



EMBEDDED
LINUX
CONFERENCE

Maintaining a Community BSP Layer: Updating meta-tegra Through Major Changes

Tim Orling, *Konsulko Group*

Ilies Chergui, *Medtronic*



The meta-tegra BSP layer supports the NVIDIA Jetson family of systems-on-module and has an active OpenEmbedded for Tegra community. What do you do when the CPU vendor makes major changes in their SDK? What do you do when upstream Open Embedded makes major changes to the core syntax? Tim and Ilies will discuss changes in the latest SDKs including the bootloader (from CBoot to UEFI) and the trusted OS (from Trusty to OP-TEE) and how these affect secure boot and disk encryption implementations. They will also discuss changes needed to support over the air updates (Mender, RAUC, SWUpdate). They will also cover how the community keeps up with upstream Open Embedded/Yocto Project changes. Finally, Tim and Ilies will discuss the roadmap for support for future Jetson platforms and Yocto Project releases.

- Services company specializing in Embedded Linux and Open Source Software
- Hardware/software build, design, development, and training services
- Based in San Jose, CA with an engineering presence worldwide

<https://konsulko.com/>



Konsulko
Group

Engineering the extraordinary

- Healthcare technology solutions
- Robotic Assisted Surgery
- Real Time Video Processing
- Based in the US and UK

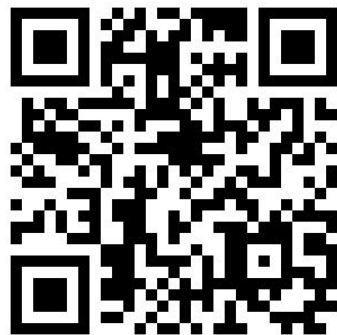
<https://www.medtronic.com/uk-en/index.html>




Medtronic



OpenEmbedded/Yocto Project community support for NVIDIA Tegra (Jetson) platforms using L4T and JetPack components

<https://github.com/oe4t>



- Working with NVIDIA Tegra BSP and Supporting Latest CUDA Versions 
 - Leon Anavi, *Konsulko Group*
Yocto Project Summit 2019
- Building a BSP Layer: An Overview of meta-tegra  
 - Matt Madison, *Alcatraz AI, Inc.*
Yocto Project Virtual Summit Europe, October 2020
- Tales from the Crypt: Implementing Secure Boot and Disk Encryption on Tegra Platforms  
 - Tim Orling, *Konsulko Group*
Embedded Linux Conference Europe, September 2022

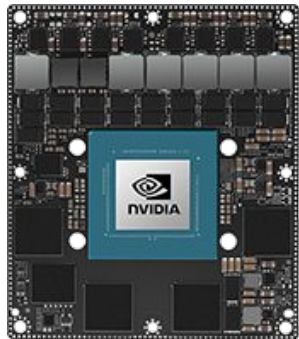


- Jetson Hardware – Supported by JetPack 5
- Embracing Change
 - JetPack 5
 - Bitbake: Override Syntax
 - Bootloader
 - Trusted OS
 - Secure Boot
 - Disk Encryption
 - Over-the-Air Updates (OTA)
 - Keeping Up with Yocto Project
 - Continuous Integration
- The Future
 - JetPack 6: Supported Platforms
 - Supported Yocto Project Releases
- Call to Arms

The background is a dark blue gradient. It features several abstract geometric shapes: a large green circle at the top left, a green rounded rectangle at the top center, a green L-shaped line at the top right, a green circle in the middle right, a green circle at the bottom right, and several smaller blue circles scattered throughout.

Jetson Hardware

Supported by JetPack 5



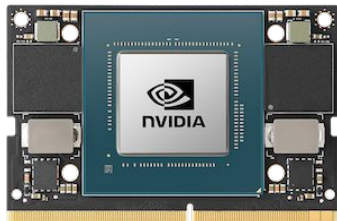
Introduced in 2023 High end of the line AI/ML focused

- 16 Cortex®-A78AE cores (ARMv8.2A)
- 2048-core “Ampere” GPU with 64 Tensor Cores
- 2 deep-learning accelerators
- 64GB LPDDR5 RAM
- 64GB eMMC
- Ethernet MAC
- On-chip audio, video, image processing, and sensor processing engines
- SPI, I2C, DP, HDMI, MIPI DSI and CSI, GPIOs, PCIe, SDIO, USB 2 & 3

Devkit



- MicroSD Card, M.2 Key M connector supporting NVMe
- 4× USB 3.2 Type A connectors (2× Gen1 and 2× Gen2), 2× USB Type C connectors
- Ethernet up to 10Gb/s
- PCIe, M.2 Key E, M.2 Key M
- 40-pin expansion header
- DisplayPort connector (HDMI compatible)
- DC Barrel jack for 7-20V power input



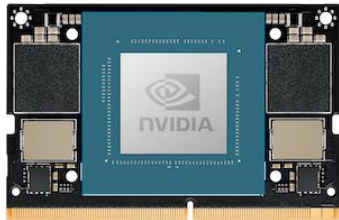
Introduced in 2023
Medium end of the line
AI/ML focused

- 8 Cortex®-A78AE cores (ARMv8.2A)
- 1024-core “Ampere” GPU with 32 Tensor Cores
- 2 deep-learning accelerators
- 16GB LPDDR5 RAM
- Supports external NVMe
- Ethernet MAC
- On-chip audio, video, image processing, and sensor processing engines
- SPI, I2C, DP & HDMI, MIPI DSI and CSI, GPIOs, PCIe, SDIO, SATA, USB 2 & 3

Devkit
(Use Orin Nano Devkit now)



- MicroSD Card, M.2 Key M connector supporting NVMe
- 4× USB 3.2 Type A connectors, 1× USB Type C connector
- Gigabit Ethernet
- PCIe, M.2 Key E, M.2 Key M
- 40-pin expansion header
- DisplayPort connector (HDMI compatible)
- DC Barrel jack for 9-20V power input



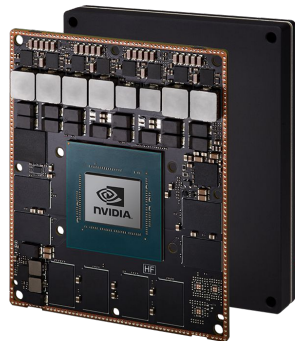
Introduced in 2023
Lower end of the line
AI/ML focused

- 6 Cortex®-A78AE cores (ARMv8.2A)
- 1024-core “Ampere” GPU with 32 Tensor Cores
- 8GB LPDDR5 RAM
- Supports external NVMe
- Ethernet MAC
- On-chip audio, video, image processing, and sensor processing engines
- SPI, I2C, DP & HDMI, MIPI DSI and CSI, GPIOs, PCIe, SDIO, USB 2 & 3

Devkit



- MicroSD Card, M.2 Key M connector supporting NVMe
- 4× USB 3.2 Type A connectors, 1× USB Type C connector
- Gigabit Ethernet
- PCIe, M.2 Key E, M.2 Key M
- 40-pin expansion header
- DisplayPort connector (HDMI compatible)
- DC Barrel jack for 9-20V power input



Introduced in 2018 High end of the line AI/ML focused

- 8 “Carmel” cores (ARMv8.2A)
- 512-core “Volta” GPU with 64 Tensor Cores
- 2 deep-learning accelerators
- 32 or 64GB LPDDR4 RAM
- 32GB eMMC
- Ethernet MAC
- On-chip audio, video, image processing, and sensor processing engines
- SPI, I2C, HDMI, MIPI DSI and CSI, GPIOs, PCIe, SDIO, SATA, USB 2 & 3

Devkit



- MicroSD/UFS combo, USB/eSATA connector
- 2x USB type C, 1 USB micro-B
- PCIe, M.2 Key E, M.2 Key M
- Ethernet
- I/O and camera headers
- Power supply



Introduced in 2020

Lower end of the line
AI/ML focused

Replacement for Jetson
TX2

- 6 “Carmel” cores (ARMv8.2A)
- 384-core “Volta” GPU with 48 Tensor Cores
- 2 deep-learning accelerators
- 8 or 16 GB LPDDR4 RAM
- 16GB eMMC
- Ethernet MAC
- On-chip audio, video, image processing, and sensor processing engines
- HDMI, MIPI CSI, USB 3, PCIe

Devkit (EOL)



- microSD card slot for main storage
- 40-pin expansion header
- Micro-USB port
- Gigabit Ethernet port
- USB 3.1 Type A ports (x4)
- HDMI output port
- DisplayPort connector
- DC Barrel jack for 19V power input
- MIPI CSI camera connectors

Embracing Change

The background is a solid dark blue. It is decorated with several abstract geometric elements: a large green circle in the top left, a green rounded rectangle in the top center, a green L-shaped line in the top right, a medium green circle in the middle right, a small dark blue circle in the middle right, a small dark blue circle in the middle right, and a large green circle in the bottom right.

- Support for Jetson Orin modules
- Linux 5.10 Kernel
- Ubuntu 20.04 based reference file system
- OP-TEE Trusted Execution Environment
- UEFI bootloader
- CUDA 11.4 (11.8 in progress for meta-tegra)



<https://info.nvidia.com/jetpack5-0-deep-dive-webinar.html>

NVIDIA **Jetson Linux 35.3.1** provides the Linux Kernel 5.10, UEFI based bootloader, Ubuntu 20.04 based root file system, NVIDIA drivers, necessary firmwares, toolchain and more.

JetPack 5.1.1 includes Jetson Linux 35.3.1 which adds following highlights: (Please refer to **release notes for additional details)**

- Adds support for Jetson Orin Nano Developer Kit
- Adds support for Jetson AGX Orin 64GB, Jetson Orin NX 8GB, Jetson Orin Nano 8GB and Jetson Orin Nano 4GB production modules
- Security:
- Over The Air Updates:
 - Image Based OTA tools supported to upgrade Xavier or Orin based modules running JetPack 5 in the field¹
- Camera:
 - Support for Multi Point Lens Shading Correction (LSC) on Orin.
 - Enhanced resilience of Argus SyncStereo app to maintain synchronization between stereo camera pairs.
- Multimedia:
 - Support for dynamic frame rate in AV1 encoding
 - New `argus_camera_sw_encode` sample for demonstrating software encoding on CPU cores
 - Updated `nvgstcapture-1.0` with option of software encoding on CPU cores

Help wanted!



¹Previous releases supported upgrading Xavier based modules in the field running JetPack 4.

<https://developer.nvidia.com/embedded/jetpack>

Bitbake: Override Syntax

Before

`_append_<machine>`

`_append_<override>`

`_prepend`

`_remove`

`_append +=`

After

`:append:<machine>`

`:append:<override>`

`:prepend`

`:remove`

Mixed use throws a warning (use `:append` = only)

<https://github.com/OE4T/meta-tegra/commit/b9507ceb23d1093b955cb34e277c0fb1f07adf0b> “meta: convert to new override syntax”

<https://git.yoctoproject.org/poky/commit/?h=honister&id=2abf8a699edd513405befbd1a0eafc8f55d6b514> “bitbake: Switch to using new override syntax”

- CBoot → UEFI
- UEFI Implementation based on Tianocore EDK II
- Why UEFI?
 - Load generic OS without requiring any platform customization of the operating system
 - Defines a standardized secure boot mechanism for authenticating third-party software
 - Defines standard methods for updating firmware
- Details available on [edk2-nvidia wiki](#)



- Trusty → OP-TEE
- Open Portable Trusted Execution Environment (OP-TEE)
 - an open-source **trusted execution environment** (TEE)
 - based on Arm® TrustZone® technology
 - created by trustedfirmware.org
 - maintained by Linaro
- To port an existing Trusty TA to OP-TEE, you must replace the application's original API calls with calls to the GlobalPlatform TEE API
- For example, a Trusty TA uses IPC to handle low-level message communication between the TA and CAs, while OP-TEE uses RPC



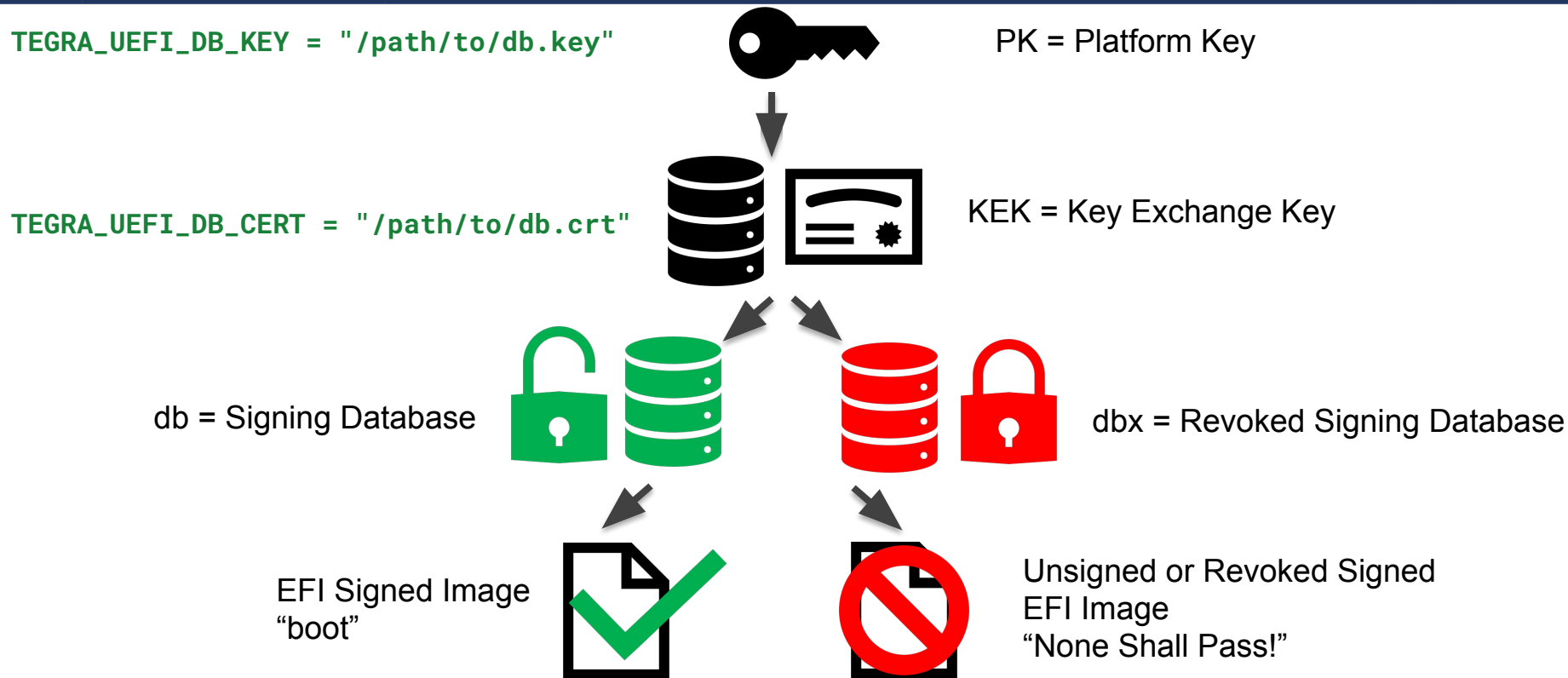


- L4T 35.1 and L4T 35.2.1 supports only signing (PKC only)
- L4T 35.3.1 and newer supports signing and encryption (PKC + SBK)
- Tegra fuses burning using the fuse configuration XML file
- Orin series supports
 - PKC: RSA 3072 bits, ECDSA P-256 and ECDSA P-521
 - SBK: 8 x 32 bits (32 bytes)
- Xavier series supports
 - PKC: RSA 2048 bits and RSA 3072 bits
 - SBK: 4 x 32 bits (16 bytes)
- Check this link to enable Secure Boot:
 - [Secure Boot Support in L4T R35.2.1 and later](#)



IMPORTANT: make sure that you provide the right **BootSecurityInfo** to avoid the device breakage.

Secure Boot: A UEFI Standard





- NVLuks app for Trusty -> NVLuks app for OP-TEE
- EKB
 - Oemk2 (Orin series) or KEK2 (Xavier series)
 - Fixed Vector (FV)
 - Sym key file for kernel encryption (unused)
 - Sym2 key file for disk encryption
- Use `nvluks-srv-app` CA to get the **password** or **passphrase**
- `nvluks-srv-app` CA uses disk UUID as context
- Use `cryptsetup` application for LUKS mechanism (Format, Open, Close, ...)
- `cryptsetup` used `dm-crypt` kernel module as its backend.

`nvluks-srv-app` provided by
the `optee-nvsamples` recipe

IMPORTANT: make sure that FV used for EKB generation matches the OP-TEE OS's FV otherwise `jetson_user_key_pta` initialisation fails which impacts the disk encryption functionality

Over-the-Air Updates (OTA)

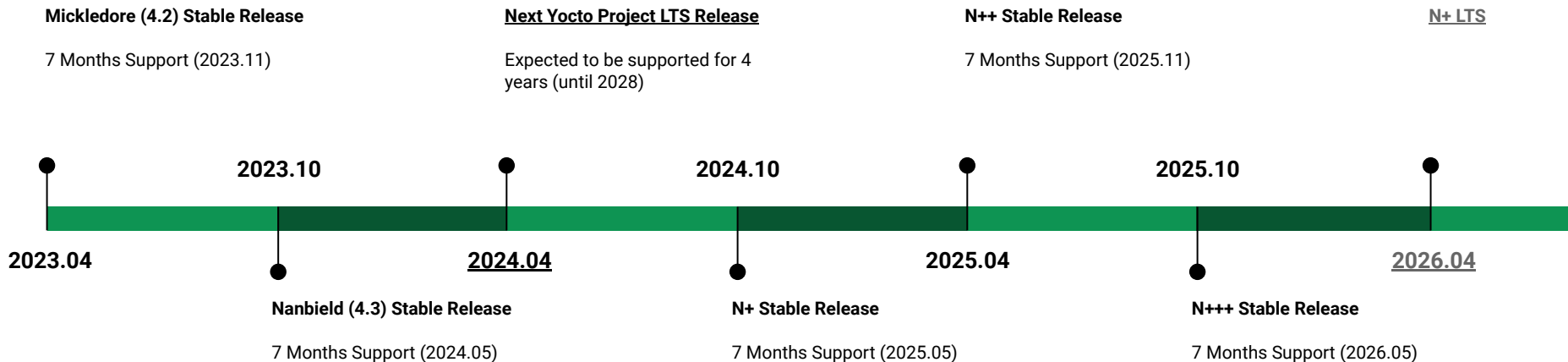


EMBEDDED
LINUX
CONFERENCE

- Mender
 - [meta-mender](#)
 - usually latest LTS (may be a few month delay after LTS is released)
 - [meta-mender-community/meta-mender-tegra](#)
 - usually latest LTS
 - depends on community contributions on a per platform basis
 - [tegra-demo-distro](#) had a [working example for JetPack 4](#)... help needed.
- RAUC
 - [meta-rauc](#)
 - [meta-rauc-community/meta-rauc-tegra](#)
- SWUpdate
 - [meta-swupdate](#)
- OSTree
 - [meta-updater](#)

Keeping Up with Yocto Project

- Non-LTS stable branches go EOL in ~7 months
- Constantly moving target; stay agile
 - Keep at least part of your team/CI building on development branch
 - Minor breakage bit by bit instead of major headache in two years





- OE4T Autobuilder
 - Buildbot based
 - Not the same as Yocto Project AB
 - meta-tegra
 - meta-tegra-community
 - tegra-demo-distro
 - Currently maintained branches
 - master - never stable, L4T R35.3.1/JetPack 5.1.1 for AGX Xavier/Xavier NX/AGX Orin/Orin NX/Orin Nano
 - mickeldore - L4T R35.3.1/JetPack 5.1.1 for AGX Xavier/Xavier NX/AGX Orin/Orin NX/Orin Nano
 - kirkstone - L4T R35.3.1/JetPack 5.1.1 for AGX Xavier/Xavier NX/AGX Orin/Orin NX/Orin Nano
 - kirkstone-l4t-r32.7.x - L4T R32.7.3/JetPack 4.6.3 for TX1/TX2/TX2-NX/Xavier/Xavier-NX/Nano/Nano-2GB
 - dunfell - L4T R32.7.3/JetPack 4.6.3 for TX1/TX2/TX2-NX/Xavier/Xavier-NX/Nano/Nano-2GB

The background is a dark blue gradient with several abstract geometric shapes in shades of green and light blue. These include circles of various sizes, some solid and some as outlines, and rounded rectangular shapes. The shapes are scattered across the frame, with some partially cut off by the edges.

The Future

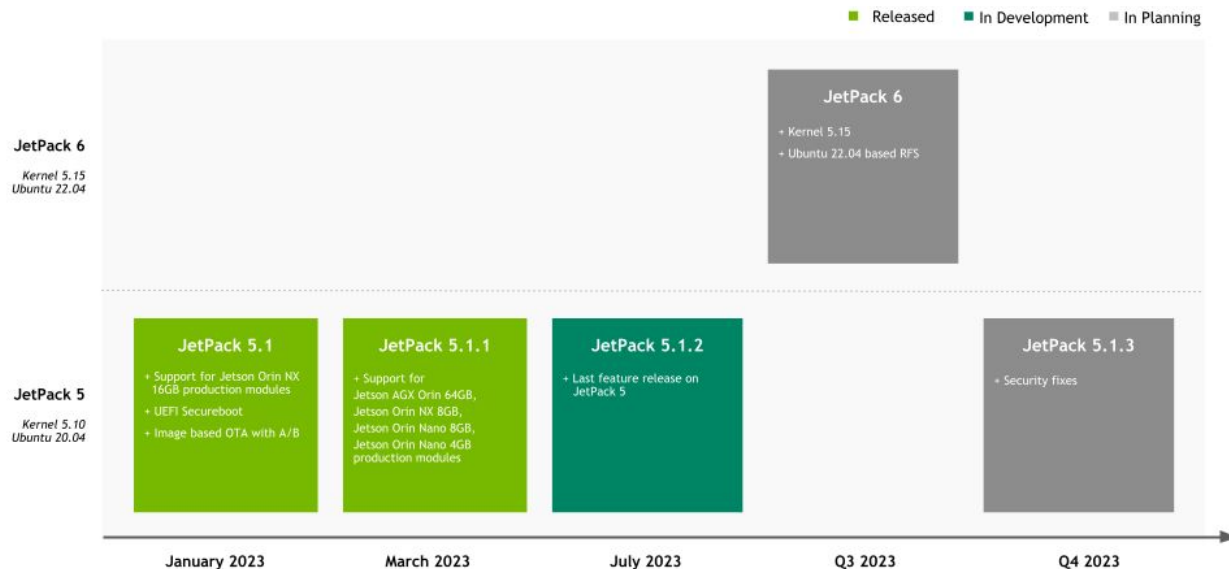
**Supported Platforms in JetPack 6 and
Supported Yocto Project Releases**

JetPack 6: Supported Platforms

- <https://developer.nvidia.com/embedded/develop/roadmap>



Expect
Jetson Orin+
only



- (Best effort keeping JetPack 5 updates applied to previous **kirkstone** branch(es), e.g. Xavier)

Supported Yocto Project Releases



EMBEDDED
LINUX
CONFERENCE

- Development
 - Newest JetPack
 - Only for platforms supported by latest JetPack
 - Layer compatibility changes when upstream branches
- Current Stable
 - Current Jetpack
 - Only for platforms supported by latest Jetpack
- Current LTS
 - Current Jetpack
 - Prior Jetpack releases may be branched and supported on best-effort basis
- Previous LTS
 - Jetpack supported at the time, updates on best-effort basis
 - Prior Jetpack releases may be branched and supported on best-effort basis

Supported Yocto Project Releases



EMBEDDED
LINUX
CONFERENCE

Mickledore (4.2) Stable Release

7 Months Support (2023.11)

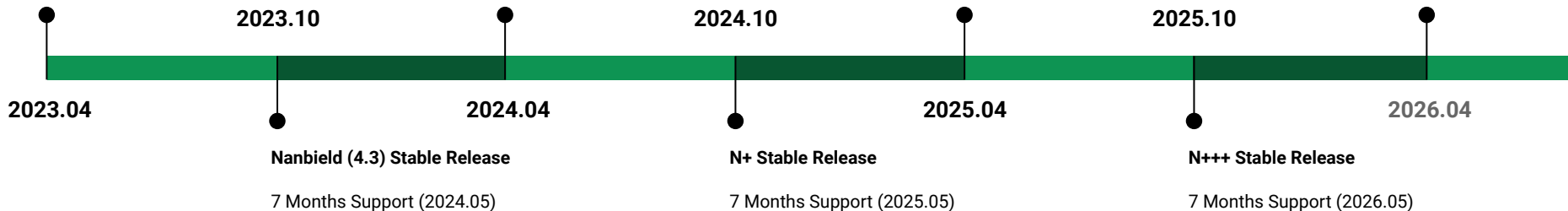
Next Yocto Project LTS Release

Expected to be supported for 4 years (until 2028)

N++ Stable Release

7 Months Support (2025.11)

N+ LTS



Getting Started

Getting started in 5 minutes
using an Xavier NX Devkit on
Kirkstone.

- `git clone`
<https://github.com/OE4T/tegra-demo-distro.git>
- `cd tegra-demo-distro`
- `git checkout kirkstone`
- `git submodule update --init`
- `./setup-env --machine jetson-xavier-nx-devkit`
- `bitbake demo-image-full`

Call to Arms

How you can get involved.

- [OE4T on GitHub \(wiki\)](#)



- [OE4T Community Chat on Gitter \(Element\)](#)





Thank You!

We could not have done this
without you.

- Matt Madison
- Dan Walkes
- Kurt Kiefer
- The OE4T Community

The background is a solid dark blue. It is decorated with several abstract geometric shapes in shades of green and light blue. These include circles of various sizes, some of which are hollow outlines, and rounded rectangular shapes. The shapes are scattered across the frame, with a higher concentration on the right side.

Questions?



**EMBEDDED
LINUX
CONFERENCE**