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## A User-Centered Approach for New PPE Development: Case Study iWomen

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The interfaces of Personal Protective Product (PPE) systems have been long known for creating unsafe circumstances for users. For example, almost half of all U.S. firefighter injuries (46%) are strains, sprains, and muscular pain from fire ground operations, and 1 in 30 hazardous condition calls resulted with the firefighters being exposed to environmental hazards such as chemicals, vapors, and radioactive materials (Haynes & Molis, 2017). Moreover, between the years of 2010 and 2014, the National Fire Protection Association estimated that female firefighters experienced an average of 1,260 injuries on the fire ground each year (Campbell, 2017). In firefighting, there is an intimate relationship with users and their PPE, as lives are at the stake due how well it fits and performs. As the firefighting population becomes more diversified, with the addition of women, different ethnicities and obese bodies, there is a need to better understand the user and their turnout gear interfaces.

Previous PPE research has been lab focused, and often actual firefighters (especially women) have not be involved as test subjects. This non-systems approach neglects to understand physical interface exposures and ergonomic compatibilities of PPE. A user-centered approach in this product space needs to be considered in an effort to reduce injury rates and save lives. This approach considers the user throughout the research and design process, so their input is always considered (Voss, 2009). The International Organization for Standardization (ISO), through their standard 9241-210, have published principles regarding using a human-centered design process. Those principles include: (1) the design is based upon an explicit understanding of users, tasks and environments, (2) users are involved through design and development, (3) the design is driven and refined by user-centered evaluation, (4) the process is iterative, (5) the design addresses the whole user experience, and (6) the design team includes multi-disciplinary skills and perspectives (ISO, 2010). The benefits of a user-centered approach have been proven to produce successful products and policies that are based upon an explicit understanding of the user's tasks, experiences and environments, as the approach is more authentic.

The researchers adopted the user center approach to understand the PPE needs of female firefighters, by conducting a classroom session at the 2018 International Association of Women in Fire and Emergency Services (iWomen) conference. In collaboration with conference directors, a protocol was developed to increase attendee awareness of current turnout gear performance (coats, pants, gloves and boots), and to identify challenges and opportunities for new product development, to improve the safety and performance for women. This method provided a unique experience, where female firefighters and their needs were always placed at the center of the conversation. During the classroom session, the attendees were asked to share information about their experience as firefighters (location, years of service and general practice of using turnout gear). They also broke-out into smaller product-specific (coats, pants, gloves and boots) focus groups to discuss their experiences, issues with gear and how they would

remedy performance issues with new design ideas. Throughout all discussions, qualitative data were collected that could be analyzed post conference. After the focus groups were conducted, the researchers presented the facts and figures surrounding injury due to poorly designed and fitting turnout gear to highlight the importance of improving PPE for women.

Session attendees were leaders of the U.S. firefighting population, including career and volunteer firefighters from urban, state or federal wildland agencies, EMT's, paramedics, inspectors, dispatchers, and fire service educators. Many of the attendees will participate with future activities of the larger research project to inform and validate work over time, which is imperative to the user-centered process. SWOT analyses were conducted with the qualitative data to identify Strengths, Weaknesses, Opportunities, and Threats of the specific product spaces - coats, pants, gloves and boots, to identify future product innovation strategies. This analysis method is used widely in the performance athletic product industry to frame up new product opportunities and the research team felt the PPE industry could benefit from this type of analysis. In all, the results of this holistic PPE research will be used to improve firefighter health and safety through innovative, user-centered PPE protective systems that address fit, ergonomics and movement, protection and gender/ethnic needs.

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