

Crowdsourcing for Innovative Personal Protection Technology

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Abstract

Personal protective equipment (PPE) plays a vital role in safeguarding workers from workplace hazards and minimizing exposure to harmful substances or conditions. To meet the changing needs and challenges faced by workers in various industries, PPE is continuously evolving. As new technologies emerge, advances in materials, design, and functionality contribute to PPE improvements. By incorporating personal protective technology (PPT) into traditional PPE, worker safety and well-being can be further enhanced. Crowdsourcing can harness a wide range of perspectives and expertise to identify novel technologies, materials, designs, or applications that can revolutionize PPE and improve worker protection. Partnering with the National Aeronautics and Space Administration (NASA) Center for Center of Excellence for Collaborative Innovation (CoECI), the National Institute for Occupational Safety and Health (NIOSH) National Personal Protection Technology Laboratory (NPPTL) launched three crowdsourcing challenges. These challenges aimed to promote innovation in several PPE areas: protective clothing, counterfeit respirators, and respirator fit. Preliminary results produced promising technologies and approaches promoting improved awareness, comfort, adaptability, and effectiveness against workplace hazards.

Personal Protection and Worker Safety and Health

Controlling exposures to hazards in the workplace is vital to protecting workers. Personal protective equipment (PPE) can minimize exposure to hazards that cause workplace injuries, illnesses, and death. It acts as a barrier between the wearer and potential dangers, reducing the risk of injury or illness. PPE is designed to protect individuals from various workplace hazards such as physical, chemical, biological, and radiological hazards. PPE can help prevent accidents and injuries by providing necessary protection. For example, safety helmets protect the head from falling objects, safety goggles shield the eyes from chemical splashes or flying debris, and gloves safeguard hands from cuts or chemical exposure. Employers in the U.S. are required to provide a workplace that is free of hazards and incorporate PPE where necessary (29U.S.C. §1910.132).

PPE primarily focuses on physical barriers and protective gear that workers wear directly on their bodies to minimize

exposure to hazards. Personal Protective Technology (PPT), on the other hand, encompasses a broader range of technologies that can be used to enhance personal protection in various ways. By leveraging PPT alongside traditional PPE, personal protection can be improved through better hazard detection, early warnings of potential dangers, facilitation of communication and training, analysis of data for risk assessment, promotion of ergonomics and wellness practices, as well as system integration for overall enhanced safety measures.

Advancing PPE Solutions and Technologies

To continuously advance the effectiveness and usability of PPE, ongoing research efforts and technological advancements across various disciplines are needed. Research exploring new materials or combinations of materials could offer enhanced protection, durability, comfort, and breathability. Improving PPE design to ensure better fit, flexibility, and ease of use could enhance user comfort and compliance. Integrating smart technologies into PPE could provide additional functionalities such as real-time monitoring of vital signs or environmental conditions. Advancements in PPE could also focus on sustainability to reduce waste generation during manufacturing or using eco-friendly materials that are biodegradable or recyclable.

Fostering technological advancements in PPE requires specific and unique conditions. Sufficient funding for research and development is crucial to drive PPT innovation. Market conditions so that companies can offset the costs investing in research and development to encourage innovation. Encouraging collaboration among researchers, manufacturers, regulatory bodies, end-users, and other impacted parties is also essential. Collaborative efforts can leverage diverse expertise, share knowledge, and accelerate the development of advanced PPE technologies.

Promoting and encouraging efforts to advance the state of knowledge and application of PPT is a primary goal of The National Personal Protective Technology Laboratory (NPPTL), within the National Institute for Occupational Safety and Health (NIOSH), mission is to. As part of its mission, NPPTL is responsible for promoting, developing, and

evaluating innovative PPT designs and approaches to improve comfort, fit, and usability. Distributed online problem solving is an approach that NPPTL explored to spur innovation in PPT.

Federal Open Innovation and Crowdsourcing

The U.S. government has embraced open innovation to engage citizens, gather information, and solve complex problems. Regulations and guidelines have been established to govern how agencies can run open innovation challenges and prize competitions. The primary regulation that governs these competitions is the America COMPETES Reauthorization Act of 2010 (COMPETES Act). Additionally, the Office of Management and Budget (OMB) has issued guidance on conducting prize competitions. Individual agencies may also have their own specific regulations and policies.

The NASA Tournament Lab (NTL) is a virtual platform that enables NASA to collaborate with the global community of problem solvers and innovators through crowdsourcing competitions. It is managed by the Center of Excellence for Collaborative Innovation (CoECI) at NASA's Johnson Space Center. The NTL hosts various challenges and competitions, inviting individuals, teams, and organizations from around the world to contribute their skills and expertise to solve complex problems faced by NASA and other government agencies. These challenges cover a wide range of topics, including space exploration, technology development, data analysis, software development, robotics, and more. By leveraging the collective intelligence of a diverse crowd, NASA aims to accelerate innovation and find creative solutions to advance its missions.

In contrast to challenges under COMPETES Act authority, procurement authority through the NTL involves funding allocated specifically for procuring solutions or technologies through challenge-based contracts. COMPETES Act authority follows specific legal requirements outlined in the legislation, including rules related to eligibility, evaluation criteria, intellectual property rights, and transparency. Procurement authority through the NTL follows federal acquisition regulations and procedures applicable to government contracts.

PPT Innovation through Crowdsourcing Challenges

Having little experience with open innovation, NPPTL partnered with NASA CoECI to develop several crowdsourcing challenges. Through the NTL, guidance was provided on all aspects of implementing open innovation initiatives, from problem definition to incentive design and post-submission evaluation of solutions. This end-to-end approach allowed

NPPTL to rapidly experiment with these new methods and efficiently stand up their own crowdsourcing capabilities.

Protective Clothing Challenge

NPPTL sought innovative ideas and solutions to help it improve protective clothing use, acceptability, knowledge, availability, and access. Through the NTL, NPPTL partnered with HeroX to develop The NIOSH Protective Clothing Challenge: Leave Nobody Unprotected. This effort leveraged collaborative innovation to generate new ideas and examples of how diversity, equity, and inclusion could be incorporated into PPE.

The competition was an ideation challenge where the best innovative concepts and solutions in the form of written submissions received a monetary award. A prize structure of first, second, and third place with a prize purse of \$55,000 was selected. Through outreach and engagement efforts the challenge produced a robust and active solver community. Considering the design, timeline, and resources invested, the challenge produced successful results:

- Omni-Fit PPE Gown with Contamination Indicator
- Apples-2-Apples Measures + Pattern Drafting Method:
- Bifunctional AAMI Surgical Sleeve
- Covering all by improving unisex sizing

Counterfeit Respirator Challenge

One of the primary responsibilities of NPPTL is to test and approve respirators used in U.S. occupational settings. During the COVID-19 response, federal/state/local agencies became increasingly aware of commercial fraud activity involving the supply and distribution NIOSH-Approved® Filtering Facepiece Respirators (FFRs). NPPTL again partnered with HeroX through the NTL to develop a prize competition focused on reducing the number of counterfeit respirators in the marketplace and improving the confidence of end users purchasing these products.

The NIOSH Counterfeit N95® Challenge sought ideas for new approaches and technologies that would educate vendors and users about counterfeit respirators. This two-phase challenge had a total prize purse of \$145,000. Four Phase 1 winning teams advanced to Phase 2, where they had over six months to demonstrate their proposed approaches.

A prototype FFR validation app and website was awarded the top prize. This winning solution demonstrated how a validation database with a private label lookup function and one-way communication with NIOSH's Certified Equipment List (CEL) could improve confidence that respirators are authentic. Three teams also received an honorable mention. While these teams did not receive a monetary prize for Phase 2, they were invited to NIOSH partner activities to promote and share their innovative solutions.

Respirator Fit Evaluation Challenge

Air-purifying FFRs that are approved by NIOSH protect the wearer from particulate respiratory hazards. A tight seal between the respirator and user's face is critical. Fit testing is a critical component of a respiratory protection program for tight-fitting respirators used in occupational settings. However, recent and reoccurring disasters have highlighted gaps ensuring appropriate respiratory protection for the public and for many workers [NASEM]. Traditional fit test approaches typically used in occupational respiratory protection programs might not be feasible in some scenarios.

A challenge focusing on respirator fit was developed with Capital Consulting Corporation, through partner NTL. The NIOSH Respirator Fit Evaluation Challenge is in search of novel technologies and innovative approaches that deliver immediate evaluation and feedback to end users about the fit of FFRs during use. The Challenge is a three-phase, \$350,000 competition collecting concept papers in Phase 1, building and evaluating prototypes in Phase 2, and sharing end solutions with NIOSH in Phase 3 for evaluation. By the end of the competition, solutions should be market-ready with user-friendly fit evaluation solutions for end users of FFRs.

While this challenge is ongoing, initial results are promising. The 20 Phase 1 winning concepts represent a diverse range of solution. These include technologies such as Light Detection and Ranging (LiDAR), infrared imagery and thermal monitoring, fabric-based sensor networks, light sensing (LED), and an app that will combine AI with facial recognition. There were 9 pre-production prototype solutions that were selected in Phase 2 to move onto Phase 3 evaluation at NPPTL. Up to three teams will be selected to receive a portion of the \$150,000 Phase 3 prize purse.

Conclusion

NIOSH and NASA have partnered to promote innovation in personal protective equipment (PPE) through crowdsourcing challenges. These challenges aim to improve worker health and safety by identifying novel technologies, materials, designs, or applications that can enhance PPE. The challenges focus on areas such as protective clothing, counterfeit respirators, and respirator fit. Preliminary results have shown promising technologies and approaches that improve awareness, ease-of-use, adaptability, and effectiveness against workplace hazards. The use of crowdsourcing allows for a wide range of perspectives and expertise to contribute to PPE innovation. Using open innovation to develop new technologies for PPE has the potential to revolutionize worker safety by driving continuous advancements in protection, comfort, and usability.