

Case Study: Northern Arizona University

A case study of a sustainable smart campus master plan.

Executive Summary

Northern Arizona University (NAU) has emerged as a national leader in re-imagining how a public research university can operate—**not just more efficiently, but more intelligently, sustainably, and resiliently**. Through an ambitious, board-approved AI-Enabled Sustainable Smart Campus strategy, NAU has transformed aging infrastructure, siloed operations, and constrained resources into a coordinated, data-driven campus ecosystem.

At the heart of this transformation is the convergence of **IT and Facilities (OT)**, enabled by a campus-scale **digital twin**, institution-wide governance, and applied artificial intelligence. The results include measurable energy savings, avoided facilities failures, improved safety, enhanced student and faculty experiences, and a fundamentally new operating model—one that NAU describes as **antifragile**: capable of learning from stress, improving through disruption, and getting stronger over time.

The Context: A Complex Campus Under Pressure

NAU is a large regional public university serving more than **28,000 students**, with a flagship mountain campus in Flagstaff, Arizona—**over 600 acres, 6.8 million square feet, and 100+ buildings**, many dating back more than a century. The campus sits at **an elevation of 7,000 feet**, adjacent to the Coconino National Forest. It faces unique climate and infrastructure challenges, including exposure to extreme weather, aging facilities, and limited access to skilled trades labor.

By the late 2010s, several pressures converged:

- Rising energy and utility costs
- Deferred maintenance across an aging building portfolio
- Difficulty recruiting and retaining facilities trades staff
- Increasing dependence on external partners for critical building systems
- Growing expectations for sustainability, safety, and student experience
- A need to compete for students amid demographic decline

Incremental fixes were no longer sufficient. The existing operating model—reactive, siloed, and reliant on institutional memory—had reached a breaking point.

Early Smart Initiatives

With the appointment of a new CIO in 2016 to oversee the consolidation of IT services across the institution and to promote a modern IT service vision, early smart campus initiatives were integrated into a new IT strategic plan. Much work remained to establish governance and infrastructure capable of supporting advanced technology initiatives and the CIO's vision for “smart” campus capabilities.

Foundational Infrastructure Initiatives

- Establish IT and Data Governance
- Improve wireless infrastructure (WiFi 6, LoRaWAN, CBRS)
- Improve cybersecurity program (policies, firewalls, virtual private network)
- Improve Internet bandwidth and resilience
- Move key applications to the SaaS model (LMS)
- Adopt a cloud computing strategy and partner (Microsoft)
- Implement technology standards (Hyflex classrooms)
- Adopt and apply the ITSM program (Service Now)
- Identify redundant and shadow technology (email, web servers, etc.)
- Reduce technical debt and update aged systems. (WebTMA)

Early Smart Campus Initiatives

- Condition-based maintenance with remote servicing of classrooms
- Modern collaboration and integrated communication platform (Microsoft Teams)
- Smartphone application with digital identity (NAUgo)
- Reimagined learning ecosystem (Canvas™ LMS, Smart Sparrow™ adaptive learning , TopHat™, Packback™, iClicker™, etc.)
- Smart trash/recycle receptacles.
- Space management and dynamic reservation
- Federated digital signage
- Administrative decision support dashboards (Enrollment, retention, financial)
- Student success monitoring (Salesforce CRM)
- Smart parking enforcement
- Bus, vehicle, and asset tracking
- Campus safety and surveillance.
- Improve/expand door-access and
- Delivery robots (NAU was 2nd to implement Starship™)
- IoT development and telemetry integration (occupancy, meters)

It would take several years to build substantial infrastructure. Still, by the time the COVID pandemic was declared in March of 2020, the infrastructure and capabilities were sufficient to shift the campus to remote work and learning overnight. Progress in updating infrastructure, improving applications, and deploying smart projects continued throughout the pandemic. The early smart initiatives that came from the IT strategic plan had demonstrated value in creating efficiencies and experiences that supported institutional strategic priorities.

From Technology Projects to Institutional Strategy

While IT-led “smart” initiatives had existed at NAU since 2016, the turning point came in 2022, when the university incorporated smart campus features directly into its 10-year Comprehensive Sustainable Smart Campus Master Plan. Approved by the Arizona Board of Regents in 2023, the plan redefined smart technologies as essential institutional infrastructure rather than optional upgrades.¹

The master planning vision was clear: a technology-enabled (AI, Cloud Computing), sustainable smart campus that fosters meaningful and “sticky” living and learning experiences for students, while improving efficiencies in human resources, energy consumption, facilities management, space utilization, resilience, and enterprise risk reduction. Several key themes guided the plan:

- **Student-Centered Design:** Creating inclusive, collaborative, and wellness-oriented spaces that support learning beyond the classroom.
- **Resource Optimization:** Prioritizing renovation, adaptive reuse, and deferred maintenance reduction over physical expansion.
- **Sustainability & Carbon Neutrality:** Integrating the Climate Action Plan and committing to carbon neutrality for Scope 1 and 2 emissions by 2030.
- **Indigenous Planning:** Expanding the Native American Cultural Center, integrating Indigenous knowledge and design, and honoring the land and its communities.
- **Smart Campus Evolution:** Leveraging technology to enhance safety, accessibility, operations, and the learning environment.
- **Statewide Access:** Strengthening NAU’s presence across Arizona through high-demand programs and potential branch campuses.

The master plan was not just an extension of the existing IT strategic plan. The comprehensive plan covered all areas of authority and university functions. Ownership of the master plan was held by the Chief Operating Officer, with the CIO, Chief Facilities Officer, Chief Sustainability Officer, and members of Data Governance sharing responsibility under a governance model that prioritized transparency, participation, and measurable results.

The Digital Twin: One Pane of Glass for the Built World

A key enabling capability was NAU’s deployment of the Willow digital twin, making NAU the first higher education institution in the U.S. to implement Willow and launch a campus-wide, real-time digital twin across multiple building management systems toward full automation of building controls. The twin unified previously disconnected data silos, including:

- Building Automation and HVAC systems
- Energy and utility metering
- Work order and maintenance systems
- BIM and GIS spatial data
- IoT telemetry and sensor data
- Occupancy and scheduling proxies

- Real-time grid emissions data

By establishing a comprehensive data estate, common ontology, and real-time building telemetry, NAU shifted facilities management from experience-based intuition to evidence-based decision-making—without removing humans from the loop.

Within six months, Willow-generated insights helped identify more than \$ 200,000 in avoidable operational costs and dramatically improved the speed and confidence of facilities' responses. These early results would prove to be just the tip of the iceberg.

From Reactive to Predictive—and Preventive

The operational impact was evident. During one incident, digital twin data uncovered unusual water usage in a building thought to be leak-free. Despite initial skepticism from experienced trades staff, the data proved accurate—twice—leading to the discovery and repair of several hidden leaks. In another case, digital twin alerts identified conditions that could have caused a repeat of a previous flooding event that had shut down an academic building and disrupted research. This time, disaster was averted.

These moments proved transformational—not just technically, but culturally. Over time, trust shifted from anecdote to analytics, and the campus moved toward condition-based and predictive maintenance at scale.

Energy savings became evident almost immediately, especially during extended campus shutdowns, when building energy use approached normal levels. With smart controls and real-time insights, NAU finally aligned occupancy with energy consumption.

People First: Change, Trust, and Adoption

NAU leaders were honest that the biggest risk was not technology failure but adoption. Facilities staff initially feared losing jobs; IT was concerned about OT cybersecurity risks; leadership worried about growing too quickly. To address this, NAU emphasized:

- Phased implementation aligned with funding realities
- Early proof points and “low-hanging fruit.”
- Embedded IT project management within Facilities
- Intentional human-in-the-loop design for work control and set-points
- Ongoing training, retraining, and psychological safety
- Transparent governance through IT and Data Councils

As adoption increased, so did confidence. Facilities teams started to “drink the Kool-Aid,” using insights to enhance uptime, prioritize tasks, and evaluate vendor performance. Trust between IT and Facilities grew significantly over time.

Outcomes That Matter to Leadership

Today, NAU leadership tracks smart campus outcomes through institutional KPIs that roll up into university-level priorities:

- Energy reduction and decarbonization progress
- Improved confidence in sustainability and carbon reporting

- Avoided downtime from flooding and mechanical failure
- Improved classroom uptime and faculty satisfaction
- Enhanced campus safety through smart access and surveillance
- Improved operator efficiency with fewer staff
- Reduced cyber and vendor risk in OT environments

Critically, NAU now oversees its campus as a unified system instead of just a group of buildings.

Objectives and Key Results

Objectives and Key Results (OKRs) are essential to Northern Arizona University's Sustainable and Smart Campus transformation by turning long-term vision into tangible, campus-wide results. As NAU shifted from standalone technology projects to a board-approved, operational plan, leadership adopted OKRs to align investments across facilities, IT, sustainability, mobility, and academic operations with the university's strategic goals. This framework prioritizes outcomes over activities—focusing on carbon reduction, student and employee experience, Indigenous engagement, operational resilience, and fiscal responsibility—while offering a clear structure for governance, accountability, and ongoing learning. Overall, these Objectives and Key Results define its strategic intent and ensure that its smart campus initiatives support the goals of NAU 2025: Elevating Excellence.

Exhibit – NAU's Objectives and Key Result Areas

Objective	Key Results (KRs)
1. Achieve a carbon-neutral, resilient campus by 2030	• Eliminate Scope 1 & 2 emissions by 2030 • Reduce campus Energy Use Intensity annually • Convert district heating to low-temp hot water • Implement a geothermal or biomass heating solution* • Complete deep energy retrofits in high-priority buildings
2. Transform campus mobility to a pedestrian-first, low-carbon system	• Prioritize pedestrians, bicycles, and transit over private vehicles • Standardize and extend the Pedway as the campus mobility spine • Add safe east–west multimodal connections • Reduce vehicle miles traveled and parking demand through TDM
3. Reduce transportation and fleet emissions	• Electrify passenger fleet vehicles to define its strategic intent and ensure the use of electric vehicles by 2030 • Electrify bus and shuttle fleet by 2035 • Install EV charging infrastructure campus-wide
4. Embed Indigenous identity, lifeways, and ways of knowing across campus	• Expand the Native American Cultural Center (NACC) • Establish medicine gardens, ceremonial and teaching spaces • Create a Tribal Sovereignty / Walk of Nations path • Integrate Indigenous language, art, and storytelling throughout campus
5. Operate the campus as an intelligent, data-driven system	• Implement a campus digital twin for planning and operations • Deploy real-time energy and water dashboards • Integrate IoT sensors for occupancy and predictive maintenance • Use analytics to prevent failures and reduce downtime
6. Improve safety, access, and experience through smart campus technologies	• Expand Wi-Fi across Pedway, open spaces, and parking • Implement smart signage at gateways and key corridors • Standardize smart ingress/egress and security systems

Objective	Key Results (KRs)
7. Optimize space utilization and shift from ownership to sharing	• Enable future-ready paths for robotics and autonomous delivery • Increase classroom utilization to ~30 hours per week • Achieve ~80% average seat fill across instructional spaces • Implement centralized scheduling for shared spaces • Consolidate and right-size academic districts
8. Professionalize campus operations and governance	• Establish a Building Manager Coordinator role • Standardize building manager training and responsibilities • Improve transparency and accountability for facilities performance • Align policies with sustainability and collaboration goals

Sustainable & Smart Campus – Core KPIs

While OKRs identified strategic intent, the university established KPIs as measures that directly align with NAU 2025 – Elevating Excellence priorities, such as student success, sustainable stewardship, Indigenous engagement, workforce effectiveness, and operational excellence. The metrics emphasize outcomes over projects—highlighting the transition from technology implementation to overall institutional performance management. Each KPI can be summarized for executive reports or examined in depth via the digital twin and dashboard platforms.

Exhibit – NAU Sample Smart Campus Master Plan KPIs

KPI Category	Key Performance Indicator (KPI)	Description / Measurement Focus
Sustainability & Climate	Scope 1 & 2 Emissions	Annual greenhouse gas emissions from onsite energy, fleet, and purchased electricity.
	Energy Use Intensity (EUI)	Campus and building-level energy use per square foot
	Carbon Neutrality Progress	Milestones toward 2030 Scope 1 & 2 carbon neutrality
	Energy Use Reduction	Reduce the total electrical energy used.
	Water Use Reduction	Total potable water use and reclaimed water utilization
	Waste Diversion Rate	Percentage of waste diverted from landfill (recycling, composting)
Mobility & Transportation	Mode Share	Percentage of trips by walking, biking, transit vs. single-occupancy vehicles
	Vehicle Miles Traveled (VMT)	Annual VMT by campus commuters and fleet
	Parking Demand	Utilization of perimeter vs. interior parking facilities
	Fleet Electrification	Percentage of passenger, facilities, and transit fleet electrified.
Facilities & Infrastructure	Deferred Maintenance Backlog	Total deferred maintenance value and annual reduction rate
	Facilities Downtime Avoided	Number of incidents avoided through preventive or predictive maintenance
	Utility System Modernization	Progress toward low-temperature hot water and plant interconnection
Smart Campus & Technology	Asset Coverage in Digital Twin	Percentage of campus buildings and utilities represented

KPI Category	Key Performance Indicator (KPI)	Description / Measurement Focus
	Predictive Maintenance Adoption	Share of work orders generated condition-based vs. reactive.
	Real-Time Monitoring Coverage	Percentage of buildings with live energy/water data
	Network Availability	Wi-Fi and network coverage and uptime in academic and outdoor spaces
Space Utilization	Classroom Utilization	Average scheduled hours per classroom per week
	Seat Fill Rate	Average classroom occupancy percentage
	Space Sharing Adoption	Percentage of centrally scheduled classrooms and shared spaces
Student, Faculty & Staff Experience	Classroom Uptime	Percentage of instructional spaces available as scheduled
	Facilities Response Time	Average time to resolve facilities service requests
	Campus Safety Indicators	Safety incidents influenced by lighting, access, or smart systems.
Indigenous Planning & Equity	Indigenous Spaces Delivered	Number of Indigenous-designed or culturally significant spaces implemented
	Indigenous Engagement	Frequency of formal engagement sessions with Indigenous communities
	Native Language & Art Presence	Count of integrated signage, art, and storytelling installations
Governance & Operations	Cross-Functional Governance Participation	Representation across IT, Facilities, Sustainability, and Indigenous Affairs
	Building Manager Training Coverage	Percentage of buildings with trained, supported managers
	KPI Reporting Maturity	Dashboards and transparency of institutional KPI reporting

Antifragility as a Design Principle

Perhaps NAU's most distinctive contribution is its embrace of **antifragility**—the idea that campuses should not merely resist failure, but **learn from it and improve**. Each incident, anomaly, or inefficiency feeds back into the data estate, sharpening insight and accelerating response.

With AI increasingly layered atop this foundation, NAU is now positioned to:

- Scale smart services campus-wide
- Modernize its enterprise data architecture
- Enable generative AI across facilities and sustainability
- Support new student services, auxiliaries, and revenue models

Today, NAU can manage buildings at scale, verify outcomes, coordinate IT/OT decisions, and respond in near real time—something that was not possible under the previous operating model.

Lessons for Peer Institutions

NAU's journey offers clear guidance for others:

1. Start with **people and governance**, not technology
2. Treat smart campus initiatives as **institutional strategy**, not projects
3. Identify and measure **KPIs and OKRs from day one**
4. Focus on **low-risk, high-value early wins**
5. Build trust in data through transparency and proof
6. Keep humans intentionally in the loop
7. Let AI and digital twins **augment expertise**, not replace it

Northern Arizona University's AI-Enabled Sustainable Smart Campus is not just a vision slide—it is a working reality. Through disciplined governance, bold leadership, and a relentless focus on results, NAU has transformed constraints into opportunities and complexity into an advantage. In doing so, NAU is not only building a smarter campus but also reshaping how universities operate in an era of uncertainty, scarcity, and rapid change.

ⁱ The NAU Sustainable Smart Campus Master Plan is available at https://in.nau.edu/wp-content/uploads/sites/139/2023/11/NAU-Smart-Campus-Master-Plan_11202023_DLR-Group-Part-1.pdf and https://in.nau.edu/wp-content/uploads/sites/139/2023/11/NAU-Smart-Campus-Master-Plan_11202023_DLR-Group-Part-2.pdf