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Hazard Note

Natural Hazards Research Australia

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What makes a good fire simulator?

About this project

Fire simulators play an important and growing role in fire management today. But despite their widespread use, there are still many questions about how fire simulators are used and what is required to ensure they are fit for purpose.

To address these knowledge gaps and identify user needs and priorities, a comprehensive engagement process was undertaken with Australia's fire simulator users. Key principles were identified that can inform future simulator design and development to best meet the needs of Australian fire managers and researchers.

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Learn more about this project

naturalhazards.com.au/research/research-projects/what-makes-good-fire-simulator

Summary

Fire simulators are specialised computer programs that represent the key drivers involved in the spread of fire through a landscape. Simulators are widely used in Australia in both fire management and research, yet there are many unknowns about the needs and priorities of simulator users. The aim of this project was to engage with Australia's fire simulator users to gather insights to provide a strong platform for future development and use of these important tools.

Through interviews (21 participants), 2 workshops (26 and 25 participants) and a questionnaire (67 responses), fire simulator users were asked, "In your opinion, what makes a good fire simulator?"

Responses highlighted that simulator user needs are diverse, evolving, and highly context-dependent. The specific requirements of users were difficult to establish due to this complexity and variation. Nevertheless, some patterns did emerge. Users consistently highlighted the importance of social factors, suggesting that meeting technical simulator criteria will be necessary but not sufficient going forward. Users also indicated that trust in and support for simulators and their outputs depend upon a combination of robust research and regular engagement and communication between stakeholders, as well as proven reliability and success of the tool.

The following criteria were consistently identified as relevant in ensuring fit-for-purpose fire simulators:

- ease of use
- speed
- configurability
- versatility
- robustness of modelling framework
- effectiveness of software framework
- handling of inputs
- handling of outputs
- scale
- validation
- support
- trust
- compatibility
- value for money.

A set of principles is suggested, rather than quantitative benchmarks, as a flexible way to ensure simulators meet user needs and are fit for purpose. These principles could be used to guide simulator development and use, while allowing flexibility to meet changing local, organisational and sectoral needs.

Above: The needs and priorities of bushfire simulator users are unknown, even though bushfire simulators are widely used by fire managers and researchers. Photo: Alan Daniels

Background

Fire simulators are key tools, relied on to support high-consequence decision-making across Australian states and territories. However, there are no agreed standards for simulators that can be used to ensure their fitness for purpose. This means there is limited guidance for simulator developers about making trade-offs, while agencies have no objective criteria on which to base decisions to adopt new simulators. Trade-offs between simulator criteria are integral to their development and use. A simulator user, for example, must trade off the time and labour required to develop an output against the detail, accuracy and communicability of results. Trade-offs also extend beyond the performance and capabilities of a specific simulator and include financial costs, computing and data requirements, and staff development requirements.

As a result, it is critical that simulator development is based on a deep understanding of user needs.

AFAC Predictive Services Group engaged two working groups (science and operations) to guide the development of the Spark fire simulator. However, both groups identified a substantial knowledge gap relating to understanding the specific needs from an Australian fire simulator:

- how existing simulators are currently being used or will be used in the future
- the standards required to make simulators fit for purpose
- the full picture of user priorities for simulator improvement or development.

The Spark working groups jointly developed the proposal for this project to resolve these knowledge gaps.

Research methodology

This engagement-focused project proceeded in 2 phases. Phase 1 focused on the identification of key themes and important areas of consideration for fire simulator development and use. These included different objectives for simulator use, different types of users, knowledge and data gaps, simulator performance criteria, limitations of current systems, and future challenges.

Phase 1 consisted of:

- **review** of Australian fire simulator literature to ensure that the engagement aspects of the project were informed by the latest research into fire simulators
- **semi-structured interviews** to identify issues and themes
- **2 workshops** to discuss and, where possible, quantify issues.

Findings from Phase 1 were used to inform stakeholder engagement in Phase 2.

Phase 2 consisted of **an online questionnaire** to quantify the issues and themes raised in Phase 1.

Participants were selected in consultation with the project management team to represent the diversity of the Australian fire simulator user community. This included a mix of jurisdictions and sectors (management, research, and private organisations). Early consultation suggested 3 distinct use cases. These were Tactical and Strategic (both generally restricted to fire agencies) and Research (within research organisations, fire agencies and consultancies). An additional category, Other, was used for community education, training and any other uses that did not fit into Tactical, Strategic or Research. While users generally associated themselves with one of the use cases, many operated simulators across multiple activities and use cases.

Research findings

The project found that simulator user needs are diverse, evolving and highly dependent on context. This complexity and variation made it difficult to determine a set of specific end-user requirements. Nevertheless, some patterns emerged.

- Users consistently highlighted the importance of social factors, suggesting that meeting technical simulator criteria will be necessary but not sufficient going forward.
- Trust in and support for simulators and their outputs depend upon a combination of robust research, regular engagement and communication between stakeholders, and proven reliability and success of the tool.
- Several criteria were identified as consistently relevant to ensuring fit-for-purpose fire simulators. These were ease of use, speed, configurability, versatility, robustness of modelling framework, effectiveness of software framework, handling of inputs, handling of outputs, scale, validation, support, trust, compatibility, and value for money.
- Out of the three main user groups (Tactical, Strategic, Research), Tactical users prioritised speed, ease of use and operational support; Strategic and Research users valued configurability and a robust modelling framework; and Strategic users also valued high-quality outputs. Overall, there were generally not clear distinctions between different use cases in terms of which criteria were important and how important they were.
- Highly diverse fire regimes and risk profiles, and significant differences in organisational and regional resources and capacity, make jurisdiction and geography important factors for developers to consider.
- Although there was a desire to establish objective, quantitative technical benchmarks for simulator performance, this proved difficult in practice because of the variety of responses and the contingency of answers. A set of principles may be a more flexible way to ensure simulators meet user needs and are fit for purpose. These principles could be used to guide simulator development and use, while allowing flexibility to meet changing local, organisational and sectoral needs.
- Within Australia's simulator 'ecosystem', some of these principles are already being implemented, while others may require more work.

Principles include:

- Drive simulator performance capability through improved fire behaviour modelling and improved quality and coverage of input data.
- Improve usability of fire simulator software and hardware, including platform stability, outputs that facilitate effective communication with audiences, and ongoing support for users and partners.
- Adopt a comprehensive and transparent approach to validation and verification, applicable to simulators and their inputs, and extending beyond accuracy to outcome-based evaluation.
- Maintain a cohesive approach to development and use through effective governance, capacity building, and inclusive and ongoing consultation between users, audiences and developers.

Table 1 describes priorities and possible actions to implement these principles.

Above: A group of people standing next to a fire. Photo: Department of Fire and Emergency Services Western Australia

Table 1: Principles, priorities and actions

Principle	Priorities	Actions to consider
Drive simulator performance through improved modelling and data	**Expand and improve simulator capability**	→ Maintain a pipeline of short- and long-term improvements to models and modules.
	Improve the availability and quality of input data	→ Expand and improve existing input data collection methods, including via automation where applicable. → Improve access and usability of input data. → Provide guidance on influence of input data scale and resolution on model performance.
Improve usability of fire simulator software and hardware	**Ensure user-centric design in development of simulator interfaces**	→ Develop front-end user interfaces to reflect new technology and scientific knowledge. → Develop intuitive and efficient workflows. → Maintain consistency, where possible, across versions and updates. → Maximise user customisability (e.g. dual modes for 'general' and 'expert' users). → Build troubleshooting support into simulators (e.g. error prompts).
	Improve stability and usability of hardware and infrastructure	→ Maintain a pipeline of short- and long-term improvements to infrastructure. → Provide offline and low resource (e.g. data, memory, computing power) alternatives for simulators.
	Improve interpretability and communicability of outputs	→ Improve transparency and customisability of outputs. → Develop a standardised reporting format for outputs that includes key points such as model assumptions and uncertainty. → Provide training and support in interpreting simulator output for audiences.
	Provide comprehensive support for simulator users and audiences	→ Ensure diverse support options are available for users and audiences. → Agree upon whether training should be nationalised or accredited.
Adopt a comprehensive and transparent approach to validation and verification	**Establish performance standards**	→ Establish standards for evaluation, verification and validation of simulators, models and data. → Establish a mechanism for reviewing and updating standards alongside evolving technology and contexts of simulator use.
	Emphasise transparency and traceability	→ Establish guidelines or expectations for documenting simulator function, simulator use processes and simulator outcomes. → Automatically collect data on the simulator use process when running a simulation.
	Establish outcome-oriented evaluation	→ Understand the effect of simulator outputs on fire management outcomes. → Develop a process for reporting simulator outcomes post-event.
Maintain a cohesive approach to development and use through governance, capacity building and engagement	**Establish effective governance**	→ Establish a clear long-term vision for future research, development and use of simulators. → Develop strategies for the integration of new science, capacity building, communication and infrastructure. → Reflect on whether current tools are appropriate for intended purposes or if alternatives may be better suited. → Consider the benefit-to-cost ratio of all proposed development and change. → Engage with ethical questions (e.g. around access, resourcing, responsibility and human–computer interactions).
	Prioritise engagement	→ Develop formal and informal mechanisms to engage a wide range of stakeholders at all stages of development to meet their evolving needs. → Consider the logistics and resources needed for ongoing, long-term stakeholder engagement.
	Build capacity	→ Develop strategies for capacity building tailored to user needs.

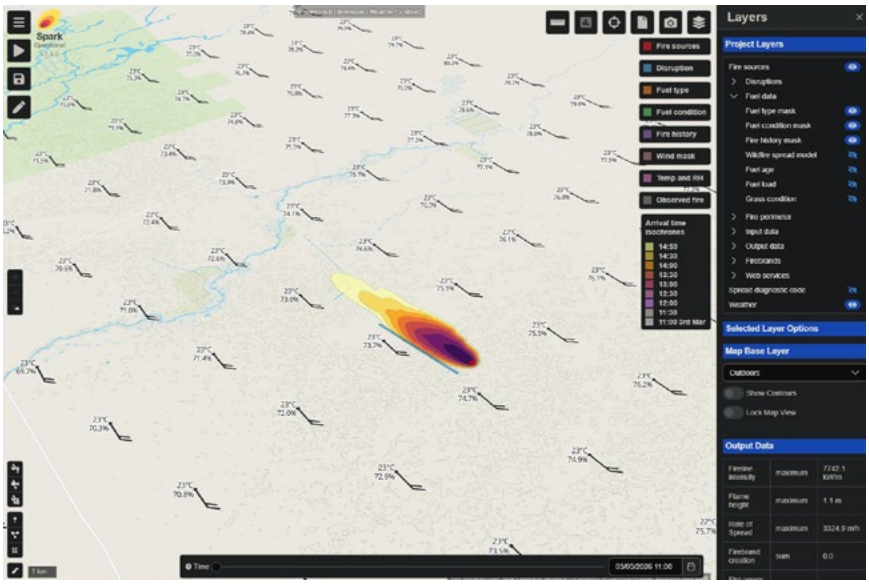
Research impact

Fire simulator users represent a large body of knowledge with a willingness to engage substantively about the process of simulator development and usage. This valuable resource has the ongoing potential to be leveraged with appropriate consultation and engagement with Australia's fire simulator ecosystem.

The findings from this research suggest that generalising user priorities and requirements or creating objective standards for simulator development may not be the best way to ensure simulators meet user needs and are fit for purpose. As an alternative to standardising simulator development, this report puts forward principles for the future development of fire simulators. These have been designed as a guide to ensure that the needs, priorities and values of the bush fire sector inform and drive simulator development and use, not as a prescriptive set of instructions for simulator development.

Consequently, the findings and outputs are generalised to achieve the following:

- Consolidate the vast and variable knowledge and perspectives of fire simulator users across Australia, and document their requirements and priorities for future improvements to fire simulators.
- Provide guidance to the fire management sector for how to strategically and collectively improve fire simulators.
- Serve as a reference document for simulator developers, including as a checklist of important areas for consideration in simulator development that can sit alongside and inform detailed in-house simulator-specific directives.



Above: An example of a fire simulator. Photo: CSIRO

End-user statement

Thomas Duff, Fire Risk, Research and Community Preparedness, Country Fire Authority, Victoria

"An understanding of user needs is critical for ensuring that decision-support tools are fit for purpose. This project was designed to engage with users of fire simulators to gain a better understanding of what they use simulators for and – in their opinion – 'what makes a good simulator'. This information will be important to support the development of cutting-edge fire simulator systems for uses including real-time fire decision-making, identification of landscape risk and gaining insight into the processes and mechanisms driving fire impacts."

Further reading

Future outputs from this project will be available on the website project page at: https://www.naturalhazards.com.au/research/research-projects/what-makes-good-fire-simulator

Fox-Hughes P , Bridge C, Faggian N, Jolly C, Matthews S, Ebert E, Jacobs H, Brown B & Bally J (2024) An evaluation of wildland fire simulators used operationally in Australia, *International Journal of Wildland Fire*, 33(4), https://doi.org/10.1071/WF23028

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