Introducing ARM® Cortex®-M7

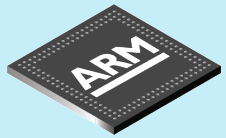
Bringing high performance to the Cortex-M processor series

Jon Taylor
CPU Product Marketing

ARM® Cortex® Processors across the Embedded Market

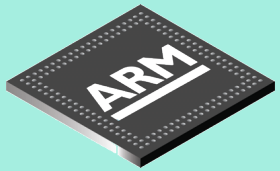
Cortex®-M processors

MCU + DSP



Smallest footprint / lowest power

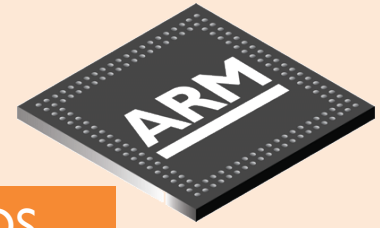
Cortex®-R processors



RTOS

Highest performance / real-time

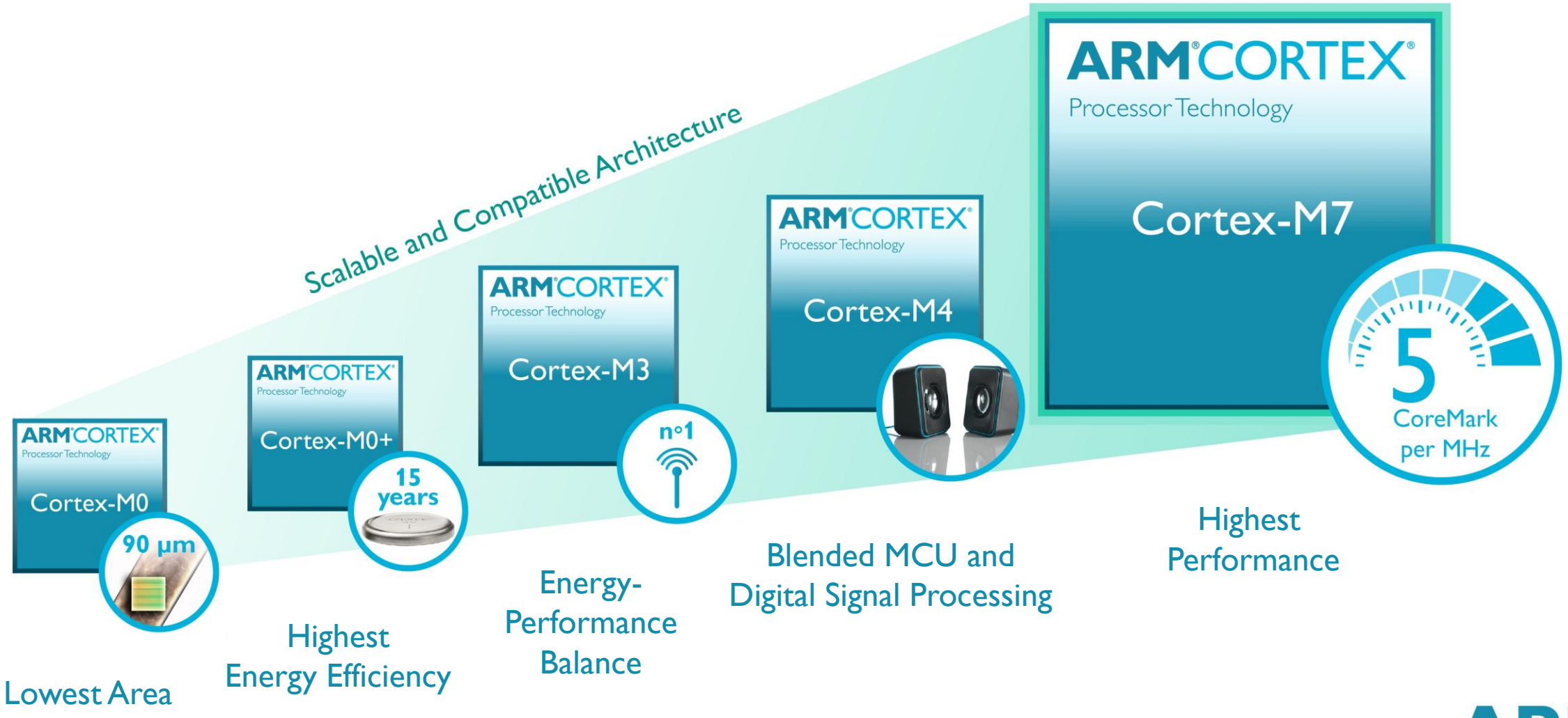
Cortex®-A processors



Rich OS

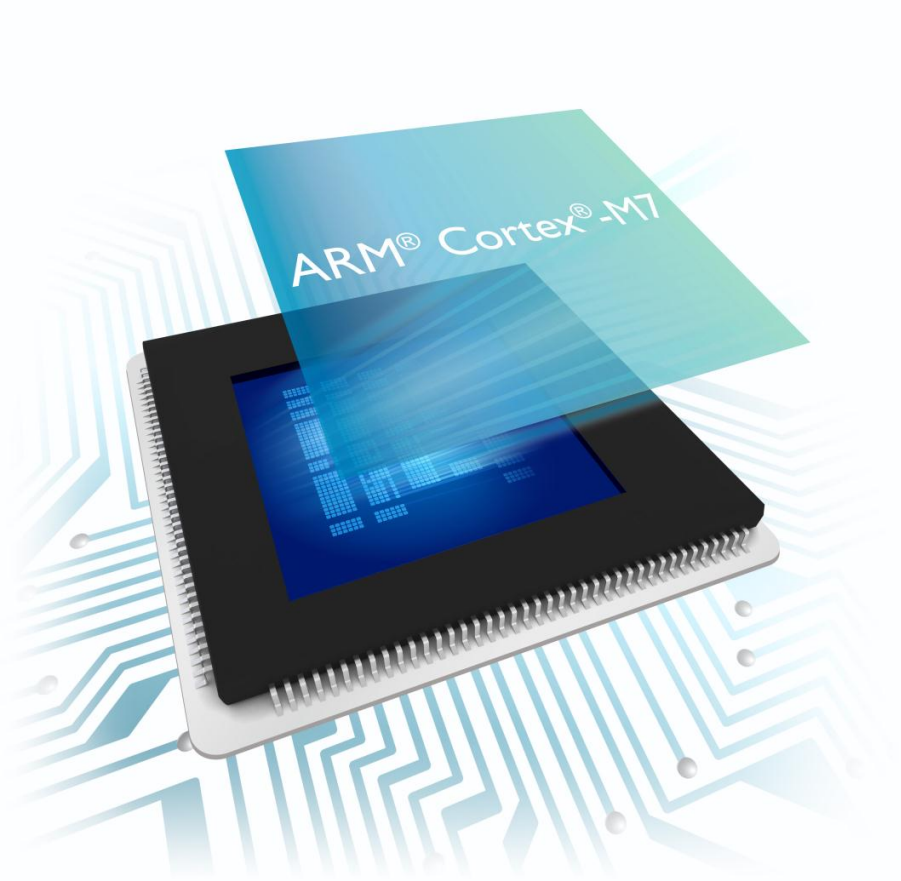
Highest performance

Taking the Cortex®-M Series to the Next Level



Cortex-M7 Overview

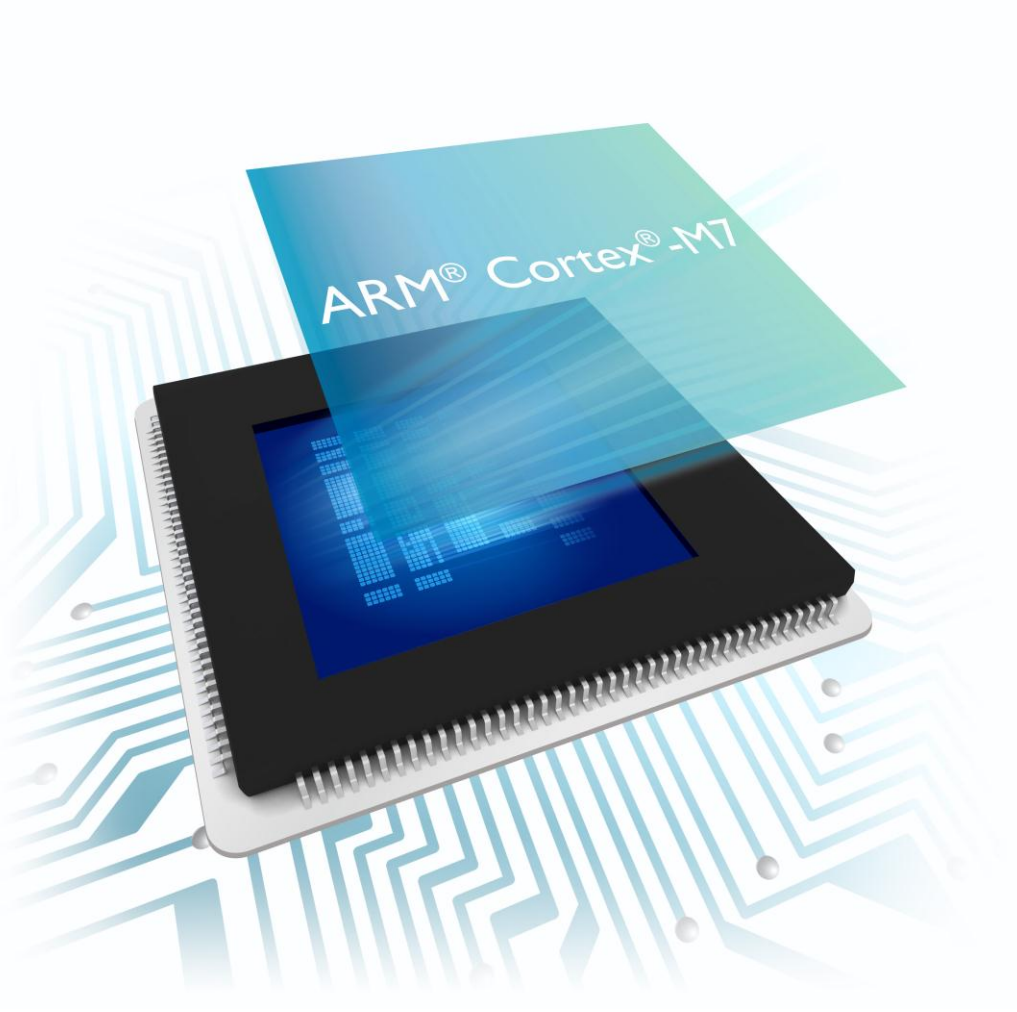
- Performance
  - Achieving 5 CoreMark/MHz – 2000 CoreMark* in 40LP
  - Typical 2x DSP performance of Cortex-M4
- Versatility
  - Highly flexible system and memory interfaces
  - Designed for functional safety implementations
- Scalability and compatibility
  - Enables simple migration from any Cortex-M processor
  - Widest third-party tools, RTOS, middleware support



* CoreMark 1.0 : IAR Embedded Workbench v7.30.1 --endian=little --cpu=Cortex-M7 -e -Ohs --use_c++_inline --no_size_constraints / Code in TCM - Data in TCM

ARM

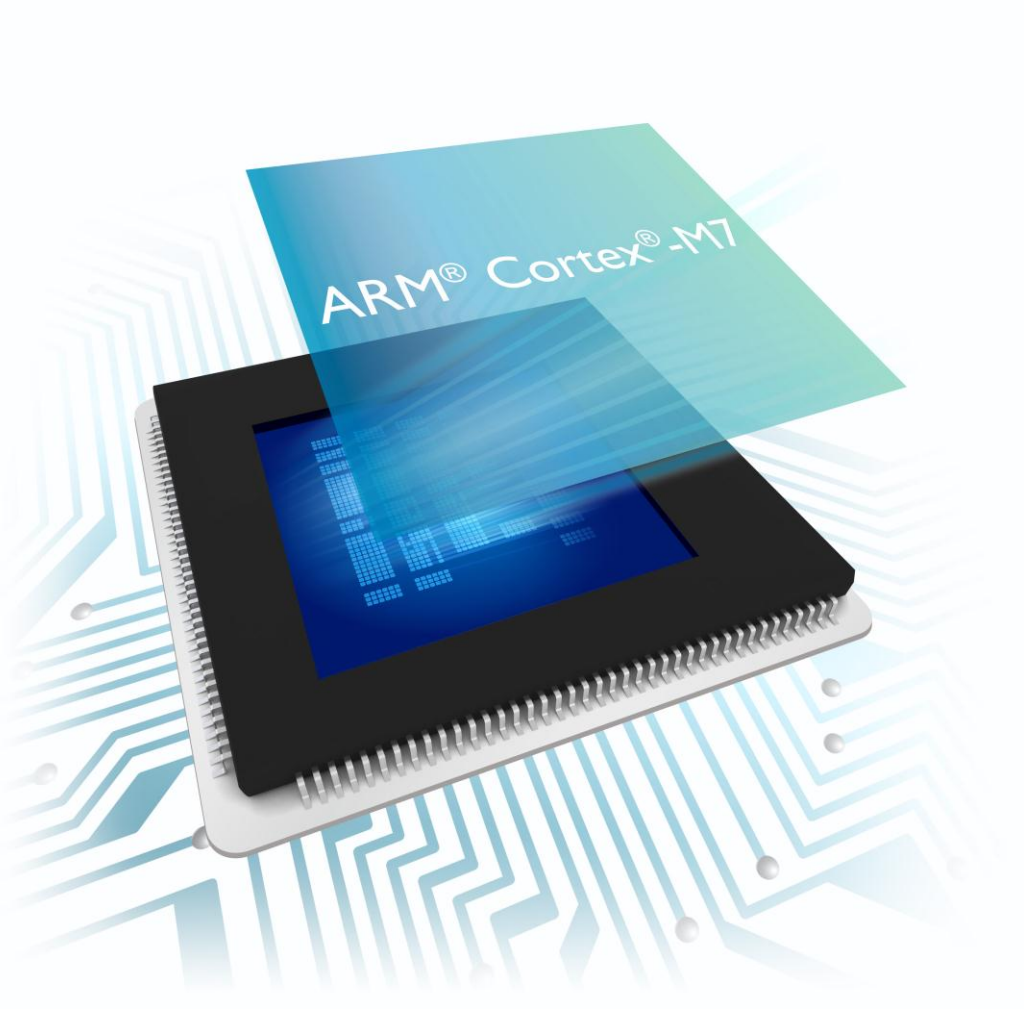
Key Features (1)



- **High-performance processor with DSP capabilities**
  - Six-stage superscalar pipeline
  - Powerful DSP instructions and SP/DP Floating Point
  - **Best-in-class core for high-end MCU or replace MCU+DSP with Cortex-M7**
- **Flexible, memory system**
  - Tightly-coupled memories for real-time determinism
  - 64-bit AXI AMBA4 memory interface with I-cache and D-cache for efficient access to external resources
  - **Build powerful MCU with more memories and powerful peripherals**

ARM

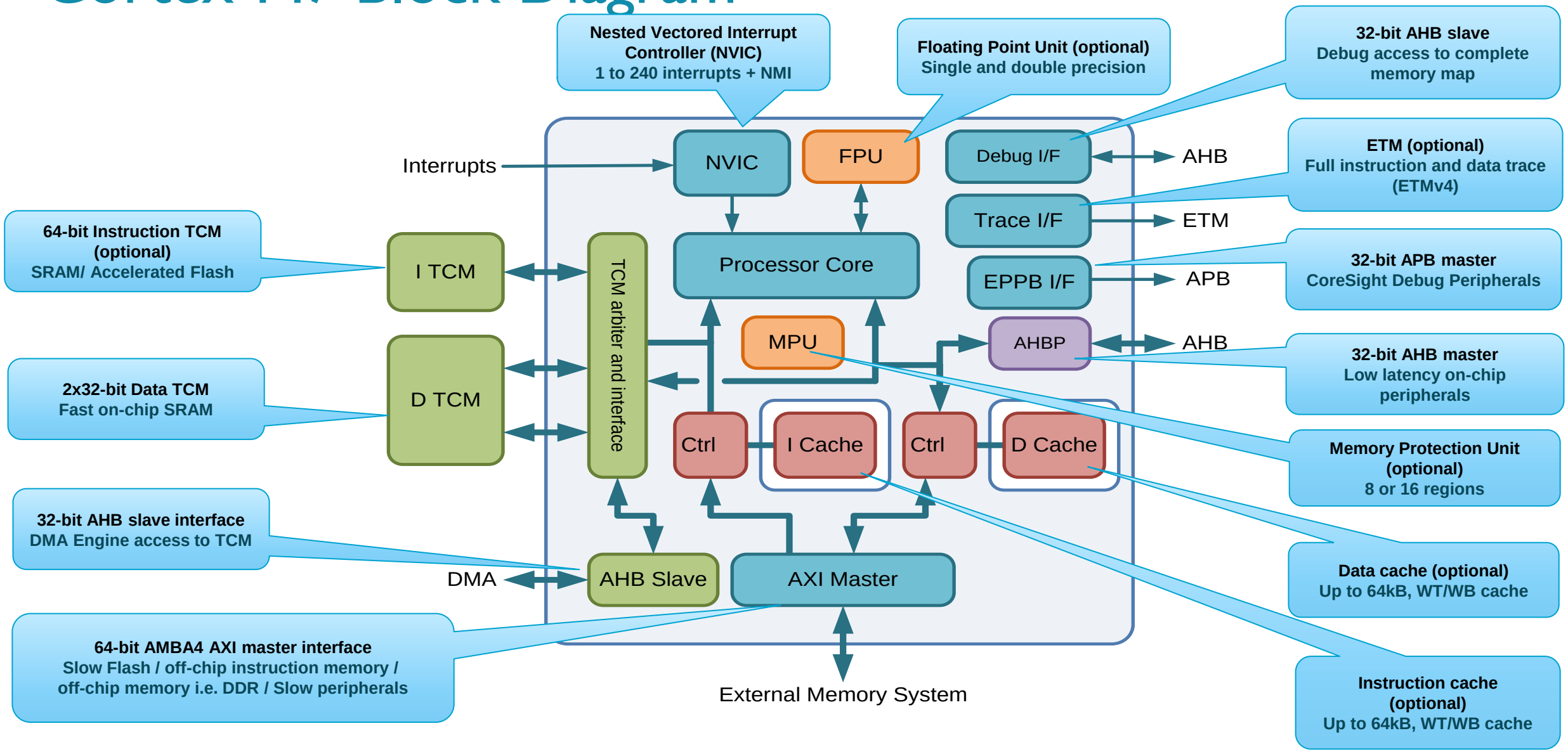
Key Features (2)



- **ARMv7-M architecture**
  - 100% binary forwards compatibility from Cortex-M4
  - Key Cortex-M family processor characteristics of ease-of-use and excellent interrupt latency
  - **Reuse code and system design from existing products**
- **Safety features**
  - Memory ECC (SEC-DED), MPU, MBIST, lock-step operation, full data trace, safety manual
  - **Enables entry into safety-critical markets.**

ARM

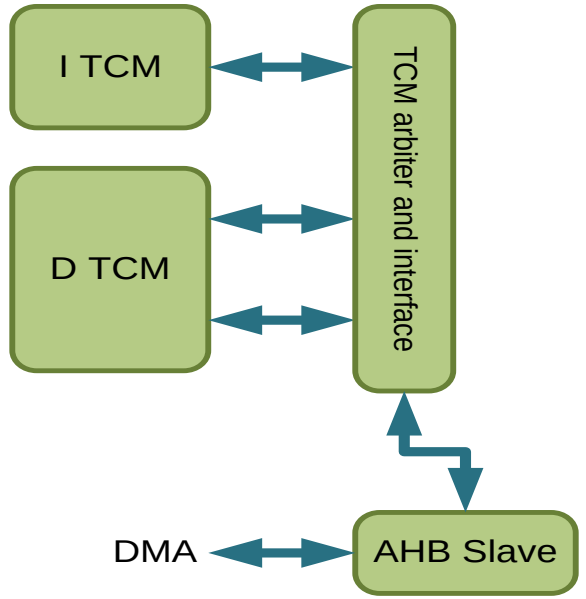
Cortex-M7 Block Diagram



ARM

Tightly Coupled Memory (TCM)

- All TCMs:
  - Support wait-states
  - Can be used at boot-up time
  - Support up to 16MB of memory
- Provide deterministic performance
  - Dedicated store buffering
- Instruction TCM (ITCM)
  - 64-bit interface
- Data TCM (DTCM)
  - 2 X 32-bit interface: D0TCM and D1TCM, SSRAM protocol to enable direct integration with memories
  - Supports dual-issue of loads when bit[2] of address is different



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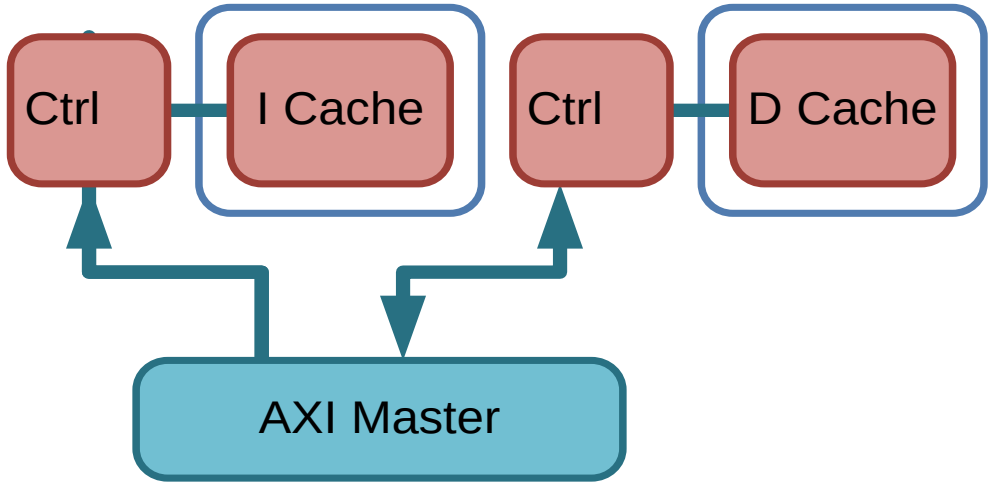
Caches - Overview

- Harvard arrangement for optimum performance
- I-cache 2-way associative, D-cache 4-way associative, pseudo-random replacement policy
- I and D both optional, configurable sizes (4kB – 64kB each)
- Extensions defined for the ARMv7-M system architecture
  - Addition of cache maintenance operations
- Full support for the following attributes
  - Write Through, no write allocate (WT)
  - Write-back, no write allocate (WBRA)
  - Write-back, write allocate (WBWA)



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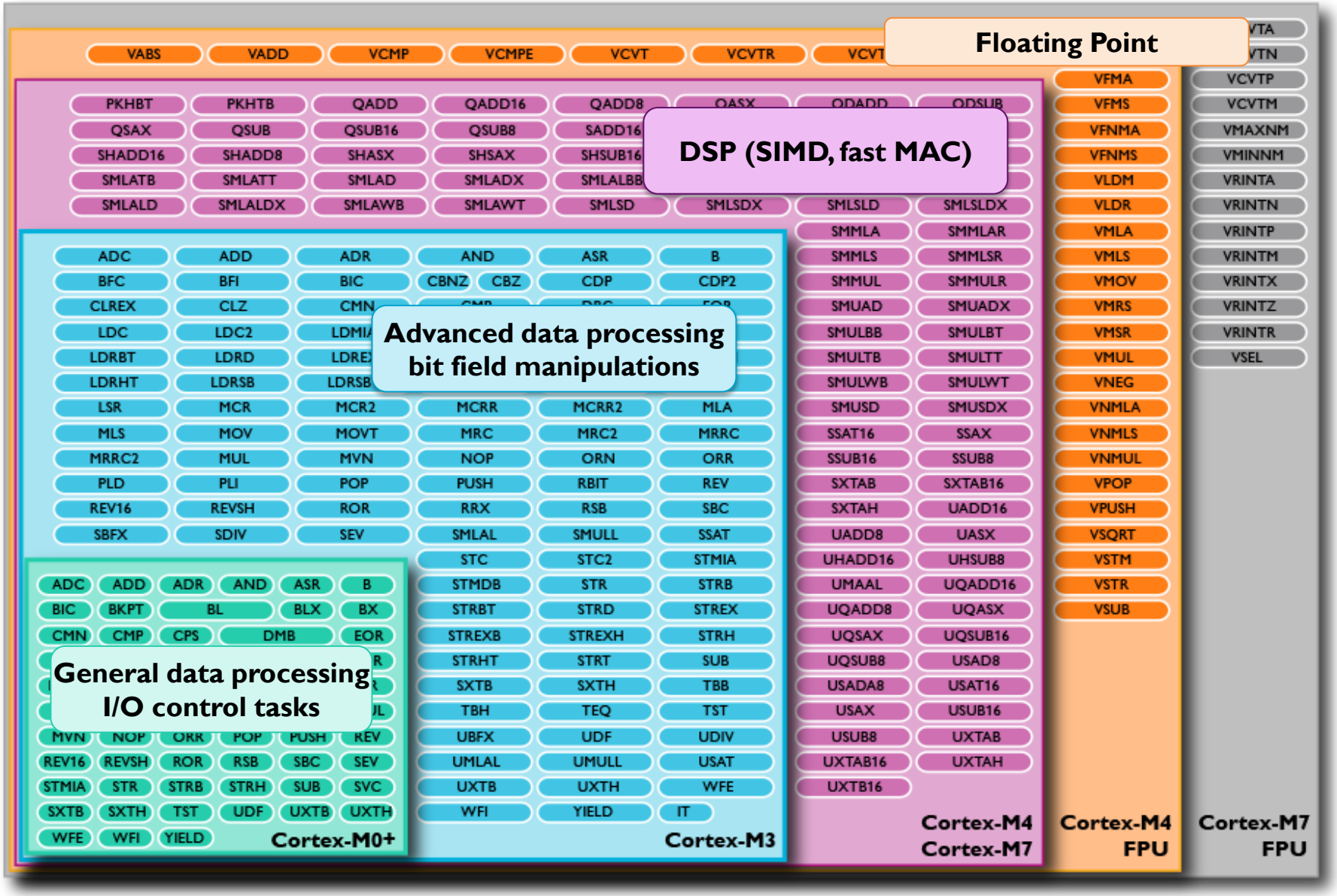
Powerful & Scalable Instruction Set



- Cortex-M7 has the same powerful instruction set as Cortex-M4:

- Integer MAC instructions are all single-cycle
- SIMD instructions can work on 8-/16-bit quantities packed in to a 32-bit word
- Arithmetic can be signed/unsigned, saturating/non-saturating
- A few new FP instructions for FPv5

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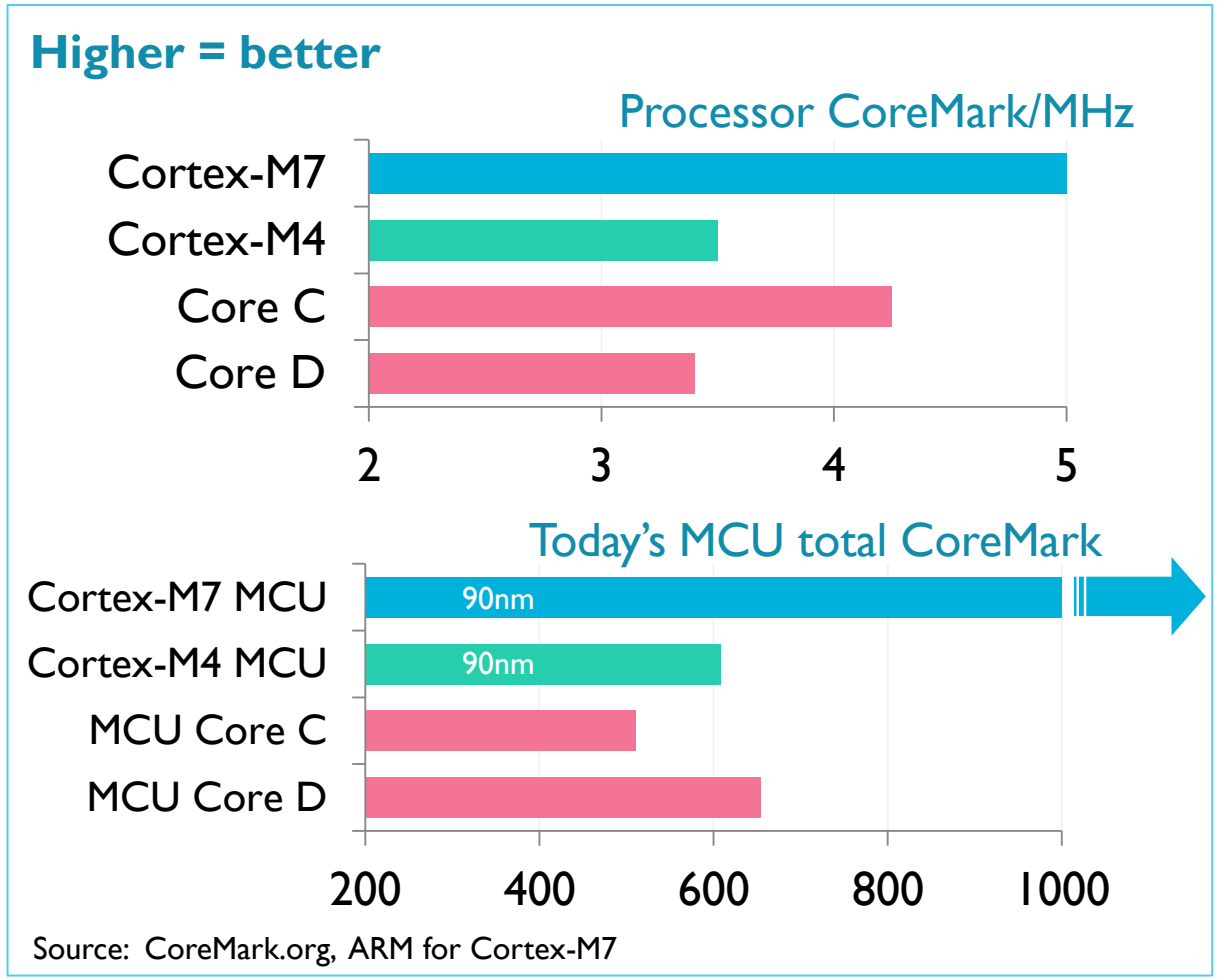
ARM Cortex-M7: Built for Performance

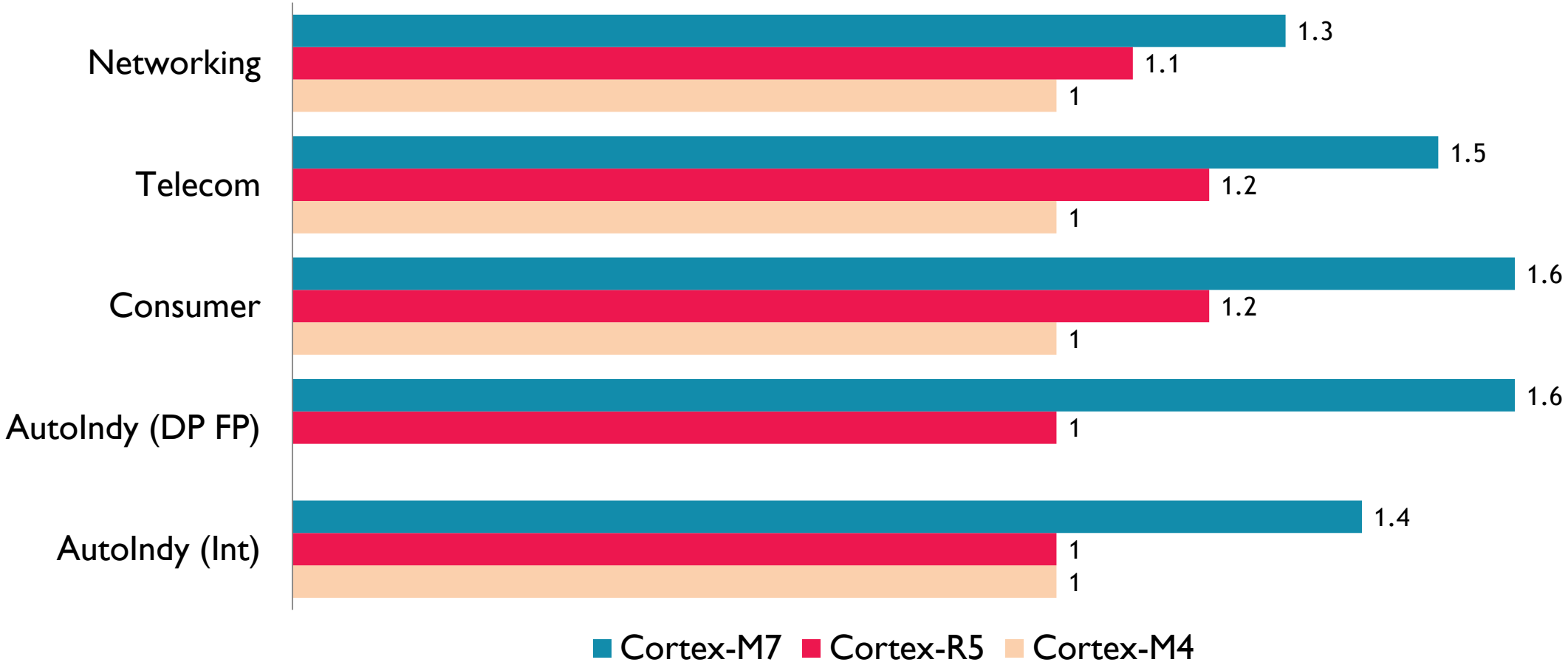
- Fast compute for demanding embedded applications
  - Six-stage superscalar pipeline with branch prediction
  - Single and double precision floating point unit
- Flexible memory system
  - 64-bit AXI AMBA4 interconnect
  - I-cache and D-cache for efficient memory operation
- Ultra-fast responsiveness for control
  - 12 cycles interrupt latency
  - Tightly coupled memories for real-time determinism

Highest core performance combined with the efficiency of Cortex-M



EEMBC IPC Comparison

- Results are geo-mean of EEMBC IPC relative to baseline (quantified as '1')
- Measured on comparable memory systems (in this case, WB caches on Cortex-M7)



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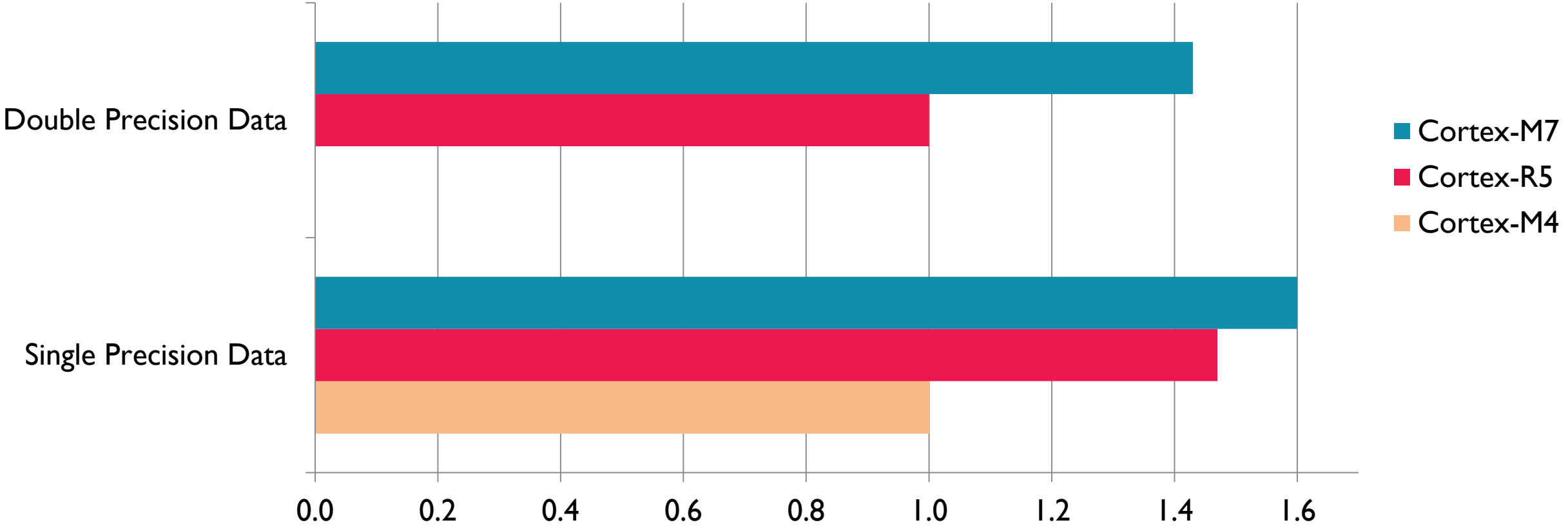
FP Benchmarking Status

- Cortex-M7 floating point performance relative to Cortex-R5 and Cortex-M4 processors



Assumes all processors running at the same clock frequency
Based on EEMBC FPMark benchmarks using 'small' data-sets
Performance relative to Cortex-R5 in the same system
Benchmarks compiled with ARM tool-chain (v5.04)`

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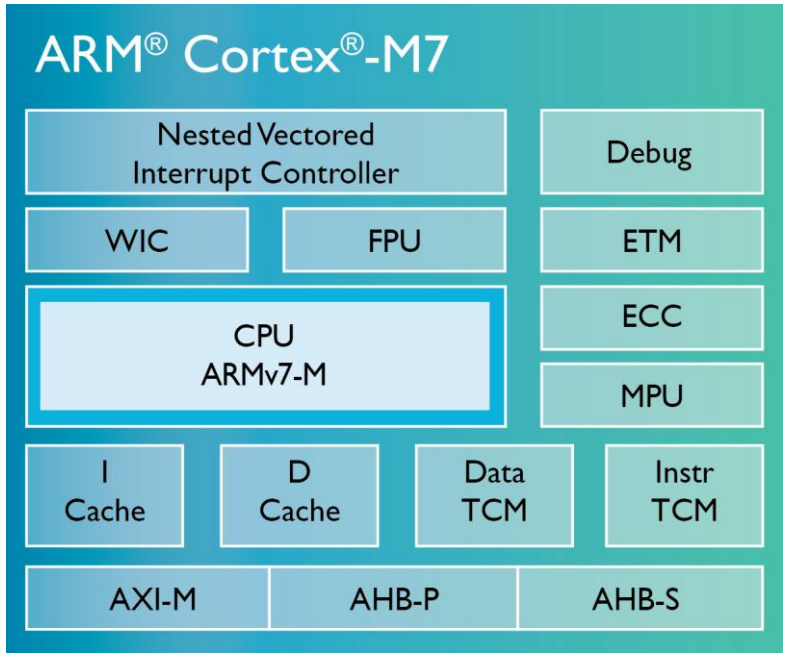
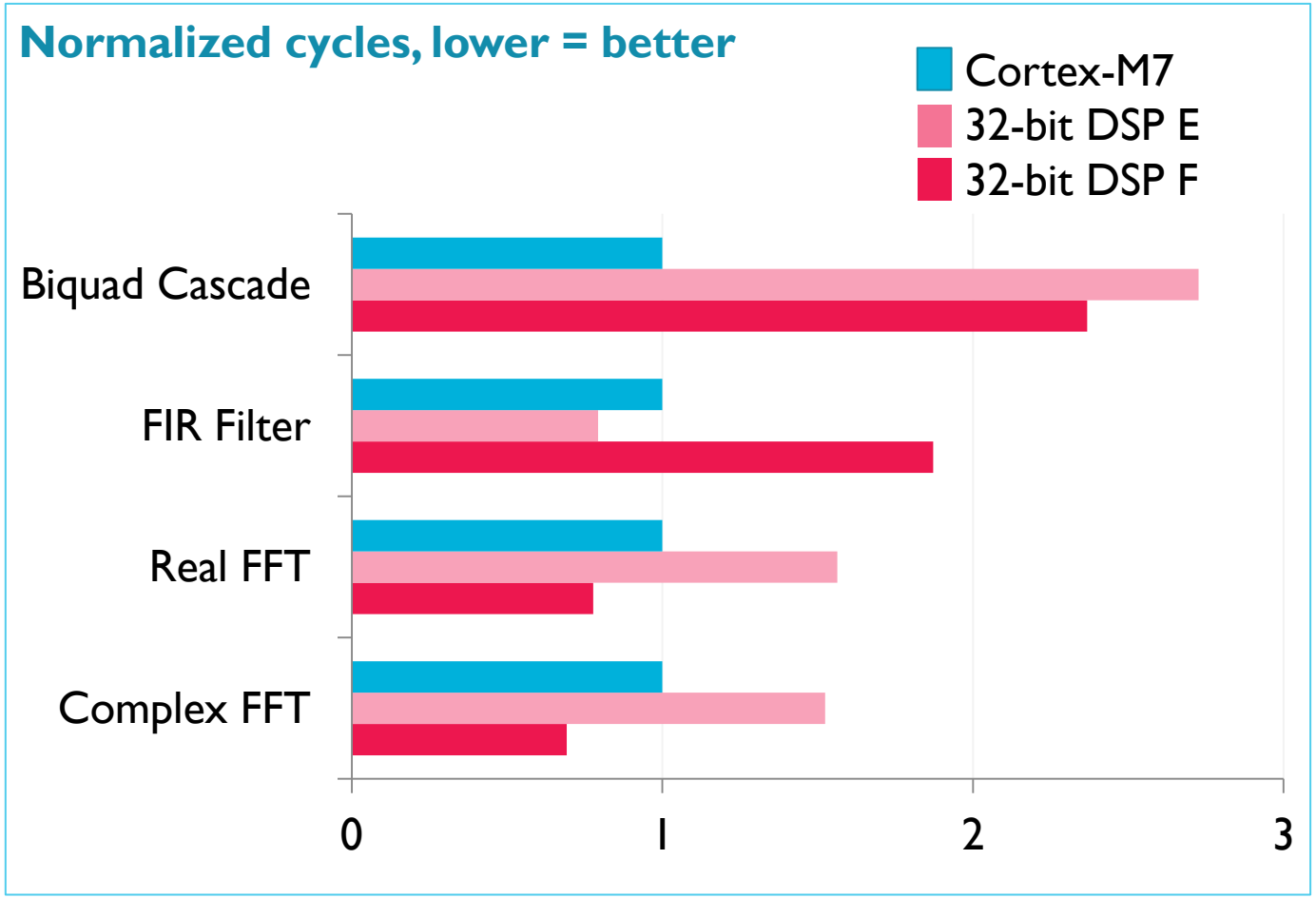
Cortex-M7: Competitive with Popular DSPs

- Essential DSP features
  - Parallel execution of loads, stores and MAC
  - SIMD support, single-cycle MAC
  - Single and double precision floating point unit
  - Minimal loop overhead (branch predictor/BTAC)
  - Optimised DSP libraries



Consistently good performance across key DSP functions



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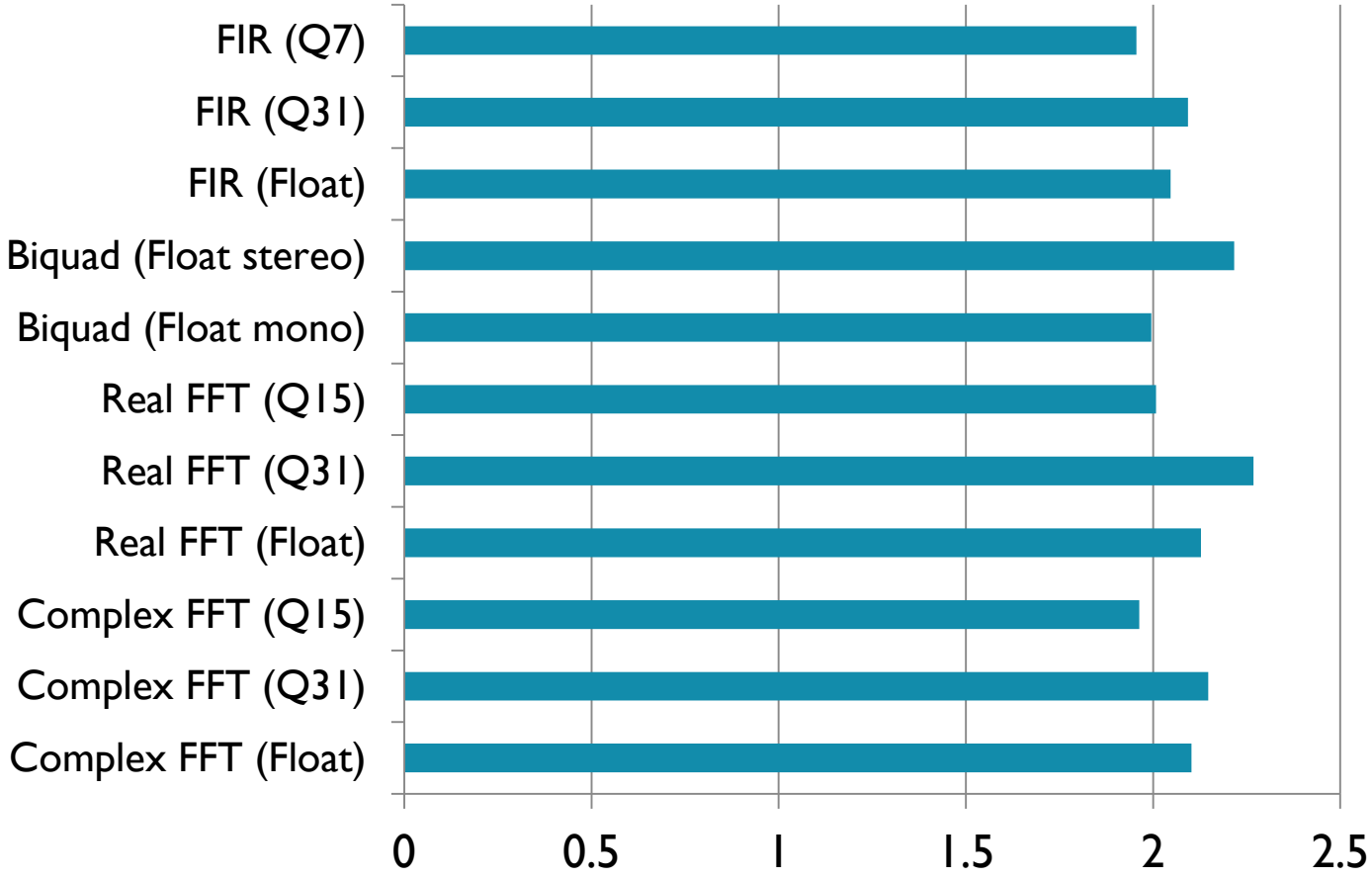
2x Performance Improvement over the Cortex-M4



- Measurements using the CMSIS DSP Library
- Available free of charge from ARM
- Now optimized for the Cortex-M7

CMSIS COMPLIANT
ARM® Cortex™ Microcontroller Software Interface Standard

Note: combines architectural improvements with expected core clock increase.
The code was compiled using the ARM C Compiler (armcc) 5.04
Comparison was made on an FPGA on a Versatile Express motherboard

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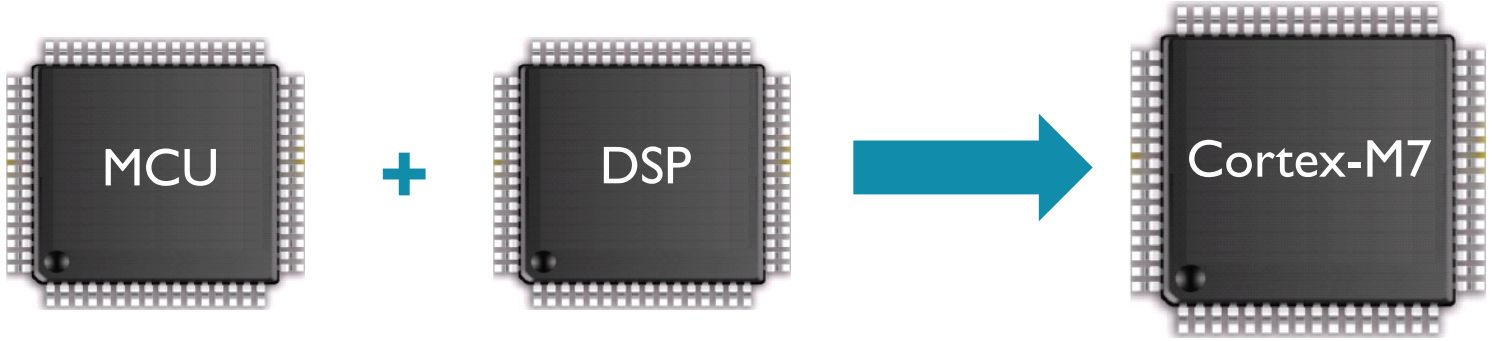
Cortex-M7 – Replacement for MCU+DSP



- **Trends:**
  - Convergence of MCU+DSP to DSC for cost reduction
  - Increased processing demands
  - Increasing consumer expectation of quality in portable devices
- **Example applications:**
  - Multi-channel audio / Dolby audio
  - Advanced motor control
  - Factory automation
  - Automotive
  - Image processing
  - Power conversions

Cortex-M7 Advantages:

- High performance core with fast DSP
- Compatibility with existing Cortex-M4 designs
- Flexible memory system

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Cortex-M7 Safety Features

- Cortex-M7 specific
  - Cache ECC
  - Dual core lock-step with delay
  - External TCM ECC interface
  - On-line MBIST interface
- ARMv7-M architecture based
  - Memory protection unit (MPU)
  - Exception logic

- These features will be included in the Cortex-M7 Safety Documentation Package:
  - Safety Manual
  - FMEA Report
  - Development Interface Report

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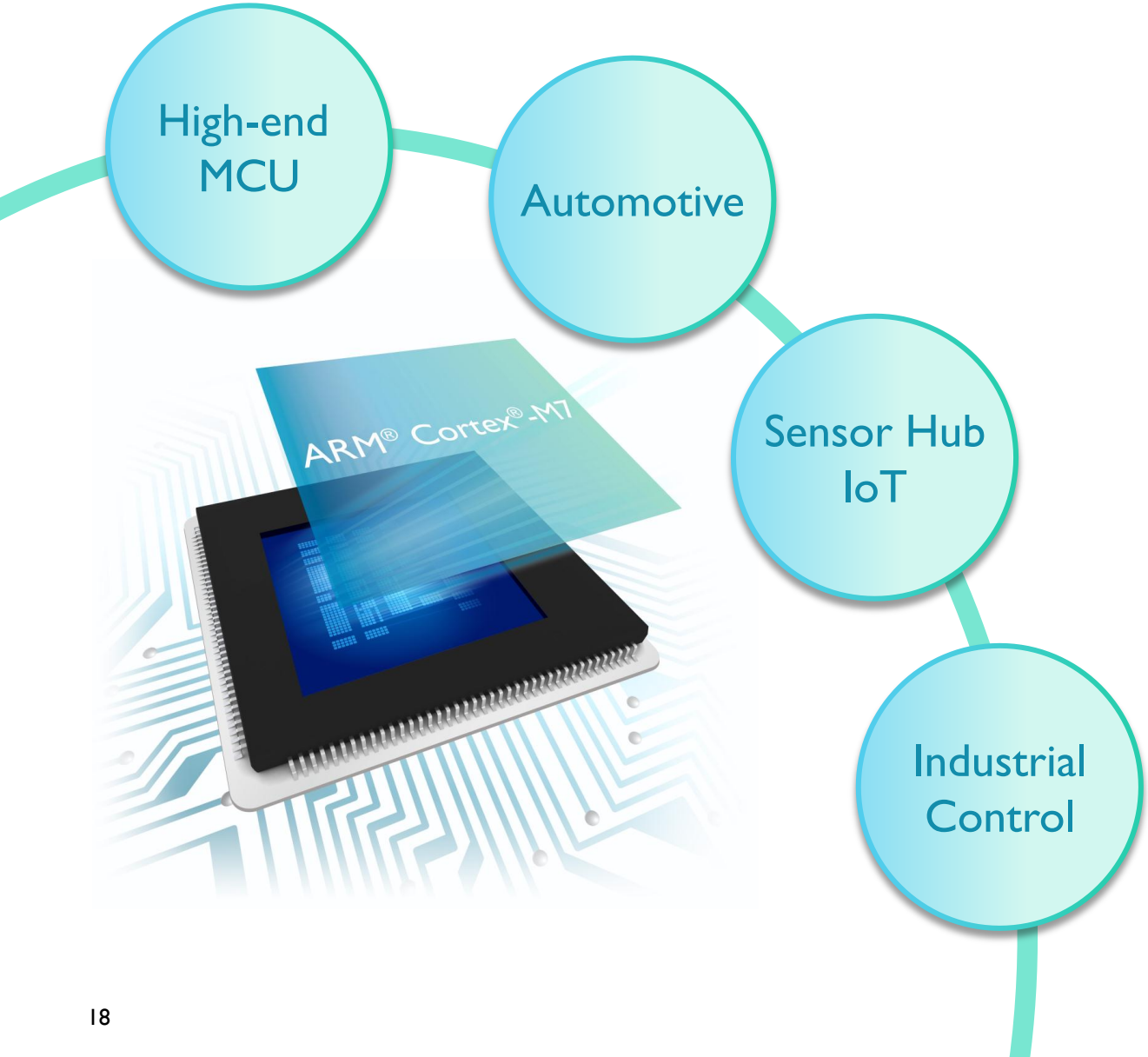
Cortex-M7 Target Applications



- Powerful processor for advanced audio/visual sensor hub processing
- Power-efficient local processor for IoT devices such as an edge router
- Flexible and reliable processor for industrial and motor control

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Enabling Smarter Systems Without the Complexity

2x More performance delivering enhanced functionality

- More displays
- More motors
- Advanced touch sensing
- Multiple connectivity options
- Enhanced voice controls

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Enabling More Capabilities for Feature-Rich Devices

2x More performance delivering improved flight management

Cortex-M7
400 MHz

Cortex-M4
168 MHz

Source: 3DRobotics, PX4 autopilot ETH Zurich

- Finer degree of control
- Accurate speed measurement
- Finer GPS accuracy
- Secure telemetry radio

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Helping Drive Richer Audio Experiences

2x More performance delivering advanced sound processing

Cortex-M7

DOLBY AUDIO Dolby Digital Plus (with post processing) 160 MHz

7.1 Multi-channel audio support

More speaker EQ processing

Capacity for decoders

More connectivity options

Cortex-M4
130 MHz

DOLBY AUDIO Dolby Digital

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Cortex-M7 in Automotive

- **Trends and challenges:**
  - Safety certification mandated in more regions
  - Convergence of functionality into fewer MCUs/ASSPs
  - Increasing user requirements and expectations

- **Typical Applications**
  - Dashboard in medium-range cars
  - Voice recognition
    (for multimedia control functions)
  - Character recognition (eg Kanji)
  - Comfort and convenience features
  - Chassis, electric power steering, steer-by-wire
  - Automotive audio

Cortex-M7 Advantages:

- High performance core with fast DSP
- Safety features built in and safety manual
- Determinism with high performance
- Full trace via ETM

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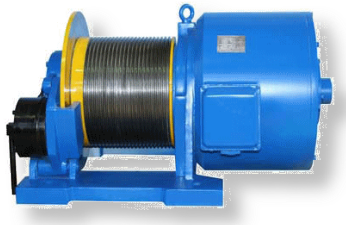
Cortex-M7 in Industrial Control

- **Trends and challenges**
  - High performance control functions
  - Safety, reliability and conformance will become mandatory
  - 80-90% of cost is software, Cortex-M offers scalability and protects software investment
- **Typical applications:**
  - Factory Automation
    - Inverters, Servos
    - Programmable Logic Controllers
    - High-speed comms
  - Intelligent motor control



Cortex-M7 Advantages:

- Increased DSP performance for control functions
- Safety features built-in
- In-order pipeline gives performance with predictability
- TCMs and low interrupt latency: Interrupt response within 100ns required
- Scalability from Cortex-M3 through Cortex-M7 up to Cortex-A53

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Cortex-M7: Harnessing the Cortex-M Ecosystem

> "With support for the new Cortex-M7 processor, we are further strengthening our leading market position by delivering development tools for ARM with an outstanding benchmark score of 5.04 CoreMark/MHz"
>
> - Stefan Skarin, IAR Systems

> "Our robust embedded software components are designed to be used in high performance applications targeted by Cortex-M7, including industrial control, safety and IoT"
>
> - Jean Labrosse, Micrium

> "ARM Cortex-M7 will bring substantially more computing power to embedded applications, and SEGGER will continue to innovate new products and features for each new generation of ARM processors"
>
> - Rolf Segger, SEGGER

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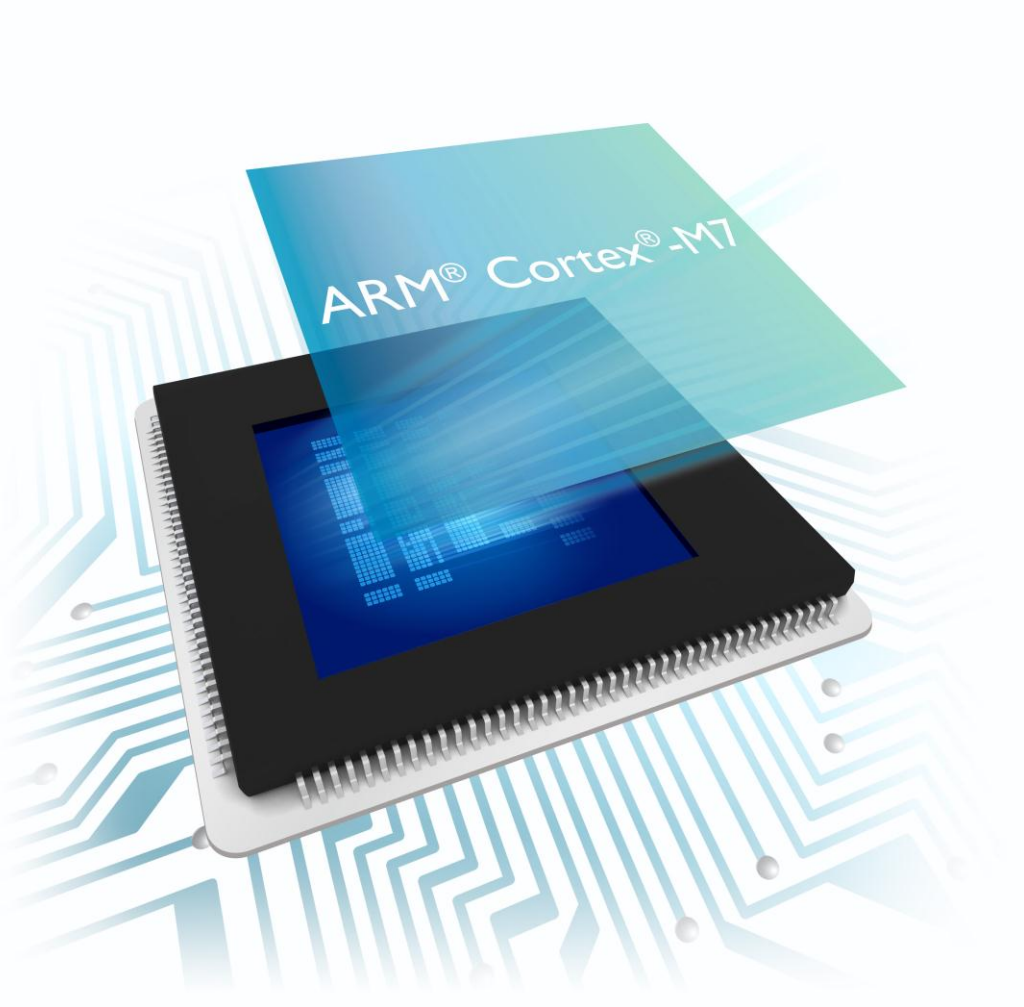
Cortex-M7 Lead Partners

"The Cortex-M7 is well positioned between Atmel's Cortex-M based MCUs and Cortex-A based MPUs enabling Atmel to offer an even greater range of processing solutions. Customers using the Cortex-M based MCU will be able to scale up performance and system functionality, while keeping the Cortex-M class ease-of-use and maximizing software reuse. We see the ARM Cortex-M7 addressing high-growth markets like IoT and wearables, as well as automotive and industrial applications that can leverage its performance and power efficiency" – Reza Kazerounian, Atmel

"Freescale Cortex-M7-based solutions dramatically extend MCU performance, opening new opportunities for our business. Our solutions will enable significant innovation and system-level efficiency in areas such as motor control, industrial automation and power conversion. These are rapidly growing markets where the high performance of the Cortex-M7 core eliminates the need for additional DSPs and microcontrollers" - Geoff Lees, Freescale

"Offering customers more intelligence and processing power on our STM32 microcontrollers is a major objective for ST, and the Cortex-M7 delivers that impressively. The Cortex-M7 core supports upwardly-scalable compatibility with our existing wide range of 500 Cortex-M STM32 microcontrollers, associated tools and software ecosystem, allowing developers to rapidly adopt our next-generation STM32 Cortex-M7-based MCUs" - Daniel Colonna, STMicroelectronics



Supercharge Cortex-M based solutions

Develop versatile, scalable solutions

Address safety critical applications

Harness the broadest ecosystem

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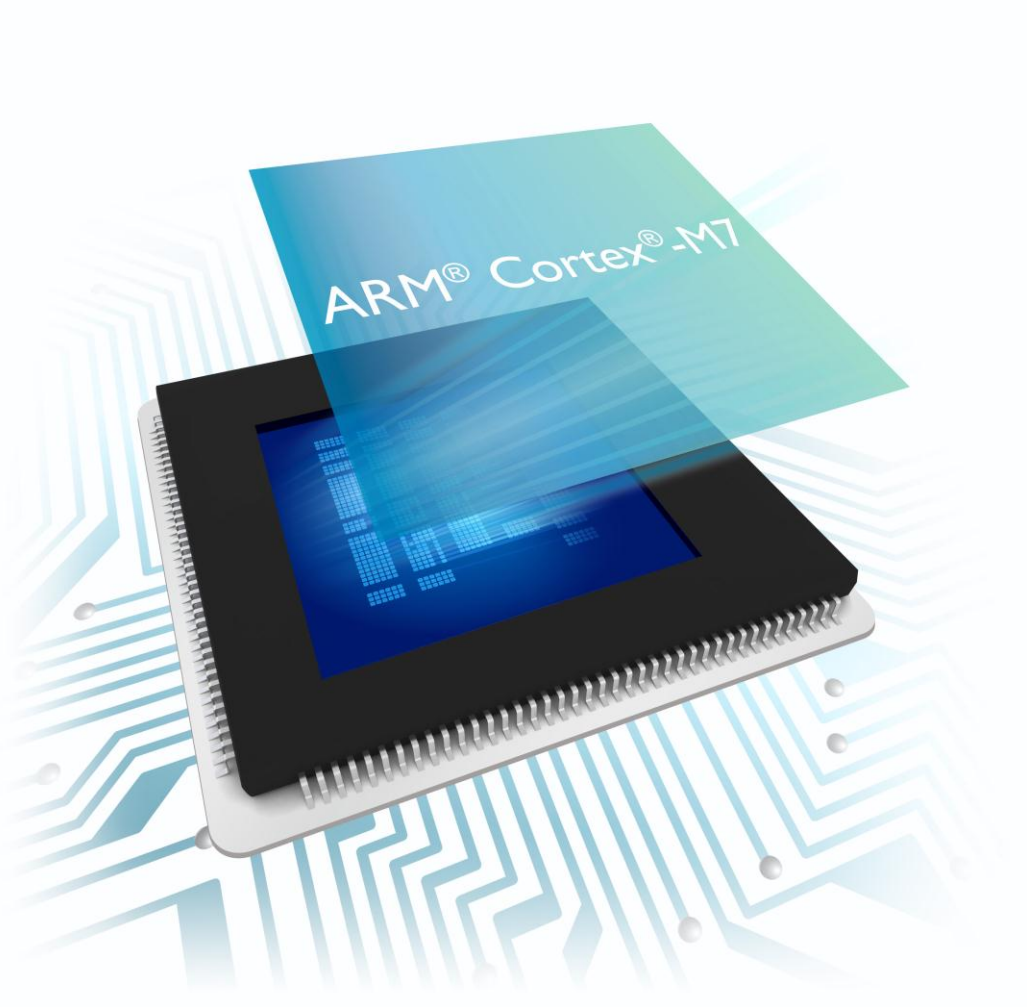

Thank You!

ARM