Describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or not at sufficient scale with respect to one or more of the 8 challenge areas identified in the 2021 Roadmap.

Due to the mandate of the Australian Urban Research Infrastructure Network (AURIN), our research community addresses specific aspects of the following challenges: Environment and Climate, Recycling and Clean Energy, Food and Beverage, as well as Space.

Environment and Climate (Challenge 7)

Emerging research directions amongst the AURIN community include the impact of climate change on cites, regional centres, infrastructure and local communities. Below are key emerging directions and their associated critical infrastructure needs:

Emerging Research Direction:

- Understanding and predicting extreme climate events at finer spatial and temporal scales.
- Developing models for climate adaptation strategies for cities and regional communities.
- Modelling climate impacts on urban environments and infrastructure services.
- Designing climate-resilient infrastructure and nature-based adaptation strategies.

Critical Infrastructure Requirements:

- **High-performance computing (HPC) and AI-driven climate models** with finer resolution for regional climate projections.
- **Advanced Earth observation systems**, including new-generation satellites and drone-based remote sensing technologies, for real-time monitoring.
- **Next-generation carbon flux monitoring systems**, including eddy covariance towers and automated soil carbon measurement technologies.
- **Urban Climate Testbeds**: Smart cities equipped with high-resolution climate sensors, green infrastructure pilots, and urban heat monitoring.

Recycling and Clean Energy (Challenge 5)

Emerging research directions amongst the AURIN community include net zero cities, energy transition in transport and circular supply chains. Below are key emerging directions and their associated critical infrastructure needs:

Emerging Research Direction:

- Hydrogen storage and novel energy carriers for grid stability and transport applications.
- Floating and offshore wind energy technologies.
- Integration of distributed energy resources (DERs) like rooftop solar, batteries, and EVs.
- Blockchain-enabled peer-to-peer energy trading.

Infrastructure Needs:

- **Hydrogen Refuelling and Distribution Network Testbeds**: Infrastructure for testing hydrogen transport, refuelling stations, and fuel cell vehicle integration.

- **Offshore Renewable Energy Testbed**: Infrastructure to support floating solar farms and offshore wind technology research in Australian waters.
- **National Smart Grid Testbed**: A large-scale facility to trial real-time grid optimisation, virtual power plants, and DER integration under real-world conditions.
- **Cybersecurity and AI Lab for Energy Networks**: Dedicated infrastructure to test grid resilience against cyber threats and optimise AI-driven energy management.
- **Vehicle-to-Grid (V2G) and Microgrid Innovation Centre**: A research hub for testing how electric vehicles, batteries, and local energy systems interact with the national grid.

Food and Beverage (Challenge 2)

Emerging research directions amongst the AURIN community include the impact of climate change, energy transition and demographic transformation on urban food security and sustainable supply chains. Below are key research areas and their associated infrastructure needs:

Emerging Research Direction:

- AI-driven food supply chain optimisation to reduce waste.
- Vertical farming for urban food security.
- Blockchain and digital twins for end-to-end food traceability.

Infrastructure Needs:

- **AI and Blockchain-Enabled Food Supply Chain Testbed**: Infrastructure for optimising logistics, reducing waste, and ensuring food traceability.
- **Automated Vertical Farming Facility**: A testbed for urban agriculture, LED-optimized plant growth, and AI-driven nutrient delivery.
- **Blockchain and Digital Traceability Innovation Hub**: Infrastructure to develop and implement real-time food tracking systems.

Space (Challenge 6)

Emerging research directions amongst the AURIN community focus on higher resolution remote sensing, hyperspectral applications and safety of global positioning systems. Below are the key emerging directions and their associated infrastructure needs:

Emerging Research Direction:

- Advanced satellite systems for climate monitoring and disaster response.
- AI-powered remote sensing for high resolution urban and infrastructure planning.

Infrastructure Needs:

- **AI and Big Data Processing Hub for Earth Observation**: A supercomputing and cloud-based analytics centre to manage and extract insights from vast satellite datasets.
- **Optical and Quantum Communication Ground Stations**: Facilities to enhance secure and high-speed satellite communication

Describe emerging research directions and the associated critical research infrastructure requirements that are either not currently available at all, or not at sufficient scale with respect to one or more of the 5 research priority areas identified in the 2024 Statement of National Science and Research Priorities.

Due to the mandate of the Australian Urban Research Infrastructure Network (AURIN), our research community addresses specific aspects of the following research priorities: Transitioning to a Net Zero Future, Supporting Healthy and Thriving Communities, and Building a Secure and Resilient Nation.

Transitioning to a Net Zero Future (NSRP 1)

Emerging research directions amongst the AURIN community focus on major advancements in renewable energy, decarbonisation of transport, smart grids, and climate resilience. While Australia has made progress, critical research infrastructure is needed to scale up technologies, integrate solutions, and accelerate the transition. Below are the key research directions and associated infrastructure needs:

Emerging Research Direction:

- Scaling up circular economy manufacturing to reduce waste and emissions.
- Expansion of vehicle-to-grid (V2G) technologies for integrated energy systems
- AI-driven demand response and grid optimisation for renewable integration.
- AI-powered climate modelling to predict and mitigate extreme weather impacts.

Infrastructure Needs:

- **Integrated Transport and Energy Systems Lab**: A testbed for V2G, smart charging, and low-carbon logistics solutions.
- **National Smart Grid Research Testbed**: A large-scale real-world grid simulation for AI-driven energy management and V2G integration.
- **Climate Resilience Modelling and Data Hub**: AI-enhanced infrastructure to improve climate risk forecasting and adaptation planning.

Supporting Healthy and Thriving Communities (NSRP 2)

Emerging research directions amongst the AURIN community include advancements in public health, environmental sustainability, and social well-being. While Australia has a strong foundation in health and community research, additional research infrastructure is needed to address emerging challenges such as ageing populations, mental health, climate-related health risks, and health inequities. Below are key research areas and their associated infrastructure needs:

Emerging Research Direction:

- Impact of urban design, social policies, and digital environments on well-being.
- Climate change's impact on health (heat stress, air pollution, infectious disease).
- Digital health solutions to improve access to healthcare in underserved communities.
- healthy ageing, cognitive decline prevention, and age-friendly communities.

Infrastructure Needs:

- **Social and Environmental Determinants of Health Lab**: A research facility focused on urban planning, housing, and social infrastructure for mental well-being.
- **Climate and Health Research Supercomputing Hub**: A facility for modelling climate-health interactions and informing policy.
- **National Air and Water Quality Monitoring Network**: Expanded sensor networks and data platforms for real-time environmental health analysis.
- **Culturally Informed Healthcare AI and Data Platform**: A secure and ethical data infrastructure for Indigenous health research.
- **Smart Ageing and Inclusive Communities Living Lab**: A real-world test environment for age-friendly housing, transport, and digital inclusion.

Building a Secure and Resilient Nation (NSRP 5)

Emerging research directions amongst the AURIN community focus on disaster preparedness, critical infrastructure protection, and national supply chain resilience. While Australia has strong capabilities in these areas, emerging challenges, such as cyber threats, climate-related disasters, global instability, and biosecurity risks, necessitate additional research infrastructure. Below are key research areas and their associated infrastructure needs:

Emerging Research Direction:

- Secure and sovereign data infrastructure to prevent cyber espionage and hacking.
- AI-driven real-time monitoring of utilities, transport, and communication networks.
- Resilient supply chain and logistics management to natural and economic hazards.
- Space-based Earth monitoring for climate, urban and resource management.

Infrastructure Needs:

- **Sovereign Cloud and Secure Data Centre**: A national facility to enhance secure data storage, processing, and digital sovereignty.
- **Climate and Extreme Weather Simulation Facility**: A high-performance computing centre for climate-risk modelling and resilience planning.
- **Smart Grid and Resilient Energy Systems Lab**: A research facility to enhance grid security, microgrid development, and renewable energy resilience.
- **Supply Chain Resilience and Advanced Logistics Hub**: Infrastructure for modelling and securing supply chains against disruptions.

Please elaborate on any of your above responses or add any other comments relevant to the development of the 2026 Roadmap. Your response can include reference or links to existing reports that you recommend be considered during the 2026 Roadmap development process.

Due to our mandate, AURIN's strategy and investment portfolio is informed by key Government and industry priorities on urban and infrastructure planning, as well as community well-being. Most recent and relevant documents include:

The National Urban Policy (2024), released by DITRDCA
The Sector Pathways Review (2024), released by CCA
The National Health and Climate Policy (2023), released by DHAC
The Critical Infrastructure Resilience Plan (2023), released by DHA
The Strategic Plan 2020-25 (2022), released by the Infrastructure Sustainability Council
The ALC Strategy 2023-25 (2023), released by the Australian Logistics Council

Based on the above information, AURIN has made significant progress in leading two major National Research Infrastructure initiatives in collaboration with other NRI facilities, Government agencies and industry partners. These initiatives are:

The Australian Urban Climate Research Infrastructure (AUCRI)
Establishing a crucial National Digital Research Infrastructure (NDRI) to inform evidence-based urban policies and interventions aimed at future proofing urban and infrastructure systems against climate change. AUCRI will position Australia as an international scientific leader in the field and optimise our investment in climate adaptation in Australian cities. AUCRI will federate five NCRIS facilities (AURIN, ACCESS-NRI, TERN, PHRN and ARDC), two ARC Centres of Excellence (Climate Extremes and Weather of the 21th Century) and two publicly funded research agencies (CSIRO and BoM). AUCRI will need to integrate Tier 1, Tier 2 and Cloud computing capabilities. AUCRI will address emerging research directions associated with Challenge #2, #5, #6 and #7, as well as NSRP #1, #2 and #5. In particular, AUCRI will address the following critical infrastructure needs:

- **High-performance computing (HPC) and AI-driven climate models** with finer resolution for regional climate projections.
- **Advanced Earth observation systems**, including new-generation satellites and drone-based remote sensing technologies, for real-time monitoring.
- **Next-generation carbon flux monitoring systems**, including eddy covariance towers and automated soil carbon measurement technologies.
- **Urban Climate Testbeds**: Smart cities equipped with high-resolution climate sensors, green infrastructure pilots, and urban heat monitoring.
- **Social and Environmental Determinants of Health Lab**: A research facility focused on urban planning, housing, and social infrastructure for mental well-being.
- **Climate and Health Research Supercomputing Hub**: A facility for modelling climate-health interactions and informing policy.
- **National Air and Water Quality Monitoring Network**: Expanded sensor networks and data platforms for real-time environmental health analysis.

- **Culturally Informed Healthcare AI and Data Platform**: A secure and ethical data infrastructure for Indigenous health research.

The Australian Urban Mobility Research Infrastructure (AUMRI)
Establishing a crucial National Digital Research Infrastructure (NDRI) enabling Australia to become a global leader in automated and zero or low-emission transport, freight and logistics sector by harnessing emerging technologies at scale and harmonising data sharing between jurisdictions, as well as academic, public and private sectors. AUMRI will advance critical technologies such as artificial intelligence (AI) and robotics to allow us to transition to net zero in environmentally responsible ways. AURIN will partner with the National Transport Research Organisation (NTRO) to implement a network of Smart Mobility Living Labs (SMLLs), in partnership with public and private sectors, and a National Data Exchange (AUM-DX) that will act as long-term technology testbeds. AUMRI will contribute to relevant CRCs, such as RACE2030 or iMOVE. AUMRI will address emerging research directions associated with Challenge #2, #5, #6 and #7, as well as NSRP #1, #2 and #5. In particular, AUCRI will address the following critical infrastructure needs:

- **Vehicle-to-Grid (V2G) and Microgrid Innovation Centre**: A research hub for testing how electric vehicles, batteries, and local energy systems interact with the national grid.
- **National Smart Grid Research Testbed**: A large-scale real-world grid simulation for AI-driven energy management and V2G integration.
- **Smart Ageing and Inclusive Communities Living Lab**: A real-world test environment for age-friendly housing, transport, and digital inclusion.
- **Sovereign Cloud and Secure Data Centre**: A national facility to enhance secure data storage, processing, and digital sovereignty.
- **Supply Chain Resilience and Advanced Logistics Hub**: Infrastructure for modelling and securing supply chains against disruptions.