



CENGN: Services and Living Labs Overview

September 17, 2025

Executive Summary

CENG N offers a suite of specialized testing and validation services designed to accelerate the commercialization of advanced digital technologies developed by Canadian startups and scaleups. These services support innovation in areas such as 5G communications, autonomous systems, IoT, robotics, and cloud-based applications.

Each service is delivered through a structured tier model—ranging from self-directed testing to full-service support—and is tailored to meet the needs of companies at various stages of product development. Services include:

- Advanced Communications Testing
- Autonomous Vehicle Testing
- IoT-Enabled Sensor Testing
- Human-Robot Interactivity Testing
- Robotics Functional Equipment Testing
- Unmanned Aerial Systems (UAS) Testing
- Performance Benchmarking

These services are enabled by CENG N's national network of **Living Labs**, which provide secure, commercial-grade environments equipped with cutting-edge infrastructure and expert support. The Living Labs serve as real-world platforms for testing, validation, and refinement—ensuring that digital solutions are market-ready, scalable, and aligned with industry standards.

Table of Contents

Executive Summary.....	1
Introduction.....	3
Services.....	3
Advanced Communications Testing Service.....	3
Autonomous Vehicle Testing Service	9
IoT-Enabled Sensor Testing Service	13
Human-Robot Interactivity Testing	17
Robotics Functional Equipment Testing Service	20
Unmanned Aerial Systems (UAS) Testing Service	23
Performance Benchmarking Service	28
Living Labs Description.....	32
Connected Robotics Living Lab.....	32
Smart Farming Living Lab	32
5G Advanced Performance Living Lab.....	34
Smart Mobility and Smart Agriculture Living Lab.....	34

Introduction

CENG N’s mission is to empower Canadian innovators by providing access to high-impact services that accelerate product development and market adoption. Through its Living Labs network, CENG N delivers a range of technical services that allow startups and scaleups to validate their technologies in realistic, sector-specific environments.

The services outlined in this guide are designed to support companies working in but not limited to smart mobility, agriculture, manufacturing, communications, and robotics. Each service is backed by expert consulting, advanced infrastructure, and flexible deployment options—enabling innovators to test performance, reliability, scalability, and compliance without the need to build their own facilities.

Living Labs act as enablers of these services, offering the physical and digital infrastructure necessary to simulate real-world conditions. By leveraging these environments, companies can reduce development risk, shorten time-to-market, and strengthen their competitive position in Canada and globally.

Services

Advanced Communications Testing Service

Overview

The Advanced Communications Testing Service helps Canadian SMEs accelerate innovation by providing access to flexible 5G test beds and spectrum bands—including commercial, Non-Competitive Local Licensing (NCLL), and experimental—across low, mid, and high-band (mmWave) frequencies. This service supports testing and validation of 5G-enabled technologies in both real-world and simulated environments, through multiple Living Labs such as Smart Farming Living Lab, Connected Robotics Living Lab and 5G Advanced Performance Living Lab, with support from Rogers Communications and Ericsson. Target sectors include autonomous mobility, smart manufacturing, precision agriculture, immersive media, and critical IoT.

Service Tiers and Scope

BASIC SERVICE TIER: SELF-DIRECTED TESTING

- Target Users: SMEs needing minimal support.
- Features:
 - Up to 5 SIMs
 - Instructions to connect up to 5 user devices (UEs) or CPEs to the 5G network.
 - No network customization or technical assistance beyond initial setup.

- Devices are configured with a QoS profile, but SMEs do not get access to network logs.
- Use Case: Ideal for early-stage testing or proof-of-concept validation.

ADVANCED SERVICE TIER – TEST PLAN CONSULTING & NETWORK CHANGE TESTING:

- Includes everything in the Basic Tier, plus:
- Additional Features:
 - Access to a shared pool of 50 SIMs (more can be requested with approval).
 - Up to 10 hours of consulting with Living Lab experts.
 - Ability to test during planned network changes, where available.
 - SMEs can request log reports (subject to approval), where available.
 - Option to integrate the SME's 5G-connected devices at the Living Lab a secure, isolated environment in CENG N's data center infrastructure, accessible over the Internet.
- Use Case: Suitable for more complex testing involving multiple devices or network behavior analysis.

PREMIUM SERVICE TIER – LOW-LATENCY EDGE COMPUTE TESTING (WHERE AVAILABLE):

- Includes everything in the Advanced Tier, plus:
- Additional Features:
 - Access to low-latency edge compute (MEC) infrastructure (where available).
 - Up to 10 additional consulting hours to:
 - Define infrastructure needs.
 - Set up applications on the edge platform.
 - Refine test plans.
- Use Case: Best for testing real-time, latency-sensitive applications like AR/VR, robotics, or autonomous systems.

SERVICE SCOPE

- In Scope: Access to 5G spectrum, limited supervised facility access, SIM provisioning
- Out of Scope: Real-time troubleshooting, unsupervised access, facility modifications

WIRELESS PERFORMANCE

Detailed throughput and latency data are provided for different spectrum bands and locations around Bayview Yards. For example, N261 mmWave, N78 High-Band and N14 Low-Band (for lower speeds, suitable for rural applications).

Testing Types

There are three main types of testing available to SMEs through the CENG N Living Labs program:

FUNCTIONAL TESTING

- Focuses on verifying that a product, device, or application behaves as expected based on its specifications.
- Examples:
 - System-level testing: End-to-end validation of device/application performance on 5G networks.
 - Integration testing: Ensures interoperability between devices, sensors, and applications in distributed systems (e.g., IoT or robotics).
 - Regression testing: Confirms that updates or changes (e.g., firmware or network updates) don't break existing functionality.

NON-FUNCTIONAL TESTING

- Evaluates the performance characteristics of a system rather than its specific functions.
- Examples:
 - Performance testing: Measures throughput, latency, jitter, and packet loss across different 5G bands (low, mid, mmWave).
 - Scalability testing: Assesses how the system handles many connected devices (e.g., smart city sensors, robotics fleets).
 - Reliability testing: Long-duration tests to validate system stability under normal and peak loads.
 - User Experience (UX) testing: Evaluates how users interact with systems like drones or robots, focusing on safety, intuitiveness, and effectiveness.

SPECIALIZED TESTING

- Targets unique scenarios, stress conditions, or compliance requirements.
- Examples:
 - Network stress testing: Simulates congestion, mobility, and failover to assess robustness.
 - Fault injection testing: Introduces controlled misconfigurations (e.g., QoS changes) to test resilience of critical or low-latency applications.
 - Compliance testing: Verifies readiness for industry-standard certifications.
- EMC testing: Assesses electromagnetic compatibility in interference-free environments like anechoic chambers

Living Labs

The Advanced Communications Testing Service may be delivered at multiple living labs.

FOCUS

- **Connected Robotics Living Lab: Powered by University of Waterloo's RoboHub and Rogers**
 - Robotics, autonomous systems, and advanced communications.
- **Smart Farming Living Lab: Powered by University of British Columbia (UBC) Farms and Rogers**
 - Agriculture, forestry, and environmental innovation
- **5G Advanced Performance Living Lab: Powered by Ericsson (at Bayview Yards, Ottawa)**
 - General-purpose 5G testing and innovation

FACILITIES & ASSETS:

- **Connected Robotics Living Lab: Powered by University of Waterloo's RoboHub and Rogers**
 - Indoor and outdoor testing spaces.
 - Anechoic chamber for interference-free testing.
 - Fleet of robots and motion capture systems.
 - Access to Rogers 5G network (including mmWave n261, mid-band n78, low band n71).
 - SIM cards, routers, and PCIe 5G modules.
- **Smart Farming Living Lab: Powered by University of British Columbia (UBC) Farms and Rogers**
 - Agriculture, forestry, and environmental innovation Farm fields and forest zones.
 - SIM cards, routers, PCIe 5G modules.
 - Equipment like tractors and drones (with pilot support)
- **5G Advanced Performance Living Lab: Powered by Ericsson (at Bayview Yards, Ottawa)**
 - Indoor/outdoor testing spaces
 - Access to various spectrum bands: N77, N78, N261, N14
 - Mobile Edge Computing (MEC) capabilities

NETWORK CAPABILITIES:

- **Connected Robotics Living Lab: Powered by University of Waterloo's RoboHub and Rogers**
 - 5G Standalone (SA) and Non-Standalone (NSA)
 - LTE bands (700, AWS-1, 2600, 1900, 850)
 - WiGig (60 GHz)
- **Smart Farming Living Lab: Powered by University of British Columbia (UBC) Farms and Rogers**
 - 5G bands: n71 (600 MHz), n78 (3.5 GHz), mmWave n261 (28 GHz)
 - LTE bands: n12 (700 MHz), n2 (1900 MHz), n66 (2100 MHz), n7 (2600 MHz)

EXPERT SUPPORT:

- **Connected Robotics Living Lab: Powered by University of Waterloo's RoboHub and Rogers**
 - Support for integration, simulation, and robotics setup.
 - Rogers provides 5G network advisory and configuration support.
- **Smart Farming Living Lab: Powered by University of British Columbia (UBC) Farms and Rogers**
 - Test plan review and agricultural equipment operation.
 - Rogers provides 5G network advisory and configuration support

COMMON FEATURES ACROSS LIVING LABS:

- Access to commercial, NCLL, and experimental 5G spectrum.
- Tiered service levels (Basic, Advanced, Premium).
- Consulting support for test planning and execution.
- Facility access must be pre-approved and supervised.
- No real-time troubleshooting or unsupervised access.

Use Cases

We list some representative examples, below, to illustrate the variety of use-cases supported by this service, depending on the facilities available at each Living Lab.

TESTING ON NCLL AND EXPERIMENTAL SPECTRUM

- Purpose: Validate devices and applications using Non-Competitive Local Licensing (NCLL) and experimental spectrum bands.
- Why It Matters: These bands are reserved for innovation, allowing safe testing without disrupting public networks. They help ensure future compatibility with national spectrum allocations.
- Example: A company tests its 5G-enabled sensor platform on the N77 band to align with Canadian spectrum regulations.

ADVANCED 5G FEATURE VALIDATION

- Purpose: Evaluate performance using cutting-edge 5G features like Standalone (SA), Multi-Access Edge Compute (MEC), and mmWave.
- Why It Matters: These features will define next-gen connectivity; early validation ensures readiness for future deployments.
- Example: Testing an AR application using MEC and mmWave to assess latency and throughput before public rollout.

MASSIVE IOT DEPLOYMENT TESTING

- Purpose: Assess system behavior with large numbers of IoT devices in real-world conditions.
- Why It Matters: Scalability and reliability are critical for smart infrastructure and industrial IoT.

- Example: Deploying thousands of environmental sensors across a smart farm to monitor connectivity and data flow.

CRITICAL IOT PERFORMANCE TESTING

- Purpose: Validate real-time responsiveness and reliability for mission-critical IoT systems.
- Why It Matters: Emergency and safety applications demand ultra-low latency and secure communication.
- Example: Testing connected body cameras and drones used by first responders to ensure reliable video streaming and control.

LARGE-SCALE 5G DEVICE DEPLOYMENT

- Purpose: Simulate high-density environments to test device and network performance.
- Why It Matters: Events like concerts or sports games stress networks; testing helps optimize performance under load.
- Example: Simulating a stadium scenario with thousands of devices to evaluate bandwidth contention and app stability.

HIGH-SPEED & LOW-LATENCY APPLICATION TESTING

- Purpose: Validate applications requiring high throughput and minimal delay.
- Why It Matters: Use cases like streaming, robotics, and autonomous vehicles depend on consistent, fast data transmission.
- Example: Testing AI-powered camera systems for real-time video analytics in traffic monitoring.

FIXED WIRELESS ACCESS (FWA) TESTING

- Purpose: Assess 5G-enabled CPEs and antennas for residential and enterprise internet.
- Why It Matters: FWA is a cost-effective alternative to fiber, especially in underserved areas.
- Example: Deploying 5G routers in rural homes to measure latency, provisioning speed, and failover reliability.

RURAL CONNECTIVITY TESTING

- Purpose: Validate solutions designed for remote or low-density regions.
- Why It Matters: Long-range, low-band spectrum is essential for bridging the digital divide.
- Example: Testing smart agriculture devices using N71 spectrum to ensure coverage across large farms.

SMART CITIES & SMART HOMES VALIDATION

- Purpose: Test IoT solutions in urban and suburban environments using live 5G networks.

- Why It Matters: Real-world validation ensures reliability of automation, monitoring, and logistics systems.
- Example: Evaluating a smart delivery tracking system in a suburban neighborhood using 5G connectivity.

RADIO INTERFERENCE & SPOOFING SIMULATION

- Purpose: Assess device resilience to signal interference and spoofing attacks.
- Why It Matters: Security and reliability are crucial for public safety and enterprise applications.
- Example: Using an anechoic chamber to simulate spoofing attempts on a drone's control system.

INDOOR ADVANCED POSITIONING (PLANNED)

- Purpose: Test indoor positioning systems where GPS is unreliable.
- Why It Matters: Accurate indoor tracking is vital for logistics, robotics, and AR navigation.
- Example: Validating an autonomous robot's navigation system inside a warehouse using 5G-based IAP APIs.

Autonomous Vehicle Testing Service

Overview

The Autonomous Vehicle Testing Service provides Canadian SMEs with access to real-world and simulated environments to test autonomous vehicles and smart mobility solutions. It supports validation of performance, safety, connectivity, and resilience under varied conditions.

Service Tiers and Scope

BASIC SERVICE TIER – DEVICE AND SYSTEM TESTING

- Purpose: Initial validation of autonomous vehicle systems.
- What's Included:
 - Access to Area X.O facilities for physical testing (e.g., track testing, ADAS verification).
 - Use of available network connectivity (5G, LTE, LoRaWAN, Wi-Fi).
 - Pre-compliance testing for standards like ISO, SOTIF, FUSA.
 - SME is responsible for developing and executing the test plan.
 - Living Lab provides advice on facility usage and compatibility.
- Best For: SMEs conducting early-stage testing of autonomous systems.

ADVANCED SERVICE TIER – APPLICATION AND SYSTEM INTEGRATION

- Purpose: Integration of vehicle systems with SME applications.
- What's Included:

- All Basic Tier services.
- Integration with a secure, isolated slice of CENG's infrastructure.
- Up to 10 hours of technical assistance from CENG engineers.
- Advisory support for test methods and procedures.
- Best For: SMEs testing how their autonomous systems interact with backend applications or cloud services.

PREMIUM SERVICE TIER – TEST ADVISORY & EXECUTION ASSISTANCE

- Purpose: Full-service support for test planning, execution, and analysis.
- What's Included:
 - All Advanced Tier services.
 - Expert support from Area X.O for:
 - Test plan development
 - Execution assistance
 - Data gathering and interpretation
 - Access to data logging, telemetry, video output, and storage (Azure or CENG data center).
- Best For: SMEs needing comprehensive support for complex or high-stakes testing.

Living Lab

Smart Mobility and Smart Agriculture Living Lab, powered by Area X.O is a cutting-edge test and demonstration facility in Ottawa.

Focus

- Accelerate innovation and commercialization of autonomous and connected vehicle technologies.
- Provide real-world and simulated environments for testing smart mobility solutions.
- Support sectors including:
 - Smart Mobility
 - Cybersecurity
 - UAVs and Robotics
 - Clean Tech
 - Public Safety
 - Smart Agriculture
 - Defense and Electrification

FACILITIES & ASSETS

- 16 km of urban-configured roadways
- Simulated intersections and railway crossings
- 100-acre smart farm for Agri-tech testing

- Aerospace and robotics test site in Killaloe
- DARTT Facility with diverse terrain (gravel, sand, water, fields, sidewalks)
- Climate simulation and weather condition testing
- Mannequins launch systems (adult, child, cyclist)
- High-resolution sensor networks and real-time data feeds
- Lexus vehicle platform with integrated sensors
- V2X Roadside and Onboard Units
- LiDAR, Radar, GNSS, IMU, and camera systems
- Drones and pilots available for hire
- Data storage via Linux, Azure, and CENG N data centers

NETWORK CAPABILITIES

- Private LTE/5G Networks:
 - LTE B7 (2600 MHz), LTE B14 (700 MHz Public Safety)
 - 5G sub-6 n78, C-Band n77, mmWave n260 & n261
- Operational Technology (OT) Networks:
 - LoRaWAN Gateway
 - Television White Space (TVWS)
 - RTK GPS with Novatel and Swift systems
- Connectivity Equipment:
 - Cradlepoint, Sierra Wireless, and Nokia 5G routers
 - SIM cards

EXPERT SUPPORT

- Advisory services for test plan development and execution
- Technical guidance on equipment setup, integration, and diagnostics
- Simulation and digital twin capabilities for pre-deployment validation
- Data logging and export support (system logs, telemetry, video)
- Co-created final project reports to document outcomes and KPIs
- Access to Area X.O experts for interpreting test results and optimizing validation strategies

Use Cases

We list some representative examples, below, to illustrate the variety of use-cases supported by this service, depending on the facilities available at each Living Lab.

AUTONOMOUS VEHICLE TESTING

- Purpose: Conduct functional testing and validation of in-cabin technologies, ADAS (Advanced Driver Assistance Systems), LIDAR, Radar, GNSS, and V2X (Vehicle-to-Everything) communications.
- Why It Matters: Ensures autonomous vehicles meet industry standards and road safety requirements, improving reliability and public trust.
- Example: An SME tests its ADAS system's lane-keeping and collision avoidance features using real-world road scenarios and V2X communication protocols.

VEHICULAR COMMUNICATIONS TESTING

- Purpose: Evaluate advanced communication technologies such as CV2X (Cellular Vehicle-to-Everything), V2I (Vehicle-to-Infrastructure), V2V (Vehicle-to-Vehicle), and 5G/IoT integration.
- Why It Matters: Real-time connectivity between vehicles and infrastructure is essential for intelligent transportation systems and traffic safety.
- Example: Testing a vehicle's ability to receive traffic light status updates via V2I to optimize speed and reduce idling time at intersections.

AUTONOMOUS DELIVERY VEHICLE TESTING

- Purpose: Validate autonomous pods for last-mile delivery in urban and suburban environments using sensors like LIDAR, radar, and cameras.
- Why It Matters: Demonstrates the feasibility of autonomous delivery, reduces operational costs, and enhances service reliability.
- Example: An SME tests its autonomous delivery pod navigating a predefined route with safe drop-off points for packages in a residential area.

AUTONOMOUS VEHICLE PLATOONING

- Purpose: Test V2V communication capabilities to enable synchronized vehicle convoys for fuel efficiency and traffic flow optimization.
- Why It Matters: Platooning reduces fuel consumption and improves road capacity, especially on highways.
- Example: Using Area X.O's Lexus vehicle and an SME's platform, two vehicles maintain close formation and coordinated braking on a highway using GNSS and radar.

CYBERSECURITY & PENETRATION TESTING

- Purpose: Assess the resilience of autonomous and connected vehicle technologies against cyber threats in both simulated and real-world environments.
- Why It Matters: Cybersecurity is critical for protecting vehicle systems, user data, and public safety.
- Example: An SME performs penetration testing on its vehicle's infotainment system to identify vulnerabilities in wireless communication protocols.

REGULATORY PRE-CERTIFICATION

- Purpose: Prepare SMEs for compliance testing with ISO and Euro NCAP standards before public deployment.
- Why It Matters: Early validation helps avoid costly delays and ensures smoother certification processes.
- Example: An SME tests its autonomous braking system in a controlled environment to meet Euro NCAP pedestrian safety benchmarks.

IoT-Enabled Sensor Testing Service

Overview

The **IoT-Enabled Sensor Testing Service** provides Canadian SMEs with access to real-world and controlled environments to test IoT devices (e.g., sensors, actuators) and systems (e.g., data collection, control applications). It supports validation of functionality, performance, connectivity, and resilience.

Service Tiers and Scope

BASIC TIER – DEVICE AND SYSTEM TESTING

This tier is designed for SMEs who want to test their IoT devices in real-world environments without backend integration.

- Device Installation: SMEs install their IoT devices (e.g., sensors, actuators) at Living Lab facilities.
- Connectivity Access: SMEs can use available network options like LoRaWAN, LTE, 5G, and Wi-Fi.
- Advisory Support: Labs provide guidance on installation and validation planning.
- Non-disruptive Setup: Installations must not interfere with the day-to-day operations of the lab (e.g., farm activities).
- No Backend Integration: Devices are not connected to SME applications or backend systems.

Example Use Cases:

- Soil moisture sensor testing in farm fields.
- Vibration sensors on agricultural equipment.
- Environmental sensors deployed in urban intersections.

ADVANCED TIER – APPLICATION AND SYSTEM INTEGRATION

This tier builds on the Basic Tier and adds support for full system integration and advanced testing.

Includes Everything in Basic Tier, plus:

- Secure Integration: Devices can be connected to SME applications via a secure, isolated slice of CENG's infrastructure.
- Remote Access: SMEs can access their applications over the Internet.
- Test Planning Support: CENG provides advisory services for test methods, procedures, and integration.
- Data Services: Includes data logging, export, and storage options (e.g., Azure or CENG data center).
- Custom Test Scenarios: Co-created test plans based on SME objectives.

Example Use Cases:

- Real-time air quality monitoring with cloud analytics.
- Smart intersection systems with sub-second latency validation.
- Livestock tracking with GPS and cloud-based alerting.

Living Labs

Focus

- Provide real-world and controlled environments for validating IoT sensors, actuators, and systems.
- Support innovation in agriculture, smart cities, environmental monitoring, and infrastructure.
- Enable SMEs to test performance, connectivity, and resilience of IoT solutions.
- Accelerate commercialization and reduce time-to-market for Canadian SMEs.

FACILITIES & ASSETS

- ***Smart Mobility and Smart Agriculture Living Lab, Area X.O (Ottawa & Killaloe, ON):***
 - 100-acre smart farm, urban-configured roadways, and simulated intersections.
 - DARTT Facility with diverse terrain (gravel, sand, water, fields, sidewalks).
 - Dedicated agricultural testing fields and private intersections.
 - High-resolution sensor networks and environmental monitoring systems.
 - Equipment: drones for rent, tractor operation support, and data storage options.
- ***Smart Farming Living Lab, UBC Smart Farm (Vancouver, BC):***
 - 24-hectare certified organic farm and forest ecosystem.
 - 5 hectares of agricultural fields and 15 hectares of forest.
 - Greenhouse and crop-specific planting options.
 - High-resolution sensor networks for GHG, climate, and soil monitoring.
 - Storage rental and access to UBC research facilities.

NETWORK CAPABILITIES

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - Private LTE/5G networks: LTE B7/B14, 5G n78/n77/n260/n261.
 - OT networks: LoRaWAN, TVWS, RTK GPS.
 - Connectivity tools: CloudGate Gateway, SIM/eSIM profiles, Azure data center.
- **Smart Farming Living Lab, UBC Smart Farm:**
 - Commercial LTE/5G via Rogers: LTE n12/n7/n66, 5G n71/n78.
 - No native LoRaWAN; SMEs may bring their own.
 - Connectivity via 5G backhaul or Ethernet.
 - Data center access through CENG infrastructure.

EXPERT SUPPORT

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - Advisory services for test plan development and execution.
 - Technical setup support, diagnostics, and equipment operation.
 - Simulation scenarios and analytics development.
 - Assistance with drone flight certification (SFOC).
 - Data logging and export (telemetry, video, system logs).
- **Smart Farming Living Lab, UBC Smart Farm:**
 - Agricultural and ecological research consulting via UBC Centre for Sustainable Food Systems.
 - Test plan review focused on plant life and organic certification compliance.
 - Equipment operation support (e.g., tractor, drone pilot).
 - Collaboration opportunities with UBC researchers for reduced pricing.

Use Cases

We list some representative examples, below, to illustrate the variety of use-cases supported by this service, depending on the facilities available at each Living Lab.

SOIL MOISTURE MONITORING

- Purpose: Validate the accuracy and reliability of a new soil moisture sensor for smart irrigation.
- Why It Matters: Accurate soil moisture data is essential for optimizing water usage, improving crop yields, and supporting sustainable agriculture.
- Example: An equipment manufacturer installs sensors in UBC Smart Farm test plots and uses a LoRaWAN gateway with 5G backhaul to transmit data to their cloud application, monitoring performance across different soil types and weather conditions over a growing season.

ENVIRONMENTAL SENSING NETWORK

- Purpose: Test an urban air quality monitoring system using IoT-enabled sensors for pollutants like CO₂, NO₂, and particulate matter.

- **Why It Matters:** Real-time environmental data supports public health initiatives and helps municipalities make informed decisions about urban planning and traffic management.
- **Example:** A system integrator installs sensors at Area X.O intersections and connects them to a cloud analytics platform via 5G to validate latency, resilience, and dashboard accuracy.

EQUIPMENT MAINTENANCE MONITORING

- **Purpose:** Evaluate vibration sensors for predictive maintenance in harsh field conditions.
- **Why It Matters:** Early detection of equipment issues reduces downtime, maintenance costs, and improves operational efficiency.
- **Example:** A startup mounts sensors on agricultural and utility equipment at Area X.O to test performance under vibration, dust, and temperature extremes, while transmitting telemetry data over LTE and 5G networks.

TRAFFIC AND SAFETY MONITORING

- **Purpose:** Validate a smart intersection solution that manages sensor arrays and generates real-time alerts.
- **Why It Matters:** Enhancing traffic safety and flow through intelligent systems reduces accidents and improves urban mobility.
- **Example:** A solution developer integrates radar, lidar, and thermal sensors at Area X.O intersections, simulates traffic scenarios, and verifies sub-second alert latency over 5G.

LIVESTOCK & WILDLIFE TRACKING

- **Purpose:** Test IoT devices for tracking crop growth, livestock, or wildlife in rural and forested environments.
- **Why It Matters:** Accurate tracking supports precision agriculture, conservation efforts, and scalable deployment of smart farming technologies.
- **Example:** An Agritech SME deploys GPS-enabled sensors at UBC Smart Farm to monitor battery life, data transmission, and scalability with hundreds of active devices connected to a cloud-based analytics platform.

GREENHOUSE GAS MONITORING

- **Purpose:** Validate GHG emission sensors for agricultural applications.
- **Why It Matters:** Monitoring emissions helps meet environmental regulations and supports sustainable farming practices.
- **Example:** A device manufacturer installs sensors in UBC Smart Farm fields to test calibration accuracy, long-term stability, and LTE/5G interoperability, demonstrating readiness for government reporting standards.

Human-Robot Interactivity Testing

Overview

CENG N's **Human-Robot Interactivity Testing Service** enables SMEs to test robotic systems designed to interact with humans in safe, controlled environments.

- Location: Delivered at the **Connected Robotics Living Lab, powered by University of Waterloo's RoboHub and Rogers.**
- Environment: Offers both indoor and outdoor testing spaces with:
 - 5G connectivity (commercial and non-commercial bands)
 - High-precision indoor positioning
 - Powered gantry, theatrical lighting, privacy glass
 - Safety and environmental controls
- Access: Limited per SME due to high demand
- Support: Includes consulting, test planning, and integration assistance from RoboHub experts

Service Tiers and Scope

IN SCOPE

- Access to expert researchers and consulting
- Use of Waterloo RoboHub's state-of-the-art facility
- Ability to rent robots from RoboHub's fleet
- Access to facilities that support human-robot interactivity testing
- Access to 5G network infrastructure and the Internet
- Real-time support from a dedicated point-of-contact during on-site testing

OUT OF SCOPE

- Long-term equipment hosting or storage
- On-site data storage
- Long-term testing projects
- Changes to 5G network configurations after initial setup
- Permanent changes to the physical facilities

CLIENT RESPONSIBILITIES

- Bring and operate their own robots/systems
- Provide insurance and meet safety requirements
- Comply with facility guidelines and training

Living Lab

Focus

- Enable testing and validation of mobile, stationary, and integrated robotic systems designed to interact with humans.
- Support safe evaluation of human-robot interaction, collaborative robotics, and multi-agent coordination.
- Facilitate innovation in robotics across sectors like healthcare, manufacturing, logistics, and hospitality

FACILITIES & ASSETS

- State-of-the-art indoor robotics testing facility with:
 - High-precision indoor positioning system
 - Powered gantry, theatrical lighting, switchable privacy glass
 - Safety and environmental controls
 - Outdoor testing space at the Avril building parking lot
- Access to a globally unique fleet of robots:
 - Gen2/Gen3 arms, Panda Powertool, LBR iiwa, NAO, TALOS, QDrone, Clearpath Warthog
 - GNSS sensors and RTK GPS antennae
 - Equipment rental available

NETWORK CAPABILITIES

- 5G & Wireless Connectivity:
 - Indoor: 5G n78 (3.5 GHz), mmWave n261 (28 GHz, non-commercial)
 - Outdoor: LTE 700, AWS-1, 2600, 1900, 850 MHz; 5G n71, n41
 - OT Wireless: 60 GHz WiGig
- Connectivity Tools:
 - SIM cards, PCIe/M.2 5G modules, Inseego MiFi routers, Quectel modems
- Network Access Support:
 - Rogers provides 5G services; RoboHub manages access and configuration

EXPERT SUPPORT

- Consulting & Advisory Services:
 - Project onboarding and design validation consulting
 - Support for equipment setup, integration, and diagnostics
 - Assistance with motion capture, simulated environments, and robot operation
- Access to over 45 faculty experts in:

- Human-Robot Interaction, Autonomous Systems, AI/ML, Embedded Systems, Assistive Devices, Robotics in Health, Art, and Design

DELIVERABLES:

- Test plan development, data logging/export, final project report
- Real-time support during on-site testing
- Short-term access with strong emphasis on planning and preparation

Use Cases

We list some representative examples, below, to illustrate the variety of use-cases supported by this service, depending on the facilities available at each Living Lab:

COLLABORATIVE ROBOT SAFETY VALIDATION

- Purpose: Validate the safety features of collaborative robots designed to work alongside humans in industrial environments.
- Why It Matters: Ensuring safe human-robot interaction is critical for workplace safety, regulatory compliance, and adoption in manufacturing settings.
- Example: An equipment manufacturer uses Waterloo RoboHub’s motion capture systems to test emergency stop functions and proximity detection in a robot designed for assembly line tasks.

SENSORS THAT IMPROVE HUMAN SAFETY

- Purpose: Evaluate the performance of safety-enhancing sensors and control systems under varied environmental conditions.
- Why It Matters: Sensor accuracy can be affected by lighting, reflections, and noise—testing ensures reliability in real-world scenarios.
- Example: An SME tests a vision-based proximity sensor by adjusting lighting and introducing reflective surfaces in RoboHub’s controlled environment to simulate factory conditions.

MULTI-AGENT SYSTEM COORDINATION TESTING

- Purpose: Assess how autonomous robots coordinate with each other and with human workers in logistics or warehousing environments.
- Why It Matters: Effective coordination improves efficiency, safety, and adaptability in dynamic workspaces.
- Example: An SME tests swarm robots handing off materials to human workers in simulated warehouse tasks, using RoboHub’s tracking systems to monitor responsiveness and navigation.

HUMAN-ROBOT SOCIAL INTERACTION STUDY

- Purpose: Study how service robots interpret and respond to human gestures, voice commands, and proximity cues.
- Why It Matters: Natural and intuitive interaction is essential for robots in healthcare, hospitality, and customer service roles.
- Example: An SME uses gaze tracking and vision systems in RoboHub's indoor spaces to evaluate how a robot responds to a user's body language and spoken instructions in a simulated hospital reception area

Robotics Functional Equipment Testing Service

Overview

The **Robotic Functional Testing Service** provides SMEs with access to secure, scalable, and monitored environments to test robotic systems in real-world conditions. It supports both autonomous and remotely operated robots across various domains such as mobility, sensing, navigation, manipulation, and integration.

Service Scope

CUSTOMER RESPONSIBILITIES

- Bring and operate their own robots
- Ensure safety compliance and insurance
- Follow facility guidelines and training

FACILITY RESPONSIBILITIES

- Provide access, training, and support
- Assist with test planning and integration

DELIVERABLES

- Pre-scheduled test environment access
- Technical setup support
- Co-developed test plans
- Data logging and export
- Final report with KPIs and performance results

Living Labs

The service is delivered through three main Living Labs, each offering unique capabilities:

FOCUS

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - Smart mobility, public safety, cybersecurity, agriculture, UAVs, CAVs, clean tech, and advanced robotics.
 - Real-world testing aligned with NIST standards.
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - Sustainable agriculture, agroecology, food systems research.
 - Emphasis on organic certification and Indigenous knowledge systems.
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Robotics research, human-robot interaction, autonomous systems.
 - Innovation in multi-robot and human-robot teams.

FACILITIES AND ASSETS

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - 100-acre smart farm, 16 km smart city zone, aerospace test site in Killaloe.
 - Diverse terrain: gravel, sand, water, fields, sidewalks.
 - Private intersections with PTZ cameras, thermal sensors, Lidar, radar.
 - LoRaWAN, TVWS, and environmental sensors.
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - 24-hectare organic farm and forest ecosystem.
 - Cultivates over 200 varieties of fruits, vegetables, and herbs, including:
 - Tomatoes, carrots, lettuce, kale, squash, beans, berries, and culinary herbs.
 - Greenhouse, forest areas, and high-resolution sensor networks.
 - Dedicated agricultural and forest testing fields.
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Indoor facility with gantry, lighting, privacy glass, and positioning systems.
 - Outdoor test space at AVRIL building.
 - Fleet of rentable robots (e.g., NAO, TALOS, QDrone, Clearpath Warthog).

NETWORK CAPABILITIES

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - Private LTE/5G network (bands: LTE B7, B14; 5G n78, n77, n260, n261).
 - Nokia Digital Automation Center (NDAC)
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - Rogers 5G network (bands: n71, n12, n2, n66, n78).

- LTE support and SIM card provisioning.
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Rogers 5G (bands: n71, n41, n78, mmWave n261).
 - LTE support and WiGig (60 GHz)

EXPERT SUPPORT

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - Consultation during project planning.
 - Support for network access and facility use.
 - Optional assistance in test plan development and reporting.
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - Access to UBC Centre for Sustainable Food Systems.
 - On-site technical support and consultation.
 - Collaboration with researchers for project integration.
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Access to over 45 faculty experts.
 - Project onboarding and design validation consulting.
 - Support for UX, sensor calibration, and simulated environments.

Use Cases

We list some representative examples, below, to illustrate the variety of use-cases supported by this service, depending on the facilities available at each Living Lab

ROBOTIC SYSTEM MONITORING AND COORDINATION

- Purpose: Validate systems that monitor and coordinate multiple robots or sensors.
- Scenario: Robots navigate sidewalks or indoor spaces while communicating with a central system.
- Environment: Includes 5G connectivity, realistic urban infrastructure (e.g., curbs, signage), and multi-camera monitoring.

ROBOTICS AND AUTOMATION FOR AGRICULTURE

- Purpose: Test autonomous agricultural robots for tasks like planting, pest control, and crop analysis.
- Scenario: Use of autonomous tractors, mobile robots, or greenhouse systems.
- Environment: Agricultural fields or vertical farming setups with geospatial mapping and soil/water testing.

AUTONOMOUS DELIVERY ROBOT NAVIGATION

- Purpose: Validate last-mile delivery robots in urban or campus settings.

- Scenario: Robots use computer vision, LiDAR, and wireless connectivity to navigate.
- Environment: Simulated urban zones with sidewalks, ramps, and crosswalks; equipped with 5G and monitoring systems.

GROUND VEHICLES FOR PUBLIC SAFETY AND EMERGENCY RESPONSE

- Purpose: Test unmanned robots for search & rescue, perimeter security, or hazardous inspections.
- Scenario: Robots with cameras, thermal sensors, and communication systems operate in disaster-like conditions.
- Environment: Outdoor areas with varied terrain, fog, water spray, and obstacles.

WAREHOUSING AND LOGISTICS AUTOMATION

- Purpose: Validate indoor robots and robotic forklifts for inventory and storage tasks.
- Scenario: Robots navigate warehouse zones, handle pallets, and avoid dynamic obstacles.
- Environment: Simulated warehouse setups with shelving, navigation aids, and environmental sensors.

MINING AND INDUSTRIAL INSPECTION

- Purpose: Test robots for monitoring, hazard detection, and equipment inspection in industrial or underground settings.
- Scenario: Robots equipped with thermal cameras, gas detectors, and LiDAR operate in low-light or hazardous zones.
- Environment: Simulated industrial terrains with visibility challenges and geospatial mapping support.

Unmanned Aerial Systems (UAS) Testing Service

Overview

The Unmanned Aerial Systems Testing Service provides startups and SMEs with access to secure, monitored environments for testing drone technologies. It supports both autonomous and remotely operated drones, including those operating Beyond Visual Line of Sight (BVLOS).

Service Design

CUSTOMER RESPONSIBILITIES

- Drones and licensed pilots can be rented as part of the project plan
- Bring and operate their own drone(s)
- Provide any required licensing, insurance, or regulatory documentation

- Ensure drones meet basic safety and remote-shutdown capability requirements
- Comply with on-site safety training and facility guidelines

FACILITY RESPONSIBILITIES

- Provide access, training, and support
- Assist with test planning and integration

DELIVERABLES

- Pre-scheduled test environment access
- Technical setup support
- Co-developed test plans
- Data logging and export
- Final report support (created by SME)

Testing Types:

These are the core capabilities that SMEs can evaluate when testing drones at the Living Labs:

MOBILITY

- Assess how drones move in different environments (urban, rural, indoor, outdoor).
- Includes vertical takeoff, hovering, and maneuverability in tight or obstacle-rich spaces

SENSING

- Validate onboard sensors such as:
 - Cameras (RGB, infrared, thermal)
 - LiDAR
 - Multispectral sensors
 - GNSS (GPS)
- Used for tasks like mapping, surveillance, crop analysis, and obstacle detection.

NAVIGATION

- Test autonomous flight paths, route-following logic, and obstacle avoidance.
- Includes GNSS-based and vision-based navigation systems.

MANIPULATION

- Evaluate drones with payload handling capabilities:
 - Cargo drop systems
 - Package delivery mechanisms
 - Precision placement or retrieval

INTEGRATION

- Ensure drones work seamlessly with other systems:
 - Ground control stations
 - Edge/cloud data centers
 - Smart city infrastructure
 - Agricultural monitoring platforms

BEYOND VISUAL LINE OF SIGHT (BVLOS)

- Test long-range autonomous operations where the drone is not visible to the operator.
- Includes airspace coordination, regulatory compliance, and safety protocols.

Living Labs

The service is delivered through three main Living Labs, each offering unique capabilities:

FOCUS

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - UAVs, smart mobility, public safety, cybersecurity, agriculture, CAVs, clean tech, and advanced robotics.
 - High-risk drone testing in controlled airspace.
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - Sustainable agriculture, agroecology, forestry, and food systems research.
 - Emphasis on organic certification and Indigenous knowledge systems
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Robotics and drone research, autonomous systems, human-robot interaction.
 - Innovation in multi-drone coordination and BVLOS testing

FACILITIES AND ASSETS

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - DARTT (Drone and Advanced Robotic Testing and Training) Facility.
 - 100-acre smart farm, smart city zone with 16 km of urban roadways.
 - Class C airspace (Ottawa) and Class G airspace (Killaloe).
 - Diverse terrain: gravel, sand, water, fields, sidewalks.
 - LoRaWAN, TVWS, GNSS stations, RTK GPS.
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - 24-hectare organic farm and forest ecosystem.
 - Cultivates over 200 varieties of fruits, vegetables, and herbs but blueberry, strawberry and apples available for testing.
 - Class C airspace over farm fields.

- 5 hectares of agricultural fields and 15 hectares of forest.
- High-resolution sensor networks for GHG, climate, and soil monitoring
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Indoor facility with gantry, lighting, privacy glass, and positioning systems.
 - Outdoor test space at AVRIL building (Class G airspace).
 - RTK antennae, GNSS sensors, and rentable drones (e.g., QDrone, Clearpath Warthog)

NETWORK CAPABILITIES

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - Private LTE/5G network (bands: LTE B7, B14; 5G n78, n77, n260, n261).
 - Nokia Digital Automation Center (NDAC)
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - Rogers 5G network (bands: n71, n12, n2, n66, n78).
 - LTE support and SIM card provisioning.
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Rogers 5G (bands: n71, n41, n78, mmWave n261).
 - LTE support and WiGig (60 GHz)

EXPERT SUPPORT

- **Smart Mobility and Smart Agriculture Living Lab, Area X.O:**
 - Consultation during project planning.
 - Support for network access and facility use.
 - Optional assistance in test plan development and reporting.
- **Smart Farming Living Lab, University of British Columbia (UBC) farms:**
 - Access to UBC Centre for Sustainable Food Systems.
 - On-site technical support and consultation.
 - Drone flight approval required via UBC's planning portal.
- **Connected Robotics Living Lab, University of Waterloo's RoboHub:**
 - Access to over 45 faculty experts.
 - Project onboarding and design validation consulting.
 - Support for UX, sensor calibration, and simulated environments

AVAILABLE ASSETS

Asset Category	Area X.O	UBC Smart Farm	Waterloo RoboHub
IT Communications	LTE B7, B14; 5G n78, n77, n260, n261; NDAC; NDN	5G n71, LTE n12, n2, n66, n7; 5G n78; SIM cards, MiFi routers	LTE 700, AWS-1, 2600, 1900, 850; 5G n71, n41, n78, n261; WiGig
OT Communications	LoRaWAN, CloudGate, TVWS	Not available	WiGig (60 GHz)

Airspace	Class C (Ottawa), Class G (Killaloe)	Class C over farm fields	Class G over AVRIL parking lot
RTK GPS / GNSS	Novatel + RTCM V3; Swift RTK GPS & IMU x5	Not available	RTK antennae on AVRIL building; GNSS sensors on request
Drone Equipment	Drone testing supported; rentals possible	SMEs must bring their own drones	Drone and robot rentals from RoboHub fleet
Agricultural Fields	100 acres (configurable plots)	5 hectares farm + 15 hectares forest	Not applicable
Sensor Network	High-resolution sensors (GHG, climate, soil, weather)	Not available	Not available
Indoor Facilities	DARTT facility with varied terrain	Greenhouse and farm buildings	High-precision positioning, gantry, lighting, privacy glass
Data Storage	Azure cloud storage available	Not available	Not available

Use Cases

We list some representative examples, below, to illustrate the variety of use-cases supported by this service, depending on the facilities available at each Living Lab

DRONE-ASSISTED TRAFFIC SURVEILLANCE

- Purpose: Validate the use of drones equipped with perception devices for aerial traffic monitoring, incident detection, and obstruction identification.
- Why It Matters: Enhances traffic management by providing real-time visibility in congested or construction-affected areas, improving response times and public safety.
- Example: A client deploys drones with cameras and GNSS to monitor traffic at private intersections within the Living Lab. Data is transmitted via 4G/5G to a central hub or edge datacenter for analysis and actionable insights.

AUTONOMOUS DRONE TESTING FOR SMART CITIES

- Purpose: Evaluate drone navigation and data-gathering capabilities in urban environments, especially for beyond-visual-line-of-sight (BVLOS) operations.
- Why It Matters: Supports smart city applications while ensuring regulatory compliance and public safety in complex urban settings.
- Example: A client tests a drone equipped with Lidar and infrared imaging across smart intersections, bike lanes, and suburban zones provided by Area X.O, using 5G connectivity for real-time communication.

DRONES AND REMOTE SENSING FOR AGRICULTURE

- Purpose: Validate drones equipped with imaging and sensing technologies for agricultural monitoring, including crop health, irrigation planning, and yield forecasting.
- Why It Matters: Enables precision agriculture, improving resource efficiency and productivity.
- Example: A customer deploys multi-rotor drones with multispectral sensors over custom-prepared test plots at the Living Lab, integrating data with geospatial tools and soil moisture monitoring systems.

DELIVERY AND CARGO DROP SYSTEMS

- Purpose: Test drones designed for last-mile delivery and logistics, focusing on payload handling, drop accuracy, and autonomous return-to-base functionality.
- Why It Matters: Supports scalable, efficient delivery solutions for urban and emergency logistics.
- Example: A client tests vertical takeoff drones with payload bays in a smart city testbed featuring sidewalks, ramps, and signage, using 5G and multi-camera systems to validate performance

AUTONOMOUS NAVIGATION AND BVLOS TESTING

- Purpose: Validate drone systems operating autonomously or beyond visual line of sight using GNSS or vision-based navigation.
- Why It Matters: Critical for extended missions in remote or complex environments where manual control is impractical.
- Example: A customer tests BVLOS drones in Area X.O's classified airspace and fenced facilities, evaluating route-following logic and airspace coordination with and without wireless connectivity.

SWARMING AND MULTI-DRONE COORDINATION

- Purpose: Test coordinated drone operations for tasks like formation flying, distributed data collection, or synchronized performance.
- Why It Matters: Enables scalable drone applications in surveillance, monitoring, and entertainment through autonomous collaboration.
- Example: A client deploys multiple drones with swarm algorithms in open airspace and indoor facilities, using 4G/5G networks to validate synchronized control and shared task execution

Performance Benchmarking Service

Overview

CENG N's Performance Benchmarking Service helps SMEs test and optimize their applications under real-world conditions. It supports various deployment environments and testing scenarios, enabling SMEs to validate performance, scalability, and reliability without needing to build their own infrastructure.

Service Tiers

The Performance Benchmarking Service from CENG N is structured into three service tiers, each offering different levels of support and infrastructure access for SMEs testing their applications. Here's a clear explanation of each tier:

BASIC SERVICE TIER – SELF-DIRECTED TESTING

Designed for SMEs with in-house expertise who need infrastructure access only.

- Includes:
 - Access to CENG N infrastructure (bare metal servers, VMs, or cloud platforms).
 - Documentation and knowledge base for setup and best practices.
 - Basic troubleshooting support (e.g., VM provisioning, network issues).
 - Weekly sync meetings and a final project report.
- Not Included:
 - Test plan development or execution.
 - Assistance with test tools or automation.
 - Performance analysis or custom software development.
- **Ideal for SMEs** who want to run their own tests independently.

ADVANCED SERVICE TIER – GUIDED TESTING WITH EXPERT SUPPORT

Designed for SMEs needing help with test planning and execution.

- Includes Everything in Basic Tier, plus:
 - Up to 10 hours of consulting support (test design, setup, execution).
 - Help with defining benchmarking objectives and selecting methodologies.
 - Infrastructure monitoring and support during testing.
 - Structured performance data presentation for SME analysis.
- Not Included:
 - Full end-to-end performance analysis (SMEs analyze results themselves).
 - Custom software development or ongoing advisory beyond the project scope.
- **Ideal for SMEs** looking for expert guidance to ensure meaningful and accurate benchmarking.

Testing Types

LOAD TESTING

- Goal: Validate application performance under high user traffic.
- Example: An e-commerce SaaS company tests its app to handle 500,000 concurrent users during Black Friday

- Tools Used: JMeter, Kubernetes Horizontal Pod Autoscaling
- Metrics: Response times, error rates, CPU/memory usage

STRESS TESTING

- Goal: Push the system to its limits to identify breaking points.
- Example: A collaboration app simulates millions of real-time notifications.
- Tools Used: Locust, JMeter
- Metrics: API rate limits, database write speeds, error rates

SCALABILITY TESTING

- Goal: Ensure the system scales effectively with demand.
- Example: A video streaming company tests VM auto-scaling using ProxMox.
- Tools Used: Locust, ProxMox API.
- Metrics: Scaling speed, performance under burst loads.

LATENCY TESTING

- Goal: Measure response times under various conditions.
- Example: A chatbot app must respond in under 500ms.
- Tools Used: JMeter, Wireshark, tc (traffic control).
- Metrics: API response time, network round-trip time, database query time.

THROUGHPUT TESTING

- Goal: Validate data processing capacity over time.
- Example: An IoT traffic monitoring system simulates data from 100,000+ sensors.
- Tools Used: JMeter, Locust, Terraform.
- Metrics: Messages per hour, processing speed, system efficiency.

RESOURCE UTILIZATION TESTING

- Goal: Optimize infrastructure usage and cost.
- Example: A SaaS company tests CPU, RAM, and disk usage across VM sizes.
- Tools Used: JMeter, Prometheus, Grafana.
- Metrics: CPU load, RAM consumption, disk I/O, bandwidth usage.

ENDURANCE (SOAK) TESTING

- Goal: Validate long-term stability and reliability.
- Example: A transaction processing app is tested for 30 days of continuous operation.
- Tools Used: Locust.

- Metrics: Memory leaks, CPU usage, database performance over time.

SECURITY PERFORMANCE TESTING

- Goal: Assess impact of security features on performance.
- Example: A startup tests its secure API gateway for latency and throughput.
- Tools Used: Open-source security test tools.
- Metrics: API response time under encryption, authentication, and rate limiting.

Infrastructure Deployment Options

CENG N offers three main infrastructure types for SMEs to run their benchmarking tests:

BARE METAL SERVERS

- Access: Full OS-level control via SSH; optional RDP/HTTPS
- Networking: Virtual Networking between VMs, Bare Metal and Internet
- Storage: Storage allocated by CENG N by project needs

VIRTUAL MACHINES (VMs)

- Standard Sizes: Standard VM sizes available
- Access: OS-level control via SSH; optional RDP/HTTPS
- Networking: Virtual Networking between VMs and Internet
- Storage: Storage allocated by CENG N by project needs

NETWORKING & MONITORING

- Secured with Zero Trust network access
- CENG N-recommended monitoring tools, or SME-provided tools may be supported

Living Labs Description

Connected Robotics Living Lab

- Location: **University of Waterloo's RoboHub**
- Focus: Robotics, autonomous systems, and human-robot interaction
- Key Features:
 - Indoor/outdoor testing spaces with advanced robotics infrastructure
 - Anechoic chamber, motion capture systems, and a fleet of robots
 - 5G (SA/NSA), LTE, and WiGig connectivity
 - Expert support from RoboHub and Rogers for integration and simulation
- Pricing
 - SMEs are strongly encouraged to **consult with Waterloo RoboHub** experts before testing to ensure their test plans are efficient and feasible within the limited time available at the facility.
 - Facility access is limited, especially for the RoboHub showcase, which is available only for short periods
 - Careful planning and preparation are essential to maximize productivity during the allocated time.

Service	Fees
Full day at your location with RoboHub experts	\$5k-\$10k per day
Half-day at your location with RoboHub experts	\$2.5k-\$5k per half-day
Full day on campus with RoboHub in-house experts	\$2.5k-\$5k per day
Half-day on campus with RoboHub in-house experts	\$1k-\$2.5k per half-day

Smart Farming Living Lab

- Location: **University of British Columbia (UBC) Farms**
- Focus: Agriculture, forestry, and environmental innovation
- Key Features:
 - Organic Farm fields and forest zones for sensor and equipment testing featuring blueberries, strawberries, apples, and forest zones
 - Agricultural machinery (tractors, drones) and high-resolution sensors
 - Rogers 5G and LTE network access
 - Support for organic certification and collaboration with UBC researchers

- Pricing
 - Pricing is determined by land usage type (e.g., shared vs. exclusive, invasive vs. non-invasive), technician time, and storage requirements—not by the selected service tier.
 - Project **pricing follows the UBC Farm Project Pricing Schedule**, which serves as the authoritative source.
 - The table below highlights the most commonly applied pricing elements.

Access / Service	Fees	Description
Admin and start-up fees, per location	\$300-\$500	For instance, conducting tests at both a field site and a forest site within the UBC Smart Farm is considered two separate locations.
Type 1: Shared, Non-invasive, low-impact, Recurring Facility (Land) Usage	\$ 0.00 per m2 per season	Shared use of 'Type 1' areas—such as farm fields, unamended grasslands, or forested zones—is permitted for low-impact activities like sensor-based scanning or collecting small soil samples.
Type 2: Exclusive or Semi-exclusive unamended grass, forest, or brush.	\$ 2.46 per m2 per season	Exclusive or semi-exclusive use of 'Type 2' areas—including unamended grasslands, forest, or brush—requires restoration of the site to its original condition upon project completion. The associated cost is \$24,600 per hectare per season.
Type 3: Shared, Non-invasive Facility (Land) Usage	\$ 3.07 per m2 per season	Shared use of 'Type 3' fields—those containing existing crops—is permitted for non-invasive robotic equipment testing, such as robotic weed removal. The crops are expected to remain viable for sale during the season. The associated cost is \$30,700 per hectare per season."
Type 4: Exclusive or Semi-Exclusive, Invasive Facility (Land) Usage	\$3.69 per m2 per season	Type 4' fields are specially planted for invasive robotic equipment testing. As the crop is not expected to be marketable during the testing season, the usage cost is \$36,900 per hectare per season. Restoration of the site may be required after project completion.
Technician Labour	\$79.72 per hour	Labour in direct support of a project, including consultation about aspects of a project
Onsite Storage Rental	\$59.85 per day	8'x10' shed on site

5G Advanced Performance Living Lab

- Location: Bayview Yards, Ottawa (Powered by Ericsson)
- Focus: General-purpose 5G testing and innovation
- Key Features:
 - Indoor/outdoor spaces with access to multiple spectrum bands
 - Mobile Edge Computing (MEC) infrastructure
- Ideal for latency-sensitive applications like AR/VR and autonomous systems
- Pricing : There is no cost to the SME, as all expenses are covered under the Living Labs initiative.

Smart Mobility and Smart Agriculture Living Lab

- Location: Area X.O (Ottawa & Killaloe, ON)
- Focus: Autonomous vehicles, smart mobility, UAVs, cybersecurity, and agriculture
- Key Features:
 - 16 km of urban-configured roadways and 100-acre smart farm
 - Featuring broad-acre crops such as corn and soybeans, along with mixed horticulture including farmer's market-style vegetables and pumpkins. With sufficient lead time, additional crop types can be accommodated.
 - DARTT facility for drone and robotics testing
 - Class C and G airspace for BVLOS drone operations
 - Private LTE/5G, LoRaWAN, TVWS, and GNSS infrastructure
 - Expert support for simulation, data logging, and regulatory compliance
- Pricing
 - No fixed price list; preliminary quotes provided upon request