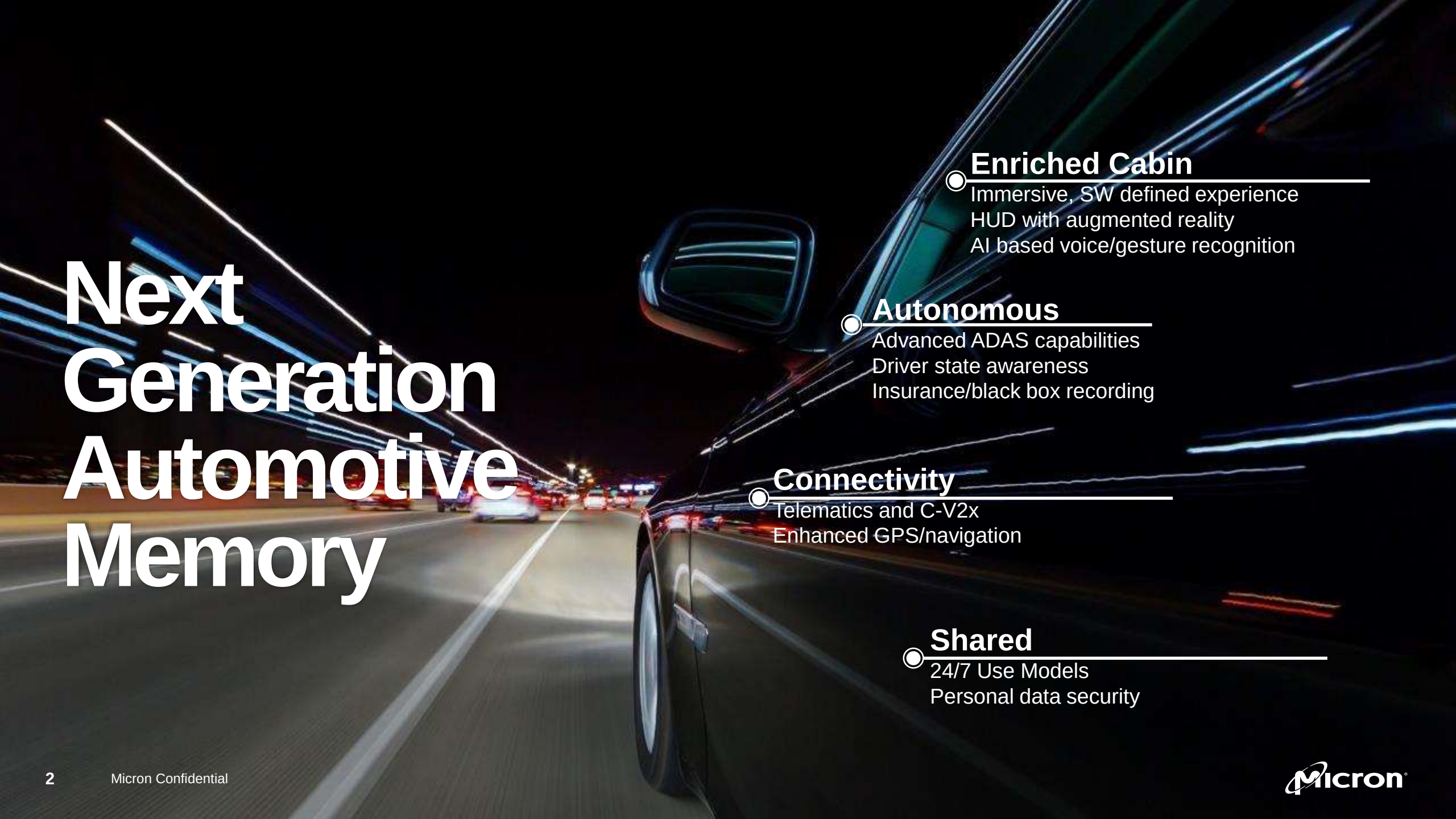
Automotive Solutions

April 2020



Next Generation Automotive Memory

Enriched Cabin
Immersive, SW defined experience
HUD with augmented reality
AI based voice/gesture recognition

Autonomous
Advanced ADAS capabilities
Driver state awareness
Insurance/black box recording

Connectivity
Telematics and C-V2x
Enhanced GPS/navigation

Shared
24/7 Use Models
Personal data security

Micron Driving Automotive Leadership and Innovation

Automotive Mindset

- > 28 years commitment, investment & dedicated support
- ISO 9001/IATF 16949 Quality Management Systems
- AEC-Q100 qualification methodology
- Zero defect target approach
- ISO 26262 design and validation for ASIL functional safety

Technical Collaboration

- Customer labs in Munich, Tokyo, Detroit, San Jose & Shanghai
- System & product experts to enable advanced solutions in security, functional safety and artificial intelligence
- Strong SoC/FPGA collaboration to accelerate time to market

Technical Leadership

- Industry Lowest Power LPDRAM
- Smallest 3D TLC NAND with CMOS under array
- Widest Automotive Memory Portfolio of AIT, AAT, and AUT Temps

Next Generation Automotive Memory

	Enriched Cabin	Connectivity & V2x Communications	Shared Use Model	ADAS & Autonomous
Application	In-Vehicle Infotainment Digital Instrument Clusters	Cellular Comm. Modules Secure Gateways	Robotaxis Commercial Fleets	Level 2/3 ADAS Level 4/5 Autonomous
Memory Solutions	Quad SPI NOR → Octal SPI NOR SLC NAND/e.MMC → UFS DDR3 → LPDDR4/5	NAND+LP2 → NAND+LP4 + e.MMC+LPDDR4 + Authenta Technology	Level 4/5 memory solutions	SLC NAND → e.MMC/PCie LPDDR2/4 → LPDDR5/GDDR6 Quad SPI NOR → Octal SPI NOR
	▪ 3x Code/Data Storage ▪ 2x DRAM ▪ 3x Bandwidth ▪ ASIL B	▪ 2x Code/Data Storage ▪ 2x DRAM ▪ 2x Bandwidth	▪ High endurance/cycling ▪ High reliability	▪ 5x Code/Data Storage ▪ 3x DRAM ▪ 10x Bandwidth ▪ ASIL – B/D

Micron

Automotive Qualified Memory Portfolio & Technologies

Broadest Portfolio

- One-Source for Automotive Grade solutions
- -40 to +125°C: DRAM and NOR Flash
- -40 to +105°C: NAND, SSD, and e.MMC, Multi-Chip Packages

Leading Solutions

- Six generations of advanced storage solutions
- First with high temperature, auto grade DRAM
- Authenta™ Secure Memory for cyber security
- Consortium based Octal NOR Flash
- Extensive collaboration for ASIL - B/D

$3B Investment and Commitment

Advanced Technology with Longevity Support

Enables Longevity Supply from a Dedicated IATF-Certified Fab within the U.S.

- 20-year history of high quality supply assurance for automotive, industrial, and networking
- Stability for AIMM and Networking customers and optimizes process migrations in leading edge fabs
- Minimizes EOL/PCN changes

Enhanced Focus and Customer Support via Center-of-Excellence

- Advanced support capability (laboratory, test, etc.)
- Adding staff of 100 R&D engineers

Supports High-Volume Production of NOR, NAND, and DRAM
Capability to Manufacture 20nm/1x nm DRAM and 3D NAND

Micron Automotive Memory Solutions

NOR
- Parallel
- Serial

VIEW RELATED ROADMAP

DRAM
- SDR/DDR
- LPSDR/LPDDR

VIEW RELATED ROADMAP

MCP

VIEW RELATED ROADMAP

NAND
- SLC NAND

VIEW RELATED ROADMAP

e·MMC/UFS

VIEW RELATED ROADMAP

SSD

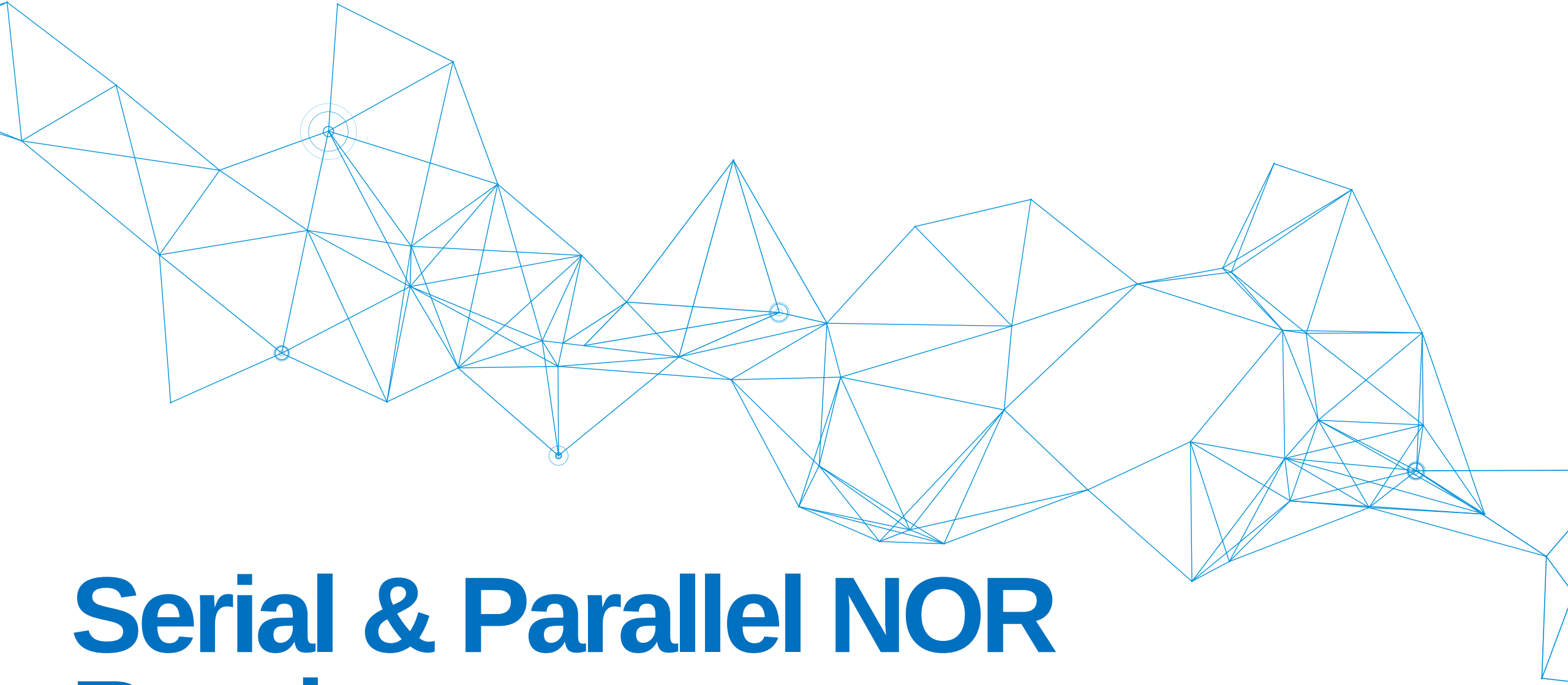
VIEW RELATED ROADMAP

microSD

VIEW RELATED ROADMAP

Micron: One-Stop Shop for Your Auto Qualified Memories

Family	Product Description	Bus Width	Density Range	Temperature Range	Safety (ISO 26262)	Security	Package Options
DRAM	SDR	x16,x32	64Mb - 256Mb	-40/+105°C			VFBGA
	DDR	x8,x16	256Mb - 512Mb	-40/+105°C			BGA
	DDR2	x8,x16	512Mb - 2Gb	-40/+105°C			BGA, VFBGA
	DDR3	x8,x16	1Gb - 8Gb	-40/+105°C/+125°C			BGA, VFBGA
	DDR4	x8,x16	4Gb - 16Gb	-40/+105°C/+125°C			BGA, VFBGA
	DDR5	x8,x16	16Gb	-40/+105°C/+125°C			BGA, FBGA
	GDDR6	x8,x16	8Gb - 16Gb	-40/+105°C			FBGA
	LPSDR	X16	512Mb	-40/+105°C			FBGA
	LPDDR	x16,x32	512Mb - 2Gb	-40/+105°C			VFBGA
	LPDDR2	x32	512Mb - 4Gb	-40/+105°C/+125°C			BGA
	LPDDR4	x16,x32,x64	4Gb - 64Gb	-40/+95°C/+105°C/+125°C	Specific PN		BGA
	LPDDR5	x32,x64	16Gb - 64Gb	-40/+95°C/+105°C/+125°C	Specific PN		BGA
NAND	NAND Parallel SLC	x8,x16	1Gb - 16Gb	-40/+85°C/+105°C			VFBGA,TSOP
	NAND Serial SLC	x1,x2,x4	1Gb - 8Gb	-40/+85°C/+105°C			SOIC, TBGA
	e.MMC	x8	4GB - 128GB	-40/+85°C/+105°C		Specific PN	LBGA, TFBGA
	UFS	x4	32GB - 512GB	-40/+95°C/+105°C			TFBGA
	SSD	-	64GB - 1TB	-40/+105°C			M.2, BGA
NOR	NOR Parallel SLC	x8,x16	512Mb - 2Gb	-40/+105°C			LBGA,TSOP
	NOR Serial	x1,x2,x4 x1,x2,x4,x8	128Mb - 2Gb 256Mb - 1Gb	-40/+105°C/+125°C -40/+105°C		Specific PN	DFN6x5, DFN 8x6, SO8W, SO16W, TPBGA24
	NOR Serial	x1, x8	256Mb - 2Gb	-40/+105°C		Specific PN	SO16W, TPBGA
MCP	NAND+LPDDR2	x8/x32	4Gb+4Gb, 4Gb+2Gb	-40/+95°C/+105°C			VFBGA
	NAND+LPDDR4	x8/x16	8Gb+8Gb, 4Gb+4Gb, 4Gb+2Gb	-40/+95°C/+105°C			VFBGA



Serial & Parallel NOR Roadmaps

Micron 45nm Automotive NOR Flash Offerings

		128Mb	256Mb	512Mb	1Gb	2Gb
Xccela™ Flash	**Xccela™ Flash** Octal 3V		MT35X (+105°C/+125°C)			
	Xccela™ Flash Octal 1.8V		MT35X (+105°C/+125°C)			
Serial (SPI)	**Twin-Quad** 3V		MT25T (+105°C)			
	Quad-I/O 3V	MT25Q (+105°C/+125°C)				
	Quad-I/O 1.8V	MT25Q (+105°C/+125°C)				
Parallel	**Parallel (x8/x16)** 3V with 1.8V I/O capability			MT28EW (+105°C)		
	Parallel (x16) 3V with 1.8V I/O capability			MT28FW (+105°C)		

Notes: 1) Not all Density and Grade combinations may be available (see www.micron.com for all valid combinations)
2) Some densities are DDP (dual-die package) and QDP (quad-die package) configurations

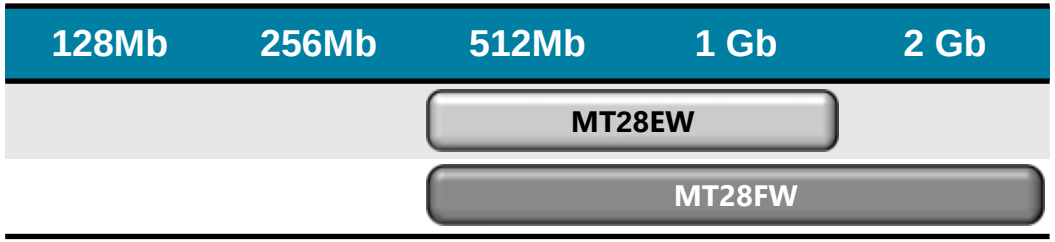
Micron 45nm NOR Flash Longevity Roadmap

Family	Density	CY19	CY20	CY21	CY22	CY23	CY24	CY25	CY26	CY27
Xccela™ Flash (MT35X)	2Gb	Automotive, +105°C and +125°C, 1.8V, BGA								
	1Gb	Automotive, +105°C and +125°C, 1.8V, BGA								
	512Mb	Automotive, +105°C and +125°C, 1.8V, BGA								
	256Mb	Automotive, +105°C and +125°C, 1.8V, BGA								
Twin-Quad (MT25T)	1Gb	Automotive, +105°C, 3.0V, BGA								
	512Mb	Automotive, +105°C, 3.0V, BGA								
	256Mb	Automotive, +105°C, 3.0V, BGA								
Quad-I/O Serial (MT25Q)	2Gb	Automotive, +105°C and +125°C, 1.8V, BGA								
	1Gb	Automotive, +105°C and +125°C, 1.8V, BGA								
	512Mb	Automotive, +105°C and +125°C, 1.8V, BGA								
	256Mb	Automotive, +105°C and +125°C, 1.8V, BGA								
	128Mb	Automotive, +105°C and +125°C, 1.8V, BGA								

Notes: 1) Other package options and voltage variants may be available
2) Roadmap subject to change based on unforeseeable market conditions

Micron Automotive Parallel NOR Flash

- Increased performance over Micron legacy M29W/EW with full feature compatibility
  - Industry standard command set
  - Industry standard and M29W/EW compatible footprint and packages
- Various automotive options (-40°C to +105°C) available
  - Densities from 512Mb to 2Gb
  - x8/x16 configurable and x16-only options



Product Family	Core Voltage	I/O Voltage	Bus Width	Density Range	Architecture	Access Time	Package Options
MT28EW	2.7V-3.6V	1.65V-3.6V	x8/x16	512Mb – 1Gb	Uniform	70-105ns	TSOP-56, FBGA-64
MT28FW	2.7V-3.6V	1.65V-3.6V	x16	512Mb - 2Gb	Uniform	105-110ns	TSOP-56, FBGA-64

MT28EW & FW Parallel NOR Flash Offerings- Automotive

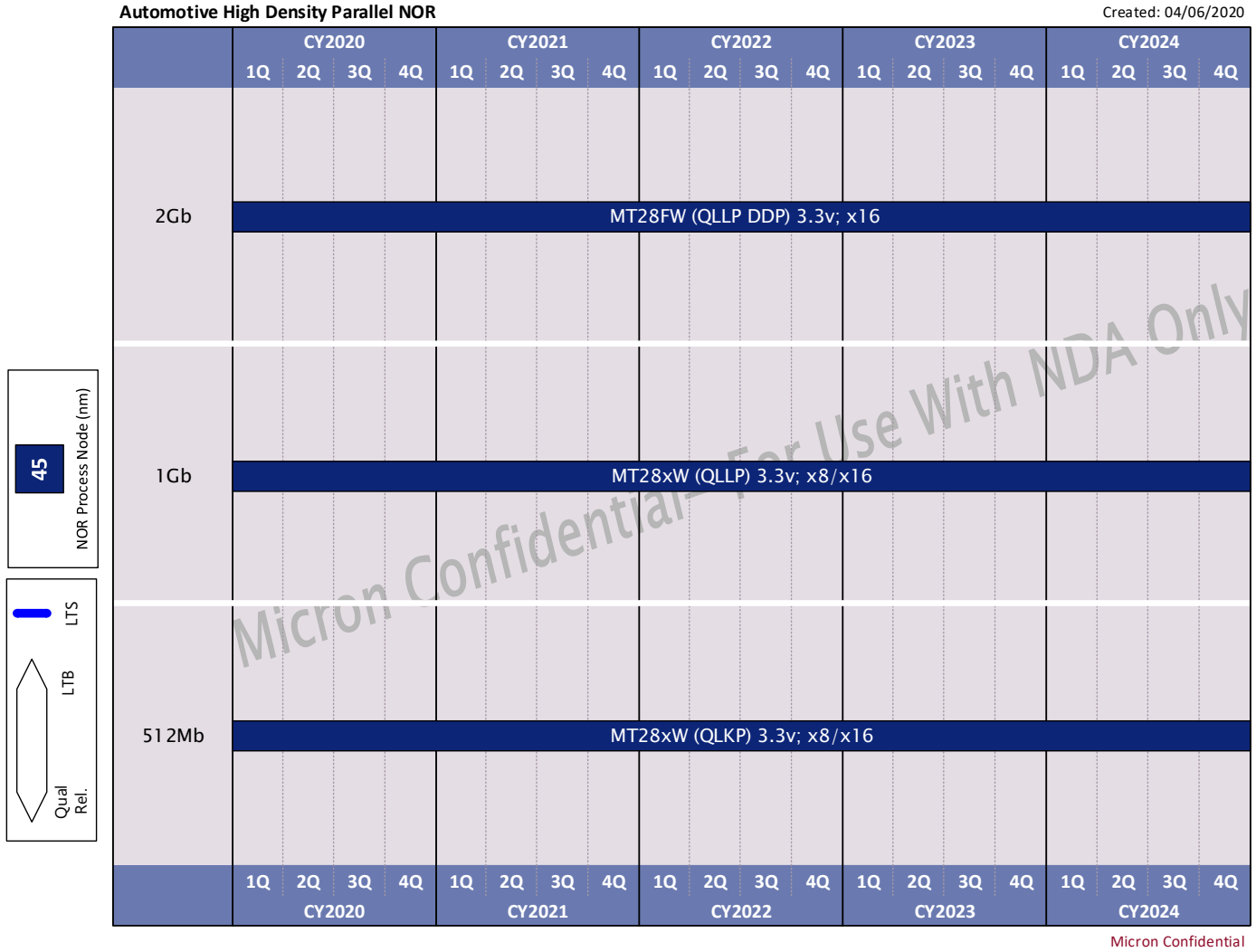
MT28EW (x8/x16, Uniform 128KB)		512Mb	1Gb	2Gb
Package Type	Size	3.0V	3.0V	
56L TSOP 56	14x20 mm	AAT	AAT	-
64B LBGA	11x13 mm	AAT	AAT	-

MT28FW (x16, Uniform 128KB)		512Mb	1Gb	2Gb
Package Type	Size	3.0V	3.0V	3.0V
56L TSOP 56	14x20 mm	AAT	AAT	-
64B LBGA	11x13 mm	AAT	AAT	AAT

	Special Options	Ambient Temperature
SIT	Standard	-40°C to +85°C
AAT	Automotive Quality	-40°C to +105°C

MT28EW/FW Parallel Flash - Automotive

Industry standard I/F delivering high density support for automotive



Key Features

Technology
- Single Level Cell – 45nm

Access Time:
- 105ns Asynchronous

Voltage
- Core (VCC) 2.7V - 3.6V
- I/Os (VCCQ) 1.65V - 3.6V

I/O Bus Width
- MT28EW - x8/x16
- MT28FW - x16

Architecture
- Uniform, High/Low Lock

Temperature Range
- Automotive Grade (-40˚C to +105˚C)

Security
- 128/512 words user programmable OTP
- 64-bit unique device number

Available Packages
- TSOP56 14x20mm,
- LBGA64 11x13mm

AEC Q100 compliant
- 1bit ECC built-in for 45nm

Serial NOR Flash Offerings - Automotive

Quad SPI (MT25Q), Twin-Quad (MT25T), and Octal SPI (MT35X)

	128Mb		256Mb		512Mb		1Gb		2Gb	
Package Type	**1.8V**	**3.0V**	**1.8V**	**3.0V**	**1.8V**	**3.0V**	**1.8V**	**3.0V**	**1.8V**	**3.0V**
DFN 6x5	MT25Q (AUT[1])	MT25Q (AUT[1])								
DFN 8x6				MT25Q (AAT[2])						
SO8W	MT25Q (AUT)	MT25Q (AUT)								
SO16W	MT25Q (AUT, AAT)	MT25Q (AUT, AAT)	MT25Q (AAT[2])	MT25Q (AAT) MT25T (AAT)	MT25Q (AAT)	MT25Q (AAT) MT25T (AAT)	MT25Q (AAT)	MT25Q (AAT) MT25T (AAT)		
24B TBGA	MT25Q (AUT, AAT)	MT25Q (AUT, AAT)	MT25Q (AUT, AAT[2]) MT35X (AUT, AAT)	MT25Q (AUT, AAT) MT35X (AAT)	MT25Q (AUT, AAT) MT35X (AUT, AAT)	MT25Q (AUT, AAT) MT25T (AAT) MT35X (AUT, AAT)	MT25Q (AUT, AAT) MT35X (AUT, AAT)	MT25Q (AUT, AAT) MT25T (AAT) MT35X (AAT)	MT25Q (AUT, AAT[2]) MT35X (AUT, AAT)	MT25Q (AUT, AAT[2])
Wafer (KGD-C1)		MT25Q (AAT[2])								

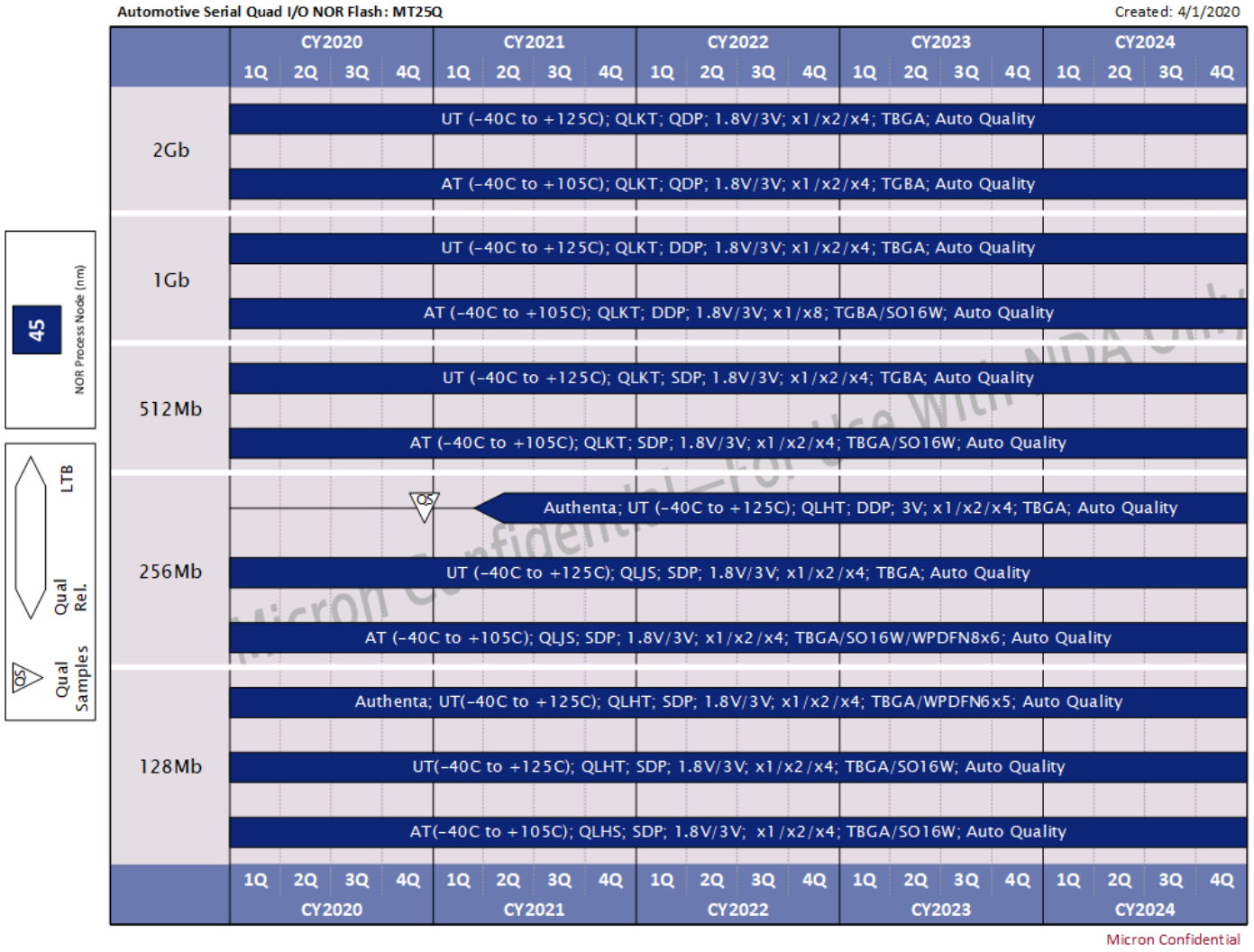
[1] DFN 6x5 offered on Authenta ™ version only

[2] Special orders, contact Micron for availability

	Special Options	Ambient Temperature
AAT	Automotive Quality	-40°C to +105°C
AUT	Automotive Quality	-40°C to +125°C

MT25Q Serial Flash - Automotive

Quad I/O 3V & 1.8V Serial NOR Flash for Automotive support



Key Features

Technology
- Single Level Cell – 45nm

Speed
- 1.8V: 166MHz(90MHz DTR)
- 3.0V: 133MHz(90MHz DTR)

Voltage
- 1.8V (1.7V – 2.0V)
- 3.0V (2.7V - 3.6V)

I/O Bus Width: x1/x2/x4

Architecture
- Uniform 64KB sector
- 4KB/ 32KB subsector erasable

Temperature Range
- Automotive grade: -40˚C to +105˚C (AT)
- Automotive grade: -40˚C to +125˚C (UT)

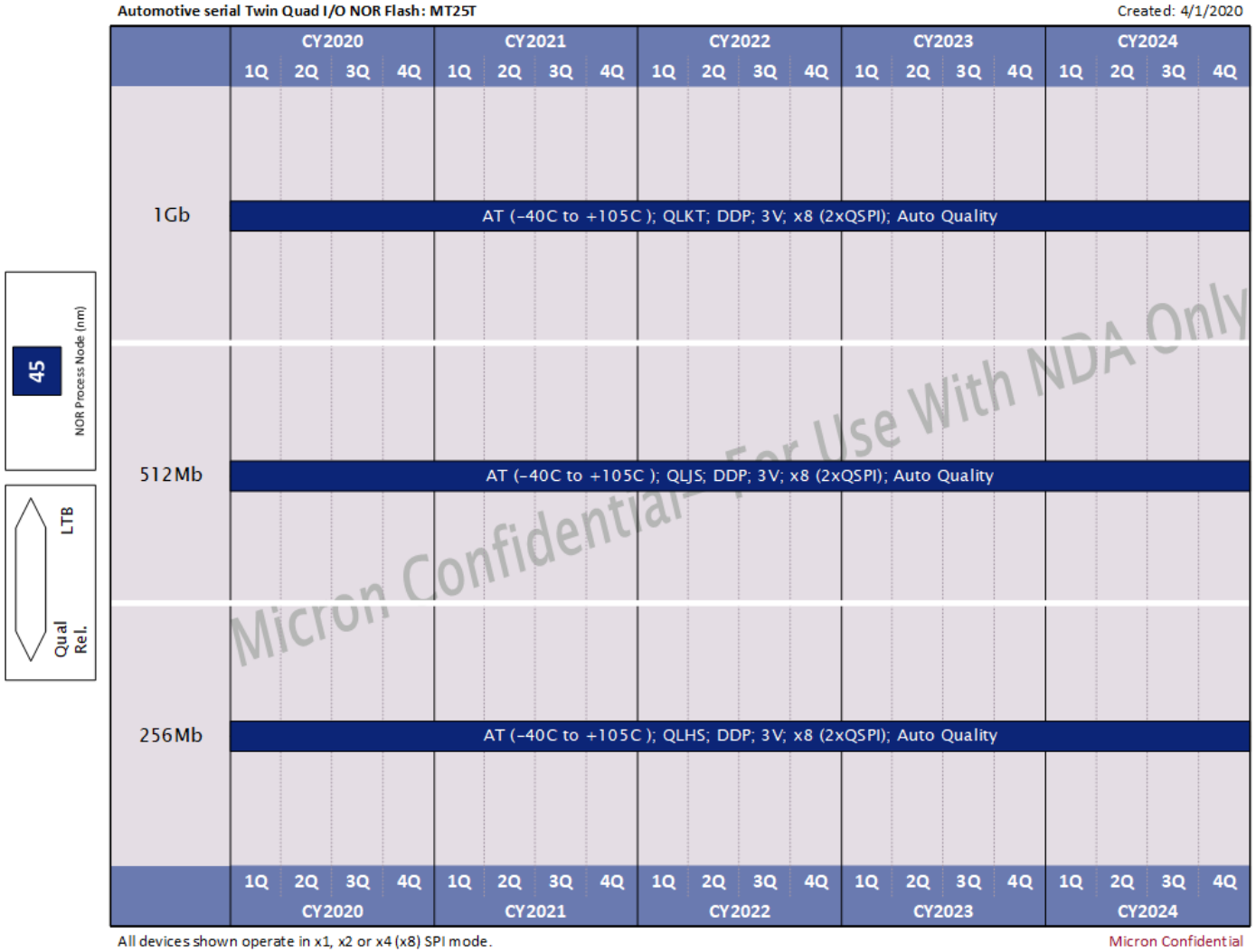
Security
- Authenta™
- Software write protection applicable to every 64KB sector via volatile lock bit
- Hardware write protection: BP0, BP1, BP2,BP3, and TB

Available Packages
- SO8W, W-DFN, SO16W, TPBGA24

AEC-Q100 compliant
- 1bit ECC built-in (2-bit detection)

MT25T Serial Flash TWIN Quad I/Os - Automotive

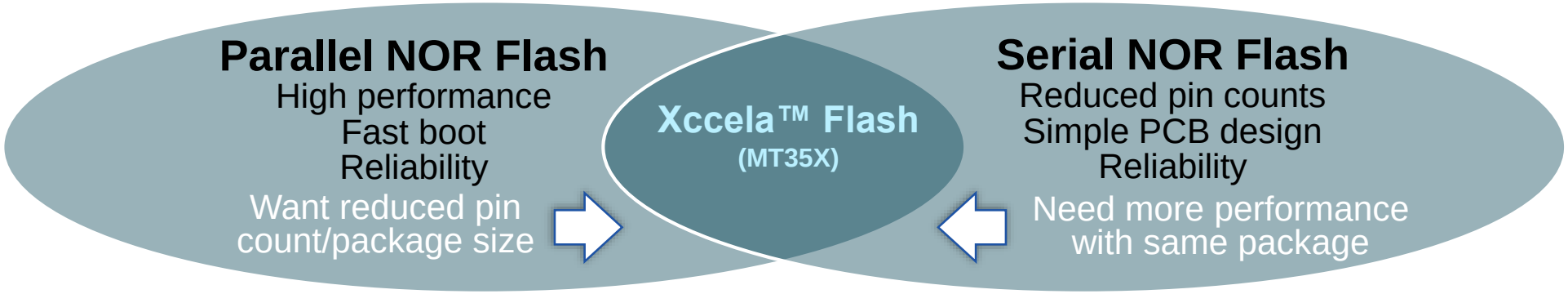
3V High Throughput extended x8 QSPI



Key Features
Technology • Single Level Cell - 45nm
Speed • 3.0V: 133MHz (90MHz DTR)
Voltage • 3.0V (2.7V - 3.6V)
I/O Bus Width • x1/x2/x4 and Twin Quad 2(x4) =x8
Architecture • Uniform 64KB sectors • 4KB/ 32KB subsector erasable
Temperature Range • Automotive grade: -40˚C to +105˚C (AT)
Write Protection • Volatile individual sector(s) protection • Non-volatile individual sector(s) protection • Password protection • One Time Programmable region
Available Packages • SO16W, TBGA 24b (11 active signals) • 1CLK/1CE and 2CLK/2CE configurations
AEC Q100 compliant • 1bit ECC built-in (2-bit detection)

Note: Not all configuration combinations may be available. Please contact Micron representatives for details.

Xccela™ Flash: Best of Parallel and Serial NOR Flash

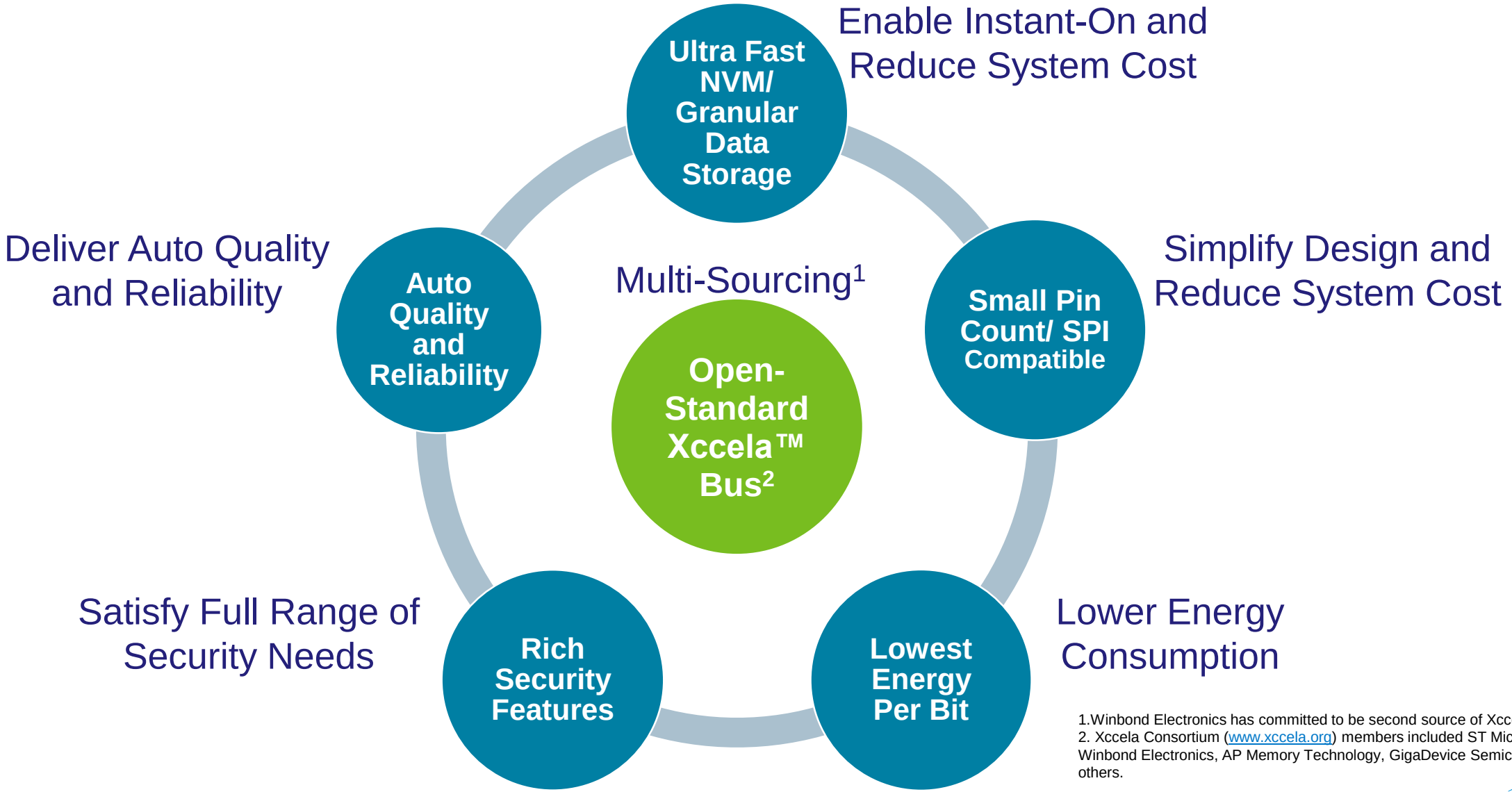


	512Mb Parallel NOR MT28EW	512Mb Quad-SPI MT25Q	512Mb Twin-Quad MT25T	512Mb Xccela Flash MT35X
Read Bandwidth	81MB/s (Page mode, async, x16)	90MB/s (90MHz, DTR mode)	180MB/s (90MHz, DTR mode)	**400MB/s (200MHz, DDR mode)**
Initial Word Access Time	95ns (x16)	157.70ns[1] (1.8V, 8-bit) 168.81ns[1] (1.8V, 16-bits)	152.14ns[1] (1.8V, 8-bit) 157.70ns[1] (1.8V, 16-bit)	**73.25ns[2] (1.8V, 8-bit)** **75.75ns[2] (1.8V, 16-bit)**
Subsequent Word Access	20ns (16-bits) (95ns across 32B page)	11.11ns (8-bits) 22.22ns (16-bits)	5.56ns (8-bits) 11.11ns (16-bits)	**2.5ns (8-bits)** **5ns (16-bits)**
Package and Pins	64-TBGA (11x13mm) 50 Active Pins	24-BGA (6x8mm) 6 Active Pins	24-BGA (6x8mm) 10 Active Pins	**24-BGA (6x8mm)** **11 Active Pins**
Effective Energy Per Bit (16Mb read)	101 pJ/bit	41 pJ/bit	41 pJ/bit	**28 pJ/bit**

5X THE PERFORMANCE, **4X** FEWER PINS, **3X** LESS ENERGY, AND **2X** SMALLER PACKAGE[3]

Notes: 1. XiP mode
2. XiP mode, 32-byte aligned reads
3. Compared to Page Mode Parallel NOR Flash

Xccela™ Flash - A Fast, Compact & Low Energy NOR Flash



1.Winbond Electronics has committed to be second source of Xccela Flash.
2. Xccela Consortium (www.xccela.org) members included ST Microelectronics, Winbond Electronics, AP Memory Technology, GigaDevice Semiconductor, and others.

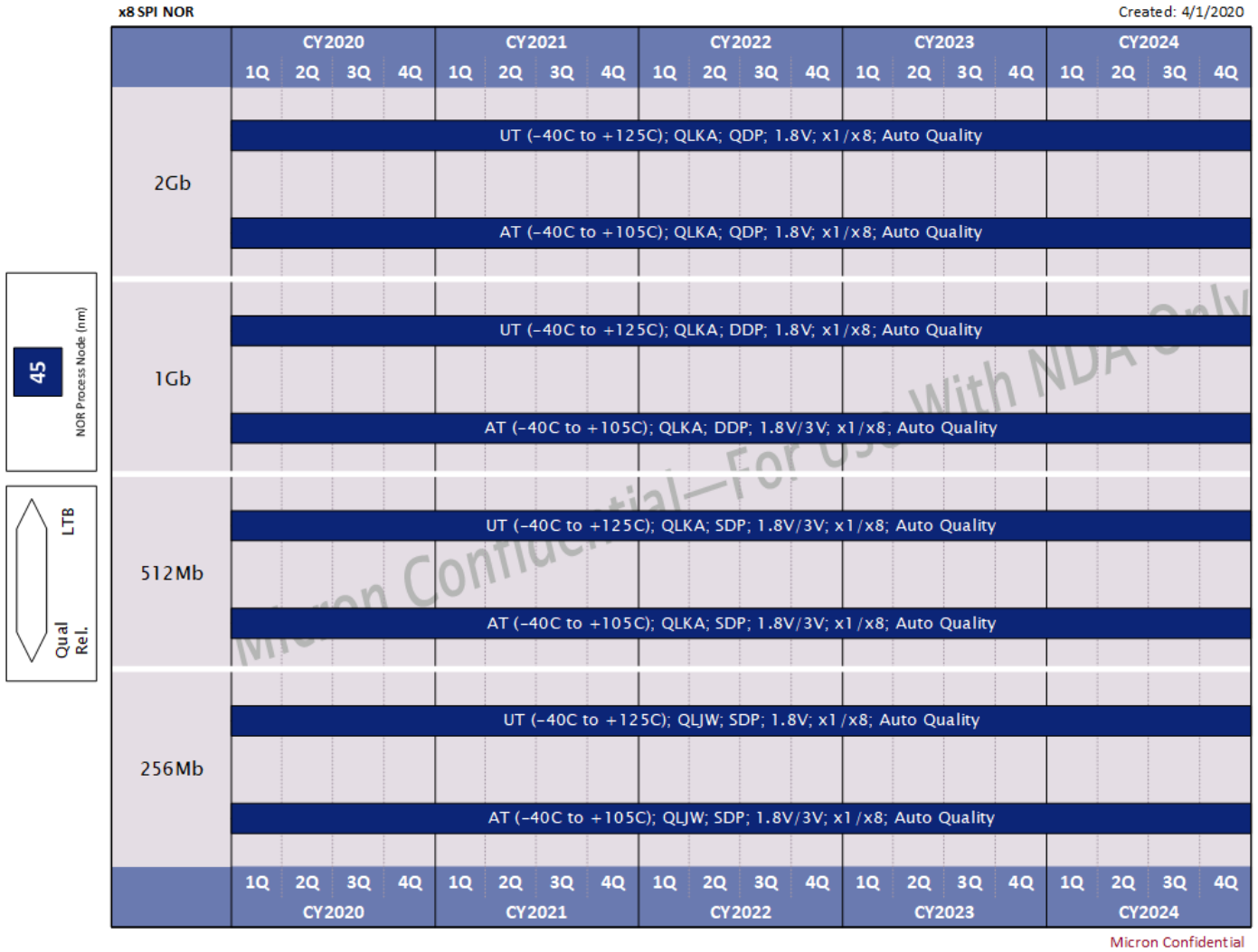
MT35X Octal Serial Flash - Xccela™ Flash Offerings

		256Mb		512Mb		1Gb		2Gb	
Package Type	**Package Size**	**1.8V**	**3.0V**	**1.8V**	**3.0V**	**1.8V**	**3.0V**	**1.8V**	**3.0V**
24B TBGA	6x8	AAT AUT	AAT	SIT AAT AUT	SIT AAT AUT	SIT AAT AUT	SIT AAT	SIT AAT AUT	SIT

	Special Options	Ambient Temperature
SIT	Standard	-40°C to +85°C
AAT	Automotive Quality	-40°C to +105°C
AUT	Automotive Quality	-40°C to +125°C

MT35X Octal Serial Flash - Xccela™ Flash – Automotive

New ULTRA Accelerated x8 DDR I/F



Note: Not all configuration combinations may be available. Please contact Micron representatives for details.

Key Features

Technology: Single Level Cell - 45nm

Speed
- 3.0V: 133MHz (STR/DTR)
- 1.8V: 200MHz (DDR with DQS)/ 166MHz (STR)
- 73.25 ns latency (XiP mode, 32-byte aligned reads)

Voltages
- 1.8V (1.7V – 2.0V)
- 3.0V (2.7V - 3.6V)

I/O Bus Width: x1, x8 (www.xccela.org)

Architecture
- Uniform 128KB sectors
- 4KB/ 32KB subsector erasable

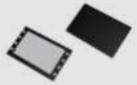
Temperature Range
- Automotive grade: -40˚C to +105˚C (AT)
- Automotive grade: -40˚C to +125˚C (UT)

Write Protection
- Volatile individual sector(s) protection
- Non-volatile individual sector(s) protection
- Password protection
- One Time Programmable region and sector(s)

Available Packages: TBGA24, x1/ x8 Boot

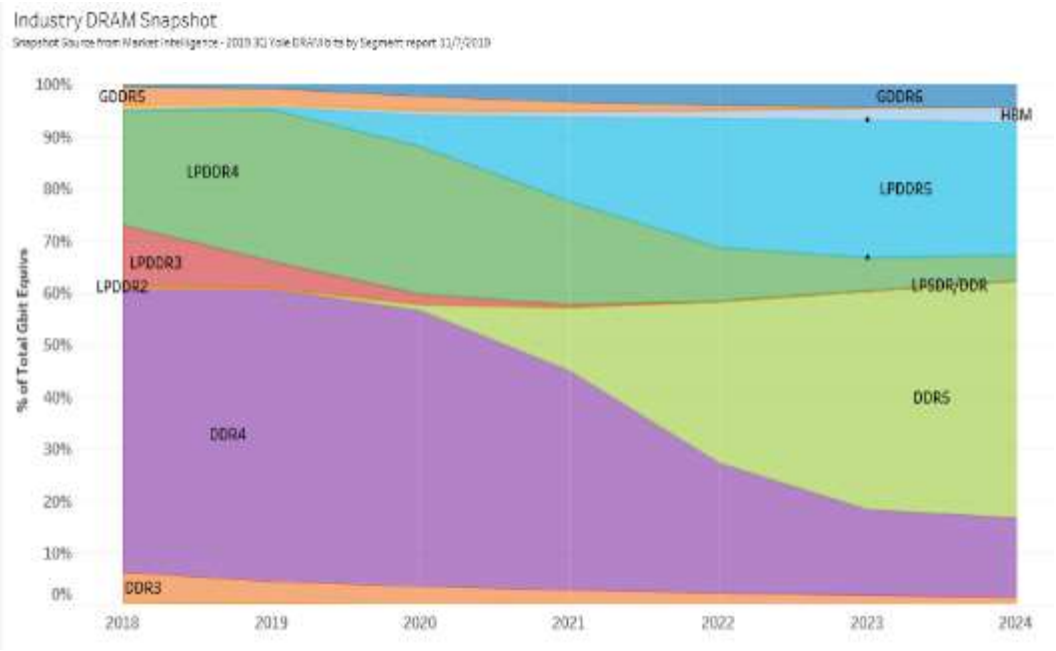
AEC Q100 compliant
- 1bit ECC built-in (2-bit detection)

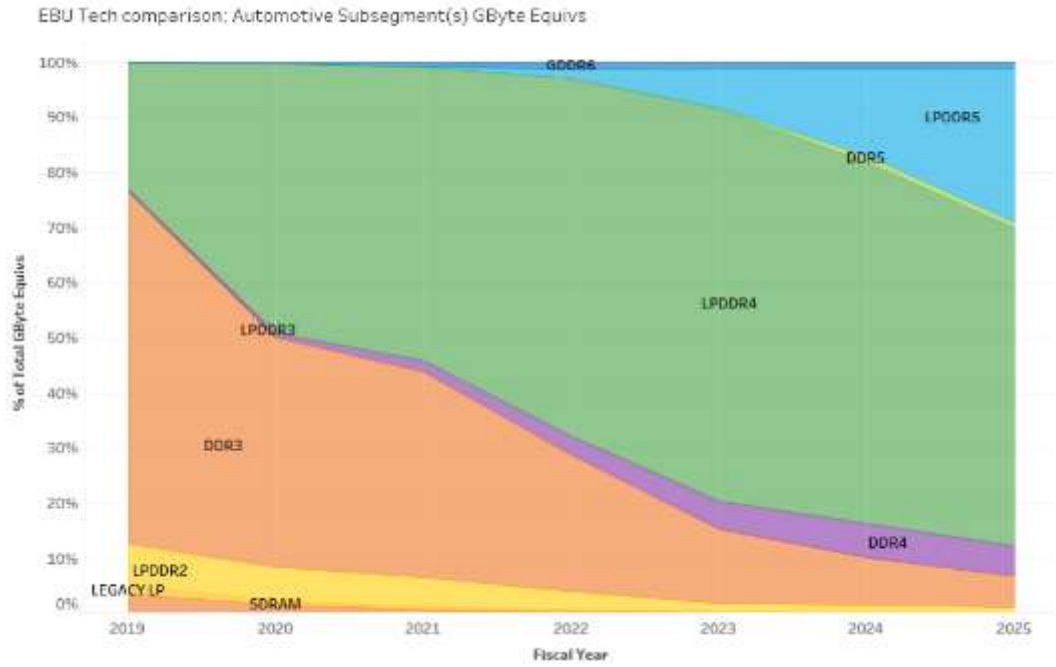
Serial Flash Package Matrix

		128Mb	256Mb	512Mb	1Gb	2Gb
CSP		Extremely thin max 0.4mm				
DFN 6x5		Very, Very thin max 0.8mm				
DFN 8x6		Very, Very thin: max 0.8mm				
SO8W		Max height 2.16mm				
SO16W		Max height 2.5mm				
TBGA 24		Thin max 1.2mm				

Micron Serial NOR products are RoHS compliant and Halogen free

DRAM Roadmap





DRAM Automotive Adoption

- Highest DRAM growth rate of all segments
  - Increasing content per system
- Continued need for long life-cycle products
  - LPSDR/LPDDR, SDR, DDR/DDR2, still required
- DDR3 is the primary choice for current gen Infotainment and Cluster applications
- LPDDR4/4x is quickly growing to be the primary interface
- Increasing MCP(SLC NAND+LP4) adoption in Telematics
- Increasing data rates to support autonomous driving/AI (GDDR6, LPDDR5x)

DRAM Temperature Ranges

- IT grade components and modules enable systems to operate in harsh environments
- AT is wider range than CT, WT or IT

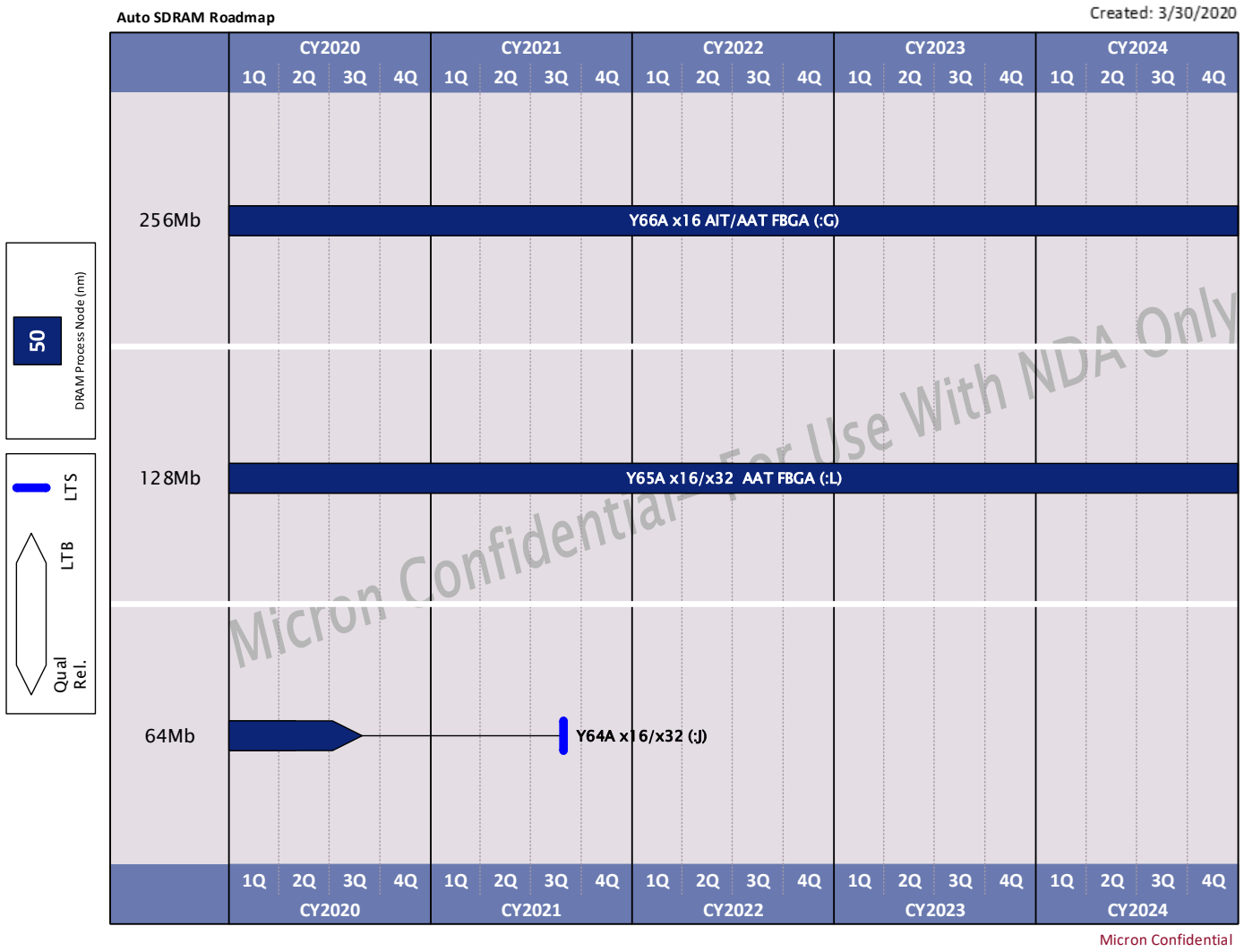
Technology	Metric[1]	Standard Temperature (CT/WT) operating range	Industrial temperature (IT/AIT[2]) operating range	Automotive temperature (AT/AAT[2]) operating range	Automotive Ultra temperature (AUT[2]) operating range[3]
SDRAM	T_a	0°C to +70°C	-40°C to +85°C	-40°C to +105°C	N/A
DDR SDRAM	T_a	0°C to +70°C	-40°C to +85°C	-40°C to +105°C	N/A
DDR2 SDRAM	T_c	0°C to +85°C	-40°C to +95°C	-40°C to +105°C	-40°C to +125°C
DDR3 SDRAM	T_c	0°C to +95°C	-40°C to +95°C	-40°C to +105°C	-40°C to +125°C
DDR4 SDRAM	T_c	0°C to +95°C	-40°C to +95°C	-40°C to +105°C	-40°C to +125°C
GDDR6	T_c	-	-	-40°C to +105°C	-
LPSDR	T_a	-25°C to +85°C	-40°C to +85°C	-40°C to +105°C	N/A
LPDDR	T_a	-25°C to +85°C	-40°C to +85°C	-40°C to +105°C	N/A
LPDDR2	T_c	-30°C to +85°C	-40°C to +85°C	-40°C to +105°C	-40°C to +125°C
LPDDR3	T_c	-30°C to +85°C	-40°C to +85°C	N/A	N/A
LPDDR4	T_c	-25°C to +85°C (=>110s) -30°C to +85°C (100s)	-40°C to +95°C	-40°C to +105°C	-40°C to +125°C
LPDDR5	T_c	-25°C to +85°C	-40°C to +95°C	-40°C to +105°C	-40°C to +125°C

[1] T_a is ambient temperature; T_c is case temperature

[2] Auto grade components follow rigorous AECQ200 standards for quality, reliability, fab/BOM control and PPAP. Auto temperature (AT) is not the same as Auto grade (see Automotive section on www.micron.com for details).

[3] AUT availability begins with Micron's 80s (30nm) devices and beyond (currently for Auto use cases only)

SDRAM Auto Roadmap (MT48)



Key Features

Voltage
- 3.3V

Package IOs
- x16, x32

Packages
- 54b VFBGA (X16)
- 90b VFBGA (X32)

Data Rate
- 333 MT/s

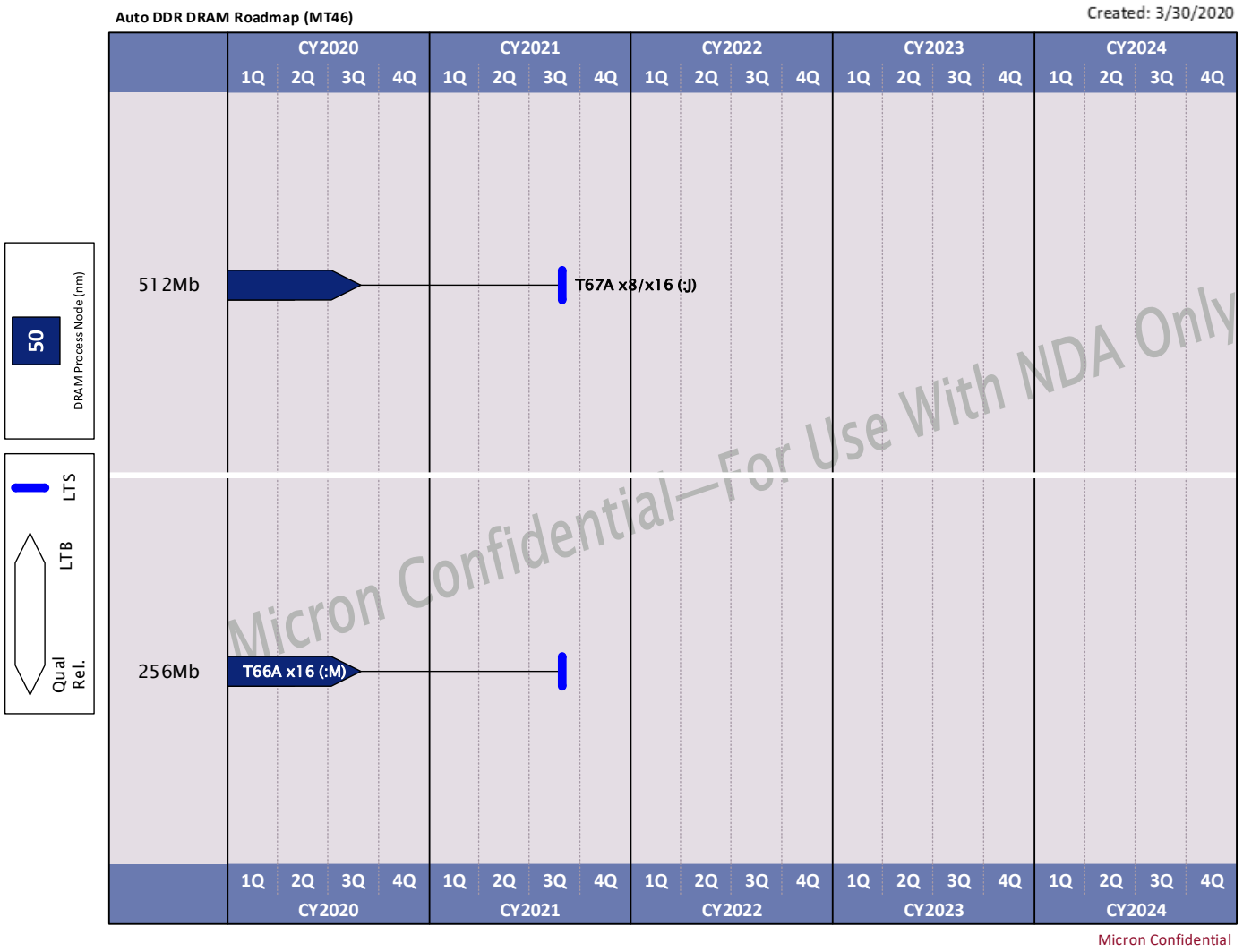
Options
- Automotive Quality (A)

Temperature
- -40°C to +85°C (IT)
- -40°C to +105°C (AT)

Example Part Number
- MT48LC4M32B2B5-6A AAT:L

Notes
- All auto TSOP parts EOL on PCN #33276

DDR Auto Roadmap (MT46)



Key Features

Voltage
- 2.5V

Package IOs
- x8, x16

Packages
- TSOP II (x8, x16)
- 60b BGA (x8, x16)

Data Rate
- 400 MT/s

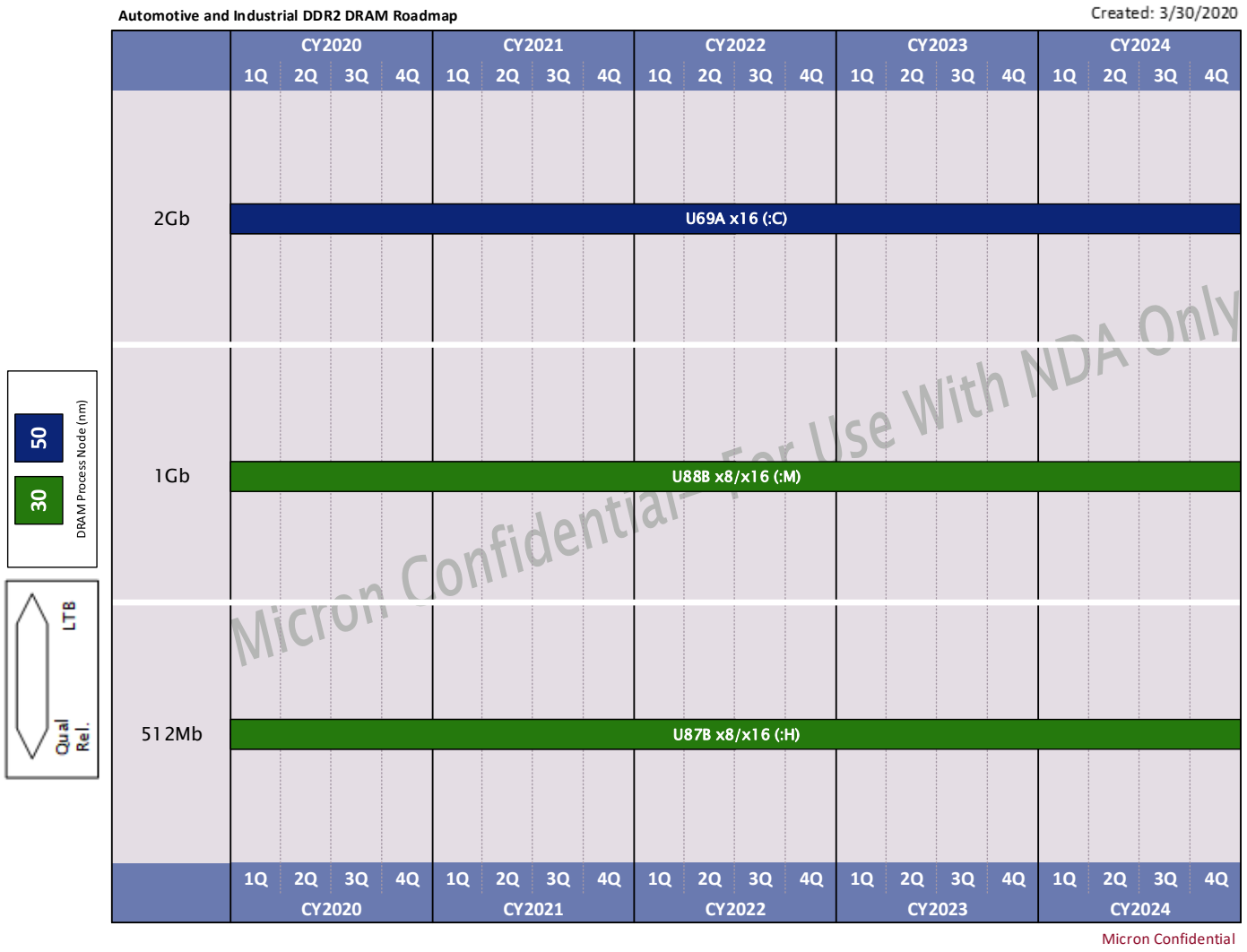
Options
- Automotive Quality (A)

Temperature
- -40°C to +85°C (IT)
- -40°C to +105°C (AT) (512Mb only)

Example Part Number
- MT46V16M16CY-5B AAT:M

Notes
- All auto TSOP parts EOL on PCN #33276

DDR2 Automotive roadmap (MT47)



Key Features

Voltage
- 1.8V (H)

Package IOs
- x8, x16

Packages
- 60b BGA (x8)
- 84b VFBGA (x16)

Data Rate
- 800 MT/s

Options
- Automotive Quality (A)
- Premium Lifecycle Part (X)

Temperature
- -40°C to +95°C (AIT)
- -40°C to +105°C (AT)

Example Part Number
- MT47H32M16NF-25E AAT:H

Notes
- 1-2Gb in PLP on specific parts until May 21‘

DDR3 Automotive Roadmap (MT41)

Key Features

Voltage
- 1.35 V (K)—New designs
- 1.5 V (J)—Legacy only

Package IOs
- x8, x16
- Full component and module portfolio

Packages
- 78b BGA (x8)
- 96b VFBGA (x16)

Data Rates
- 1600-1866 MT/s

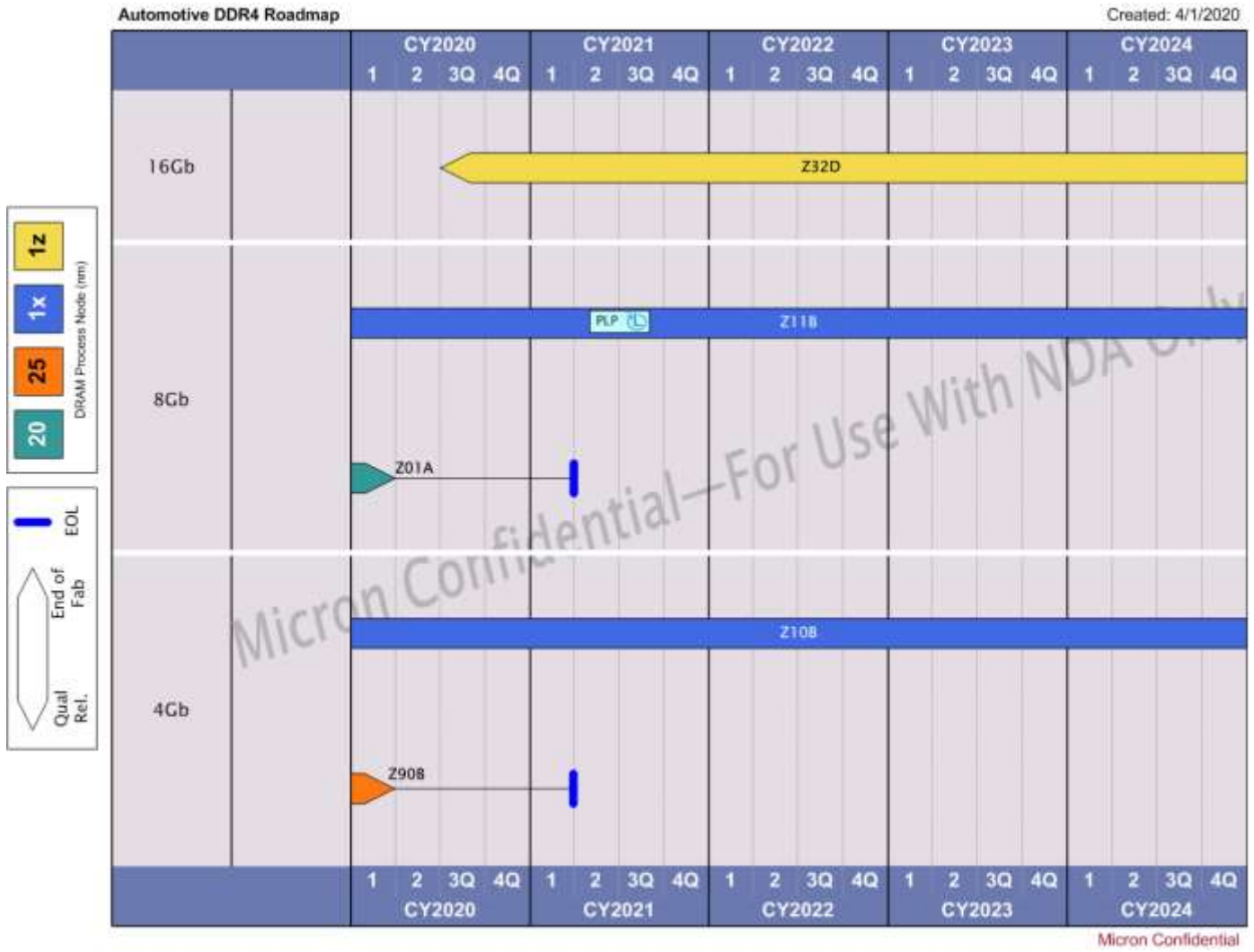
Options
- Automotive Quality (A)
- Premium Lifecycle Part (X)

Temperature
- -40°C to +95°C (IT)
- -40°C to +105°C (AT)
- -40°C to +125°C (UT)

Example Part Number
- MT41K256M8DA-125 AIT:K

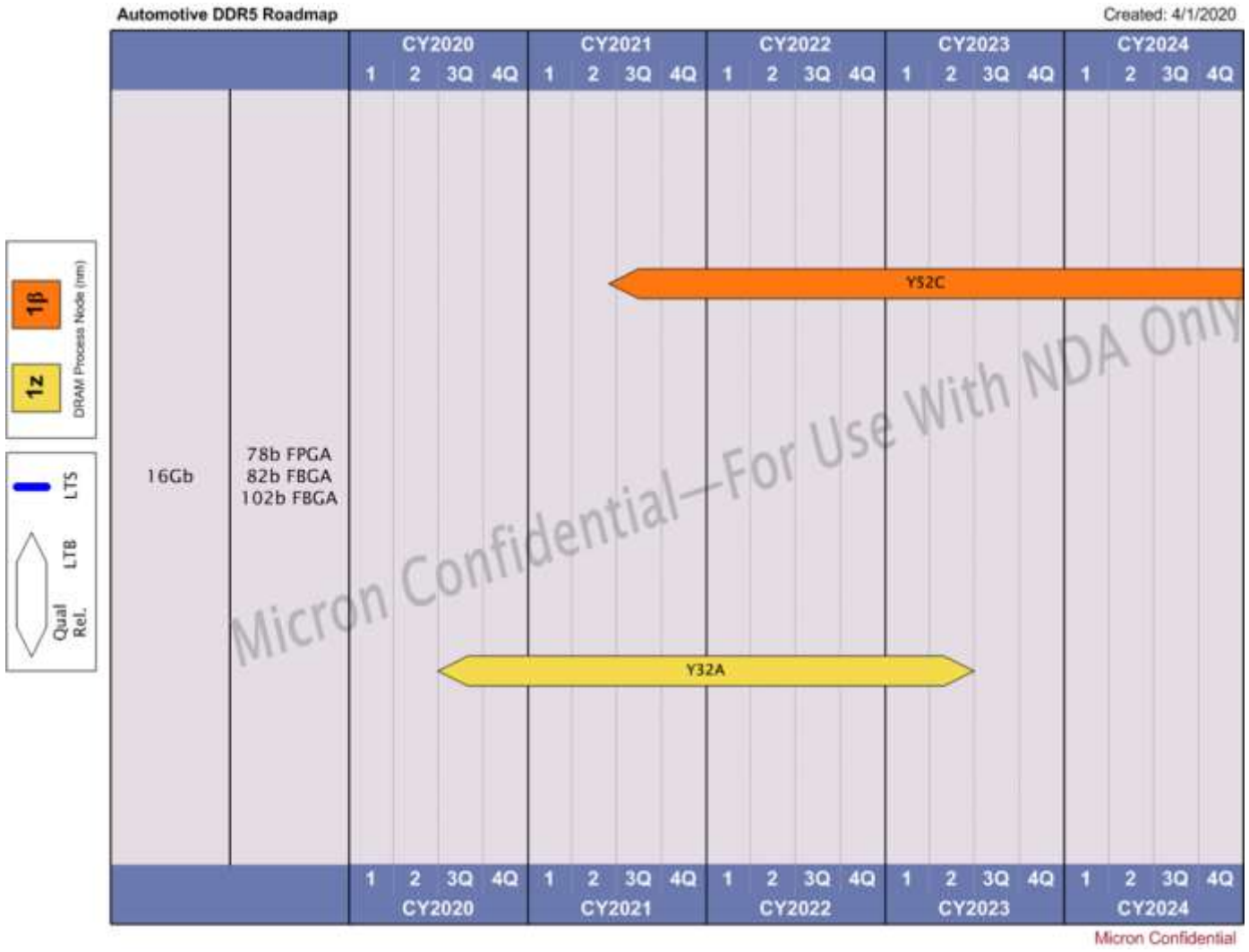
Notes
- 1-4Gb in PLP
- PCN 32855 V91A EOL – LTB 30 Sep 2020

DDR4 Automotive Roadmap (MT40)



Key Features
Voltage • 1.2V
Package IOs • x8, x16
Packages • 78b BGA (x8) • 96b VFBGA (x16)
Data Rates • 2400MT/s – 3200 MT/s
Options • Automotive Quality (A)
Temperature • -40°C to +95°C (AIT) • -40°C to +105°C (AAT) • -40°C to +125°C (AUT)
Example Part Number • MT40A512M8HX-093:A
Notes: LTS = Last Time Ship PCN# 33176 4Gb Z90B PCN# 33194 8Gb Z01A

DDR5 Automotive Roadmap (MT60)



Key Features

Voltage
- 1.1V

Package IOs
- x8, x16

Packages 1z
- 82b BGA (x8)
- 102b FBGA (x16)

Packages 1β
- 78b BGA (x8)
- 102b FBGA (x16)

Note:1z signal ballout is the same as 1β signal ballout. The 82 Ball package just has 4 out-rigger balls for package support

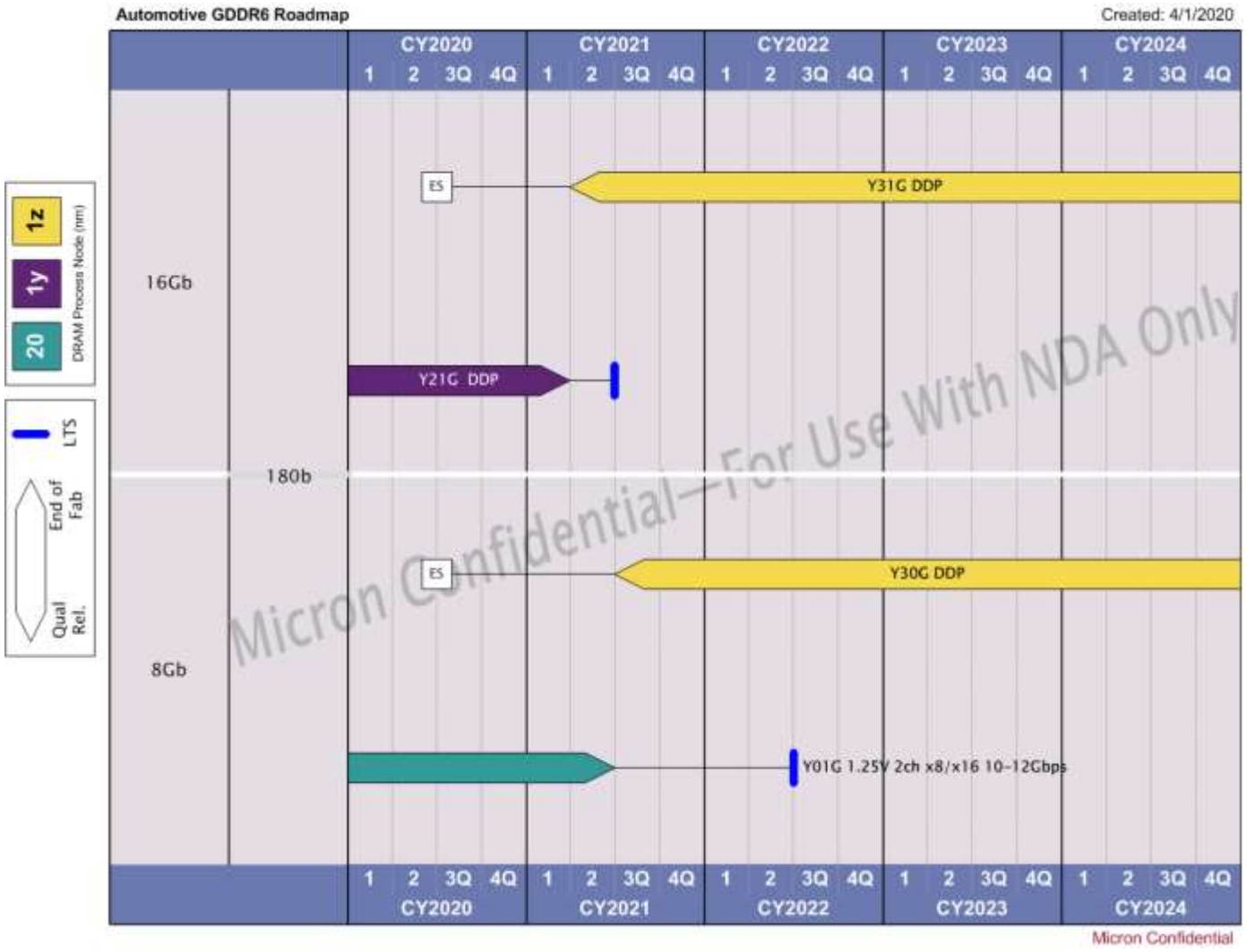
Data Rates
- 4800MT/s – 6400 MT/s

Options
- Automotive Quality (A) on 1β node

Temperature
- -40°C to+95°C (AIT) on 1z and 1a
- -40°C to +105°C (AAT) on 1a node
- -40°C to +125°C (AUT) on 1a node

Example Part Number
- TBD

GDDR6 Automotive Roadmap (MT61)



Key Features
Voltage • 1.25V
Package IOs • 2ch x8, x16
Package • 180b FBGA
Data Rates • 12 Gbps 20nm • 14 Gbps 1z node
Options • Automotive Quality (A)
Temperature • -40°C to +105°C (AAT)
Notes • 1Y node early enablemnt only on 16Gb with Commercial Temperature support.
Example Part Number • MT61M256M32JE-14 AAT:A
Early enablement only CT

LPRAM Roadmap

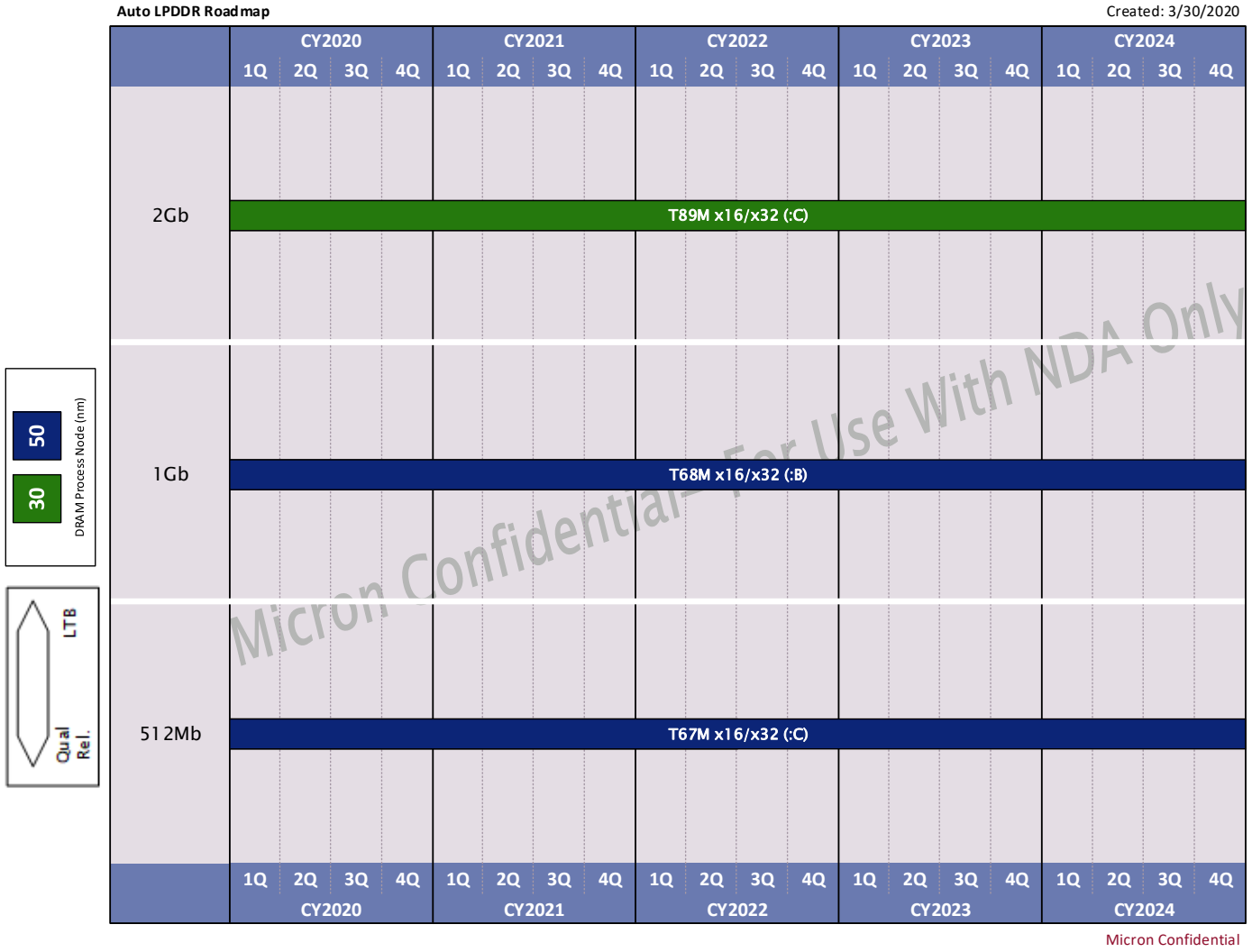
LPDDR4x is…

- LPDDR4x is an addendum to the LPDDR4 specification that enables VDDQ (I/O supply) reduction from 1.1V to 0.6V
  - Enables about 30% reduction in I/O power
    - This equates to 10-15% reduction in LPDDR4 component power
    - Note: If the SoC also uses 0.6V I/O drivers instead of 1.1V, it enables similar I/O power savings and significant CK/CA power savings for the SoC
- Not all of Micron's designs support LPDDR4x
  - Please consult the LPDDR4 roadmap for details (look for the LP4x icon)
- LP4x is the mainstream LPDDR technology moving forward
- All of Micron's LP4x products are backward compatible with LP4 parts
- Marketing part numbers (MPNs)
  - MT53D LP4x family guarantees 0.6V VDDQ (Z11M 200b is the only exception)
  - MT53E LP4x family guarantees both 0.6V and 1.1V VDDQ

LPDDR5x is…

- Additional Data Rate and Frequency
  - 8533Mbps (WCK : 4266MHz), 7500Mbps (WCK : 3750MHz)
  - CK frequency : 1066.5Mhz, 937.5Mhz
  - Compared to LPDDR5 6400Mbps (WCK : 3200MHz), 5500Mbps (WCK : 2750MMHz)
- Bank Architecture, Channel configuration
  - No change from LPDDR5
- System Assumption
  - Same as LPDDR5: # of rank, system form factor
- Supply Voltage
  - No change from LPDDR5
- Functions
  - No additional functions
  - SI improvement required to reach data rate target

LPDDR Automotive Roadmap



Key Features

Voltage
- 1.8V (H)

Package IOs
- x16, x32

Packages
- 60b VFBGA (x16)
- 90b VFBGA (x32)

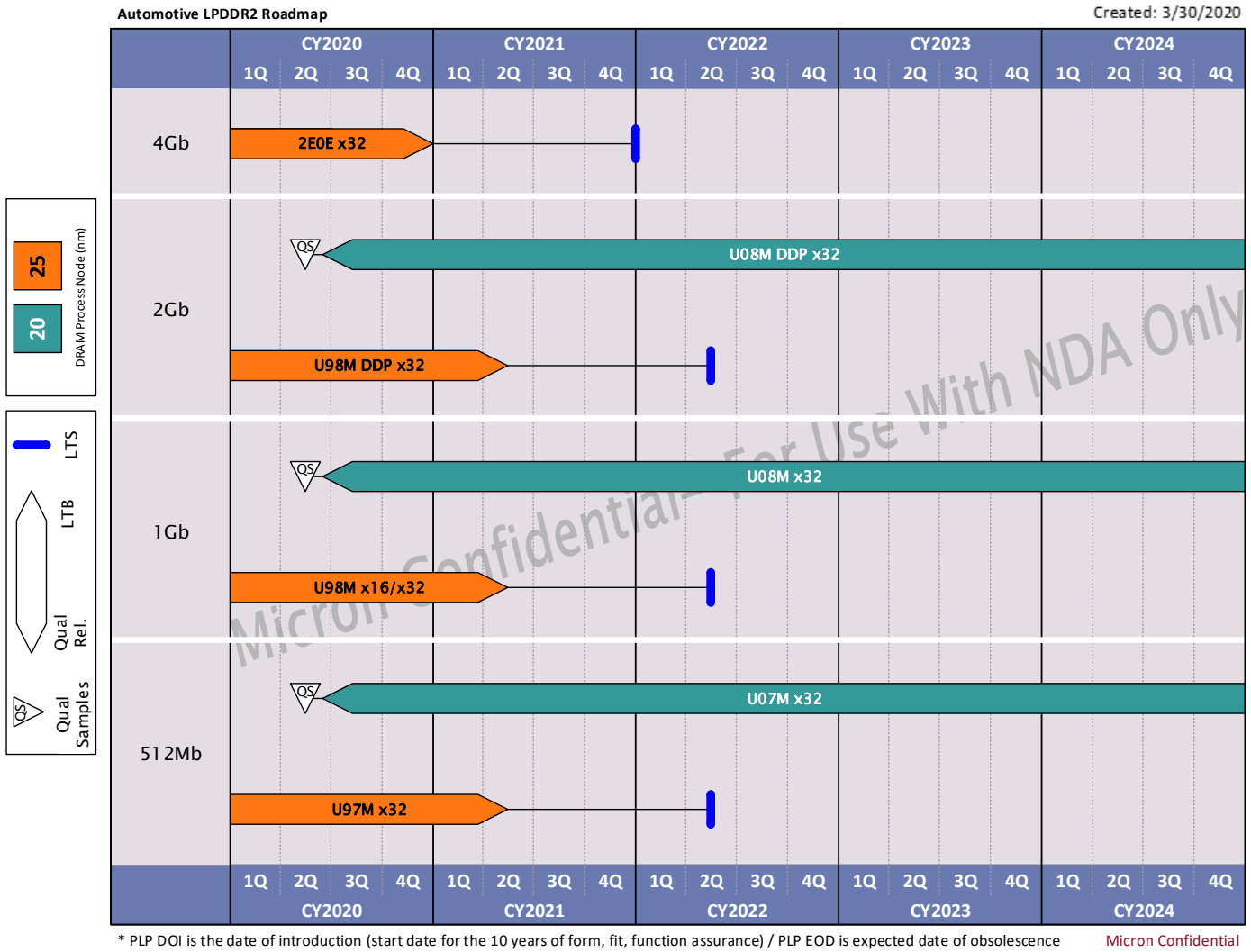
Speed
- 167-208 Mhz

Options
- Automotive Quality (A)

Temperature
- -40°C to +85°C (IT)
- -40°C to +105°C (AAT)

Notes

LPDDR2 Automotive Roadmap (MT42)



* PLP DOI is the date of introduction (start date for the 10 years of form, fit, function assurance) / PLP EOD is expected date of obsolescence

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Key Features

Voltage: 1.2V (L)

Package IO: x32 Only

Package: 134b BGA (x32)

Speed: 533Mhz

Options: Automotive Quality (A)

Temperature

- -40°C to +85°C (IT)
- -40°C to +105°C (AAT)
- -40°C to +125°C (AUT)

Example Part Number:

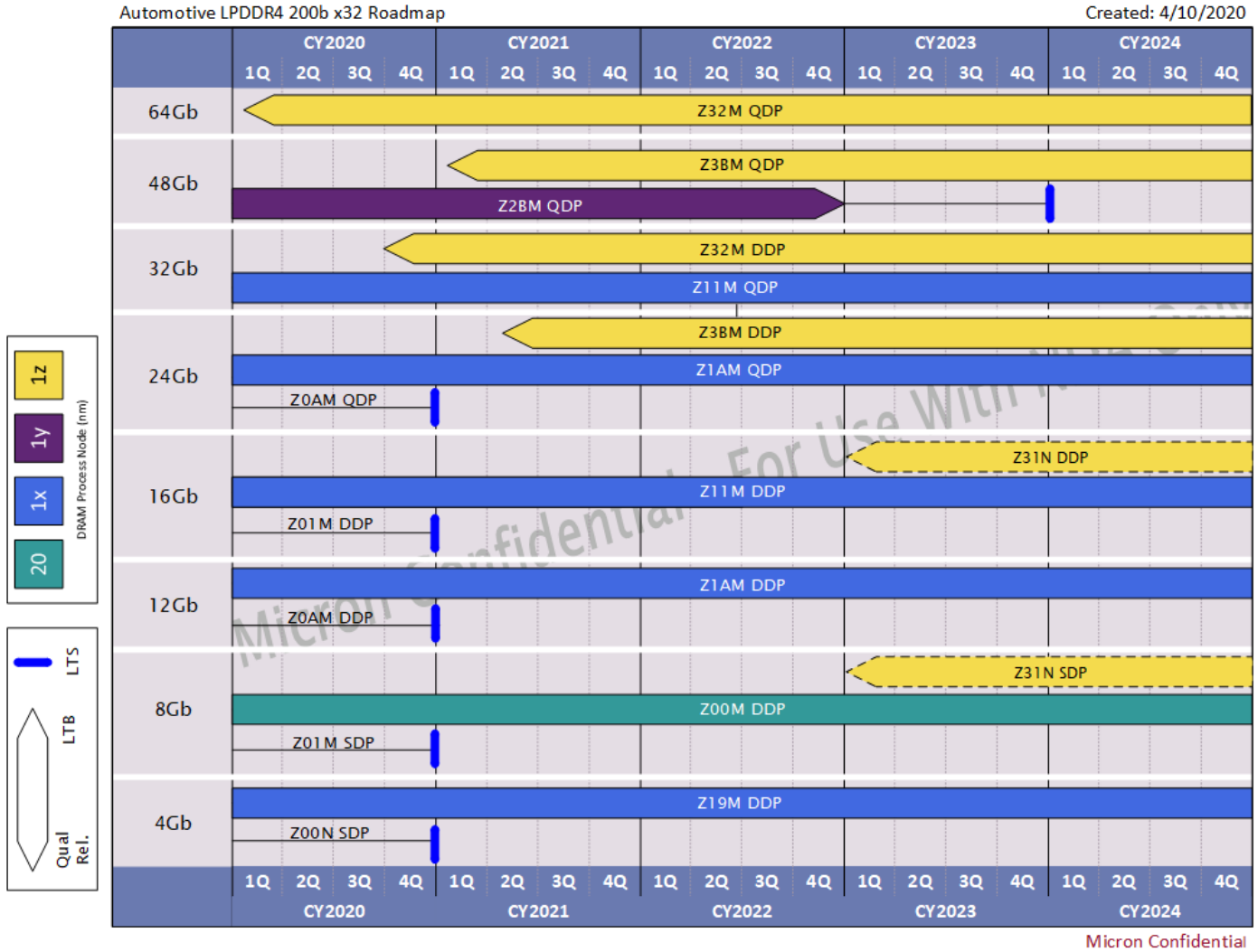
- MT42L32M32D1HE-18 AAT:D

Notes:

U97M/U98M/U07M/U08M AAT/AUT parts on PLP

- 512Mb
- 1Gb
- 2Gb

LPDDR4/LPDDR4x Automotive Roadmap (MT53 200b x32)



Key Features

Voltage: LP4/LP4x: 1.1V VDD, 1.1V and 0.6V VDDQ

Bus Width: x32 (DCx16)

Package: 200b BGA 10.0mm x 14.5mm

Speed
- 1600MHz / 3.2Gbps (-062)
- 1866MHz / 3.7Gbps (-053)
- 2133MHz / 4.2Gbps (-046)

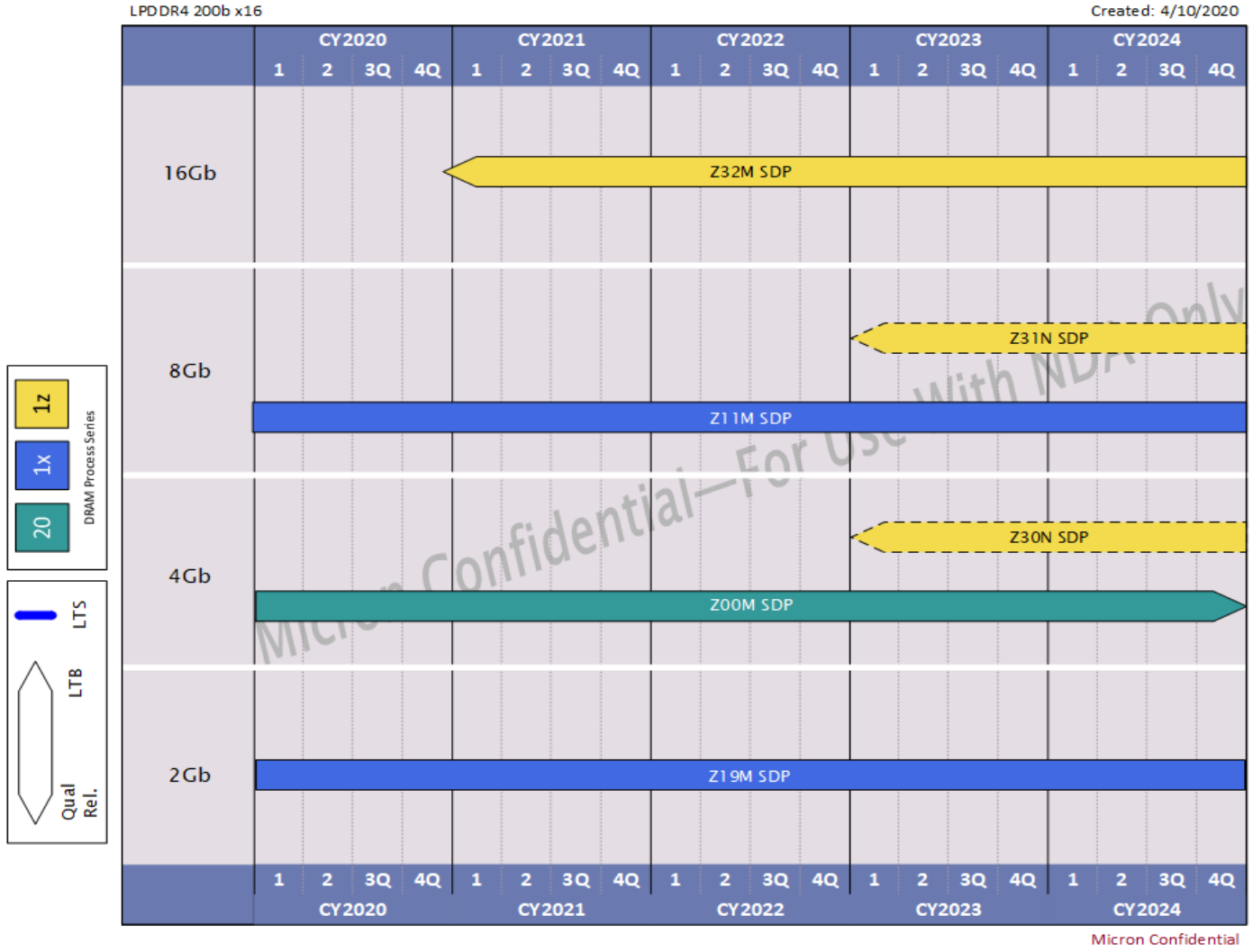
Options:
- Automotive Quality (A)
- Z31N has Funcional Safety ASIL rated specific part numbers available

Temperature
- -40°C to +95°C (AIT)
- -40°C to +105°C (AAT)
- -40°C to +125°C (AUT)

Example Part Number: MT53E512M32D2FW-046 AAT:D

Notes
- 100s to 110s Migration PCN 32982

LPDDR4/LPDDR4x Automotive Roadmap (MT53 200b x16)



Key Features

Voltage: LP4/LP4x: 1.1V VDD, 1.1V and 0.6V VDDQ

Bus Width: x16 (SCx16)

Packages: 200b BGA 10.0mm x 14.5mm

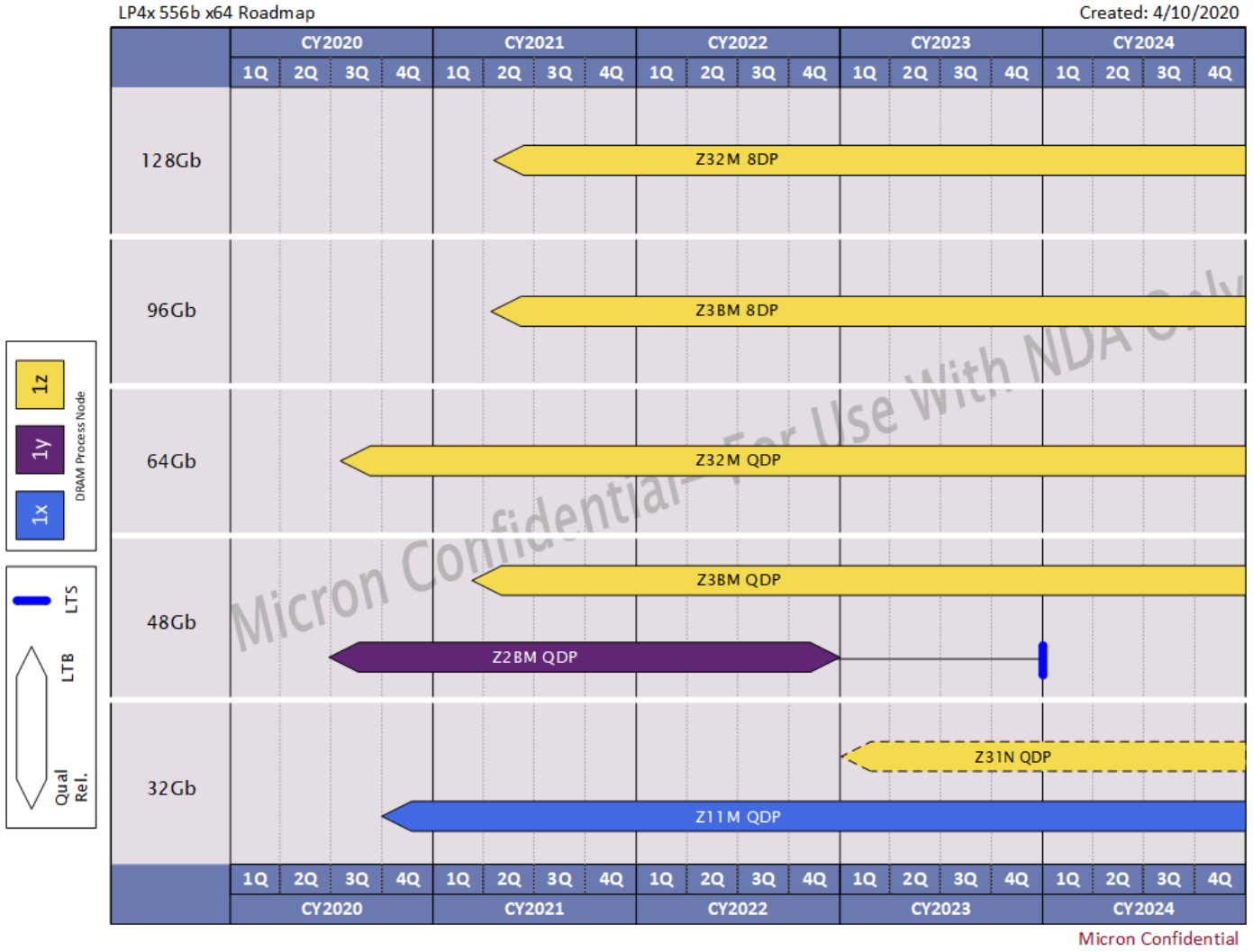
Speed
- 1866MHz / 3.7Gbps (-053)
- 2133MHz / 4.2Gbps (-046)

Options:
- Automotive Quality (A)
- Z31N and Z30N have Funcional Safety ASIL rated specific part numbers available

Temperature
- -40°C to +95°C (AIT)
- -40°C to +105°C (AAT)

Example Part Number: MT53E128M16D1DS-046 AAT:A

LPDDR4/LPDDR4x Automotive Roadmap (MT53E 556b x64)



Key Features

Voltage: LP4/LP4x: 1.1V VDD, 1.1Vand0.6V VDDQ

Bus Width: x64 (QCx16)

Package: 556ball 12.4mm x 12.4mm

Speed
- 1866MHz / 3.7Gbps (-053)
- 2133MHz / 4.2Gbps (-046)

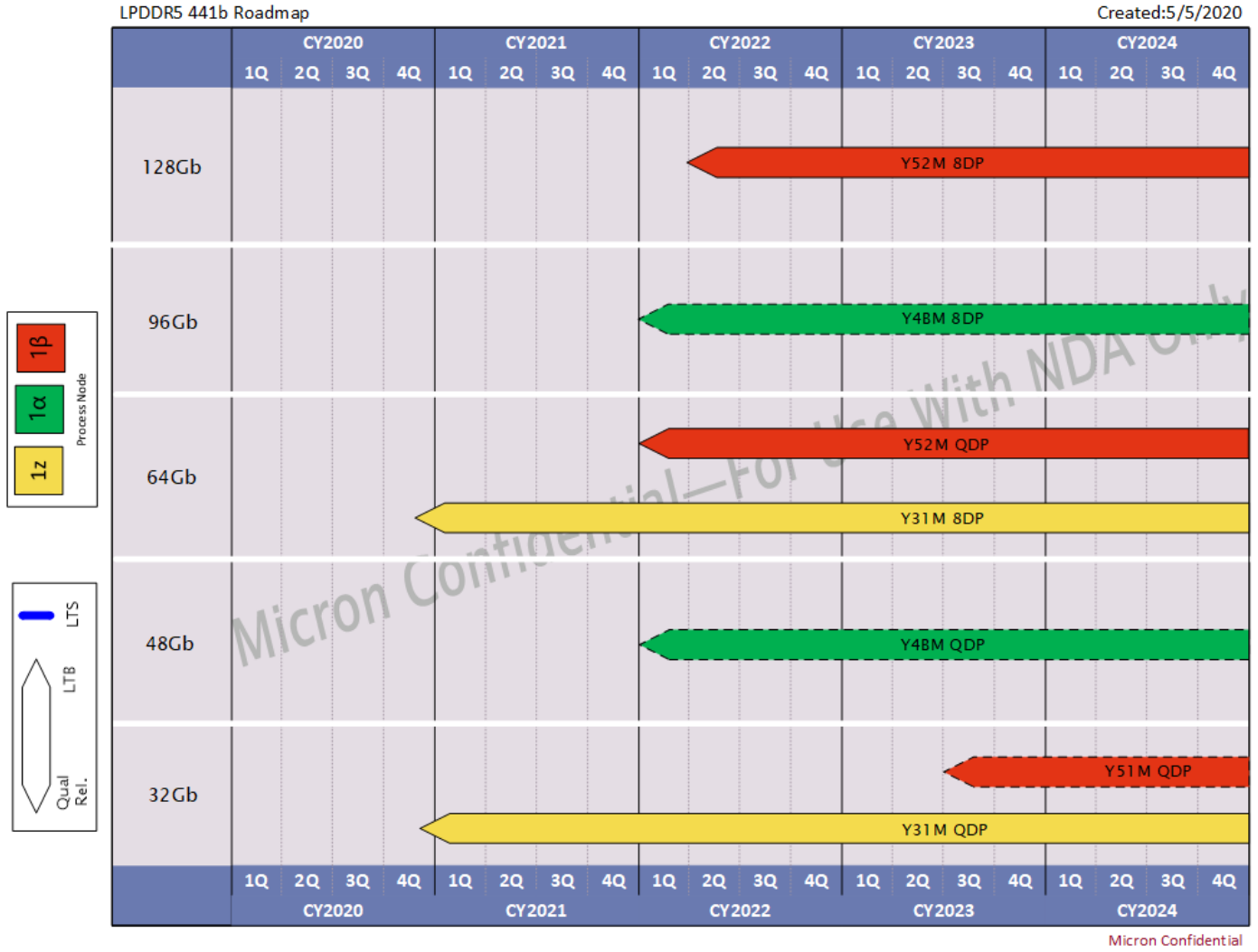
Options:
- Automotive Quality (A)
- Z31N has Funcional Safety ASIL rated specific part numbers available

Temperature
- -40°C to +95°C (AIT)
- -40°C to +105°C (AAT)
- -40°C to +125°C (AUT)

Example Part Number: MT53E768M64D4HJ-046 AAT:A

Notes
- Only promoted for Automotive applications soldering to PCB directly and not on top of processor

Automotive LPDDR5/LPDDR5x MT62 441b x64 Roadmap



Key Features

Voltage: VDD2=1.05V, VDDQ = 0.5V, VDD1 = 1.8V

Bus Width: x64 (4Chx16)

Package: 441b BGA 14.0mm x 14.0mm

Speed:

- 800MHz / 6.4Gbps / -031 LP5 (Y31M)
- 937.5MHz / 7.5Gbps / -026 LP5x (Y52M & Y5BM)
- 1066.5MHz / 8.5Gbps / -023 LP5x (Y52M & Y5BM)
- LP5x speeds are backward compatible with LP5 6.4Gbps

Options:

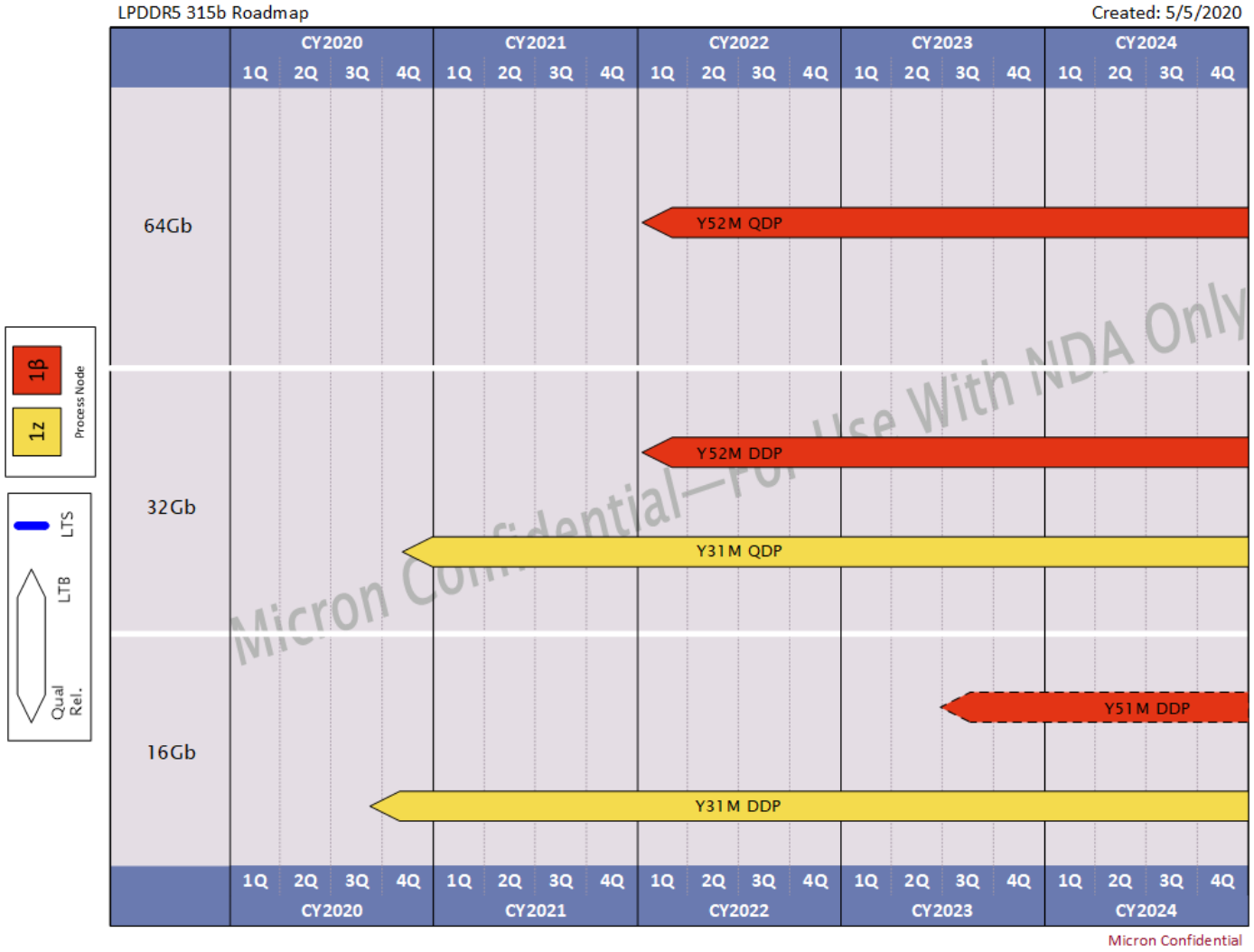
- Automotive Quality (A)
- Funcional Safety ASIL rated specific part numbers available

Temperature

- -40°C to +125°C (AUT)
- -40°C to +105°C (AAT)
- -40°C to +95°C (AIT)

Example Part Number: MT62F512M64D4EK-031 AAT:B

Automotive LPDDR5/LPDDR5x MT62 315b x32 Roadmap



Key Features

Voltage: VDD2=1.05V, VDDQ = 0.5V, VDD1 = 1.8V

Bus Width: x32 (2Chx16)

Package: 315b BGA 12.4mm x 15.0mm

Speed:

- 800MHz / 6.4Gbps / -031 LP5 (Y31M)
- 937.5MHz / 7.5Gbps / -026 LP5x (Y52M)
- 1066.5MHz / 8.5Gbps / -023 LP5x (Y52M)
- LP5x speeds are backward compatible with LP5 6.4Gbps

Options:

- Automotive Quality (A)
- Funcional Safety ASIL rated specific part numbers available

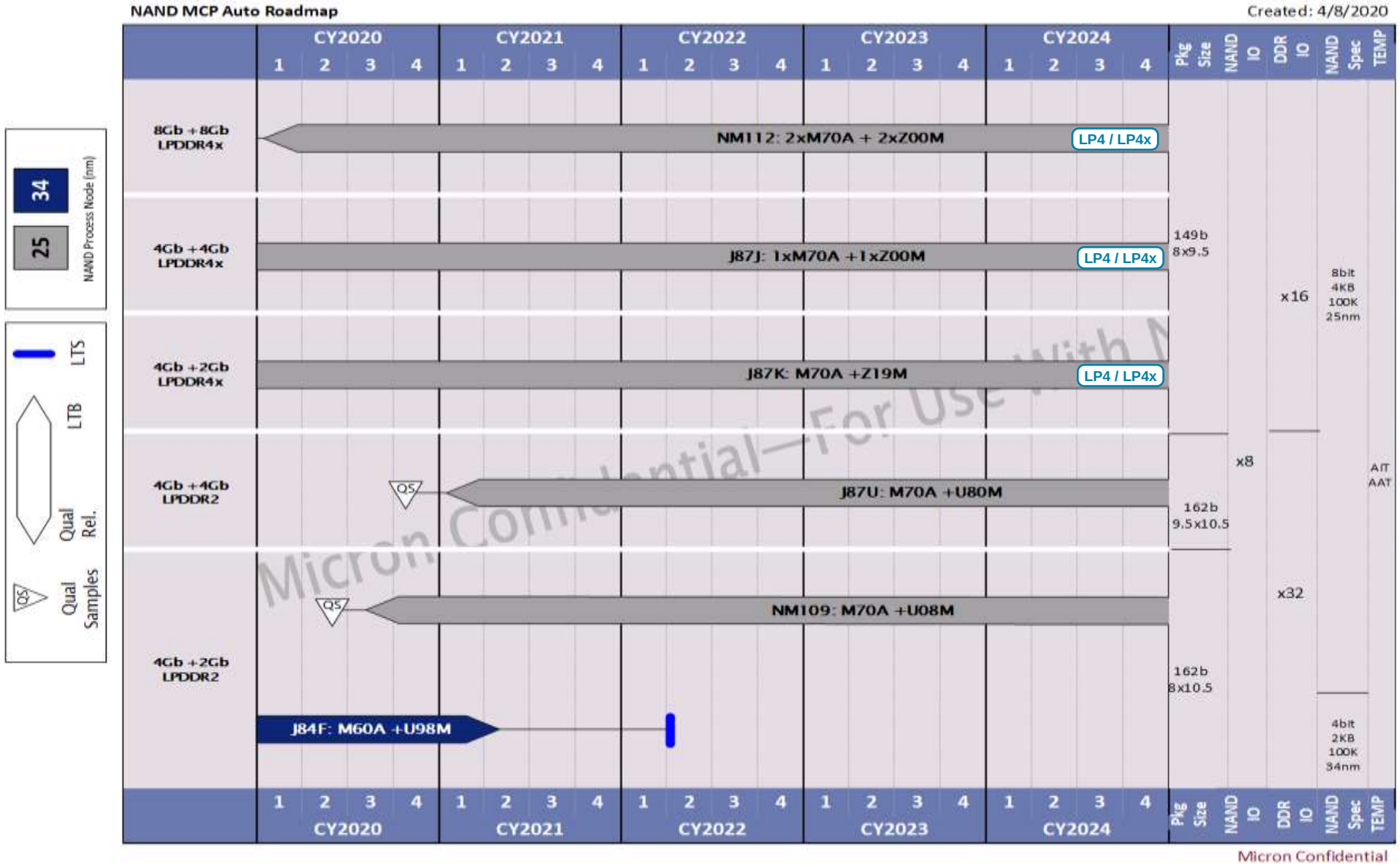
Temperature

- -40°C to +125°C (AUT)
- -40°C to +105°C (AAT)
- -40°C to +95°C (AIT)

Example Part Number: MT62F1G32D4DS-031 AAT:B

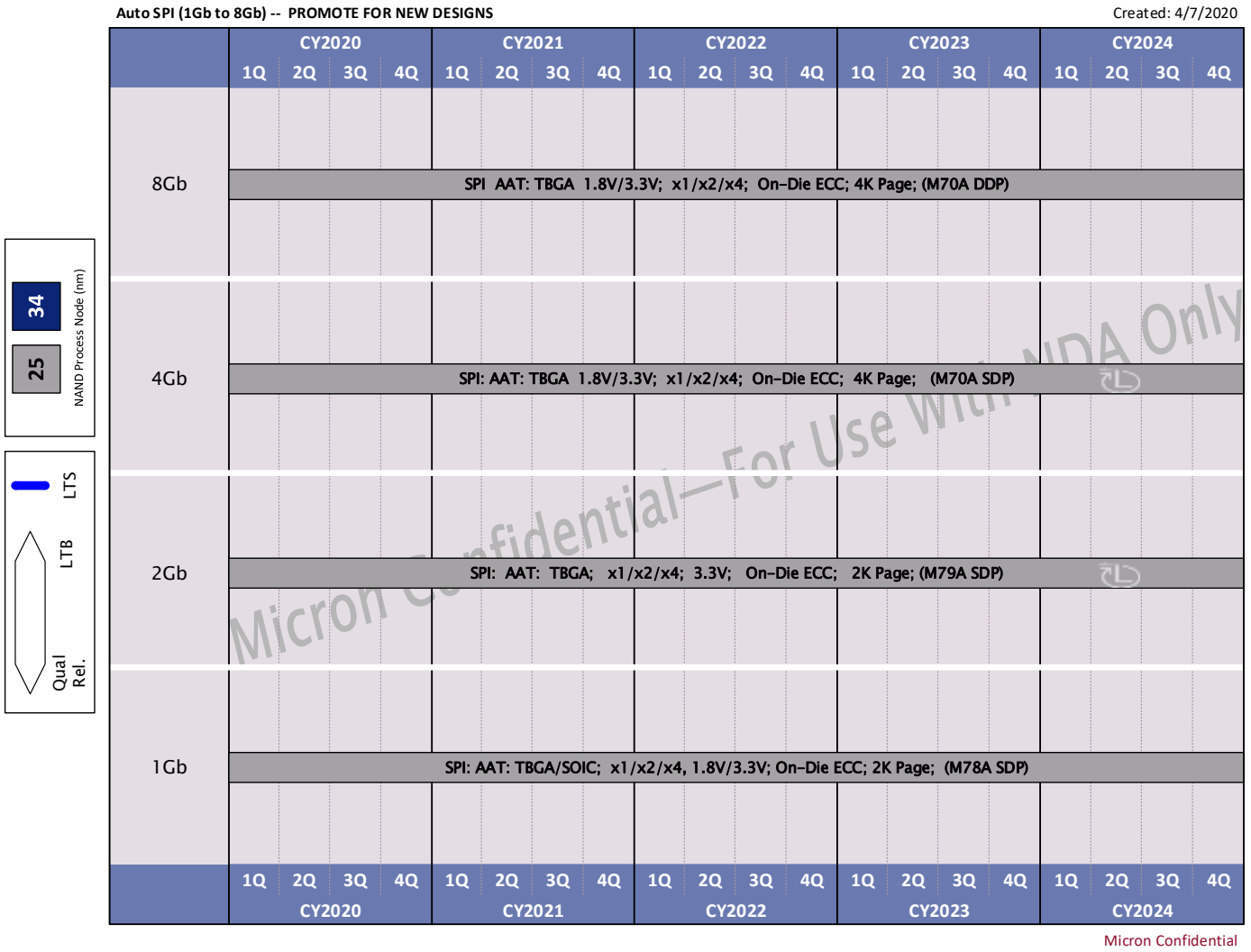
MCP Roadmap

EBU Automotive MCPs



SLC NAND Roadmap

Auto SLC SPI NAND (1G - 8Gb)



Key Features

Performance
- Standard Program: 8.3 MB/s (max)
- Standard Read: 30 MB/s (max)

Voltage and Bus Width
- 1.8V/3.3V – x1/x2/x4

ECC Configuration
- 25nm: On-Die ECC

Temperature
- Industrial range (-40°C to +85˚C) AIT
  *Contact Marketing for potential opportunity
- Automotive range (-40°C to +105˚C) AAT

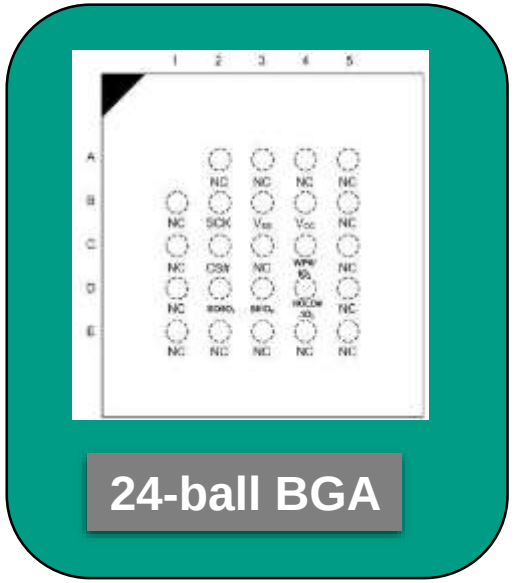
Packages
- 16-pin SOIC(M78A)
- 24-ball TBGA 6x8 (recommended)

Quality and Reliability
- 25nm: 100K P/E Cycle
- AEC-Q100 Compliance

Security
- OTP area, Unique ID

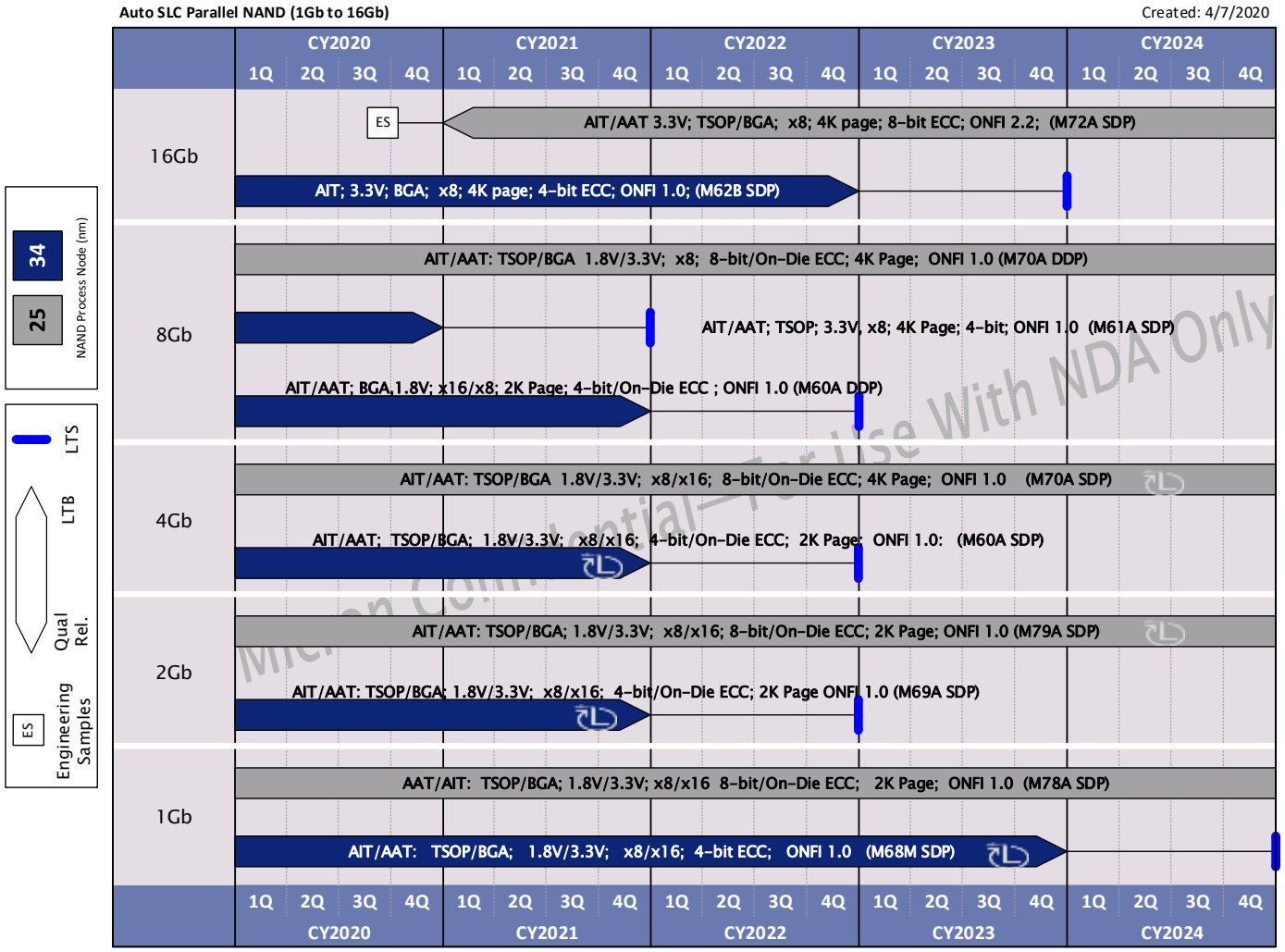
PLP Support
- Full list at micron.com/PLP

25nm: SPI SLC NAND Package Offerings – Automotive



SPI NAND	Interface	Vcc	Temp	M78A SDP 1Gb	M79A SDP 2Gb	M70A SDP 4Gb	M70A DDP 8Gb
16-Pin SOIC 10.3x10.3x2.65	x1, x2, x4	3.3V	AAT	MT29F1G01ABAFDSF-AAT:F	MT29F2G01ABAGDSF-AAT:G	N/A	N/A
24-Ball TBGA 6.00x8.00x1.20	x1, x2, x4	3.3V	AAT	MT29F1G01ABAFD12-AAT:F	MT29F2G01ABAGD12-AAT:G	MT29F4G01ABAFD12-AAT:F	MT29F8G01ADAFD12-AAT:F
	x1, x2, x4	1.8V	AAT	MT29F1G01ABBFD12-AAT:F	MT29F2G01ABBGD12-AAT:G	MT29F4G01ABBFD12-AAT:F	MT29F8G01ADBFD12-AAT:F

Auto SLC Parallel NAND (1G - 16Gb)



* PLP DOI is the date of introduction (start date for the 10 years of form, fit, function assurance) /PLP EOD is the expected date of obsolescence

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Key Features

Performance
- Standard Program: 8.3 MB/s (max)
- Standard Read: 30 MB/s (max)

Voltage and Bus Width: 1.8V/3.3V – x8, x16

ECC Configuration
- 34nm 1Gb to 4Gb: 4-bit/(512+spare)Bytes or On-Die ECC
- 34nm 8Gb to 16Gb: 4-bit/(512+spare)Bytes
- 25nm 1Gb to 16Gb: 8-bit/(512+spare)Bytes or On-Die ECC

Temperature
- Industrial range (-40°C to +85˚C) AIT
- Automotive range (-40°C to +105˚C) AAT

Packages
- 48-pin TSOP 12mm x 20mm (recommended)
- 63-ball 9mm x 11mm VFBGA

Quality and Reliability
- 34nm: 100K P/E Cycles
- 25nm: 100K P/E Cycles
- AEC-Q100 compliance

Security: OTP area, Unique ID

PLP Support
- 1 Gb – 8 Gb solutions
- Full list at micron.com/PLP

SLC Package Options for New Design

PNAND	# Die	Interface	Vcc/ Vccq	# CE	M68M	M78A	M79A	M70A	M71M
12x20x1.2 48-Pin TSOP	SDP	Async	3.3/3.3V 1.8/1.8V	1	1Gb	2Gb	4Gb	4Gb	8Gb
10.5x13x1 9x11x1 63-Ball VFBGA	SDP	Async	3.3/3.3V 1.8/1.8V	1	1Gb	2Gb	4Gb	4Gb	8Gb

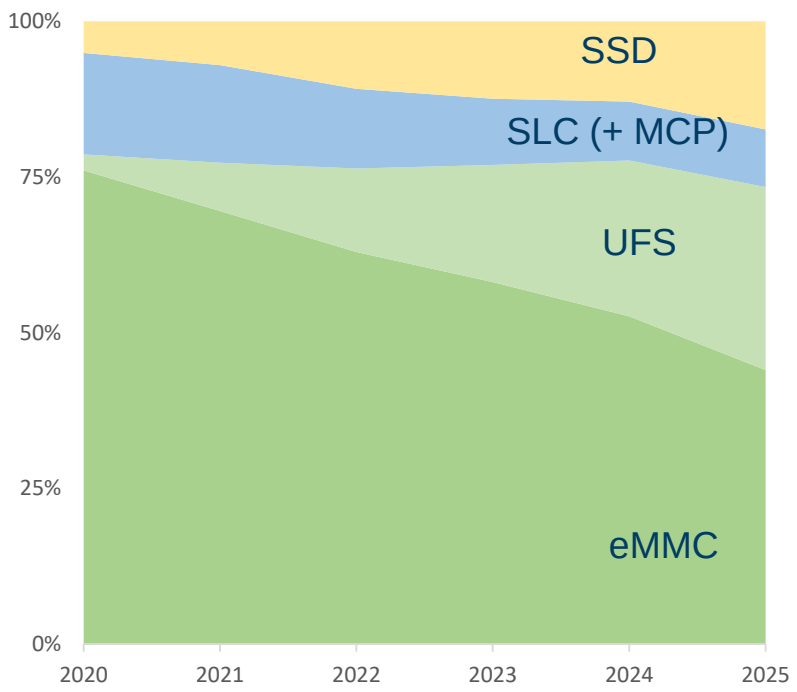
e.MMC & UFS Roadmaps

Automotive NAND Trends

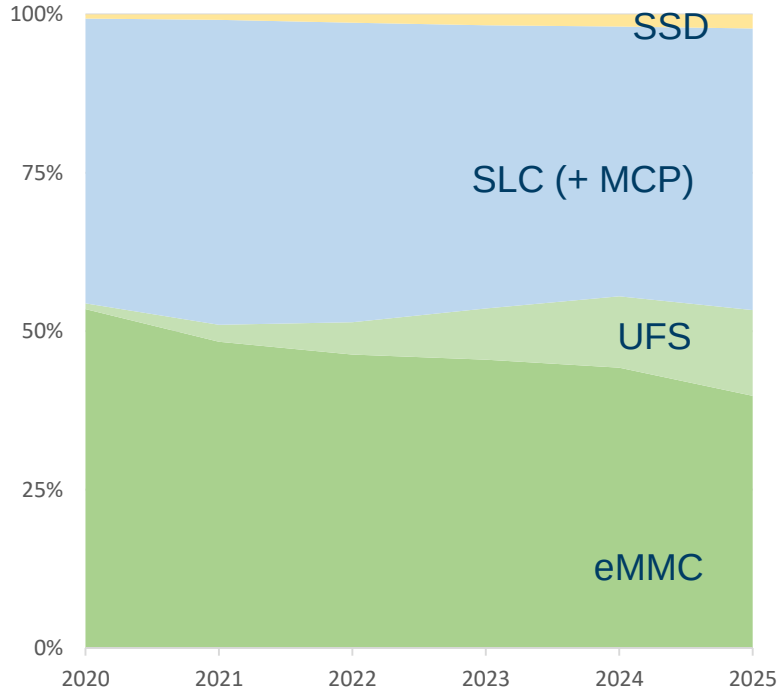
Interface Trends

- Strong SLC demand for ADAS boot & telematics MCPs
- Continued eMMC need in ADAS and low end IVI platforms
- UFS adoption in mid end and premium IVI due to faster performance vs eMMC
- Strong interest in BGA SSD
  - SRIOV based centralized storage for ADAS with black box
  - UFS alternative for IVI.

TAM ($)

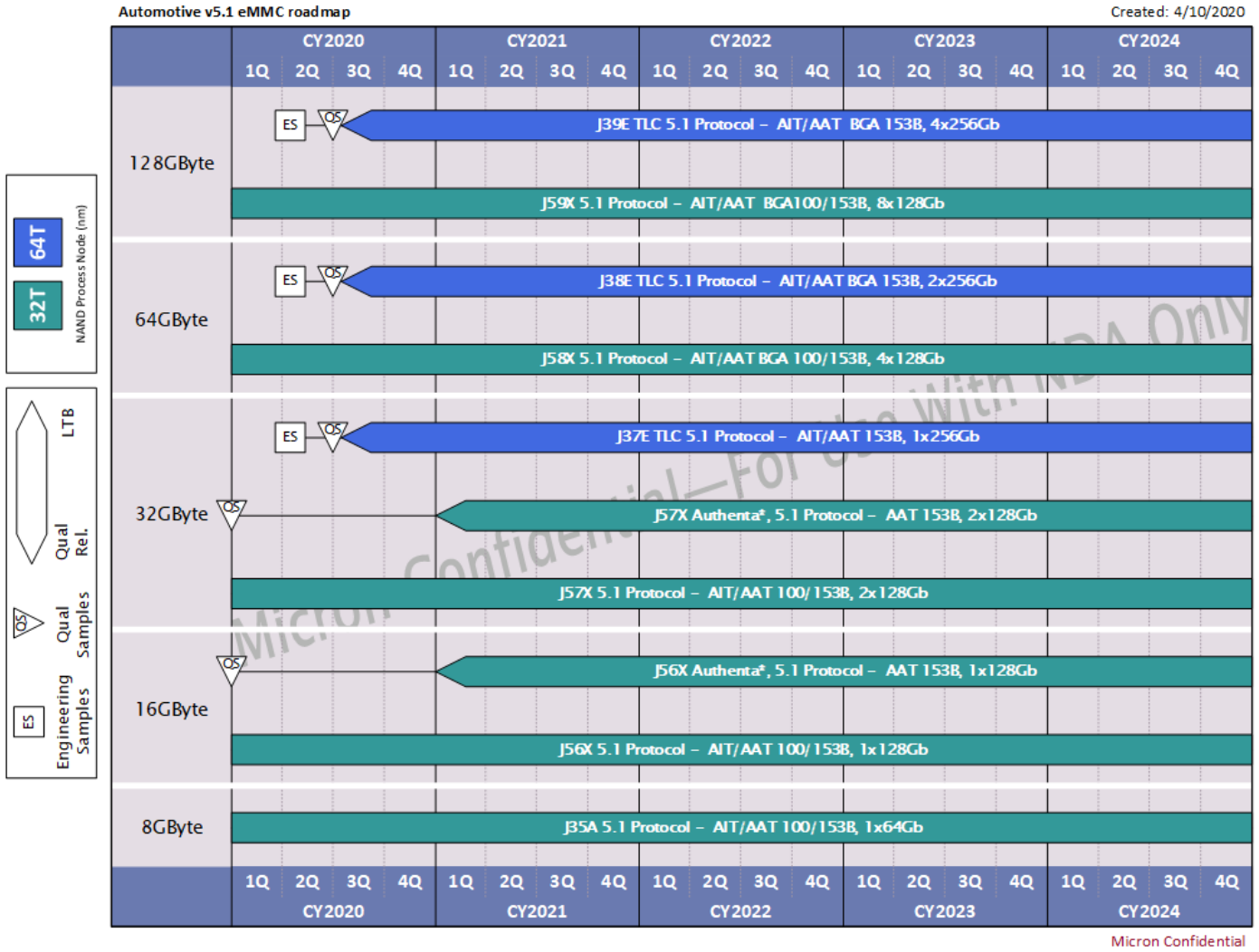


TAM (Units)



Automotive v5.1 e.MMC Protocol Roadmap

Design In Portfolio

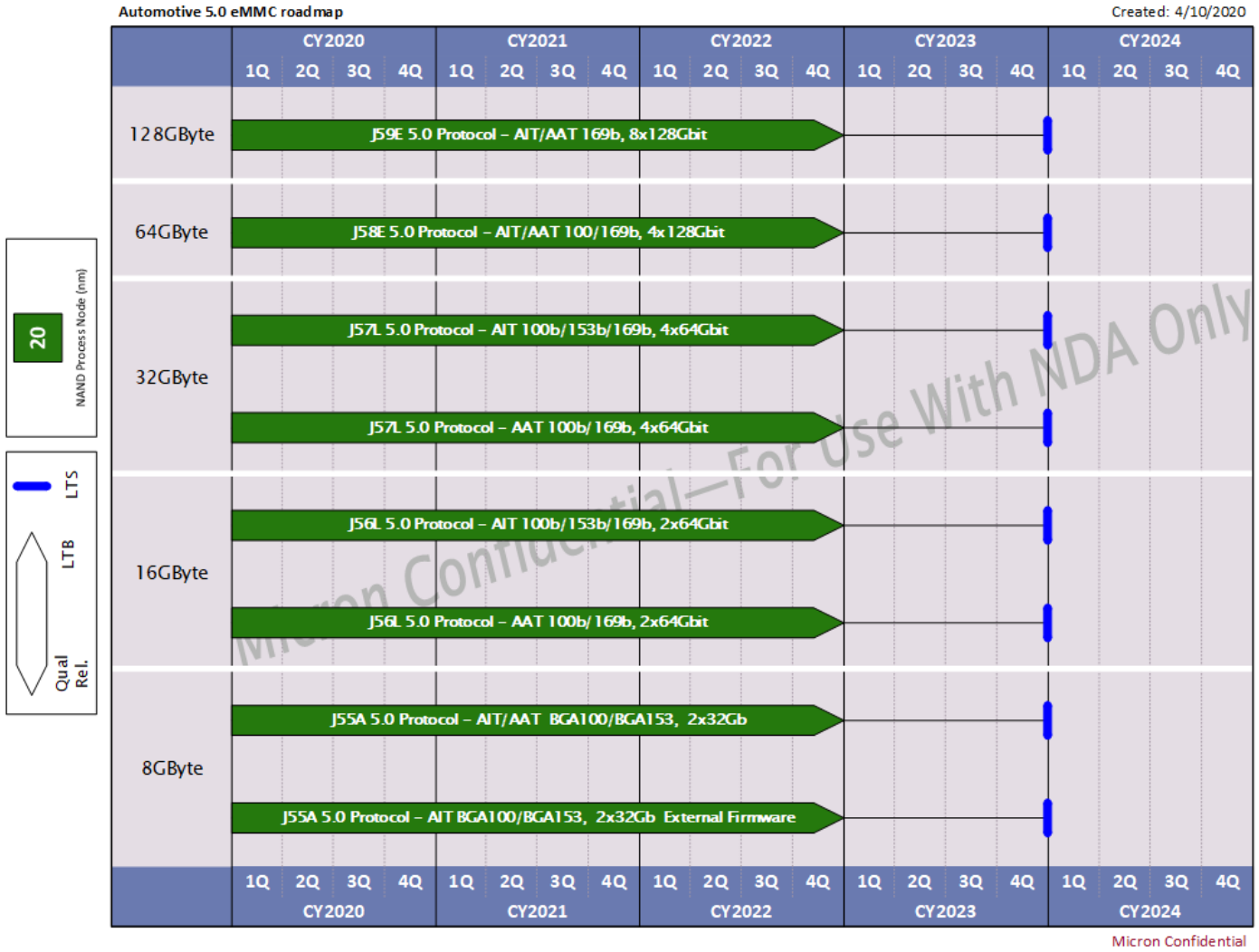


Key Features

Technology	
3D NAND 32T 2b/c (MLC)	3D NAND 64T 3b/c (TLC)
Micron Internal Firmware	
e.MMC Specification • JESD84-B51	
Operating Voltage	
• Vccq = 1.65V-1.95V – (EDS enabled parts); • Vccq = 2.7V-3.6V	• Vccq = 1.65V-1.95V – (EDS enabled parts);
Operating Temperature	
• Grade 2 (-40°C to +105°C) AAT with up to +115°C Tcase; • Grade 3 (-40°C to +85°C) AIT	• Grade 2 (-40°C to +115°C Tcase) AAT • Grade 3 (-40°C to +85°C) AIT
Performance	
• Seq. Write: up to 120 MB/s • Seq. Read: up to 320 MB/s	
Packages	
• LBGA100 (14x18x1.4mm) • TfBGA153 (11.5x13x1.2mm)	• TfBGA153 (11.5x13x1.2mm)
Authenta™ Security	
• Enables hardware roots of trust in flash • Remote key management service	

Automotive v5.0 e.MMC Protocol Roadmap

Legacy Product Portfolio



Key Features

Technology
- 80 MLC NAND tech 20nm
- Micron Internal Firmware

eMMC Specification
- JESD84

Operating Voltage
- Vcc = 2.7V - 3.6V
- Vccq = 1.65V-1.95V; 2.7V-3.6V

Operating Temperature
- Grade 2 (-40°C to +105°C) AAT
- Grade 3 (-40°C to +85°C) AIT

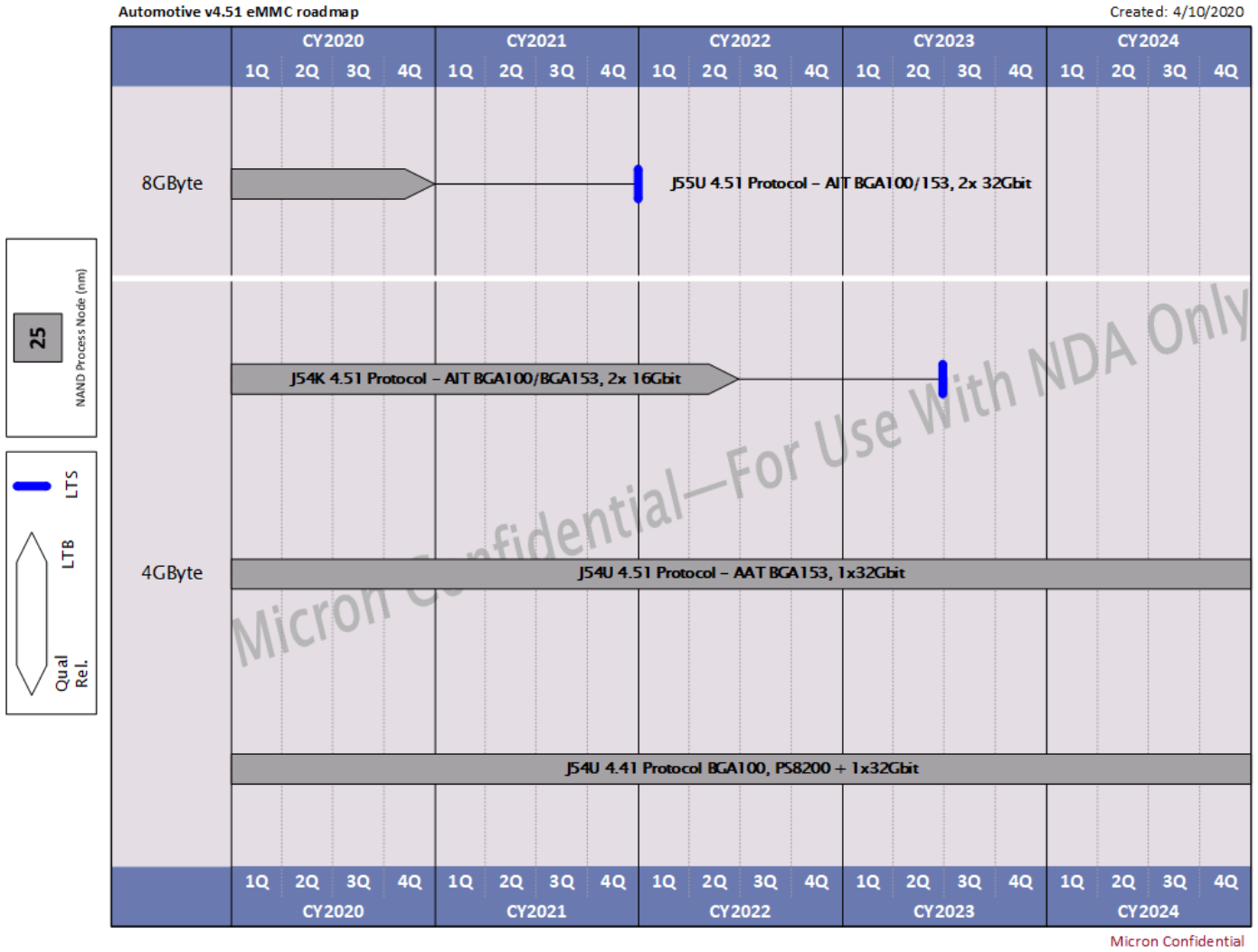
Performance
- Seq. Write: up to 70 MB/s
- Seq. Read: up to 280 MB/s

Packages
- 8/16/32/64GB: LBGA100 (14x18x1.4mm)
- 8GB:TfBGA153 (11.5x13x1.2mm)
- 16/32GB: BGA169 (14x18x1.2mm)
- 16/32GB: BGA153 (11.5x13x1.0mm)
- 64/128GB: BGA169 (14x18x1.2/1.4mm)

FW Version
- Page Based

Automotive v4.51/v4.41 e.MMC Protocol Roadmap

Legacy Product Portfolio



Key Features

Technology
- 70 MLC NAND tech 25nm
- External Vendor Firmware

eMMC Specification
- JESD84

Operating Voltage
- Vcc = 2.7V - 3.6V
- Vccq = 1.65V-1.95V; 2.7V-3.6V

Operating Temperature
- Grade 2 (-40°C to +105°C) AAT
- Grade 3 (-40°C to +85°C) AIT

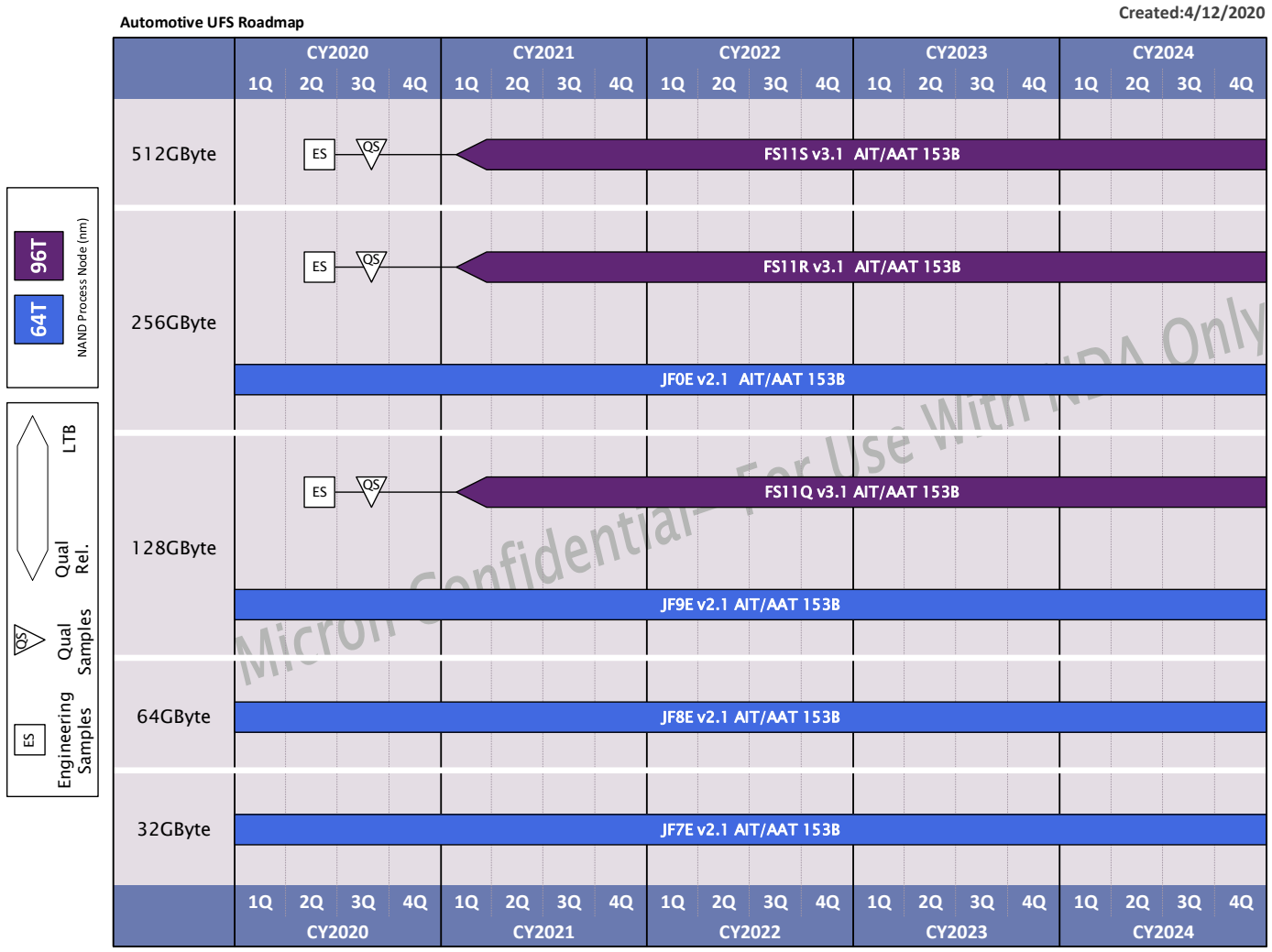
Performance v4.51
- Seq. Write: up to 37 MB/s
- Seq. Read: up to 140 MB/s

Performance v4.41
- Seq. Write: up to 20 MB/s
- Seq. Read: up to 44 MB/s

Packages
- 4/8/16/32GB: LBGA100 (14x18x1.4mm)
- 4/8/16GB:TfBGA153 (11.5x13x1.2mm)

FW Version
- Block Based

Auto UFS Technology Roadmap



Key Features

Technology
- v2.1: 110s 3D TLC NAND
- v3.1: 120s 3D TLC NAND

UFS Specifications
- JESD220C 2.1
- JESD220D 3.1

Operating Temperatures (Tcase)
- Grade 2 (-40ºC to 105ºC) - AAT
- Grade 3 (-40ºC to 95ºC) – AIT

Package
- TFBGA153 (11.5x13x1.2mm)

Pinout
- FS11Q/R will have JEDEC-5Vss package only

Dotted line indicates conceptual products; schedules are subject to change

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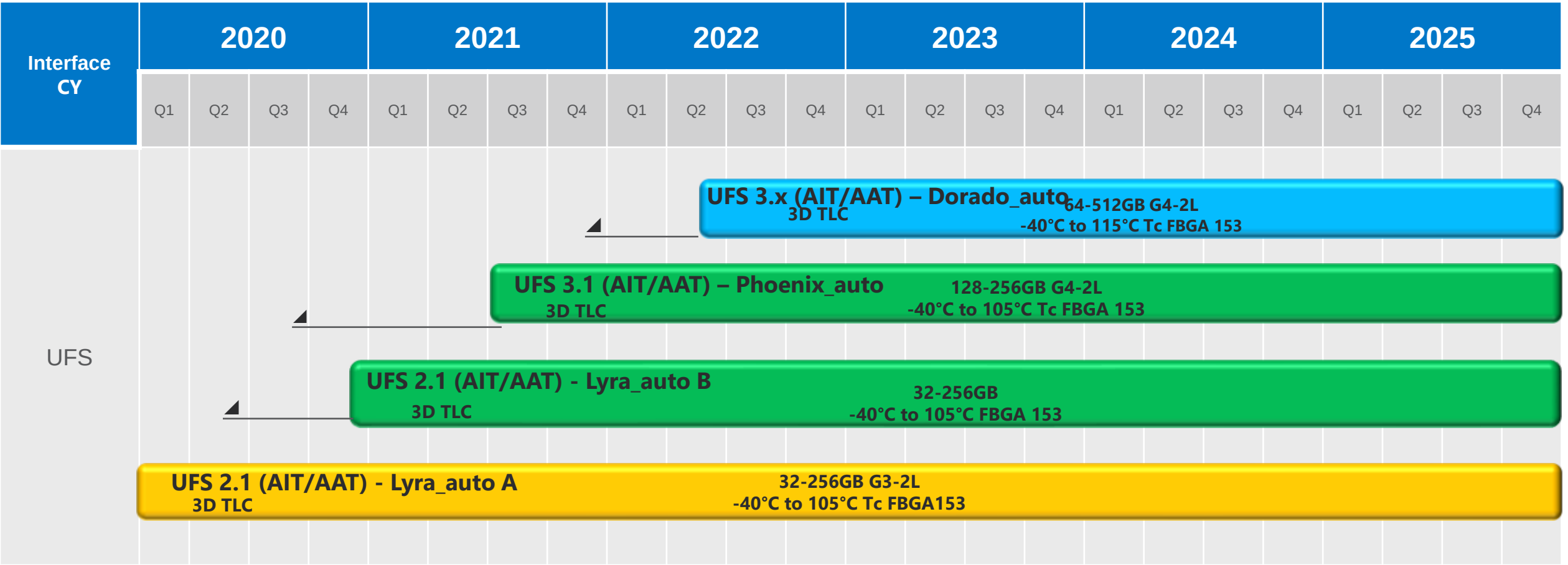
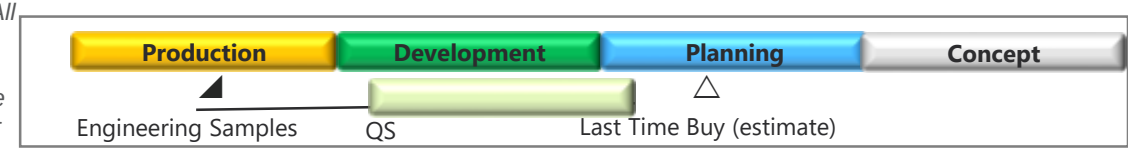
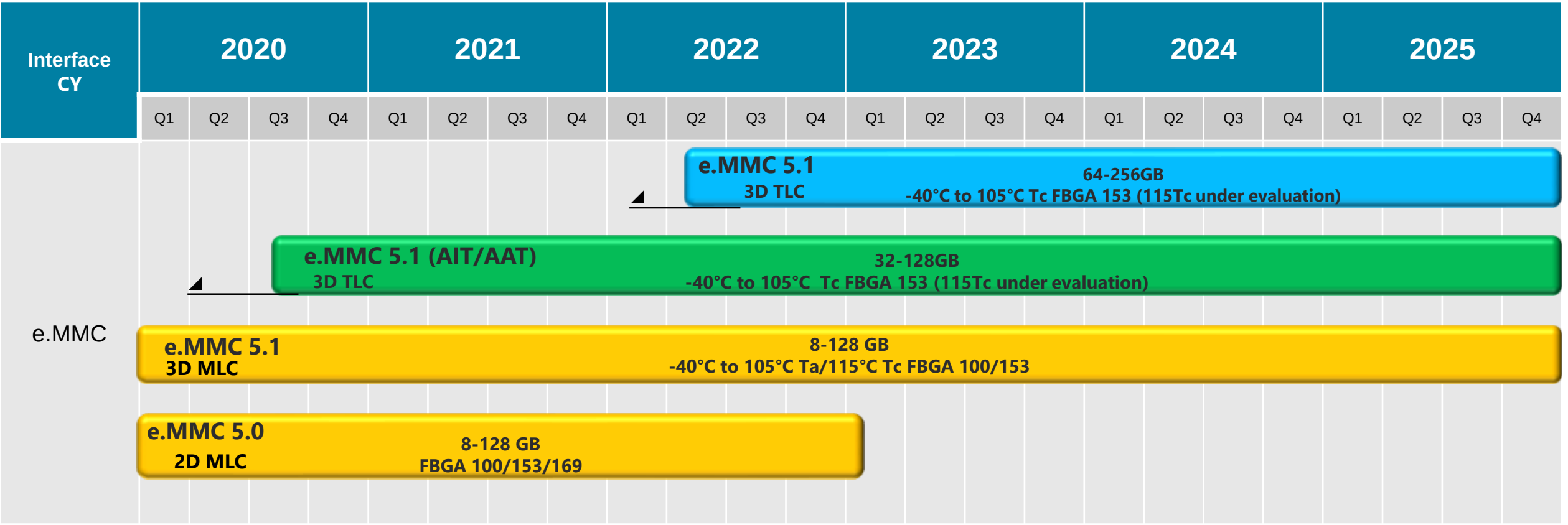
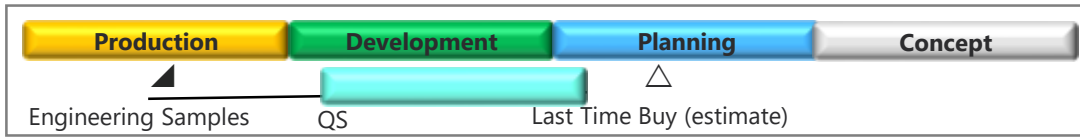
Automotive UFS Technology Road Map





Automotive eMMC Technology Road Map





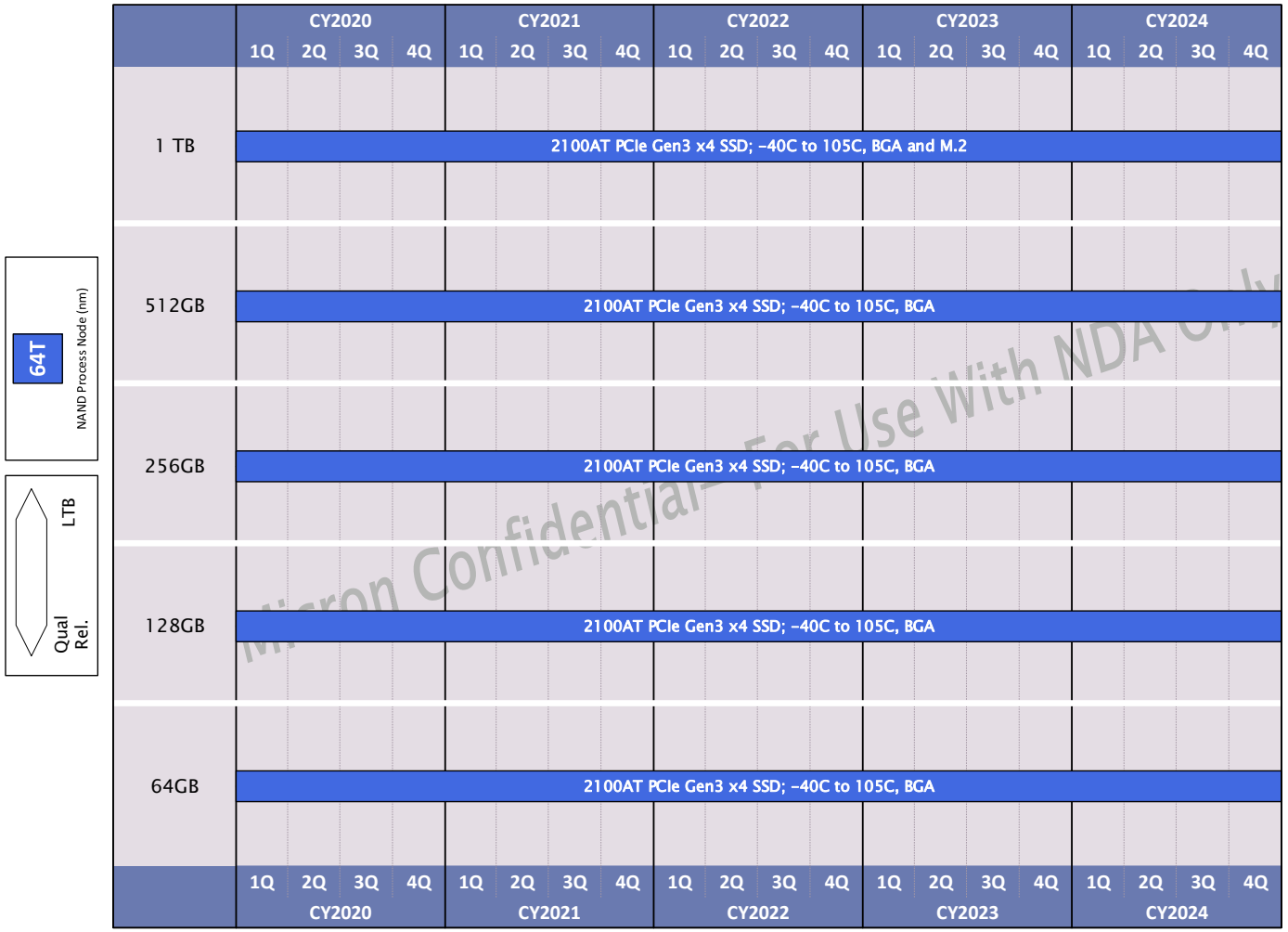
SSD Roadmap

Automotive SSD Road Map

- Dotted line indicates conceptual products; schedules and features are subject to change

EBU SSD Auto Road Map

Created: 3/30/2020



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2100AT

PCIe Gen3 x4

Operating Temperature (Tcase)
Extended AT = -40°C to +105°C

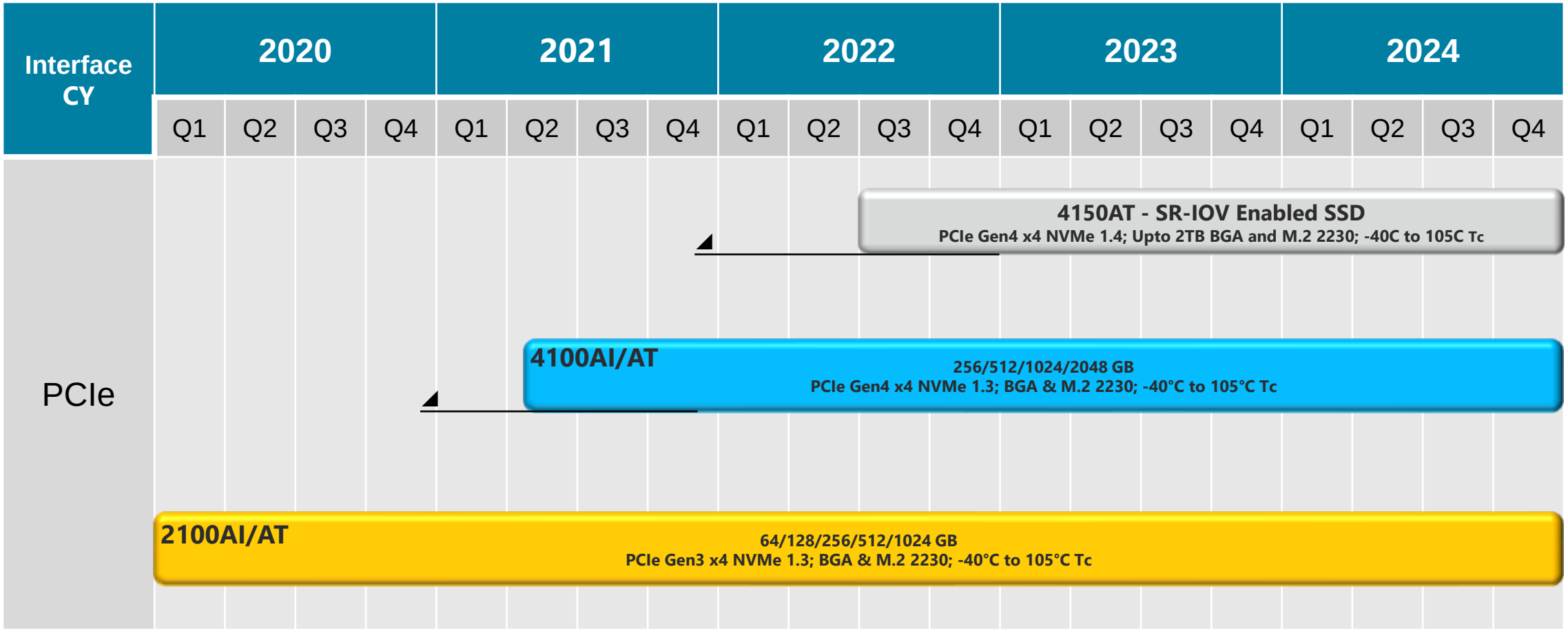
Packages
M.2 (20mmx30mm;1.6mm for 1TB from the top)
BGA (16x20x1.2mm; 1.6mm for 1TB)

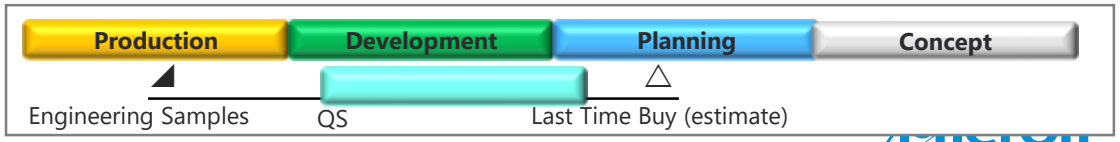
Reliability
MTTF: 3.0 M hours

TBW
64GB: 30TB
128GB: 60TB
256GB: 120TB
512GB: 240TB
1024GB: 480TB

Encryption
256-bit AES Encryption
TCG Opal 2.0

Automotive SSD Technology Road Map





SSD Form Factors

2100AT

Parameter	M.2 (PCIe)	µSSD (PCIe)
Capacities (GB)	256GB/512GB/1TB	64GB/128GB/256GB/512GB/1TB
Interface	PCIe Gen3 x4	PCIe Gen3 x4
Specification	PCIe M.2 Spec. Rev. 1.1	PCIe BGA Spec. Rev. 1.1
Dimensions	(L) 30 mm (W) 22 mm (H) 1.2 mm (from the top); 1.6 mm for 1TB	(L) 20 mm (W) 16 mm (H) 1.2 mm; 1.6 mm for 1TB
Other	M key	291 Balls

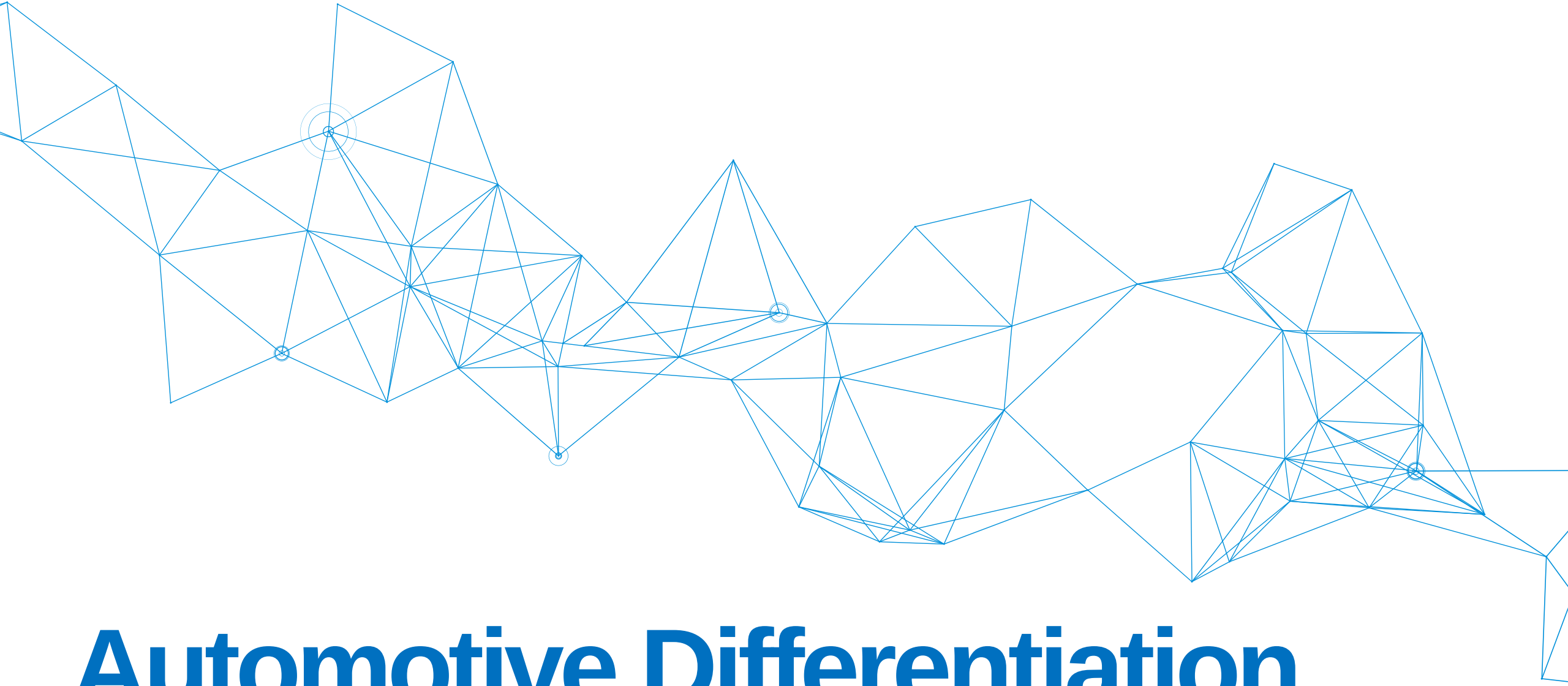
microSD Roadmap

New Product Idea

Automotive

- Investigating market potential for automotive grade microSD
- Micron 110s 3D TLC upgraded to automotive grade in CY2019
- Automotive application such as navigation, infotainment, drive recorder, dash cams
- Automotive quality and design guidelines for NVM based products. E.g. AEC-Q100
- Operating Temperature range -40°C to +105°C

Please send questions and/or interests to Jyh Chau (jchau@micron.com), memory card PLM



Automotive Differentiation

Automotive Differentiation

Industry Quality Deliverable

	-IT	-AIT/-AAT/-AUT
Temperature Range	IT = -40 to +85° C (+95C for DDR2/DDR3/DDR4)	AUT (Auto Grade 1) = -40 to +125° C AAT (Auto Grade 2) = -40 to +105° C AIT (Auto Grade-3) = -40 to +85° C
AEC-Q10x qualification	JEDEC	Yes (from 20nm DRAM, 25nm NAND, 65nm NOR (Previous technologies under gap report)) (e.MMC: Aligned to AEC-Q100 approach. Working toward full compliance to AEC-Q104)
Burn-In	Limited	Yes (BURN on all DRAM, Enhanced Test During BURN on NAND)
ISO/TS16949 certified manufacturing locations	ISO9001	Yes (according to certification roadmap)
PPAP submission	No	Yes
Fab and assembly audit support	Limited to 1 day	Full with customer requirements
Documentation support (questionnaires)	Submission of Micron‘s internal qualification and reliability report under NDA	Full questionnaire support

Automotive Differentiation

Customer Quality Agreements

	-IT	-AIT/-AAT/-AUT
Quality Agreements	Non-automotive grade parts excluded from any quality agreement	Can be negotiated.
Failure analysis response time	Target 14 calendar days (e.MMC 28 calendar days) * No interim reports ** see level of problem solving	1-2-14 calendar rule (e.MMC 28 calendar days)
Problem solving	Technical report with electrical failure analysis	8D full methodology for each failure
Containment Action	For excursions only	Yes
Corrective Action / Preventive Actions	Epidemic failures only	Yes, for each failure
Joint robust validation activities	No	Yes

Automotive Differentiation

Customer Business Support

	-IT	-AIT/-AAT/-AUT
Liability	Replacement only	Per agreed contract
PCN/PTN according to JEDEC	Yes (JESD46c/48a)	Yes (JESD46c/48a)
PTN for PLP products*	No	12 months + 12 months
Legacy Fab strategy Product in PLP	No	Yes
Supply prioritization	No	Yes
Buffer stock / CMI / VMI	No	Can be negotiated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