

GCI Topics Scope Document

2022 GCI Summit Meeting Materials *For reference during Topic Workshopping Sessions*

Overview

Our approach with the [Grand Challenges Initiative](#) is to begin with topics that are not unique to fire engineering, but instead represent pressing global challenges where fire safety science and engineering can contribute to ongoing discussions that affect the daily lives of billions. Rather than selecting these unilaterally, the SFPE Foundation polled members of the SFPE community and other stakeholders to solicit input. Based on survey and interview feedback, the [April 2022 GCI Summit](#), resulting working groups, white papers, and implementation efforts will focus on the four topics listed below.

At the 2022 GCI Summit, the “Topic Workshopping Sessions” in the program will provide an opportunity for all attendees to share their views on how fire engineering can contribute to solving challenges in each of the four topic areas with respect to four main questions:

1. What’s missing from the list for this topic area (see below)? What aspects of these problems are suited for engineering-based resources or tools?
2. What do we know already? What tools or resources can we use today?
3. What tools, resources, or knowledge is missing? Where are the gaps? Where are the barriers/challenges to contributing?
4. Who needs to be involved to see progress in this area?

To facilitate that discussion, SFPE Foundation staff and the GCI Student Research Fellows have compiled the initial lists below to begin to scope out the range of areas where fire engineering can contribute to solving problems in each grand challenge topic area. These lists are just a starting point for discussion – we want feedback from all GCI Founding Partners and GCI Summit participants to help shape the priority areas. Your input in these sessions will inform the initial outlines for the white papers being developed by our Working Groups over the next year. Now is the time to share your views on where and how fire engineering can contribute, what our priorities should be as a field, and how we can get there over the next 10 years.

Energy & Infrastructure

New (renewable) energy sources provide significant opportunities for sustainable development, but also raise new questions, including about fire safety. These energy sources also require new infrastructure to support them, at a time when the general renewal of the (US) infrastructure is at the top of the agenda. Representative topics in this area include:

- 1. Fire hazards of new sustainable energy technologies (ET)**
 - Solar/wind/solid and liquid biomass/RDF/Hydrogen based
- 2. Energy storage systems**
 - Manufacturing (fire and explosion risks in process chain, e.g., of metal hydrides for H₂ storage, reliability of processes)
 - Handling & transporting (safe transportation/HazMat procedures and definition)
 - Use/Disposal (Safer chemistry, inspection, monitoring, containment, resilience and ageing of systems, safe disposal procedures)
 - Safety standards implementation/revision
- 3. Transport/vehicle fires**
 - Private and public transport new technologies hazards
 - Fuel cells
 - Batteries
 - Tunnel fire protection, evacuation, design fires
 - Fire safety of portable mobility vehicles (e.g., Charging and safe procedures for bikes, scooters)
- 4. Fire protection for new energy technologies**
 - Fire suppression (efficacy, system design criteria)
 - Fire passive protection
 - Fire detection/alarm/communication systems
 - Firefighting training for new energy technologies
 - Smoke control systems
 - Durability/ageing of FP components
 - Failure modes due to extreme environments (Maritime and air transport; electrical, hydrogen fueled)
 - Designing considering first responders
- 5. Fire modeling**
 - Spread models
 - Fire effects on building/infrastructure electrical systems
 - Nonstandard fuels heat profiles in fires
 - Heat radiation, blast waves effects on infrastructures
 - Human behavior in fire from new ET
 - CFD modeling improvement
 - Heat transfer modeling for energy storage cell design
- 6. Risk assessment**
 - Fire frequencies (new and old ET)
 - Availability of FP systems, failure on demand
 - Guidance for quantifying measurement and calculation uncertainty
 - Reliability & repeatability of fire tests
 - Human errors assessment methods
 - Fire accident reporting/case studies investigations
- 7. Traditional energy systems & industrial infrastructures**
 - Improvement to petrochemical equipment safety
 - Model for safely designing tank farms



Contact us:

Leslie Marshall, Ph.D.
Director, SFPE Foundation
9711 Washingtonian Blvd., Suite 380
Gaithersburg, MD 20878
+1 (301) 718-2910
foundation@sfpe.org

- Improvement of risk management practices at chemical facilities
- Improved identification of high-risk industrial facilities
- Revision/implementation of installation and safety standards
- Data for hazard identification/severity
- Components ageing effect on fire safety

Resilience & Sustainability

Increasing efforts to build and live in sustainable ways and to improve the resilience of communities against environmental challenges, including fire events, open up new areas of research. Representative topics in this area include:

1. Building Material/Practices

- Assessing fire hazards of new building materials/practices
- Data on:
 - Combustibility of external cladding systems
 - Fire loads for structural fire engineering
 - Effectiveness of existing/new fire safety solutions
- Structural FP performance
- Quantification of structural fire resilience
- Post-fire seismic behavior
- Adequacy of passive fire resistive construction
- Standardized/accepted approach for developing material properties
- Retardant behavior
- Building material properties as inputs for fire models

2. Best practices/Guidelines

- Best practices for retrofitting existing buildings to achieve equivalent levels of safety (and sustainability)
- Development of design tools/best practices for fire safety engineering for resilient systems/buildings
- Corrosion protection design best practices
- Guidelines on suppression effectiveness at various heights
- Lessons learned to reduce risks in developing countries

3. Fire risk

- Fire risks in new (public) transport technologies
- Development of risk-based analysis to compare hazards of fire to long-term health impacts of fire mitigation measures
- Risk assessment/management systems
- Evaluate fire hazards of flammable refrigerants
- Risk- and reliability-based methods for ITM of fire protection systems
 - Preventative and predictive maintenance
 - Human impact on ITM reliability
 - Reliability of installed equipment

4. Fire protection design

- Identify/quantify sustainability benefits of smoke control systems and natural ventilation
- Life expectancy of installed fire protection systems
- Evaluation of
 - Smoke control systems impact on reduction of risk of losses
 - Adequacy of passive fire resistive construction
 - Effectiveness of fire stop installation by multiple trades versus certified technicians
 - Life quality indices to assess FP performance
- Cost-effective and resilient FP practices for developing countries
- FP System design

5. Environmental impact of fire testing



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foundation@sfpe.org

6. **Demographics**
 - Vulnerable populations
 - Anthropometry
 - Cultural differences
7. **Quantification of building code performance data**
8. **Naturally occurring events**
 - Rate, severity
 - Fire as a secondary impact
9. **Effect of firefighting interventions on occupant risk**
10. **Tools to evaluate impact of ventilation on compartment fires**

Climate Change

The impacts and challenges of a changing climate have been increasingly visible, most obviously in the form of new and growing threats of wildfires and extended droughts. Representative topics in this area include:

- 1. Impact of climate change on fire safety**
 - Role of climate change in fire hotspots
 - Risks or the likelihood of wildfire in warmer, drier and drought conditions
 - Longer fire seasons
 - Extreme ambient conditions, local demographic characteristics
- 2. Impact of fires on environment**
 - Environmental and health impacts of fire and fire suppression activities
 - Flame retardant/extinguishers toxicity
 - WUI fire ecology and long-term effect
 - WUI fire hazard identification and quantification
 - Ecology (post-fire effects - mortality, seasonality, climate change, resilience)
 - Remote sensing (pre- and post-burn fuels measurements)
- 3. Understanding fire spread in WUI and urban fires**
 - Fundamental WUI Fire behavior and fire spread
 - Impact of WUI firebrands
 - Ignition of WUI materials (Human/Natural)
 - Common characteristics between fire spread in WUI fires and urban fires
 - Smoldering combustion, and sustained burning
 - Interaction of local topography, weather, vegetation, and structures
 - Applicability of current fuel models for local species
 - Flammability data base for native/local species and new materials
 - Extreme fire behavior: trench effect, fire whirls, etc.
 - Post fire investigation and lessons learnt from WUI fires
 - Assessment of design fire scenarios
 - WUI risk management (temperature and heat exposure on people and structures)
- 4. Risk assessment**
 - Growth of the Wildland-Urban Interface
 - Risk assessment of WUI structures/ Design against exterior building fires
 - Risk of combustible fuels/ignition sources in WUI/wildland
 - Informal settlements in WUI
- 5. Firefighting/Mitigation/Prevention**
 - Building fire protection in the Wildland-Urban Interface (WUI)
 - WUI firebrand ignition prevention
 - Impact of WUI on fire service
 - Fire fighter safety, Firefighting PPE and tools (Fire Service/Data)
 - Strengthening firefighter technology (aerial water/foam-based agents)
 - Reliability of
 - Water supplies
 - Suppression systems failure modes, aging, and complex systems

- Compare/contrast tactics internationally to determine impact of firefighting/construction differences on fire growth/severity
- Model fire department response leading to better models of
 - Reverse evacuation
 - Egress/ingress
 - Duration of water for FP systems
 - Structural collapse
 - Firefighter response recreation and training aids
- Wildland/WUI fire damage mitigation
- WUI fire remote sensing, warning, and notification/communication
- Advanced tools for planning/response
- Satellite-based information of Vegetation survey, Fire detection, Burnt area
- Firefighter injuries (Fire Service/Risk)

6. Safe evacuation and guidance

- Human behavior analysis
- Emergency management strategies/Predesignated places
- Educating and preparing the public awareness of WUI fires
- Training about fire prevention and safety for homeowners, land managers and fire agencies

7. Cost analysis

- Cost of fire events
- Cost of suppression v/s effectiveness v/s risk
- Cost/benefit of different types and multiple levels of FP measures

8. Codes and standards

- Fire safety regulations improvement/ revision of existing prescriptive codes
- Data to support WUI codes and standards
- WUI specific Performance-based design to meet the objectives of life and property protection
- Existing buildings

9. Urban Planning

- Landscape planning tools
- WUI resilience design tools
- Safety distances in WUI
- Hazard Maps

10. Computational Model

- Simulation & Model Prediction
- WUI fire behavior prediction tools
- Wildland/WUI fire modeling
- CFD code Validation

Digitalization, Artificial Intelligence, & Cybersecurity

Digitalization and artificial intelligence play an increasing role in our societies, not only in business environments but also in people's personal lives (e.g., through AI implementation on their cell phones). With this increased role come new opportunities to draw on these tools to increase fire safety. Representative topics in this area include:

1. **Use of cloud-based home/consumer devices to pinpoint fire origins**
2. **Drawing on cell phones to develop smart egress systems**
3. **Big data and AI-technologies to model building fires**
 - Data collection for fires
 - Construction and management of fire database
 - Advanced AI technologies
 - Reliability and uncertainty of AI model
4. **Data mining to identify chemical process deviations**
5. **Behavioral response to emergency notifications**
6. **Combined fire and evacuation models**
7. **Behavior based models**
 - Cultural
 - Pre-evacuation time
 - Actions other than evacuating
8. **Risk/probabilistic models of Human Behavior regarding:**
 - Residential buildings
 - Large populations
 - Community level
 - High-challenge environments
 - Quantifying the level of "life safety" in a building
 - Effects of fire on visibility and gases
 - Impact of public education on fire risk
9. **Building information modeling**
10. **Smart buildings**
11. **Improved test methods**
12. **Integrated FP systems and building connectivity**
13. **Smart firefighting**
 - IoT integration
 - Mechanical augmentation
 - Fire department communication with BIM
 - Firefighter tracking and location
14. **Automated, quantifiable exposure monitoring**
15. **Massively parallel computing**
16. **Digital recordings of distributed control systems and programmable logic controllers**
17. **Digital data collection (black boxes)**
18. **Fire scene identification based on computer vision technologies:**
 - Identification of building dimensions, fire location, and sizes
 - Overview of large scenes from drones
19. **Linking of 3D scanning technology with computer fire models**
20. **Methods to preserve evidence**
21. **Tools to extract data from digital sources**
22. **Improved software to create multiple-source dynamic event timelines**



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- 23. Simulation tools to recreate process conditions in chemical plants
- 24. Advanced calculation methods to evaluate hypothesis
- 25. Tools to estimate damage effects
- 26. Virtual reality/augmented reality to describe and test scenarios
- 27. Potential ethic issues (cybersecurity, privacy, models based on AI)