.

Alternatively, if training to scripted SOGs always results in expected (successful) outcomes, personnel can be lulled into a sense of confidence that the SOGs will work in all cases as designed which may not always be the case.

Members identified the need to train in varied environmental conditions (e.g., hot/cold, dark, rain, snow, etc.) to improve the understanding of complexities such conditions bring to an incident and personnel. For example, training on a day with excessive heat/humidity might help identify the unique challenges of fatigue and heat stress and help the department understand what is needed to overcome those challenges.

A dichotomy to the previous recommendation was also offered during the debrief as members noted the need to avoid training on days with excessive weather conditions to ensure personnel are fresh for duty. Valid arguments could be made for both recommendations and consideration should be given to the benefit and consequence that can be derived from each.

SECTORING OF DUTIES & SUPERVISION

The management of complex incidents can benefit from the division of labor and the assignment of tasks to specific supervisors with pre-assigned duties. As an incident's complexity grows, so can the cognitive workload and this can quickly overwhelm an incident commander.

HIGH RISE INCIDENT PREPARATION

Members identified opportunities for improved preparation and training for high-rise fire incidents that include, but may not be limited to:

1. Consideration for changing hose packs from 2 ½" hose to 1 ¾" hose.
2. Practice pressurizing stairwells/ventilation practices.
3. Practice hose line placement.
4. Review policy on use of elevators and elevator control.

5. Practice procedure for resource staging (personnel and air).
6. Consider using doorway markers.
7. Consider using illuminated search ropes and/or disposable chem lights.
8. Revisit SOG on stairwell usage.
9. Practice maintaining orientation while working with complex floor plans.
10. Improve accountability.
11. Improve command and coordination.
12. Ensure a designated safety function.
13. Ensure a designated staging function.
14. Ensure the designation of divisions for interior operations.

RELATED ITEMS

The items captured here were general observations/recommendations made by members during the debriefing sessions.

PHYSICAL FITNESS

It was noted at various times in the small group and large group facilitation sessions there is an opportunity to improve the evaluation of personel fitness levels and to improve the overall fitness of personnel. Some members readily acknowledged their lack of stamina to meet the high physical demands at this incident and noted the need for improved general fitness.

Some members noted they conduct fitness assessments of their personnel using high-rise packs and treadmills. This is a progressive way to understand, in advance, the abilities and limitations of fellow crewmembers. This assessment is voluntary. It is uncertain what steps for remediation are taken if a member is found to lack essential fitness.

Members acknowledged the benefits of pre-hydration on days where excessive heat is predicted.

Members recommended a process to assess personnel capabilities on a regular bases and the implementation of a process/program to improve overall fitness.

RADIO COMMUNICATIONS TECHNOLOGY

Opportunities exist to explore how to improve radio communications technology so personnel operating in IDLH environments can easily and coherently communicate with supervisors. The practice of portable radios without extended (lapel) microphones being stored in radio pockets appears to be challenging and frustrating operational personnel.

Where radios are stored and their physical use has been left to individual preference and the resulting challenges appear to be well understood by many on the department. It was also noted that the clarity of radio traffic is a challenge depending on where the radios are located when being used. Exploring radio communications technology may provide some solutions to these challenges.

Prior to investing in new equipment it may be beneficial to contact departments using the new technology to glean their likes and dislikes and infer how the equipment might work in Asheville. A large investment in technology that does not work, or that personnel refuse to use, will not resolve this challenge.

GEOGRAPHIC ORIENTATION

Members acknowledged challenges with developing and maintaining interior orientation in low visibility conditions. This was due, in part, to an unexpected reconfiguration of the door access on the fifth floor (North-facing orientation) that was different from all the floors below (West-facing orientation).

Crews recommended a system to identify the sides of the structure based on a compass orientation (i.e., North, South, East, West) versus an alpha or numeric orientation (i.e., 1-2-3-4 or A-B-C-D). While this has a theoretical application, such a system is not without challenges and would require further exploration.

USE OF NON-COMMITTED ENGINEERS AT WORKING FIRES

It was recommended that non-committed engineers be utilized in incident operations. Discussion was held about the support duties performed by engineers. This served to enlighten some members as to work that was performed by engineers during the incident. However, it was noted that some companies were staged in a non-committed status throughout the incident, creating an opportunity for the engineer to become part of the firefighting crew or to perform specified support duties.

ELECTRICAL AMPERAGE OF GENERATORS

It was noted that the generators on some apparatus are insufficient to meet the electrical demands of the ventilation fans. It was shared that the fans are 16 amp and the generators are 15 amp. This causes the breakers to turn off frequently. This created a problem for one of the apparatus operators who, as he described it, required him to manually hold the breaker open for long durations during the incident. It was noted this is a recurring problem.

CAD RELIABILITY

It was noted that the CAD system has challenges with reliability. When recommendations were made to use the CAD to track unit responses and for accountability, personnel stated the CAD is not reliable.

USE OF CAD TO SIGNAL ARRIVAL ON-SCENE

It was recommended that responding units use the CAD to signal their arrival on-scene by depressing an "arrival" button. Notwithstanding the CAD issues previously noted, this method of tracking arrival would reduce radio traffic. It would be necessary for the commander or a designee to monitor the CAD.

INCIDENT PREPLANS

It was recommended that building preplans be accessible on mobile data computers. While the computers have the software needed there may be some challenges with the software being slow and cumbersome for ready access by the user. It was noted that by the time information loads, company personnel are likely to have already arrived at a scene and started operations.

It was noted by members that, notwithstanding the challenges of computer access to preplan information, members could make efforts to improve their knowledge of building preplans.

DISPATCH TRAINING ON SOGS

It was noted some dispatchers provide high quality services in predictable ways. However, it was equally noted that there are dispatchers who routinely and consistently do not follow the fire departments standards for dispatching. This has led to a lack of confidence in dispatching services by firefighters.

EXTREME WEATHER SOG

It was recommended that the fire department develop and implement a standard operating guideline for severe weather events. This may include considerations for additional staffing on the initial and subsequent alarms, climate controlled staging (e.g., a bus), and additional rehab services.

RIT PACKS

It was recommended that the department create more rapid intervention team (RIT) packs so they are more readily available for deployment.

TRAINING ON TOOLS, EQUIPMENT, SOGS

It was noted throughout the debrief that there is an inconsistency in how members are trained from station-to-station and shift-to-shift. It was suggested that the model of independent training sessions set up by company officers or shift supervisors may contribute to an inconsistency of job performance as crews operate together at incident scenes.

Some crew members were quick to note, with frustration, the quality of the training they have received has been below their expectations. This observation was not directly to issues related specifically to the 445 Biltmore Avenue incident. Rather, it was observed that, in general, the quality, quantity and focus to ensure department members are well-trained and well-prepared could improve.

This includes familiarity with tools, equipment, standard operating guidelines, multi-company coordination and the integration of command officers into the training evolutions.

INCIDENT DE-ESCALATION

It was noted the process to deescalate the 445 Biltmore Avenue incident may have been unnecessarily long. This was not one of the components discussed with participants during the debriefings but was offered as a recommendation for improvement during the large room session. Sometimes the need to extend a scene presence may not be readily apparent to all operational personnel. When the need is present, it may benefit all personnel for command staff to communicate the purpose for the extended scene times and then make a conscientious effort to release companies as soon as feasible.

AIR MANAGEMENT

It was noted throughout the debriefing sessions that the department members regularly and routinely operate in hazardous environments until their low air alarm bells activate and then they prepare to depart the structure. As several participants noted, most of the incidents the department responds to are residential dwelling fires or multi-family dwelling fires where egress is readily available. This can give firefighters a false sense of security in how they manage their air, believing they are just a few steps from safety after the low air alarm begins to ring.

While this may be the case in the majority of fires experienced in Asheville, this was not the case for the 445 Biltmore Avenue incident. Ingress and egress were significantly different and far more complex at this incident. The fire being on the top floor, the smoke and heat conditions, the building being non-sprinklered, the floor plan configuration being a complex and unpredictable maze of small offices and hallways complicated with fortified and locked doors all contributed to conditions where firefighters would be challenged to make a rapid exit to tenable conditions once their low air alarm activated.

A smoke filled stairwell that required crews to begin breathing air well before they reached the fire floor complicated air management. A staging area for replacement bottles several floors below the fire floor would have provided a means for crews to travel a shorter distance both for a bottle change and for returning to the fire floor.

Several crews reported working on the fire floor until their low air alarm activated in what seems to be a standard practice. The department should review the guidelines and training on air management and consider adjusting both to allow for a reserve of breathable air, especially in structure fires with complex conditions.

SUMMARY

As with nearly every casualty incident, it is relatively easy for evaluators to identity what could and should have been done on the heels of tragedy. After the fact the lessons often seem so apparent. It is important to keep in mind that no one went to work on July 28, 2011 with any knowledge or expectation that a member would be lost. The fire department and all of its members performed to the best of their abilities with an expectation that firefighters were operating safely.

It is very important that members avoid harsh judgment of their co-workers and guard their opinions about what could and should have been done. It is a very important step in the learning process to avoid judging. The discussions during the debrief sessions met the expectation of learning as the members were exceptionally professional yet open to share their ideas and concerns.

The challenge that remains is for the Asheville Fire Department to develop an improvement process and plan that involves all levels of the organization. There are many best practices available to help the fire department with the challenges and opportunities identified in this report. The facilitators encourage the department to utilize the resources of regional and national subject matter experts to help guide the department in areas of improvement that may include: High rise operations, air management, incident communications, situational awareness, accountability, mayday/rapid intervention, training program development, physical fitness, and standard operating guideline development/implementation/training.

PART 2: RUTLEDGE REPORT

BACKGROUND INFORMATION

I heard about this incident through a fire service news service to which I subscribe. Line of Duty Deaths (LODD) are normally announced by FEMA via email and numerous other sources including *Fire Engineering's* website.

Having authored and co-authored several fire service programs about interior structural firefighting gives me a strong background in this area. Three of the largest programs I developed or co-developed are still in existence today - Certified Firefighter II Academy (240 hour), Breathing Apparatus Specialists School (Smoke Divers, 40 hour), and Fire Attack and Suppression Training (FAST, 40 hour) - at the Illinois Fire Service Institute of the University of Illinois.

In addition to spending countless hours in our burn facilities conducting live burn training we were often asked to assist fire departments and other instructors in training burns of structures due for demolition. Some of our duties were to visit and assist other fire departments to learn more about structural firefighting. Chicago, Detroit and Cleveland were three in which we worked as well as many other fire departments throughout the Midwest. We garnered considerable knowledge and experience this way and incorporated this information into our teaching. We urged fire departments to consider changes after testing them thoroughly first. Therefore I feel my wide-ranging experience gives me a unique perspective.

During my teaching years at the Illinois Fire Service Institute I spoke several times at the *Fire Department Instructor's Conference* (FDIC) about how to conduct a *Smoke Diver* school and counseled numerous fire departments on how to develop similar programs in their own departments. I also authored a training manual titled, *Breathing Apparatus Training Techniques* in 1976. I was invited to sit on the National Fire Protection Association's NFPA 1981, Committee for Self Contained Breathing Apparatus. We developed the live burn standard for SCBAs currently in use today.

While teaching in the fire service full time I also served as a Pilot and Flight Instructor part-time. I often used my aviation experience in teaching firefighters especially in the area of communications. I was able to model and test a language or verbiage that was more easily understood when spoken by stressed firefighters through SCBA masks.

My experience at Delta Air Lines in conducting what we called *Crew Resource Management* and *Facilitated Debriefs* offered tremendous insight into problem areas flight crews might encounter during the course of their everyday duties of commercial flying. I have long felt these debriefs could hold similar value for those in the fire service. My goal was to test this process in hopes that it might offer the fire service an inside look at an incident from the participant's point of view. Then, after conducting several debriefs with flight crews we realized we were giving

crews the opportunity to not only tell their story, but to reveal what caused them to take certain actions during the incident.

During my years at Delta I also served as a volunteer on the *Peachtree City Fire Department*, a combination fire department in Peachtree City, Georgia. I was the Volunteer Training Captain for ten years. In that four-station department there were six senior officers, Fire Chief, Assistant Chief, Training Officer, and two Captains. We rotated duty every six weeks to provide command coverage 24 hours a day.

During that time I developed a unique system for operating at our fire calls. In this combination department full-time firefighters brought the equipment as volunteers responded to the scene. To provide better organization we formed functional units that existed only for the duration of the incident. This did two things, first it enabled us to form work units of four firefighters, which is more efficient. We named them by their function, such as *Truck*, *Engine*, *Squad* and gave them a unique number so the units would not be confused with fire apparatus.

Our system utilized a unique accountability tracking system I later named *Continuous Accountability Tracking* (CAT). My previous research indicated that in most SCBA operations the number of personnel fluctuates especially in volunteer operations. Systems such as the *PASSPORT* or *Personnel Accountability Reports* (PAR) have difficulty accounting for members, especially in the changing dynamic environment of a structure fire.

Since many fire departments used these systems we thought we would add another layer of protection by increasing redundancy in the existing accountability systems by utilizing standard sequential verbiage found in air traffic communications. This enabled us to track our crews and update their personnel accountability in the structural firefighting situations. Below is an example of the typical communication information and sequence.

- Unit ID
- Location
- Work Task
- Number of personnel
- Needs/requests

In addition to increasing firefighters' safety this method helped build everyone's *Situational Awareness* (SA) on the fire scene. A by-product of the system was that this message format drastically reduced communication problems, enhanced accountability and provided valuable information to the Incident Commander.

My goal in Peachtree City was to put in place the second part of the system I used during my heavy burn years in Illinois and that was the use of *Report Clauses* by command officers. When command gives a fire unit instructions or orders, they end the order with a clause that says, "Report a _____." Normally these can be developed for each department depending on their procedures. Generically some might be:

- Report a primary (Call me when you finished your primary search.)
- Report a secondary (Call me when you finished your secondary search.)
- Report conditions (Tell me present conditions in the building.)
- Report status (Report your crew status, location, task, crew count, needs.) Report ladder raised (Report ladder raised prior to climbing.)
- Report reaching _____(Report when you arrive _____)
- Report venting (Report when you are ventilating) See sample audios - (Appendix 3 – Audio tests)

When crews call in their reports it updates everyone listening not only on their task, but the location and number of personnel. Using standardized phraseology these reports take as little as five seconds to complete. During periods of heavy radio usage broken transmissions can often be interpolated for clarity. Additionally, reports serve as "cues" to command officers on status, of work, location of units and crew counts of units inside the structure.

An Incident Commander is human and as such his/her short-term memory may not be able to keep up with everything and things can quickly snowball. These reports help bring everyone up to speed and most of all monitor your firefighters. Moreover, when their crew counts vary from what they had originally been at the beginning of the incident numerous people can crosscheck with a unit for their well-being (Loukopoulos, Dismukes, & Barshi, 2009, 87).

Systems like the one described have virtually no dollar cost to the fire department, but they will improve operations exponentially if they are practiced and enforced. Those two things are key to the success. Intermittent use of this system *will not* work. As fighter pilots used to say, "You don't rise to the occasion – you default to your level of training."

ASSISTANCE REQUEST

In early July of 2011 Dr. Richard Gasaway and I met a former Delta Air Lines colleague, Jeff Hill, in Nashville, TN to discuss debriefs and Crew Resource Management (CRM) in aviation, the fire service and medicine. Our discussion centered around the use of both *Mediated* and *Facilitated Debriefs* for better understanding of the professions. Mr. Hill's insight into his use of debriefs in medicine was very helpful in designing our debrief process for the fire service. Next to aviation, medicine is probably the largest profession to use debriefs and CRM in general. Collectively, prebriefs, debriefs and other tools used in aviation are rapidly being adopted in numerous professions to ensure safety.

In mid-August Dr. Gasaway contacted me after having reached out to the Asheville Fire Department about a Facilitated Debrief for those involved in the fire that killed Captain Bowen. We both agreed it might be helpful for both the members on the fire department directly involved in the incident and for the department in general.

I requested information regarding equipment, staffing, along with some basic background information that allowed us to identify by name, rank, hire date, apparatus manned, and their radio call identifier. We also requested the complete (unedited) version of the fireground audio tape. Chief Barry Hendren sent all of these to me and I then put this information into a database I used throughout the interview process. This information was necessary for us to be able to identify experience levels of firefighters and group them by operating units on the day of the incident. Since radio traffic uses a slightly different identifier the radio call identifier helped us match the audio with the individual speaking.

The Facilitated Debrief primarily does two things. First, it allows participants to give their observations on the event and secondly, it offers them an opportunity to send information/recommendations to others. Only participants are invited to the debrief and an effort was made to keep recommendations anonymous if possible. However, in this case we held two debrief events. One debrief involved engine, truck, or squad companies as well as individual interviews of each command chief. The second debrief was a group debrief where all participants were invited to attend.

DEBRIEF PROCESS

Description - Small Group Debrief

Our groups varied from a single participant up to five participants. Each single participant (Incident Commander, Battalion Chief and Fire Chief) was debriefed privately, and then we debriefed units by companies in their small groups of four to five firefighters identified as directly involved in the fire.

Prior to the interviews we asked each member to complete a twenty-five question survey I had developed to learn more about their views of individual company operations both at the fire of 28 July and other fires in Asheville.

Small Group Interview - Format

The interviews consisted of three phases - Tell the story, discussion of topics and a T- Chart exercise.

Tell the story

Our intent was to encourage the firefighters to tell their stories in their own words. We would ask, "What were you seeing?" What were you focusing on?" and "What did you expect to happen?" (Dekker, 2002). We often sought details such as, "Did you think it would light up?" (A firefighter expression for an area bursting into flames.) We also asked, "Were you scared?" (As a way of assessing their stress levels.)

We recapped their stories to ensure we understood the things they had heard, felt,

seen and experienced, and noted critical junctures in their stories we could use to match with other stories.

"You must try to attain the perspective of the people who were there at the time. Their decisions were based on what they saw on the inside of the tunnel – not on what you happen to know today" (Dekker, 2002, p. 79).

All of the personnel we interviewed in Asheville were helpful and forthcoming in their stories. It was obvious to this interviewer that they had told this story many times before. Yet, they seemed to realize that we wanted their personal story and their insight into the incident. We also told them that we would be seeking their contributions and recommendations to be passed along to management at the large group session. In most cases it would be beneficial to interview the members as soon as possible after the incident, but in this case there were other understandable priorities (Klair, 2000).

The fire environment is dynamic and constantly changing. Firefighters rely on their training and background experiences to make their decisions, but no two fires are alike. No doubt this was the case at the 445 Biltmore Building. What one person experiences within the fire building may be totally different from someone else's experience even if they occurred at the same time in very close proximity. One group of firefighters told us of having to "hunker down" on the floor to get below the heat level on the fifth floor, and while on the floor noticed the boots of another company walking by them, obviously in much less distress.

We often had to probe deeper and ask for more details to find out how much heat they felt, what was the noise level at the time and what were the smoke conditions like specifically. We queried them about other related items to help place us, the interviewers, into their shoes at the time (Dekker, 2006, p. 95).

We sought to gather more detailed information about the visibility and how it affected their unit operations. Heat level information was specifically needed as it may have caused an immediate threat to their safety. Since noise levels are known producers of stress, the building fire alarm (claxon), PASS device noise, as well as their SCBA low air pressure alarms were examined in detail.

We probed the unit's air consumption monitoring as well. As they described the maze of hallways, doors and piles of uncharged fire hose a very confusing scene developed. As one firefighter related to us, "I felt like I was trapped in a cattle chute!" All of this information helped us understand the world in which the Asheville firefighters were working when inside the 445 Building on 28 July 2011. To this investigator their story sounded like they were working in a rat maze while trying to fight a fire, without water in a tangle of uncharged hoseline. This undoubtedly created a great deal of stress, which will be discussed later.

When considering these stories we tried to compare stories of other participants

who were in the area to build an image of events taking place at the same time. Sidney Dekker (Dekker, 2002, p. 69) believes this is a good idea to consider when asking them to tell their story that; " . . . the people involved in the mishap themselves also carry a great deal of potential for distortion, as human memory tends to order and structure events more than they were; it makes events and stories more linear and plausible" (Dekker, 2002).

Interview topics

The interviewers had selected interview topics that we felt would assist us in deriving recommendations we could pass along to fire department managers. We targeted the topics listed below and during the telling of their stories we captured information and added it to our topics list. Having a list of topics helped to keep our focus and aided in developing recommendations pertaining to each topic. Topics used:

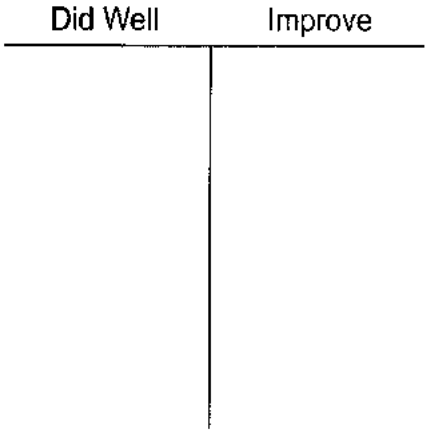
- Workload Management
- Teamwork (Crew Coordination)
- Decision Making
- SOPs/SOGs (Standard Operating Procedures/Standard Operating Guidelines)
- Training
- Communications
    - Inter/Intra Crew
    - Radio

These topics were not presented in any specific order and often overlapped but an effort was made to extract information concerning each topic area. We could sometimes target questions to obtain additional information about our topics during our recap of their stories, so the information we captured was far from linier. Dr. Gasaway also had these topics listed on 3" X 5" cards that we laid on the desk in front of the company and asked each member to select a card they would like to discuss. But, eventually our goal was to discuss each of the topics with the group.

Dr. Gasaway took notes during these interviews while I conducted parts of the interview. My recollection in drafting this report is strictly from memory of the event; Dr. Gasaway's notes might provide greater detail

Chart activity

During the T-Chart exercise we asked each participant interviewed to develop a list of things that they "Did Well" and things they needed to "Improve".



T-Chart: Format 1

Interviewees seemed to carefully consider this activity. Some, in my opinion, seemed to have more difficulty identifying things they "Did Well" as compared to things they could "Improve". This is normal from my prior experience in conducting this exercise. People are often reluctant to praise themselves in front of their peers. However, once the T- Chart exercise was completed we usually had an equal number on each side of the chart. We believe this technique was informative for both the interviewers and the firefighters.

After the T-Chart exercise was completed interviewees were asked if they had any final inputs or comments they wished to make and then all interviewees were invited to participate in the large group debrief to be conducted on Wednesday, September 21, 2011.

Survey

A twenty-five-question Likert survey was distributed to each member of each group questioned. The purpose of the survey was to learn more about individual's feelings and attitudes in their group activities. The results of this survey are found in Appendix 3. Assuming each of the five responses is a number, the figures reflect the average on a one to five scale. In total, fourteen (14) surveys returned. Throughout this report I may from time to time refer to the numeric values of responses in this survey.

Building Tour

Dr. Gasaway and I were taken to the 445 Building where the fire occurred and were given a tour of the fire building. By this time all of the walls and partitions had been removed but there was enough of an outline of where they had been and with an excellent description by Chief Burnette we were able to gain valuable insight into the fire itself and the building in general. My first inclination after seeing the building was that this building presented the Asheville Fire Department with a much more difficult scenario than surmised from our interviews. The slope on the North side of the building would have presented difficulties in placing a ladder apparatus into service and reaching the fire floor was questionable. Also,

we found that the references to the floors or levels could have been confusing as most of the firefighters entered on the ground floor then traveled up the inside stairs to floor one, two and all the way up to floor five. My understanding is that even though the fire was on floor five, the firefighters were actually climbing up six floors to fight this fire. The open spaciousness of the ceiling level on this floor allowed the smoke and heat to disperse. There was a virtual maze of walls, partitions, office furniture and locked doors at floor level. Heat and smoke were unaffected by the partitions and had free access to firefighters according to our interviews (Norman, 2005, p. 344).

FIRE – OVERVIEW

Fire Remarks - General

This was a high-rise fire as it exceeded the height of the available ladders in Asheville. Definitions vary but for firefighting purposes it was beyond the reach of Asheville's ladder, at least to reach the rooftop. Many high-rises are equipped with automatic sprinklers and/or wet or dry standpipes for firefighting. In this case the building had a wet standpipe and fire department good practice dictates that fire departments back up the wet standpipe by connecting into auxiliary Fire Department Connections (FDCs), which was done at this fire.

According to first arriving firefighters the fire, visible on the North side of the building, was not particularly large and it never seemed to grow appreciably in size. The term heard most often throughout our interviews was that it was a typical "room and contents" fire, only it was on the fifth floor. It actually was on the sixth floor because the first floor was called "Ground". Investigators apparently found it was an arson fire so perhaps it burned hotter and longer than usual helping to disperse contaminants throughout the building.

Stack Effect – Smoke Behavior

Under usual conditions smoke and heat rise from the fire site and travel up any available vertical openings such as stairwells, elevator shafts, or ventilation shafts. When they meet an obstruction to vertical travel they spread laterally in what is termed *mushrooming*. If it is cold outside the warmer inside air within the building tends to move up in much the same way. This can take place in any vertical opening such as stairwells, elevator or smoke shafts (Norman, 2005).

Normally in firefighting operations in high-rise or other large buildings the fire department takes advantage of the thermal updrafts by creating openings over the vertical shafts in skylights, elevator shafts or in some cases cutting a hole on the roof, which allows smoke to ventilate out of the structure. This lets the toxic byproducts of smoke go up and out the top as fresh air comes in from below. Then if firefighters are able to coordinate the opening of vertical shafts with hose line operations they can move into the interior and extinguish the fire (Avillo, 2008).

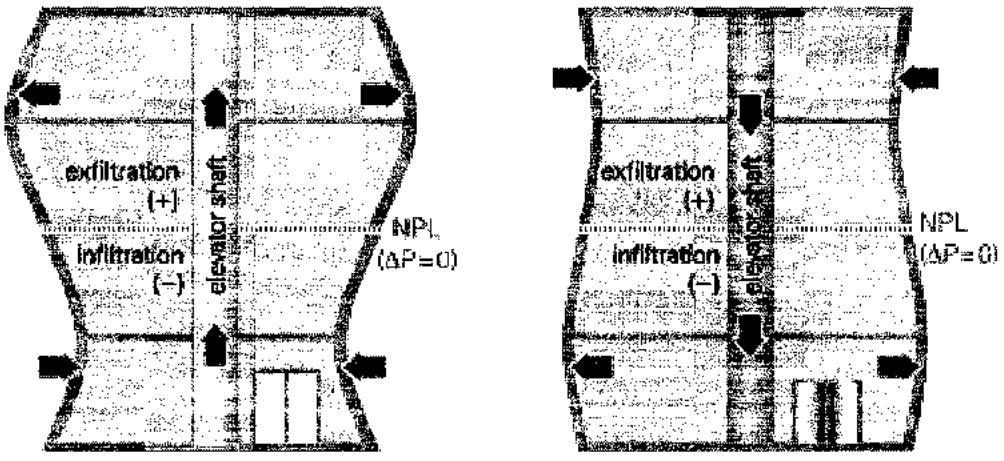
In most fire situations the fire department should seek to gain control of the HVAC systems in the building. It may even be hard to tell smoke is spreading via the HVAC system, the Reverse Stack Effect or both (Rutledge, 2011). However if control of these systems is achieved personnel can observe their effects and respond accordingly. The building's pre-plan helps in achieving this.

This thermal lifting can be very strong in some buildings and smoke can move high above the fire floor before it begins to mushroom. A fire in Las Vegas, NV in 1980 killed many people who were 15 to 20 stories over the fire floor (Norman, 2005, p. 337).

Inverse (Reverse) Stack Effect – Smoke Behavior

The fire at the 445 Building had indications of an Inverse or Reverse Stack Effect Fire (Rutledge, 2011). On hot days, when the outside temperature is hotter than the inside air temperature, the air flow in the building reverses and flows downward and out the bottom of the building (Norman, 2005, p. 338). Chief John Norman, FDNY goes on to say, "You take a tremendous pounding just trying to get to the fire, you have to wear your mask from the moment you enter the building all the way up the stairs, as opposed to staging just below the fire before finally going on air" (Norman, 2005, p. 339). This seemed to be the case at the 445 Building fire on 28 July.

"When indoor air is cooler than outdoor air, the column of air inside the building is more dense. The result is a net negative pressure at the top of the building and a corresponding net positive pressure at the bottom. Unless building pressure is controlled, outdoor air will infiltrate the upper floors while indoor air exfiltrates from the lower levels. The pressure difference also induces downward airflow in stairwells and shafts—reverse stack effect" (Stanke, 2002).



Winter (normal) stack effect

- Inward-swinging doors may not latch
- Exfiltrating indoor air drives moisture into building envelope

Summer (reverse) stack effect

- Outward-swinging doors may stand open
- Infiltrating outdoor air drives moisture into building envelope

Inverse (Reverse) Stack Effect during fires occurs especially in hot weather. The dense cold air tends to sink down vertical shafts and draws smoke with it, rather than the normal thermal pattern of smoke rising until it meets an obstruction, then mushrooming out. This of course can present unique problems to firefighters who are unfamiliar with this phenomenon (Norman, 2005, p. 338), and (Avillo, 2008, p. 354).

Combating Reverse Stack Effect

Cross ventilation can be helpful in the case of Reverse Stack Effect but caution must be used. Taking windows out on the upper floors of these buildings present serious hazards on the ground, as the glass is very heavy and can easily injure or kill. Departments dealing with these type of fires on a daily basis often carry rolls of very tacky shelf lining or paper to stick onto the glass in the window as then pull the broken glass back into the room to prevent it from falling all the way to the ground (Norman, 2005, p. 339).

Positive Pressure Ventilation (PPV)

A fire in an unsprinklered structure usually generates more smoke than a smoke management system can handle if there is one. However other systems may be employed to move smoke (Bachtler & Brennan, p. 1064).

The Reverse Stack Effect can be combated by the use of Positive Pressure Ventilation (PPV) (Rutledge, 2011). Large fans (electric or gasoline powered) can be used to force the dense air and smoke back up and out the top of the building. "Since PPV fans are set back from the doorways, they do not clutter the access routes. A fan blowing in can move almost twice the volume of smoke as compared to the negative mode, especially if churning occurs (Norman, 2005, p. 201-2 & 339).

During our interviews we did hear of an effort to put a ventilation fan at the bottom of the stairwell and I assume it was an attempt to reverse the smoke direction. However, due to power demands in the circuit supplying the fan, breakers kept blowing and the ventilation effect was intermittent at best. We also know from our interviews that at least one firefighter went up the stairs from the fifth floor to the roof and checked for fire extension. However, the rooftop door may have swung closed after this effort was made. Any of these efforts must be coordinated as the movement of smoke and fire gases can extend the fire unless provisions have been made to prevent this from occurring.

Smoke Dampers

An inspection after the fire examined the Smoke Dampers. Apparently one of them activated, at least the fusible link melted, but could not open due to a mechanical obstruction which probably occurred during one of the building's remodels. I believe Chief Burnette is investigating this at present.

"Openings are sealed with dampers. In the event of a fire, only the damper on the fire floor and the top outside damper are opened to exhaust smoke from the fire floor to outside. Tamura, 1973 explains smoke and smoke shafts, "The smoke shaft is intended primarily to assist in preventing smoke from spreading. At high temperatures fire would result in the passage of hot gases through the smoke shaft, which can result in greater venting action" (Tamura & Shaw, 1973).

Water Supply - Standpipe

There were apparent difficulties with the standpipe supplying water in this fire. We were told that after the fire the standpipe in question tested out OK, but testing was still in progress and engineers had scheduled follow-up tests.

Water Supply - Alternatives

It is not uncommon for hose lines, sprinklers or standpipes to fail in any building fire and reality dictates firefighters must prepare for this event and have alternatives ready. In these cases, hose lines can be stretched up the stairs within reason or sometimes even threaded into and out of the building for support if necessary. However, building height and nozzle choice can create limiting factors. Smooth Bore nozzles can provide good water flow for firefighting while operating at fifty pounds pressure. NFPA standpipe requirements may not provide the pressure necessary for the higher-pressure fog nozzles. Another option is to use an aerial device as a standpipe thru a window opening. This can often be limited by access to building proximity and ladder height. This method was finally used to extinguish the fire in the fire building.

TOPICS

WORKLOAD MANAGEMENT

Workload - General

I believe the communication techniques used at this fire in Asheville increased the workload of every individual on the fire scene. While early arriving units self-deployed into the structure, command did not seem to know their exact location or circumstances they had encountered within. When this occurs the radio channels will quickly light up as units seek direction and command seeks information. This will usually lead to an increase in firefighter workload.

Units were unfamiliar with the building plans when queried about their familiarity in Survey Item #25, a score of 1.29 average showed they strongly disagreed. Just navigating the structure presented problems as neither command nor the firefighters knew where they were. Survey Item #10's score of 1.62 indicates they strongly disagreed that command knew exactly where they were at all times during

this fire. This confusion also contributes to firefighter workload. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

All in all workloads increased with communication difficulties, lack of water and no available pre-plan. Also, conditions in the building interior worsened perhaps due to the HVAC system contributing to the spread of smoke. Firefighters for some reason did not make use of the elevator in this building. In this high-risk, low frequency fire the Asheville Fire Department was put to a severe test.

Workload - Firefighters

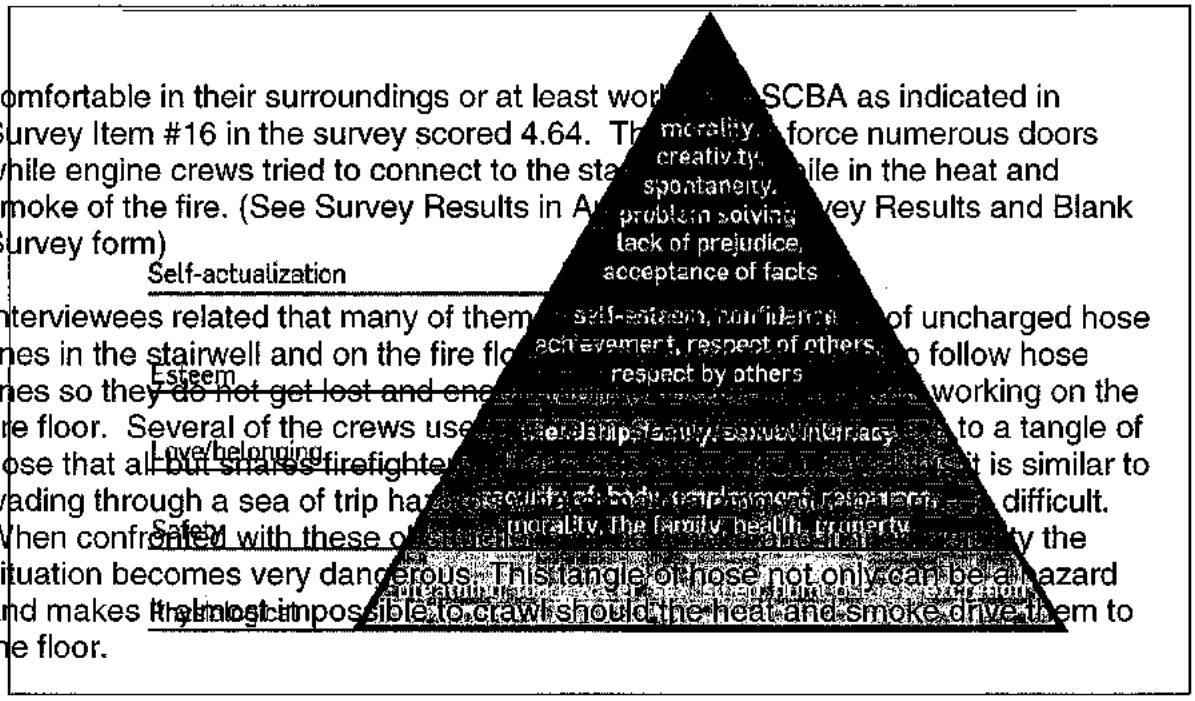
The firefighters in Asheville were stressed tremendously during this fire. Almost all of the interviewees told us they had used more than one air bottle. In the temperatures they were working, their thermal stress had to be extremely high. Just the walk up the stairs carrying all that equipment and hose had to have been very demanding.

It was not suggested to us that their workload during the initial firefighting operations was particularly difficult but they did have to force a few doors on some floors. However as time went on it seemed to take a toll on the firefighters that day. Several attempts were made to connect and flow water in the hose lines without success. Surely any firefighters who consumed two bottles of air in the heat present at the fire had to have been stressed. This Reverse Stack Effect fire had tremendous impact on the firefighters in Asheville on 28 July in my opinion. Survey Item #17 on the survey indicated this fire was unusually difficult. Those responding agreed with their average score of 4.14. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Virtually every unit we interviewed said they had to connect to their SCBA and use breathing air when they entered the ground level stairwell. Then they climbed up six floors to reach the fire floor. Although the fire floor was referred to as the "Fifth Floor" it was actually up six floors from where the firefighters entered the building on the ground floor West side. The effect of the outside air temperature, the protective clothing, the weight of the hose/gear carried and the trek up six floors put the firefighters at a serious deficit as far as energy and air were concerned. As Dr. Denise Smith, Heat Stress researcher says, " . . . the addition of a live fire (a common situation for firefighters) contributes to increased cardiovascular and psychological strain at a standardized workload" (Smith, 1997).

Avillo, (2008) refers to the Blast Furnace Hallway. "The blast furnace hallway occurs when the windows of the fire room are left open or are broken out, either by the fire or by uncoordinated fire fighting operations, and the prevailing wind is blowing from the windows toward the entry door and down the hallway towards the attack team (Avillo, 2008, p. 346). In Asheville, fortunately the wind was insignificant but the effect could have been disastrous.

However, due to their leadership and experience these work crews performed remarkably well under challenging conditions. They appeared to be relatively



comfortable in their surroundings or at least wor SCBA as indicated in Survey Item #16 in the survey scored 4.64. Th force numerous doors while engine crews tried to connect to the sta ile in the heat and smoke of the fire. (See Survey Results in A ey Results and Blank Survey form)

Interviewees related that many of them of uncharged hose lines in the stairwell and on the fire flo o follow hose lines so they ~~do not get lost and end~~ working on the fire floor. Several of the crews use to a tangle of hose that ~~all but snares firefighte~~ it is similar to wading through a sea of trip ha difficult. When confronted with these o y the situation becomes very dangerous. This tangle of hose not only can be a hazard and makes it almost impossible to crawl should the heat and smoke drive them to the floor.

I would say in my experience the firefighter's actual work time on the fire floor, fighting the fire was limited. Most firefighters can only count on about 16 minutes of time in a firefight under normal conditions. I would guess that was almost reduced to half in this circumstance.

I believe stress played a larger part in the events of 28 July than one might think. Descriptions of firefighter behavior by interviewees themselves indicated there were times when behavior may have bordered on panic. Certainly this is understandable when you become disoriented and are out of air. You are dealing with the very basics of survival. To use an example you are at the bottom of Maslow's hierarchy of needs.
"Air, water, and food are metabolic requirements for survival in all animals, including humans. Clothing and shelter provide necessary protection from the elements. (Encyclopedia, 2011)

One of the interviewees gave a vivid description of the situation as the firefighters desperately tried to find a way out of the building as they ran out of air. After dropping his radio one firefighter said, "I could have reached over and picked it up . . . but it would have cost me a breath." Later, that same firefighter located a door only to find it locked. When asked, "Why didn't you force it?" His response was, "It would have cost me two breaths of air." This provides a dramatic description of firefighters now fighting for survival and operating on the very bottom level of Maslow's hierarchy.

This interviewer has been in that very situation and knows exactly how he felt. He didn't make it out on his own, but did reach a window where he was seen and thereafter rescued. It was a sobering and frightening experience. How this Asheville firefighter managed to drag his captain down the stairs is beyond imagination!

Behavior is also described by Bachrach (2003), "a strong, fearful perception by an individual that he is out of control, that he is not capable of coping with the situation in which he finds himself, leading to behaviors that not only do not solve the problem posed by the danger but actually may work directly against such solution" (Bachrach & Egstrom, 2003).

We did hear from interviewees that this might have been the case if only temporary. There is little known about the effects of stress and heat in combination with each other.

Research has been conducted on heat stress and for additional information I would recommend contacting, Dr. Denise L. Smith, Ph. D. Skidmore College (dlsmith@fsi.uiuc.edu).

Workload - Command

Incident Command in contrast to the firefighters had a relatively light workload according to our interviews. The Incident Commander believed his crews knew what they were doing and that they would prevail as in the past. I believe that was the general feeling right up until the MAYDAY. After that, from the sound of the audios, the Incident Commander was desperately trying to find out who had called the MAYDAY and made efforts to locate them too. This seems to be the norm in MAYDAYs and certainly not just in Asheville.

It appeared the Incident Commander was very frustrated in trying to determine

what channel and what radio called the MAYDAY. This frustration was apparent when listening to the audio recordings. The multiple channels, the radio numbers and the mixture of unit identifications did not seem to help matters. The radio number was identified as the one transmitting the MAYDAY, but there was apparently no link to the specific person or their unit.

The command individual under the most stress during this incident apparently was the Battalion Chief who assisted the Incident Commander. He commented that he felt "completely overwhelmed". A good portion of this was trying to determine what additional units were responding to the fire. Apparently a portion of the alarm assignment was not filled. This reduced the available staffing on scene. I cannot exactly recall the specifics of the chief's other roles but he appeared to be doing all he could to supplement command's decisions. Dr. Gasaway has greater details about his work at the fire scene.

TEAMWORK (CREW COORDINATION)

There are two primary components of a team's perspective of a task. First is the collective representation of the group, or group identity such as Rescue 1, Engine 16 or Truck 12. Second is the team's mental model of the team's activity or task (Driskell, Salas, & Johnston, 1999, 293).

To help teams build their own mental models prebriefs are important. They are critical for the team to understand the task. However, that said, the Asheville crews seem to have understood their tasks according to their high score of 3.46 on Survey Item #8 and that they understood instructions given to them by command on Survey Item #7's score of 3.07 says they apparently understood most radio communications. Still in Survey Item #5's score of 3.14 shows they agreed that they did *not* know what was going on at times. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

One must understand the dynamics of crew operations while using SCBA in a smoke filled environment to explain some of this. The modern day SCBA mask or face piece is equipped with an inner rubber nose cup that fits over the firefighter's mouth and nose. There is also an outer transparent thermo resistant plate that is sealed in plastic or rubber lining that seals the mask to the firefighter's face.

The effect of these layers of plastic and rubber while sealing the mask to the face of the firefighter places severe limits on communication. In most cases one must shout loudly just to be heard a few feet away. In addition firefighters are often crawling on their hands and knees to avoid the heat above them and to give them better visibility along the floor. The anatomical position of the body when crawling compresses the firefighter's diaphragm, which further restricts respirations and decreases one's ability to speak. If this occurs when firefighters are crawling in a line down a hallway, as is often the case, it is doubtful the last person in line will be able to hear the first person in line. Becoming separated without direction can become a very real problem when smoke limits visibility.

Sometimes the first person in the line, usually the officer, gives an order and it has to be passed along to the firefighter on the end. Additionally, if the fire officer checks on the crew he or she must either see them or note their location by voice communication. In the 445 Building the building's fire alarm was sounding loudly and after a few minutes the firefighter's low-pressure alarms probably sounded. This noise filled environment hampers communication and teamwork, but Asheville firefighters were experienced and no doubt were aware of these factors and performed well despite the limitations placed on them.

During periods of stress the individual's attention narrows as peripheral task cues are first ignored, followed by further restriction of central or task-relevant cues. To the extent that the task-related cues are neglected, performance suffers (Driskell et al., 1999, p. 300).

This may have been the case in Asheville but it did not appear to be a large problem to most fire crews, but it may have been a problem for some individuals.

Karl Weick in his lecture about the Mann Gulch wildfire disaster discusses team performance in the incident in 1949, where a flare up of a wildland fire overran 13 firefighters. Weick quotes a former wildland forest service firefighter and writer named Norman McLean, who authored the book, *Young Men and Fire* about the incident (Maclean, 1992). McLean investigated the Mann Gulch fire and his perspective on a similar event where he was almost killed is most interesting. McLean recollects,

"We don't remember as exactly the desperate moments when our lives are in the balance as we remember the moments after, when the balance has tipped in our favor" (Weick, 1993).

Weick also brings up a good point in his analysis about what we now call tunnel vision. When smokejumpers arrived at Mann Gulch, they expected to find what they called a "Ten O'Clock" fire. This is a fire that can be surrounded completely by smokejumpers and put out by ten o'clock the next morning. When this did not happen they began to fall apart. Without a strong leader disaster soon followed.

The famous Sigmund Freud discussed the failure of military groups:

> "A panic arises if a group of that kind becomes disintegrated. Its characteristics are that none of the orders given by superiors are any longer listened to, and that each individual is only solicitous on his own account, and without any consideration for the rest. The mutual ties have ceased to exist and a gigantic and senseless fear is set free" (Freud, 1922).

This did not appear to be the case in Asheville's incident. Survey Items # 4, 8, 12 seemed to indicate confidence in their team leaders that the Mann Gulch crew lacked. I was impressed at how well these firefighters both worked and stayed together. During our interviews they expressed confidence in themselves and in their unit leaders. Although some members in their unit were too aggressive, the score of 3.00 on Survey Item #21 is not overly strong. Perhaps some may confuse overexcitement with aggressiveness in a fire, but these views seem to be highly subjective. It is also interesting to consider that,

> "When teams get behind, team members often ignore team play and each person tries to win the game on his or her own with predictable results. Interestingly, this seems to occur more on inexperienced vs. more experienced teams" (Driskell et al., 1999, p. 300).

Teamwork seemed to be lacking between command and interior units as indicated by Survey Items, #5, #10, and #6. However, in my experience communication is usually a large problem and this was verified by our interviews. The communication difficulty often leads to complaints of uncertainty and distrust for command officers and their decisions. However, I did not hear of specific incidences of this, only those involving the communications. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Command officers must rely primarily on their radios to build their situational awareness. If they are not getting the information they need command officers will query interior crews for that information which sometimes overloads communications in general. If they get the information, they should repeat it (sometimes called a READBACK) to verify accuracy and to repeat the information without the SCBA caused distortion so that all personnel on the scene can hear it. Other members working on the inside may need this information, not just the Incident Commander. Also the Incident commander needs to HEARBACK, the message to correct any information that might have been misunderstood. Good radio communication technique is vital during these operations. What works on the room and contents fire will probably *not* work so well on larger fires.

DECISION MAKING

Prior to our arrival in Asheville I had listened to the audio recording only one time due to time constraints. Later during our interviews we repeatedly heard comments about a "room and contents" fire. I can only assume that command officers were *not* that familiar with the type of fire they faced on 28 July. However, it is the low frequency/high risk fire that can be particularly difficult to control and can be very dangerous. Certainly they must be viewed very seriously for other aspects. The air temperature alone might have justified an extra alarm had it not been in a high rise, but certainly a fire at that level will go through many firefighters and expose them all to high levels of stress.

When units on the fire floor could not get water from the standpipe I am not sure if command offered solutions. The solutions seemed to have been generated from someone recommending using the ladder as a standpipe to supply them, I believe it was the Safety Officer in Car 3. I did not hear of any efforts to use some of the extra hose in the stairwell and string it back down the stairs to serve as a replacement water supply. A modern day pumper would have no problem supplying a hoseline up to that floor with sufficient volume and pressure to extinguish the fire.

Because many of the initial units seemed to self-deploy I wonder if command knew how much hose had been carried into the building. One commander expressed confidence in the crews, but did he know the equipment they carried or the amount of hose?

In almost every MAYDAY command requests a PAR. My view is that if a PAR request is necessary than command may not be tracking crews dynamically from the beginning. It is always good to confirm accountability but it should not be substituted for constant tracking of crew numbers.

I did not hear numbers during the fire in Asheville only requests and acknowledgements of "PAR".

Knowing the specific location that crews are working is good practice and vital to firefighter safety. Emergencies will always tie up radio traffic and doing a PAR in the middle of them may compound the problem, as vital communications could be lost. An older Chief once said to me, "We say that firefighter safety is our number one priority, but first we have to fight this fire." His meaning implies that while we might say safety is number one, we still do not do very well at keeping track of interior crews.

This may seem to be only a problem with command at fires but equal responsibility lies with the company level officer counting their crews. Command officers cannot see what is taking place inside the building and must rely almost exclusively on radio communications to give them "the picture" of inside activity. While some crewmembers may report directly to command for a face-to-face meeting, by and large it is through the radio.

I have three indications that communications problems existed during this fire. First the response to Survey Item #10 concerning the location of firefighters in the building does not express confidence in command knowing their location within the building. Secondly, Survey Item #9 indicates unit leaders were not counting their crews very often and lastly Survey Item #5 could indicate communication problems both within the crew and with command as well. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

The picture of crew location might have been quite different but we were not made aware of it. On a follow up day, after our building tour we attempted to locate a command accountability board but were unable to find one. If that is the

primary accountability system I can only believe that the use of "PARs" was the backup system and it failed. Firefighter Johnson tagged along with Rescue #3's crew. Was he included in the PAR? If Johnson was included in the PAR and the only person who knew the exact number in Rescue 3's crew was the Captain, then PAR failed. Two men from Rescue #3 came

down the stairs and two were taken out in the MAYDAY rescue and taken to the hospital. If the only tool available was the daily *riding list* showing four firefighters on Rescue #3, then who accounted for firefighter Eric Johnson? Had he not escaped there might well have been two firefighters lost in this fire. Count your personnel as a unit officer and pass those counts along to command often. You want to repeat those counts for the world to hear.

Survey Item #11 indicated that firefighters moved freely about the building. The score of 3.08 indicated they moved about without restraint and I did not hear a great deal otherwise from radio traffic. Were they searching, fighting fire or just trying to find the seat of the fire? This not only confuses command in normal operations but it can prove disastrous in an emergency. However, in a maze such as described by firefighters on the fire floor disorientation may have been a larger problem than was revealed during our interviews. Firefighters did take out windows on the West side of the building when radio communications showed they clearly thought they were on the North side of the building. This action is evidence that there must have been more disorientation than we thought. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Survey Item # 9's score of 2.21 indicates the crew leaders themselves may not have been ranking accountability near the top of their priority list. Every five minutes is a very long time, especially in the maze in which the crews told us they were operating. Unless the crew is solidly united there have been cases where a member feels they are alone and has left the safety of their crew thinking they had been abandoned. Crew counts do more than just ensure everyone is accounted for they help unite the crew as a unit. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Another Survey Item of interest which had to come into play in the area of decision making was Survey Item #25's very low score of 1.29 that concerned firefighter familiarity with the building's pre-plan. I do not recall command officers referring to a pre-plan when making their decisions and apparently interior crews were not aware of the pre-plan as well. During subsequent interviews concerning pre-plans everyone seemed to agree pre-plans existed but there appeared to be great difficulty, under no stress, in finding pre-plans. Command must have been working in the blind without a building pre- plan and firefighters inside fared no better. That said, the particular command officers involved in the 28 July incident might have had previous knowledge of the building along with firefighters who had made previous responses to the location. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

SOPS/SOGS

In our interviews it appeared that the firefighters in Asheville were not very familiar with the SOPs/SOGs, which is not unusual in most fire departments. Like any large organization rules are often written by administration and passed on down the line. They often get less and less review as they come down and are seldom reviewed during training.

Efforts seemed to have been made to gain "buy in" of the SOPs/SOGs that existed in Asheville. By and large firefighters seemed to have a general knowledge of them, but none were specific. There even seemed to be differences of opinion on the definition of a "High Rise." Again, this is not unusual in my experience with fire departments. The key to knowledge of these documents is the company officer and his key is the Battalion Chief whose key is the Division Chief, whose key is the Assistant Chief and so it goes.

Like published procedures in any industry if they are not "living" documents they are doomed to a slow death in the filing cabinet. "Living documents" are ones that are disseminated, studied, practiced, tested and enforced time and time again. In commercial aviation an FAA inspector can board your aircraft at any time to ensure compliance. SOPs/SOGs should be under constant scrutiny seeking improvement. Probably the biggest hindrance for their success is the fact that users are rarely given an assessment on how well they know and understand them. That must start at the top and work its way down.

"Organizations that look relentlessly for symptoms of malfunctioning, and are able to link these symptoms to strategies, positions or priorities, are better able to create practices that preclude problems or stop them from developing into unmanageably big ones" (Dekker, 2011, p. 96).

Chief Glen Ayers (1969) successfully used time and motion studies to cut down the times of his basic firefighting tasks on his fire department. First he listed the steps in each procedure and then he combined, eliminated, rearranged and simplified steps in the tasks. When finished he picked up the stopwatch and started timing these evolutions. Now he had specific standards he can measure.

Most procedures on a fire department are at the task level so they should be thoroughly documented and tested. Later time performance criteria can be added. Today's modern computer era makes it relatively easy to photograph and detail specifics of an evolution.

The interpretation of SOPs/SOGs must start with the senior officers within a department. Explanations of the documents by senior officers are key to the firefighters understanding them. We did hear a great deal concerning SOPs/SOGs but the comments seemed to lack any interpretation from senior officers. Successful implementation of these documents means communication between companies and those generating the SOPs/SOGs.

There seemed to be some involvement in their creation in the Asheville Fire Department but seemed to be lacking in their dissemination.

TRAINING

Like anyone who must master physical tasks, training is the key. Survey Item #13 and #22 seemed to indicate training was needed for incidents of this type and some firefighters needed more training in general. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

"Washington, D.C. fire officer Bob Bingham says in his excellent text, Street Smart Firefighting, "The main reason that bungled fires continue to happen is that we often skate along doing the bare minimum on our routine calls, and when we have a serious fire, our bad habits come back to haunt us" (Bingham, 2004, p. 27). Bingham goes on to say, "Always do it the right way. It isn't always necessary, but it will ensure that you will be doing it the right way when it counts" (Bingham, 2004, p. 28).

Task level training is not difficult, but a good training facility can be a big help. A key ingredient necessary for success is to have Performance Standards developed for each of the key firefighting tasks. Only when you have a standard that can be tested and practiced can it be driven down to the company level. Anything less and you will only get what your Company Officer shows you and that may or may not be the department's standard. Like the disagreement we heard in the large group debrief on the definition of a "High Rise" there will be numerous variations found at the task level unless you have standards.

It has been estimated that firefighters only fight fire four percent of the time. That leaves 96% of their time being spent on other duties (Brunacini, 1978). Task training, especially firefighter task training, requires practice, lots of practice (Druckman & Bjork, 1991, p.30). Survey Item #13's response of 4.36 indicates they are craving practice, at least in high rise type fires. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Survey Item #19's score of 2.00 indicates that company officers are not doing debriefs after their incidents on a regular basis. The post-incident debrief can be a valuable tool not only for training but also for communication in general. Debriefs can help generate training ideas, but if they are not conducted or the findings forwarded up the chain of command, firefighters can become discouraged, and can lose faith in their company officers. That philosophy can also extend to senior officers within any department. They have a vested interest in the training of their personnel and should also participate in the training whenever possible. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Most firefighters I know are action-oriented people. Their bread and butter are the task level operations in everyday firefighting operations. We heard multiple comments indicating that since the incident they have not had any training.

Perhaps this is an exaggeration, but it does point to one thing. They want more training. A debrief will probably give you plenty of information about what the firefighters think they should be training on, but there may be extenuating circumstances preventing that training from taking place at this time. However, the firefighters do not see the lack of training favorably. They want to do a good job, they want to work together and they want to do it safely – they want more training.

COMMUNICATIONS

Inter/Intra Crew

Communications within crews seemed to work relatively well. Already mentioned was the difficulty of speaking among crewmembers as being a major factor in all firefighting operations. Survey Item #1's score of 2.62 indicated that prebriefs probably were not used to a great extent prior to building entry, however this may have changed after encountering adverse conditions. One must conclude from Survey Item #8 that instructions were understood when given by the crew leader. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Radio

We did hear many comments about the radio being very busy and in some cases units were unable to transmit their message to command. Some firefighters got frustrated and just quit trying. The MAYDAY brought more communication problems as they usually do. Responding apparatus too interrupted it.

Radio communications are always a problem in any multi-alarm fire. Numerous crews are all waiting to grab any available lull in traffic to convey information. However, even after listening to the audio recordings I am not quite sure I understand some primary elements of the system.

What is the order of communication in Asheville Fire Department's communication system? Does command say, "Command to Engine one," for example then wait for a response/acknowledgement? (Me calling you!) Or does command say the name of the unit they are calling first then themselves? (Hey you, it's me!) A close analysis of the first technique shows that to communicate you must make four transmissions.

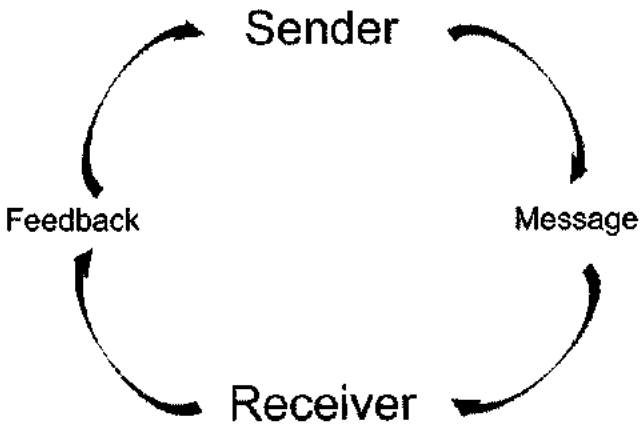
1. "Command to Engine one."
2. "Engine one, go ahead."
3. "Engine one, take a line up to the fire floor."
4. "Message received."

Using the other method does two things, first it alerts the crew being called that the message to follow is for them. Second, it cuts transmissions in half.

1. Engine one, Command, take a line up to the fire floor."
2. Command, Engine one, message received."

It seems that when seeking better communications one should consider this second alternative.

The audio recording contained numerous acknowledgements of something, but did not repeat or READBACK the message. In several cases I simply could not understand, yet it was acknowledge as if understood. This is critical for good communication. The reason being the Incident Commander is not the only one who needs information. Acknowledging is one thing but giving a good READBACK is a critical step in communications loop, especially in garbled SCBA messages.



Communication Loop

Another problem seemed to be in the radio procedure to be used when a MAYDAY is called. Most departments recommend the Incident Commander stay focused on the fire situation and delegate the MAYDAY to another officer so situational awareness can be maintained on each. George Miller in his classic work of 1956 on short-term memory says, "First, the span of absolute judgment and the span of immediate memory impose severe limitations on the amount of information that we are able to receive, process, and remember" (Miller, 1956). When an Incident Commander tries to control both the fire and the MAYDAY, he is not multi-tasking. "Although individuals may think they are performing several tasks simultaneously, human ability to process more than one stream of information at a time and respond accordingly is limited" (Loukopoulos et al., 2009, p. 14). This may explain why some units involved in the events of 28 July could not achieve radio contact with the Incident Commander.

ALARM RESPONSE

The Asheville Fire Department is a quality fire department that does a fine job of providing excellent fire protection in their community. After conducting interviews and listening to the audio recording of the events of 28 July 2011, I would offer some recommendations or suggestions to make a good fire department even better. However, like any outsider I do not profess to know it all. I hope that Asheville looks into some of the suggestions and perhaps even tries some of them before dismissing them. With a firm commitment from the members of the Asheville Fire Department to make improvements, success will be their reward.

Increase initial response – Staffing and equipment

Several interviewees indicated that the response to this fire was short on equipment and on staffing. Certainly the stresses placed on initial units support adding additional equipment and staffing to similar scenes. These three things should be considered on all alarms - occupancy, severity of the fire, and weather conditions. Any one of these might have triggered a call for extra alarms at this incident. Alarm response recommendations should come from the fire department and should the city alter staffing, equipment needs should be adjusted to provide adequate firefighters for staffing at extra alarm fires. Dispatch should be included in discussions on the specifics of this plan.

Dispatch additional aerial apparatus on commercial structures

Include at least two truck companies and sometimes three if necessary. Certain hazards may need special companies such as Haz-Mat or other apparatus or expertise. Pre-plan these and have them called immediately.

Dispatch additional support units and utility notification

Air trucks, light trucks, hose wagons, rehab buses and other support vehicles should be automatically dispatched at major incidents at some point. Do *not* rely on command requests for this equipment or it will most likely be late. Incident Commanders are far too busy to think of these items and querying for them by dispatch causes an unnecessary interruption.

Dispatch additional administrative personnel at working fires

Dispatch additional administrative and inspection personnel and use them as command staff. "Some fire departments dispatch additional chief officers, communication officers, staffed command post vehicles to help better effectuate fireground radio communications. They in essence provide a trained dispatcher at the scene of the emergency to help the IC manage fireground radio communications" (Varone, 2003, p.7). Interestingly Varone goes on to say that,

"When the less frequent but larger incidents occur, we use the radio exactly as we are accustomed to doing at smaller incidents" (Varone, 2003). Protocols should be practiced at all incidents. Include personnel from dispatch when constructing these changes to get their input. Any or all of these recommendations help address the critical safety factor of providing a backup to the IC.

Dispatch large ventilation fans for all working commercial fires

Positive Pressure Ventilation (PPV) may be used but it takes time to set up fans and pressurize the stairwells. Do not wait until it is too late. Start them coming on working fires.

Ensure that a complete pre-plan is available to Incident Commanders

Dispatch personnel to extract vital details for building pre-plans to control building systems and utilities at working fires. If necessary have someone respond to the structure and coordinate all efforts to control building utilities, elevators, HVAC and other systems necessary for good firefighting. These *must* be available from the onset of a major firefight.

Modify response to include special units and utility considerations

During this incident command officers were often distracted with concerns about additional apparatus, staffing, air trucks and utilities. Good practice demands that these should be automated to a large extent to allow command officers to focus on the task at hand and more importantly on the safety of their firefighters.

Consider utilization of a MABAS plan

Consider adopting a Mutual Aid Box Alarm System (MABAS) plan. MABAS is an excellent means of providing help just by depressing the microphone and asking for another alarm. I would highly recommend using this or a similar system to enhance the firefighting capabilities and overall safety for everyone. A good pre-plan should detail these considerations.

Increase personnel assigned to working fires

Adjust alarm assignments at all working fires when weather conditions dictate in order to bring extra firefighting personnel to the scene as soon as possible during the working fire. Excessive heat, snow, floods or other mitigating factors slow response times and demand additional staffing and equipment. Include personnel from dispatch when constructing these changes to get their input and perhaps even have them respond to the scene themselves.

Control self-deployment of initial responders

Self-deployment should be controlled. If company officers feel it is warranted, units should be mandated that they report their destination, work task and crew counts when self-deploying at working fires. Asheville firefighters are good at what they do and it appears they have been successful on single-family room and contents fires. Subsequent arriving units should do the same until command is established and coordinates firefighting efforts. Practice this religiously in structure fires on every call and you will have far fewer problems at your larger incidents. *You don't rise to the occasion; you default to your level of training.* If you do *not* practice this on smaller incidents you will have problems at larger incidents.

Sterilize structures at working fires

Consider the structure to be *sterile*, meaning no firefighting units have entered the structure. Thereafter all fire units must report *going in* and *coming out* of that structure. Do *not* allow this to be violated or you will play catch-up for the entire fire and put firefighters at risk. This also allows firefighters to take initial actions but provides for situational awareness for incoming units and establishes a pattern for other units to follow. More importantly it is much safer for the firefighters.

Mandate entry and exit control

Good accountability practice demands entry and exit control. This not only includes control on initial entry but later entries as well. This is often the case in high-rise fires when crews are staged below the fire floor. Entry control is vital to firefighter safety and as soon as possible an officer should move up to this position.

Backup all existing accountability systems

Do not rely strictly on Passports or PARs, but use a radio based crew count for everyone. If you use PAR try moving to a "PAR plus" system that gives a number count. Command should insist on a count when PAR is called. If crews are constantly counted it helps group cohesiveness and ensures firefighter safety. Make it a habit and your operations will remain quality and your communications problems will diminish.

Mandate the use of "CLEAR" when exiting a structure

Mandate all units report CLEAR of the structure and include their "crew count" or "PAR plus) *every time* they go in and out of a structure during an emergency or working fire. This is repeated because it is IMPORTANT.

Crews were severely tested in this midday summertime fire. Several were hospitalized from their efforts and others were all but exhausted. Firefighting is especially difficult in summer; heat can quickly strain firefighters to the limits of safety. Adequate personnel must be added to alarm responses to relieve firefighters stressed from the heat and measures developed to prevent excessive stress on all firefighters.

Develop alternative plans to increase supporting staffing

Additional staffing contingency plans should be added to dispatch requirements during environmental extremes. Consider the use of mutual aid early in the event to provide additional staffing, not necessarily for firefighting but for the support of firefighting. Should inside staging be initiated these units may be useful in resupplying the firefighting crews.

Develop additional medical protocols for extreme events

The department might want to seek professional medical assistance in developing protocols for these types of incidents. Multiple firefighters told us about heat levels and stress levels. This apparently sent several firefighters to the hospital. Numerous firefighters told us they used at least two bottles of air during this fire. "Our data reflecting the extremely strenuous nature of firefighting suggests that any attempt to have firefighters work longer by supplying larger cylinders for the SCBA would simply result in greater levels of fatigue from which it would be extremely difficult to recover" (Williams-Bell, Boisseau, McGill, Kostiuk, & Hughson, 2010).

Study air management information at major fires

An excellent reference is the article titled, "Air Management And Physiological Responses During Simulated Firefighting Tasks In A High-Rise Structure" (Williams-Bell et al., 2010).

Increase staffing of medical personnel on command staff

Addition medical personnel should be available to advise on command staff on firefighters' conditions and make recommendations. Also, sufficient staffing should be provided to supplement command positions dealing with firefighter safety and well-being.

Mandate annual air consumption testing

All companies should undergo annual Consumption Testing with full gear and SCBA to provide each member of the department with a time estimate of their work time in SCBA. These tests can be developed in house to reflect department needs and administered in the station utilizing training personnel but should also

be developed and monitored by medical personnel. (See appendix under Appendix 2 – Consumption Testing)

Company officers should know and consider the results of members' consumption tests under their command at all times and pace the unit accordingly. Personnel of different sizes will consume air at different rates.

"Knowledge of maximum rates of air consumption (in % of air cylinder or l/min) for specific tasks can enable incident commanders to develop strategies for air management to insure that firefighters can safely exit a burning structure before the sounding of their low air alarms. Our data on the high physical demands of firefighting in combination with our

observations of the rapid utilization of the air supply in the SCBA cylinder point not to increasing the size of the air cylinder but to different strategies for air management" (Williams-Bell et al., 2010, p. 258-9).

Utilize 2-1/2" hose with Smooth Bore nozzles in standpipe operations

It was mentioned that the cause of some problems on the fifth floor was the fault of using 2-1/2" hose. My opinion is that the hose may have been a contributing factor but it was <u>not</u> the cause. I would caution the department from moving away for the use of 2-1/2" hose and the smooth bore nozzle. Just the increased fire flow and reach warrants this line to say nothing of its ability to function when residual debris from within the standpipe traverses the hose line and comes out of the nozzle (Avillo, 2008, p. 346).

I was in a dire situation one night when debris clogged our fog nozzle. One minute we were barely holding our own and the next we were running for our lives. Later we found that a hose-coupling gasket had come loose and fouled the nozzle.

Many standpipe systems are not designed for fog nozzles and may not allow adequate pressure for fire streams if used. NFPA 14 is designed around the use of 2-1/2" hose and Smooth Bore nozzles. Their requirement for 65 psi on the top floor reflects this. That pressure is sufficient to develop a good 250 GPM stream from a Smooth Bore, but that pressure may severely limit the flow when using a fog nozzle (Norman, 2005, p. 130-131).

Generally the teamwork was good, but units must be prepared to deal with situations that may occur at larger incidents. My recommendations are to do some simple adjustments that will strengthen their solidarity and build their confidence.

Mandate unit prebriefs prior to task work

Conduct short crew prebriefs prior to task work. Since firefighting operations usually consist of various work tasks a format suitable for task performance can be used that simply emphasizes key points in the task. However, you need to record the steps in your work tasks and ensure officers are using them as their guidelines for briefings. They should be consistent throughout the organization. One prebriefing format is shown below.

- Who?
- When?
- Where?How?
- What? (Flin, O'Connor, & Crichton, 2008, p. 85)

Conduct crew debriefs after drill and call of any kind.

It is important for the leader in such debriefs critique themselves first so subordinates will be more forthcoming in their own critiques.

- Establish what happened (the facts).
- Discuss why it happened.
- Highlight what was done well (Positive reinforcement).
- Determine what could have been done differently.
- Agree on lessons learned.
- Solicit recommendations from participants.
- Determine what information should be passed on to others (Cannon-Bowers & Salas, 2006, p. 283).

Mandate intra-crew counts every 90 seconds in structure fires

The crew leader does *not* broadcast this over the radio but rather counts his crew frequently. This may seem excessive but it is necessary to ensure a habit is formed and to focus crew welfare as the most important job of the company officer. Basically, the unit officer calls out the unit name and members respond by count. (Never use names.) When repeated often, company officers will become familiar with not only the number, but the tone of voice and clarity that each member projects through their SCBA mask. I have had numerous officers tell me they felt more responsible for their firefighters when they did this. If this is not done often it will fail. These lapses are the direct responsibility of the company officer and their number one priority should be the safety of their personnel. It must become habit, be it an obnoxious habit – it works.

Notify command of any change in crew numbers immediately and confirm

If crew counts change, command *must* be notified each and every time. If members drop out of a crew they should notify command of their location and command should confirm it. Unit officers should immediately modify their crew count to reflect the new number. Unit leaders are responsible for passing along accountability information to command as soon as possible after any change.

Employ split-crew procedures

Should an officer split their crew they should have a rendezvous time and place to ensure the safety of members who might be without radios. These splits should also be passed along to command when able with counts of both crews and rendezvous locations if possible.

Develop standard phraseology

Develop a standard phraseology and sequence to be used during crew counts. Ensure that specific words from either command or company officers have exact meanings. Consider some of these but develop your own and give single syllable words preference:

- *Location* - Where are you in relation to other group members?
- *Air* - How much air do you have?
- *Tool* - What tool do you have?
- *Status* - How are you doing?

Talk/listen in sequence

As crews *talk* in sequence command will learn to *listen* in sequence, then when messages are garbled or interrupted by another transmission command may be able to recognize the information. Of course a good READBACK/HEARBACK is necessary for complete communication. This technique may seem like an extreme but it will cut back on the overall number of transmissions by eliminating all the repeat communications necessary when good protocol is not followed. Consider:

- Unit ID
- Location
- Work task
- Crew count

Mandate and train MAYDAYs to include Unit ID and Location

Mandate a MAYDAY give both Unit ID and Location. Members will be used to saying things in that order and command will be naturally listening in that order. It serves as a backup on a MAYDAY. Practice! Practice! Practice!

Utilize tool assignments at structure fires

Company officers need to know what tools they have available at structure fires. They will then be able to utilize crewmembers to the fullest. Tool assignments are helpful but not necessarily mandatory. Consideration of events may override tool assignments and should be left to the company officer's discretion. Training should develop unit games/tasks and problem solving exercises to promote team problem solving. Consider recording these exercises and pass information along to other shifts.

Practice some joint exercises/drills

Consider some joint exercises/drills with another shift or shift members. This helps to establish teamwork between shifts. Include dispatchers in some of these events so they gain an understanding of the differences between police and fire operations.

Work to develop key behaviors in teams

Listed below are some key behaviors that are essential to team building. Try to fashion you team to meet these behaviors. Also, the table below can easily be turned into an assessment tool simply by scoring each member on a 1 – 10 scale. Chief officers might take part in these assessments and have the team fill out an assessment form on the Chief Officers.

Key Behaviors Essential to High-Level Team Performance

Team Resources:	1. How good are team members? 2. Are they still struggling with basic procedures?
Team Identity:	1. Does everyone know who does what? 2. Is anyone "out of it"? 3. Do people help each other out? 4. Is anyone "micromanaging"?
Team self-mgt:	1. Is the leader competent? 2. Do they spot and correct problems?
Team thinking:	1. Are they headed for the same goals? 2. Does everyone have the same picture? 3. Are they behind the power curve? 4. Does uncertainty paralyze them?

(Flin, 1997, p. 195) and (Zsambok & Klein, 1987, p. 350)

Demand entry and exit control on all working fires

Demand entry and exit control on all working fires. Command staff should track personnel locations and times inside structure and crew counts at *all* times.

Command does not have to talk on the radio. Command needs to coordinate.

Trying to listen and talk to interior crews can quickly overwhelm even the most seasoned Incident Commander. Consider another person whose only responsibility is to monitor and track personnel accountability of firefighters by radio. Command is still in control and is now free to coordinate his various resources to mitigate the problem. This also ensures that above all, we are tracking our firefighters.

You cannot talk to others, listen/talk to the radio and assign companies work tasks with any efficiency when so task saturated. Commanders need to control the situation and they will do far better if someone else is handling the radio traffic of crews while they focus on strategic obligations. If co-located the IC only has to tell that person what needs to be done. Use this position to assess the individual's communication skills and possibly let it serve as training for promotion. Insist they maintain a standard of practice that is developed by the department.

RIT must be established early and maintained

RIT must be established early and maintained throughout the incident. Resist the temptation to throw RIT into the firefight and reappoint another RIT. Ensure RIT members monitor crew locations, work times and conditions throughout the fire. Good practice dictates they are not to be used in normal firefighting operations.

Develop, print and use tactical workbooks

Fire officers primarily use their experience in making fireground decisions. Develop Operations Manuals that will be living documents that are used as *checklists*, *backups* or *reference manuals* for command officers. They may also contain information on NIMS and defining roles for different personnel in fireground operations. These should be in officers' vehicles at all times and updated monthly. Benchmark information can also be stored for various fireground evolutions. They should have backup information available for use and crosschecking during operations.

These manuals can and should be developed in house with input from command officers. They should have pages specific to various incidents and perhaps even

tabs for quick reference. These should be prepared so they are understandable and easily read during actual emergencies. Small things such as Upper vs Lower case have an impact and can help in the development of these documents (FAA, 1995).

These operations manuals are used as a crosscheck for initial operational decisions. Involve dispatch in the development of these manuals and consider using them to provide personnel to respond to incidents on specific pre-determined incidents as well.

Examples might include:

- Structure fire – minor/major
- Gas leaks – interior/exterior
- Major vehicle accident-entrapment
- Major vehicle accident-Haz. Mat.
- Water rescue
- Ice rescue
- Major storm
- CO Detector/Alarm

Ensure that computerized pre-plans are available

Ensure that computerized pre-plans exist for all target hazards and that they are available in chief officer cars. Dispatch should also be able to pull up these plans as well. Consider a chief officer or your fire marshal to respond for coordinating efforts to control HVAC systems, elevators and other building systems and utilities. This is vital to safe operations during firefighting.

Periodically determine task benchmarks during structure fires

Command officers should have a working knowledge of how long specific tasks take to accomplish. These as well as air consumption should help in checking on crew well being at specific times in an incident. Chief officers should participate in task level training to provide them with the knowledge needed to benchmark their crews to ensure their welfare. Use Chief officers to grade and evaluate personnel on the performance of the tasks. Most will find that crews will burn air much faster at larger events triggering the decision to call an extra alarm sooner. Command officer must know these times for crew safety.

Ensure that company officers are conducting prebriefs at incidents

These prebriefs are vital to crew function and it is the IC's job to ensure they are conducted at all working fires. Prebriefs review key steps in fire service tasks. Operations will go much smoother when prebriefs are conducted. When omitted, problems may occur at larger events. Command should insist their subordinate officers conduct prebriefs on all firefighting tasks.

Conducting a debrief after working fires

This is the incident commander's job. Start with a self-critique and take comments from all levels of the working units. Do not allow these to evolve into finger pointing or blame, but seek a deeper reason such as communication, radio difficulties or something you can take back to the organization and change. Look at debriefs as an opportunity to improve operations. Write down suggestions and take them into consideration no matter how small. Most important, if you write down a suggestion from a member, *always* get back to them on the results of their suggestion. Your integrity and credibility are riding on demonstrating your willingness to improve.

Develop and maintain a reading list for all levels in the fire department. Share this list with your PD and dispatch. Many of these lists can be found at various military websites. Ask senior officers to conduct a book review on relevant books. These sessions will do a great deal on your fireground as well. Examples of military websites, The National Defense University Library and Concepts for Air Force Leadership.

Ensure that officers use NIMS

There is no doubt that fires, especially structure fires have declined over the years. The effect is that firefighters gain less experience fighting them and incident commanders do not get the practice on major events. Develop terms that work for Asheville Fire Department, distribute them department wide, practice them and by all means use them.

Define, train and use appropriate fireground labels

- Ventilation Group
- Roof Division
- Attack Group
- Water Supply
- Floor Five Division
- Staging Group
- Rear Division etc.

Develop Duties/Responsibilities Cards for department use

Each group should have an associated Duties and Responsibilities Card for the associated assignment. All command vehicles should include extra cards to give individuals from mutual aid departments when needed. As supplemental staff becomes available command officers can make assignments for the appropriate needs during that incident and hand out cards to assignees. Practice with these cards on a monthly basis with all levels of personnel. When it becomes second nature, it will improve your fireground operations.

Ensure officers have knowledge of task times for units under their control
Team members and team leaders should be taught more in depth knowledge about their task assignment by units. Engine companies should know how many feet of 2-1/2" hose is required to attack a fire on a given floor in multi-story structures. This should include the amount of hose necessary to maneuver and fight the fire. This should be practiced and published. Command officers need this knowledge to judge progress during incidents.

Truck company members and officers should know exactly which ladders are required to reach certain heights on specific buildings. They must also know on specific buildings where best to spot an aerial ladder/tower. Access should be considered as well as rear mount versus front mount equipment. They should be timed and tested in putting an aerial master stream into operation. As always, Chief officers should be present at these tests and training so they will know the limitations themselves.

Mandate that audio recordings be reviewed after working fires

These recordings are your most valuable assets. Digital recorders are inexpensive and editing software is free. Many firefighters have been lost and some killed because of communication problems. If you want to solve you communications problems you will record, edit and review you communications for improvement. Make it standard practice to record all fire related events and review these recordings after events. Insist on proper address corrections, entry procedures, accountability procedures and exit procedures on each structural fire call. (See also, Record and review audios of drills)

Officers and firefighters should be corrected when radio protocol is violated. Senior officers in the fire department should review working fire communications to ensure proper communications protocols are being used. If you are to successfully improve your fireground operations you must monitor how orders are given and messages are acknowledged. You might find that there are simple solutions to problems but they must be reviewed.

SOPS/SOGS

Improve appearance, visibility and distribution of SOPs/SOGs

Increase the visibility and use of SOPs/SOGs throughout the department. When developing these documents their acceptance and use is often tied to the way the document looks. Consult graphics people or enlist help in designing documents that are easy to use. Flowcharts, logic tables with the use of conditional tables, warning notes, cautions, and cross-references help make these documents more *readable*. The easier they are to read the more they will be used and followed. Incorporate an assessment tool with the document to check the understanding of members on the various procedures (Wieringa, Moore, & Barnes, 1998).

A very useful text for producing these is, Procedure Writing: Principles and Practices, by Dougas Wieringa, Christopher Moore and Valerie Barnes (Wieringa et al., 1998).

Ensure SOPs/SOGs are distributed in person and available via intranet

Ensure all SOPs/SOGs are disseminated and explained by Battalion Chiefs in person. These same chiefs should be responsible for periodically testing firefighter knowledge of the SOPs/SOGs with the aid of training.

Periodically ask officers to give a class on a selected SOP/SOG

Ask training to have officers do company training on your SOPs/SOGs. This not only ensures they have them, but also checks their knowledge of the current documents. Chief officers should also be involved in this activity.

Keep a List of Effective Pages (LOEP), for all SOPs/SOGs

Keep a List of Effective Pages (LOEP), for all SOPs/SOGs, and other operational documents at every fire station and have it available on your intranet. This enables everyone to know which is the latest standard being used today in your department. The LOEP is also an effective method of storing or archiving procedural standards as well. Samples of LOEP formats can be found in many government documents. Sample LOEP. Modify this format to fit your department as necessary and update it monthly.

These documents should be stored electronically and copies made available through your department intranet if at all possible. Try to have examples of their use available to all members.

Ensure that all SOPs/SOGs are numbered and dated.

Ensure that all SOPs/SOGs are numbered and dated as members need to know which one is current. The LOEP should reflect what is current and what changes are made from document to document to clarify these changes. Chiefs should carry a current list with them when visiting stations and periodically audited to ensure these are maintained at the stations.

Maintain and do not be afraid to change standards

Standards are vital to successful operations but sometimes need modification. Be sure to notify and disseminate any changes to everyone concerned. LTC Harry Tunnell's words, "Define standards, train people on what they are, and enforce them. It is not a standard until it is written and understood. Your unit will fight the way they have been trained regardless of whether you want them to or not" (McCoy, 2007, p. 39).

Two items were clearly related to us by interviewees. The need for:

- More and better training
- Chiefs to be involved in training

Increase company drills for determining location in smoke

Many firefighters become lost because they are distracted and do not keep a good mental map of their location. Good training can enhance their ability to locate themselves within a building. Many state and local Smoke Diver or other schools teach these enhanced techniques and members should be encouraged to attend and bring back vital information to the department.

Conducting quick primary searches then drawing a map of objects, dimensions and exits help firefighters think about these things and will help them determine their location. Additionally, knowing corner information is extremely important especially in larger structures. In my experience using letters for corner designations such as the "C/D corner" or the "B/C corner" when spoken thru the SCBA is all but impossible to understand. Numbers seem much clearer but you need to do your own radio testing. (Listen to sample audio, Avoid using letters if possible use the phonetic alphabet)

Conduct tool/equipment training drills

Determine and practice which tools/equipment will be carried to the emergency for various tasks. Time these operations and consider RIT baskets etc. Develop written instructions on the details of this and share it with others. Ensure they are passed along to members temporarily assigned to the unit. Brief each crewmember as to their task assignment.

Listen to included audio tests, then conduct your own

I have included some audio tests in Appendix 3 but it is important for your department to conduct their own testing. Do not wait until another fire. Test now and select a method, then train on it, monitor it and record it. Chief officers should be responsible for ensuring that proper verbiage and nomenclature be used.

Ask chief officers to conduct search and rescue drills

If these are the officers that run your fires, they need to take part in these drills to observe their companies in task operations. Secretaries and other personnel can handle administrative tasks but the people who will control firefighters in their operations need to take part in their training. Anything short of that does not ensure firefighter safety at emergency scenes.

Design training drills where Chief officers participate

Design training drills where Chief officers participate. This will help in every area of your operations. Also, use these chiefs to develop a list of "Need to Know" that can be used for incident radio reports. The goal is to use one-word requests such as:

- Status
- Conditions
- Location, etc.

Ensure enhanced RIT training is conducted

Enhanced RIT drill training should be increased. Begin by ensuring RIT members are monitoring the radio to determine exact locations of the various units. Anybody on RIT should be fanatical on counts and locations. Also practice removing injured firefighters from fire structures. RIT teams also need practice on consumption times, air management and multi-RIT operations. Especially critical is briefing the next RIT team used in multi-RIT operations. Unit members who are *not* giving good location or accountability information should be counseled and may require additional training. All department personnel should support this. Your safety and performance will grow with COMMITMENT.

Have RIT members search a room when totally blind, then exit the structure, sit down and draw the interior of the room, identifying objects, dimensions and exit locations. Repeat several times and make it increasingly difficult each time. Drop baby items around the floor and incorporate a crib to ensure they search in the crib. Then ask RIT members to design a search scenario for other firefighters.

Enhance crew awareness during routine activities

Good officers are always seeking to enhance their crew's performance. Provide these officers with suggestions for activities they can use to enhance firefighter awareness of things they will need to know on the fireground. When traveling to and from fire stations ask fire officers to stop the rig and ask the firefighters to "read the building". Where are the stairs, which way does the hallway run, what do the vent stacks tell you at a residence, what is the occupancy? Query engine companies about how much hose is needed to reach a specific point or to guess the fire flow of a specified area. Truck companies can do the similar exercises only with ladders, noting roof access points, openings, rafter directions and other hazards associated with roof operations. Jot down this information and pass it along to others.

Practice and demand redundancy on all accountability systems

Accountability systems need a backup or redundancy in addition to the PAR and the *Riding List* carried by chiefs. These systems need to be dynamic and constantly updated throughout an incident to provide good accountability through crew changes and emergencies. Continuous crew counts (PAR plus) and location information may seem like overkill, but they are vital for the protection of your firefighters. As Chief Larry Anderson (ret.) says:" The Dallas Fire Department uses a passport accountability system. Getting used to the routine was the toughest part. During my thirty years we have lost six firefighters in structure fires.

I firmly believe they died because we did not know where they were" (Angulo, 2010, p. 50). Drills on accountability help to ensure firefighters do not become lost in structures.

Conduct special hose line drills

Practice major hose line advances several times a year, probably monthly. One method is called the "Conga Line", where 4 – 6 firefighters are each loaded with 100 – 150 feet of 2-1/2" hose. The engineer loads the hose onto the firefighter's shoulder. The first firefighter steps away from the pumper in three giant steps forward and one step back to provide slack in between firefighters as the second firefighter steps to the tailboard to be loaded. After all the hose is loaded the group moves out. On a pre-determined signal the rear firefighter drops and secures the hose line as the others deploy their respective hose loads. Eventually work this drill up stairways and it will provide a viable alternative when standpipes and aerials do not solve the problem. Variations on this drill are endless. Video and record the steps for later practice. Ask Chief officers to time these drills or set various objects. Chiefs should know how long these operations take and the drill helps them in later decisions. Again this drill may seem like nothing but it is very effective and will prove well worth practicing some day at the larger fire. Your firefighters will not only move efficiently but they will feel better doing it. Teamwork moves hose. Know it – practice it.

Use evaluation assessment forms for all physical tasks

Below is a sample evaluation form for setting up an aerial ladder. The procedure can change but the format allows for easy administration and provides consistency. (See also, Appendix 5 – Sample Checklists)

_____ *Fire Department* ON = indicates switch position	Driver: _____ Date: _____		
_____ (Setup) (All operations performed by driver only)	Correct	Incorrect	Comments
Front Tires ..... Straighten (5) Brake ..... Set (10) Shift ..... NEUTRAL (5) Tower Master Switch ..... ON (5) Tower PTO Switch ..... ON (5)			( )
Front Tires ..... Chock (10) Red Lift Control Knob ..... Pull Out (5) Engineer's Platform ..... Pull Out (5)			( )
Outrigger Pads ..... Set (5) Idle Switch ..... FAST (5) Outriggers ..... Extend R & L Together (2) Outriggers ..... Lower (3) Outrigger Lights ..... Check Illuminated (2) Level Apparatus ..... + or – 5 Degrees (5) Safety Pins ..... Insert (5) Idle Switch ..... IDLE (3) Rear Panel Door ..... Closed (2)			( )
Engineer's Platform ..... Mount with both feet (5) Idle Switch ..... FAST (5) Ladder Lift Control ..... Raise (5)			( )
Total Points:	____		Pts. Elapsed Time _____

Conduct timed training for all task drills

Over the years I have had many firefighters tell me about the techniques used in their training helped them save lives on the fireground. Timed drills and evolutions do work well, but any instructor needs to keep in mind that safety is never sacrificed for time.

"Overlearning involves providing additional practice beyond the criterion level of mastery" (Rose, 1997, p. 203). Overlearning works very well especially in critical skills needed by professional firefighters. "The overlearning had 65% fewer errors after eight (8) weeks with an optimum time of retention is 38 days (Copper, 1992, p. 352). Firefighting is skill based and one must master numerous physical tasks from ladder carries to SCBA donning and those skills should be maintained by frequent practice. These skills should be documented using written step-by-step details, recorded by both photographs and video

along with time and safety standards. Once this has been accomplished it is necessary to develop assessment tools for each task. One can turn a list of objectives into a checklist or rating scale to give a relative grade for each step in a procedure. Often assistance in developing these tools can be obtained through a local high school or junior college. These assessment tools should be used to ensure the quality level of your firefighters. Timing and safety deductions ensure that bad habits are not passed along to others. One can also use competitive skill training but this should be closely monitored.

Define benchmarks for specific firefighting tasks

Repetitive skill training works as does overlearning. Your firefighters will have fewer errors and retain their skills longer if the skill is overlearned (Copper, 1992). Establish a standard locally approved method, and then time various companies and/or individuals in the execution of these tasks. Use these benchmarks for periodic testing and for training retention. "After initial training skills, overtrained subjects required 22% fewer trials to retrain" (Copper, 1992). Simulations may have to provide some level of experience but at the task level the senior officer needs fundamental knowledge of task performance. Start the above at first with basic firefighting tasks such as:

- Pull and advance an 1-3/4" hoseline (2-ff)
- Pull and advance an 2-1/2" hoseline (2-ff)
- Remove, carry and raise a pumper extension ladder (2-ff)
- Remove, carry and raise a 35' extension ladder (4-ff)
- Climb and enter a second story window as a unit. (4 ff)
- Search lower level of a home, using crew counts in under 2 min. (2 ff)
- Stretch a hoseline up to the 4th floor of a building.
- Place a master stream on the roof of another building for a point advantage
- Spot, set and deploy ladder (pipe or tower master stream operation)

Why benchmarks? "Chess masters "see" patterns of interrelated chess pieces on the chess board. It is these familiar patterns that enable them to select the best move because the familiar patterns are associated with optimal moves" (Druckman & Bjork, 1991, p. 66). Your fire chiefs need to learn the pattern of their firefighters' moves in order to judge and affect a strategy on the fireground. They will not learn this in the office; they will learn this by working with the companies under their command on the drill ground.

Purchase a quality firefighting simulator

Purchase a firefighting simulator (just one brand and I believe some are free) system that can be networked, as this will allow more robust training. This tool can be used to practice many of your operations. They are also very useful in assessment of fire officers for promotion or other considerations. Photos of buildings can be taken from different angles to provide views of conditions. Then, start gathering information about your target hazards and build from there. Ask various members to role play in simulations and by all means record these simulations. Insist on proper phraseology. Once personnel understand the

simulator, deploy Chief officers to run various simulations with their various companies. This allows them to communicate what information they will be seeking in a similar situation. Remember, good decision makers are experienced and experience can be gained through good simulations. As always, during debriefs, the chief officers should start with a critique of themselves first to encourage others to participate.

Practice decision making at all levels

Simulators can help accomplish this. Decision making skills can be taught and methods should certainly be studied at all levels of the department. "Decision Skills Training does not attempt to teach decision-making per se. Instead we attempt to facilitate the development of the decision maker's experience base within a particular domain (firefighting), which should, in turn, result in improved recognition decision-making skills" (Salas & Klein, 2001, p. 41). Drills, simulator training and skill practice all aid in this process.

Increase training in Naturalistic Decision Making (NDM)

Drills should be designed to vary some of the key elements fire officers use to control fires. This practice offers excellent practice in decision-making on the firegound as well as delivering orders by radio.

"Early NDM research discovered that expert professional judgment was largely based on a process in which experts expend effort on situational assessment (figuring out the nature of the problem), then evaluate single options through mental simulation, and then arrive at a satisfactory answer or action" (Ericsson, Chamess, Feltovich, & Hoffman,2006, p. 532).

Fire officers primarily use Naturalistic Decision Making (NDM) when making decisions at fires or other emergencies. This method is used primarily in situations where there are:

- Ill structured problems
- Uncertain dynamic environments
- Shifting ill defined goals
- Action/feedback loops
- Time stress
- High stakes
- Multiple players

Create senior officer training scenarios

I would suggest the use of simulators to help senior officers prepare for larger events that may not be as common. These should start off using simulated initial "on scene" reports that have been recorded by training during training sessions held for first in officers. These can grow into simulations where, conditions vary, obstacles present themselves and additional staffing is needed. The scenarios may even involve using dispatch for training as well. In some cases it may be

beneficial to invite outside expertise to assist in these evolutions. As Colonel B.P. McCoy says in his excellent book, *The Passion of Command,* "Only by rigorous training held to an unyielding standard can a commander truly assess the individual and collective capabilities of his men" (McCoy, 2007, p. 32).

Do not under estimate the value of simulation in teaching at all levels within your department. "A good simulation can sometimes provide more training value than direct experience. A good simulation lets you stop the action, back up and see what went on, and cram many trials together so a person can develop a sense of typicality. Another training strategy is to compile stories of difficult cases and make these the training materials" (Klein, 1998, p. 43).

Conduct numerous accountability drills

Accountability drills should be conducted monthly. People die because they get lost in buildings. These drills will help prevent that from happening. There are methods one can use that do not cost any money and do not require a burn building or bunker gear for that matter. Do them blind and ask locations to be identified often. Insist RIT is set up and monitors operations. Variations can be crew number changes, mock MAYDAYs, air management problems, (query command on their work time), simulated collapses and crew rotation problems.

Conduct risk factor analysis drills

Set up a situation or scenario then provide a list of risk factors concerning that situation. Give officers three minutes, working independently, to rank the risk factors from most risk to least risk. Ask for explanations and examples from all. Record these sessions to pass along valuable information to others.

Record and review audios of drills

Record and review audios of all drills and events conducted to ensure quality. These prove valuable and will certainly help point out weaknesses in your operations. You will not notice some things during the event, but the audios may reveal things you may want to address (*See also,* Analyze audio recordings of all incidents).

Brainstorm with firefighters after drills on what is needed

If you listen they will tell you what they need. Usually after one drill members are motivated to do more training to increase their proficiency. Take advantage of this and ask for suggestions. During these sessions of brainstorming introduce and allow junior officers or members to command incidents. This will help them realize the priorities command has plus it gives them experience. Allow the Chief officers to critique but ensure it is kept positive and helpful.

Increase and supplement more station training

Train more often and encourage training in the stations but increase your efforts to support that training. The fact that we are responding to fewer structural fires than previous generations actually reduces our technical proficiency at our craft and carries with it increased risks (Brezler, 2010).

Work diligently and strive for perfection. Training quality firefighters to do the job of protecting the citizens of your community will reward your efforts. "I will always harbor doubts over my efforts prior to and during combat, whether or not my personal preparation and leadership was all it could be. For the rest of my life – each time I look in the mirror I will be acutely reminded of my shortcomings, and a piece of my heart will chip away, for in the shadows of my eyes I will see their faces, staring back at me – for the rest of my life" (McCoy, 2007, p. 78).

COMMUNICATIONS

From many of our interviewees we heard about communication difficulties. Also after listening to the unedited audio recording of the fire on 28 July, 2011 in Asheville I too noted communication difficulties. This is a common problem at major incidents and is not unique, however there are techniques that can be used to minimize the communication problems. The communication order, standard phraseology, succinct sequential messages and readbacks of messages all help eliminate many of the errors that often boost the number of transmissions to convey information.

In firefighting and in war uncertainty is constantly with any leader. Probably the best way to reduce it is to communicate better. "Commanders gain most of their information from very few cues. The ultimate requirement is to be able to operate effectively in spite of uncertainty" (Schmitt & Klein, 1996, p. 65-66). Diligent work is necessary to streamline any communication system. The secret is COMMITMENT from all levels of the department. Resistance to change will spell a quick death to any changes and oftentimes this is a tactic employed by those who are not willing to change. Careful considerations of these factors are necessary for success in any changes to a communication system.

Nevertheless operations will no doubt improve if personnel are willing to change to a more efficient system of communicating by radio. Evidence indicates this problem is found in many fire operations. Gasaway ranked communications as number two in his barriers to the incident commanders situational awareness, "because it restricts his ability to understand what is going on" (Gasaway, 2009, p. 319). Gasaway's Incident Commanders also related the incomplete communications loop as, "trying to put together a jigsaw puzzle without having all the pieces – the puzzle is incomplete and it impacts the commander's ability to understand what is happening and his or her ability to predict the direction the incident is heading" (Gasaway, 2009, p. 321).

Flin, also mentions communications as a problem for incident commanders. "The typical problem for the commander is that insufficient information is available to form a proper situational assessment, and the incoming situation reports are inadequate, inaccurate or incomplete" (Flin, 1997, p. 109). So your goal is to build a communication system that offers solutions to these problems by designing a clear, concise language the starts from the very beginning of the incident and continues to the end.

Insist on quality acknowledgements

"If companies fail to get radio acknowledgment from command they are prone to ignore the radio and to freelance" (Bingham, 1997). One of interviewees admitted to doing exactly that when unable to communicate.

Roger Lunt describes a simple communication used every day in our lives that can also serve as an example. Lunt explains in his book on avoiding fire department induced CHAOS, "What if you place your order at a fast food restaurant and the employee replied with a "Copy", "Received", "10-4", or simply double clicked the microphone. Do you hold a higher level of communication at your fire scene than the fast food operator at the drive-in? (Lunt, 2009). "If communications breaks down, it will be difficult to have a fire scene void of some level of CHAOS" (Lunt, 2009, p. 31).

Develop a language and communication system around the use of SCBA

A NIOSH list indicates one of top five causes of firefighter death involves poor communication (Brunacini, 2002, p. 69). Certainly in most major fires communications is usually one of the predominant problems. What determines unique fire service communication needs is the use of SCBA. Many of the SCBA masks can be fitted with internal microphone and other technologies that aid in communication but are often cost prohibitive for many departments. Therefore, departments need to recognize the need for unique verbiage and operational considerations when using radios with SCBA.

Insist on good quality initial reports

It is no secret that a good initial report can be helpful to everyone responding to an emergency. That report should include a verification statement of the correct address of the emergency. Life problems or potential problems should be stated even if they are only a possibility, and of course what actions your unit is taking. These reports can and should be practiced by all officers in the department frequently.

Mandate a communication order of – "Hey you, its me"

Practice, "Hey you, it's me," communications on all radio communications. It is simpler and cuts your communications in half.

Utilize standard verbiage that incorporate the following repeatedly.

- Unit ID
- Location
- Work Task
- Number of personnel
- Needs/requests

Utilize *Report Clauses* during fireground operations

One very useful tool to be considered is the use of Report Clauses that were mentioned earlier in this report. These are extremely useful for the Incident Commander. It provides cues to the IC that he needs to maintain his situational awareness. When given it builds in the requirement for the fire officer to call the IC back and report. If this is given in the correct format using the already mentioned information, several pieces of valuable information is given in just five seconds. This in itself helps dramatically in reducing extraneous radio traffic.

This will require a complete change in how commanders give their orders. They have to put themselves into the company officer's shoes and think ahead of the fire. What will tell me when this task is accomplished? Since many fireground tasks are the same only given to different groups ICs will quickly adapt to this technique. Sample audios are found in the appendix but I encourage you to develop you own.

In addition this report gives information to everyone on the frequency and not just to the Incident Commander. Should the IC become distracted or interrupted during command communications major problems can result.

The aviation industry documents numerous accidents attributed to communication, interruptions and language problems (Jones, 2003, p. 237).

Insist on quality READBACKS

"Simply repeating the main points of each exchange confirms to the sender and receiver that communication has occurred and it has been understood" (Stumbaugh, 2008).

Many will insist that this just clogs up the radio but it is the repeats of attempts to acquire information that clogs the radio. One only needs to visit a large metro airport and listen to the busy ATC communications used by pilots and controllers. All communications use the READBACK/HEARBACK technique to ensure both parties clearly understand.

To complete the communication loop all messages should contain a READBACK. This is simply a repeat of the information received. This may seem unnecessary but it does save time and communications. George Bernard Shaw once said, "The greatest problem in communications is the illusion that it has been accomplished" (Kanki & Smith, 2001, p. 95). Even in the medical

settings these techniques are being use by trauma teams to provide better critical care in the emergency room (Cole & Crichton, 2006).

Avoid using letters if possible use the phonetic alphabet

Letters do not penetrate the SCBA mask well. NIMS does not specify building side nomenclature contrary to popular opinion. Consider numbered sides for structures. This aids tremendously in knowing corner locations. Should a MAYDAY arise make it a habit of your firefighters to know what corner is nearby.

There are drills that can ease this process somewhat when practiced without the pressure of real operations. Later simulations can take on a more realistic appearance as confidence and competence grows. Flin goes on to say that, "From a training and simulation point of view, one critical component in maintaining personnel performance in a stress environment is to provide practice and the exercise of critical tasks under operational conditions similar to those likely to be encountered in the real environment" (Flin, 1997, p. 116).

Require frequent crew counts or PAR plus (Insist on numbers)

Use "crew counts" or PAR plus the number in your operations. These should be checked frequently by the company officer and clearly stated when doing a READBACK.

Analyze audio recordings of all incidents

Your operations will be enhanced if you listen to your audio recordings after each event. To do this they must be recorded. Afterward, they can be separated and analyzed for proper procedure. If your communication system is to work it must be analyzed. (*See also,* Record and review audios of drills)

You can enlist local help or your explorer youth to assist in these projects where their computer skills may surpass members. After recordings are digitized, dead air can be eliminated to just contain vital information. Command should review their methods of communicating, as should each unit involved. Critiques are the only way your system will improve.

Link all radios to specific personnel

Each radio on the fire ground should be linked to an individual so dispatch can quickly identify who is transmitting. Dispatch and operations should work together on this procedure so it is speedy and thorough. Firefighter lives are at stake and quick identification can help find the fallen firefighter in an emergency. Even a simple database or spreadsheet can be established and kept dynamically containing this information and searched by a variety of different fields. Perhaps your IT personnel can assist with this project.

Record daily radio traffic

Initially you will need to record everyday traffic to monitor the, "Hey you, it's me" technique. If you do not personnel will quickly slide back into their old habits. Remember, "You do not rise to the occasion, you default to your level of training." Record daily radio traffic and especially all drills and fires. Pour over these and analyze them thoroughly and hold members responsible for proper technique, *all the time,* not just during fires. "Lieutenant Colonel Bryan P. McCoy says, "It takes two months for the mind and the body to develop a true habit" (McCoy, 2007).

Streamline radio call signs

Modify radio call signs to Engine #, Truck#, Squad# and eliminate individual call signs such as, "eleven-0-one" etc. It becomes very confusing and it should be crystal clear to all members. Pick a system that is easily understood by all and test it using SCBAs.

Use radio holder straps and radios equipped with shoulder microphones

Radio straps complete with speaker microphones should be used by firefighters. Most important is that it ensures the radio will remain with the firefighter and not be lost. Two firefighters in serious trouble both lost their radios using the existing system of putting portables in breast pockets. It is practically impossible to crawl when holding a radio and if you do you are sacrificing that hand for personal protection, balance or tool carrying. Firefighters need to hear and the breast pocket approach is not conducive to quality hearing.

Necessary changes must be made when operating with radios with speaker microphones. These are usually carried on the inside of the bunker coat with the speaker/microphone threaded up and out the neck or front then clipped to the collar of the turnout coat so it can be heard. The firefighter only needs to turn his or her head and depress the microphone button to transmit.

However, with the radio inside the turnout coat, it can be difficult to change frequencies. In many cases emergency frequencies are usually programmed either at the top or the bottom end of the knob so one only needs to turn it up all the way or down. Develop a procedure that works best in your department.

Consider the use of bone microphones

Consider the use of bone microphones was something we heard in our interviews. This should be researched and considered. Should budgetary need forbid large scale purchases they might be considered for use in special operations such as Hazardous Materials, Technical Rescue or RIT operations.

Use a standardized tracking system for firefighter accountability

Continuous Accountability Tracking (CAT) might be considered for a base until you can develop your own system. The earlier section on my background discusses some of the features of this system. There are drills available to teach this system.

Reports from firefighters most importantly serve as cues to the IC on where and what firefighters are doing. In *The Multitasking Myth* Loukopoulos, Dismukes and Barshi say, "cues act as reminders that help prompt retrieval of intentions from memory. Although individuals may think they are performing several tasks simultaneously, human ability to process more than one stream of information at a time and respond accordingly is limited" (Loukopoulos et al., 2009). Certainly any one who has observed an Incident Commander in action agrees that they are very busy and can easily be overloaded and lose situational awareness. That can cost firefighters their lives.

Eliminate ordinal numbers

Eliminate ordinal numbers such as *first, second, third,* etc. These words cannot be clearly understood through the SCBA mask. When referring to floors or levels of a structure use one, two, three, or "on the one", "on the two" etc. The word "Division" is commonly used in NIMS but it is three syllables by itself, add in the number and it is four syllables. Recall one of our interviewees who almost lost his life stated, "It would have cost me a breath." In those situations every breath can mean life or death, do not plan your operations around what works most of the time, plan them around the worst case scenario if you value the lives of your firefighters. Naturally, prior to any changes I recommend thorough testing under realistic conditions.

Demand *CLEAR* on building exit

Demand CLEAR with count or PAR plus on building exit and entry. Command officers should insist on this each and every time a unit enters. Interior officers should do the same. Appoint someone to *always* have an accurate number of personnel in the building at all times and test them on that number frequently. Senior officers, starting with the Fire Chief should see that this is done when monitoring the radio traffic. (*See also,* Mandate the use of "CLEAR" when exiting a structure)

Backup all accountability systems

Do *not* rely solely on riding lists for accountability. The 445 Building fire illustrated the danger in this when the rescue company had an add-on member. Even if command had been notified, it is still playing with people's lives. Counts should be over the radio so everyone can hear and back up everyone else.

Practice good reports

"Information is like gold in combat, clear, concise reporting in a calm, steady voice is the irreducible bottom line. We not only repeatedly drilled our unit leaders on reporting, but we drilled them over the map board of our G-Day objectives. We practiced reporting the most likely situations we would experience – for example, enemy contact, and requests for fire, position reports, and medical evacuations" (McCoy, 2007, p. 33).

EQUIPMENT

Purchase large gasoline powered vent fans

Purchase large gasoline powered ventilation fans for use in high rise or large structures. Have them dispatched on the initial alarm. Study the dynamics of the Reverse stack effect fire and practice using these.

Purchase radio carrying straps and associated speaker/microphones

Purchase radio carrying straps and shoulder microphones and insist firefighters use them. Two firefighters lost their radios in the 445 Building fire.

Purchase additional thermal imagers

Purchase additional thermal imaging cameras, enough for each engine, truck and rescue company. Often civic groups will assist with the purchase of this equipment. Specify when these cameras are to be taken into structures and used during searches. Also, consider extra training on their use.

Purchase several digital recorders

Purchase several small digital recorders and editing software. They are usually under

$100 and can be plugged into the microphone jack of a radio to record calls. Most have a feature that will only record when someone is transmitting, saving hours of recording. There is downloadable software for free on the Internet.

Purchase an illuminated rope

Purchase or test illuminated light ropes, it may help in your operations.

REFERENCES

Angulo, R. A. (2010). They're counting on you. *FireRescue Magazine, April, 2010*(April, 2010), 48-54.

Avillo, A. (2008). *Fireground strategies.* Tulsa, OK: Penwell Corporation.

Ayers, G. (1969). Time and motion studies. *Fire Chief, April*(April, 1969), 15-19.

Bachrach, A., & Egstrom, G. (2003). Diving behavior. In A. Bouve & J. Davis Eds.), *Diving medicine* (pp. 432): W. W. Saunders Company.

Bachtler, J. R., & Brennan, T. F. (Eds.). *The fire chief's handbook.* Tulsa, OK: Penwell Publishing.

Bingham, R. C. (1997). Improving fireground radio communications. *Fire Engineering, February*(February), 38, 42, 44-49.

Bingham, R. C. (2004). *Street smart firefighting.* Vienna, VA: Valley Press.

Brezler, J. C. (2010). *Make yourself hard to kill.* New York. Retrieved from www.leadershipunderfire.vpweb.com

Brunacini, A. V. (1978). The four percent solution. *Fire Command,* 21.

Brunacini, A. V. (2002). Bruno's communication tenets for ics. *FireRescue Magazine, April, 2002*(April, 2002), 69-77.

Cannon-Bowers, J. A., & Salas, E. (Eds.). (2006). *Making decisions under stress: Implications for individual & team training* (Third ed.). Washington, D.C.: American Psychology Association.

Cole, E., & Crichton, N. (2006). The culture of a trauma team in relation to human factors. *Journal of Clinical Nursing, 15.*

Copper, C. (1992). Effect of overlearning on retention. *Journal of Applied Psychology, 77*(5), 615-622.

Dekker, S. (2002). *The field guide to human error investigations.* Burlington, VT: Ashgate Publishing.

Dekker, S. (2011). *Drift into failure: From hunting broken components to understanding complex systems.* Burlington, VT: Ashgate Publishing Company.

Driskell, J. E., Salas, E., & Johnston, J. (1999). Does stress lead to a loss of team perspective? *Group Dynamics: Theory, Research and Practice, 3*(No. 4), 11.

Druckman, D., & Bjork, R. A. (Eds.). (1991). *In the mind's eye: Enhancing human performance*. Washington, D.C.: National Academy Press.

Encyclopedia, W. T. F. (2011). Maslow's hierarchy of needs. from http://en.wikipedia.org/wiki/Maslow's_hierarchy_of_needs

Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (Eds.). (2006). *The cambridge handbook of expertise and expert performance*. New York: Cambridge University Press - http://www.cambridge.org/americas/.

FAA. (1995). *Human performance considerations in the use and design of aircraft checklists*. Washington, DC: FAA Retrieved from http://www.skybrary.aero/bookshelf/books/1566.pdf.

Flin, R. (1997). *Sitting in the hot seat*. New York, NY: John Wiley and Sons, Inc.

Flin, R., O'Connor, P., & Crichton, M. (2008). *Safety at the sharp end: A guide to non- technical skills*. Burlington, VT: Ashgate Publishing Company.

Freud, S. (1922). *Group psychology and the analysis of the ego*. New York: Norton.

Gasaway, R. B. (2009). *Fireground command decision making: Understanding the barriers challenging command situation awareness*. Roseville, MN: Gasaway Consulting Group, LLC.

Jones, K. (2003). Miscommunication between pilots and air traffic controllers. *Language Problems and Language Planning, 27*(3), 233-248.

Kanki, B. G., & Smith, G. M. (2001). Training aviation communicatiion skills. In E. Salas, C. A. Bowers & E. Edens (Eds.), *Improving teamwork in organizations: Applications of resource management training* (pp. 55-72). Mahwah, NJ: Lawrence Erlbaum Associates.

Klair, M. B. (2000). The mediated debrief of problem flights *Facilitation and debriefing in aviation training and operations* (pp. 72-92). Burlington, VT: Ashgate Publishing.

Klein, G. (1998). *Sources of power, how people make decisions* (Second Printing ed.). Cambride, Massachusetts and London, England: MIT Press.

Loukopoulos, L. D., Dismukes, R. K., & Barshi, I. (2009). *The multitasking myth.* Burlington, VT: Ashgate Publishing Company.

Lunt, R. (2009). *Avoiding fire department induced chaos.* Maclean, N. (1992). *Young men and fire.* Chicago and London: University of Chicago Press.

McCoy, C. B. P. (2007). *Passion of command: The moral imperative of leadership.* Quantico, VA: Marine Corps Association.

Miller, G. A. (1956). The magical number seven, plus or minus two some limits on our capacity for processing information. *Psychological Review, Vol. 101*(No. 2), 343-352, 9.

Norman, J. (2005). *Fire officer's handbook of tactics* (Third ed.). Tulsa: Penwell Corporation.

Rose, D. J. (1997). *Multilevel approach to the study of motor control and learning.* Needham Heights, MA: Allyn & Bacon.

Rutledge, J. W. (2011). [Interview with chief mac mccastland, retired oak lawn fire department and battalion chief kevin krasneck, division of special operations, chicago fire department].

Salas, E., & Klein, G. (2001). *Linking expertise and naturalistic decision making.* Mahwah, NJ: Lawrence Erlbaum Associates.

Schmitt, M. J. F., & Klein, G. A. (1996). Fighting in the fog: Dealing with battlefield uncertainty. *Marine Corps Gazette, 80*(8), 62-69.

Stanke, D. (2002). Managing the ins and outs of commercial building pressurization. *Engineers Newsletter, 31.* Retrieved from http://www.trane.com/commercial/library/vol31_2/index.asp

Stumbaugh, S. (2008). Improving fireground communications. *Fire Engineering*(July, 2008), 1-6.

Tamura, G. T., & Shaw, C. Y. (1973). Basis for the design of smoke shafts. *Fire Technology, 9* (3), 209-222. Research Paper No. 595 of the Division of Building Research

Varone, C. (2003). Firefighter safety and radio communication. *Fire Engineering, March, 2003*, 1-13.

Weick, K. E. (1993). *The collapse of sensemaking in organizations: The mann gulch disaster.* [Katz-Newcomb lecture presented at the University of Michigan, April 23-24, 1993.]. Katz-Newcomb Lecture, (Administrative Science Quarterly). Copyright by Cornell University, 1993, Ithaca, NY.

Wieringa, D., Moore, C., & Barnes, V. (1998). *Procedure writing: Principles and practices* (Second ed.). Columbus Richland: Battelle Press http://www.battelle.org/publications/.

Williams-Bell, F. M., Boisseau, G., McGill, J., Kostiuk, A., & Hughson, R. L. (2010). Air management and physiological responses during simulated firefighting tasks in a high-rise structure. *Applied Ergonomics, 41*, 251-259.

Zsambok, C. E., & Klein, G. (1987). *Naturalistic decision making.* Mahwah, NJ: Lawrence Erlbaum Associates

ABOUT THE FACILITATION TEAM

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Dr. Gasaway entered the fire service in 1979 and has served as firefighter, paramedic, lieutenant, captain, assistant chief and fire chief in 6 fire and EMS agencies in West Virginia, Ohio and Minnesota. Dr. Gasaway is now engaged in several endeavors to improve emergency services leadership in safety including the Gasaway Consulting Group, Center for the Advancement of Situation Awareness and Decision Making, SAMatters.com and the Public Safety Laboratory. He can be reached at: Rich@RichGasaway.com or 612-548-4424

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After serving his country as a Navy Corpsman during the Vietnam War, Mr. Rutledge joined the fire service and was soon tapped to teach full-time at the Illinois Fire Service Institute. He developed and co-developed a variety of fire service programs throughout the 70's and 80's including the Smoke Divers and FAST schools. During that time Mr. Rutledge also worked part-time as a commercial airline pilot and flight instructor.

In 1990 he accepted a full-time position with Delta Airlines in flight operations. There he developed pilot computer-based training programs, taught crew resource management and human factors and he investigated Federal Aviation Administration-related incidents and mishaps. He has earned bachelors of science and masters of public administration degrees. Following his retirement from Delta Airlines, Mr. Rutledge has continued his public safety service through teaching and consulting. He can be reached at: jackrutledge@mindspring.com or 404-229-3041.

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primary accountability system I can only believe that the use of "PARs" was the backup system and it failed. Firefighter Johnson tagged along with Rescue #3's crew. Was he included in the PAR? If Johnson was included in the PAR and the only person who knew the exact number in Rescue 3's crew was the Captain, then PAR failed. Two men from Rescue #3 came

down the stairs and two were taken out in the MAYDAY rescue and taken to the hospital. If the only tool available was the daily *riding list* showing four firefighters on Rescue #3, then who accounted for firefighter Eric Johnson? Had he not escaped there might well have been two firefighters lost in this fire. Count your personnel as a unit officer and pass those counts along to command often. You want to repeat those counts for the world to hear.

Survey Item #11 indicated that firefighters moved freely about the building. The score of 3.08 indicated they moved about without restraint and I did not hear a great deal otherwise from radio traffic. Were they searching, fighting fire or just trying to find the seat of the fire? This not only confuses command in normal operations but it can prove disastrous in an emergency. However, in a maze such as described by firefighters on the fire floor disorientation may have been a larger problem than was revealed during our interviews. Firefighters did take out windows on the West side of the building when radio communications showed they clearly thought they were on the North side of the building. This action is evidence that there must have been more disorientation than we thought. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Survey Item # 9's score of 2.21 indicates the crew leaders themselves may not have been ranking accountability near the top of their priority list. Every five minutes is a very long time, especially in the maze in which the crews told us they were operating. Unless the crew is solidly united there have been cases where a member feels they are alone and has left the safety of their crew thinking they had been abandoned. Crew counts do more than just ensure everyone is accounted for they help unite the crew as a unit. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Another Survey Item of interest which had to come into play in the area of decision making was Survey Item #25's very low score of 1.29 that concerned firefighter familiarity with the building's pre-plan. I do not recall command officers referring to a pre-plan when making their decisions and apparently interior crews were not aware of the pre-plan as well. During subsequent interviews concerning pre-plans everyone seemed to agree pre-plans existed but there appeared to be great difficulty, under no stress, in finding pre-plans. Command must have been working in the blind without a building pre- plan and firefighters inside fared no better. That said, the particular command officers involved in the 28 July incident might have had previous knowledge of the building along with firefighters who had made previous responses to the location. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

SOPS/SOGS

In our interviews it appeared that the firefighters in Asheville were not very familiar with the SOPs/SOGs, which is not unusual in most fire departments. Like any large organization rules are often written by administration and passed on down the line. They often get less and less review as they come down and are seldom reviewed during training.

Efforts seemed to have been made to gain "buy in" of the SOPs/SOGs that existed in Asheville. By and large firefighters seemed to have a general knowledge of them, but none were specific. There even seemed to be differences of opinion on the definition of a "High Rise." Again, this is not unusual in my experience with fire departments. The key to knowledge of these documents is the company officer and his key is the Battalion Chief whose key is the Division Chief, whose key is the Assistant Chief and so it goes.

Like published procedures in any industry if they are not "living" documents they are doomed to a slow death in the filing cabinet. "Living documents" are ones that are disseminated, studied, practiced, tested and enforced time and time again. In commercial aviation an FAA inspector can board your aircraft at any time to ensure compliance. SOPs/SOGs should be under constant scrutiny seeking improvement. Probably the biggest hindrance for their success is the fact that users are rarely given an assessment on how well they know and understand them. That must start at the top and work its way down.

"Organizations that look relentlessly for symptoms of malfunctioning, and are able to link these symptoms to strategies, positions or priorities, are better able to create practices that preclude problems or stop them from developing into unmanageably big ones" (Dekker, 2011, p. 96).

Chief Glen Ayers (1969) successfully used time and motion studies to cut down the times of his basic firefighting tasks on his fire department. First he listed the steps in each procedure and then he combined, eliminated, rearranged and simplified steps in the tasks. When finished he picked up the stopwatch and started timing these evolutions. Now he had specific standards he can measure.

Most procedures on a fire department are at the task level so they should be thoroughly documented and tested. Later time performance criteria can be added. Today's modern computer era makes it relatively easy to photograph and detail specifics of an evolution.

The interpretation of SOPs/SOGs must start with the senior officers within a department. Explanations of the documents by senior officers are key to the firefighters understanding them. We did hear a great deal concerning SOPs/SOGs but the comments seemed to lack any interpretation from senior officers. Successful implementation of these documents means communication between companies and those generating the SOPs/SOGs.

There seemed to be some involvement in their creation in the Asheville Fire Department but seemed to be lacking in their dissemination.

TRAINING

Like anyone who must master physical tasks, training is the key. Survey Item #13 and #22 seemed to indicate training was needed for incidents of this type and some firefighters needed more training in general. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

"Washington, D.C. fire officer Bob Bingham says in his excellent text, Street Smart Firefighting, "The main reason that bungled fires continue to happen is that we often skate along doing the bare minimum on our routine calls, and when we have a serious fire, our bad habits come back to haunt us" (Bingham, 2004, p. 27). Bingham goes on to say, "Always do it the right way. It isn't always necessary, but it will ensure that you will be doing it the right way when it counts" (Bingham, 2004, p. 28).

Task level training is not difficult, but a good training facility can be a big help. A key ingredient necessary for success is to have Performance Standards developed for each of the key firefighting tasks. Only when you have a standard that can be tested and practiced can it be driven down to the company level. Anything less and you will only get what your Company Officer shows you and that may or may not be the department's standard. Like the disagreement we heard in the large group debrief on the definition of a "High Rise" there will be numerous variations found at the task level unless you have standards.

It has been estimated that firefighters only fight fire four percent of the time. That leaves 96% of their time being spent on other duties (Brunacini, 1978). Task training, especially firefighter task training, requires practice, lots of practice (Druckman & Bjork, 1991, p.30). Survey Item #13's response of 4.36 indicates they are craving practice, at least in high rise type fires. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Survey Item #19's score of 2.00 indicates that company officers are not doing debriefs after their incidents on a regular basis. The post-incident debrief can be a valuable tool not only for training but also for communication in general. Debriefs can help generate training ideas, but if they are not conducted or the findings forwarded up the chain of command, firefighters can become discouraged, and can lose faith in their company officers. That philosophy can also extend to senior officers within any department. They have a vested interest in the training of their personnel and should also participate in the training whenever possible. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Most firefighters I know are action-oriented people. Their bread and butter are the task level operations in everyday firefighting operations. We heard multiple comments indicating that since the incident they have not had any training.

Perhaps this is an exaggeration, but it does point to one thing. They want more training. A debrief will probably give you plenty of information about what the firefighters think they should be training on, but there may be extenuating circumstances preventing that training from taking place at this time. However, the firefighters do not see the lack of training favorably. They want to do a good job, they want to work together and they want to do it safely – they want more training.

COMMUNICATIONS

Inter/Intra Crew

Communications within crews seemed to work relatively well. Already mentioned was the difficulty of speaking among crewmembers as being a major factor in all firefighting operations. Survey Item #1's score of 2.62 indicated that prebriefs probably were not used to a great extent prior to building entry, however this may have changed after encountering adverse conditions. One must conclude from Survey Item #8 that instructions were understood when given by the crew leader. (See Survey Results in Appendix 4 – Survey Results and Blank Survey form)

Radio

We did hear many comments about the radio being very busy and in some cases units were unable to transmit their message to command. Some firefighters got frustrated and just quit trying. The MAYDAY brought more communication problems as they usually do. Responding apparatus too interrupted it.

Radio communications are always a problem in any multi-alarm fire. Numerous crews are all waiting to grab any available lull in traffic to convey information. However, even after listening to the audio recordings I am not quite sure I understand some primary elements of the system.

What is the order of communication in Asheville Fire Department's communication system? Does command say, "Command to Engine one," for example then wait for a response/acknowledgement? (Me calling you!) Or does command say the name of the unit they are calling first then themselves? (Hey you, it's me!) A close analysis of the first technique shows that to communicate you must make four transmissions.

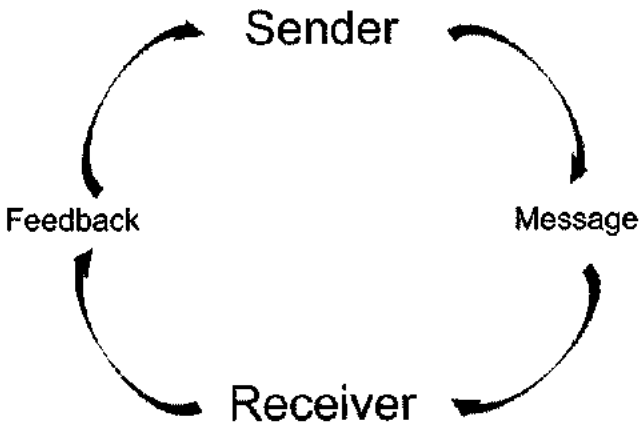
1. "Command to Engine one."
2. "Engine one, go ahead."
3. "Engine one, take a line up to the fire floor."
4. "Message received."

Using the other method does two things, first it alerts the crew being called that the message to follow is for them. Second, it cuts transmissions in half.

1. Engine one, Command, take a line up to the fire floor."
2. Command, Engine one, message received."

It seems that when seeking better communications one should consider this second alternative.

The audio recording contained numerous acknowledgements of something, but did not repeat or READBACK the message. In several cases I simply could not understand, yet it was acknowledge as if understood. This is critical for good communication. The reason being the Incident Commander is not the only one who needs information. Acknowledging is one thing but giving a good READBACK is a critical step in communications loop, especially in garbled SCBA messages.



Communication Loop

Another problem seemed to be in the radio procedure to be used when a MAYDAY is called. Most departments recommend the Incident Commander stay focused on the fire situation and delegate the MAYDAY to another officer so situational awareness can be maintained on each. George Miller in his classic work of 1956 on short-term memory says, "First, the span of absolute judgment and the span of immediate memory impose severe limitations on the amount of information that we are able to receive, process, and remember" (Miller, 1956). When an Incident Commander tries to control both the fire and the MAYDAY, he is not multi-tasking. "Although individuals may think they are performing several tasks simultaneously, human ability to process more than one stream of information at a time and respond accordingly is limited" (Loukopoulos et al., 2009, p. 14). This may explain why some units involved in the events of 28 July could not achieve radio contact with the Incident Commander.

ALARM RESPONSE

The Asheville Fire Department is a quality fire department that does a fine job of providing excellent fire protection in their community. After conducting interviews and listening to the audio recording of the events of 28 July 2011, I would offer some recommendations or suggestions to make a good fire department even better. However, like any outsider I do not profess to know it all. I hope that Asheville looks into some of the suggestions and perhaps even tries some of them before dismissing them. With a firm commitment from the members of the Asheville Fire Department to make improvements, success will be their reward.

Increase initial response – Staffing and equipment

Several interviewees indicated that the response to this fire was short on equipment and on staffing. Certainly the stresses placed on initial units support adding additional equipment and staffing to similar scenes. These three things should be considered on all alarms - occupancy, severity of the fire, and weather conditions. Any one of these might have triggered a call for extra alarms at this incident. Alarm response recommendations should come from the fire department and should the city alter staffing, equipment needs should be adjusted to provide adequate firefighters for staffing at extra alarm fires. Dispatch should be included in discussions on the specifics of this plan.

Dispatch additional aerial apparatus on commercial structures

Include at least two truck companies and sometimes three if necessary. Certain hazards may need special companies such as Haz-Mat or other apparatus or expertise. Pre-plan these and have them called immediately.

Dispatch additional support units and utility notification

Air trucks, light trucks, hose wagons, rehab buses and other support vehicles should be automatically dispatched at major incidents at some point. Do *not* rely on command requests for this equipment or it will most likely be late. Incident Commanders are far too busy to think of these items and querying for them by dispatch causes an unnecessary interruption.

Dispatch additional administrative personnel at working fires

Dispatch additional administrative and inspection personnel and use them as command staff. "Some fire departments dispatch additional chief officers, communication officers, staffed command post vehicles to help better effectuate fireground radio communications. They in essence provide a trained dispatcher at the scene of the emergency to help the IC manage fireground radio communications" (Varone, 2003, p.7). Interestingly Varone goes on to say that,

"When the less frequent but larger incidents occur, we use the radio exactly as we are accustomed to doing at smaller incidents" (Varone, 2003). Protocols should be practiced at all incidents. Include personnel from dispatch when constructing these changes to get their input. Any or all of these recommendations help address the critical safety factor of providing a backup to the IC.

Dispatch large ventilation fans for all working commercial fires

Positive Pressure Ventilation (PPV) may be used but it takes time to set up fans and pressurize the stairwells. Do not wait until it is too late. Start them coming on working fires.

Ensure that a complete pre-plan is available to Incident Commanders

Dispatch personnel to extract vital details for building pre-plans to control building systems and utilities at working fires. If necessary have someone respond to the structure and coordinate all efforts to control building utilities, elevators, HVAC and other systems necessary for good firefighting. These *must* be available from the onset of a major firefight.

Modify response to include special units and utility considerations

During this incident command officers were often distracted with concerns about additional apparatus, staffing, air trucks and utilities. Good practice demands that these should be automated to a large extent to allow command officers to focus on the task at hand and more importantly on the safety of their firefighters.

Consider utilization of a MABAS plan

Consider adopting a Mutual Aid Box Alarm System (MABAS) plan. MABAS is an excellent means of providing help just by depressing the microphone and asking for another alarm. I would highly recommend using this or a similar system to enhance the firefighting capabilities and overall safety for everyone. A good pre-plan should detail these considerations.

Increase personnel assigned to working fires

Adjust alarm assignments at all working fires when weather conditions dictate in order to bring extra firefighting personnel to the scene as soon as possible during the working fire. Excessive heat, snow, floods or other mitigating factors slow response times and demand additional staffing and equipment. Include personnel from dispatch when constructing these changes to get their input and perhaps even have them respond to the scene themselves.

Control self-deployment of initial responders

Self-deployment should be controlled. If company officers feel it is warranted, units should be mandated that they report their destination, work task and crew counts when self-deploying at working fires. Asheville firefighters are good at what they do and it appears they have been successful on single-family room and contents fires. Subsequent arriving units should do the same until command is established and coordinates firefighting efforts. Practice this religiously in structure fires on every call and you will have far fewer problems at your larger incidents. *You don't rise to the occasion; you default to your level of training.* If you do *not* practice this on smaller incidents you will have problems at larger incidents.

Sterilize structures at working fires

Consider the structure to be *sterile*, meaning no firefighting units have entered the structure. Thereafter all fire units must report *going in* and *coming out* of that structure. Do *not* allow this to be violated or you will play catch-up for the entire fire and put firefighters at risk. This also allows firefighters to take initial actions but provides for situational awareness for incoming units and establishes a pattern for other units to follow. More importantly it is much safer for the firefighters.

Mandate entry and exit control

Good accountability practice demands entry and exit control. This not only includes control on initial entry but later entries as well. This is often the case in high-rise fires when crews are staged below the fire floor. Entry control is vital to firefighter safety and as soon as possible an officer should move up to this position.

Backup all existing accountability systems

Do not rely strictly on Passports or PARs, but use a radio based crew count for everyone. If you use PAR try moving to a "PAR plus" system that gives a number count. Command should insist on a count when PAR is called. If crews are constantly counted it helps group cohesiveness and ensures firefighter safety. Make it a habit and your operations will remain quality and your communications problems will diminish.

Mandate the use of "CLEAR" when exiting a structure

Mandate all units report CLEAR of the structure and include their "crew count" or "PAR plus) *every time* they go in and out of a structure during an emergency or working fire. This is repeated because it is IMPORTANT.

Crews were severely tested in this midday summertime fire. Several were hospitalized from their efforts and others were all but exhausted. Firefighting is especially difficult in summer; heat can quickly strain firefighters to the limits of safety. Adequate personnel must be added to alarm responses to relieve firefighters stressed from the heat and measures developed to prevent excessive stress on all firefighters.

Develop alternative plans to increase supporting staffing

Additional staffing contingency plans should be added to dispatch requirements during environmental extremes. Consider the use of mutual aid early in the event to provide additional staffing, not necessarily for firefighting but for the support of firefighting. Should inside staging be initiated these units may be useful in resupplying the firefighting crews.

Develop additional medical protocols for extreme events

The department might want to seek professional medical assistance in developing protocols for these types of incidents. Multiple firefighters told us about heat levels and stress levels. This apparently sent several firefighters to the hospital. Numerous firefighters told us they used at least two bottles of air during this fire. "Our data reflecting the extremely strenuous nature of firefighting suggests that any attempt to have firefighters work longer by supplying larger cylinders for the SCBA would simply result in greater levels of fatigue from which it would be extremely difficult to recover" (Williams-Bell, Boisseau, McGill, Kostiuk, & Hughson, 2010).

Study air management information at major fires

An excellent reference is the article titled, "Air Management And Physiological Responses During Simulated Firefighting Tasks In A High-Rise Structure" (Williams-Bell et al., 2010).

Increase staffing of medical personnel on command staff

Addition medical personnel should be available to advise on command staff on firefighters' conditions and make recommendations. Also, sufficient staffing should be provided to supplement command positions dealing with firefighter safety and well-being.

Mandate annual air consumption testing

All companies should undergo annual Consumption Testing with full gear and SCBA to provide each member of the department with a time estimate of their work time in SCBA. These tests can be developed in house to reflect department needs and administered in the station utilizing training personnel but should also

be developed and monitored by medical personnel. (See appendix under Appendix 2 – Consumption Testing)

Company officers should know and consider the results of members' consumption tests under their command at all times and pace the unit accordingly. Personnel of different sizes will consume air at different rates.

"Knowledge of maximum rates of air consumption (in % of air cylinder or l/min) for specific tasks can enable incident commanders to develop strategies for air management to insure that firefighters can safely exit a burning structure before the sounding of their low air alarms. Our data on the high physical demands of firefighting in combination with our

observations of the rapid utilization of the air supply in the SCBA cylinder point not to increasing the size of the air cylinder but to different strategies for air management" (Williams-Bell et al., 2010, p. 258-9).

Utilize 2-1/2" hose with Smooth Bore nozzles in standpipe operations

It was mentioned that the cause of some problems on the fifth floor was the fault of using 2-1/2" hose. My opinion is that the hose may have been a contributing factor but it was <u>not</u> the cause. I would caution the department from moving away for the use of 2-1/2" hose and the smooth bore nozzle. Just the increased fire flow and reach warrants this line to say nothing of its ability to function when residual debris from within the standpipe traverses the hose line and comes out of the nozzle (Avillo, 2008, p. 346).

I was in a dire situation one night when debris clogged our fog nozzle. One minute we were barely holding our own and the next we were running for our lives. Later we found that a hose-coupling gasket had come loose and fouled the nozzle.

Many standpipe systems are not designed for fog nozzles and may not allow adequate pressure for fire streams if used. NFPA 14 is designed around the use of 2-1/2" hose and Smooth Bore nozzles. Their requirement for 65 psi on the top floor reflects this. That pressure is sufficient to develop a good 250 GPM stream from a Smooth Bore, but that pressure may severely limit the flow when using a fog nozzle (Norman, 2005, p. 130-131).

Generally the teamwork was good, but units must be prepared to deal with situations that may occur at larger incidents. My recommendations are to do some simple adjustments that will strengthen their solidarity and build their confidence.

Mandate unit prebriefs prior to task work

Conduct short crew prebriefs prior to task work. Since firefighting operations usually consist of various work tasks a format suitable for task performance can be used that simply emphasizes key points in the task. However, you need to record the steps in your work tasks and ensure officers are using them as their guidelines for briefings. They should be consistent throughout the organization. One prebriefing format is shown below.

- Who?
- When?
- Where?How?
- What? (Flin, O'Connor, & Crichton, 2008, p. 85)

Conduct crew debriefs after drill and call of any kind.

It is important for the leader in such debriefs critique themselves first so subordinates will be more forthcoming in their own critiques.

- Establish what happened (the facts).
- Discuss why it happened.
- Highlight what was done well (Positive reinforcement).
- Determine what could have been done differently.
- Agree on lessons learned.
- Solicit recommendations from participants.
- Determine what information should be passed on to others (Cannon-Bowers & Salas, 2006, p. 283).

Mandate intra-crew counts every 90 seconds in structure fires

The crew leader does *not* broadcast this over the radio but rather counts his crew frequently. This may seem excessive but it is necessary to ensure a habit is formed and to focus crew welfare as the most important job of the company officer. Basically, the unit officer calls out the unit name and members respond by count. (Never use names.) When repeated often, company officers will become familiar with not only the number, but the tone of voice and clarity that each member projects through their SCBA mask. I have had numerous officers tell me they felt more responsible for their firefighters when they did this. If this is not done often it will fail. These lapses are the direct responsibility of the company officer and their number one priority should be the safety of their personnel. It must become habit, be it an obnoxious habit – it works.

Notify command of any change in crew numbers immediately and confirm

If crew counts change, command *must* be notified each and every time. If members drop out of a crew they should notify command of their location and command should confirm it. Unit officers should immediately modify their crew count to reflect the new number. Unit leaders are responsible for passing along accountability information to command as soon as possible after any change.

Employ split-crew procedures

Should an officer split their crew they should have a rendezvous time and place to ensure the safety of members who might be without radios. These splits should also be passed along to command when able with counts of both crews and rendezvous locations if possible.

Develop standard phraseology

Develop a standard phraseology and sequence to be used during crew counts. Ensure that specific words from either command or company officers have exact meanings. Consider some of these but develop your own and give single syllable words preference:

- *Location* - Where are you in relation to other group members?
- *Air* - How much air do you have?
- *Tool* - What tool do you have?
- *Status* - How are you doing?

Talk/listen in sequence

As crews *talk* in sequence command will learn to *listen* in sequence, then when messages are garbled or interrupted by another transmission command may be able to recognize the information. Of course a good READBACK/HEARBACK is necessary for complete communication. This technique may seem like an extreme but it will cut back on the overall number of transmissions by eliminating all the repeat communications necessary when good protocol is not followed. Consider:

- Unit ID
- Location
- Work task
- Crew count

Mandate and train MAYDAYs to include Unit ID and Location

Mandate a MAYDAY give both Unit ID and Location. Members will be used to saying things in that order and command will be naturally listening in that order. It serves as a backup on a MAYDAY. Practice! Practice! Practice!

Utilize tool assignments at structure fires

Company officers need to know what tools they have available at structure fires. They will then be able to utilize crewmembers to the fullest. Tool assignments are helpful but not necessarily mandatory. Consideration of events may override tool assignments and should be left to the company officer's discretion. Training should develop unit games/tasks and problem solving exercises to promote team problem solving. Consider recording these exercises and pass information along to other shifts.

Practice some joint exercises/drills

Consider some joint exercises/drills with another shift or shift members. This helps to establish teamwork between shifts. Include dispatchers in some of these events so they gain an understanding of the differences between police and fire operations.

Work to develop key behaviors in teams

Listed below are some key behaviors that are essential to team building. Try to fashion you team to meet these behaviors. Also, the table below can easily be turned into an assessment tool simply by scoring each member on a 1 – 10 scale. Chief officers might take part in these assessments and have the team fill out an assessment form on the Chief Officers.

Key Behaviors Essential to High-Level Team Performance

Team Resources:	1. How good are team members? 2. Are they still struggling with basic procedures?
Team Identity:	1. Does everyone know who does what? 2. Is anyone "out of it"? 3. Do people help each other out? 4. Is anyone "micromanaging"?
Team self-mgt:	1. Is the leader competent? 2. Do they spot and correct problems?
Team thinking:	1. Are they headed for the same goals? 2. Does everyone have the same picture? 3. Are they behind the power curve? 4. Does uncertainty paralyze them?

(Flin, 1997, p. 195) and (Zsambok & Klein, 1987, p. 350)

Demand entry and exit control on all working fires

Demand entry and exit control on all working fires. Command staff should track personnel locations and times inside structure and crew counts at *all* times.

Command does not have to talk on the radio. Command needs to coordinate.

Trying to listen and talk to interior crews can quickly overwhelm even the most seasoned Incident Commander. Consider another person whose only responsibility is to monitor and track personnel accountability of firefighters by radio. Command is still in control and is now free to coordinate his various resources to mitigate the problem. This also ensures that above all, we are tracking our firefighters.

You cannot talk to others, listen/talk to the radio and assign companies work tasks with any efficiency when so task saturated. Commanders need to control the situation and they will do far better if someone else is handling the radio traffic of crews while they focus on strategic obligations. If co-located the IC only has to tell that person what needs to be done. Use this position to assess the individual's communication skills and possibly let it serve as training for promotion. Insist they maintain a standard of practice that is developed by the department.

RIT must be established early and maintained

RIT must be established early and maintained throughout the incident. Resist the temptation to throw RIT into the firefight and reappoint another RIT. Ensure RIT members monitor crew locations, work times and conditions throughout the fire. Good practice dictates they are not to be used in normal firefighting operations.

Develop, print and use tactical workbooks

Fire officers primarily use their experience in making fireground decisions. Develop Operations Manuals that will be living documents that are used as *checklists*, *backups* or *reference manuals* for command officers. They may also contain information on NIMS and defining roles for different personnel in fireground operations. These should be in officers' vehicles at all times and updated monthly. Benchmark information can also be stored for various fireground evolutions. They should have backup information available for use and crosschecking during operations.

These manuals can and should be developed in house with input from command officers. They should have pages specific to various incidents and perhaps even

tabs for quick reference. These should be prepared so they are understandable and easily read during actual emergencies. Small things such as Upper vs Lower case have an impact and can help in the development of these documents (FAA, 1995).

These operations manuals are used as a crosscheck for initial operational decisions. Involve dispatch in the development of these manuals and consider using them to provide personnel to respond to incidents on specific pre-determined incidents as well.

Examples might include:

- Structure fire – minor/major
- Gas leaks – interior/exterior
- Major vehicle accident-entrapment
- Major vehicle accident-Haz. Mat.
- Water rescue
- Ice rescue
- Major storm
- CO Detector/Alarm

Ensure that computerized pre-plans are available

Ensure that computerized pre-plans exist for all target hazards and that they are available in chief officer cars. Dispatch should also be able to pull up these plans as well. Consider a chief officer or your fire marshal to respond for coordinating efforts to control HVAC systems, elevators and other building systems and utilities. This is vital to safe operations during firefighting.

Periodically determine task benchmarks during structure fires

Command officers should have a working knowledge of how long specific tasks take to accomplish. These as well as air consumption should help in checking on crew well being at specific times in an incident. Chief officers should participate in task level training to provide them with the knowledge needed to benchmark their crews to ensure their welfare. Use Chief officers to grade and evaluate personnel on the performance of the tasks. Most will find that crews will burn air much faster at larger events triggering the decision to call an extra alarm sooner. Command officer must know these times for crew safety.

Ensure that company officers are conducting prebriefs at incidents

These prebriefs are vital to crew function and it is the IC's job to ensure they are conducted at all working fires. Prebriefs review key steps in fire service tasks. Operations will go much smoother when prebriefs are conducted. When omitted, problems may occur at larger events. Command should insist their subordinate officers conduct prebriefs on all firefighting tasks.

Conducting a debrief after working fires

This is the incident commander's job. Start with a self-critique and take comments from all levels of the working units. Do not allow these to evolve into finger pointing or blame, but seek a deeper reason such as communication, radio difficulties or something you can take back to the organization and change. Look at debriefs as an opportunity to improve operations. Write down suggestions and take them into consideration no matter how small. Most important, if you write down a suggestion from a member, *always* get back to them on the results of their suggestion. Your integrity and credibility are riding on demonstrating your willingness to improve.

Develop and maintain a reading list for all levels in the fire department. Share this list with your PD and dispatch. Many of these lists can be found at various military websites. Ask senior officers to conduct a book review on relevant books. These sessions will do a great deal on your fireground as well. Examples of military websites, The National Defense University Library and Concepts for Air Force Leadership.

Ensure that officers use NIMS

There is no doubt that fires, especially structure fires have declined over the years. The effect is that firefighters gain less experience fighting them and incident commanders do not get the practice on major events. Develop terms that work for Asheville Fire Department, distribute them department wide, practice them and by all means use them.

Define, train and use appropriate fireground labels

- Ventilation Group
- Roof Division
- Attack Group
- Water Supply
- Floor Five Division
- Staging Group
- Rear Division etc.

Develop Duties/Responsibilities Cards for department use

Each group should have an associated Duties and Responsibilities Card for the associated assignment. All command vehicles should include extra cards to give individuals from mutual aid departments when needed. As supplemental staff becomes available command officers can make assignments for the appropriate needs during that incident and hand out cards to assignees. Practice with these cards on a monthly basis with all levels of personnel. When it becomes second nature, it will improve your fireground operations.

Ensure officers have knowledge of task times for units under their control
Team members and team leaders should be taught more in depth knowledge about their task assignment by units. Engine companies should know how many feet of 2-1/2" hose is required to attack a fire on a given floor in multi-story structures. This should include the amount of hose necessary to maneuver and fight the fire. This should be practiced and published. Command officers need this knowledge to judge progress during incidents.

Truck company members and officers should know exactly which ladders are required to reach certain heights on specific buildings. They must also know on specific buildings where best to spot an aerial ladder/tower. Access should be considered as well as rear mount versus front mount equipment. They should be timed and tested in putting an aerial master stream into operation. As always, Chief officers should be present at these tests and training so they will know the limitations themselves.

Mandate that audio recordings be reviewed after working fires

These recordings are your most valuable assets. Digital recorders are inexpensive and editing software is free. Many firefighters have been lost and some killed because of communication problems. If you want to solve you communications problems you will record, edit and review you communications for improvement. Make it standard practice to record all fire related events and review these recordings after events. Insist on proper address corrections, entry procedures, accountability procedures and exit procedures on each structural fire call. (See also, Record and review audios of drills)

Officers and firefighters should be corrected when radio protocol is violated. Senior officers in the fire department should review working fire communications to ensure proper communications protocols are being used. If you are to successfully improve your fireground operations you must monitor how orders are given and messages are acknowledged. You might find that there are simple solutions to problems but they must be reviewed.

SOPS/SOGS

Improve appearance, visibility and distribution of SOPs/SOGs

Increase the visibility and use of SOPs/SOGs throughout the department. When developing these documents their acceptance and use is often tied to the way the document looks. Consult graphics people or enlist help in designing documents that are easy to use. Flowcharts, logic tables with the use of conditional tables, warning notes, cautions, and cross-references help make these documents more *readable*. The easier they are to read the more they will be used and followed. Incorporate an assessment tool with the document to check the understanding of members on the various procedures (Wieringa, Moore, & Barnes, 1998).

A very useful text for producing these is, Procedure Writing: Principles and Practices, by Dougas Wieringa, Christopher Moore and Valerie Barnes (Wieringa et al., 1998).

Ensure SOPs/SOGs are distributed in person and available via intranet

Ensure all SOPs/SOGs are disseminated and explained by Battalion Chiefs in person. These same chiefs should be responsible for periodically testing firefighter knowledge of the SOPs/SOGs with the aid of training.

Periodically ask officers to give a class on a selected SOP/SOG

Ask training to have officers do company training on your SOPs/SOGs. This not only ensures they have them, but also checks their knowledge of the current documents. Chief officers should also be involved in this activity.

Keep a List of Effective Pages (LOEP), for all SOPs/SOGs

Keep a List of Effective Pages (LOEP), for all SOPs/SOGs, and other operational documents at every fire station and have it available on your intranet. This enables everyone to know which is the latest standard being used today in your department. The LOEP is also an effective method of storing or archiving procedural standards as well. Samples of LOEP formats can be found in many government documents. Sample LOEP. Modify this format to fit your department as necessary and update it monthly.

These documents should be stored electronically and copies made available through your department intranet if at all possible. Try to have examples of their use available to all members.

Ensure that all SOPs/SOGs are numbered and dated.

Ensure that all SOPs/SOGs are numbered and dated as members need to know which one is current. The LOEP should reflect what is current and what changes are made from document to document to clarify these changes. Chiefs should carry a current list with them when visiting stations and periodically audited to ensure these are maintained at the stations.

Maintain and do not be afraid to change standards

Standards are vital to successful operations but sometimes need modification. Be sure to notify and disseminate any changes to everyone concerned. LTC Harry Tunnell's words, "Define standards, train people on what they are, and enforce them. It is not a standard until it is written and understood. Your unit will fight the way they have been trained regardless of whether you want them to or not" (McCoy, 2007, p. 39).

Two items were clearly related to us by interviewees. The need for:

- More and better training
- Chiefs to be involved in training

Increase company drills for determining location in smoke

Many firefighters become lost because they are distracted and do not keep a good mental map of their location. Good training can enhance their ability to locate themselves within a building. Many state and local Smoke Diver or other schools teach these enhanced techniques and members should be encouraged to attend and bring back vital information to the department.

Conducting quick primary searches then drawing a map of objects, dimensions and exits help firefighters think about these things and will help them determine their location. Additionally, knowing corner information is extremely important especially in larger structures. In my experience using letters for corner designations such as the "C/D corner" or the "B/C corner" when spoken thru the SCBA is all but impossible to understand. Numbers seem much clearer but you need to do your own radio testing. (Listen to sample audio, Avoid using letters if possible use the phonetic alphabet)

Conduct tool/equipment training drills

Determine and practice which tools/equipment will be carried to the emergency for various tasks. Time these operations and consider RIT baskets etc. Develop written instructions on the details of this and share it with others. Ensure they are passed along to members temporarily assigned to the unit. Brief each crewmember as to their task assignment.

Listen to included audio tests, then conduct your own

I have included some audio tests in Appendix 3 but it is important for your department to conduct their own testing. Do not wait until another fire. Test now and select a method, then train on it, monitor it and record it. Chief officers should be responsible for ensuring that proper verbiage and nomenclature be used.

Ask chief officers to conduct search and rescue drills

If these are the officers that run your fires, they need to take part in these drills to observe their companies in task operations. Secretaries and other personnel can handle administrative tasks but the people who will control firefighters in their operations need to take part in their training. Anything short of that does not ensure firefighter safety at emergency scenes.

Design training drills where Chief officers participate

Design training drills where Chief officers participate. This will help in every area of your operations. Also, use these chiefs to develop a list of "Need to Know" that can be used for incident radio reports. The goal is to use one-word requests such as:

- Status
- Conditions
- Location, etc.

Ensure enhanced RIT training is conducted

Enhanced RIT drill training should be increased. Begin by ensuring RIT members are monitoring the radio to determine exact locations of the various units. Anybody on RIT should be fanatical on counts and locations. Also practice removing injured firefighters from fire structures. RIT teams also need practice on consumption times, air management and multi-RIT operations. Especially critical is briefing the next RIT team used in multi-RIT operations. Unit members who are *not* giving good location or accountability information should be counseled and may require additional training. All department personnel should support this. Your safety and performance will grow with COMMITMENT.

Have RIT members search a room when totally blind, then exit the structure, sit down and draw the interior of the room, identifying objects, dimensions and exit locations. Repeat several times and make it increasingly difficult each time. Drop baby items around the floor and incorporate a crib to ensure they search in the crib. Then ask RIT members to design a search scenario for other firefighters.

Enhance crew awareness during routine activities

Good officers are always seeking to enhance their crew's performance. Provide these officers with suggestions for activities they can use to enhance firefighter awareness of things they will need to know on the fireground. When traveling to and from fire stations ask fire officers to stop the rig and ask the firefighters to "read the building". Where are the stairs, which way does the hallway run, what do the vent stacks tell you at a residence, what is the occupancy? Query engine companies about how much hose is needed to reach a specific point or to guess the fire flow of a specified area. Truck companies can do the similar exercises only with ladders, noting roof access points, openings, rafter directions and other hazards associated with roof operations. Jot down this information and pass it along to others.

Practice and demand redundancy on all accountability systems

Accountability systems need a backup or redundancy in addition to the PAR and the *Riding List* carried by chiefs. These systems need to be dynamic and constantly updated throughout an incident to provide good accountability through crew changes and emergencies. Continuous crew counts (PAR plus) and location information may seem like overkill, but they are vital for the protection of your firefighters. As Chief Larry Anderson (ret.) says:" The Dallas Fire Department uses a passport accountability system. Getting used to the routine was the toughest part. During my thirty years we have lost six firefighters in structure fires.

I firmly believe they died because we did not know where they were" (Angulo, 2010, p. 50). Drills on accountability help to ensure firefighters do not become lost in structures.

Conduct special hose line drills

Practice major hose line advances several times a year, probably monthly. One method is called the "Conga Line", where 4 – 6 firefighters are each loaded with 100 – 150 feet of 2-1/2" hose. The engineer loads the hose onto the firefighter's shoulder. The first firefighter steps away from the pumper in three giant steps forward and one step back to provide slack in between firefighters as the second firefighter steps to the tailboard to be loaded. After all the hose is loaded the group moves out. On a pre-determined signal the rear firefighter drops and secures the hose line as the others deploy their respective hose loads. Eventually work this drill up stairways and it will provide a viable alternative when standpipes and aerials do not solve the problem. Variations on this drill are endless. Video and record the steps for later practice. Ask Chief officers to time these drills or set various objects. Chiefs should know how long these operations take and the drill helps them in later decisions. Again this drill may seem like nothing but it is very effective and will prove well worth practicing some day at the larger fire. Your firefighters will not only move efficiently but they will feel better doing it. Teamwork moves hose. Know it – practice it.

Use evaluation assessment forms for all physical tasks

Below is a sample evaluation form for setting up an aerial ladder. The procedure can change but the format allows for easy administration and provides consistency. (See also, Appendix 5 – Sample Checklists)

_____ *Fire Department* ON = indicates switch position	Driver: _____ Date: _____		
_____ (Setup) (All operations performed by driver only)	Correct	Incorrect	Comments
Front Tires ..... Straighten (5) Brake ..... Set (10) Shift ..... NEUTRAL (5) Tower Master Switch ..... ON (5) Tower PTO Switch ..... ON (5)			( )
Front Tires ..... Chock (10) Red Lift Control Knob ..... Pull Out (5) Engineer's Platform ..... Pull Out (5)			( )
Outrigger Pads ..... Set (5) Idle Switch ..... FAST (5) Outriggers ..... Extend R & L Together (2) Outriggers ..... Lower (3) Outrigger Lights ..... Check Illuminated (2) Level Apparatus ..... + or – 5 Degrees (5) Safety Pins ..... Insert (5) Idle Switch ..... IDLE (3) Rear Panel Door ..... Closed (2)			( )
Engineer's Platform ..... Mount with both feet (5) Idle Switch ..... FAST (5) Ladder Lift Control ..... Raise (5)			( )
Total Points:	____		Pts. Elapsed Time _____

Conduct timed training for all task drills

Over the years I have had many firefighters tell me about the techniques used in their training helped them save lives on the fireground. Timed drills and evolutions do work well, but any instructor needs to keep in mind that safety is never sacrificed for time.

"Overlearning involves providing additional practice beyond the criterion level of mastery" (Rose, 1997, p. 203). Overlearning works very well especially in critical skills needed by professional firefighters. "The overlearning had 65% fewer errors after eight (8) weeks with an optimum time of retention is 38 days (Copper, 1992, p. 352). Firefighting is skill based and one must master numerous physical tasks from ladder carries to SCBA donning and those skills should be maintained by frequent practice. These skills should be documented using written step-by-step details, recorded by both photographs and video

along with time and safety standards. Once this has been accomplished it is necessary to develop assessment tools for each task. One can turn a list of objectives into a checklist or rating scale to give a relative grade for each step in a procedure. Often assistance in developing these tools can be obtained through a local high school or junior college. These assessment tools should be used to ensure the quality level of your firefighters. Timing and safety deductions ensure that bad habits are not passed along to others. One can also use competitive skill training but this should be closely monitored.

Define benchmarks for specific firefighting tasks

Repetitive skill training works as does overlearning. Your firefighters will have fewer errors and retain their skills longer if the skill is overlearned (Copper, 1992). Establish a standard locally approved method, and then time various companies and/or individuals in the execution of these tasks. Use these benchmarks for periodic testing and for training retention. "After initial training skills, overtrained subjects required 22% fewer trials to retrain" (Copper, 1992). Simulations may have to provide some level of experience but at the task level the senior officer needs fundamental knowledge of task performance. Start the above at first with basic firefighting tasks such as:

- Pull and advance an 1-3/4" hoseline (2-ff)
- Pull and advance an 2-1/2" hoseline (2-ff)
- Remove, carry and raise a pumper extension ladder (2-ff)
- Remove, carry and raise a 35' extension ladder (4-ff)
- Climb and enter a second story window as a unit. (4 ff)
- Search lower level of a home, using crew counts in under 2 min. (2 ff)
- Stretch a hoseline up to the 4th floor of a building.
- Place a master stream on the roof of another building for a point advantage
- Spot, set and deploy ladder (pipe or tower master stream operation)

Why benchmarks? "Chess masters "see" patterns of interrelated chess pieces on the chess board. It is these familiar patterns that enable them to select the best move because the familiar patterns are associated with optimal moves" (Druckman & Bjork, 1991, p. 66). Your fire chiefs need to learn the pattern of their firefighters' moves in order to judge and affect a strategy on the fireground. They will not learn this in the office; they will learn this by working with the companies under their command on the drill ground.

Purchase a quality firefighting simulator

Purchase a firefighting simulator (just one brand and I believe some are free) system that can be networked, as this will allow more robust training. This tool can be used to practice many of your operations. They are also very useful in assessment of fire officers for promotion or other considerations. Photos of buildings can be taken from different angles to provide views of conditions. Then, start gathering information about your target hazards and build from there. Ask various members to role play in simulations and by all means record these simulations. Insist on proper phraseology. Once personnel understand the

simulator, deploy Chief officers to run various simulations with their various companies. This allows them to communicate what information they will be seeking in a similar situation. Remember, good decision makers are experienced and experience can be gained through good simulations. As always, during debriefs, the chief officers should start with a critique of themselves first to encourage others to participate.

Practice decision making at all levels

Simulators can help accomplish this. Decision making skills can be taught and methods should certainly be studied at all levels of the department. "Decision Skills Training does not attempt to teach decision-making per se. Instead we attempt to facilitate the development of the decision maker's experience base within a particular domain (firefighting), which should, in turn, result in improved recognition decision-making skills" (Salas & Klein, 2001, p. 41). Drills, simulator training and skill practice all aid in this process.

Increase training in Naturalistic Decision Making (NDM)

Drills should be designed to vary some of the key elements fire officers use to control fires. This practice offers excellent practice in decision-making on the firegound as well as delivering orders by radio.

"Early NDM research discovered that expert professional judgment was largely based on a process in which experts expend effort on situational assessment (figuring out the nature of the problem), then evaluate single options through mental simulation, and then arrive at a satisfactory answer or action" (Ericsson, Chamess, Feltovich, & Hoffman,2006, p. 532).

Fire officers primarily use Naturalistic Decision Making (NDM) when making decisions at fires or other emergencies. This method is used primarily in situations where there are:

- Ill structured problems
- Uncertain dynamic environments
- Shifting ill defined goals
- Action/feedback loops
- Time stress
- High stakes
- Multiple players

Create senior officer training scenarios

I would suggest the use of simulators to help senior officers prepare for larger events that may not be as common. These should start off using simulated initial "on scene" reports that have been recorded by training during training sessions held for first in officers. These can grow into simulations where, conditions vary, obstacles present themselves and additional staffing is needed. The scenarios may even involve using dispatch for training as well. In some cases it may be

beneficial to invite outside expertise to assist in these evolutions. As Colonel B.P. McCoy says in his excellent book, *The Passion of Command,* "Only by rigorous training held to an unyielding standard can a commander truly assess the individual and collective capabilities of his men" (McCoy, 2007, p. 32).

Do not under estimate the value of simulation in teaching at all levels within your department. "A good simulation can sometimes provide more training value than direct experience. A good simulation lets you stop the action, back up and see what went on, and cram many trials together so a person can develop a sense of typicality. Another training strategy is to compile stories of difficult cases and make these the training materials" (Klein, 1998, p. 43).

Conduct numerous accountability drills

Accountability drills should be conducted monthly. People die because they get lost in buildings. These drills will help prevent that from happening. There are methods one can use that do not cost any money and do not require a burn building or bunker gear for that matter. Do them blind and ask locations to be identified often. Insist RIT is set up and monitors operations. Variations can be crew number changes, mock MAYDAYs, air management problems, (query command on their work time), simulated collapses and crew rotation problems.

Conduct risk factor analysis drills

Set up a situation or scenario then provide a list of risk factors concerning that situation. Give officers three minutes, working independently, to rank the risk factors from most risk to least risk. Ask for explanations and examples from all. Record these sessions to pass along valuable information to others.

Record and review audios of drills

Record and review audios of all drills and events conducted to ensure quality. These prove valuable and will certainly help point out weaknesses in your operations. You will not notice some things during the event, but the audios may reveal things you may want to address (*See also,* Analyze audio recordings of all incidents).

Brainstorm with firefighters after drills on what is needed

If you listen they will tell you what they need. Usually after one drill members are motivated to do more training to increase their proficiency. Take advantage of this and ask for suggestions. During these sessions of brainstorming introduce and allow junior officers or members to command incidents. This will help them realize the priorities command has plus it gives them experience. Allow the Chief officers to critique but ensure it is kept positive and helpful.

Increase and supplement more station training

Train more often and encourage training in the stations but increase your efforts to support that training. The fact that we are responding to fewer structural fires than previous generations actually reduces our technical proficiency at our craft and carries with it increased risks (Brezler, 2010).

Work diligently and strive for perfection. Training quality firefighters to do the job of protecting the citizens of your community will reward your efforts. "I will always harbor doubts over my efforts prior to and during combat, whether or not my personal preparation and leadership was all it could be. For the rest of my life – each time I look in the mirror I will be acutely reminded of my shortcomings, and a piece of my heart will chip away, for in the shadows of my eyes I will see their faces, staring back at me – for the rest of my life" (McCoy, 2007, p. 78).

COMMUNICATIONS

From many of our interviewees we heard about communication difficulties. Also after listening to the unedited audio recording of the fire on 28 July, 2011 in Asheville I too noted communication difficulties. This is a common problem at major incidents and is not unique, however there are techniques that can be used to minimize the communication problems. The communication order, standard phraseology, succinct sequential messages and readbacks of messages all help eliminate many of the errors that often boost the number of transmissions to convey information.

In firefighting and in war uncertainty is constantly with any leader. Probably the best way to reduce it is to communicate better. "Commanders gain most of their information from very few cues. The ultimate requirement is to be able to operate effectively in spite of uncertainty" (Schmitt & Klein, 1996, p. 65-66). Diligent work is necessary to streamline any communication system. The secret is COMMITMENT from all levels of the department. Resistance to change will spell a quick death to any changes and oftentimes this is a tactic employed by those who are not willing to change. Careful considerations of these factors are necessary for success in any changes to a communication system.

Nevertheless operations will no doubt improve if personnel are willing to change to a more efficient system of communicating by radio. Evidence indicates this problem is found in many fire operations. Gasaway ranked communications as number two in his barriers to the incident commanders situational awareness, "because it restricts his ability to understand what is going on" (Gasaway, 2009, p. 319). Gasaway's Incident Commanders also related the incomplete communications loop as, "trying to put together a jigsaw puzzle without having all the pieces – the puzzle is incomplete and it impacts the commander's ability to understand what is happening and his or her ability to predict the direction the incident is heading" (Gasaway, 2009, p. 321).

Flin, also mentions communications as a problem for incident commanders. "The typical problem for the commander is that insufficient information is available to form a proper situational assessment, and the incoming situation reports are inadequate, inaccurate or incomplete" (Flin, 1997, p. 109). So your goal is to build a communication system that offers solutions to these problems by designing a clear, concise language the starts from the very beginning of the incident and continues to the end.

Insist on quality acknowledgements

"If companies fail to get radio acknowledgment from command they are prone to ignore the radio and to freelance" (Bingham, 1997). One of interviewees admitted to doing exactly that when unable to communicate.

Roger Lunt describes a simple communication used every day in our lives that can also serve as an example. Lunt explains in his book on avoiding fire department induced CHAOS, "What if you place your order at a fast food restaurant and the employee replied with a "Copy", "Received", "10-4", or simply double clicked the microphone. Do you hold a higher level of communication at your fire scene than the fast food operator at the drive-in? (Lunt, 2009). "If communications breaks down, it will be difficult to have a fire scene void of some level of CHAOS" (Lunt, 2009, p. 31).

Develop a language and communication system around the use of SCBA

A NIOSH list indicates one of top five causes of firefighter death involves poor communication (Brunacini, 2002, p. 69). Certainly in most major fires communications is usually one of the predominant problems. What determines unique fire service communication needs is the use of SCBA. Many of the SCBA masks can be fitted with internal microphone and other technologies that aid in communication but are often cost prohibitive for many departments. Therefore, departments need to recognize the need for unique verbiage and operational considerations when using radios with SCBA.

Insist on good quality initial reports

It is no secret that a good initial report can be helpful to everyone responding to an emergency. That report should include a verification statement of the correct address of the emergency. Life problems or potential problems should be stated even if they are only a possibility, and of course what actions your unit is taking. These reports can and should be practiced by all officers in the department frequently.

Mandate a communication order of – "Hey you, its me"

Practice, "Hey you, it's me," communications on all radio communications. It is simpler and cuts your communications in half.

Utilize standard verbiage that incorporate the following repeatedly.

- Unit ID
- Location
- Work Task
- Number of personnel
- Needs/requests

Utilize *Report Clauses* during fireground operations

One very useful tool to be considered is the use of Report Clauses that were mentioned earlier in this report. These are extremely useful for the Incident Commander. It provides cues to the IC that he needs to maintain his situational awareness. When given it builds in the requirement for the fire officer to call the IC back and report. If this is given in the correct format using the already mentioned information, several pieces of valuable information is given in just five seconds. This in itself helps dramatically in reducing extraneous radio traffic.

This will require a complete change in how commanders give their orders. They have to put themselves into the company officer's shoes and think ahead of the fire. What will tell me when this task is accomplished? Since many fireground tasks are the same only given to different groups ICs will quickly adapt to this technique. Sample audios are found in the appendix but I encourage you to develop you own.

In addition this report gives information to everyone on the frequency and not just to the Incident Commander. Should the IC become distracted or interrupted during command communications major problems can result.

The aviation industry documents numerous accidents attributed to communication, interruptions and language problems (Jones, 2003, p. 237).

Insist on quality READBACKS

"Simply repeating the main points of each exchange confirms to the sender and receiver that communication has occurred and it has been understood" (Stumbaugh, 2008).

Many will insist that this just clogs up the radio but it is the repeats of attempts to acquire information that clogs the radio. One only needs to visit a large metro airport and listen to the busy ATC communications used by pilots and controllers. All communications use the READBACK/HEARBACK technique to ensure both parties clearly understand.

To complete the communication loop all messages should contain a READBACK. This is simply a repeat of the information received. This may seem unnecessary but it does save time and communications. George Bernard Shaw once said, "The greatest problem in communications is the illusion that it has been accomplished" (Kanki & Smith, 2001, p. 95). Even in the medical

settings these techniques are being use by trauma teams to provide better critical care in the emergency room (Cole & Crichton, 2006).

Avoid using letters if possible use the phonetic alphabet

Letters do not penetrate the SCBA mask well. NIMS does not specify building side nomenclature contrary to popular opinion. Consider numbered sides for structures. This aids tremendously in knowing corner locations. Should a MAYDAY arise make it a habit of your firefighters to know what corner is nearby.

There are drills that can ease this process somewhat when practiced without the pressure of real operations. Later simulations can take on a more realistic appearance as confidence and competence grows. Flin goes on to say that, "From a training and simulation point of view, one critical component in maintaining personnel performance in a stress environment is to provide practice and the exercise of critical tasks under operational conditions similar to those likely to be encountered in the real environment" (Flin, 1997, p. 116).

Require frequent crew counts or PAR plus (Insist on numbers)

Use "crew counts" or PAR plus the number in your operations. These should be checked frequently by the company officer and clearly stated when doing a READBACK.

Analyze audio recordings of all incidents

Your operations will be enhanced if you listen to your audio recordings after each event. To do this they must be recorded. Afterward, they can be separated and analyzed for proper procedure. If your communication system is to work it must be analyzed. (*See also,* Record and review audios of drills)

You can enlist local help or your explorer youth to assist in these projects where their computer skills may surpass members. After recordings are digitized, dead air can be eliminated to just contain vital information. Command should review their methods of communicating, as should each unit involved. Critiques are the only way your system will improve.

Link all radios to specific personnel

Each radio on the fire ground should be linked to an individual so dispatch can quickly identify who is transmitting. Dispatch and operations should work together on this procedure so it is speedy and thorough. Firefighter lives are at stake and quick identification can help find the fallen firefighter in an emergency. Even a simple database or spreadsheet can be established and kept dynamically containing this information and searched by a variety of different fields. Perhaps your IT personnel can assist with this project.

Record daily radio traffic

Initially you will need to record everyday traffic to monitor the, "Hey you, it's me" technique. If you do not personnel will quickly slide back into their old habits. Remember, "You do not rise to the occasion, you default to your level of training." Record daily radio traffic and especially all drills and fires. Pour over these and analyze them thoroughly and hold members responsible for proper technique, *all the time,* not just during fires. "Lieutenant Colonel Bryan P. McCoy says, "It takes two months for the mind and the body to develop a true habit" (McCoy, 2007).

Streamline radio call signs

Modify radio call signs to Engine #, Truck#, Squad# and eliminate individual call signs such as, "eleven-0-one" etc. It becomes very confusing and it should be crystal clear to all members. Pick a system that is easily understood by all and test it using SCBAs.

Use radio holder straps and radios equipped with shoulder microphones

Radio straps complete with speaker microphones should be used by firefighters. Most important is that it ensures the radio will remain with the firefighter and not be lost. Two firefighters in serious trouble both lost their radios using the existing system of putting portables in breast pockets. It is practically impossible to crawl when holding a radio and if you do you are sacrificing that hand for personal protection, balance or tool carrying. Firefighters need to hear and the breast pocket approach is not conducive to quality hearing.

Necessary changes must be made when operating with radios with speaker microphones. These are usually carried on the inside of the bunker coat with the speaker/microphone threaded up and out the neck or front then clipped to the collar of the turnout coat so it can be heard. The firefighter only needs to turn his or her head and depress the microphone button to transmit.

However, with the radio inside the turnout coat, it can be difficult to change frequencies. In many cases emergency frequencies are usually programmed either at the top or the bottom end of the knob so one only needs to turn it up all the way or down. Develop a procedure that works best in your department.

Consider the use of bone microphones

Consider the use of bone microphones was something we heard in our interviews. This should be researched and considered. Should budgetary need forbid large scale purchases they might be considered for use in special operations such as Hazardous Materials, Technical Rescue or RIT operations.

Use a standardized tracking system for firefighter accountability

Continuous Accountability Tracking (CAT) might be considered for a base until you can develop your own system. The earlier section on my background discusses some of the features of this system. There are drills available to teach this system.

Reports from firefighters most importantly serve as cues to the IC on where and what firefighters are doing. In *The Multitasking Myth* Loukopoulos, Dismukes and Barshi say, "cues act as reminders that help prompt retrieval of intentions from memory. Although individuals may think they are performing several tasks simultaneously, human ability to process more than one stream of information at a time and respond accordingly is limited" (Loukopoulos et al., 2009). Certainly any one who has observed an Incident Commander in action agrees that they are very busy and can easily be overloaded and lose situational awareness. That can cost firefighters their lives.

Eliminate ordinal numbers

Eliminate ordinal numbers such as *first, second, third,* etc. These words cannot be clearly understood through the SCBA mask. When referring to floors or levels of a structure use one, two, three, or "on the one", "on the two" etc. The word "Division" is commonly used in NIMS but it is three syllables by itself, add in the number and it is four syllables. Recall one of our interviewees who almost lost his life stated, "It would have cost me a breath." In those situations every breath can mean life or death, do not plan your operations around what works most of the time, plan them around the worst case scenario if you value the lives of your firefighters. Naturally, prior to any changes I recommend thorough testing under realistic conditions.

Demand *CLEAR* on building exit

Demand CLEAR with count or PAR plus on building exit and entry. Command officers should insist on this each and every time a unit enters. Interior officers should do the same. Appoint someone to *always* have an accurate number of personnel in the building at all times and test them on that number frequently. Senior officers, starting with the Fire Chief should see that this is done when monitoring the radio traffic. (*See also,* Mandate the use of "CLEAR" when exiting a structure)

Backup all accountability systems

Do *not* rely solely on riding lists for accountability. The 445 Building fire illustrated the danger in this when the rescue company had an add-on member. Even if command had been notified, it is still playing with people's lives. Counts should be over the radio so everyone can hear and back up everyone else.

Practice good reports

"Information is like gold in combat, clear, concise reporting in a calm, steady voice is the irreducible bottom line. We not only repeatedly drilled our unit leaders on reporting, but we drilled them over the map board of our G-Day objectives. We practiced reporting the most likely situations we would experience – for example, enemy contact, and requests for fire, position reports, and medical evacuations" (McCoy, 2007, p. 33).

EQUIPMENT

Purchase large gasoline powered vent fans

Purchase large gasoline powered ventilation fans for use in high rise or large structures. Have them dispatched on the initial alarm. Study the dynamics of the Reverse stack effect fire and practice using these.

Purchase radio carrying straps and associated speaker/microphones

Purchase radio carrying straps and shoulder microphones and insist firefighters use them. Two firefighters lost their radios in the 445 Building fire.

Purchase additional thermal imagers

Purchase additional thermal imaging cameras, enough for each engine, truck and rescue company. Often civic groups will assist with the purchase of this equipment. Specify when these cameras are to be taken into structures and used during searches. Also, consider extra training on their use.

Purchase several digital recorders

Purchase several small digital recorders and editing software. They are usually under

$100 and can be plugged into the microphone jack of a radio to record calls. Most have a feature that will only record when someone is transmitting, saving hours of recording. There is downloadable software for free on the Internet.

Purchase an illuminated rope

Purchase or test illuminated light ropes, it may help in your operations.

REFERENCES

Angulo, R. A. (2010). They're counting on you. *FireRescue Magazine, April, 2010*(April, 2010), 48-54.

Avillo, A. (2008). *Fireground strategies.* Tulsa, OK: Penwell Corporation.

Ayers, G. (1969). Time and motion studies. *Fire Chief, April*(April, 1969), 15-19.

Bachrach, A., & Egstrom, G. (2003). Diving behavior. In A. Bouve & J. Davis Eds.), *Diving medicine* (pp. 432): W. W. Saunders Company.

Bachtler, J. R., & Brennan, T. F. (Eds.). *The fire chief's handbook.* Tulsa, OK: Penwell Publishing.

Bingham, R. C. (1997). Improving fireground radio communications. *Fire Engineering, February*(February), 38, 42, 44-49.

Bingham, R. C. (2004). *Street smart firefighting.* Vienna, VA: Valley Press.

Brezler, J. C. (2010). *Make yourself hard to kill.* New York. Retrieved from www.leadershipunderfire.vpweb.com

Brunacini, A. V. (1978). The four percent solution. *Fire Command,* 21.

Brunacini, A. V. (2002). Bruno's communication tenets for ics. *FireRescue Magazine, April, 2002*(April, 2002), 69-77.

Cannon-Bowers, J. A., & Salas, E. (Eds.). (2006). *Making decisions under stress: Implications for individual & team training* (Third ed.). Washington, D.C.: American Psychology Association.

Cole, E., & Crichton, N. (2006). The culture of a trauma team in relation to human factors. *Journal of Clinical Nursing, 15.*

Copper, C. (1992). Effect of overlearning on retention. *Journal of Applied Psychology, 77*(5), 615-622.

Dekker, S. (2002). *The field guide to human error investigations.* Burlington, VT: Ashgate Publishing.

Dekker, S. (2011). *Drift into failure: From hunting broken components to understanding complex systems.* Burlington, VT: Ashgate Publishing Company.

Driskell, J. E., Salas, E., & Johnston, J. (1999). Does stress lead to a loss of team perspective? *Group Dynamics: Theory, Research and Practice, 3*(No. 4), 11.

Druckman, D., & Bjork, R. A. (Eds.). (1991). *In the mind's eye: Enhancing human performance*. Washington, D.C.: National Academy Press.

Encyclopedia, W. T. F. (2011). Maslow's hierarchy of needs. from http://en.wikipedia.org/wiki/Maslow's_hierarchy_of_needs

Ericsson, K. A., Charness, N., Feltovich, P. J., & Hoffman, R. R. (Eds.). (2006). *The cambridge handbook of expertise and expert performance*. New York: Cambridge University Press - http://www.cambridge.org/americas/.

FAA. (1995). *Human performance considerations in the use and design of aircraft checklists*. Washington, DC: FAA Retrieved from http://www.skybrary.aero/bookshelf/books/1566.pdf.

Flin, R. (1997). *Sitting in the hot seat*. New York, NY: John Wiley and Sons, Inc.

Flin, R., O'Connor, P., & Crichton, M. (2008). *Safety at the sharp end: A guide to non- technical skills*. Burlington, VT: Ashgate Publishing Company.

Freud, S. (1922). *Group psychology and the analysis of the ego*. New York: Norton.

Gasaway, R. B. (2009). *Fireground command decision making: Understanding the barriers challenging command situation awareness*. Roseville, MN: Gasaway Consulting Group, LLC.

Jones, K. (2003). Miscommunication between pilots and air traffic controllers. *Language Problems and Language Planning, 27*(3), 233-248.

Kanki, B. G., & Smith, G. M. (2001). Training aviation communicatiion skills. In E. Salas, C. A. Bowers & E. Edens (Eds.), *Improving teamwork in organizations: Applications of resource management training* (pp. 55-72). Mahwah, NJ: Lawrence Erlbaum Associates.

Klair, M. B. (2000). The mediated debrief of problem flights *Facilitation and debriefing in aviation training and operations* (pp. 72-92). Burlington, VT: Ashgate Publishing.

Klein, G. (1998). *Sources of power, how people make decisions* (Second Printing ed.). Cambride, Massachusetts and London, England: MIT Press.

Loukopoulos, L. D., Dismukes, R. K., & Barshi, I. (2009). *The multitasking myth.* Burlington, VT: Ashgate Publishing Company.

Lunt, R. (2009). *Avoiding fire department induced chaos.* Maclean, N. (1992). *Young men and fire.* Chicago and London: University of Chicago Press.

McCoy, C. B. P. (2007). *Passion of command: The moral imperative of leadership.* Quantico, VA: Marine Corps Association.

Miller, G. A. (1956). The magical number seven, plus or minus two some limits on our capacity for processing information. *Psychological Review, Vol. 101*(No. 2), 343-352, 9.

Norman, J. (2005). *Fire officer's handbook of tactics* (Third ed.). Tulsa: Penwell Corporation.

Rose, D. J. (1997). *Multilevel approach to the study of motor control and learning.* Needham Heights, MA: Allyn & Bacon.

Rutledge, J. W. (2011). [Interview with chief mac mccastland, retired oak lawn fire department and battalion chief kevin krasneck, division of special operations, chicago fire department].

Salas, E., & Klein, G. (2001). *Linking expertise and naturalistic decision making.* Mahwah, NJ: Lawrence Erlbaum Associates.

Schmitt, M. J. F., & Klein, G. A. (1996). Fighting in the fog: Dealing with battlefield uncertainty. *Marine Corps Gazette, 80*(8), 62-69.

Stanke, D. (2002). Managing the ins and outs of commercial building pressurization. *Engineers Newsletter, 31.* Retrieved from http://www.trane.com/commercial/library/vol31_2/index.asp

Stumbaugh, S. (2008). Improving fireground communications. *Fire Engineering*(July, 2008), 1-6.

Tamura, G. T., & Shaw, C. Y. (1973). Basis for the design of smoke shafts. *Fire Technology, 9* (3), 209-222. Research Paper No. 595 of the Division of Building Research

Varone, C. (2003). Firefighter safety and radio communication. *Fire Engineering, March, 2003*, 1-13.

Weick, K. E. (1993). *The collapse of sensemaking in organizations: The mann gulch disaster.* [Katz-Newcomb lecture presented at the University of Michigan, April 23-24, 1993.]. Katz-Newcomb Lecture, (Administrative Science Quarterly). Copyright by Cornell University, 1993, Ithaca, NY.

Wieringa, D., Moore, C., & Barnes, V. (1998). *Procedure writing: Principles and practices* (Second ed.). Columbus Richland: Battelle Press http://www.battelle.org/publications/.

Williams-Bell, F. M., Boisseau, G., McGill, J., Kostiuk, A., & Hughson, R. L. (2010). Air management and physiological responses during simulated firefighting tasks in a high-rise structure. *Applied Ergonomics, 41*, 251-259.

Zsambok, C. E., & Klein, G. (1987). *Naturalistic decision making.* Mahwah, NJ: Lawrence Erlbaum Associates

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In 1990 he accepted a full-time position with Delta Airlines in flight operations. There he developed pilot computer-based training programs, taught crew resource management and human factors and he investigated Federal Aviation Administration-related incidents and mishaps. He has earned bachelors of science and masters of public administration degrees. Following his retirement from Delta Airlines, Mr. Rutledge has continued his public safety service through teaching and consulting. He can be reached at: jackrutledge@mindspring.com or 404-229-3041.

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APPENDIX 1: AIR MANAGEMENT INFORMATION

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Air management and physiological responses during simulated firefighting tasks in a high-rise structure

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ABSTRACT

Air consumption, oxygen uptake (VO_2), carbon dioxide output (VCO_2) and respiratory exchange ratio ($RER = VCO_2/VO_2$) were measured directly from the self-contained breathing apparatus (SCBA) as 36 professional firefighters (three women) completed scenarios of high-rise stair climbing and fifth floor search and rescue. During stair climbing VO_2 was $75 \pm 8\%$ VO_{2max} (mean ± SD), $RER = 1.10 \pm 0.10$, and heart rate = $91 \pm 3\%$ maximum (based on maximum treadmill data). Firefighters stopped climbing on consuming 55% of the air cylinder then descended. In the fifth floor search and rescue VO_2 was slightly lower than stair climbing but RER remained elevated (1.13 ± 0.12) reflecting high anaerobic metabolism. The first low air alarm sounded, indicating 25% of the air remaining in a "30-min cylinder", during the stair climb at 8 min with 19 of 36 sounding before 12 min. Aggressive air management strategies are required for safety in high-rise firefighting.

1. Introduction

Firefighters will encounter emergency situations in high-rise buildings in which it is necessary to enter the fire while breathing from their self-contained breathing apparatus (SCBA), climb several flights of stairs, perform fire suppression or emergency search and rescue operations and then safely exit the building. To date, only one study has actually measured oxygen uptake (VO_2) directly while breathing through the SCBA but they did not report on air consumption for different tasks (Sothmann et al., 1991) and the data were not able to inform on an air management strategy. Other recent studies of firefighters (Bilzon et al., 2001; Holmér and Gavhed, 2007; von Heimburg et al., 2006) replaced the SCBA with a portable metabolic measurement system and observed rates of air consumption that exceed by 2–3 fold the nominal 40 l/min the National Institute for Occupational Safety and Health (NIOSH) standards for designating air cylinder volumes (e.g. "30-min" cylinder).

It is well known that the demands of firefighting are strenuous (Bilzon et al., 2001; Gledhill and Jamnik, 1992; Holmér and Gavhed, 2007; Lemon and Hermiston, 1977; Romet and Frim, 1987; Sothmann et al., 1991; von Heimburg et al., 2006). Further, within the firefighting profession it is recognized that the actual duration for work while wearing an SCBA could be considerably less than the nominal values and time for a safe exit is limited after the low air alarm sounds (Bernzweig, 2004).

We undertook the current study to obtain quantitative data from professional firefighters who first performed laboratory testing of fitness then completed two different high-rise emergency simulations while breathing from their SCBA. We selected stair climb while carrying a pack with two lengths of hose as a task that might be performed under extreme conditions that could be encountered if elevators were inoperative. Firefighters climbed to 55% of their air supply then dropped the high-rise pack and descended the stairs to an exit on the ground floor. In the second scenario we had firefighters climb five floors then perform a search and rescue. Based on recent observations by von Heimburg et al. (2006), we anticipated that experienced firefighters might perform the search and rescue more quickly and that they would use less air from their SCBA cylinder.

2. Methods

2.1. Subjects

Thirty-three men and three women (age from 30 to 53 years, mean 40.7 ± 6.6 years, with 0.5–30 years of service, mean 12.0 ± 8.5 years) were recruited from the Toronto Fire Services. This research was approved by the Office of Research Ethics at the University of Waterloo, informed written consent was obtained

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prior to participation in the study, and each person was informed that he or she could withdraw from the study at any time without penalty.

2.2. Materials and methods

During the maximal treadmill tests and simulated firefighting scenarios, breath-by-breath pulmonary gas exchange and heart rate were measured using the Cosmed K4b^2 portable metabolic system (Cosmed, Italy). Prior to each test, the O_2 and CO_2 gas analyzers were calibrated using a precision-analyzed gas mixture. The volume flowmeter was calibrated using a 3.0 L hand-pumped syringe. Heart rate was recorded during the tests using the Polar monitoring system. For the simulated firefighting scenarios the Cosmed K4b^2 was integrated with a Mine Safety Appliances (MSA™) SCBA system. There were no modifications to the inspired side of the SCBA, a small gas sample line was introduced through the voice box to a position close to the mouth, and a *t*-shaped adapter was placed on the expired port from the SCBA. This *t*-shaped adapter allowed the volume turbine of the Cosmed system to be placed so that it did not interfere with normal activities and volume was measured accurately. Volume measurements agreed within ±1% between the volume turbine and the change in weight of the air cylinder. VO_2 values were compared with a mechanical calibrator and shown to be accurate within ±4%.

2.3. Experimental design

Testing was conducted on 2 separate days, 1 day for the maximal treadmill test and predictive muscular strength and endurance tests, and the other for the simulated firefighting scenarios. A minimum of 2 h separated the two randomly ordered firefighting scenarios to minimize carryover effects.

An incremental exercise test was conducted on a motorized treadmill (Quinton, Washington) to determine VO_{2max}. Following a 4 min warm-up at a brisk walking pace, speed was increased 1.6 km/h every 2 min until a comfortable running speed was reached and this was followed by 2% increases in grade every 2 min. The test was terminated when participants were unable to continue and reached volitional fatigue. VO_{2max} was taken as the highest 20-s average during the final minute.

Muscular strength measures were obtained using a predictive one-repetition maximum (1-RM), as previously described (Kraemer and Fry, 2006):

$$\text{Predicted } 1-\text{RM} = \text{Load Lifted}/(1 - 0.025*\text{reps})$$

Subjects completed a warm-up of five repetitions with a load ~40% of their 1-RM. After a 1 min rest period, they performed a maximal effort with a load predicted to cause fatigue in fewer than 10 repetitions (Kraemer and Fry, 2006). A 3–5 min rest period preceded the next 1-RM test. The order of muscle testing was: maximal handgrip dynamometer (Takei Co. Ltd., Tokyo, Japan), flat bench press, seated 45° incline leg press, military shoulder press, and standing bicep curls. Upper body endurance was assessed with a bench press of 30 kg at 30 repetitions/min. Lower body endurance was measured with an absolute load of 123 kg on the incline leg press at a cadence of 25 repetitions/min. Subjects were required to lift the load until they were unable to maintain cadence.

2.4. Firefighting scenarios

Two different high-rise scenarios were developed through discussions with training officers, Commanders, and District Chiefs within the Toronto Fire Services. One was designed to determine physiological responses and air demands during a "maximal" stair climb, and the second was developed as a typical search and rescue operation. The firefighters performed the tasks singly to allow for completion of the tasks at the pace self-selected to be their normal work effort. During both scenarios, subjects wore full personal protective equipment (PPE, bunker pants and jacket, flash hood, gloves, helmet, and boots) that weighed approximately 9.2 kg and integrated Cosmed K4b^2-SCBA system (weight 9.5 kg). Prior to each test subjects stood for 2 min while breathing room air through the SCBA facemask to collect pre-exercise data. All testing took place in Toronto City Hall which had a total of 23 floors for a vertical climb of 73.14 m.

The high-rise stair climb scenario was implemented to determine the total number of flights of stairs firefighters were capable of climbing, while carrying an additional 18 kg high-rise pack (consisting of two 38 mm hose bundles). Vertical ascent was terminated when firefighters had consumed 55% of the air in their cylinder allowing 20% for exit before their low air alarm sounded, or on reaching the top (23rd) floor. At the point of 55% depletion, the subjects were requested to drop the high-rise pack and descend the stairs in order to achieve a safe exit. The SCBA cylinders were filled each day using the standard protocol for the fire services with actual pressure averaging ~4300 psi. The testing was based on depleting 55% of this constant pressure. Prior to each test the gauge reading of each cylinder was determined and 55% of 4300 was subtracted to give the actual pressure at turn around. A research assistant walked with the firefighter to time progress and to monitor the pressure gauge and signal the turn around point. Eight firefighters reached the 23rd floor turnaround point without depleting 55% of the cylinder air.

The fifth floor search and rescue scenario was implemented to simulate an actual fire scenario in a high-rise structure. Firefighters were requested to complete the following protocol:

1. Ascend five stories while carrying an additional 18 kg high-rise pack. Five stories were chosen as this is normally the maximum number of floors climbed without the use of an elevator in a high-rise structure.
2. On arriving at the fifth floor, the firefighter dropped the high-rise pack and crawled on hands and knees in order to advance an uncharged 38 mm hose line a distance of 18.3 m. At intervals throughout the hose advance each firefighter completed three separate room searches (average area 15.6 m^2) that simulated a scan for a victim.
3. After the search, the firefighter used a sledge hammer to hit a forcible entry simulator in order to breach a door (simulator set to a resistance between 700 and 800 psi [4826–5516 kN/m^2], requiring at least four solid strikes).
4. Enter the room and rescue a 75 kg mannequin a distance of 23 m back to the stairwell.
5. Descend five stories in order to achieve a safe exit.

For both high-rise scenarios, each firefighter was requested to perform at a work rate that he or she would utilize at a typical fire scene.

2.5. Data analysis and statistics

For the high-rise stair climb scenario, performance time was recorded for each flight that was completed by the firefighter. During the fifth floor high-rise scenario, performance time was recorded for individual tasks separately. Breath-by-breath gas exchange variables were averaged for V_E, VO_2, VCO_2, RER, and HR to obtain single values for each stage of testing with the exception of the five floor stair climb in the search and rescue task where the

final 25 s was taken as representative of the demands. Data are presented as both the individual responses and as the mean and standard deviation (SD). Comparisons between phases of the tasks were made by repeated measures ANOVA using SigmaStat 3.1. Regressions were performed to determine the relationship between experience and air consumption and total time during the fifth floor scenario.

3. Results

3.1. Anthropometric and maximal exercise testing

Anthropometric data and results from the maximal treadmill test are depicted in Table 1. Data from the one-repetition maximal strength tests and muscular endurance tests are displayed in Table 2. The firefighters' average age and years of service in the present study were similar to the statistics obtained for individuals with the rank of firefighter within the City of Toronto Fire Services (41.5 years of age and 13.2 years of service) and the proportion of women was approximately the same as in the Fire Services.

3.2. High-rise stair climb scenario

The average duration of the stair climb plus descent was 10:22 (min:s) with a range from 8:14 to 14:11. Average number of floors climbed while consuming 55% of a typical air cylinder was 20 ± 2.5 flights (range 14.5–23 flights, six men and two women were turned around on reaching the maximum number of floors). The individual subject values for V_E, VO_2 and RER are shown in Fig. 1. Each of V_E, VO_2, and HR increased rapidly over the first five to six floors of the stair climb then reached relatively stable levels until the turn around point and decreased slightly during the descent (Figs. 1 and 2). There were considerable between subject variations in response but the individual subject values that were relatively constant after the 6th floor coincided with the sustained lower velocity after an initial rapid ascent (Fig. 3). Mean V_E during the stair climb was 85.3 l/min (range 56.8–113.6 l/min). Mean VO_2 after passing the fifth floor in the stair climb was 3165 ± 518 ml/min (range 2015–4249 ml/min) which correspond to 38.3 ± 5.2 ml/kg per min (range 25.2–47.0 ml/kg per min) and 75 ± 8% VO_{2max} (range 58–91% VO_{2max}). Mean VCO_2 was 3777 ± 664 ml/min (range 2320–4889 ml/min). Mean respiratory exchange ratio for the stair climb was 1.10 ± 0.10 (range 0.92–1.39). Heart rate averaged 91 ± 3% HR_{max} (range 83–96%).

The descent portion of the scenario required a mean VO_2 of 2482 ± 480 ml/min, corresponding to 27.6 ± 4.4 ml/kg per min and 54 ± 9% VO_{2max}, mean VCO_2 of 2755 ± 594 ml/min, and RER of 1.11 ± 0.10. The heart rate response decreased slightly to 85 ± 5% HR_{max}, but indicates that even during an average descent duration of 3:53 (min:s) (range 2:29–5:30), cardiorespiratory responses remained elevated.

3.3. Fifth floor search and rescue scenario

The fifth floor high-rise scenario required an average completion time of 5:27 ± 1:01 (min:s), with a range from 4:11 to 9:38. Taken across the full fifth floor scenario expired ventilation averaged 90.7 ± 14.6 l/min (61.6–118.5 l/min, Fig. 4), with a mean VO_2 of 3015 ± 469 ml/min (2213–4118 ml/min), corresponding to 34.1 ml/kg per min (range 23.2–41.7 ml/kg per min, Fig. 4). VCO_2 of 3385 ± 528 ml/min (range 2216–4217 ml/min), RER of 1.13 ± 0.12 (range 0.94–1.29, Fig. 4), and HR of 160 ± 13 bpm (range 127–189 bpm). The fifth floor scenario required 67 ± 10% VO_{2max} (range 46–87%) and 88 ± 5% HR_{max} (range 80–94%) (Fig. 5).

The VO_2 was significantly greater during the five floor stair climb compared to any of the tasks after the first room search ($p < 0.05$). VO_2 increased significantly during the victim rescue task compared to the hose drag and forcible entry tasks that preceded it ($p < 0.05$). The heart rate response continued to increase after the stair climb into the first room search before declining then increasing again during the victim rescue ($p < 0.05$).

3.4. Air management

The air consumption as a percentage of the nominal "30-min" cylinder is shown as a function of time for each individual in Fig. 6 during the stair climb (Fig. 6A) and search and rescue scenario (Fig. 6B). Mean air consumption during the stair climbing scenario that required from 8:14 to 14:11 min:s was 71% of the cylinder, with a range from 55 to 81%. Of the 36 firefighters studied 19 (53%) had their low air alarm activated indicating less than 25% of their air remaining prior to achieving a safe exit. On reaching a relatively constant level of ventilation between the fifth and 14th floors the average air consumption for the entire group was 2.4% of the air cylinder per floor, with the maximum individual value 3.5% and the minimum level 1.6% per floor of high-rise climbed.

In comparison during the fifth floor scenario that was completed in 4:11 to 9:38 min:s average air consumption was 37% of the air cylinder, with a range from 24 to 50%. Air consumption for the individual components of the task was determined as the group average along with minimum and maximum. The five floor stair climb carrying the high-rise pack with two lengths of hose from a standing start required 6.5% (4% minimum, 10% maximum). The hose drag (total distance 18.3 m) plus three room search (average surface area per room 15.6 m^2) required an average of 17% of the air cylinder (10% minimum, 29% maximum). The forcible entry required an average of 1.4% (0.7% minimum, 3.4% maximum). The rescue of the 75 kg mannequin a distance of 23 m required an average of 5.8% of the air cylinder (2.8% minimum, 7.3% maximum). Finally, descent of the five floors to the safe exit required an average of 6% of the air cylinder (4% minimum, 10% maximum).

To test whether age or experience had any relationship to speed of completing the fifth floor scenario or to air consumption during the tasks, Pearson product-moment correlations were calculated. Time to complete the search and rescue scenario was positively related to age ($r = 0.47$, $P = 0.005$) and to years of experience ($r = 0.47$, $P = 0.009$) suggesting slower times in older, more experienced firefighters. Completion time was not related to body mass ($r = -0.09$, $P = 0.61$). Total air consumption increased with age ($r = 0.61$, $P < 0.001$), with years of experience as a firefighter ($r = 0.47$, $P = 0.004$), and was positively correlated with body mass ($r = 0.36$, $P = 0.03$).

Table 1
Anthropometric and maximal treadmill test data for all firefighters.

Age (years)	Service (years)	Height (m)	Body mass (kg)	V_E (l/min)	VO_2 (ml/min)	VO_2 (ml/kg per min)	VCO_2 (ml/min)	RER	HR (bpm)
40.7 ± 6.6	12 ± 8.5	178.3 ± 6.4	87.5 ± 12.2	144.8 ± 22.0	4470 ± 696	51.4 ± 6.5	4455 ± 590	1.01 ± 0.10	183 ± 9

Data are presented as mean ± SD.

Table 2
Data from the predicted one-repetition maximal strength testing and muscular endurance tests.

Predicted 1-RM					Muscular endurance	
Handgrip (kg)	Bench press (kg)	Shoulder press (kg)	Biceps curls (kg)	Leg press (kg)	Leg press (reps)	Bench press (reps)
56.5 ± 7.9	94.6 ± 27.6	66.3 ± 14.8	43.8 ± 8.5	349.4 ± 70.3	52.0 ± 34.7	41.8 ± 14.3

Data are presented as mean ± SD.

4. Discussion

This study provides new information to assist in planning strategies for air management by professional firefighters performing tasks in a high-rise structure while breathing from their SCBA. Previous research has reported either VO_2 but no air consumption information while breathing through the SCBA (Sothmann et al., 1991) or VO_2 and V_E but not while breathing through the SCBA (Bilzon et al., 2001; Holmér and Gavhed, 2007; von Heimburg et al., 2006). Our data showed the anticipated high VO_2 and heart rate for both high-rise scenarios. In addition, we report for the first time the markedly elevated VCO_2 during high-rise tasks, which provides through the respiratory exchange ratio insight into the magnitude of lactic acid production and the contribution of anaerobic metabolism to energy supply. As well, we have the important applied observation during the high-rise stair climb that 53% of firefighters had their low air alarms sound in 8–12 min on their so-called "30-min" air cylinders before they reached a safe exit from the stairs. Further, linear extrapolation of the rate of air consumption during the fifth floor search and rescue suggested that the low air alarm could be activated in as little as 9 min. Thus, high-rise tasks performed at work rates self-selected by professional firefighters as typical of their normal activities clearly demonstrate the need for aggressive air management strategies to ensure the health and safety of all firefighters.

4.1. High-rise stair climb scenario

Rationale for performing the stair climb scenario can be found in the fire in the 45 storey LaSalle Bank Building December 6, 2004 in which firefighters had to climb up to 14 floors while breathing from their SCBA. Smoke inhalation due to exhausting the air supply was responsible for many of the 23 injuries. In our study we arbitrarily set the turn around point for stair climbing with the 18 kg high-rise pack to be at 55% air consumption. The lowest turn around point was 14.5 floors and eight (six men, two women) of 36 individuals reached the top 23rd floor before turning around. Under these conditions, 19 of 36 firefighters had their low air alarm sound before reaching the exit (Fig. 6A).

After starting from a standing position the VO_2 and heart rate increased rapidly during the first five floors of the high-rise stair climb as expected with the onset of heavy work (Hughson et al., 2000;

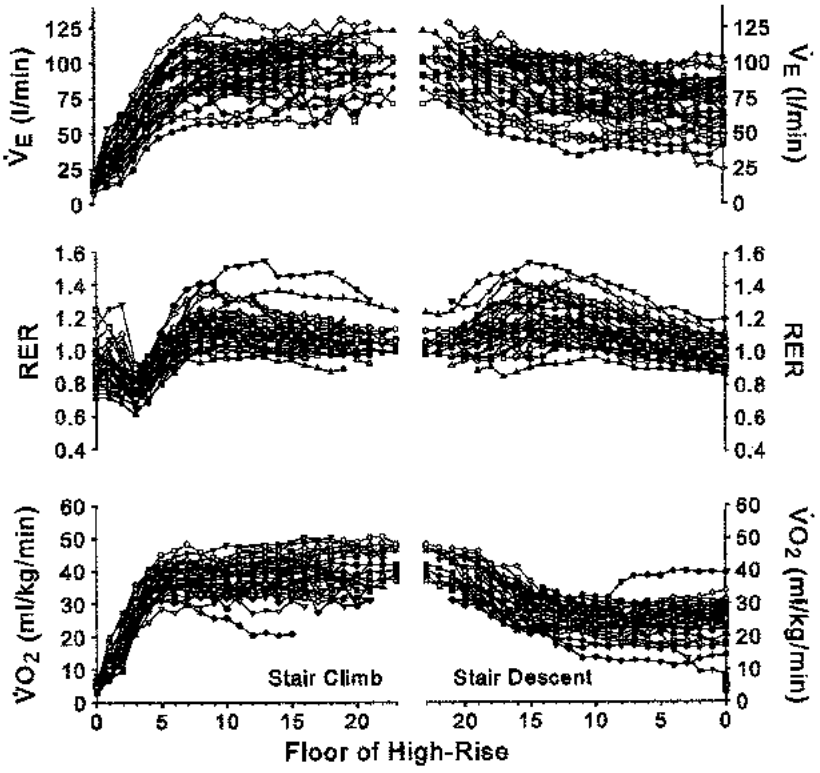

Fig. 1. Individual firefighter data are shown for expired ventilation (V_E), respiratory gas exchange ratio ($RER = VCO_2/VO_2$), and relative oxygen uptake (VO_2, ml/kg per min) during the stair climbing task with extra weight of two hose lengths in a high rise pack. Firefighters turned around when their SCBA was reduced to 55% of its volume or when they reached the top 23rd floor. Firefighters who stopped before the maximum 23rd floor have their first data point during descent at the floor below where they stopped.

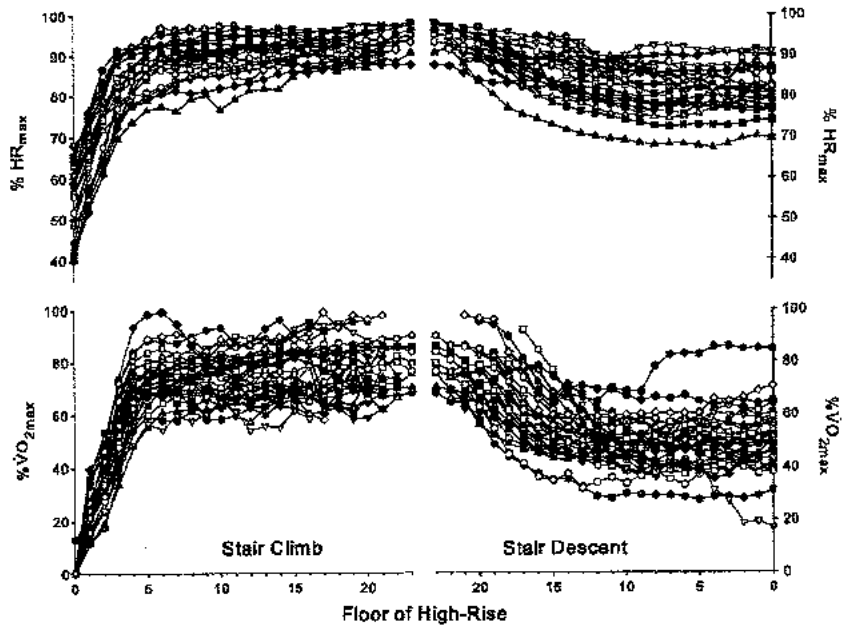

Fig. 2. Individual firefighter data are shown for heart rate and oxygen uptake as percentage of the maximum value observed during treadmill exercise (HR_{max} and VO_{2max}, respectively) during the stair climbing task with extra weight of two hose lengths in a high-rise pack. Firefighters turned around when their SCBA was reduced to 55% of its volume or when they reached the top 23rd floor. Firefighters who stopped before the maximum 23rd floor have their first data point during descent at the floor below where they stopped.

Tordi et al., 2003) such as stair climbing while carrying additional weight (Manning and Griggs, 1983; O'Connell et al., 1986; von Heimburg et al., 2006). The firefighters in our study began climbing at a rate of 0.31 ± 0.05 m/s and slowed to 0.20 ± 0.05 m/s by the fifth floor. This was similar to other studies in which the average velocity was 0.23 m/s over six floors (von Heimburg et al., 2006), step mill climbing was completed at 0.20 m/s for 5-min (O'Connell et al., 1986).

Beyond the sixth floor the firefighters in our study slowed a bit more to a velocity of 0.16 ± 0.05 m/s at the 15th floor but in spite of this their VO_2 (38 ml/kg per min, 75% VO_{2max}) and heart rate (91% of maximum) remained elevated until the turn around point. During the descent portion of the scenario oxygen requirements decreased to approximately 28 ml/kg per min or 54% VO_{2max}, while heart rate remained high at 86% of maximum. The rate of stair descent varied considerably between individuals probably reflecting several factors including fatigue.

The plot of RER reveals a range of responses while standing on the ground floor that reflects variable levels of normal versus hyperventilation that caused RER to be elevated in some individuals. On starting to climb the stairs, there was an initial decrease reflecting a brief lag for the increase in VCO_2 relative to VO_2 as CO_2 was stored in the tissues and blood (Hughson and Inman, 1985). However, by the eighth floor RER exceeded 1.0 in the majority of subjects, with a group mean of 1.10. This high level of RER would not be expected if these individuals were exercising at the same relative VO_2 (75% VO_{2max}) on a cycle ergometer or walking on a treadmill (Linnarsson, 1974). RER would be expected to increase above 1.0 only when VO_2 exceeded ~90% VO_{2max} (Perrey et al., 2003; Tordi et al., 2003). The sustained

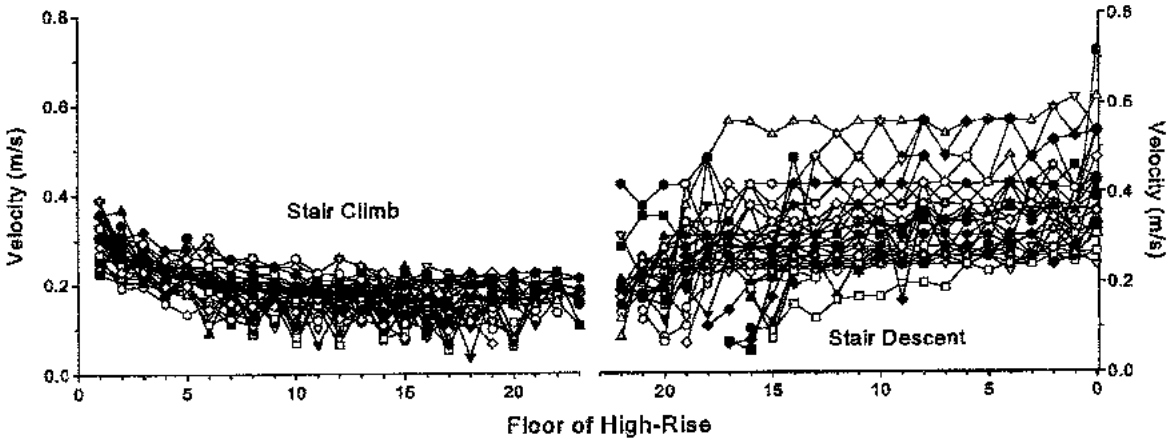

Fig. 3. Individual firefighter values are shown for the absolute vertical velocity during the stair climb (left side) and stair descent (right side). Firefighters who stopped before the maximum 23rd floor have their first data point during descent at the floor below where they stopped.

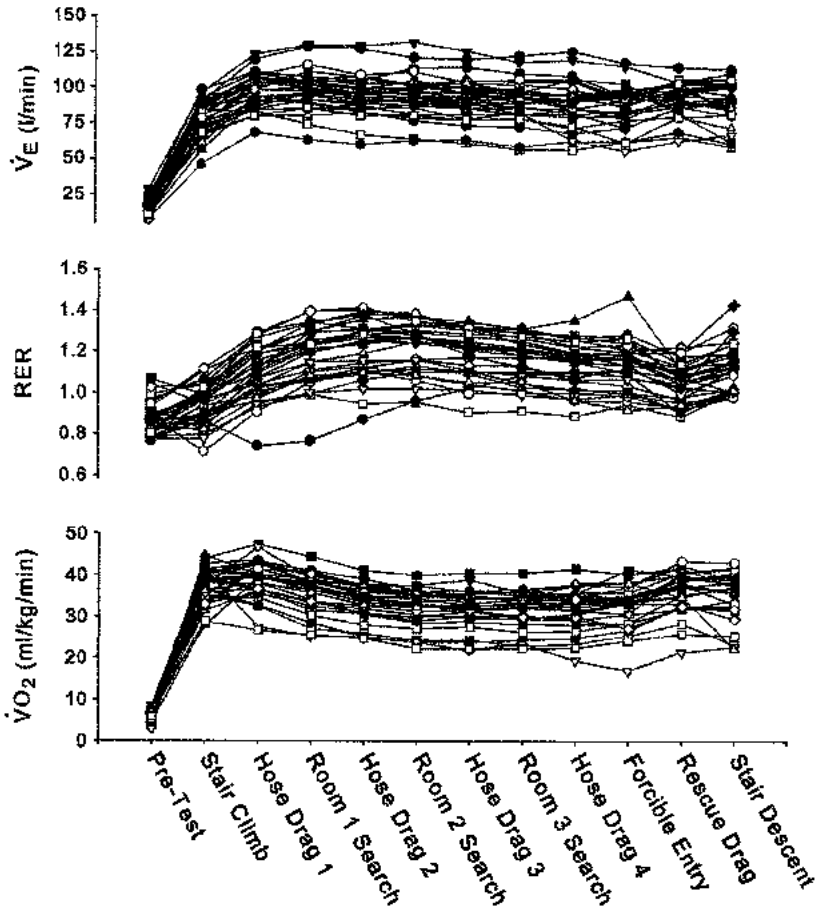

Fig. 4. Expired ventilation (V_E), respiratory gas exchange (RER = VCO_2/VO_2), and relative oxygen uptake (VO_2, ml/kg per min) during the fifth floor search and rescue simulation. Individual subjects are shown with separate symbols and lines for each of the individual tasks. Values during stair climbing are from the final 20 s of the five floor climb, the floor-by-floor responses were very similar to those presented in Fig. 1. Firefighters crawled and dragged a hose to three separate rooms where they conducted a search before reaching the forcible entry simulator, rescuing a 75 kg "victim" and descending five floors to a safe exit.

high RER reflects an important difference between firefighting and typical aerobic exercises. We speculate that high levels of muscle tension required to lift not only body mass but the weight of the personal protective gear plus the 18 kg high-rise pack impaired muscle blood flow and oxygen delivery causing increased reliance on anaerobic metabolism. The small increase in RER as the firefighters descended the stairs probably reflects some CO_2 coming out of body stores at the relatively lower work rate of descent versus ascent.

4.2. Fifth floor scenario

The fifth floor high-rise scenario was selected as representative of fire suppression and victim search and rescue situations encountered by most firefighters. Standard operating procedures for this fire service require firefighters to walk up to the fire if the climb is five floors or less. This scenario which lasted 5:27 ± 1:01 (min:s) with a range from 4:11 to 9:38, was rated as 7.9 ± 1.0 out of 10 when the firefighters were asked on completion of the task how they would "rate the simulation in comparison to actual fire scene activities?" This rating was relatively high in spite of the fact that the simulations were performed without smoke or visual obstruction.

This research is the first to report full details of respiratory gas exchange during search and rescue tasks while breathing through an SCBA. Sothmann et al. (1991) measured VO_2 and HR from a system integrated with the SCBA; however, that system was technically limited because it measured only ventilation and O_2 with an assumption that RER = 1.0 which could lead to non-trivial errors under extreme conditions. Recent research has utilized portable gas exchange measurement systems during performance of simulations of firefighting activities but did not integrate the systems with the SCBA (Bilzon et al., 2001; Holmér and Gavhed, 2007; von Heimburg et al., 2006), while older studies collected gas in bags for later analysis (Gledhill and Jamnik, 1992; Lemon and Hermiston, 1977). Given observations of the impact of breathing through the SCBA on exercise performance with possible alterations in the pattern of breathing and reductions in VO_{2max} (Donovan and McConnell, 1999; Dreger et al., 2006; Louhevaara et al., 1985) our data provide new insight into the physiological stress of firefighting under conditions that replicate as closely as possible the actual breathing situation encountered.

Based on data from von Heimburg et al. (2006), we anticipated that larger and more experienced firefighters might perform the tasks more quickly and use less air. We found the opposite that the older more experienced and heavier firefighters consumed more total air from their cylinders during the fifth floor search and rescue task. There was wide variation between individuals but perhaps

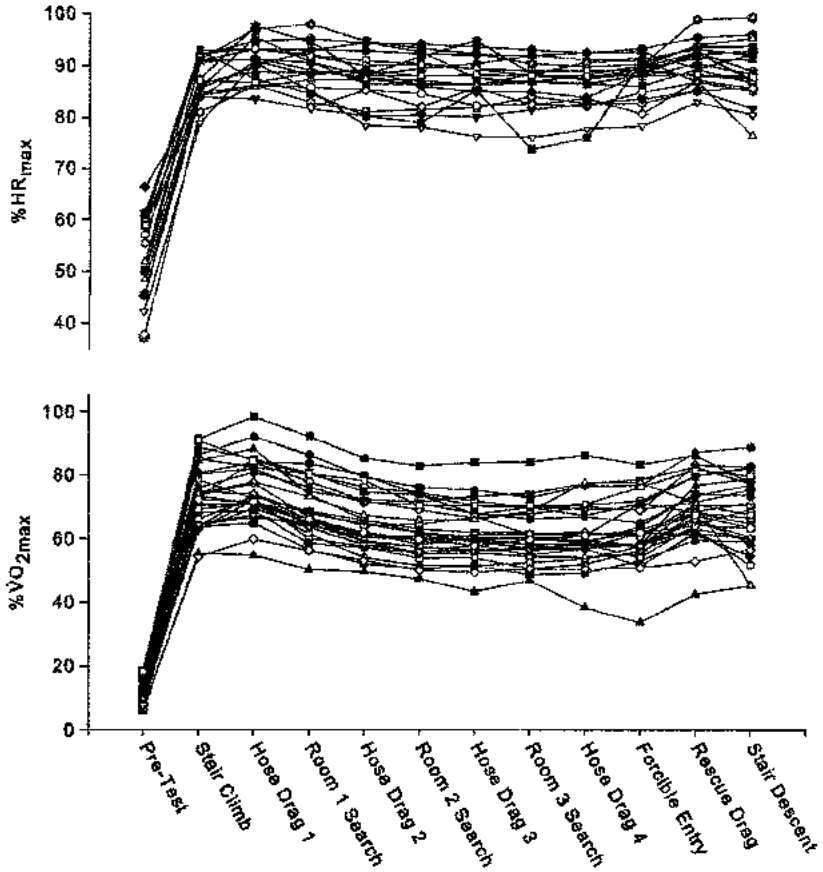

Fig. 5. Individual firefighter data are shown for heart rate and oxygen uptake as percentage of the maximum value observed during treadmill exercise (HR_{max} and VO_{2max}, respectively) during the fifth floor search and rescue simulation. Individual subjects are shown with separate symbols and lines for each of the individual tasks. Values during stair climbing are from the final 20 s of the five floor climb. Firefighters crawled and dragged a hose to three separate rooms where they conducted a search before reaching the forcible entry simulator, rescuing a 75 kg "victim" and descending five floors to a safe exit.

more importantly our firefighters worked at their own pace and the older firefighters who took somewhat longer to complete the tasks might have been more thorough in their room searches. In contrast, von Heimburg et al. asked their firefighters to perform the task as quickly as possible. The overall physical characteristics including VO_{2max}, body mass and upper body strength measurements were similar between these two studies, while the difference in leg press strength reflects different equipment.

The relatively long period of advancing a hose and searching while crawling on hands and knees is a typical task in a high-rise structure fire, but previous research has not isolated this activity. Holmér and Gavhed (Holmér and Gavhed, 2007) mention crawling as part of one task but give no specific data. The energy cost of the crawling search technique was high with VO_2 between approximately 47–82% VO_{2max}. Importantly, the level of ventilation sustained during this crawling activity was very high ranging from 63 to 131 l/min while the firefighters were in the second room. Although we did not measure maximal exercise capability in these individuals while wearing the SCBA, previous findings by Louhevaara et al. (1985) and recent results from Dreger et al. (2006) showed limitations in V_E and VO_2 while wearing the SCBA. Dreger et al. (2006) reported a 17.3% reduction in VO_{2max} from 52.4 to 43.0 ml/kg per min due in part to a 14.5% reduction in peak ventilation from 167 to 143 l/min while breathing from the SCBA. There are major implications for the work of breathing and possible ventilatory limitations during the current study especially considering the crawling position in which the arms and back were used to support movement. It might be anticipated that this could further restrict ventilation while wearing the SCBA. Future research is required to quantify the impact of body position as well as breathing from the SCBA on peak V_E and VO_2 to put the measured values during the high-rise scenario into perspective.

The data on RER measured throughout a simulated work task by firefighters breathing from an SCBA provide unique insight into metabolic demands. The only previous study to report RER during firefighting tasks by Lemon and Herniston (1977) were confined to observations of very brief work periods (30–90 s) so the RER values were low and appeared unimportant. RER during treadmill testing while breathing through the SCBA was reduced (Louhevaara et al., 1985) or unchanged (Dreger et al., 2006), so it does not appear that the SCBA per se was responsible for the high values. Rather, the sustained increased RER reflected a major contribution to energy supply by anaerobic metabolism as considered in more detail in the next section.

4.3. Air management for firefighters

The duration of the search and rescue scenario was relatively brief (from 4:11 to 9:38 min:s for the individual firefighters). As a consequence, average air consumption was only 37% of the

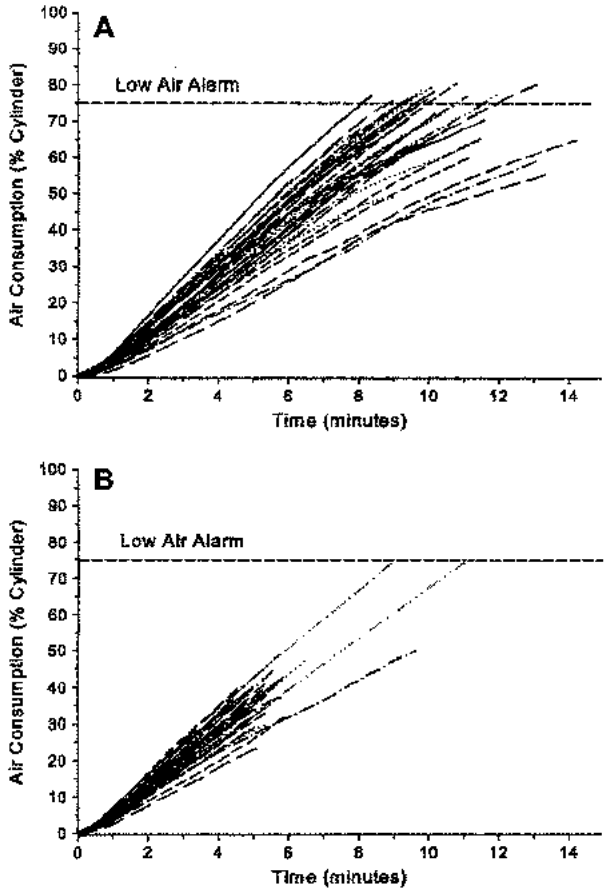

Fig. 6. Individual firefighter air consumptions are shown as a % of the cylinder volume for a standard "30-min" cylinder during the stair climb with added weight of high-rise pack (A) and during the fifth floor search and rescue task (B). In the stair climb (A), 19 of 36 firefighters consumed greater than 75% of the air in their cylinders and had their low air alarms sound. In the fifth floor search and rescue, the task duration was sufficiently short that no firefighter had his/her low air alarm sound. However, the gray lines in B show that at the existing rate of air consumption the low air alarm could have sounded as early as 9 min (dash single dot line) or approximately 11 min (dash double dot line) for the group average.

cylinder (range from 25 to 51%) and no low air alarms were activated. However, Fig. 6B shows with two gray lines added as linear extrapolations of the air consumption what might have happened if the firefighters had been required to continue to search more rooms before finding the victim. The line to the left (dash, single dot) is an extrapolation of firefighters who used air at the highest rates. For these individuals, it was predicted that the low air alarm could sound in 9 min. The other gray line (dash, double dot) is an extrapolation based on the average rate of air consumption. This line predicts that 50% of firefighters would have had their low air alarm activated if they had continued to work to a total time of 11 min.

It is important to recognize that the extrapolations presented in Fig. 6B are simply predictions based on a linear model of air consumption. Indeed, it is unknown if the firefighters would have been able to sustain the level of activity required to demand ventilation at the measured rate. However, the data on air consumption taken together with the measured metabolic requirements of the search and rescue can be utilized to consider a frequently asked question in the fire services as to whether firefighters should use a larger cylinder to increase the level of safety? The current data and other recent evidence argue strongly against this practice.

The energy demands of firefighting have been described for many years as approximately 60–70% VO_{2max} and our data are consistent with this in firefighters who are breathing through their SCBA. However, if the data of Dreger et al. (2006) can be extrapolated to all SCBA systems then it is likely that the value normally taken to be 100% VO_{2max} (from treadmill VO_{2max} with standard laboratory equipment) should be reduced by ~17% due to the impact of breathing through the SCBA. This would increase the relative intensity of work when expressed as a percentage of VO_{2max} (in the current case to about 76% from 62% during the search of the second room). Yet, even at 76% VO_{2max}, we would not anticipate a major anaerobic contribution to energy supply as reflected by the high RER. The consistent excess CO_2 output during this scenario must reflect a large net accumulation of lactic acid. We can calculate based on the average values of VO_2 (~3000 ml/min), a work duration of 5.5 min and the RER of 1.13 that the body produced at total of 1950 ml of excess CO_2 which reflects the depletion of bicarbonate (87 mmol) as a buffer of an equivalent amount of hydrogen ion dissociated from lactic acid. This calculation gives an estimated increase in blood lactate concentration similar to the 13 mmol/l measured by von Heimburg (2006) after stair climbing and victim rescue. It is probable that climbing stairs with the added weight of the high-rise pack and the personal protective gear in addition to activities such as crawling, forcible entry and victim drag caused sustained high levels of muscle tension that restricted blood flow forcing the muscles to produce more lactate.

Our data reflecting the extremely strenuous nature of firefighting suggest that any attempt to have firefighters work longer by supplying larger cylinders for the SCBA would simply result in greater levels of fatigue from which it would be extremely difficult to recover. It is well known that the maximum total high intensity work is accomplished by short periods of activity with rest intervals (Astrand and Rodahl, 1985). Therefore under conditions where firefighters perform active duty cycles at a fire scene, it is best to keep the work period relatively short for two key reasons. First, longer cycles will cause greater fatigue with increased likelihood of injury. Second, as we have demonstrated, individual firefighters can consume air at such a rate that their low air alarms are activated in less than 10-min. Firefighters should be safely out of emergency fire situations before their low air alarm sounds allowing for unexpected emergencies including the possible need for self-rescue (Bernzweig, 2004).

4.4. Limitations

A major limitation in the current study was that the activities were performed under non-emergency situations. There was no smoke nor was vision intentionally impaired by black out and there were no obstructions. It is impossible to predict how actual emergencies might alter the work rate and the physiological response to any given work rate. The firefighters were asked to perform the activities at their normal working pace. They might have performed a bit faster knowing that they were in a research project, and knowing the specific task might have prompted them to perform the task a bit faster because they anticipated the end point.

The current study was conducted on professional firefighters who volunteered to participate in the research project. Even though the study population reflected very well the average age, years of experience, and sex distribution in the City's Fire Service and they had similar physical characteristics to other study groups (von Heimburg et al., 2006), it is likely that we obtained a relatively fitter

population. It could be anticipated that less fit individuals would not volunteer for this study. Therefore, the current data should be used with some caution; it is possible that larger, less fit individuals might consume air at a greater rate than the study subjects. Approximately 10% of the firefighters in the City's Fire Service are women and we had three of 36 but it is not possible to extrapolate from this small sample size. The women were generally smaller than the average man but they successfully completed these tasks. Two of the eight firefighters who reached the 23rd floor in the stair climbing task that involved carrying an additional 18 kg hose pack in addition to the personal protective gear were women.

5. Conclusions

We observed in two high-rise firefighting simulations of continuous stair climbing plus exit and a fifth floor search and rescue task that individual firefighters could use air at a rate causing their low air alarms to sound in as little as 8:14 (min:s) and that approximately 50% of firefighters could have their alarms sound within 11–12 min when working at a rate they self-selected as their normal effort. We presented evidence based on the respiratory exchange ratio ($RER = VCO_2/VO_2$) that the intensity of the effort of firefighting is much greater than running or cycling exercise that has an equivalent VO_2. There is a major anaerobic energy contribution with strong evidence for large increases in blood lactate concentration. Our data on the high physical demands of firefighting in combination with our observations of the rapid utilization of the air supply in the SCBA cylinder point not to increasing the size of the air cylinder but to different strategies for air management. The terminology "30-min" cylinder is misleading and potentially dangerous. Instead, cylinders should be designated by their nominal volume (e.g. 1200 l). Knowledge of maximum rates of air consumption (in % of air cylinder or l/min) for specific tasks can enable incident commanders to develop strategies for air management to insure that firefighters can safely exit a burning structure before the sounding of their low air alarms.

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References

Astrand, P.-O., Rodahl, K., 1985. Textbook of Work Physiology. McGraw-Hill Book Co, New York.
Bernzweig, D., 2004. Expanding "time to exit" for firefighters. Fire Eng 157 (6), 63–74.
Bilzon, J.L.J., Scarpello, E.G., Smith, C.V., Ravenhill, N.A., Rayson, M.P., 2001. Characterization of the metabolic demands of simulated shipboard Royal Navy fire-fighting tasks. Ergonomics 44, 766–780.
Donovan, K.J., McConnell, A.K., 1999. Do fire-fighters develop specific ventilatory responses in order to cope with exercise whilst wearing self-contained breathing apparatus? Eur. J. Appl. Physiol. Occup. Physiol 80, 107–112.
Dreger, R.W., Jones, R.L., Petersen, S.R., 2006. Effects of the self-contained breathing apparatus and fire protective clothing on maximal oxygen uptake. Ergonomics 49, 911–920.
Gledhill, N., Jamnik, V.K., 1992. Characterization of the physical demands of firefighting. Can J. Sport Sci. 17, 207–213.
Holmér, I., Gavhed, D., 2007. Classification of metabolic and respiratory demands in fire fighting activity with extreme workloads. Appl. Ergonomics 38, 45–52.
Hughson, R.L., Inman, M.D., 1985. Gas exchange analysis of immediate CO_2 storage at onset of exercise. Resp. Physiol 59, 265–278.
Hughson, R.L., O'Leary, D.D., Betik, A.C., Hebestreit, H., 2000. Kinetics of oxygen uptake at the onset of exercise near or above peak oxygen uptake. J. Appl. Physiol 88, 1812–1819.
Kraemer, W.J., Fry, A.C., 2006. Strength testing: development and evaluation of methodology. In: Maud, P.J., Foster, C. (Eds.), Physiological Assessment and Human Fitness. Human Kinetics, Champaign, IL, pp. 115–138.
Lemon, P.W., Herniston, R.T., 1977. The human energy cost of fire fighting. J. Occup. Med 19, 558–562.
Linnarsson, D., 1974. Dynamics of pulmonary gas exchange and heart rate changes at start and end of exercise. Acta Physiol. Scand. Suppl. 415, 1–68.
Louhevaara, V., Smolander, J., Tuomi, T., Korhonen, O., Jaakkola, J., 1985. Effects of an SCBA on breathing pattern, gas exchange, and heart rate during exercise. J. Occup. Med 27, 213–216.
Manning, J.E., Griggs, T.R., 1983. Heart rates in fire fighters using light and heavy breathing equipment: similar near-maximal exertion in response to multiple work load conditions. J. Occup. Med 25, 215–218.
O'Connell, E.R., Thomas, P.C., Cady, L.D., Karwasky, R.J., 1986. Energy costs of simulated stair climbing as a job-related task in fire fighting. J. Occup. Med 28, 282–284.
Perrey, S., Candau, R., Rouillon, J.D., Hughson, R.L., 2003. The effect of prolonged submaximal exercise on gas exchange kinetics and ventilation during heavy exercise in humans. Eur. J. Appl. Physiol 89, 587–594.
Romet, T.T., Frim, J., 1987. Physiological responses to fire fighting activities. Eur. J. Appl. Physiol. Occup. Physiol 56, 633–638.
Sothmann, M., Saupe, K., Raven, P.B., Pawelczyk, J.P., Davis, P.O., Dotson, C.O., Landy, F., Silimas, M., 1991. Oxygen consumption during fire suppression: error of heart rate estimation. Ergonomics 34, 1469–1474.
Tordi, N., Perrey, S., Harvey, A., Hughson, R.L., 2003. Oxygen uptake kinetics during two bouts of heavy cycling separated by fatiguing sprint exercise in humans. J. Appl. Physiol 94, 533–541.
von Heimburg, E.D., Rasmussen, A.K., Medbo, J.I., 2006. Physiological responses of firefighters and performance predictors during a simulated rescue of hospital patients. Ergonomics 49, 111–126.

APPENDIX 2: CONSUMPTION TESTING

BREATHING APPARATUS TRAINING TECHNIQUES

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Cover Graphics:
Pat Monigold

Basic physiology tells us that different fire fighters will consume their air at different rates with many variables governing how much air they will use. In order to give each student some awareness as to how much air will be consumed, a comprehensive Consumption Testing Program is recommended.

The Consumption Testing Program involves a fire fighter working on an obstacle course and experimenting with breathing rates. The obstacle course is fixed and set. The fire fighter will work on the course once each day during the program. During laps throughout the course the fire fighter will experiment with different breathing rates and should determine an approximate use rate per minute when working at various rates. This allows the fire fighters to estimate the amount of time they personally can work in a fire situation. Care and emphasis should be placed on making the fire fighters aware that different factors in a fire situation will affect them differently than on the training ground. For instance, anxiety, high heat levels, high humidity levels and extreme stresses can all lead to increased air consumption during an actual fire.

A sample obstacle course is enclosed in this brochure, (See Appendix A, page 1 subheading INSTRUCTOR ACTIVITIES: CONSUMPTION TESTING.

1. Set up and check obstacle course. (Obstacle course must be the same each day the fire fighter works it.)

2. Break up teams. (One member on the course, other team member timing and recording.)

3. Set maximum number of fire fighters working on the course at one time. (6)

4. Remind fire fighters to either increase their work load or experiment with different breathing rates.

5. Be sure all fire fighters record their beginning pressure, their ending pressure, their beginning time, their ending time, the number of laps, and the station number they stopped at. (See Appendix A, page 2)

6. While fire fighters are on the course, record donning times. Note: Class averages can be taken. A sample completed class average is enclosed. (See Appendix A pages 3-4).

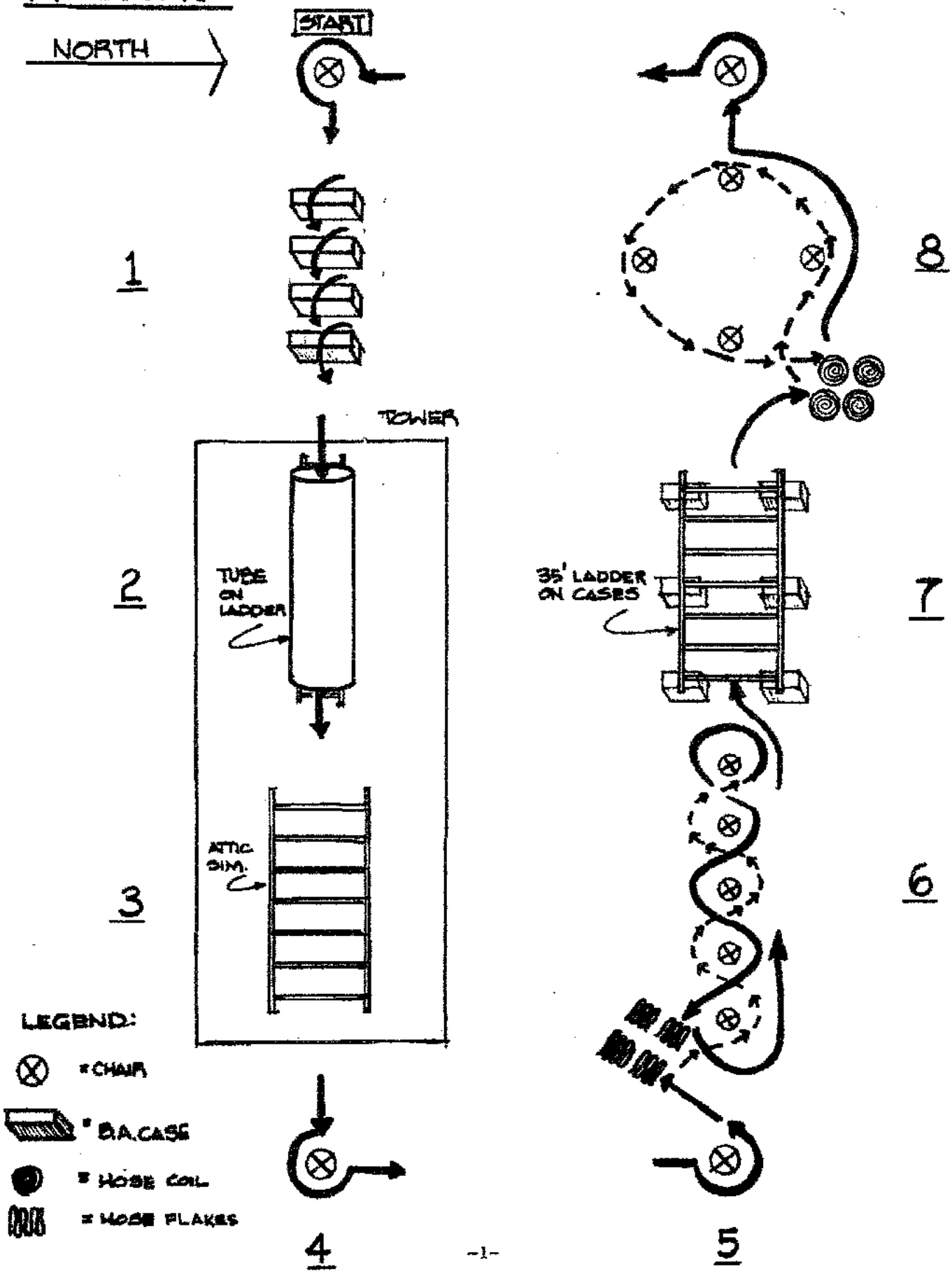
OBSTACLE COURSE PROCEDURE:

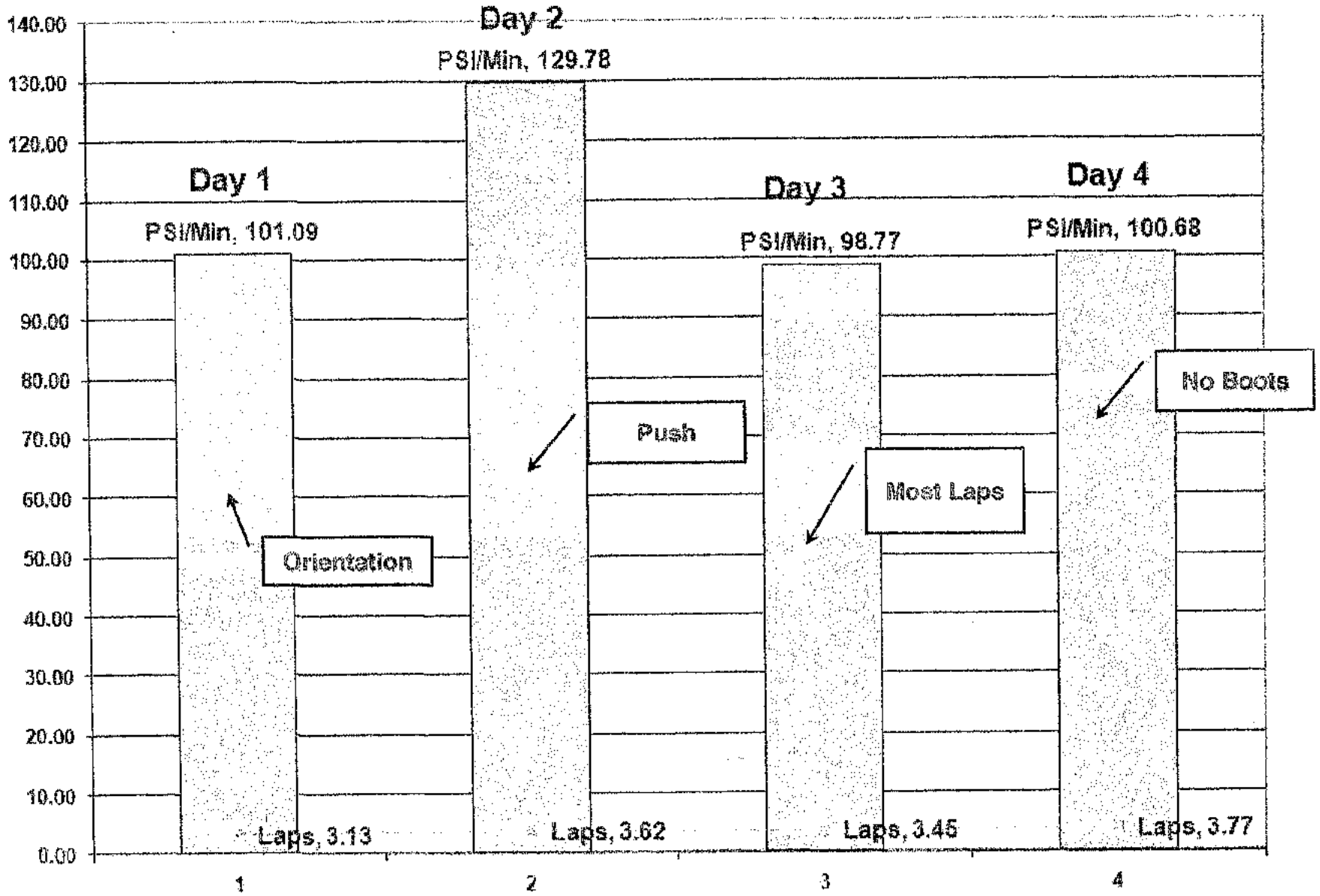
After the obstacle course has been set up, instructors will check the course to make sure it is identical to previously used courses. Instructors will then line the fire fighters up and make sure that the team leader and the team members are ready. Donning of the breathing apparatus will take place, and just prior to the beginning of the course pressures of the air in the tanks will be recorded. Upon a command of "start", the fire fighter will plug into the regulator and begin working on the course. At this time the time will be started. The fire fighter then will circumnavigate the course until the alarm bell goes off. Upon hearing the alarm bell, the fire fighter will step off the course, time will stop, and an ending pressure will be recorded. The fire fighter then records the number of laps completed around the course, and the station at which stopped. The following day, a different breathing strategy will be tried. This will have an effect on consumption rate, and will also have an effect on the number of laps completed. Ideally, the fire fighter is striving to find a breathing strategy which will allow completion of the most number of laps while using the fewest psi of air per minute.

These results can then be tabulated after some 5-10 trials to reach an average consumption rate. The averages of each fire fighter can then be put into a class average. Data from this will usually indicate that larger body-sized fire fighters will consume air at a higher rate.

Also at the University of Illinois, we like to have a drill to show fire fighters the effects of wearing protective equipment. During all of the previous drills, fire fighters were in full protective clothing with the boots in the "up" position or with bunkers on. One one day of the trials, or more if desired, fire fighters should be asked to navigate the course without any boots on, using just street shoes. This usually leads to significantly lower breathing apparatus consumption rates.

"A" COURSE


NORTH
START
1
TOWER
2
TUBE ON LADDER
3
ATTIC SIM.
4
5
6
35' LADDER ON CASES
7
8
LEGEND:
= CHAIR
= B.A. CASE
= HOSE COIL
= HOSE FLAKES


Day 2
PSI/Min, 129.78
Day 1
PSI/Min, 101.09
Day 3
PSI/Min, 98.77
Day 4
PSI/Min, 100.68
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Push
No Boots
Most Laps
Orientation
Laps, 3.13
Laps, 3.62
Laps, 3.45
Laps, 3.77
1
2
3
4

APPENDIX 3: AUDIO TEST

CAT Order Master (54 sec) Orders given/received using: • *Unit Number* • *Location* • *Task* • *Crew count*	
Clear vs Out – Repetitive (7 sec) *Which is clearer when spoken thru and SCBA mask?*	
Corner-Comparison (42 sec) Note clarity of various corner phraseology.	
MAYDAY vs HELP (38 sec) *Which is clearer when spoken thru and SCBA mask?*	
Mayday-Help, firefighter #2 (5 sec) *Which is clearer when spoken thru and SCBA mask?*	
Side-1, 2, 3, 4 - A, B, C, D - Alpha, Bravo, Charlie, Delta (28 sec) *Which is clearer when spoken thru and SCBA mask?*	

APPENDIX 4: SURVEY RESULTS & BLANK SURVEY FORM

Rutledge – Survey Results

1. My company officer conducts pre-brief prior to building entry.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **2.62**

2. We always know our corner locations in heavy smoke.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **2.85**

3. Our workload was during structure fire(s) at least four.

Very Low	Low	Moderate	High	Very High

Comment: **2.92**

4. I had confidence in my unit leader during the incident.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.54**

5. Sometimes I did not know what was going on.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.14**

6. At times I felt like we were lost.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **2.69**

7. We clearly understood mask radio communications.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.07**

8. I understood instructions from my unit leader during the incident.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.46**

9. Our crew do accountability checks (PAR) every 5 minutes.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **2.21**

10. I felt command always knows exactly where we are in a building.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **1.62**

11. Our crew move freely from place to place within a building without telling command.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.08**

12. We always use PASS devices with confidence.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.07**

13. We need more training in events of this type.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **4.36**

14. I felt I performed very well at this incident.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.43**

15. My unit leader performed very well at this incident.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **3.31**

16. Normally I am comfortable working in smoke with SCBA.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment: **4.64**

Rutledge – Survey Results

17. This fire was unusually difficult due to smoke heat conditions.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 4.14

18. When we received orders we knew exactly what to do.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 3.08

19. After every incident our unit/company holds a de-brief.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 2.00

20. In fire operations our teams always conduct a de-brief.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 2.92

21. Some members of my unit are overly aggressive.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 3.00

22. Some members of my unit need more training.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 3.21

23. We changed our overhead for fire extension.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 3.31

24. In fire operations our teams always conducts a de-brief.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 3.29

25. We were very familiar with the building's pre-plan.

☐ Strongly Disagree	☐ Disagree	☐ Neutral	☐ Agree	☐ Strongly Agree

Comment: 1.29

1. My company officer conducts pre-brief prior to building entry.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

2. We always know our corner locations in heavy smoke.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

3. Our workgroup size during structure fires is at least four.

❑	❑	❑	❑	❑
Very Low	Low	Moderate	High	Very High

Comment:

4. I had confidence in my unit leader during the incident.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

5. Sometimes I did not know what was going on.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

6. At times I felt like we were lost.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

7. We clearly understood most radio communications.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

8. I understood instructions from my unit leader during the incident.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

9. Our units do accountability checks (PAR) every 5 minutes.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

10. I feel command always knows exactly where we are in a building.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

11. Our units move freely from place to place within a building without telling command.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

12. We always use PASS devices with confidence.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

13. We need more training in events of this type.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

14. I felt I performed very well at this incident.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

15. My unit leader performed very well at this incident.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

16. Normally I am comfortable working in smoke with SCBA.

❑	❑	❑	❑	❑
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Comment:

17. This fire was unusually difficult due to smoke heat conditions.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

18. When we received orders we knew exactly what to do.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

19. After every incident our unit/company holds a de-brief.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

20. In fire operations our teams always conduct a de-brief.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

21. Some members of my unit are overly *aggressive*.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

22. Some members of my unit need more training.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

23. We checked our overhead for fire extension.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

24. In fire operations our teams always conducts a de-brief.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

25. We were very familiar with the building's pre-plan.

❑ Strongly Disagree	❑ Disagree	❑ Neutral	❑ Agree	❑ Strongly Agree

Comment:

APPENDIX 5: SAMPLE CHECKLISTS

Sample Fire Service Checklists

By
Jack Rutledge
Peachtree City, GA
770-631-8824
jackrutledge@mindspring.com

Date: _____

Name: _____

TITLE **Hose**

OBJECTIVE Identifies, selects, rolls, packs and couples hose lines.

Firefighters will select various size hoses, remove them from the apparatus, demonstrate various hose rolls and coupling techniques, then repack all hose.

	Correct	Incorrect

Identify Various Hose Sizes

1. Identifies 1-3/4" Hose
2. Identifies 1-1/2" Hose
3. Identifies 3" Hose

Coupling/Spanner Operations

1. Identifies Higbee Indicator & Higbee Cut (Ess. pg. 342) (Time =)
2. Couples - Foot Tilt (1 ff) (Ess. pg. 368) (Time =)
3. Couples - Two Firefighter (2 ff's) (Ess. pg. 368) (Time =)
4. Couples - Foot Tilt (1 ff) (Ess. pg. 368) (Time =)
5. Uncouples - Knee Press (1 ff) (Ess. pg. 368) (Time =)
6. Uncouples - Stiff Arm (1 ff) (Ess. pg. 369) (Time =)
7. Uncouples - (1 ff) Using spanner wrenches. (Time =)

Rolls - Performance

1. Straight Roll (Ess. pg. 352) (Time =)
2. Donut Roll (#1 only) (Ess. pg. 353) (Time =)
3. Twin Donut (Ess. pg. 354) (Time =)

Load

1. Identifys straight or reverse load.
2. Performs "Dutchman" (Ess. pg. 365)

Date: _____ **Evaluator:** _____

Unit: _____

Date: _____

Hose Line Advance
1-3/4"

		CORRECT	INCORRECT	COMMENTS:
Command Post				
1. Reports to Command				
a. Turns in Ring	(5)			
b. Listens for response	(5)			
2. Listens for Unit Assignment	(5)			
3. Echos assignment	(5)			
Total Points	(20)			( )
Pre-Entry				
1. Obtains Equipment	(10)			
a. SCBA				
b. Tools				
2. Counts Off	(5)			
3. Activates PASS	(5)			
Total Points	(20)			( )
Entry and Work				
1. Door entry	(5)			
2. Stairway Work	(5)			
3. Hose Work	(5)			
4. Counts Off	(5)			
5. General Safety	(10)			
Total Points	(30)			( )
Building Exit				
1. Reports to Commnad	(10)			
2. Counts Off	(10)			
3. Returns Equipment	(10)			
Total Points	(30)			( )

Elapsed Time: _____ sec.

Total Points: _____ pts.

TITLE **28' Ladder Raise**

OBJECTIVE Takes 28' from designated vehicle, removes, carries it 30', turns 180 degrees, throws, raises all the way, and lowers it into building. (Gear - no SCBA)

Firefighters will take appropriate ladder from apparatus, carry it to predetermined place, spot, throw and raise ladde,r all the way, and place it on the building. Halyard may be secured after ladder is safely on building. (no time for halyard tie)

		Correct	Incorrect
Remove from Apparatus			
1. FF positioned correctly to remove.	(Minus 2 sec)		
2. Carrys on Right Shoulder	(Minus 3 sec)		
2. Place arm through by 2nd. Rung of ladder.	(Minus 5 sec)		
Spotting			
1. Selects spot 1/4 of height.	(Minus 2 sec)		
2. Places Right foot on heel	(Minus 8 sec)		
3. Places Right hand forward	(Minus 8 sec)		
Raise			
1. Checks overhead	(Minus 5 sec)		
2. Heeled by both firefighters	(Minus 3 sec)		
3. Hand over hand on halyard	(Minus 3 sec)		
4. Ladder lean toward building	(Minus 2 sec)		
5. Sets on building correctly	(Minus 2 sec)		
Halyard Tie			
1. Completes after ladder set on build	(Minus 3 sec)		
2. Ties correctly	(Minus 3 sec)		

Firefighter #1 _____

Firefighter #2 _____

Time: _____

Date: _____ **Evaluator:** _____

Unit: _____

Date: _____

Hose Line Advance
1-3/4"

		CORRECT	INCORRECT	COMMENTS:
Command Post				
1. Reports to Command				
a. Turns in Ring	(5)			
b. Listens for response	(5)			
2. Listens for Unit Assignment	(5)			
3. Echos assignment	(5)			
Total Points	(20)			( )
Pre-Entry				
1. Obtains Equipment	(10)			
a. SCBA				
b. Tools				
2. Counts Off	(5)			
3. Activates PASS	(5)			
Total Points	(20)			( )
Entry and Work				
1. Door entry	(5)			
2. Stairway Work	(5)			
3. Hose Work	(5)			
4. Counts Off	(5)			
5. General Safety	(10)			
Total Points	(30)			( )
Building Exit				
1. Reports to Commnad	(10)			
2. Counts Off	(10)			
3. Returns Equipment	(10)			
Total Points	(30)			( )

Elapsed Time:_____ sec.

Total Points: _____ pts.

Name _____

Date _____

SCBA Donning

		Correct	Incorrect	
Pre-Donning Check (30 sec.)				
Tank Pressure	(10)			
Tank Connection	(10)			
Tank Bracket	(20)			
All Straps loose	(20)			
Donning Switch - off	(20)			Time = _____
By-Pass - off	(10)			
Mask Checked	(10)			Points = _____
Donning (40 sec.)				
Checks air supply	(20)			
Opens tank valve all the way	(20)			
Lifts & Donns Overhead	(20)			
Tightens straps correctly				
Shoulder first	(5)			
Waist next	(5)			
Performs four (4) Safety Checks				
Mask Seal	(5)			
Regulator Operation	(5)			Time = _____
Exhalation Valve Function	(5)			
Bypass operation	(5)			Points = _____
PASS Device - on	(10)			
S.C.B.A. Doffing (30 sec.)				
PASS Device - off	(10)			
Loostens straps				
Waist strap to 1-1/2 in. of end	(10)			
Shoulder straps to end	(10)			Time = _____
Removes right shoulder first	(10)			
Cylinder valve - closed	(30)			
Breaths off excess air	(30)			Points = _____

Evaluators Signiature

Date _____

Firefighter #1 _____ Firefighter #2 _____

28" Pumper Extension Ladder Raise

Remove ladder from pumper, carry 50", raise and climb ladder in full turnout gear, in 2.5 Minutes. (Forcible Entry tools carried - optional)

	Correct	Incorrect
1. Places roof ladder on rail alongside pumper		
2. Places ladder on shoulder correctly a. Right shoulder in ladder b. Shoulders in second rung		
3. Spots heel for raise a. Heel 1/4 vertical distance b. Spots to correct side of window c. Spots to avoid overhead obstructions		
4. Sets ladder for raise a. Vocal command to "Set ladder" b. Feet hand position - Heel Man 1. Right foot forward on heel 2. Right hand forward for lateral stability 3. Stabalizes ladder during raise 4. Observes overhead for obstructions d. Feet hand position - Beam Man 1. Raises ladder on command 2. Hand over hand up rail of ladder		
5. Raises ladder a. Pivots to "fly out" position b. Fingers straight c. Hand over hand on halyard d. Estimates Distance to objective (Window or 4 Rungs above)		
6. Climbs hand over hand		

APPENDIX 6: REPORT CLAUSES

CAT Order Master (54 sec) Orders given/received using: • *Unit Number* • *Location* • *Task* • *Crew count*	
Clear vs Out – Repetitive (7 sec) *Which is clearer when spoken thru and SCBA mask?*	
Corner-Comparison (42 sec) Note clarity of various corner phraseology.	
MAYDAY vs HELP (38 sec) *Which is clearer when spoken thru and SCBA mask?*	
Mayday-Help, firefighter #2 (5 sec) *Which is clearer when spoken thru and SCBA mask?*	
Side-1, 2, 3, 4 - A, B, C, D - Alpha, Bravo, Charlie, Delta (28 sec) *Which is clearer when spoken thru and SCBA mask?*	