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EXPLORING & DESIGNING IN THE CONTEXT OF SEARCH AND RESCUE

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ABSTRACT
In the face of extreme weather and terrain, Search and Rescue (SAR) volunteers face a growing challenge of rapid changes in environmental conditions. This demands that rescuers manage layered demands to prevent accidents and save lives. The volunteer-based work of ICE-SAR (Icelandic Association for Search and Rescue) is constantly balancing risks and rewards with each operation. With a community of 5000+ volunteers, their 'workforce' compares to the marine industry, energy sector and tourism companies in Iceland. With scale, they can be involved in research and development of technical personal protective equipment (PPE). Their circumstances are valued for beta-testing equipment in different rescue specialty group trainings, including mountain rescue, marine rescue and technical teams. In the SAR context design, engineering and technology transfer happen in real-time. Designing for complex systems calls for the right know-how and creativity, coupled with extensive knowledge, practice and field testing. Industry partners contribute further expertise, funding and equipment. This paper presents an innovative model for design and engineering education with lessons learned from an innovative Technology Transfer Design Sprint that took place simultaneously in-the-field, in studio and online. Bringing user-centred design to this context with "risk-familiar users" resulted in a vibrant opportunity for hybrid (soft/hard) design education. Introducing students to these users, who are trained to deal with unknowns and high-risk situations, can engage and prepare them to design inclusive, relevant and resilient solutions. Rapid and risk-receptive design processes are needed for adapting to the demand of SAR users, or better said: its "rescuesers".

Keywords: Extreme environments, technology transfer, technical apparel, personal protective equipment (PPE), search & rescue, design innovation, risk

1 INTRODUCTION
Living on a remote volcanic island brings challenges, such as possible rapid weather changes, extreme weather conditions, volcanic eruptions and other natural hazards. In order to respond to harsh conditions and emergencies in the best way possible, it´s important to design and develop reliable and optimised products, services and systems which can prevent accidents and save human lives and other valuables. Extreme conditions often present extreme product development challenges for the users, and for the designers. Search and Rescue (SAR) volunteers face rapid changes in environmental conditions and those working in Iceland face gale force winds, temperature shifts, lack of shelter and the island's natural hazards, among others. These conditions require rescuers to manage layered challenges to prevent accidents and save lives, while keeping themselves safe.
As Design Educators, our responsibility is to future-proof design education. Introducing students to the users, who are familiar and trained to deal with unknowns and high-risk situations, can engage and prepare them to design inclusive and relevant solutions. In order to connect the development of solutions for existing societal, environmental, economic, technological and (geo)political challenges to a larger context and goals, projects should be connected to a guiding framework, such as the UN Sustainable Development Goals and the objectives and policies of other governmental bodies such as the Arctic Council. Working in interdisciplinary teams on solving grand challenges increases the likelihood of developing appropriate solutions. Technology Transfer organisations can facilitate collaborative platforms where there is room for design and engineering students and other academia to engage with end-users, industry, governmental organisations, policy makers and other professionals with the aim to

develop inclusive, contextual and resilient solutions and applications to improve the everyday life of people and make a positive difference for the environment. During and after the process, Technology Transfer Offices (TTO) can also support academia with advice on Research and Development (R&D), innovation management, intellectual property protection, market analysis, and patent landscapes, with an objective of connecting inventions and innovative design and engineering projects with investors and the industry. The larger goal is to enable science & technology to have more impact on society, both nationally and internationally [1].

Contrary to popular belief, publishing your research will not guarantee that someone will notice your concept and develop it into a tangible product that will reach the end user. Technologies first need to be developed and that is achieved through collaborations with industrial partners [2] and Intellectual Property. This is one of the goals of the Technology Transfer Design Sprint. In a design sprint, facilitators aim to merge business strategy, behaviour science, innovation, and design thinking into one innovative process [3]. Knapp [3] describes the design sprint as a time-constrained, five-phase process that uses design thinking with the aim of reducing the risk when bringing a new product, service or a feature to the market. The process aims to help teams to clearly define goals, validating assumptions and deciding on a product roadmap before starting development. In fact, the method is ideal when seeking to gain insights on early concepts, to improve those concepts before building or launching a product [4]. It seeks to address strategic issues using interdisciplinary, rapid prototyping, and usability testing and guides you through the design process much faster and more directed. It combines both tangible output and progress as a team. It's a learning-by-doing-process to experience a customer-centric and prototyping mindset [3]. The five phases include: (1) **Understand:** Discover the business opportunity, the audience, the competition, the value proposition, and define metrics of success, (2) **Diverge:** Explore, develop and iterate creative ways of solving the problem, regardless of feasibility, (3) **Converge:** Identify ideas that fit the next product cycle and explore them in further detail through storyboarding, (4) **Prototype:** Design and prepare prototype(s) that can be tested with people. (5) **Test:** Conduct 1:1 usability testing with the product's primary target audience.

In applying the design sprint model, this paper presents an innovative adaptation of the model, developed for design and engineering education via a hybrid model that took place simultaneously in-the-field, in the studio, and online, with a specific set of collaborators and a niche set of users.

2 THE CONTEXT OF SAR AND 'RESCUESERS'

Introducing students to end-users who are trained to deal with unknowns and high-risk situations, can engage and prepare them to design inclusive, relevant and resilient solutions. Rapid and risk-receptive design processes are needed for adapting to the user demands and the environments in which they operate. ICE-SAR (Icelandic Association of Search and Rescue) has been active in Iceland for over 100 years. It is a non-profit, non-commercial, volunteer-based organization that specializes in SAR services on land and at sea around the coast of Iceland. The professionalism that characterizes the work of Icelandic rescue teams has brought worldwide attention. Specialist trainings undertaken by particular rescue groups has resulted in exceptional knowledge of the various conditions that are known to occur, both at sea and on land. Specialist training formats include seminars, courses, field exercises, first aid and wilderness first responder courses and exams. Both employees and volunteers travel to different parts of the country to acquire insights into the best ways to protect themselves and others from the dangers inherent in Icelandic environments. Their joint mission is to prevent accidents and save human lives and valuables. In order to fulfil that role, there are groups of volunteers always available, night and day, year round. Rescue teams are called out about 1800 times a year on average [5] to perform a variety of tasks in challenging situations**.**

Designing solutions for a niche user-group such as SAR teams requires involvement of its end-users who share their knowledge, experience and provide in-depth insights on the challenges they face. For example, the volcanic eruption of Geldingadalur in 2021 (Figure 1a) added extra challenges for Icelandic SAR teams; from searching for lost people, helping injured visitors and keeping everyone, including SAR volunteers, at a safe distance from lava and endangered grounds. The eruption was relatively close to the capital area, only approximately 50km away. SAR teams needed to be prepared and on duty 24/7. This scenario was unexpected when we started organising the design sprint in 2020, and it added an extra dimension and real-time element to the event. There were many red alerts for the area between March to September 2021, especially during the Auðna Technology Transfer design sprint, and still ICE-SAR members were dedicated to support the events and its participants with tours of their facilities,

demonstrations of their gear, by speaking about the challenges and supporting participants. The situation in Geldingadalur made the mission of this design sprint extra urgent and real. The circumstances are valued for beta testing PPE in different rescue specialty group trainings for earthquakes as well as mountain rescue, marine rescue and technical teams.

3 ACCIDENT PREVENTION

Achieving goals under uncertain conditions and extreme environments demands skilful action and learned strategies in order to make good decisions and avoid harm. Concepts surrounding risk of loss or harm occurring have preoccupied humankind in many different forms and cultural representations throughout history, often linked to deep socio-cultural, technological and religious transformations over time [6]. Those concepts are of great value in design and engineering education and need to be taken in account in R&D processes while working with niche user groups such as SAR volunteers.

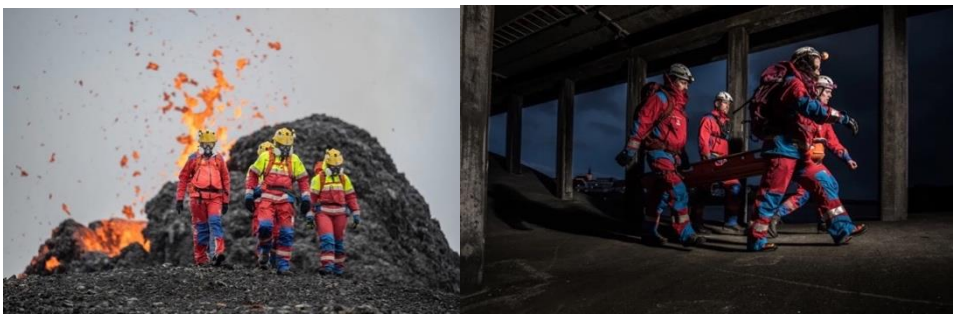

Figure 1a. Search and Rescue situation during the volcanic eruption in Geldingadalur, Iceland, 2021, 1b. Search and Rescue situation during the evacuation of victims, Iceland, 2021

4 ENVIRONMENTAL CONTEXTS OF SAR

Icelanders live with natural disasters of various kinds (Figure 1a, 1b). It is therefore important that in every area there is a group of volunteers who respond with knowledge and skills in an emergency. The nature of 'search' is that it is an emergency and every response involving a search must be immediate, therefore proximity is important. Around 100 rescue teams form a dense safety net throughout the country and their volunteers are ready to respond when shocks strike and accidents occur [5]. ICE-SAR volunteers are on standby 24/7 for emergencies. The rescue teams are specialized in search and rescue both on land and at sea. To be able to address the diverse tasks, the rescue teams are well educated in their fields and thoroughly trained. They strive to outfit their people to the highest standard, with both personal gear and specialist rescue equipment. In recent years, specialization within rescue teams has increased, making the work more purposeful: land and mountaineering groups, avalanche groups, marine rescue groups, diving groups, advanced groups, medical groups, technical teams, high-angle rescue groups, urban SAR, K-9 search dog groups and the International Urban Search and Rescue Unit (USAR) that is part of the International Search and Rescue Advisory Group (INSARAG) from the United Nations.

5 DESIGN BASED IMPLEMENTATION RESEARCH (DBIR) AND USER-CENTERED DESIGN

Design-Based Implementation Research, (DBIR) is an approach for working with multiple stakeholders such as researchers, designers, engineers, human factor experts, industry professionals, and governmental organisations. It aims to enable the collaborative identification of challenges, strategies, and design solutions while learning from the process to support innovations in new contexts [7]. There is a need for DBIR as a research approach that challenges educational researchers and practitioners to transcend traditional research barriers and facilitate the design of educational interventions that are effective, sustainable, and scalable. This approach was applied mainly during the development of the design sprint, specifically in the identification and integration of the contributors and their expertise. It is this latter aspect that warranted an integrated user-centred design approach.

User-centred design is based on 4 fundamental principles; (1) users are involved in the design process from the very beginning, (2) the importance of requirement clarification, (3) introduce a user feedback

loop in the product development cycle, with the collection and analysis of feedback from users regularly to support more user-focused decisions, and (4) an iterative design process. While Principle (1) was applied extensively prior to the Design Sprint, Principle (3) was prioritized during the sprint. The following section outlines how the sprint was developed and delivered.

6 TECHNOLOGY TRANSFER DESIGN SPRINT FOR SEARCH AND RESCUE: A PIONEERING EDUCATIONAL MODEL.

Designing for complex systems calls for the right know-how and creativity, coupled with extensive knowledge, practice and field testing. Industry partners can contribute further expertise, funding and equipment. This paper describes an innovative model for design and engineering education that brings user-centred design to this context with "risk-familiar users". For the Auðna Technology Transfer Design Sprint the primary user group were the risk-familiar ICE-SAR members, and they were the main users represented. The secondary group was highly diverse since anyone can become a victim: including children, the elderly, tourists, outdoor enthusiasts and employees across industries on water or land. The preparations for the Design Sprint took 1.5 years from ideation to execution and included several high-level discussions between stakeholders that were facilitated by Auðna - TTO Iceland. The main goal of the collaboration was to develop resilient solutions for the challenging work of Search and Rescue teams. In support of user-centred design, a questionnaire was distributed to 5000+ ICE-SAR volunteers to aid in identifying the challenges they experience. The responses were analysed and grouped into **8 high-level main challenge-topics**.

1. **Clothing & Equipment**
2. **Hygiene**
3. **Environmental Monitoring**
4. **Communication**
5. **Nutrition**
6. **Augmented Reality / Virtual Reality (AR/VR) for remote healthcare and situational awareness**
7. **Remote Power**
8. **Advanced Materials**

The programme included lectures, exercises, mentorship, multi-disciplinary teamwork and more. Participants were from multiple disciplines, including scientists, designers, engineers, nutritionists, emergency medicine physicians, ICT-experts, human factor experts, chemists and more. While typically industry projects are 6-7 weeks, this 4-day Design Sprint provided participants with the opportunity to develop and test concepts in real-time with experts and end-users as part of the process. The criteria for the solutions were assessed by the ICE-SAR management, which should: (1) add value for the ICE-SAR organisation by increasing the safety of SAR workers and people in need, and by increasing the efficiency of ICE-SAR operations and (2) be realistic to execute, with a plan on how to bring it to the market within the next 5 years.

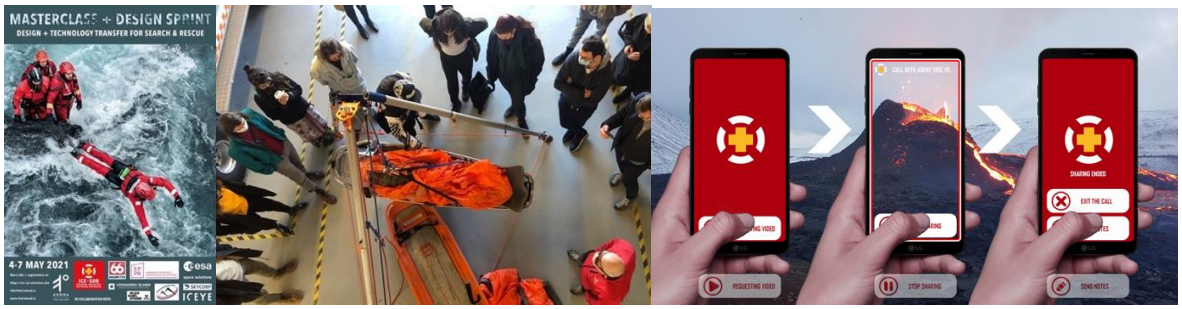

Figure 2a. Technology Transfer Design Sprint for Search and Rescue Poster 2021, 2b. Exercises and exploration of SAR challenges in the field during the Technology Transfer Design Sprint 2021. 2c. One of the solutions that teams came up with was a comprehensive real-time communication app.

The approach for Auðna Technology Transfer Design Sprint for ICE-SAR involved:

1. Identifying current challenges of SAR operations with ICE-SAR, suitable for design solutions (solutions were based on current challenges and the need to come up with implementable innovations).
2. Educating participants about Technology Transfer, SAR operations, and their operational environments.

3. Facilitating interdisciplinary teams to develop and design resilient solutions (products, systems, services) for the challenging operations of SAR teams.
4. Ensuring multi-disciplinary evaluation of proposals (SAR professionals, Arctic Council EPPR Working Group (Emergency Prevention, Preparedness and Response), ESA Space Solutions, ARCSAR (Arctic Security and Emergency Preparedness Network), industry professionals, explorers, design educators.
5. Bringing academia, industry and governmental organisations together to increase the chance for positive change and networking.

7 A HYBRID COLLABORATIVE PLATFORM

The design sprint model presented in this paper used a hybrid collaborative platform (Figure 3a, 3b) developed by the company East of Moon that had been applied to previous hackathons, across a range of fields. Of note, the platform was used as a key tool during the planning and development process and then was shared and provided as the key collaborative tool for all participants and contributors during the event. This real-time, on-line platform enabled a comprehensive and visual overview of all the topics, challenges and solutions for the workshop host, ICE-SAR and other partners, and it provided a way for the participants to share ideas, give comments and suggestions, get feedback from SAR mentors and other experts, and work in interdisciplinary teams despite different time zones.

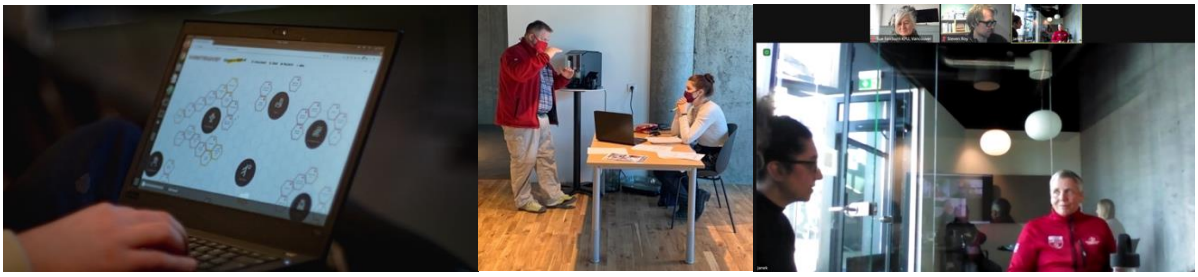

Figure 3a. Collaborative mission development online hybrid platform, 3b. Direct feedback from on-site and remote SAR volunteers (image credit: Auðna Technology Transfer Office). 3c. Cross-disciplinary team-based working; remotely Canada/Iceland and on-site/in-person (image credit: S. Fairburn).

8 RESULTS, FINDINGS, AND INSIGHTS

Having SAR volunteers as primary users and advisers in the design process allowed students to work in collaboration with a unique skill set, knowledge base and culture. The Auðna Technology Transfer design sprint proved itself relevant for the field of SAR while simultaneously offering intense, immersive learning to diverse student groups working in multidisciplinary teams, both on-site and remote. During the design sprint there was a red alert situation with an ongoing volcanic eruption in Geldingadalur (Figure 1a). Despite this massive operation that took most of ICE-SAR attention during this period, ICE-SAR mentors were dedicated to contributing and supporting the design sprint activities between their shifts, further evidence of their commitment to the development of PPE suitable for their specific rescue contexts. This design sprint model accelerated the learning process of participants and enabled them to adopt a "field intense" attitude. There were 6 teams and each team generated 2-3 concepts. Team concepts included: smart solutions for better real-time communication systems, new solutions for nutrition, an improved a lightweight rescue stretcher among other solutions for hypothermia and hygiene in extreme conditions. Each team presented one concept to a high-level panel who gave valuable feedback. A month after the event, another feedback session was hosted with the ICE-SAR management, where participants presented further developed concepts and received additional feedback:

"The design sprint was a great learning experience. The online platform gave us the chance to work with people in different time zones on SAR challenges with direct feedback from SAR mentor and others. It allowed people with different backgrounds and expertise to collaborate, which is relevant for any product development process." – A. Grenier, Master student, Icelandic University of the Arts.

"It was such a unique experience for us here at KPU in Canada to be able to participate remotely..." – B. van Rikxoort, year 3 student, Wilson School of Design, KPU.

"It was more intense than was expected. We had to learn to split our workload, use skills faster, and we realised that you don't need to focus on details." – Gavin Grace, Wilson School of Design, KPU.
"It´s a fantastic initiative that we can co-create solutions for the challenges that our Search and Rescue operations face through the Auðna Technology Transfer Design Sprint. I look forward to continuing this collaboration and connecting this platform to the international biennial SAR conference (RESCUE)"– Guðbrandur Örn Arnarson, operations manager, ICE-SAR.
The participation of ICE-SAR members in the design process was a huge factor in the successful results of the teams. The ICE-SAR organisation attained ideas out of the Auðna Technology Transfer Design Sprint that can be implemented in their operations, with further opportunity to develop projects with the support of Auðna – Technology Transfer Iceland and other collaborators. The next steps are to continue and expand this platform and strengthen international cooperation on SAR and security operations further and bring to market a selection of relevant projects developed through the platform.

9 CONCLUDING THOUGHTS

The Technology Transfer design sprint proved itself relevant for the field of SAR while simultaneously offering intense, immersive learning to diverse student groups working in multidisciplinary teams, both on-site and remote. Bringing industry, professionals, governmental organisations, policy makers, researchers, designers, engineers and other creatives together, resulted in an opportunity for interdisciplinary collaboration and innovation, with the added support of the real-time collaborative platform. This hybrid: real-time/on-site/on-line model could be translated and expanded internationally and to other remote or extreme contexts. It created an immersive and relevant learning experience for all participants, especially with an ongoing volcanic eruption and proximal real-time emergency. Prioritizing user needs and contexts, and striving to create user-focused design, leads to products that better match user needs, especially when the lives of others depend on them.

REFERENCES

[1] Auðna – Technology Transfer Office Iceland (2018). Available: *https://www.ttoiceland.is* [Accessed on 28 January 2022].
[2] Lenagh A. (2012) UNeMed. Available: *https://www.unemed.com/blog/the-importance-of-technology-transfer* [Accessed on 28 January 2022].
[3] Knapp J. and Zeratsky J. (2016) The Design Sprint: How to Solve Big Problems and Test New Ideas in Five Days. Available: *https://www.thesprintbook.com/the-design-sprint* [Accessed on 28 January 2022].
[4] Thoring K., Klöckner H. and Mueller R. (2022), Designing the Future with the Delphi Sprint: Introducing a Novel Method for Design Science Research, Proceedings 55th International Conference on Systems Science, [Accessed 29 April 2022] Available: https://scholarspace.manoa.hawaii.edu/bitstream/10125/80046/1/0566.pdf
[5] Arnarson B. Ö. (2022), Icelandic Association for Search and Rescue. Available: *https://www.landsbjorg.is/icelandic-association-for-search-and-rescue* [Accessed on 8 February 2022].
[6] Lupton D. (2013) Risk, 2nd ed. New York: Routledge. Available: *https://www.academia.edu/2078301/Risk_2nd_edition_2013_London_Routledge* [Accessed on 6 March 2022].
[7] Ryoo J. (2015), Exploratorium, Design-Based Implementation Research. Available: *https://www.exploratorium.edu/sites/default/files/pdfs/brief_DBIR.pdf* [Accessed on 6 March 2022].