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ANALYSIS OF COMMERCIALY AVAILABLE HELMET AND BOOT OPTIONS FOR THE JOINT FIREFIGHTER INTEGRATED RESPONSE ENSEMBLE (JFIRE)

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1. SUMMARY

The Air Force Civil Engineering Support Agency (AFCESA) is currently establishing requirements to modify the Joint Firefighter Integrated Response Ensemble (JFIRE) for firefighters. The JFIRE consists of the Joint Services Integrated Suit Technology (JSLIST) chemical protective suit, helmet, gloves, boots, proximity jacket/trousers and self-contained breathing apparatus (SCBA), which firefighters may be required to wear for extended periods of time. Advances in materials have the potential to reduce the weight and profile thereby reducing fatigue and improving emergency response efforts.

AFCESA conducted a market survey to identify potential sources that may possess the expertise, capabilities and experience to meet the requirements for qualification and production of a modified JFIRE for United States Air Force firefighting and emergency services personnel. The purpose of this report is to document the physical properties of the boots and helmets submitted by industry. This report does not address other issues, such as compatibility, durability, ergonomics or chemical/biological protection that could impact firefighter performance while in JFIRE.

The Air Force Research Laboratory (AFRL) received eight different helmets from four manufacturers including Bullard (USRX, LT), Modular Helmet Systems Ltd (MHSL) (Targa 0086), Lion (Legacy 5) and Cairns (Rescue 360R, Invader 664, Invader 664 Proximity and Commando HP3). AFRL received nine different sets of National Fire Protection Association (NFPA) 1971 certified boots from four different manufacturers including Honeywell (Pro 3006, Pro 3009 and Pro-Warrington 5050), AirBoss-Defense (Combat 9451 and The Boss 4098), Globe (1201210, 1201400, 1201480) and Shoe Technologies Company (STC) (STC Commander). Each helmet and boot were measured and weighed to determine differences in profile and mass compared to the baseline.

Four of the eight helmets submitted showed a decrease in weight compared to the baseline. The Rescue 360R measured the greatest weight reduction; however, it is not NFPA 1971 certified. The USRX, LT and Invader 664 Proximity reduced weight by 6-11 percent.

Five helmets met or exceeded the requirements correlation matrix (RCM) threshold for brim circumference with the USRX showing the greatest reduction at 18 percent. All eight helmets showed a reduction in dome circumference with the USRX showing the greatest reduction at 12 percent, closely followed by the LT and Rescue 360R at 11 percent. Seven helmets showed a reduction in dome measurements, however, none met the RCM. The USRX and LT showed the greatest reduction in the dome at seven percent front to back and nine percent side to side. All eight helmets showed a reduction in helmet length, as measured from the bottom. Five helmets met or exceeded the RCM threshold for front to back. Seven helmets met or exceeded the RCM threshold for side to side. The USRX showed the greatest overall reduction for a NFPA compliant helmet at 19 percent front to back and 13 percent side to side.

All nine boots submitted exceeded the RCM objective (25 percent) reduction in weight ranging from 31-45 percent (3.3-4.9 lb). None of the boots submitted met the RCM objective (25 percent) or threshold (10 percent) reduction in profile for all three of the measurements. The

Boss 4098 and Pro 3006 came closest to meeting the RCM threshold with significant reductions in the ankle and calf but not the toe box.

Only one proximity boot (Honeywell Ranger 6211) was NFPA 1971 certified at the time the RCM was developed. Globe and Honeywell have developed a new concept incorporating an aluminized polybenzimidazole (PBI®) shell fabric used for other proximity personal protective equipment (PPE) under a leather boot, which allows the boot to be NFPA 1971 for both structural and proximity firefighting. In addition, both boots were NFPA 1992 certified for liquid chemical splash protection. Using dual-certified boots should reduce cost and logistics as a single boot can meet many of the requirements for Air Force firefighters.

Only four of the eight helmets submitted for consideration weighed less than the baseline helmet. The Cairns Rescue 360R showed the greatest reduction in weight (19 percent) but cannot be considered for JFIRE because it does not meet NFPA 1971. The Cairns Invader 664 Proximity, Bullard USRX and Bullard LT showed weight reductions of 11, 8 and 6 percent, respectively. All the helmets submitted were made of fiberglass or thermoplastic materials so they were already lightweight relative to the baseline helmet.

None of the helmets submitted met the RCM threshold to reduce profile for all six measurements. None of the helmets met the RCM threshold to reduce profile for the top of the dome from front to back or side to side. The dome is the one area of the helmet where a reduction in profile was least likely due to design and safety requirements; therefore, significant changes were not expected. The Bullard USRX showed the best overall reduction of any helmet at 13 percent. The Cairns Rescue 360R showed the greatest reduction in profile (15.3 percent) but cannot be considered for JFIRE because it does not meet NFPA 1971.

Significant reductions in weight were measured for all boot submissions. Advances in materials allowed manufacturers to reduce weight by almost five lb. Weight reductions ranged from 31-45 percent, which exceed the RCM objective of 25 percent. The boots should reduce fatigue and improve safety by removing unnecessary weight from the firefighter ensemble.

None of the boots submitted met the RCM threshold to reduce the profile for all three measurements. The AirBoss-Defense Boss 4098 and Honeywell Pro 3006 met the threshold for the ankle and calf but not the toe box. This may be due to overall design requirements for firefighter boots, which require multiple layers of construction, toe caps for crush protection and extra room to allow pant legs to be tucked inside.

The Bullard USRX helmet and Globe Proximity boot are recommended for the modified JFIRE program because they provided the best reduction in profile and weight. Bullard will need to make a NFPA 1971 certified proximity shroud, overcover and shield for the helmet to be a viable option. The helmet and boots need to be incorporated into final developmental and operational testing before it is adopted into JFIRE.

2. INTRODUCTION

2.1. Background

AFCESA is currently establishing requirements to modify the JFIRE for firefighters. The JFIRE consists of the JSLIST chemical protective suit, helmet, gloves, boots, proximity jacket/trousers and an SCBA, which firefighters may be required to wear for extended periods of time. The components for JFIRE were selected over 15 years ago, and advances in materials have the potential to reduce the weight and profile thereby reducing fatigue and improving emergency response efforts.

AFCESA conducted a market survey to identify potential sources that may possess the expertise, capabilities and experience to meet the requirements for qualification and production of a modified JFIRE for Air Force firefighting and emergency services personnel. Vendors were asked to submit components that were commercially available or would be commercially available within 12 months. The physical properties assessment of the components was conducted by AFRL.

Advances to firefighter boots have focused solely on the structural side. Only one proximity boot (Honeywell Ranger 6211) was NFPA 1971 certified at the time the RCM was developed; therefore, AFCESA did not specify a proximity requirement in the RCM. During the time the allotted for vendors to submit candidates, AFCESA was approached by Globe with a new leather boot that was being tested to meet both structural and proximity requirements. This new concept incorporating an aluminized PBI[®] shell fabric used for other proximity PPE under a leather boot allowed Globe to be the first manufacturer with a NFPA 1971 boot dual-certified for both structural and proximity firefighting. Since the boot was submitted for the Modified JFIRE program, Globe has also received NFPA 1992: Standard on Liquid-Splash Protective Ensembles and Clothing for Hazardous Materials Emergencies certification. After the submission deadline, Honeywell approached AFCESA with a similar version of a NFPA 1971 dual-certified leather fire boot (Pro-Warrington 5050). This boot was also later NFPA 1992 certified. AFCESA allowed the Pro-Warrington 5050 boot into the study as an alternative to the Globe Proximity.

2.2. Purpose

The purpose of this report is to document the physical properties of the boots and helmets submitted by industry and provide data to make decisions for components to be used in the modified JFIRE.

2.3. Scope

This report is limited to documenting AFRL's physical properties assessment of the boots and helmets as they pertain to the RCM. This report does not address other issues, such as compatibility, durability, ergonomics or chemical/biological protection that could impact firefighter performance while in JFIRE.

3. METHODS, ASSUMPTIONS, AND PROCEDURES

3.1. Requirements Correlation Matrix

The RCM was developed by AFCESA to establish threshold and objective requirements for each modified JFIRE element. Elements not meeting the minimum threshold requirement may not be considered for this program. Vendors were encouraged to meet the objective requirements set by the RCM.

Table 1 shows the RCM for the helmet and boots as defined by AFCESA. These requirements were intended to reduce the overall weight and profile of the JFIRE. AFCESA required all submissions to meet or have the potential to meet NFPA 1971 Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting (1).

Table 1. Requirements Correlation Matrix for JFIRE Helmet and Boots

Table 1: Requirements Correlation Matrix for UH-60 Helmet and Boots		
Helmet	Threshold	Objective
	Must meet NFPA Standards 1971	
	Reduce profile of current helmet by 10%	Reduce profile of current helmet 25%
	Reduce weight of current helmet by 10%	Reduce weight of current helmet 25%
	Capable of face shield option	Capable of face shield option
	Helmet shall be compatible with the MSA FireHawk M7 Responder SCBA.	
Boots	Threshold	Objective
	Must meet NFPA Standards 1971	
	Combat style boot that can be worn with work station uniform.	
	Reduce weight of current footwear by 10%	Reduce weight of current footwear 25%

3.2. Helmets

AFRL received eight different helmets from four manufacturers. The Morning Pride Proximity Plus Modern helmet is a typical helmet currently used by Air Force firefighters and is included as a baseline for comparison purposes. Six of the eight helmets were listed as NFPA 1971 certified with the exception of the MHSL Targa 0086 submitted by Lion and the Cairns Rescue 360R. The Targa is a helmet currently used in Europe. According to Lion, the helmet can be configured for a variety of operations and was submitted for informational purposes only as it will not meet the Threshold requirements for NFPA 1971 certification and is not compatible with the Mine Safety Appliances Firehawk SCBA. The Cairns Rescue 360R meets NFPA 1951 Standard on Protective Ensembles for Technical Rescue Incidents but not NFPA 1971. The 360R was submitted by Cairns as an example of the smallest helmet style available to first responders even though it did not meet the RCM. Helmets were submitted with a variety of options including the face shield, shroud and overcover; however, the primary objective was a reduction in weight and profile of the helmet so a comparison of the options is not provided in this report. Any helmet, with the exception of the Targa 0086, could be outfitted by the manufacturer with

an NFPA 1971 Proximity compliant shield, shroud and overcover. Table 2 summarizes the helmets submitted for review and any applicable NFPA standards.

A Universal Reference Locator (URL) to the manufacturer website with detailed specifications is provided in the Appendix.

Table 2. Summary of Helmets Submitted for JFIRE Program

Manufacturer	Model Number	Accessories			NFPA
		Shield	Shroud	Overcover	
Honeywell (baseline)	Morning Pride Proximity Plus Modern	Yes	Yes	Yes	1971
Bullard	USRX	Yes	No	No	1971
Bullard	LT	No	No	No	1971
MHSL	Targa 0086	Yes	No	No	NA*
Lion	Legacy 5	Yes	Yes	Yes	1971
Cairns	Rescue 360R	No	No	No	1951
Cairns	Invader 664 (Proximity)	Yes	Yes	Yes	1971
Cairns	Commando HP3	No	No	No	1971
Cairns	Invader 664	No	No	No	1971

*NA – Not applicable. Helmet submitted for informational purposes only.

Figure 1 shows the top, front, side and back view of the Morning Pride Proximity Plus Modern helmet used as the baseline. Traditional firefighter helmets are designed with a wide brim on the rear of the helmet, called a duckbill, to prevent water from running down the firefighter's coat. With the addition of helmet shrouds to protect the neck, this particular feature is no longer required to accomplish its original function and can hinder firefighter performance, especially in confined spaces.

The Proximity Plus is constructed from FYR-Glass.



Figure 1. Honeywell Morning Pride Proximity Plus Modern, Baseline Helmet

Figures 2-9 show the top, front, side and back view of each helmet submitted for evaluation. The Bullard USRX is constructed with high-heat thermoplastic (Figure 2).



Figure 2. Bullard USRX

The Bullard LT is constructed with high-heat thermoplastic (Figure 3).



Figure 3. Bullard LT

The MHSL Targa 0086 is constructed from lightweight polyamide alloys (Figure 4).



Figure 4. MHSL Targa 0086

The Lion Legacy 5 Proximity is constructed from fiberglass materials (Figure 5).



Figure 5. Lion Legacy 5 Proximity

The Cairns Rescue 360R is constructed from Ultem thermoplastic (Figure 6).



Figure 6. Cairns Rescue 360R

The Cairns Invader 664 Proximity is constructed from DuraGlas® fiberglass (Figure 7).



Figure 7. Cairns Invader 664 Proximity

The Cairns HP3 Commando is constructed from lightweight DuraGlas® fiberglass (Figure 8).



Figure 8. Cairns Commando HP3

The Cairns Invader 664 is constructed from DuraGlas® fiberglass (Figure 9).



Figure 9. Cairns Invader 664

Each helmet was measured and weighed (Ohaus Explorer Pro Model # EP8101C) to determine differences in profile and mass compared to the baseline. Currently, industry does not have a standard for measuring helmets to determine overall profile, therefore a series of six measurements were taken that could be replicated on each helmet for comparison purposes. Measurements included brim circumference, dome circumference, dome front to back, dome side to side, bottom front to back and bottom side to side. These measurements were completed using a measuring tape (to the nearest 1/16th in) with all attachments removed (shield, shroud and overcover).

Figure 10 shows the circumference measurements including the brim and dome. The brim was measured on the outside surface. The dome was measured where the dome meets the brim.



Figure 10. Example of Brim and Dome Circumference Measurements

Figure 11 and Figure 12 show the location of the measurements taken from the top of the dome including front to back and side to side.



Figure 11. Schematic Showing Measurement of Dome from Front to Back



Figure 12. Schematic Showing Measurement of Dome from Side to Side

Figure 13 shows how the measurements are taken for the bottom of each helmet, including front to back and side to side. Both measurements were taken using the center of the dome as the reference point.

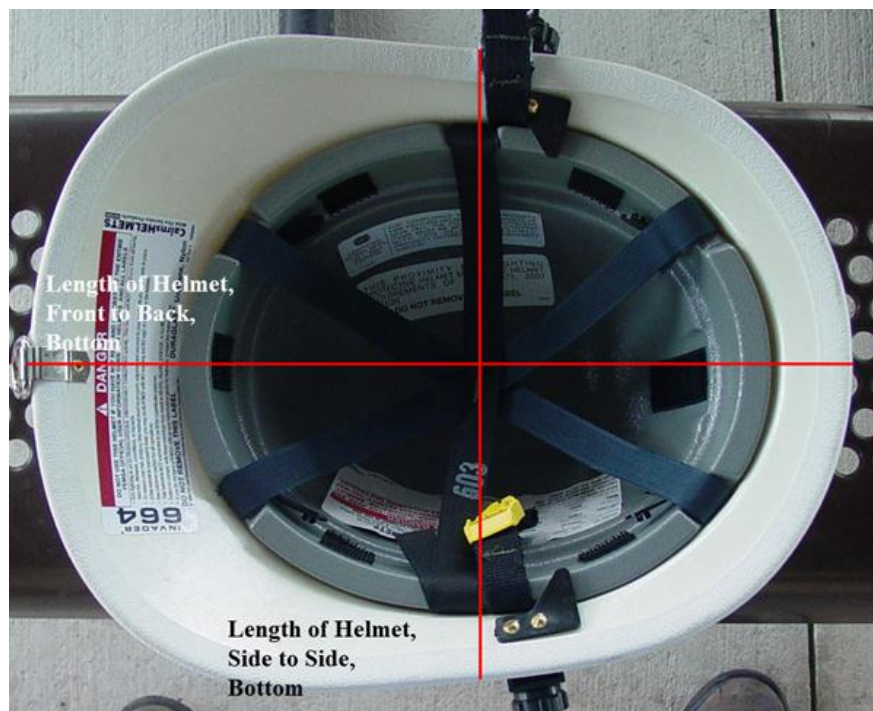


Figure 13. Schematic Showing Location of Bottom Measurements

3.3. Boots

AFRL received nine different sets of boots from four different manufacturers (Table 3). All of the boots were NFPA 1971 compliant. The Honeywell Ranger 6211 is the only boot used for proximity firefighting by Air Force firefighters and is included for comparison purposes as a baseline.

Table 3. Summary of Boots Submitted for JFIRE Program

Manufacturer	Model Number	Style		Boot Height (in)	Outer Shell	NFPA
		Pull-up	Lace-up		Material	
Honeywell (baseline)	Ranger 6211	X		16	Rubber	1971 P
AirBoss-Defense	Combat 9451	X		16	Rubber	1971 S
AirBoss-Defense	The Boss 4098	X		14	Rubber	1971 S
Globe	Globe 1201210		X	12	Leather	1971 S
Globe	Globe 1201400	X		14	Leather	1971 S
STC	STC Commander		X	14	Leather	1971 S
Honeywell	Pro 3009	X		14	Leather	1971 S
Honeywell	Pro 3006		X	10	Leather	1971 S
Globe	Globe 1201480	X		14	Leather	1971 P/S
Honeywell	Pro-Warrington 5050	X		14	Leather	1971 P/S

P = Proximity; S = Structural

All boots were size 10.5D (most common men's shoe size) Each boot was measured and weighed (Ohaus Explorer Pro Model # EP8101C) to determine differences in profile and mass compared to the baseline. Currently, industry does not have a standard for measuring boots to determine overall profile, therefore a series of three measurements were taken that could be replicated on each boot for comparison purposes (Figure 14). Measurements included the toe box, ankle and calf and were completed using a measuring tape (to the nearest 1/16th in).

A link to the manufacturer website with detailed specifications is provided in the Appendix.



Figure 14. Schematic Showing Boot Measurements

Figures 15–24 show pictures of all the boot sets, beginning with the baseline Honeywell Ranger 6211.



Figure 15. Typical Boots Used by Current USAF Firefighters, the Honeywell Ranger 6211



Figure 16. AirBoss-Defense Combat 9451



Figure 17. AirBoss-Defense The Boss 4098



Figure 18. Globe 1201210



Figure 19. Globe 1201400



Figure 20. STC Commander



Figure 21. Honeywell Pro 3009



Figure 22. Honeywell Pro 3006



Figure 23. Globe 1201480



Figure 24. Pro-Warrington 5050

4. RESULTS AND DISCUSSION

4.1. Helmets

Table 4 summarizes the weights for each helmet component and the percent difference from the baseline. Comparisons were not made between the shield, shroud and overcover. Four of the eight helmets showed a decrease in weight compared to the baseline MP Proximity Plus, which weighed 2.72 lb. The two NFPA 1971 non-compliant helmets had the greatest variations in weight from the baseline helmet. The Rescue 360R showed the greatest reduction in weight at 2.29 lb (19 percent as compared to the baseline) while the Targa 0086 showed the greatest increase at 3.36 lb (28 percent). The USRX, LT and Invader 664 Proximity weighed 6–11 percent (0.14-0.24 lb) less than the baseline.

Table 4. Weights of Helmet Components

Manufacturer	Model	Weight (lb)				Percent Difference
		Helmet	Shield	Shroud	Overcover	
Honeywell (baseline)	MP Proximity Plus	2.72	0.62	0.49	0.22	Baseline
Bullard	USRX	2.53	0.69	0.70	0.30	-8
Bullard	LT	2.58	-	-	-	-6
MHSL	Targa 0086*	3.36	-	-	-	28
Lion	Legacy 5	3.06	0.56	0.84	0.19	15
Cairns	Rescue 360R*	2.29	-	-	-	-19
Cairns	Invader 664 Prox	2.48	0.57	0.95	0.22	-11
Cairns	Commando HP3	2.78	-	-	-	2
Cairns	Invader 664	2.96	-	-	-	10

*Does not meet NFPA 1971

Table 5 and Table 6 show the results of the six measurements taken on each helmet.

All eight helmets showed a reduction in brim circumference; however, only five helmets met or exceeded the RCM threshold. The baseline MP Proximity Plus measured 42.125 in. The USRX had the greatest reduction in brim circumference of the six NFPA 1971 compliant helmets submitted, measuring 34.5 in (18 percent). The Rescue 360R at 33.75 in and the Targa 0086 at 30.5 in had the smallest brims of the eight helmets, but neither are NFPA 1971 compliant. Three helmets including the Legacy 5, Invader 664 Pro and Invader 664 were only slightly smaller than the baseline (41.25 in, 2 percent reduction).

All eight helmets showed a reduction in dome circumference; however, only three met or exceeded the RCM threshold. The baseline MP Proximity Plus measured 32 in. The USRX showed the greatest reduction in dome circumference measuring at 28.25 in (12 percent), closely followed by the LT and Rescue 360R at 28.5 in each (11 percent). The USRX and LT are both NFPA 1971 compliant, while the Rescue 360R is not. The Legacy 5 showed the smallest reduction at 31 in (3 percent).

Seven helmets showed a reduction in dome measurements, as measured from the top, while the Targa 0086 showed an increase in both measurements due to its motorcycle helmet-like design. None of the helmets met the RCM threshold for these measurements. The baseline MP Proximity Plus measured 18.25 in front to back and 16.5 in side to side. The USRX and LT showed the greatest reduction at 17 in front to back (7 percent) and 15 in side to side (9 percent). Both helmets were manufactured by Bullard and have the same dome design.

All eight helmets showed a reduction in helmet length, as measured from the bottom. Five helmets met or exceeded the RCM threshold for front to back measurements. Seven helmets met or exceeded the RCM threshold for side to side measurements. The baseline MP Proximity Plus measured 14.25 in front to back and 12.125 in side to side. The Targa 0086 and Rescue 360R showed the greatest reduction from side to side but are not NFPA compliant. The USRX showed the greatest overall reduction for a NFPA compliant helmet measuring 11.5 in front to back (19 percent) and 10.5 in side to side (13 percent).

Table 5. Helmet Profile Measurements

Helmet Model	Profile Measurements (in)					
	Brim Circumference	Dome Circumference	Top Front-to-Back	Top Side-to-Side	Bottom Front-to-Back	Bottom Side-to-Side
MP Proximity Plus	42.125	32	18.25	16.5	14.25	12.125
USRX	34.5	28.25	17	15	11.5	10.5
LT	37.5	28.5	17	15	12.75	10.25
Targa 0086*	30.5	33	26.625	21	12.5	8.75
Legacy 5	41.25	31	17.75	15.75	14	11.75
Rescue 360R*	33.75	28.5	17	15.5	11.75	9
Invader 664 Prox	41.25	30.5	17.75	16	14	10.75
Commando HP3	36.75	30.75	17.75	16	12.25	10.25
Invader 664	41.25	30.75	17.75	15.75	13.875	10.75

*Does not meet NFPA 1971

Table 6. Helmet Profile Differences from Baseline Helmet Model

Helmet Model	Percent Difference					
	Brim Circumference	Dome Circumference	Top Front-to-Back	Top Side-to-Side	Bottom Front-to-Back	Bottom Side-to-Side
MP Proximity Plus	-	-	-	-	-	-
USRX	-18	-12	-7	-9	-19	-13
LT	-11	-11	-7	-9	-11	-15
Targa 0086*	-28	3	40	27	-12	-28
Legacy 5	-2	-3	-3	-5	-2	-3
Rescue 360R*	-20	-11	-7	-6	-18	-26
Invader 664 Prox	-2	-5	-3	-3	-2	-11
Commando HP3	-13	-4	-3	-3	-14	-15
Invader 664	-2	-4	-3	-5	-3	-11

*Does not meet NFPA 1971

4.2. Boots

Table 7 shows the weight of the boots and the percent weight difference in comparison to the baseline boot. All nine boots submitted exceeded the RCM objective (25 percent) reduction in weight with the Honeywell Pro 3006 and 3009 having the greatest reductions at 44 and 45 percent (4.7 and 4.9 lb).

Table 7. Boot Weights and Percent Difference

Manufacturer	Model Number	Weight (lb)			Percent Difference
		Right	Left	Total	
Honeywell (baseline)	Ranger 6211	5.4	5.4	10.8	Baseline
AirBoss-Defense	Combat 9451	3.7	3.7	7.4	-31
AirBoss-Defense	The Boss 4098	3.5	3.5	7.0	-35
Globe	Globe 1201210	3.2	3.2	6.4	-41
Globe	Globe 1201400	3.3	3.3	6.6	-39
STC	STC Commander	3.5	3.5	7.0	-35
Honeywell	Pro 3009	2.9	3.0	5.9	-45
Honeywell	Pro 3006	3.1	3.0	6.1	-44
Globe	Globe 1201480	3.5	3.5	7.0	-35
Honeywell	Pro-Warrington 5050	3.8	3.7	7.5	-31

Table 8 and Table 9 show the measurements from the nine sets of boots submitted for this program plus the Ranger 6211 used as the baseline. None of the boots submitted met the RCM objective (25 percent) or threshold (10 percent) reduction in profile for all three of the measurements. The Boss 4098 and Pro 3006 came closest to meeting with RCM threshold with significant reductions in the ankle and calf but not the toe box.

Table 8. Boot Profile Measurements

Boot Model	Profile Measurements (in)		
Model Number	Toe Box	Ankle	Calf
Ranger 6211	14.0	17.0	20.5
Combat 9451	14.0	15.0	19.0
The Boss 4098	13.8	14.5	18.0
Globe 1201210	13.5	15.0	18.8
Globe 1201400	13.5	17.5	20.0
STC Commander	14.3	16.0	18.5
Pro 3009	13.3	15.5	19.5
Pro 3006	14.0	15.0	17.3
Globe 1201480	14.8	17.5	20.0
Pro-Warrington 5050	14.0	16.8	21.0

Table 9. Boot Profile Differences from Baseline Model

Boot Model	Percent Difference			
	Toe Box	Ankle	Calf	Average
Ranger 6211	-	-	-	-
Combat 9451	0	12	7	6
The Boss 4098	2	15	12	10
Globe 1201210	4	12	9	8
Globe 1201400	4	-3	2	1
STC Commander	-2	6	10	5
Pro 3009	5	9	5	6
Pro 3006	0	12	16	9
Globe 1201480	-4	-3	2	-2
Pro-Warrington 5050	0	1	-2	0

5. CONCLUSIONS

Two helmets (Lion Targa 0086 and Cairns Rescue 360R) submitted for this program did not meet the NFPA 1971 certification requirement defined in the RCM but were included in the study for information purposes.

Only four of the eight helmets submitted for consideration weighed less than the baseline helmet. The Cairns Rescue 360R showed the greatest reduction in weight (19 percent) but cannot be considered for JFIRE because it does not meet NFPA 1971. The Cairns Invader 664 Proximity, Bullard USRX and Bullard LT showed weight reductions of 11, 8 and 6 percent, respectively. All the helmets submitted were made of fiberglass or thermoplastic materials so they were already lightweight relative to the baseline helmet. JFIRE does not list a specific helmet as it does for the other elements; therefore, the Air Force uses many difference models, which vary in weight and profile. A greater reduction in weight would have been seen if the baseline helmet used for comparison was the largest helmet currently in use.

None of the helmets submitted met the RCM threshold to reduce profile for all six measurements. None of the helmets met the RCM threshold to reduce profile for the top of the dome from front to back or side to side. The dome is the one area of the helmet where a reduction in profile was least likely due to design and safety requirements; therefore, significant changes were not expected. The Bullard USRX showed the best overall reduction of any helmet at 13 percent. The Cairns Rescue 360R showed the greatest reduction in profile (15.3 percent) but cannot be considered for JFIRE because it does not meet NFPA 1971

Significant reductions in weight were measured for all boot submissions. Advances in materials allowed manufacturers to reduce weight by almost 5 lb. Weight reductions ranged from 31–45 percent, which exceed the RCM objective of 25 percent. The boots should reduce fatigue and improve safety by removing unnecessary weight from the firefighter ensemble.

None of the boots submitted met the RCM threshold to reduce the profile for all three measurements. The AirBoss-Defense Boss 4098 and Honeywell Pro 3006 met the threshold for the ankle and calf but not the toe box. This may be due to overall design requirements for firefighter boots, which require multiple layers of construction, toe caps for crush protection and extra room to allow pant legs to be tucked inside.

All nine boots are NFPA 1971 certified for structural, however, two of the boots (Globe 1201480 and Honeywell Pro-Warrington 5050) are NFPA 1971 certified for proximity and NFPA 1992 for liquid chemical splash. Using dual-certified boots should reduce cost and logistics as a single boot can meet many of the requirements for Air Force firefighters.

6. RECOMMENDATIONS

Recommend the Bullard USRX helmet for the modified JFIRE program because it provided the best reduction in profile and weight. Bullard will need to make a NFPA 1971 certified proximity shroud, overcover and shield for the helmet to be a viable option. The helmet needs to be incorporated into final developmental and operational testing before it is adopted into JFIRE.

Recommend the Globe Proximity boot for the modified JFIRE program because it exceeds the RCM objective for weight reduction and is dual-certified for structural and proximity firefighting applications as well as liquid chemical splash protection. The boots need to be incorporated into final developmental and operational testing before it is adopted into JFIRE.

7. REFERENCES

1. **National Fire Protection Association.** Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting. Quincy : National Fire Protection Association, 2006. NFPA 1971.

APPENDIX: MANUFACTURER INFORMATION ON BOOTS AND HELMETS

Table A-1. Helmet Manufacturers

Manufacturer	Model	Website
Honeywell	MP Proximity Plus	http://www.honeywellfirstresponder.com/en-US/Pages/Product.aspx?category=Crash Fire&cat=HLS-HFRP&pid=HTLF2PROX
Bullard	USRX	http://www.bullard.com/V3/products/fire_service/USAR/USRX/
Bullard	LT	http://www.bullard.com/V3/products/fire_service/structural/LT/
MHSL	Targa 0086	http://targahelmet.com/structural.htm
Lion	Legacy 5	http://www.lionprotects.com/paul-conway-helmets-legacy-5
Cairns	Rescue 360R	http://www.msafire.com/catalog/product500646.html
Cairns	Invader 664 Prox	http://www.msafire.com/catalog/product16865.html
Cairns	Commando HP3	http://www.msafire.com/catalog/product878.html
Cairns	Invader 664	http://www.msafire.com/catalog/product16865.html

Table A-2. Boot Manufacturers

Manufacturer	Model Number	Website
Honeywell	Ranger 6211	http://www.honeywellfirstresponder.com/en-US/Pages/Product.aspx?category=HoneywellRubberBoots&cat=HLS-HFRP&pid=6211
AirBoss-Defense	Combat 9451	http://www.airbossdefense.com/sites/default/files/Combat_spec.pdf
AirBoss-Defense	The Boss 4098	http://www.airbossdefense.com/sites/default/files/The_Boss%20specification.pdf
Globe	Globe 1201210	http://www.globeturnoutgear.com/boots/structural-12-zipper-speed-lace
Globe	Globe 1201400	http://www.globeturnoutgear.com/boots/structural-supreme-14-pull-on
STC	STC Commander	http://www.stcfootwear.com/product/77/fire-boots
Honeywell	Pro 3009	http://www.honeywellfirstresponder.com/en-US/Pages/Product.aspx?category=ProLeather&cat=HLS-HFRP&pid=3009
Honeywell	Pro 3006	http://www.honeywellfirstresponder.com/en-US/Pages/Product.aspx?category=ProLeather&cat=HLS-HFRP&id=3006
Globe	Globe 1201480	http://www.globeturnoutgear.com/boots/proximity-14-pull-on
Honeywell	Pro-Warrington 5050	http://www.honeywellfirstresponder.com/en-US/Pages/Product.aspx?category=ProProximityRubber&cat=HLS-HFRP&pid=5050

LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

AFCESA	Air Force Civil Engineering Support Agency
AFRL	Air Force Research Laboratory
in	inch
JFIRE	Joint Firefighter Integrated Response Ensemble program
JSLIST	Joint Services Lightweight integrated Suit Technology
lb	pound
MHSL	Modular Helmet Systems Ltd
NFPA	National Fire Protection Association
PBI [®]	aluminized polybenzimidazole
PPE	personal protective equipment
RCM	requirements correlation matrix
SCBA	self-contained breathing apparatus
STC	Shoe Technologies Company