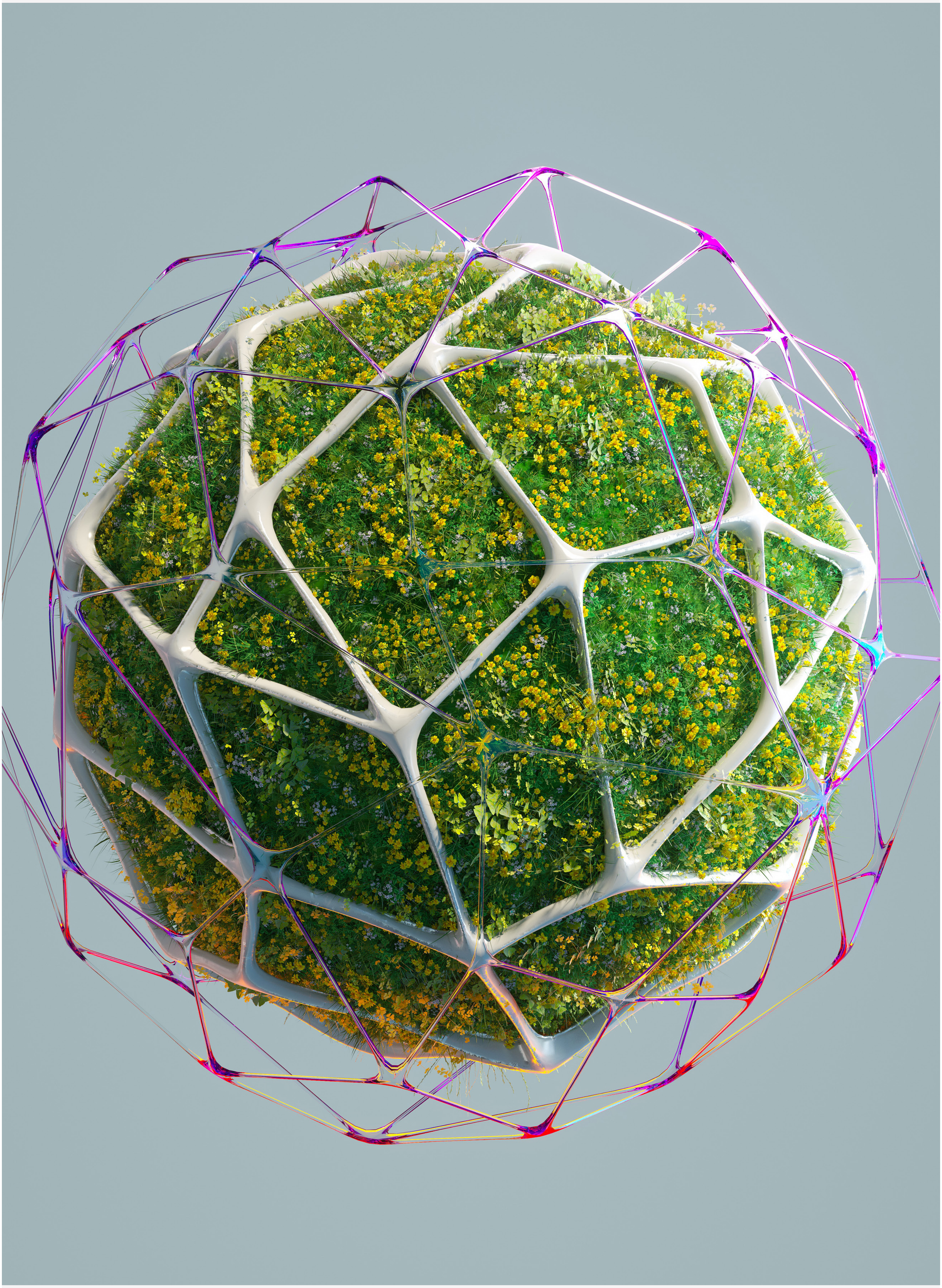
SABRE ALLIANCE

Safeguarding Australia through Biotechnology Response and Engagement

Vignette Trends Analysis and Learnings (VITAL) for Key SABRE Operational Themes: A 2023 Outlook



Authors

Patrick Thomas, Irene Caminschi, Amelia Vom, Kate Shields, Mark Hutchinson and Craig Rogers

Produced by

Safeguarding Australia through Biotechnology Response and Engagement (SABRE) Alliance

Land and Joint Warfare
Defence Science and Technology Group
Department of Defence
PO Box 7931
Canberra BC ACT 2610

www.dst.defence.gov.au

Telephone: 1300 333 362

CG: JUL002-23

Executive Summary

Defence launched the Safeguarding Australia through Biotechnology Response and Engagement (SABRE) in July 2022. SABRE seeks to bring together biotechnology capabilities from Australia's universities, research institutes, manufacturers, and small businesses to connect them with the needs of the Defence and National Security sectors. The SABRE Alliance stakeholders strategically draw, leverage and grow capability, capacity and expertise from across the Australian biotechnology to enable Defence and National Security to benefit from biotechnology opportunities and build capability to mitigate potential future threats.

Here, we describe a systematic, subject matter expert led, and transparent set of vignettes (simulated threat scenarios) to draw out operational concepts developed by representatives from defence, industry and academic biotechnology organisations. This approach was devised to aggregate hundreds of interdisciplinary inputs and yield results that are meaningful for industry, academic and government decision makers. These vignettes addressed converging themes of cross-sector partnerships, international cooperation, emerging technologies, and collaboration between governments, biotechnology industry, and academia to mitigate complex national security challenges. We aim to describe this approach widely in order to enable its broader dissemination amongst other interested stakeholders.

In the first vignette, experts present the threat posed by a multifaceted and unknown agent to Defence personnel and humanitarian aid workers in a deployed disaster relief environment. The discussion emphasises the importance of cross-sector partnerships to identify vulnerabilities and mitigate risks in these complex systems. Focusing on the need for international cooperation in addressing transnational threats, the **second vignette** addressed the threat to National Security posed by a biologically engineered organism (illustrating a chemical, biological, radiological, and nuclear [CBRN] synthetic biology scenario). Participants were positioned to emphasise the need for intelligence sharing, emerging technologies to detect, attribute and assess the hazards posed by the threat, and collaborative efforts to disrupt malicious organism spread. **The final vignette** addressed the challenge of Australia's response to a highly contagious viral animal biosecurity incursion. Participants faced a national agricultural threat and addressed the needs for wide area surveillance, open data sharing approaches, and collaboration between governments, biotechnology industry, and academia to mitigate the real-world threat.

Contents

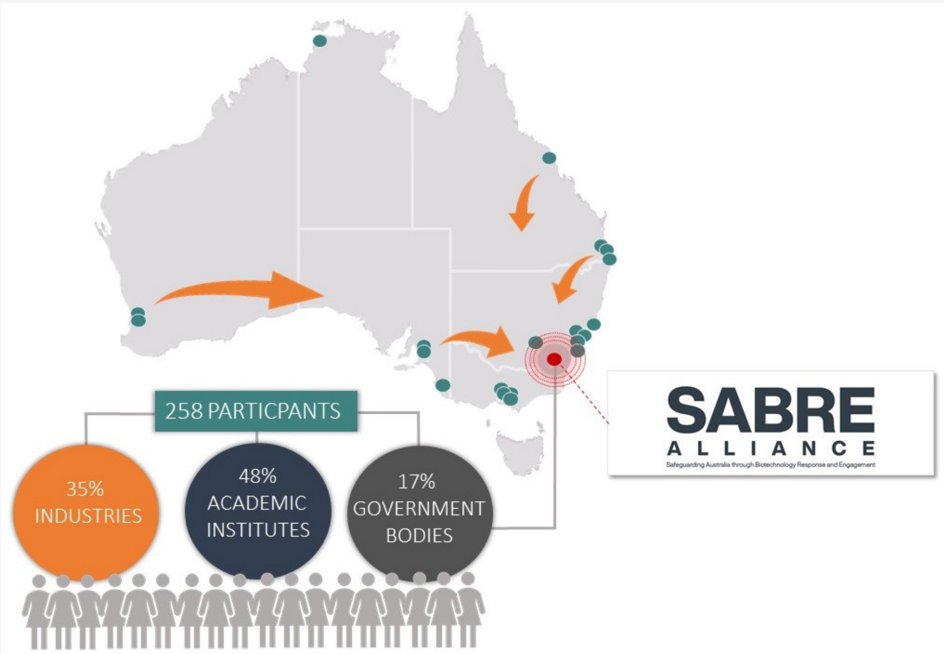
Glossary

SABRE	Safeguarding Australia through Biotechnology Response and Engagement
DSTG	Defence Science and Technology Group
ADF	Australian Defence Force
CBRN	Chemical, biological, radiological, and nuclear
PPE	Personal protective equipment
NGO	Non-Governmental Organisation
GC/MS	Gas chromatography–mass spectrometry
AI	Artificial intelligence
ML	Machine learning
eDNA	Environmental deoxyribonucleic acid
HADR	Humanitarian Assistance and Disaster Relief
WB	Wheat Blast
LSD	Lumpy Skin Disease
R&D	Research and development
HQ	Headquarters
DIVA	Differentiating Infected from Vaccinated Animals
RFID	Radio frequency identification
IoT	Internet of Things
CRC	Cooperative Research Centre

1. Objectives and Goals of Utilising Vignette Based Scenarios

By bringing together diverse perspectives and expertise, the workshop emphasised the importance of partnership and innovation to build stronger, more resilient systems that can adapt to the evolving threat landscape. Throughout the event, over 200 participants across the 3 separated spaces were immersed in these vignettes, designed to showcase how Safeguarding Australia through Biotechnology Response and Engagement (SABRE) could rapidly connect key capabilities to respond swiftly in a live-threat environment. The purpose of these vignettes was to develop collaborations and to converge toward improved biotechnology capabilities for a diverse array of Australian biosecurity threats.

The *Building the SABRE Biosecurity Alliance event* in Canberra drew in over 240 participants across the biotechnology ecosystem, with 48% from academia, 35% from industry and 17% from Government/Defence.



1.1.1 Objectives for the SABRE alliance

- Allow exploration and identification of what constrains the solution discovery and delivery process (e.g. knowledge gaps, human factors, legislation, siloing, geography, and funding)
- Help stakeholders realise and identify existing challenges within the sector.
- Help stakeholders identify teams and individuals with capabilities and capacity.
- Allow for cross vignette incubation of ideas and solutions.
- Identify opportunities for new collaborations leveraging capabilities across sectors (e.g. AI, space, materials and biotechnology)

- Create excitement for convergent solutions and formation of mission driven and diverse teams.
- Build awareness of SABRE with senior government/industry/academia and its value of participation and support.

1.1.2. Goals of the vignettes:

- Identify and characterise the threat.
- Identify key emerging technology, which with strategic investment, could be positioned to meet the future threat/s.
- Identify capabilities required, where to access existing capabilities and potential constraints.
- Identify pathway(s) including funding and infrastructure to develop a new solution (i.e. realistic, and real-world).
- Identify opportunities for dual use applications.
- Identify opportunities for new collaborations leveraging capabilities across sectors (e.g. AI, space, materials, and biotechnology).
- Minimise adverse human health impact, and economic and food supply disruption.
- Operate safely and effectively.
- Minimise casualties.
- Operate within legal and regulatory frameworks.

1.1.3. Professional challenges:

1. What regulatory frameworks do these solutions fall under?
2. Identifying potential buyers and consumers
3. Identify who has the capability and capacity to deploy these solutions.
4. What are the unintended consequences of the new solutions?
5. What are the developmental timelines needed for these solutions?

Overall, the workshop underscored the importance of partnership and innovation in addressing complex biosecurity to human to national security challenges. By bringing together diverse perspectives and expertise, we will build stronger, more resilient systems that can adapt to the evolving threat landscape. Addressed in Section 2 are details of each vignette and the use of ‘pivot’ points which were injected into the scenario to add complexity to the participants. This is followed by outcomes, perceptions, and overall findings from the observations of participants and scribes during the *2023 Building the SABRE Biosecurity Alliance event.*

2. SABRE Vignettes and Delegate Observations

2.1. Vignette 1: Natural disaster: friend or foe

This vignette outlined a non-combative expeditionary scenario set in a flooded urban environment following high intensity rainfall and inadequate drainage. This vignette examined a variety of approaches to explore the 'response' and 'recovery' phases which comprise the contaminated incident aftermath. The threat here is assumed to be multi-faceted, and may have including a viral, parasitic, or bacterial (endemic or not) aetiological agent. It was recommended that participants were to consider rapid and emerging technologies for chemical, biological, radiological, and nuclear (CBRN) applications to address the situation effectively.

2.1.1. Unknown agent threats to Defence personnel and UN humanitarian aid workers

In February 2030, The Australian Defence Force (ADF) were called upon to conduct a humanitarian assistance and disaster relief (HADR) mission in support of a regional host nation in the tropics which has suffered significant destruction following several days of severe flash flooding. Response and recovery objectives included looking for causalities, liaising with local authorities and clean up support of the affected area(s). The disaster has led to numerous human casualties (>25 reported people; bodies since removed) whose bodies had settled in shallow run-off water in various depressed areas of the dense urban city following significant overflow from central waterways. In the days following deployment, the ADF have observed that local survivors and first responders have quickly developed acute inflammatory symptoms such as chills, headaches, and muscle pain. The onset of symptoms occurred after their attempts of entering homes entrenched in muddy debris, raising alarms to a potential natural contaminating agent in the water and local waterways. The ADF are needed to rapidly identify the presence of potential threat agents and map the contaminated area to prevent further exposure. Moreover, the ADF were required to provide advice to other agencies on the subsequent containment/clean-up procedures. No other intelligence toward the nature of the potential threat agent is available, however, caution should be exercised as per business as usual.

PIVOT 1

In the days following, more ADF members fall ill while participating in the recovery efforts. This is despite having taken extra precaution. In fact, some of the unwell ADF members reported not having contact with any regional water sources. **It is unclear at this stage what is causing the illness, but there are concerns that the ADF personnel may have been exposed to the same agent that has affected the local population**. As a result of the outbreak of illness, the ADF has suspended the clean-up efforts in the affected areas. Medical teams have been dispatched to the ADF's command centre to assess and treat the sick personnel, some of whom are responding to treatment. However, a substantial number do not respond at all, escalating the threat. As more members of the ADF continue to succumb to the illness, the threat levels have increased.

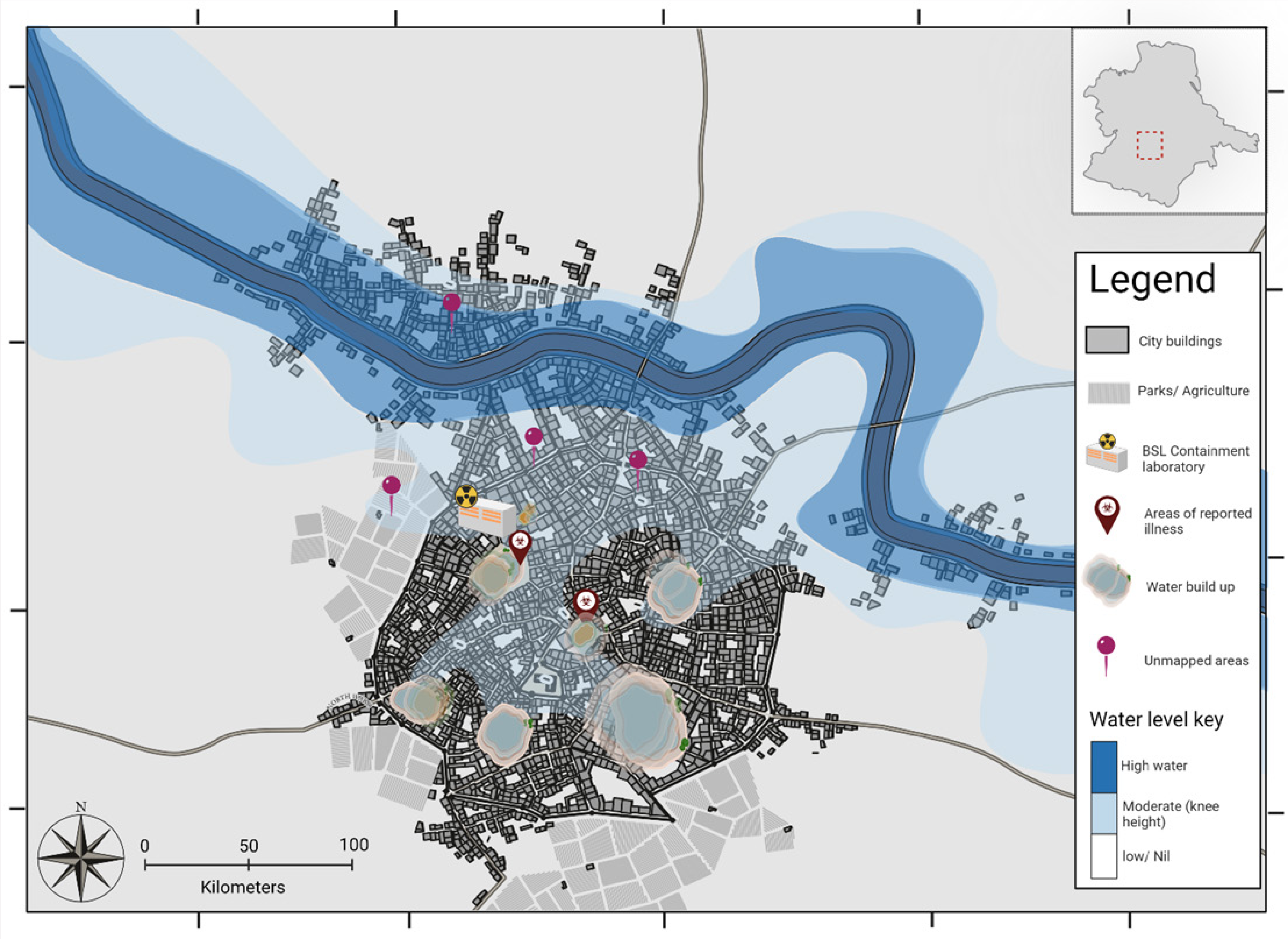
PIVOT 2

Intelligence indicates that one of the areas affected by the severe flash flooding was a nearby undeclared laboratory which was used to study life-threatening infectious agents that pose a high risk of aerosol-transmitted laboratory infections for which no vaccine or therapy is available. Unfortunately, the lab was destroyed in the flood and there are fears that some of the agents may have been released into the central canal or waters remaining from the floods. This has raised serious concerns among the ADF, and other agencies involved in the relief effort, the significant impacts on health risk to the local population.

The overall goals for mission success are identifying the threat while ensuring the safety and protection of the armed forces so that they can complete the mission without pause and return home safely. Additional concerns that should also be addressed are how to decontaminate equipment and validate the decontamination process has been successful.

2.1.2 Participant notes:

- This is a non-combative expeditionary scenario, operating within an urban environment.
- Urban flooding can be due to high intensity rainfall (pluvial flooding) *or* due to inadequate drainage from the area itself.
- Assuming the threat is multi-faceted, including viral, parasitic, or bacterial (endemic or not).
- Consider rapid and emerging technologies for CBRN applications.



Vignette Figure 1. Schematic of flood affected city in regional nation. Flood water has since settled but is still at dangerous levels in various areas of the city.

This vignette will examine a variety of approaches to explore the 'response' and 'recovery' phases which comprise the contaminated incident aftermath, including:

- Protecting personnel through personal protective equipment (PPE), ingestible or injectable supplements/treatments.
- Detecting potential threat agents using emerging solutions (determine if agents arose from a laboratory release or endemic to the region).
- Intelligence and data analysis (e.g. social media scanning to get an idea of what has been going on, using Big Data and artificial intelligence/machine learning [AI/ML] approaches) to potentially identify threat agents, the hazards they pose and attribution of their source.
- Mitigation strategies for threat agents using emerging solutions.
- Modelling of the impact if ADF goes into a situation unprepared. (What data/data sources would be required to model containment strategies and how could they be fused and analysed?)

2.1.3. Stimulating questions which were asked by the facilitators:

2.1.3.1 Surveillance and Detection:

1. What data/data sources would be required to model containment strategies and how could they be fused and analysed?
2. What data/data sources could be used to determine infection locations.
3. What types of new and emerging technologies could be used to detect potential threat agents (determine if agents arose from a laboratory release or endemic to the region)?

2.1.3.2. Identification:

1. What types of new and emerging technologies could be implemented to give a quick diagnostic?
2. Can these technologies be deployed with a disaster relief taskforce?
3. If not currently deployable, is it viable that they could be made so?
4. What sort of technical support would be required (and is it therefore feasible to deploy)?
5. What approaches can be used to characterise the organism in the field?
6. What tools can be used to understand the transmission traits of the pathogen?

2.1.3.3 Mitigation:

1. What are the potential mitigation strategies for threat agents using emerging solutions?
    - Active and functional PPE (note weather and operating constraints)
    - Air, food and water sterilisation tools

2.1.3.4. Prevention and treatment:

1. What interventions can be provided pre-deployment versus as an intervention?
2. What equipment decontamination and validation techniques are available to avoid spread of the threat agent?
3. What surveillance or modelling could be deployed to identify a new threat earlier to active response measures faster?
4. What new science or technology should be invested in to prepare for such a future event?
5. What organisational lessons could be learnt from this incursion to better prepare?

2.1.4. Scenario team reflection:

1. What worked today?
2. What errors or incorrect assumptions were made?
3. What would you do differently next time in a scenario like this?
4. What were you surprised by?
5. What will you do next to engage in the SABRE Alliance?

2.1.5. Key themes:

The key themes captured from the discussion include modalities for surveillance and early detection, treatment, and decontamination.
The participants focused heavily on the technology, however, were urged to consider human-centric elements such as inter-group communication and logistics, including consumables and how long these would last in the field. Participants expressed that a whole of group discussion beforehand was required to establish goals, objectives, assumptions and determine specific missions. The need for more industry input was raised to give advice on what is currently possible. Overall, the group discussions crossed social and political structure, the threat, and the environment of the area that the threat was located at. The detection and surveillance of pathogens were discussed, including molecular characterisation and attribution to assist in eradication. Decontamination was also a topic of discussion, with the group considering the

deployment of autonomous vehicles to decontaminate. The participants also discussed surveillance (including - but not limited to - multi-sensor surveillance technologies), dispersion modelling and tracking locations of affected individuals. Notably, discussions tried to extend on current CBRN products such as ion-mobility spectrometry for detection of volatile organic compounds. R&D into novel presumptive identification technologies would be of use to first responders. Ethical issues and privacy concerns were raised in the context of digital medical records. To manage this outbreak, mobile detection technology would be required to determine which individuals are in the area and for communication avenues. Contactless delivery strategies such as the use of unmanned aerial vehicles or drones could be used to drop sensors or pick up samples and send them back to a HQ for analysis. A database with AI capabilities could be used to sequence and identify pathogens quickly. Communication networks would need to be established, and relationships would need to be built to share data reliably between agencies at all classification levels.

Key themes from this scenario:

1. Detection
2. Surveillance
3. Mitigation
4. Containment
5. Identification
6. Technology
7. Sampling
8. Genomics
9. PPE
10. Communication

2.1.6. Participant observations:

Overall, the themes revolve around the need for preparedness, collaboration, and communication to detect, prevent, and manage the spread of the pathogen. The discussion points highlight the importance of considering logistics, having a clear goal and objective, and ensuring the involvement of different stakeholders.

1. **Mitigation of threat:** There was a heavy emphasis on technology, with little focus on people. Important points were made about the social and political structures of the area, and who is and isn't in the room – which was an important voice in this scenario. Inter-group communication is very important, and a clear communication network needs to be established. Logistics should be considered, such as consumables and how long they would last in the field.

2. **Prevention:** Prevention involved a combination of active surveillance, detection, mitigation, and treatment following the initial spread. This was assuming a fully compliant community existing in the deployed area. It was deemed important to keep waterborne areas separated from infected areas, and PPE available to prevent further spread.
3. **Stakeholders:** ADF, other government departments, Non-Governmental Organisations (NGOs), local communities, industry experts, and individuals with expertise in surveillance and detection, genomics, artificial intelligence, point-of-care testing, and disease management. Additionally, communication and collaboration with the local community and consideration of human-centric elements are emphasised as important factors to address pathogen spread. Stakeholders who were considered ranged from providing additional resources and expertise, offering insights and information about the area, giving advice on logistics and consumables, detecting and responding to bacterial infections, providing sequencing equipment and AI databases of samples, developing diagnostic tools, treatments, and prevention measures, analysing data to identify patterns, coordinating efforts, enforcing compliance with prevention measures, disseminating information to the local community, and providing financial and logistical support in disaster zones.
4. **Detection method:** Participants all conclusively agreed that responders need effective situational awareness and hazard prediction. Samples should be taken from water pools and infected areas. Detection of pathogen spread involves a three-part process, with responses from infected individuals being one part. Various detection methods include taking different samples from affected individuals, using robots to test for radioactivity, passive observation for environmental factors, and using mobile labs. It is important to create a map showing the affected individuals and to isolate contaminated areas. Wearable technology and drones can also be used to detect and collect samples of bacterial infections. Portable gas chromatography–mass spectrometry (GC/MS) devices can be used for pathogen detection, and data should be collected to identify patterns and establish relationships for sharing data with global databases.
5. **Technologies:** Surveillance and detection technology plays a crucial role in identifying and managing pathogen outbreaks, which can be achieved through point-of-care testing, genomics, AI, and sample analysis. In disaster zones, pathogens can be sequenced using AI databases and specialised equipment, while AI can create a comprehensive database of samples for future reference. Additionally, wearable technology can be used for personnel deployed in high-risk areas, while chemical testing and drug screens can aid in identifying and developing new treatments.

6. **Data capture and storage**: Multi-parametric data should be collected on where people have been, and patterns should be compared against global databases. It is critical that relationships between relevant stakeholders are established to share data. The participants emphasised the importance of data fusion to model a CBRN event and improving data quality (resolution or latency) for the requirements of CBRN modelling for incident control.
7. **Collaboration and communication:** Whole-of-group discussion to establish goals, objectives, and assumptions. Industry input is necessary to provide advice on what is feasible. Inter-group communication plays a significant role, and it is essential to establish a clear communication network.

2.2. Vignette 2: Re-designing the Threat: Synthetic Perils on the Horizon

The second vignette focused on the need for international cooperation in addressing transnational threats, such as one posed by a genetically modified organism. Synthetic biology is a field of science that combines biology, engineering, and computer science to design and construct new biological components, devices, and systems that do not exist naturally[1],[2]. It involves the manipulation of genetic material and the creation of artificial organisms or the modification of existing organisms to perform specific functions.
In the context of a CBRN threat, synthetic biology could potentially be used to create and engineer biological agents that are more potent, more resistant to existing countermeasures, or with enhanced abilities to evade detection. This raises concerns about the deliberate creation of dangerous pathogens or the modification of existing pathogens to make them more harmful or harder to control. In this scenario, participants were faced with both a significant outbreak of a known plant disease, and the intentional modification of this significant biosecurity threat by a malicious actor. Wheat blast (WB) itself is a known international biosecurity threat and can cause severe damage to wheat crops, leading to significant economic losses and food security concerns. Participants were positioned to emphasise the need for intelligence sharing, emerging technologies to detect, attribute and assess the hazards posed by the threat, and collaborative efforts to disrupt malicious organism spread from a fictional developed country.

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[1] CSIRO Futures (2021) *A National Synthetic Biology Roadmap: Identifying commercial and economic opportunities for Australia*. CSIRO, Canberra.

[2] Gray, P., Meek, S., Griffiths, P., Trapani, J., Small, I., Vickers, C., Waldby, C., and Wood, R. (2018). *Synthetic Biology in Australia: An Outlook to 2030*. Report for the Australian Council of Learned Academies, www.acola.org.au.

2.2.1. Genetically modified wheat blast threat.

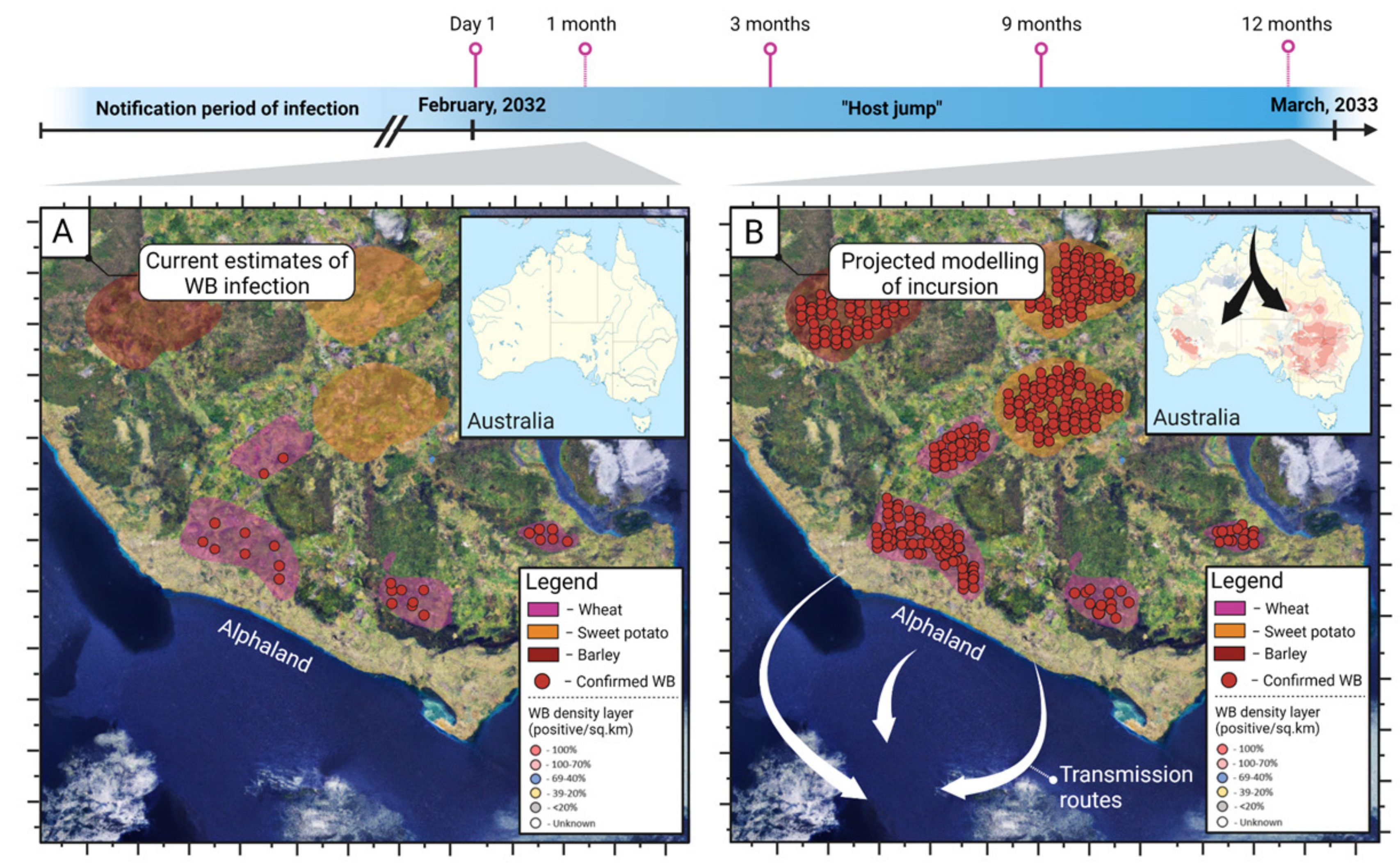
In February 2032, a newly emerged filamentous ascomycetous fungus strain has been detected. Reports from a small agricultural nation, Alphaland, make public that it is primarily decimating wheat crops along their south coast. Initial confirmatory identification testing shows the causative agent to be an isolate of *Magnaporthe oryzae* pathotype *Triticum* (or WB), a well-known and destructive disease of wheat head. The infection routes started as normal, following partial and complete infection routes, however, at a faster rate than is typically noted from reports coming out of other afflicted nations. One month following the initial reports, farmers in regional Alphaland report that this strain shows low fungicide efficacy, and preventative wheat crop rotations have failed to subdue its uncharacteristically rapid spread. National agriculture authorities in Alphaland launch an offensive, felling hectares of crops across the southern borders, but note a failure to prevent the spread of the fungal disease or eradication from the soil. As well as spreading faster than normal, complete infection now takes hold almost immediately and has spread into other crop exports, including rice, corn, barley, and oats. **In Alphaland, this 'host jump' has led to an expansion in the host range and the subsequent affliction of other plant species, sparking further fears of impacts on the economy**. 3 months following the initial reports, catastrophic economic destruction of 90% of sweet potato, wheat and barley crops has taken hold across Alphaland and has led to public panic and uncertainty about Australia's larger wheat industry should biosecurity measures fail. With this WB acting out of character and out of control – and fearing a mutant strain - researchers evaluated the genomic sequence from samples of seedlings and spikes collected by farmers against canonical WB – finding it is a highly mutated variant of WB. By 2033, unmitigated destruction of the local Agricultural market has caused substantial economic pressures and civil unrest in multiple trade countries, including Alphaland, leading Australia to establish a Joint Interagency Taskforce (JIT) which has been created to exercise extreme monitoring and preparedness to this threat. This WB poses a significant national security threat, and with domestic public pressure mounting, the ADF, as part of the JIT, is now tasked with working with other stakeholders to prevent, detect, and respond to this biosecurity threat.

PIVOT 1

Intelligence supplied by special operators indicate there may be evidence of intent from an adversary with highly technical facilities trying to destabilise economies in the region with a genetically modified strain of WB; one which has greater resistant to climatic extremes, enhanced host range and which is highly proliferative potential and virulent. Unless immediate preventative action in Australia is taken, further spread following this global bioterrorism attack will impact capability and capacity for international agricultural exports, and which will have a significant negative impact on the national economy.

2.2.2. Participant notes:

- A convenient and specific diagnostic tool is needed for evaluating seed health and early detection in the wheat field to initiate timely mitigation measures and thereby decreasing pathogen initial inoculum and dispersal.
- Open data sharing approaches will be useful to prevent this seed- and air-borne plant disease's widespread devastation of wheat crop.
- Movement of farming equipment, animal feed and people need to be considered as a possible spreading vector.
- Strategies to explain the threat whilst minimising food security panic are needed.



Vignette Figure 2. (A) Extent of WB damage in Alphaland in early 2028. **(B)** shows the threat and overall extend of WB decimation of agricultural crops as estimated by WB airborne modelling. Colour key indicates damage of potential agricultural sites as a factor of percentage.

This vignette could potentially examine a variety of aspects of the threat, including:
STEM Challenges:

1. Identification of sources of the threat and methods of entry into Australia.
2. Use of emerging technologies to detect, attribute and assess the hazards posed by the threat agent as early as possible (likely include surveillance type technology).
3. Strategies to mitigate the infection (isolate, treat, create resistance).
4. Modelling of infection should it take hold and how to contain.
5. Modelling of impact (food biosecurity, economic, social) should infection take hold in Australia and not be able to be contained.
6. Characterisation of the pathophysiology of the disease and how it impacts each plant species.
7. Methods of containment and verification of ‘clean’ equipment, infrastructure and food produce.
8. Methods of decontamination of effected areas and equipment.
9. Methods of repurposing or destroying contaminated products.

2.2.3. Stimulating questions to ask:

2.2.3.1 Surveillance and detection:

1. What data would be required to model the spread of infection?
How could it be fused and processed to create realistic scenarios and strategies?
2. How can wide areas of regional Australian farmland be surveyed (thinking new and emerging technology) to provide initial indications of infection?

2.2.3.2 Identification:

1. What types of new and emerging technologies could be implemented to give a quick diagnosis in the field?
2. How could it be determined if the organism has been manipulated in a laboratory or potentially identify the origin if genetically modified?
3. What model systems would be needed to safely characterise this type of threat?

2.2.3.3. Mitigation:

1. What are the potential mitigation strategies?
    - Could there be a detect and isolate strategy?
2. What prospective methods of resilience or hardening could be introduced to create a safety margin around the infected areas?

3. What co-planting or crop rotations could be considered to rehabilitee the affected areas?
4. What legislative changes might be needed to allow resilient GM crops to be deployed?

2.2.3.4 Prevention/Treatment:

1. Could there be a countermeasure? If so, how could a this be developed in a rapid fashion?
2. What interventions can be provided pre-deployment versus as an intervention?
3. What equipment decontamination and validation techniques are available to avoid spread of the threat agent.
4. What surveillance or modelling could be deployed to identify a new threat earlier to active response measures faster?
5. What new science or technology should be invested in to prepare for such a future event?
6. What organisational lessons could be learnt from this incursion to better prepare?

2.2.3.5 Scenario team reflection:

1. What worked today?
2. What errors or incorrect assumptions were made?
3. What would you do differently next time in a scenario like this?
4. What were you surprised by?
5. What will you do next to engage in the SABRE Alliance?

2.2.4. Key themes:

The key themes identified by the participants were related to coordinated incident control and preventing the spread of fungal pathogens that could potentially harm crops and endanger food security. Some of the key domains include CBRN modelling and surveillance, rapid communication strategies across multi-agency teams, biosecurity practices, legislative changes, and stakeholder engagement in the face of a synthetically engineered agent. Other important topics include developing effective detection methods and technologies (especially those to improve the ability to detect genetically modified agents), data capture and data storage, improving crisis management, leveraging emerging technologies, enhancing genetic and policy measures, and promoting diversity in food production. The involvement of various stakeholders such as social scientists, indigenous communities, citizen scientists, and government departments was also highlighted. Overall, the points emphasise the need for a comprehensive and collaborative approach to addressing the challenges of pathogen management and prevention.

Some key themes from this scenario:

1. Mitigation of threat
2. Prevention
3. Technologies
4. Communication
5. People
6. Detection methods
7. Solutions
8. Policy
9. Data capture/storage
10. Monitoring/observation.

2.2.5. Participant observations:

To mitigate the threat posed by the synthetically modified Wheat Blast strain and prevent further economic destruction and public panic in Australia, the following domains were considered by the participants:

1. **Mitigation of threat:** A crisis subcommittee needs to be created to coordinate the response effort. Onsite detection is necessary, and complete genome sequencing on the new strain and on sweet potato/barley is required.
2. **Prevention:** Legislative changes may be required, and plant security Cooperative Research Centre (CRC) can be engaged to enact and eradicate the threat. Various strategies can be employed, including AI sensors at airports, enhanced surveillance at borders, and biosensors on shipping containers. The management strategy could involve isolating affected areas and enhancing cross-farm hygiene.
3. **Stakeholders**: National and international groups, farmer groups, and Indigenous communities need to be engaged. Social scientists, communications experts, and biosecurity practitioners can help develop effective strategies.
4. **Detection method:** Environmental DNA (eDNA), DNA directly sampled from the air and vehicle and machinery clean down procedures, wastewater catchments and airports can be used to detect and identify the modified strain. Syndromic assessment of plants, spore traps, and honeybees/pollination can be used to detect the fungal pathogen. Computational platforms to rapidly and reliably identify and characterise engineered organisms could potentially examine if the fungus is synthetically modified by conducting a complete genome sequencing of the new strain of WB, as well as on the sweet potato and barley crops that have also been affected. By comparing the genome sequences

of the new strain with known strains of WB, modular algorithmic approaches could identify any potential genetic engineering that may have been attributed to the fungus. This information could then be used to inform the development of more targeted and effective treatments or preventive measures (**2.2.3. Item 2**) against the modified fungus.

5. **Technologies:** Technologies such as biosensors, visual detection methods, drones, and AI sensors can be used to monitor and detect the threat.
6. **Data capture and storage:** Data fusion, national data management teams, and central points of truth can help capture and manage data. Apps can be used to share data, communicate information and educate people.
7. **Collaboration and communication:** Collaboration between government R&D, federal and company, and Indigenous Australia is essential. Emerging technologies can be leveraged, and key stakeholders identified.
8. **People first:** The impact on people and communities must be considered, and Indigenous ranger groups, frontline farmers, and citizen scientists should be engaged. Policy changes and food security preparedness are also necessary.

2.3. Vignette 3: Lumpy Skin Disease Outbreak; Response to Incursion

Lumpy Skin Disease (LSD) is a highly contagious viral disease of cattle and buffalo that causes relatively low mortality. **It does not affect humans**.
The disease can result in animal welfare issues and significant production losses[3]. This scenario presented a biosecurity threat across Northern Australia from a highly contagious strain of LSD in biting insects. The task force is set up to identify the potential sources of the threat and methods of entry into Australia. This vignette addressed the challenge of Australia's response to a highly contagious animal viral biosecurity incursion. Participants were faced with a national agricultural threat and were required to address the needs for wide area surveillance, open data sharing approaches, and collaboration between governments, biotechnology industry, and academia to mitigate this real-world threat. The primary concern is the spread of the disease outside its traditional phasic pattern due to climate conditions favouring vector activity. Vaccines are available but not routinely used to protect cattle, and there is little knowledge of the mosquito vector flight patterns, dispersal profile, and proximity to susceptible animals (feral and/or livestock).

[3] Australian Government, Department of Agriculture, Fisheries and Forestry. 14 April, 2023.

2.3.1. Lumpy Skin disease outbreak – agricultural biosecurity threat challenges

Routine biosecurity surveillance conducted during March 2029 conducted by health authorities in the Northern Territory has identified a species of biting insects harbouring a highly contagious strain of the causative viral agent of LSD, a threat which has the potential to decimate the Northern Australia's cattle industry and create immense animal wellbeing concerns. LSD has already caused significant damage in multiple countries, where it had led to the culling of thousands of cattle and other livestock. Authorities believe that unregulated movement of infected animals through these countries has led to the wind-borne introduction of infected vectors into northern Australia. Following notification to the Department of Agriculture, Fisheries and Forestry (DAFF) the government rapidly forms a Joint Interagency task force (JIT) to coordinate the response effort, bringing together representatives from various agencies, including the ADF for logistical support and border surveillance. The JIT and member organisations are tasked to identify potential sources of the threat and methods of entry into Australia. Using serological and polymerase chain reaction testing, the joint effort has led to the unequivocal demonstration of LSD traces in cattle stations in the NT. With NT bracing for an unnaturally warm, wet, and humid climate conditions favouring vector activity over the next 9 months, state-government driven **predictive modelling indicates LSD will spread more rapidly outside of its traditional phasic pattern**. There is little knowledge of the mosquito vector flight patterns, dispersal profile and proximity to susceptible cattle, and no information is available to model its trajectory. Fears that LSD may also be now harboured within midges, biting flies and ticks which are infecting unmanaged feral cattle and buffalo are further perpetuating this threat. Vaccines are available but not routinely used to protect cattle as it has implications in Australia's ability to claim a disease-free status. There is no intelligence to indicate that this is an adversary seeking to harm Australia's interests. The ADF have now been tasked to coordinate strategies for risk modelling, targeted surveillance, development and validation of improved diagnostic tests and other key aspects of preparedness.

PIVOT 1

LSD has taken hold and is not able to be contained, decimating cattle across Northern Australia (including QLD and the NT). The JIT, including ADF and partner organisations have now been tasked with full response and recovery to prevent the socioeconomic and biosecurity implications of this threat.

PIVOT 2

Large numbers of animals are dying or needing to be humanely killed leading to increased risks of environmental pollution resulting from the decomposing carcasses. This secondary challenge requires urgent attention with new solutions for appropriately using or disposing of the bodies.

2.3.2. Participant notes

- A prediction model is needed for identification of high risk areas that integrates climatic, geographic, animal movement and vector presence across large tracts of northern Australia.
- A wide area surveillance tool is needed for early field detection of the viral vectors and animal disease (both livestock and feral) which will lead to local confirmation of the infection.
- A rapid and cost-effective tool for the confirmation of presence of the disease is needed, which also has agility to pivot to the detection of other types of diseases.
- Also required are timely mitigation measures which decrease pathogen initial inoculum and dispersal, and which may include improved vaccines and drug related therapies.
- Open data sharing approaches will be useful to reduce or prevent this insect spread disease and widespread devastation of the cattle industry.
- Monitoring the movement of people and stock is needed to reduce the transmission of disease.
- Training of large numbers of stock hands and transportation workers in disease identification, testing and reporting is needed.
- Establishing a sustainable model for maintaining the modelling and surveillance capability and identifying dual use opportunities for the new capabilities.

This vignette could potentially examine a variety of aspects of the threat, including:

STEM challenges:

1. Identification of sources of the threat and methods of entry into Australia.
2. Use of emerging technologies to detect the threat as early as possible (likely include surveillance type technology).
3. Strategies to mitigate the infection (isolate, treat, create resistance).
4. Modelling of infection should it take hold and how to contain.
5. Understanding the pathophysiology of the organism and its effect on the vector and the host.
6. Modelling of impact (food biosecurity, economic, social) once infection takes hold in Australia and is not able to be contained.
7. Establishing a sustainable model for the surveillance and response capability.

2.3.3. Stimulating questions to ask:

2.3.3.1. Surveillance and detection:

1. What data would be required to model and predict at risk areas?
2. What data would be required to model the spread of infection?
3. How could the data be fused and processed to create realistic scenarios and strategies?
4. How could stand off imaging/sensing techniques be used to predict illness?
5. How is the disease managed in feral versus production animals?
6. Could transportation nodes be a site where mass animal health monitoring could be enabled?

2.3.2.2. Identification:

1. What types of new and emerging technologies could be implemented to give a quick and cost-effective diagnostic?
2. How can wide areas of regional Australia be surveyed (thinking new and emerging technology) to provide initial indications of infection? What sorts of technology could be implemented?
3. What happens once sick animals are identified?
4. What notification systems need to be activated?

2.3.3.3. Mitigation:

1. What are the potential mitigation strategies?
2. Could there be an isolation strategy?
3. What strategies could be applied to the host versus the vector?
4. What are the unintended consequences that might be created by intervening?
5. What measurements should be taken during the event to aid in future biosecurity events?

2.3.3.4. Prevention and treatment

1. Could there be a treatment? If so, how could a treatment be developed in a rapid fashion?
2. What are the consequences of treatment/vaccination?
3. What innovations can be implemented that would allow for the safe and appropriate repurposing or disposal of all the carcasses?
4. What other non-genomic or pharmaceutical strategies could be implemented to enhance the resilience of the livestock?
5. What welfare matters need to be addressed for the sick animals?

2.3.3.5 Scenario team reflection:

1. What worked today?
2. What errors or incorrect assumptions were made?
3. What would you do differently next time in a scenario like this?
4. What were you surprised by?
5. What will you do next to engage in the SABRE Alliance?

2.3.4. Key themes:

Participants provided various solutions to mitigate the spread of the disease, including development of novel LSD vaccines, electronic tagging, drones, targeted pesticides, and genetic engineering of cattle to be resistant to the disease. The participants also highlighted the importance of collaborating with traditional landowners, engaging with communities and using local knowledge, and the challenges of building farmers' trust on their properties, detecting sub-clinical cases, and identifying the population and geographical location.

Some key themes from this scenario:

1. Mitigation
2. Vaccination
3. Diagnostic Assay
4. Surveillance
5. Chemical Approaches
6. Challenge
7. Collaborators
8. Barriers
9. Detection
10. Welfare Matters

2.3.5. Participant observations:

To manage animal health in large geographical areas and prevent the incursion of LSD, the following domestic biosecurity measures were highlighted by participants:

1. **Mitigation:** participants suggested that electronic tagging is a viable way to manage herds by sending biometric data, but this approach relies on network connectivity. The use of drones to identify sick animals, and vaccination is also an option. Government and NGOs should form strong linkages with indigenous rangers in the region for biosecurity compliance. Relating to the killing sick animals, their remains uncertainty about how to dispose of carcasses. The DIVA strategy, i.e. *differentiating infected from vaccinated animals*[4], will be important here

[4] Animal Health Australia (2022). *Response strategy: Lumpy skin disease (version 5.0).*

to spare vaccinated cattle from culling. Novel chemical approaches, including development of bioactive small molecules and application of protein engineering platforms were also flagged as additional measures that can be taken to mitigate the spread of disease. Additional strategies participants suggested include feeding stations containing Ivermectin and releasing non-biting male insects.

2. **Prevention:** Preventative measures discussed included the use of vaccines and genetic engineering of cattle, and modification of insect vectors to be resistant. However, the current technology for using additives in food is not cost-effective and at scale. Emerging technology could change this and should be flagged by horizon scanning groups.
3. **Stakeholders:** Engaging with communities and using local knowledge is important to gain support for disease management efforts. Collaboration with state-based wildlife organisations (WILD) and indigenous ranger populations can support the use of approved surveillance drones to identify (and potentially eliminate sick cattle). Engagement of local farmers are also an important part of the disease management process.
4. **Detection method:** To detect and track the spread of disease, the participants suggested using various technology-supported concepts such as tracking cattle movement through wide area surveillance, image recognition to identify individuals, RFID tags, and drones or indigenous rangers.
5. **Technologies:** Electronic tags can send data, such as temperature, blood testing, or other biomarkers of the animal, via satellite to the owner to identify sick animals. Drones can be used to administer vaccinations and observe livestock using infrared (but limited range creates challenges). Other technologies include mRNA multivalent DIVA strategies (i.e. messenger RNA technology to develop a vaccine that can protect animals against multiple strains of a virus), other genetic approaches such as pheromones to repel insects, genetically engineered hosts to carry pheromones, targeted pesticides, and remote sensing using Internet of Things (IoT) devices.
6. **Data capture and storage:** The importance of data on water sources was highlighted profoundly here. Delegates suggested overlaying spatial modelling of climate models that can help to understand insect movement and the spread of disease. GPS tracking can give insight into movement and signs of lethargy. There are many streams of data, and coordination is necessary to make sense of it all.

Australian Veterinary Emergency Plan (AUSVETPLAN), edition 5, Canberra, ACT.

7. **Collaboration:** Collaboration was critical to managing this LSD outbreak effectively. To increase capability, a sentinel network is useful to set up early. Additionally, a collaboration with InSpace at Australian National University (Academic) to develop and test various remote sensing technologies, such as drones and IoT devices, for monitoring and managing animal health and behaviour. Additionally, the National Stronger Regions Fund (NSRF) Strategic Network for funding or resources to support research and innovation related to animal health and management in regional areas. Importantly engaging with traditional landowners to promote education and preparedness.
8. **People first:** The participant observations emphasise considering the social license for a drone killing an animal and the suffering of the animals. Novel methods of composting, such as jet engines powered by methane, can help to dispose of carcasses and make fertilizer, but containment of disease must be ensured.
9. **Challenges:** The participant observations highlight various challenges, including policy drivers such as farmers' behaviours, negative impacts on trade due to vaccinations, and connectivity challenges. There is uncertainty about whether drones can detect sub-clinical cases, and creating a business case for antivirals would be difficult. It is also unclear how stable the virus is in the environment, and whether native animals are more susceptible. Eradicating feral animals is a significant challenge, and water buffalo may have cultural significance to traditional owners. The porous nature of borders requires a layered approach to disease management. Other challenges include barriers, not wanting to eliminate pollinators, the threat of ADF personnel from other endemic viruses, welfare matters, fly strike, microbial sensitivity to antimicrobials, and issues related to disposal of carcasses.

3. Key Overarching Themes Explored Throughout All Three Biosecurity Vignettes

Across the 3 scenarios, common themes clearly emphasised the importance of **preparedness, collaboration,** and **communication** in **detecting, preventing,** and **managing** pathogen outbreaks. They also emphasised the need for **various stakeholders, detection methods, technologies (those that are dual use in nature), data capture** and **storage,** and **prevention strategies** to be considered in such situations.

Converged themes
Mitigation strategies
Targeted prevention
Stakeholders
Detection methods
Dual use technologies
Data Capture and Storage
Collaboration
Communication

3.1.1. SABRE recommendations

Moving forward, strategies for SABRE to enable preparedness against biosecurity threats should endeavour to link up various stakeholders, including the ADF, other government departments, NGOs, local communities, industry experts, and individuals with expertise in:

1. surveillance and detection
2. genomics
3. artificial intelligence
4. point-of-care (POCT) technologies and disease management.

Biosecurity is a critical aspect of protecting public health, agriculture, and the environment from biological threats, including disease outbreaks, invasive species, and bioterrorism. The workshop highlighted the pressing need for emerging technologies in surveillance and detection, the importance of communication, collaboration, and rapid data sharing to significantly enhance biosecurity detection and response to potential threats.

Surveillance and detection technologies include genomic surveillance that use next-generation sequencing and bioinformatics tools to identify and track the spread of infectious diseases or invasive species; biosensors to detect biological or chemical substances in real-time; remote sensing technology including satellites and drones to capture images and data from large areas of land or water and; autonomous monitoring systems which use sensors and AI algorithms to monitor and detect biosecurity threats without human intervention.

Moreover, Australia needs to prioritise data sharing and integration. For example, genomics surveillance relies on the analysis and interpretation of vast amounts of genomic data. To enhance surveillance efforts, it is crucial to establish efficient data sharing mechanisms and integrate data from various sources. An integrated diverse data source, such as genomic data, environmental monitoring data, and surveillance data offers stakeholders a comprehensive understanding of biosecurity risks to be able to make informed decisions.

Technologies such as point-of-care testing played a key role in all three vignettes as a means to rapid detection, early identification, and immediate response to potential threats. Its portable, accessible, and ability to provide on-site results enhance surveillance, facilitate proactive interventions, and optimise resource allocation.

An emerging capability touched on in Vignette 2 is synthetic biology. There were several synthetic biology expert participants that shared ideas on potential novel diagnostic tools for rapid and accurate detection of genetically engineered pathogens. It would involve DNA sampled from the air, truck wash stations, wastewater catchments and airports. In the first instance, a SABRE sub-working group may be useful to direct activities in this domain.

Finally inter-group communication should be established, and a clear communication network should be put in place for effective collaboration, coordination, and information sharing among various stakeholders with the appropriate amount of security and accreditation. Furthermore, legislative changes (TBD) may be required, and CRCs can be engaged to enact and eradicate future threats. In consultation with our stakeholders, crisis subcommittees representing various entities should be created to coordinate the response effort, and onsite detection when considering emerging threats. Whole-of-group discussion is necessary to establish goals, objectives, and assumptions, and industry input is necessary to provide advice on what is feasible. Social scientists, communications experts, and biosecurity practitioners can help develop effective strategies. SABRE facilitate the establishment of some type of Community of Interest, given the increasing interest in developing R&D and capabilities in this space.

4. Conclusion

This report was signed to inform and encourage the further workshopping of these concepts to develop critical and actionable steps toward forming a national strategy. The outcomes to our initial workshop have identified a number of vital core themes that can be used to identify institutional SABRE champions, and stakeholder representatives to lead shaping strategies, priorities, programs and initiatives. As we move towards these goals, we aim to explore funding and executing a network of integrated pilot SABRE R&D programs, projects and workforce development initiatives. To advance these steps, discussions will be held with stakeholders on the development of SABRE concepts of operation, resourcing strategies and refining the scope and focus of the three core themes towards sharper and clearer goals.

The SABRE Alliance is committed to enhancing Australia's biotechnology capabilities through technological advancements in surveillance and detection, genomics, point-of-care diagnostics, and AI to strengthen the nation's ability to safeguard its ecosystems, human health, and agricultural industries.
By embracing innovation and fostering collaborations, Australia continues to stay at the forefront of national biosecurity, ensuring its resilience against emerging threats.

5. Appendix a: Consulted Stakeholders

SABRE would like to thank the following organisations for their contributions to the development, delivery and discussions to SABRE and of this work.

Australian Defence Force

Australian Research Data Commons (ARDC)

Australian Plant Phenomics Facility (APPF)

Bioplatforms Australia

CSIRO

Cultiv8

Defence Science and Technology Group

DMTC

MTPConnect

Office of National Intelligence

Science and Technology Australia

The University of Adelaide

The University of Melbourne