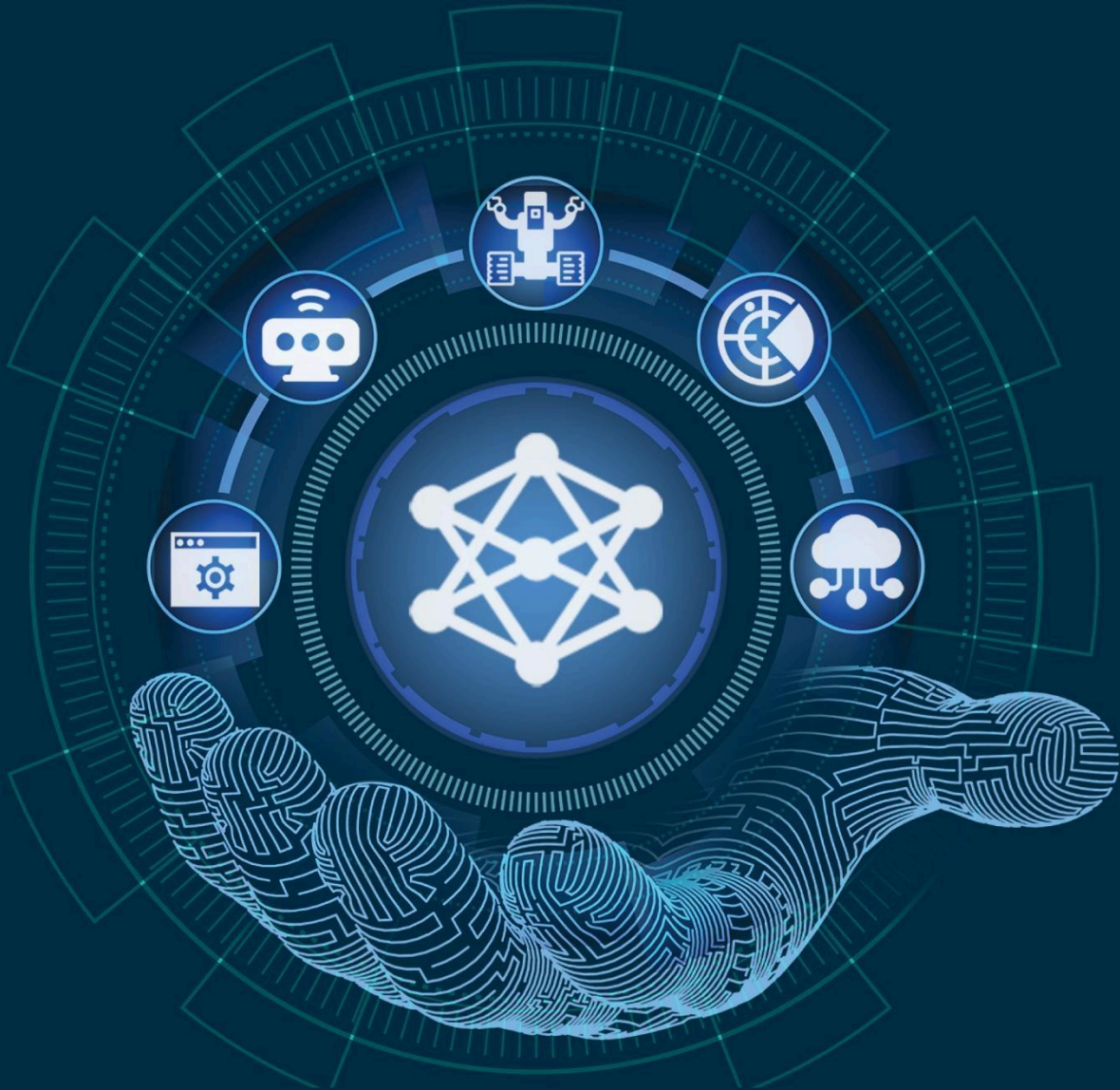


NEPI

WHITE PAPER

**A Software Platform for Rapid
Smart System Development**



numurus
— SMART SYSTEM SOLUTIONS

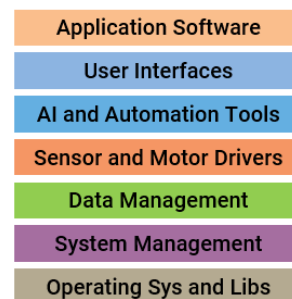
NEPI Software Platform

for Rapid Smart System Solution Development

THE CHALLENGE

Modern smart systems are possible because of an underlying layer of disparate complex software technologies that each require software developers with deep, specialized knowledge and experience. As Anders Beck states in his article [5 Robotics Predictions for 2023](#), while companies are driving innovations by combining these technologies, all companies suffer from the same problem – they can't be good at everything. Software engineer positions in general have been difficult to fill for the last several decades, and engineers with highly specialized skill sets are even more difficult to find.

Developing Smart Systems Requires a Lot of Software

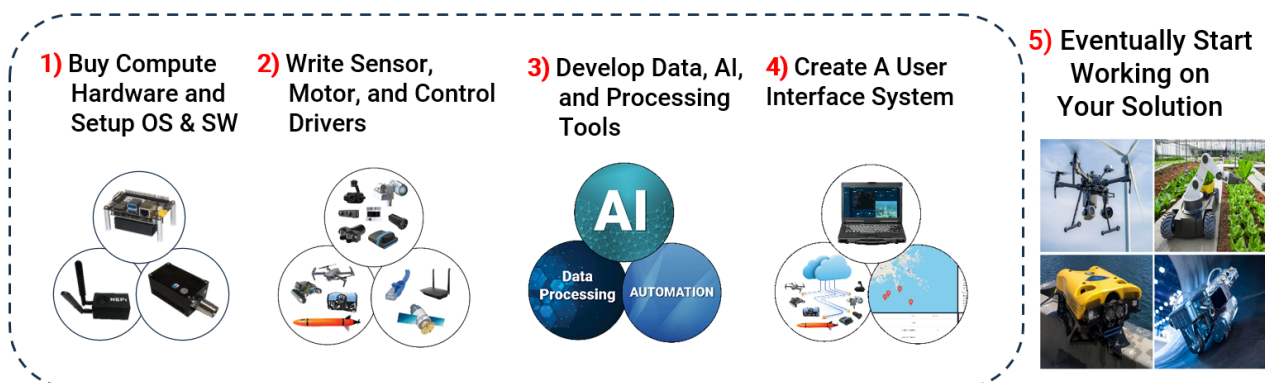


and a Lot of Time & People to Build It



A key factor in accelerating smart system software development is determining which software components are best built in-house versus leveraging software development platforms and expert services. A complete smart system solution is the combination of disparate software components, and while some provide core product differentiating capabilities like custom data processing, AI models, planning, decision making, and other application layer features, most of the software required is low-level nuts and bolts, the operating system, drivers, and middleware provide little to no strategic value for a company but consumes extensive resources building everything from scratch.

Typical Smart System Development Process



THE SOLUTION

NEPI – A Software Suite for AI and Automation Development

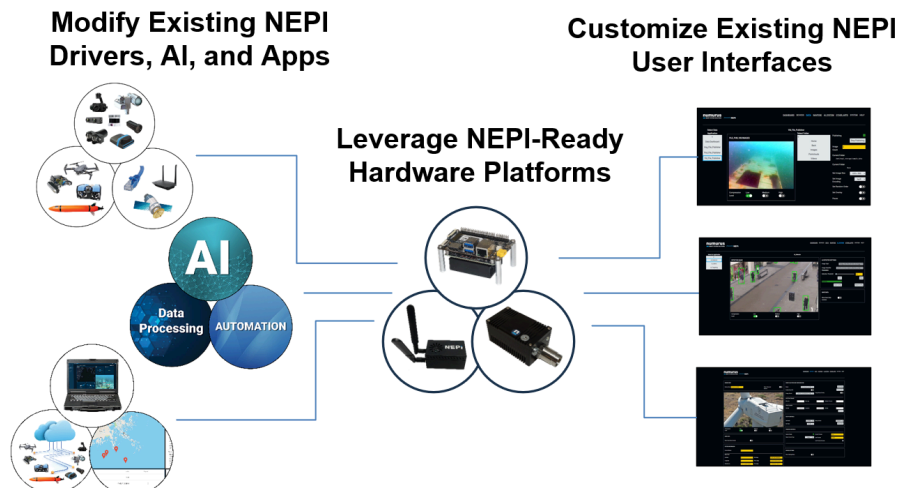
Until now, embedded chips for processing in-field AI and automation have been limited to a handful of bare-bones software environment options, leaving a lot of work to get projects off the ground and create product-ready solutions. NEPI, a full-featured, open-source software environment for embedded AI and automation speeds up both prototyping and delivery of customer solutions.



The NEPI software system includes a number of features that help you add AI and automation to your data collection operations in days, not months. These features include:

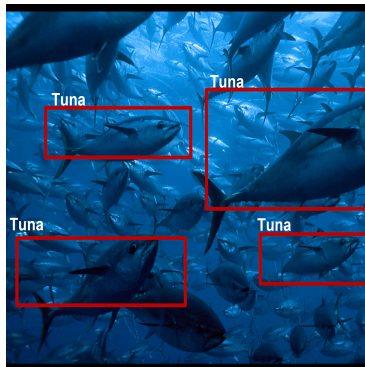
- **Plug-&-Play Hardware Interfacing** (Cameras, Sonar, Lasers, PanTilts, GPS, Robots...)
- **Integrated AI and Automation Applications** (Tracking, Monitoring, Inspection...)
- **Event-Driven Data Collection System** (Triggers, Detections, States...)
- **Low-Code Automation System** (API Based Collection Automation Scripting)

Rather than building everything from scratch, developers can quickly leverage, modify, and customize NEPI components to get their projects done in months, not years.



NEPI APPLICATIONS

NEPI is a versatile platform supporting AI-enabled smart solutions for nearly any application. Some of the more common NEPI applications are described below.

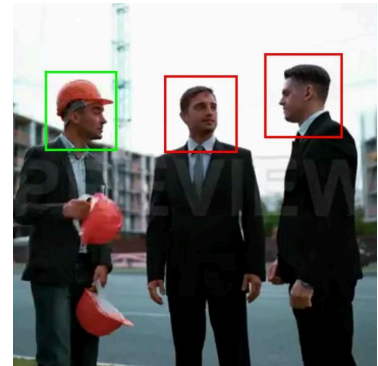


SMART SENSING SOLUTIONS

Smart sensing solutions aim to create information, not raw data, in real-time at the point of data collection. Such solutions have several benefits including reducing the need for human-in-the-loop operations, providing robotic platforms and manipulators actionable information, and managing enhanced data processing algorithms as environmental conditions or mission objectives change.

SMART MONITORING SOLUTIONS

Smart monitoring solutions aim to both detect and take actions when specific situations occur. These actions can include a combination of both static and dynamic responses from logging data, sending alerts and statistical data, tracking objects, activating alarms, turning lights on/off, locking/opening doors, or anything else your monitoring solution might require.



SMART INSPECTION SOLUTIONS

Smart inspection solutions aim to increase the quality of critical data collection, while reducing the quantity of non-critical data collection for both human and robotic inspection operations. In many situations, the cost of inspection operations is high, so getting the right data during an inspection on the first pass is important to reduce costs and deliver the needed results to stakeholders as fast as possible.

SMART SYSTEM LEARNING TOOLS

Smart system learning tools aim to help educators leapfrog the technology complexities hampering the STEM education community from teaching the skills students need to work in the rapidly growing AI and automation industry. The challenge is not that the technologies directly related to the skills these students need to learn are overly complex, it is that the underlying supporting technologies are both vast and, in some cases, extremely complex.



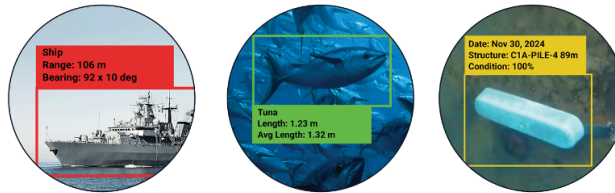
NEPI SOLUTION DEVELOPMENT PROCESS

Numurus offers a variety of S2X processors that come pre-installed with the NEPI software system, allowing developers to setup and test their solutions in days, not months or years.

1) Select an S2X Processor Package



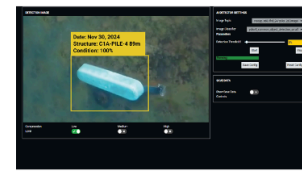
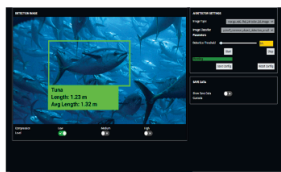
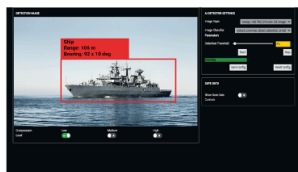
2) Upload Your AI Models



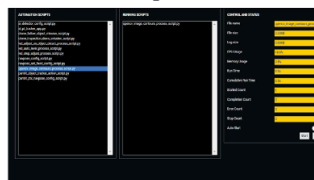
3) Connect Your Hardware



4) Configure Integrated AI Applications



5) Configure Your Automation Scripts

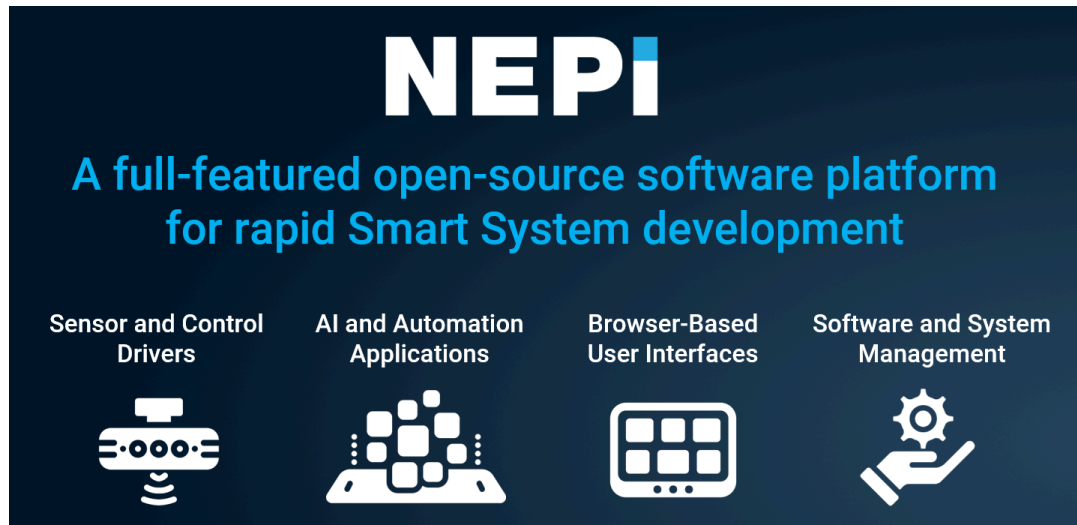


6) Deploy and Test

Learn more about Numurus' S2X Smart Data Systems at:
<https://numurus.com/products-nepi-enabled-hardware/>

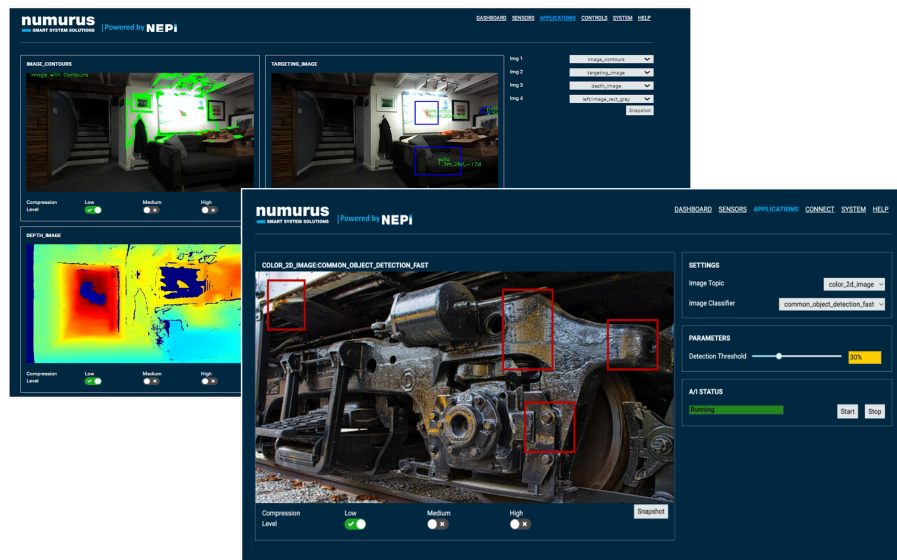
NEPI SOFTWARE SYSTEM

The NEPI software system is comprised of three main components that include a suite of system, network, driver, data, software, ai, and application management nodes, a browser-based user interface system, and a network samba shared user storage drive that together provide a complete environment for rapidly creating application specific AI and automation solutions.



NEPI RESIDENT USER INTERFACE (RUI) SYSTEM

NEPI's Resident User Interface (RUI) provides a customizable browser-based user interface hosted on the NEPI device for configuring, validating, and monitoring system managed components like hardware drivers, AI models, and applications. The NEPI RUI is comprised of a top-level menu with additional submenus appearing under each top menu item as shown and described below:



Learn more about NEPI SOFTWARE SYSTEM at:

<https://nepi.com/documentation/nepi-engine-software-manual/>

NEPI MANAGED COMPONENTS

While the NEPI software system provides all of the required system management components, it is the device drivers, AI, and applications that NEPI connects that together provide fieldable end-customer solutions. While custom developed components can be quickly integrated into a NEPI based solution, Numurus offers a growing suite of NEPI drivers, AI frameworks, and applications to further accelerate solution development efforts.

HARDWARE ABSTRACTION DRIVERS

Leveraging NEPI's hardware interface class libraries, NEPI device drivers provide plug-and-play connectivity that abstracts each device's native interface to NEPI standard SDK interfaces, allowing downstream applications to just work without needing any details about the hardware specific interfaces.

- Camera, Laser, and Sonar Drivers
- Light and Strobe Drivers
- Pan and Tilt Drivers
- Robotic Control System Drivers
- Nav and Pose Device Drivers

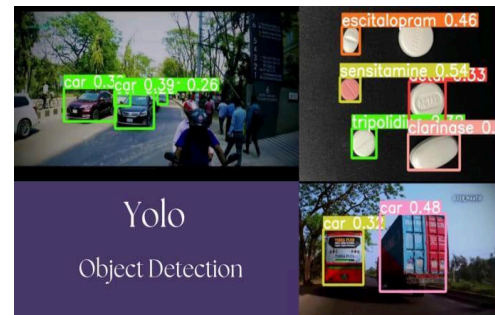


Learn more about NEPI Hardware Drivers at:

<https://nepi.com/documentation/nepi-engine-hardware-driver-interface-system/>

AI FRAMEWORKS AND MODELS

Leveraging NEPI's ai framework and model interface class libraries, NEPI provides drag-and-drop deployment of ai models that abstract each model's native framework interface to a NEPI standard SDK interface, allowing downstream applications to just work without needing any details about the model processing framework.



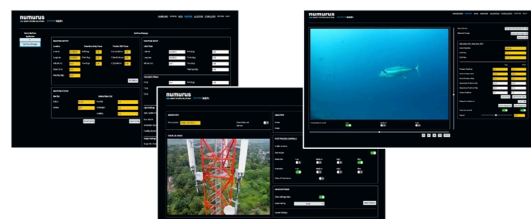
Learn more about NEPI's AI Management System at:

<https://nepi.com/documentation/nepi-engine-hardware-driver-interface-system/>

APPLICATIONS

Leveraging NEPI's driver and ai framework SDK abstraction interfaces, NEPI applications can quickly be created, modified, and deployed without needing specifics about the hardware and ai components they will ultimately interface with.

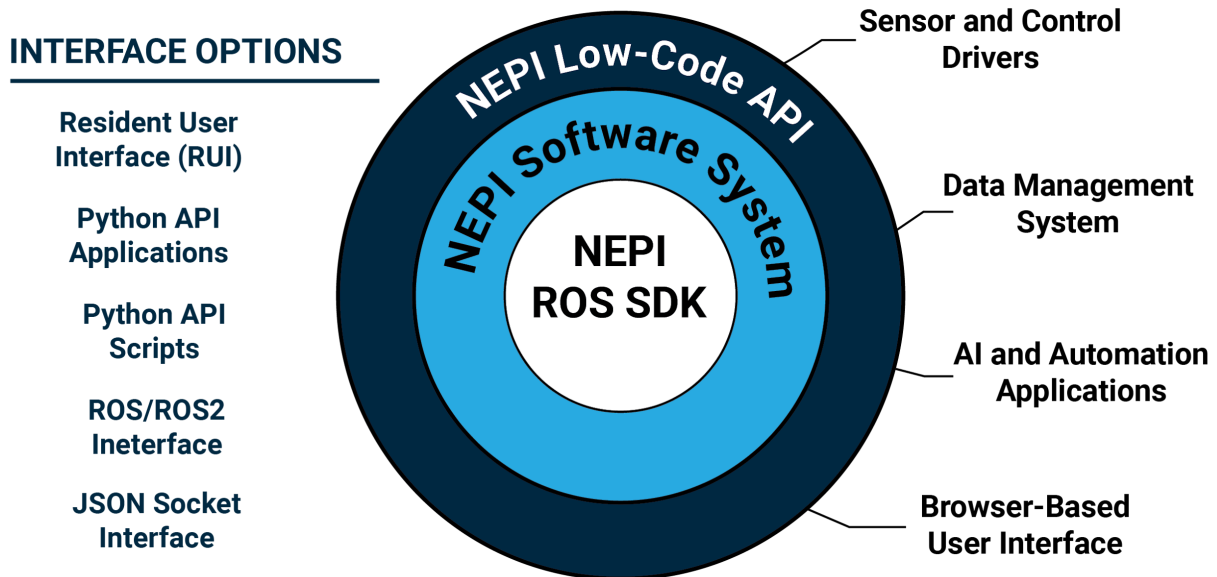
- System Management Apps
- Device Management Apps
- Data Management Apps
- AI and Automation Apps



See videos of available NEPI Applications at: <https://www.youtube.com/playlist/nepi3p0>

NEPI SOFTWARE ARCHITECTURE

NEPI installs on top of the base operating system provided by edge-compute board and chip manufacturers, creating a feature-rich environment for edge-AI and other edge automation development projects. While NEPI supports several API interfaces, primary NEPI command-line and programmatic interfacing is provided by a collection of ROS communication primitives and shared interface classes.



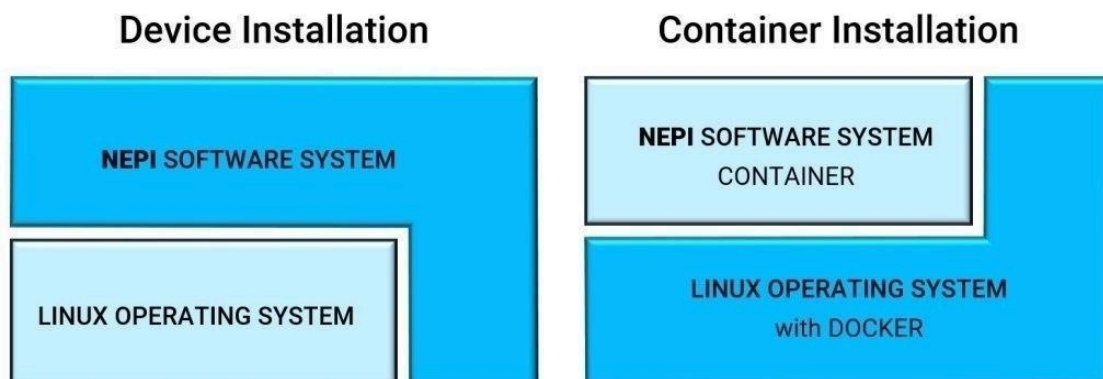
Learn more about NEPI API Interfaces at:

<https://nepi.com/documentation/nepi-engine-api-manual/>

Learn more about NEPI SDK Interface Library at:

https://github.com/nepi-engine/nepi_engine/tree/main/nepi_sdk

NEPI software can be installed directly on a device's operating system or as a container running in the device's operating system. While the container installation option provides a straightforward process and superior porting flexibility, NEPI installed directly on the device's OS provides additional clock, network, Wi-Fi, security, and software management features.



Learn more about NEPI SOFTWARE ARCHITECTURE at:

<https://nepi.com/documentation/nepi-engine-nepi-file-system/>

NEPI DEVELOPER RESOURCES

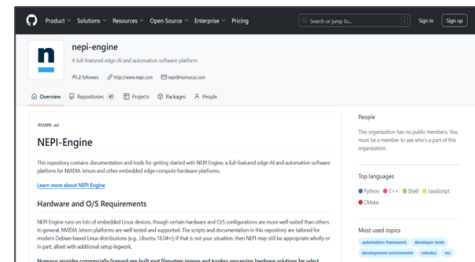
There are significant challenges that should be considered as you embark upon a smart sensor, robotic or Edge-AI smart system development.

PUBLIC GITHUB REPO

The NEPI GitHub site hosts the NEPI source-code repository and installation instructions.

Learn more about Numurus Products and Services at:

<https://github.com/nepi-engine>



ONLINE DOCUMENTATION AND TUTORIALS

The NEPI.com website offers developers a large collection of NEPI documentation and tutorials

Learn more about Numurus Products and Services at:

<https://nepi.com>

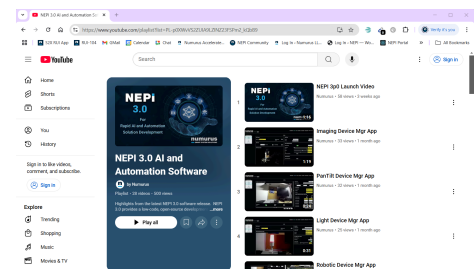


ONLINE VIDEOS

The NEPI YouTube channel provides a collection of NEPI feature, use, and development tutorial videos.

Learn more about Numurus Products and Services at:

<https://www.youtube.com/playlist/nepi3p0>

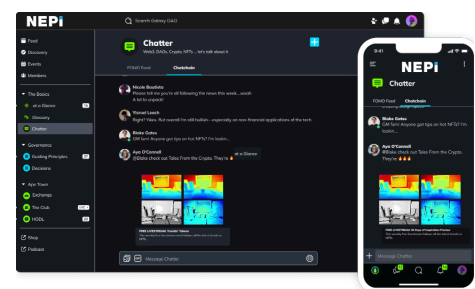


COMMUNITY SITE

The community.nepi.com website provides both NEPI users and developers to quickly get answers on software issues and discuss future software needs.

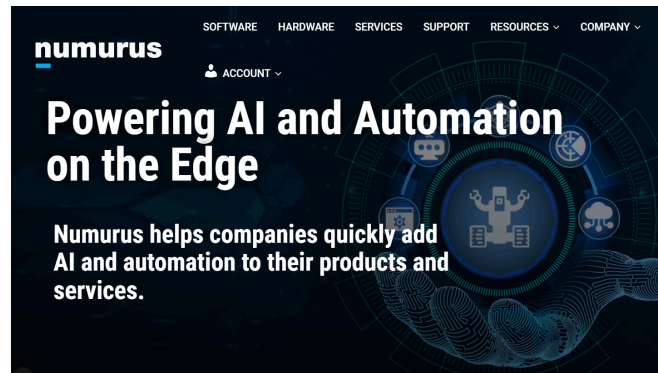
Learn more about Numurus Products and Services at:

<https://nepi.com/community/>



NUMURUS PRODUCTS & SERVICES

Numurus delivers products and services that reduce the cost, time, and risks of bringing smart inspection and automation solutions to market. Numurus offers turn-key NEPI containerized images, NEPI-enabled edge-compute hardware, and professional services with AI, robotic, and smart sensing specialized engineers that further accelerate solution development efforts.



NEPI

TURN-KEY NEPI SOFTWARE (IMAGES & CONTAINERS)

Numurus offers ready-to-deploy pre-built NEPI software images that include an optimized Ubuntu OS and NEPI software environment along with a suite of NEPI hardware drivers, AI frameworks, and applications.

NEPI-READY COMPUTE HARDWARE (OTS & CUSTOM)

Numurus sells off-the-shelf and custom edge-compute hardware stacks pre-installed with the NEPI software system and NEPI hardware drivers, AI frameworks, and applications.



PROJECT SUPPORT & PROTOTYPING

Numurus offers smart system software, edge-compute, and prototyping design services to reduce project risks and timeline. Numurus' design services' team includes AI, automation, robotic, and smart sensing specialized engineers that accelerate NEPI-enabled solution implementation efforts.

Learn more about Numurus Products and Services at: <https://numurus.com>

CUSTOMER SUCCESS STORY

KEVIN DECKER, CEO | OCEAN AERO *"The combination of Numurus' NEPI smart system software, off-the-shelf compute hardware, and its responsive engineering support team was a big factor in the success of this project. It saved our internal team from a lot of development work we'd otherwise have to do ourselves"*

Ocean Aero, creator of the TRITON autonomous underwater and surface vehicle (AUSV), launched an internal development effort to deploy at-sea AI-enabled inspection automation capabilities to its TRITON robotic platforms. In support of the Defense Innovation Unit's (DIU) Unmanned Systems for Maritime Domain Awareness program, the first project was to automate 360-degree maritime threat detection between a suite of on-board cameras and on-board artificial intelligence models integrated onto a forward-deployed TRITON AUSV platform, and send detected threat information wirelessly to remote operations centers.

To accelerate their at-sea AI and automated solution development, Ocean Aero turned to Numurus for turnkey edge-compute hardware preinstalled with Numurus' NEPI AI and automation software, a full-featured software platform for AI and automation solution development, which allowed them to rapidly create and field the AI enabled solution they had envisioned.

At-Sea Threat Detection Automation

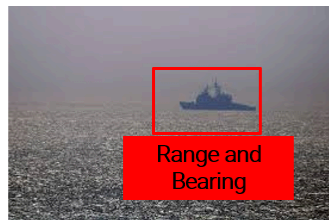
| Powered by **NEPI**



AI Detect
on multiple camera streams



Estimate
target range and bearing



Collect Data
from steerable high-res camera



Within 6 months of kicking off their 360-degree maritime detection automation project leveraging off-the-shelf NEPI-enabled hardware development platforms with minimal support from Numurus' professional services team, Ocean Aero successfully interfaced 5 directional cameras with onboard AI models, then fielded, tested, and demonstrated automated maritime domain awareness capabilities running on its TRITON AUSV systems. This resulted in less dependency on an operator-in-the-loop to detect and identify threats and increased delivery of actionable information to local and remote end-points.

See the complete story and more at: <https://numurus.com/case-studies/>