



## Machine Learning with Simulink and NVIDIA Jetson

*Leela S. Karumbunathan, NVIDIA*



*Bill Chou, MathWorks*



**MATLAB EXPO**

## AGENDA

- NVIDIA and MathWorks Partnership
- What is the Jetson AGX Orin
- Workflow: Simulink to Jetson AGX Orin
- Example: Deploy lane and vehicle detection to Jetson AGX Orin

# NVIDIA AND MATHWORKS COLLABORATION

Integrate NVIDIA GPUs with MATLAB from Embedded to Enterprise

## GENERAL-PURPOSE TECHNICAL COMPUTING

**NVIDIA GPU SUPPORT IN 1,000+ FUNCTIONS:**

- MATLAB
- Deep Learning Toolbox
- Image Processing Toolbox
- Signal Processing Toolbox
- Plus others...

**No need for CUDA expertise!**



## ON-PREM AND CLOUD

**MATLAB and NVIDIA GPU CLOUD**

Instantly access on-premises and cloud GPUs with MATLAB and NGC



## EMBEDDED SYSTEMS

**OPTIMIZED CUDA GENERATION FROM MATLAB CODE**

MATLAB & Simulink

GPU Coder

CUDA

cuBLAS, cuSolver, cuDNN, TensorRT



# CHALLENGES WITH GENERATING AN AI APPLICATION FOR EDGE DEVICES

- Pick the right hardware for the AI application
- Simulate and test the AI application
- Deploy the AI application to the edge device

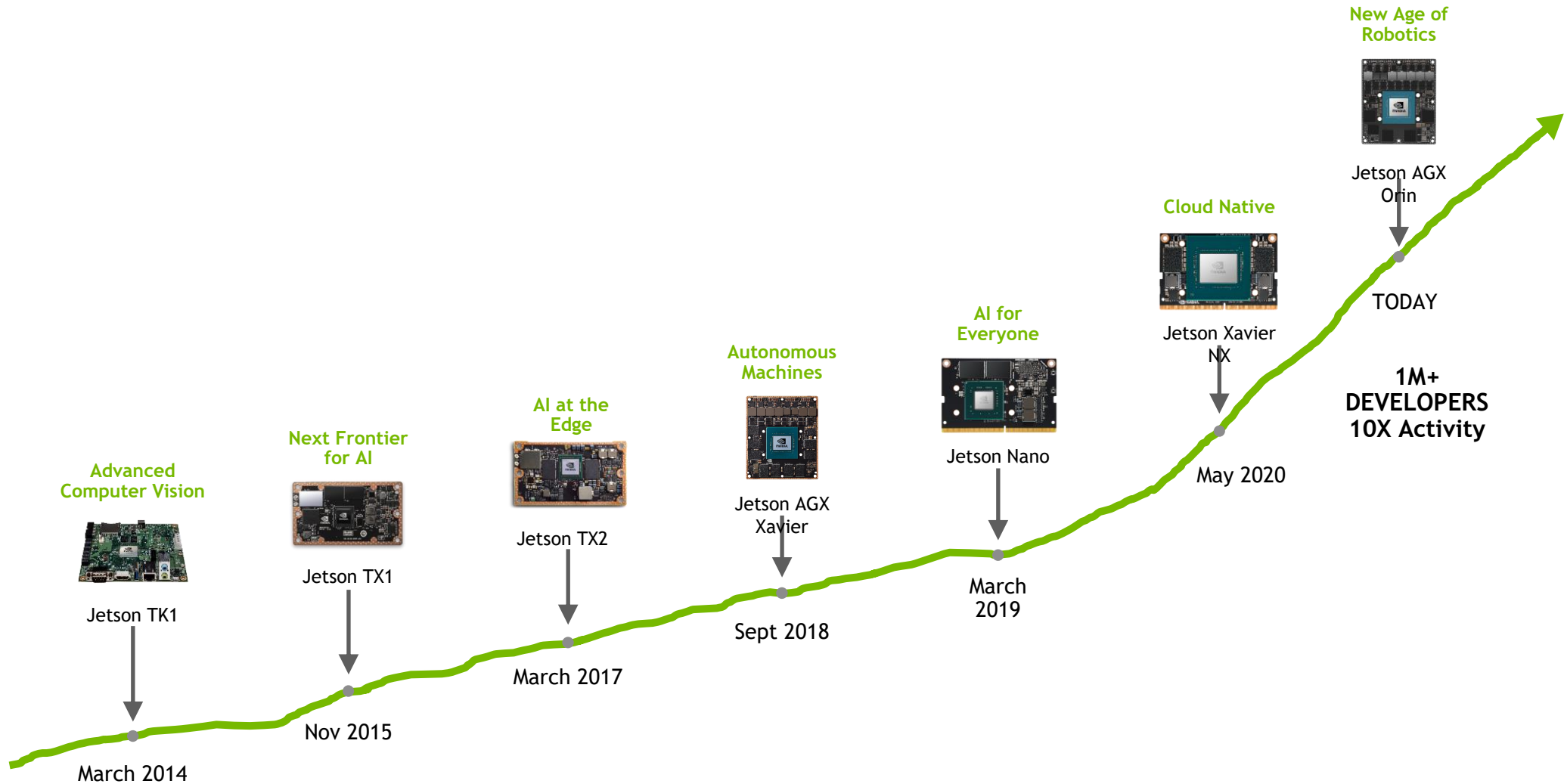


# CHALLENGES WITH GENERATING AN AI APPLICATION FOR EDGE DEVICES

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# NVIDIA JETSON POWERING THE NEXT AIOT & ROBOTICS REVOLUTION

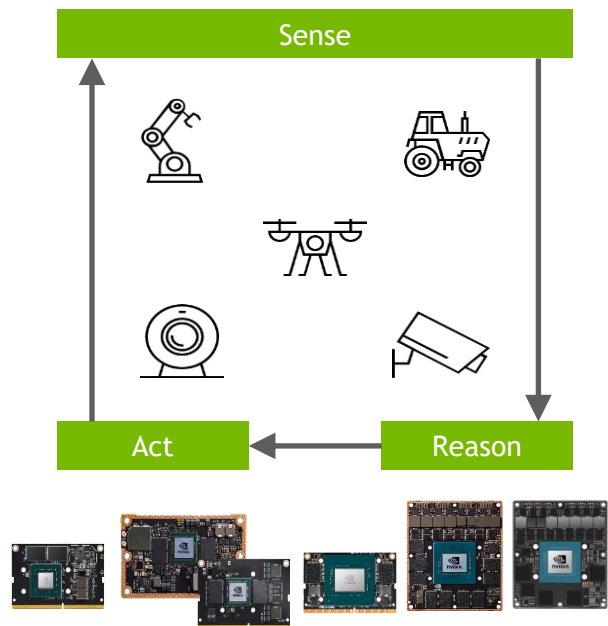


# NVIDIA JETSON

Software-defined AI Platform

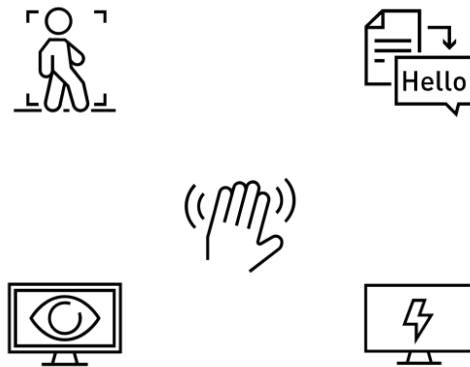
## AI AT THE EDGE

Sensor Fusion & Compute Performance



## SOFTWARE DEFINED

SDK, OS, Design Tools, Libs, GEMs



## ECOSYSTEM

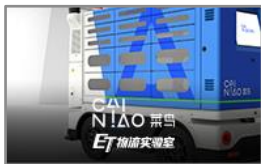
Expertise, Time to Market





# EDGE AI MOMENTUM BUILDING ON NVIDIA JETSON

## DELIVERY



## RETAIL



## AMR



## AGRICULTURE



## SERVICES



## LOGISTICS



## MANUFACTURING



## HEALTHCARE



1,000,000  
Developers

6,000+  
Customers



# GROWING JETSON ECOSYSTEM PARTNERS (130+)



## DISTRIBUTION

Logos of distribution partners: ANUW, C.R.G. ELECTRONICS, E.D.O.M. TECHNOLOGY CO., LTD., STIEX, HANCOM HANCOM MDS, macnica, NEXTY Electronics, OPEN ZEKA, RPtech, Siliconhighway, SYNEX.

## SOFTWARE

Logos of software partners categorized into four groups:

- ISV:** ABEJA, cogniteam, CyberLink, DATA FROM SKY, Ignitorium, INEXTECH, IRONYUN, KOQUIS, kudarr, MIT, miovision, NetworkOptix, NOTRAFFIC, NOVAUTO, neurala, ottopia, pervasive technologies, Phantom Auto, PIXEVIA, SAFR, SLAMCORE, SmartCow, UPSWIFT, WESMART.
- TOOLS/SYSTEMS SW:** balena, concurrent REAL-TIME, MathWorks, MENDER, RidgeRun, WNDVR.
- CSP-IOT:** AWS Greengrass, Azure.
- SOFTWARE SERVICES:** AIIXON, alwaysAI, antmicro, Castehink, FOUNDRYSO, FUJISOFT, Infosys, 美林数据 MERITDATA, NEX OPTIC, PATHPARTNER, quantiphi, QUEST, SMA SOFT, timesys, Witelio.

## HW AND SENSORS

Logos of hardware and sensor partners categorized into two groups:

- CAMERA AND SENSORS:** Allied Vision, APPRO.PHO, BASLER, Boulder AI, Canon, CEPTON, D3 Engineering, OMP, e-con Systems, infochips, FLIR, FRAMOS, ITD Lab, ITANZI, Legend, LIPS, LIVOX, LMI TECHNOLOGIES, MYNTAI, Photonox, robosense, SICK, SONY, STEREO LABS, IMAGING SOURCE, ThunderSoft, Velodyne LiDAR, ximea, 3D VISION LABS.
- HARDWARE AND DESIGN SERVICES:** AAEON, ADLINK, ADAANTECH, aetina, AIMobile, AI, AVIDA, AVerMedia, AXIOMTEK, BitFlow, CUI, Connect Tech Inc., Convergent TECHNOLOGIES, CREW SYSTEMS, CURTISS-WRIGHT, DIAMOND SYSTEMS, elix, EUROTECH, EverFocus, forecr, Geniatech, HIVECELL, infineon, inspur, LCFC, LEETOP, maxim integrated, MICROCHIP, 洪文动力 HONGWEN DONGLI, MISTRAL, neosys TECHNOLOGY, onyx, PCP SOLUTIONS, Pink-AI, Pleora Technologies, PowerLeader, QUECTEL, 瑞泰新时代, REBOTNIX, SERCOM, silex technology, syslogic, TANNA TECHBIZ, Telit, TOSHIBA, TZTEK, Vecow, VIDTEK, VVDN, WIBASE, Wisdom Starry, WOLF.

# THE JETSON FAMILY

For AI at the Edge and Autonomous Machines

Next Gen  
Jetson

## JETSON Orin NX Series

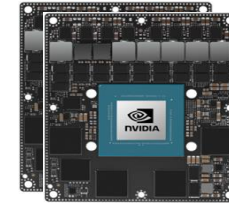
100 TOPs (INT8)



10 - 25W  
8GB/16GB  
45mm x 70mm

## JETSON AGX Orin Series

275 TOPs (INT8)



15 - 60W  
32GB/64GB  
100mm x 87mm

ENTRY

MAINSTREAM

AUTONOMOUS MACHINES

## JETSON NANO

0.5 TFLOPS (FP16)



5 - 10W  
45mm x 70mm

## JETSON TX2 series

1.33 TFLOPS (FP16)



7.5 - 15W\*  
45mm x 70mm  
50mm x 87mm

## JETSON Xavier NX series

6 TFLOPS (FP16)

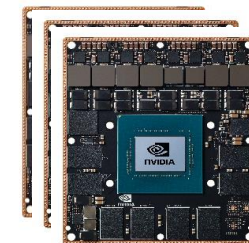
21 TOPs (INT8)



10 - 20W  
8GB/16GB  
45mm x 70mm

## JETSON AGX Xavier Series

11 TFLOPS (FP16)

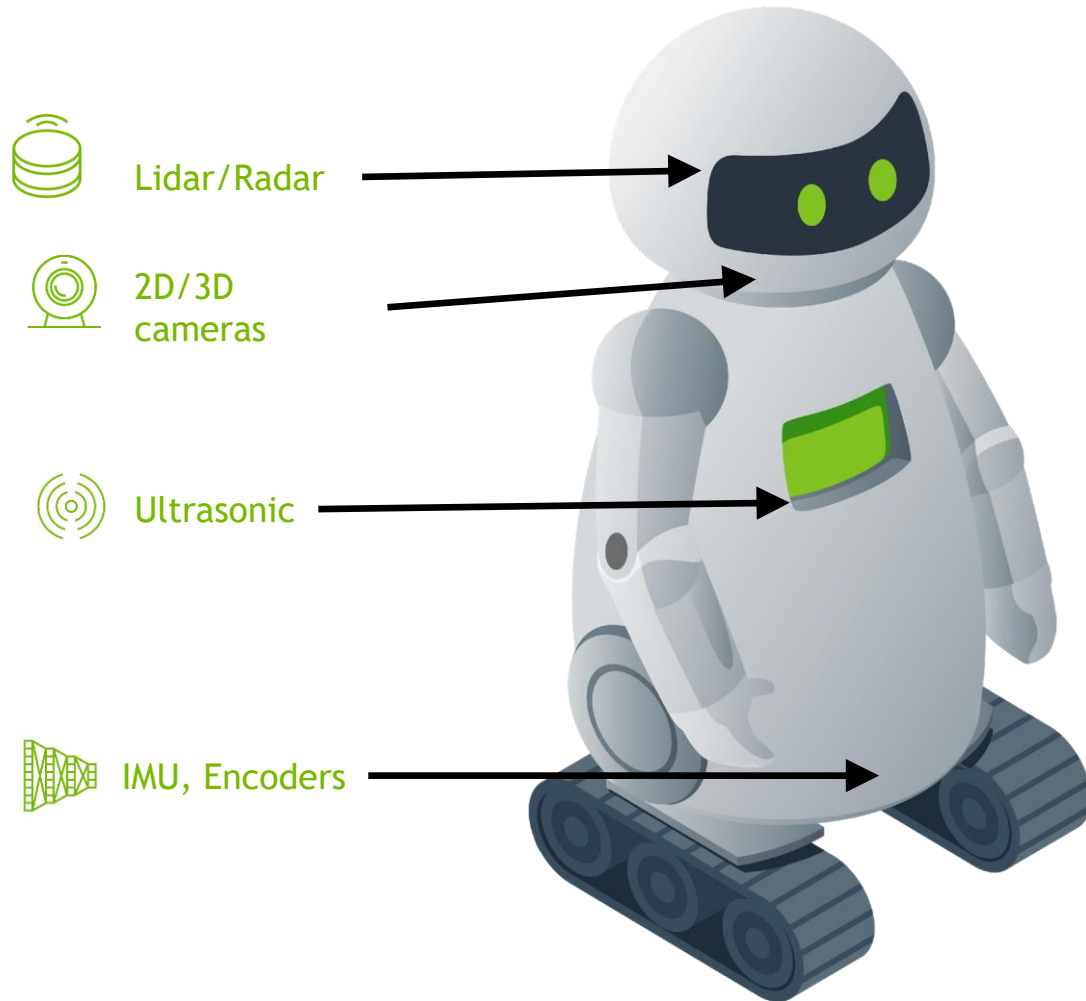


10 - 30W\*\*  
32GB/64GB  
100mm x 87mm

Full specs at [developer.nvidia.com/jetson](https://developer.nvidia.com/jetson)

\*TX2i: 10-20W \*\* Jetson AGX Xavier Industrial 20W-40W

# NEW AGE OF ROBOTS DRIVEN BY INCREASING NEEDS OF MACHINE LEARNING



**Multi-modal  
Sensor  
Perception**  
10's of DL TOPS

**Mapping &  
Localization**  
10's of DL TOPS

**Path Planning &  
Control**  
1's of DL TOPS  
+ CV + CPU

**Human Robot  
Interaction**  
10's of DL TOPS  
+ Adv. Graphics

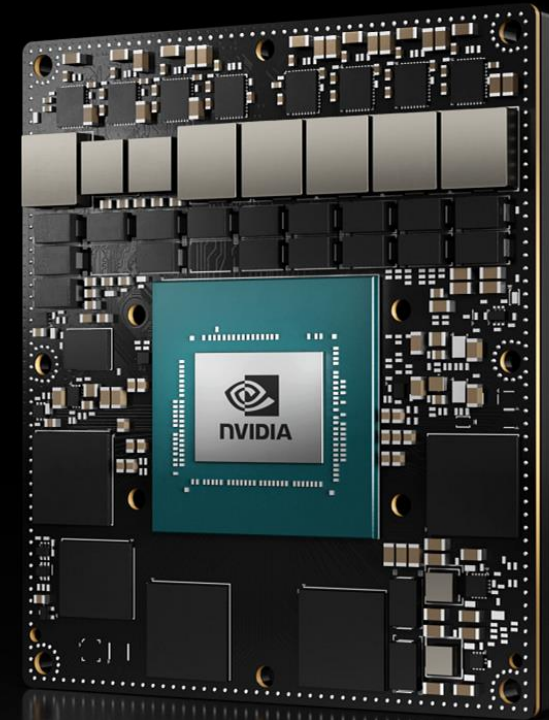
**Situational  
Awareness**  
10's of DL  
TOPS

**Safety &  
Redundancy**

## JETSON AGX ORIN SERIES

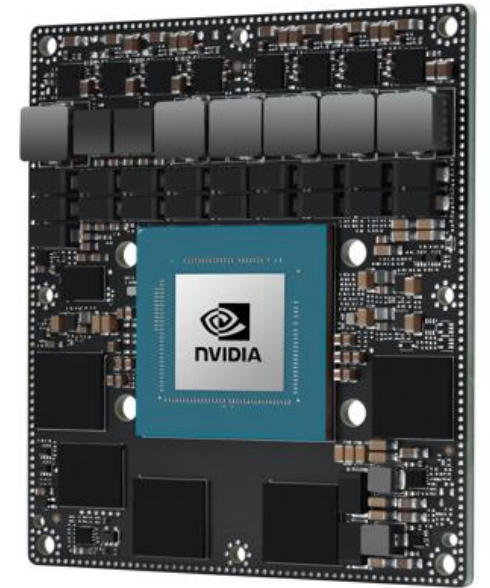
Server Class AI Performance at the Edge

- Up to **275 INT8 TOPS** powered by Ampere GPU +DLA
- Up to 12x A78 ARM CPU
- Up to 64 GB memory, 204 GB/s
- Production Modules will be available in **Q4 2022**
- Get started developing for AGX Orin series with AGX Orin Devkit



# JETSON AGX ORIN SERIES

	Jetson AGX Xavier	Jetson AGX Xavier 64GB	Jetson AGX Orin 32GB	Jetson AGX Orin 64GB
AI Performance	32 TOPS (De)		200 TOPS (Sp)   100 TOPS (De)	275 TOPS (Sp)   138 TOPS (De)
GPU	512-core NVIDIA Volta GPU with 64 Tensor Cores		1792-core NVIDIA Ampere GPU with 56 Tensor Cores	2048-core NVIDIA Ampere GPU with 64 Tensor Cores
DL Accelerator	2x NVDLA		2x NVDLA v2	
Vision Accelerator	2x PVA v1		PVA v2	
CPU	8-core NVIDIA Carmel Arm®v8.2 64-bit CPU 8MB L2 + 4MB L3		8-core NVIDIA Arm® Cortex A78AE v8.2 64-bit CPU 2MB L2 + 4MB L3	12-core NVIDIA Arm® Cortex A78AE v8.2 64-bit CPU 3MB L2 + 6MB L3
Memory	32GB 256-bit LPDDR4x @ 2133MHz 137 GB/s	64GB 256-bit LPDDR4x @ 2133MHz 137 GB/s	32 GB 256-bit LPDDR5 @ 3200MHz 204.8 GB/s	64 GB 256-bit LPDDR5 @ 3200MHz 204.8 GB/s
Storage	32GB eMMC 5.1		64 GB eMMC 5.1	
Video Encode	4x 4K60   8x 4K30   16x 1080p60   32x 1080p30 (H.265) H.264, VP9		1x 4K60   3x 4K30   6x 1080p60   12x 1080p30 (H.265) H.264, AV1	2x 4K60   4x 4K30   8x 1080p60   16x 1080p30 (H.265) H.264, AV1
Video Decode	2x 8K30   6x 4K60   12x 4K30   26x 1080p60   52x 1080p30 (H.265) H.264, VP9		1x 8K30   2x 4K60   4x 4K30   9x 1080p60   18x 1080p30 (H.265) H.264, VP9, AV1	1x 8K30   3x 4K60   6x 4K30   12x 1080p60   24x 1080p30 (H.265) H.264, VP9, AV1
Camera	16 lanes MIPI CSI-2 (36 Virtual Channels)   8 lanes SLVS-EC   D-PHY 40Gbps / C-PHY 62 Gbps		16 lanes MIPI CSI-2 (16 Virtual Channels*) D-PHY 2.1 40Gbps / C-PHY 2.0 164Gbps	
PCI Express	16 lanes PCIe Gen 4 1 x8 + 1 x4 + 1 x2 + 2 x1		22 lanes PCIe Gen 4 Up to 2 x8, 1 x4, 2 x1	
Ethernet	1 Gbe RGMII		1 Gbe RGMII   4x 10Gbe XFI	
Mechanical	100mm x 87mm 699 pin connector		100mm x 87mm 699 pin connector	
Power	10W to 30W		15W to 40W	15W to 60W



\*Virtual Channel related camera information for Jetson AGX Orin is not final and subject to change. Video Decode will be finalized by Mid Match

# JETSON ORIN MODULES FOR NEXT-GEN AI PERFORMANCE



## JETSON AGX XAVIER 64GB

- 32 Dense INT8 TOPS
- 10W to 30W
- \$1299\*

## JETSON AGX XAVIER (32GB)

- 32 Dense INT8 TOPS
- 10W to 30W
- \$899\*

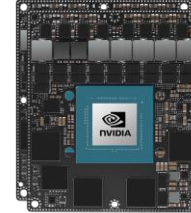


## JETSON XAVIER NX 16GB

- 21 Dense INT8 TOPS
- 10W to 20W
- \$499\*

## JETSON XAVIER NX (8GB)

- 21 Dense INT8 TOPS
- 10W to 20W
- \$399\*



## JETSON AGX ORIN 64GB

- 275 SPARSE | 138 DENSE, INT8 TOPS
- 15W to 60W
- \$1599\*
- Available: Oct 2022

## JETSON AGX ORIN 32GB

- 200 SPARSE | 100 DENSE, INT8 TOPS
- 15W to 40W
- \$899\*
- Available: Oct 2022



## JETSON ORIN NX 16GB

- 100 SPARSE | 50 DENSE, INT8 TOPS
- 10W to 25W
- \$599\*
- Available: Late Q4, 2022

## JETSON ORIN NX 8GB

- 70 SPARSE | 35 DENSE, INT8 TOPS
- 10W to 20W
- \$399\*
- Available: Late Q4, 2022



# START YOUR DEVELOPMENT TODAY

Get Started With the AGX Orin Series and the Orin NX Series

## EMULATION MODE

- The AGX Orin developer kit can emulate the performance of the AGX Orin Series and the Orin NX Series
- Developers can get started with their development of all four modules today!

## DEVELOPER KIT CONTENTS

- Jetson AGX Orin Module and Heatsink
- Reference carrier board
- 802.11ac/abgn Wireless Network Interface Controller
- Power adapter and USB Type-C cord
- USB Type-C to USB Type-A cord
- Quick Start and Support Guide



## JETSON AGX ORIN DEVELOPER KIT\*

15W - 60W

275 TOPS (INT8)

\$1999

Available Now

110mm x 110mm x 71.65mm

[Jetson AGX Orin for Next-Gen Robotics | NVIDIA](https://developer.nvidia.com/embedded/jetson-agx-orin-developer-kit)  
<https://developer.nvidia.com/embedded/jetson-agx-orin-developer-kit>

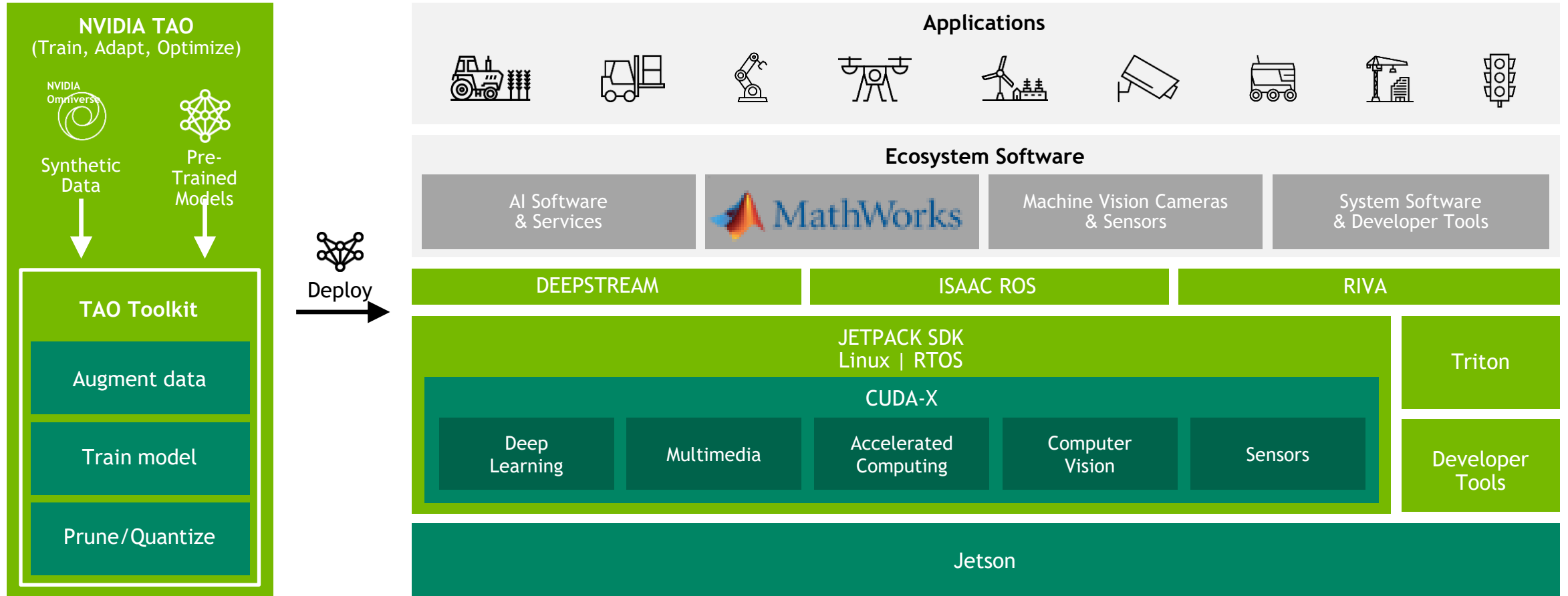
\* The Jetson AGX Orin Developer Kit will be available with 32GB of memory.

NVIDIA recommends to use Developer Kits for only development purposes. For production, customers should leverage our production modules. Our production modules have been tested for production environments.



# THE SECRET IS CONTINUOUS SOFTWARE ADVANCEMENTS

Accelerate AI Applications and Time-to-Market



# CHALLENGES WITH GENERATING AN AI APPLICATION FOR EDGE DEVICES

- Pick the right hardware for the AI application
- Simulate and test the AI application
- Deploy the AI application to the edge device



# AI-DRIVEN SYSTEM DESIGN

## Data Preparation



Data cleansing and preparation



Human insight



Simulation-generated data

## AI Modeling



Model design and tuning



Hardware accelerated training



Interoperability

## Simulation & Test



Integration with complex systems



System simulation



System verification and validation

## Deployment



Embedded devices



Enterprise systems



Edge, cloud, desktop

## AI-DRIVEN SYSTEM DESIGN

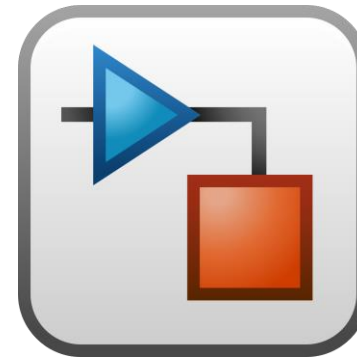
Data Preparation



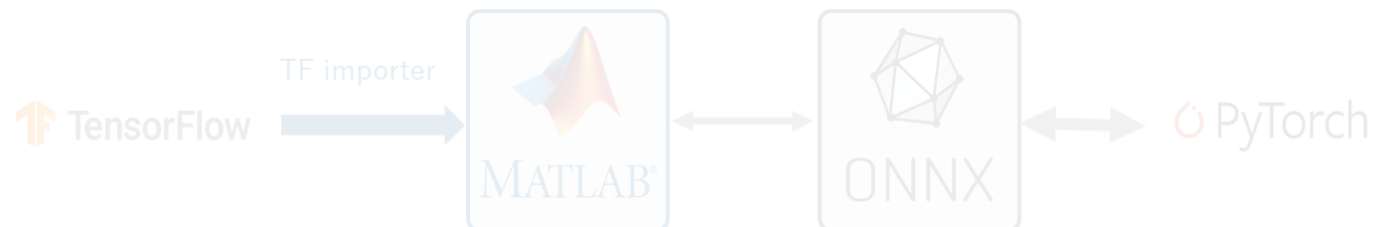
AI Modeling



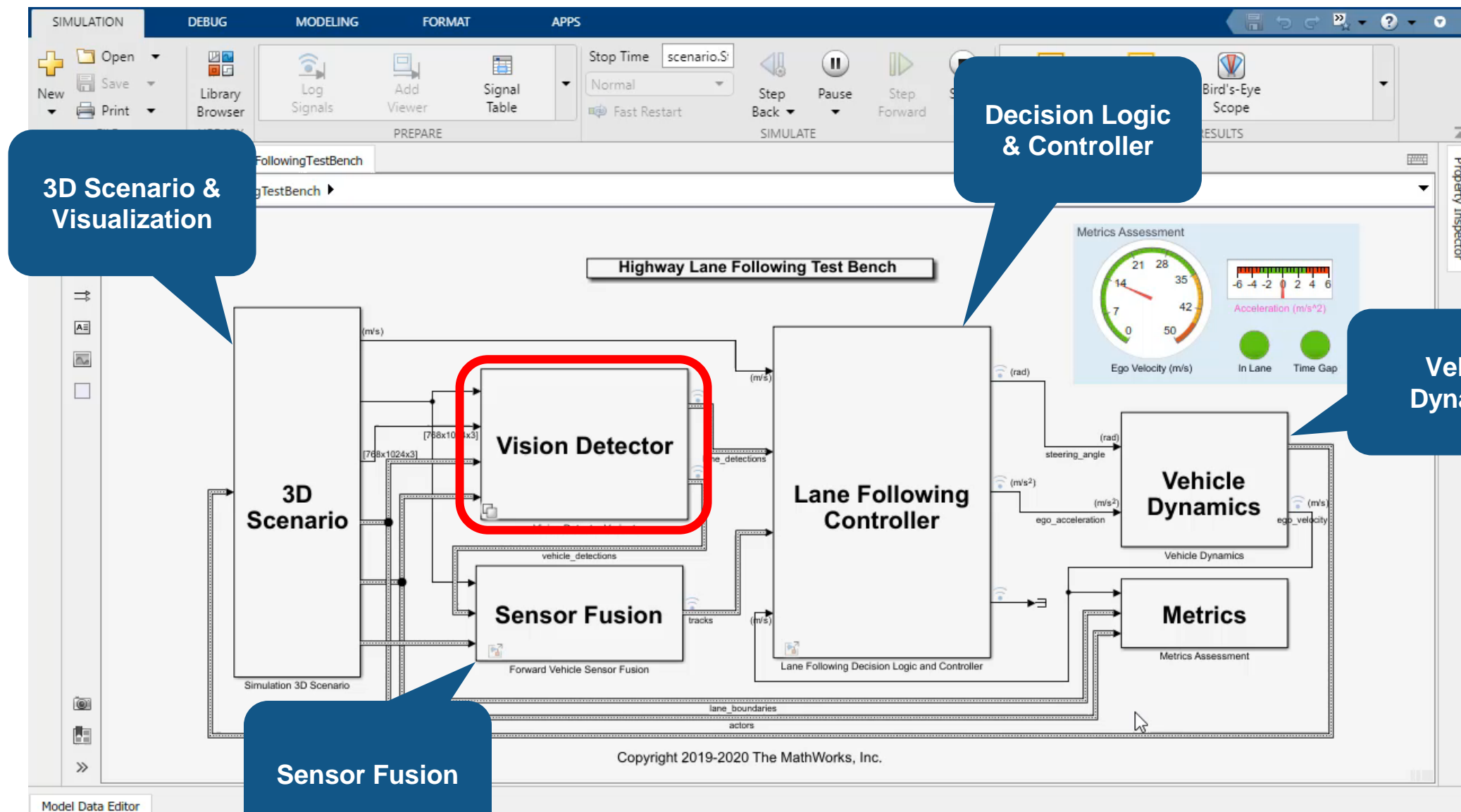
Simulation &amp; Test



Deployment



# HIGHWAY LANE FOLLOWING SIMULATION IN SIMULINK



3D Scenario & Visualization

Decision Logic & Controller

Vehicle Dynamics

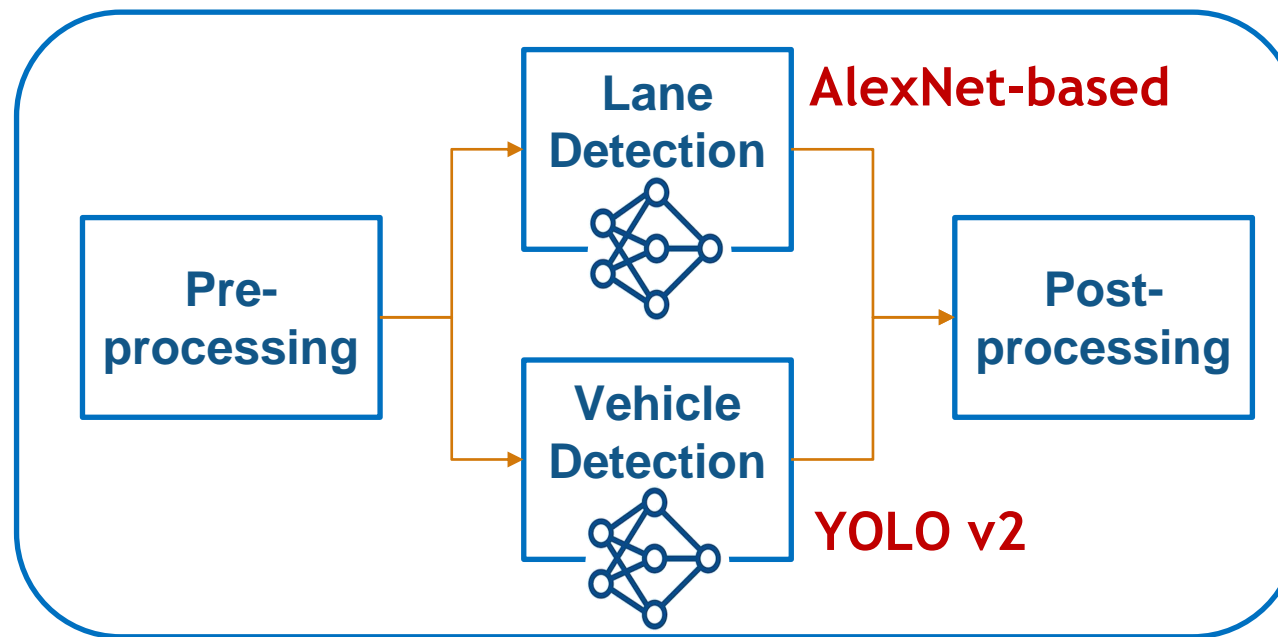
Sensor Fusion

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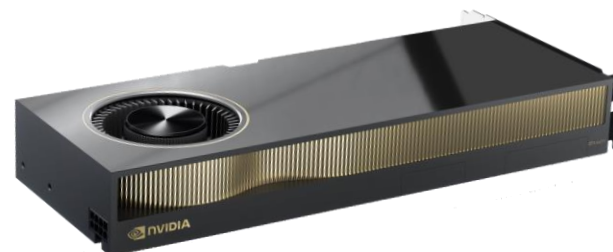
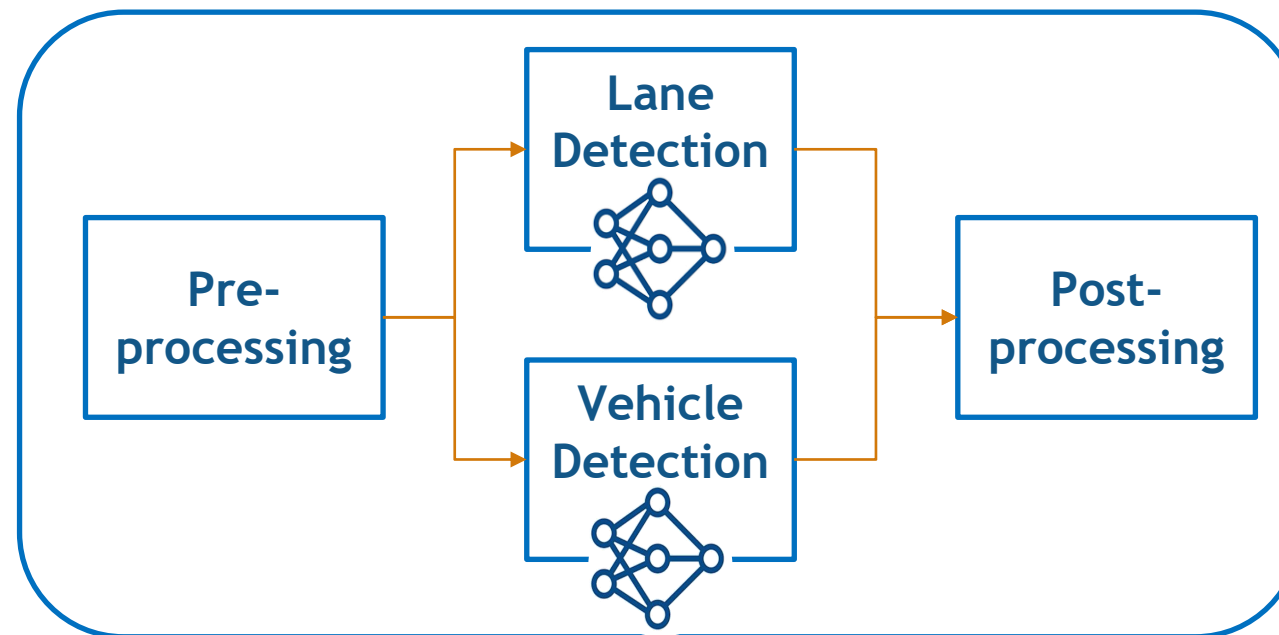


# LANE AND VEHICLE DETECTION





## RUN SIMULATION ON DESKTOP GPU



# RUN SIMULATION ON DESKTOP GPU



The screenshot displays the MATLAB Simulink environment. The top toolbar is set to the 'FUNCTION' tab, showing simulation controls like 'Pause', 'Step Forward', and 'Stop'. The main workspace contains a Simulink model for 'laneAndVehicleDetection2'. The model consists of three main blocks: 'Resize Image', 'Lane Detection', and 'Detect Coordinates'. The 'Lane Detection' block is a neural network icon. Below it, a 'Lane Detection (YOLOv2)' block is shown with two outputs: 'bboxes' and 'scores'. The 'Detect Coordinates' block is a 'Postprocessing' block. Two video windows are open: 'Input1' on the left shows a street scene from a car's perspective, and 'Output' on the right shows the same scene with yellow bounding boxes around cars and green dashed lines for lane detection. The 'Output' window also displays numerical values for the detected objects.

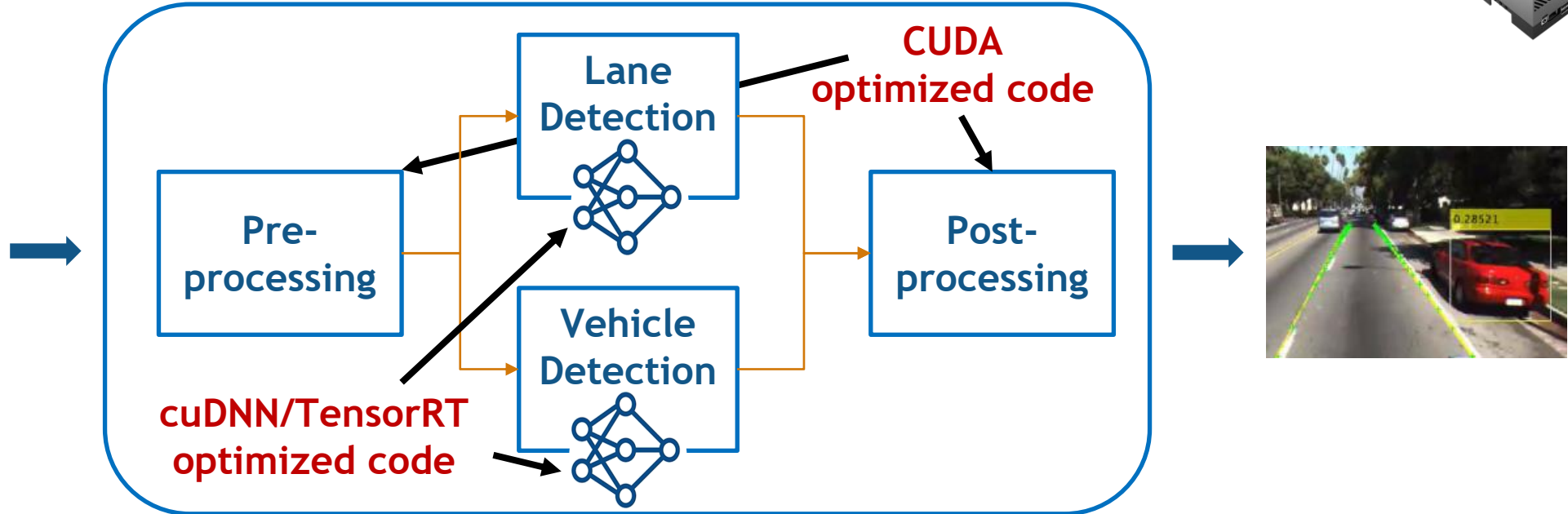
# CHALLENGES WITH GENERATING AN AI APPLICATION FOR EDGE DEVICES

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## USE GPU CODER TO GENERATE CUDA CODE AND DEPLOY TO JETSON AGX ORIN







# USE GPU CODER TO GENERATE CUDA CODE AND DEPLOY TO JETSON AGX ORIN

The image displays the MATLAB/Simulink environment for deploying a lane and vehicle detection model to an NVIDIA Jetson AGX Orin. The interface is divided into several key sections:

- Hardware Board:** Set to "NVIDIA Jetson".
- Model Browser:** Shows the project name "laneAndVehicleDetection2jetson".
- Block Diagram:** A Simulink model with an input block labeled "Traffic Video" connected to a "Preprocessing" block containing a "Resize Image" block. The output of the preprocessing block is connected to a "Vehicle" block.
- Diagnostic Viewer:** Displays the generated code for the "laneAndVehicleDetection2jetson" model. The code includes instructions for writing source files (e.g., "trainedLaneNet0\_laneAndVehicleDetection2jetson0.cu") and header files (e.g., "laneAndVehicleDetection2jetson.h"). It also shows the execution of the "SDL Video Display" block.
- SDL Video Display:** A window showing a real-time video feed of a road scene. Yellow bounding boxes are overlaid on the video, indicating detected vehicles and lanes. The bounding boxes contain numerical values, likely confidence scores or coordinates.



# Applying AI Research with MATLAB and Simulink

Dr Gary Matson, Image Processing, MBDA

## Challenge

MBDA engineers wanted to leverage new AI research. This required bringing advanced AI developments, which are at a low TRL (Technology Readiness Level), into the existing MBDA standard engineering and product development process. Hence, the team needed to design a pathway to take advantage of emerging AI technologies.

## Solution

The team built a required process to align with the existing MATLAB and Simulink based development environment. This includes importing trained neural networks into MATLAB with Deep Learning Toolbox for further use in Simulink models, and hence wider missile models. The team also used GPU Coder to deploy these models on embedded accelerated chipsets.

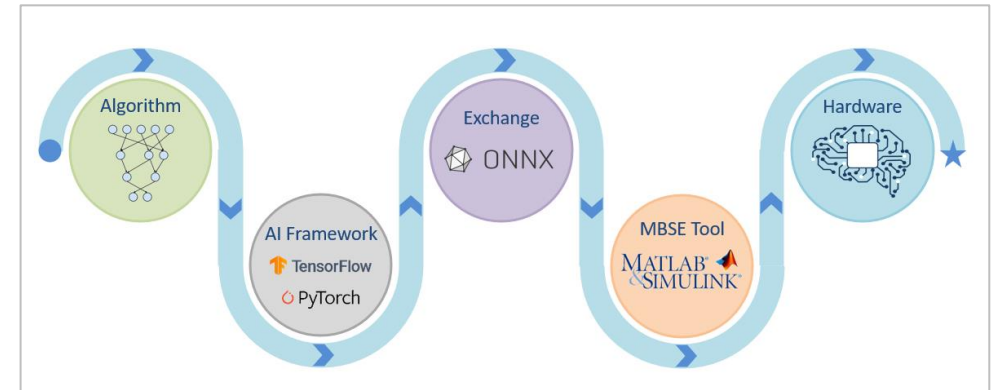
## Results

- **Cost and Effort:** Accelerated deployment time of advanced AI capabilities not currently available in MATLAB and use of low-cost, low-power consumption hardware.
- **Capability:** Enabled use of deep learning solutions, developed in engineers' tools of choice, within the MBDA standard engineering process. Facilitated their real-time deployment on AI accelerated hardware.
- **Impact:** Demonstrated proof of concept and accelerated the TRL progression of AI for MBDA applications.



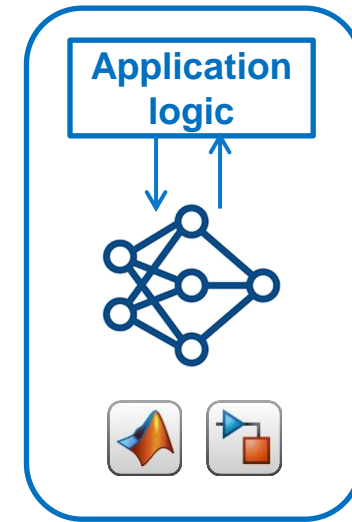
Using MATLAB and Simulink accelerated the deployment of advanced AI solutions in MBDA missile models. This capability is essential for using AI in MBDA products in the future.

*Dr Gary Matson, MBDA*



# START BUILDING AND DEPLOYING AI APPLICATIONS FROM SIMULINK TO JETSON AGX ORIN

- Learn more about the NVIDIA Jetson AGX Orin
  - [tinyurl.com/jetson-orin](https://tinyurl.com/jetson-orin)
- Check out the blog for a detailed walkthrough of the example:
  - [tinyurl.com/gpu-coder-blog](https://tinyurl.com/gpu-coder-blog)
- Get started today with GPU Coder
  - [tinyurl.com/gpu-coder](https://tinyurl.com/gpu-coder)



# MATLAB EXPO

Thank you



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