FTF FREESCALE TECHNOLOGY FORUM 2015

From Head to Sole – Freescale Solutions for the **Wearables Market**

FTF-HCW-F1122

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J U N E . 2 0 1 5

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External Use

Agenda

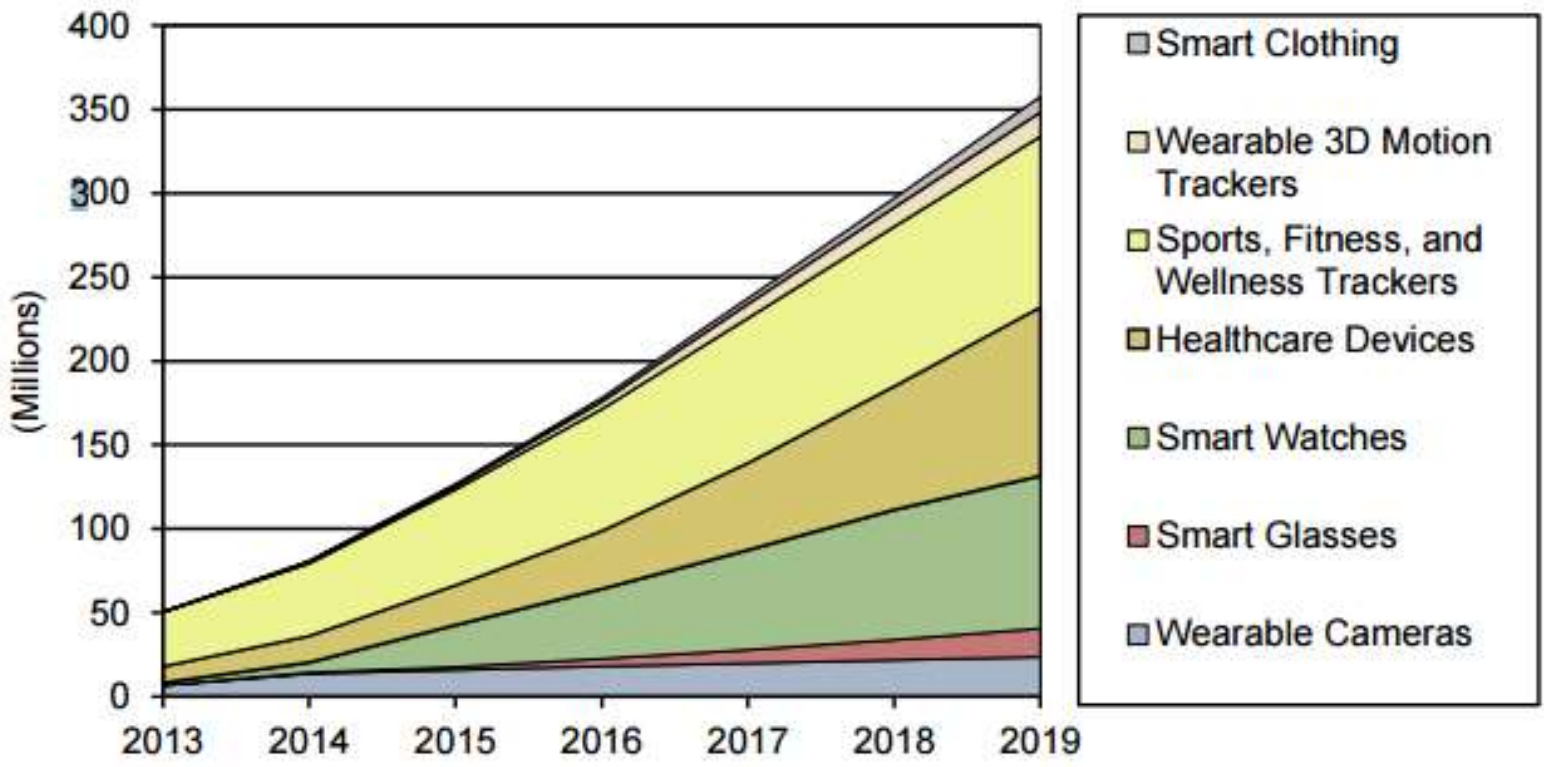
- Diverse Usage Models of Wearable Tech
- Freescale Product Offerings to Address Wearables
- Overview of the Challenges of Wearable Design
- Freescale and Partner Hardware Designs
- SW Development Environment
  - Kinetis MCUs
  - i.MX applications processors
- Resource Summary

Diverse Usage Models of Wearable Tech

Wearable Market Forecast: Why Are We Here?

By 2019

- 455M devices generating $46.5B
- Healthcare devices biggest category 121 M units
- Smartwatches generate the most revenue, $21B



Sources: ABI Research, Credit Suisse Equity Research

Wearables… One Size Does Not Fit All

Wearables…A Diverse Market

Vertical	Categories
Fitness & Wellness	**Sports & Heart Rate Monitors** **Pedometers, Activity Monitors** Smart Sport Glasses Smart Clothing **Sleep Monitors** Emotional Measurements
Healthcare & Medical	CGM (Continuous Glucose Monitoring) **ECG Monitoring** **Pulse Oximetry** **Blood Pressure Monitors** Drug Delivery (Insulin Pumps) Wearable Patches (ECG, HRM, SpO2)
Infotainment	**Smart Watches** Augmented Reality Headsets **Smart Glasses** Wearable Imaging Devices
Industrial & Military	Hand-worn Terminals Augmented Reality Headsets **Smart Clothing**

Data Collection

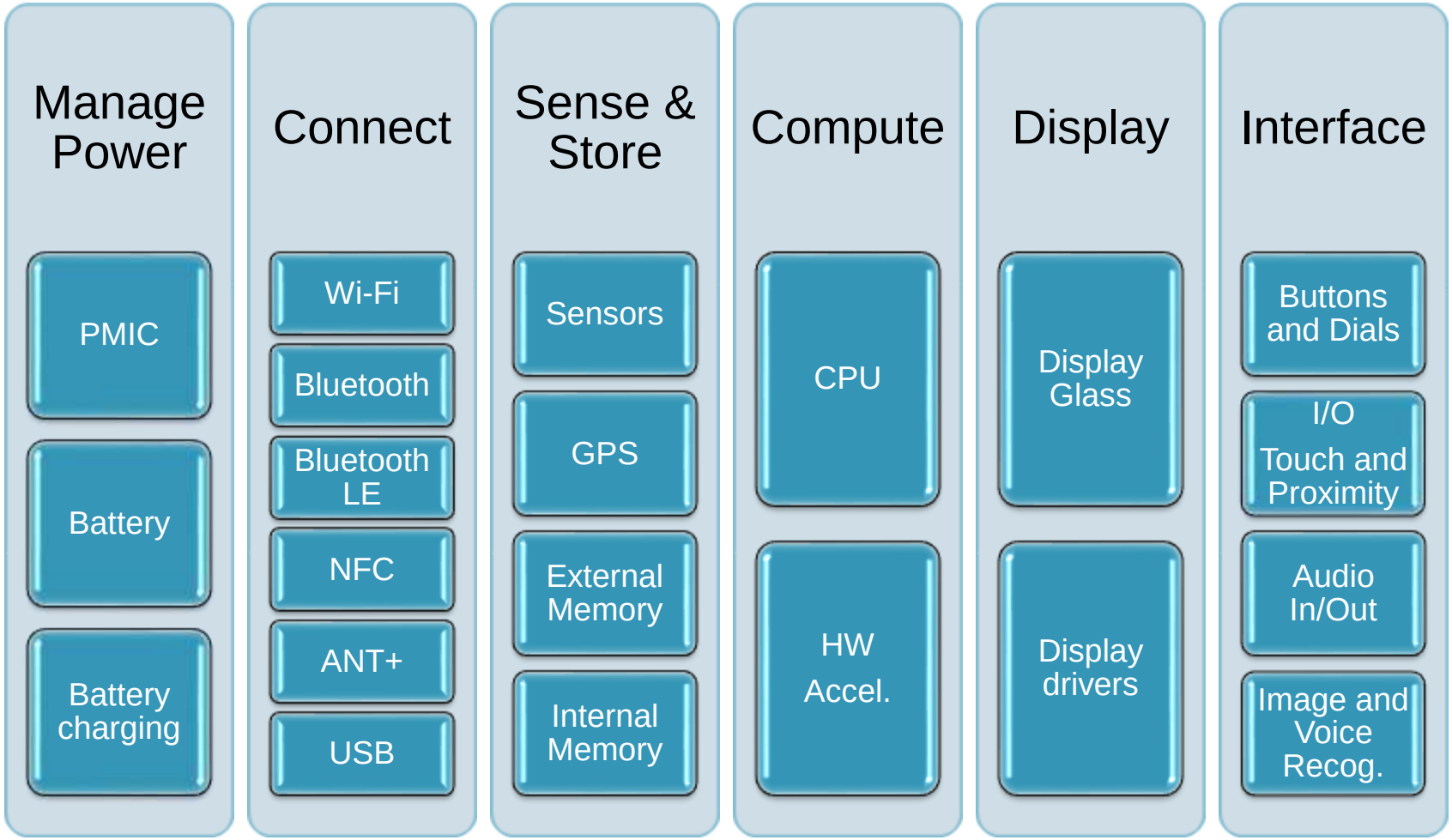
- How long has this machine been working?
- What is its efficiency percentage?
- When will one of its parts break/need replacing?

- How long has the employee been working?
- What is their efficiency percentage?
- How fatigued are they?

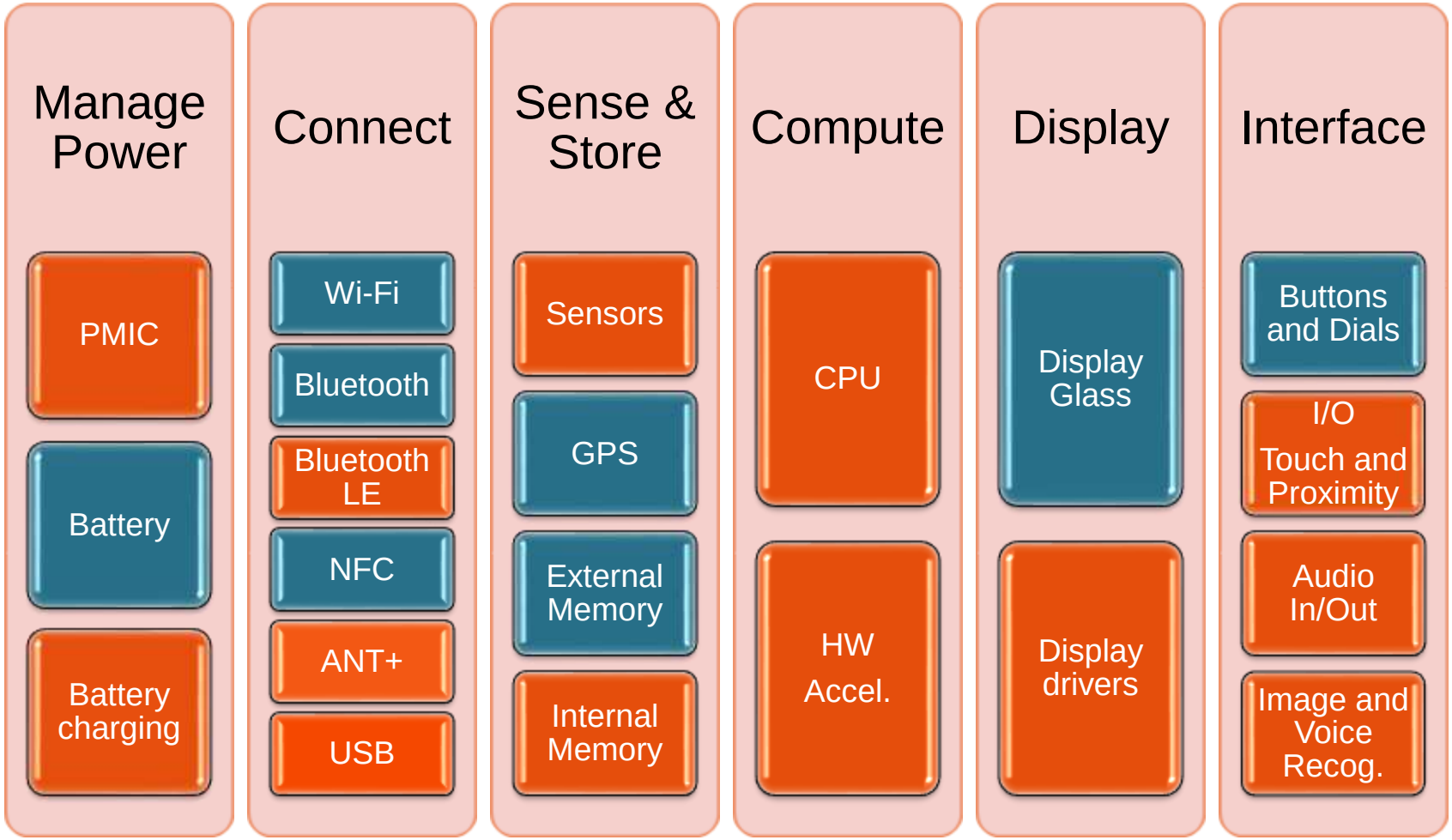
Industrial & Military…Large Wearable Opportunities

Freescale Product Offerings to Address Wearables

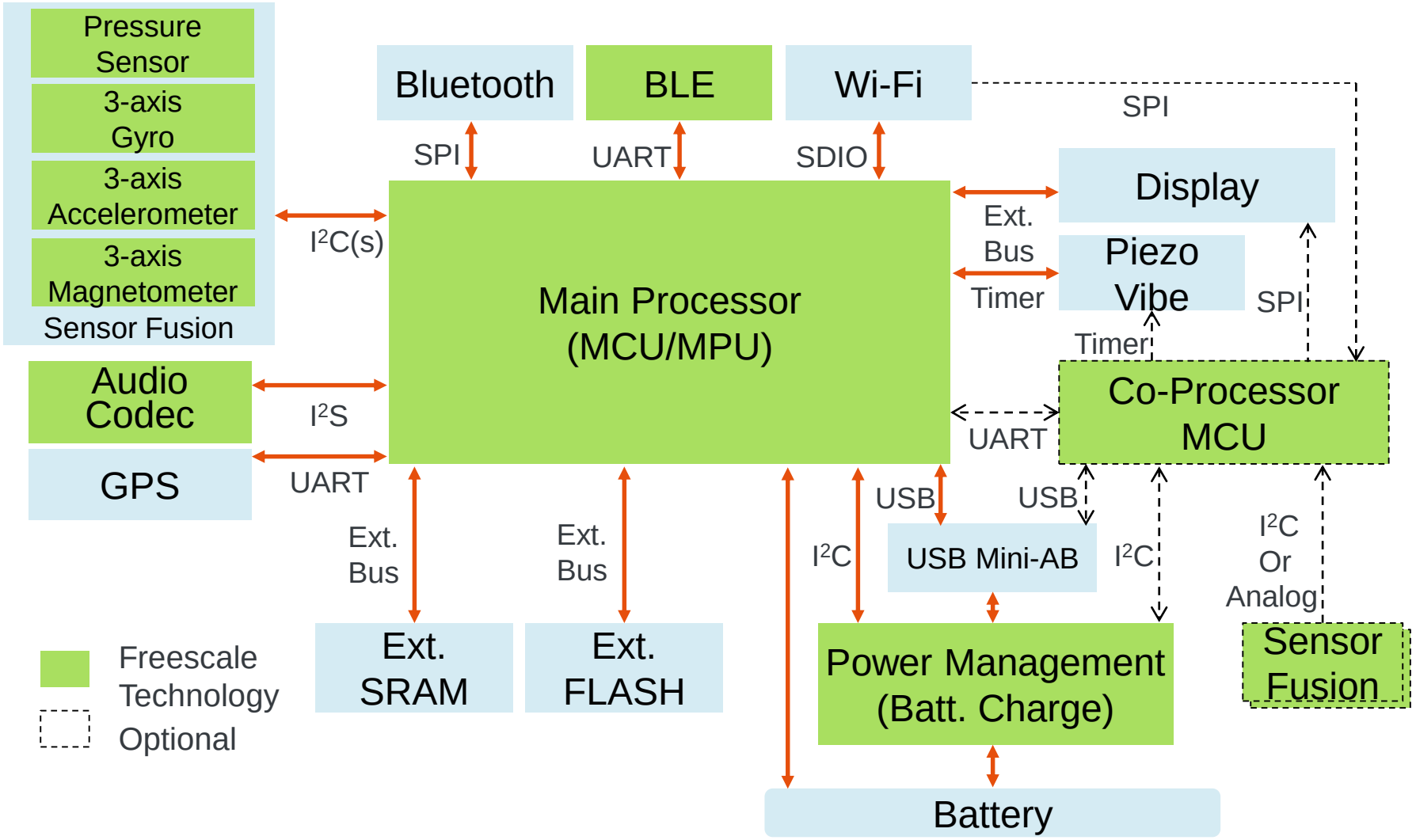
Wearable Blocks



Wearable Blocks: Freescale Solutions



Wearable Internet Thing Functional Diagram



Kinetis MCU Portfolio - >1000 Product Variants

2048 KB Flash
256 KB SRAM
180 MHz

Actual Size
169WLCSP
5.63 mm x
5.49 mm

PERFORMANCE

MEMORY INTEGRATION

32 KB Flash
2 KB SRAM
48 MHz

Actual Size
20WLCSP
1.99 mm x
1.6 mm

K Series — Performance and Integration
Cortex-M4-based MCUs

L Series — Ultra-Low Power
Cortex-M0+-based MCUs

V Series — Motor Control and Power Conversion
Cortex-M0+/M4/M7 cores

E Series — 5V / Robust
Cortex-M0+-based MCUs

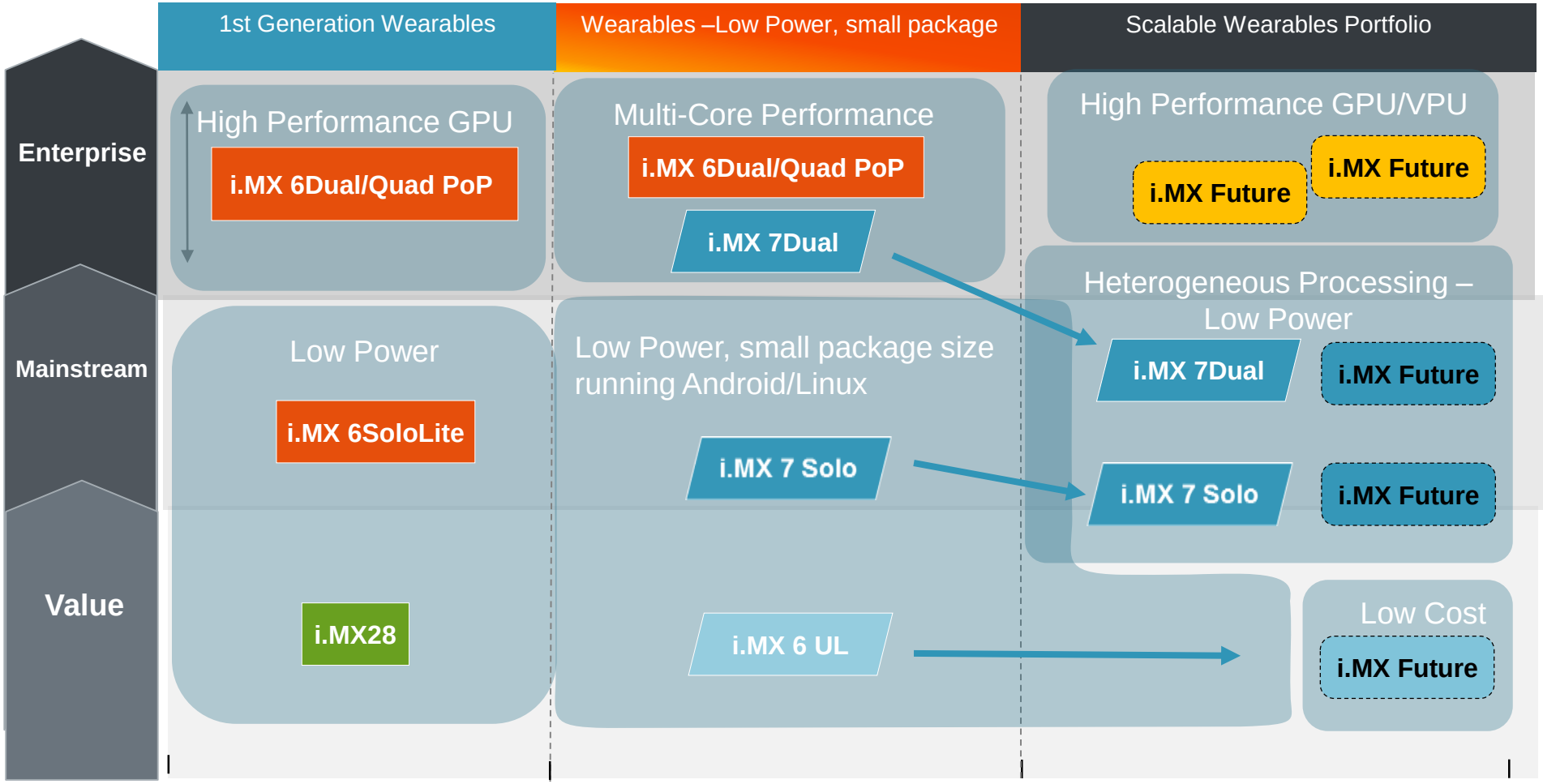
M Series — Metrology
Cortex-M0+ core

EA Series — Automotive
Cortex-M0+-based MCUs

W Series — Wireless Connectivity
Cortex-M0+/M4 cores

MINI MCUs — Miniature chip-scale packages
World's smallest ARM-based MCUs

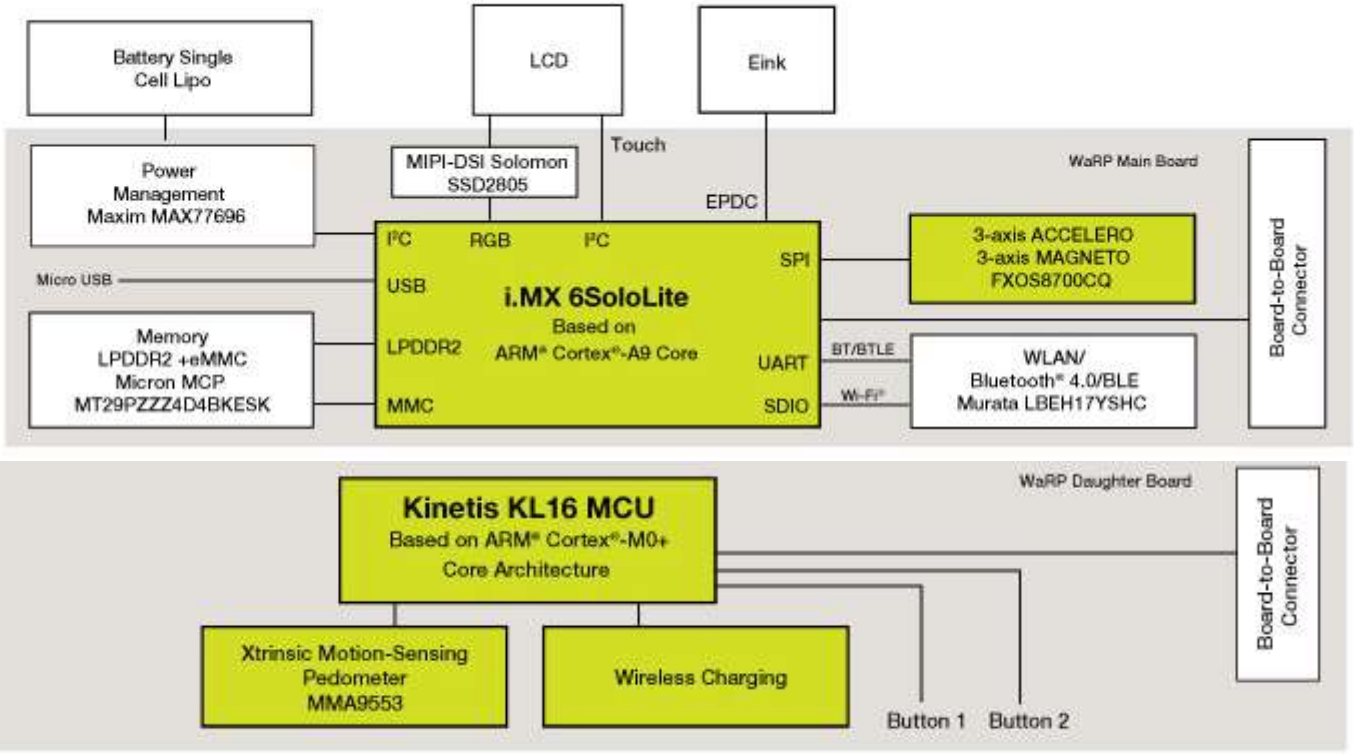
i.MX Applications Processor Wearables Roadmap/Market Coverage



WaRP Block Diagram

Main Board PCB size:
38 mm x 16 mm
(1.4”x 0.6”)

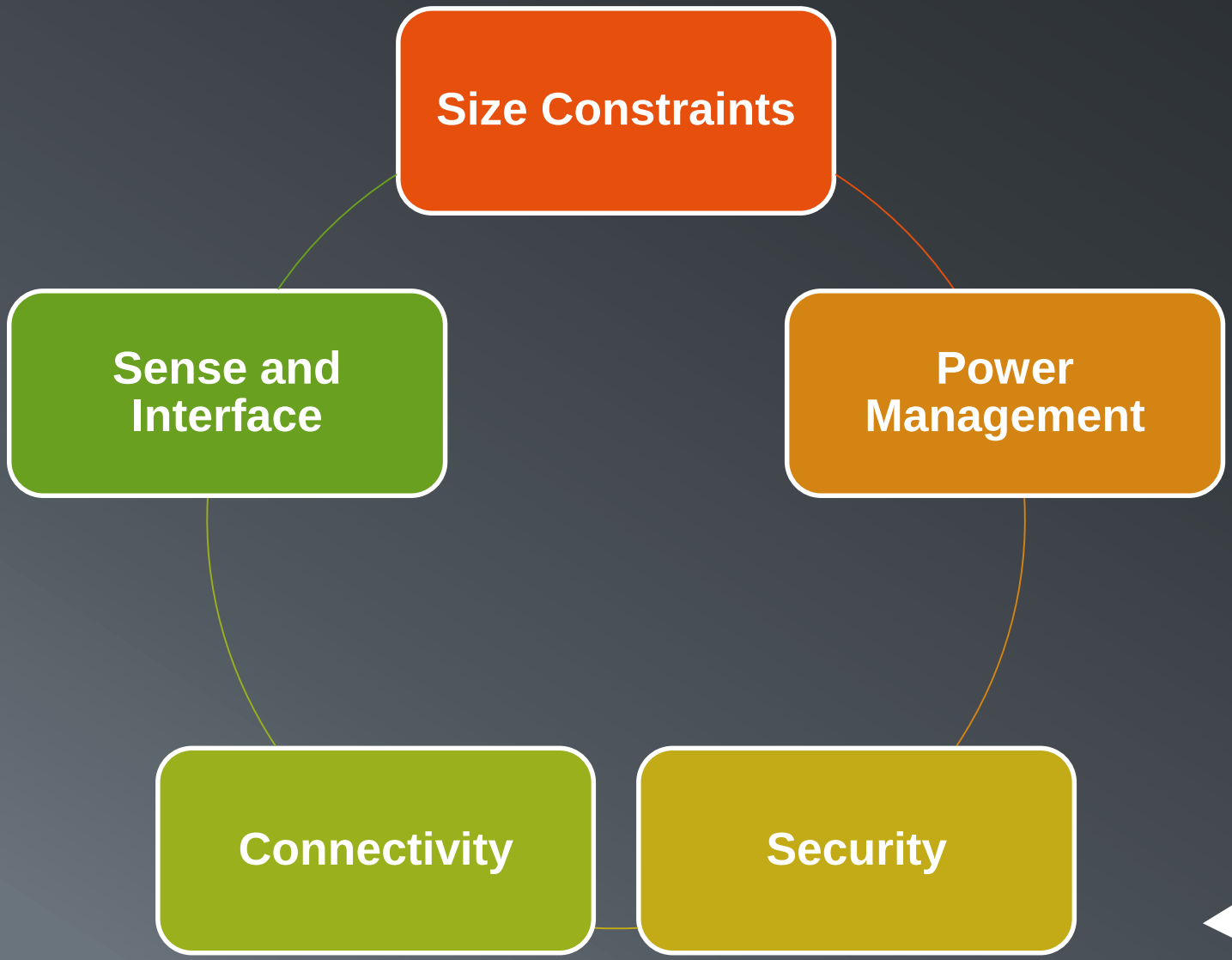
Daughter Board
PCB size:
42 mm x 42 mm
(1.65” x 1.65”)



Freescale Technology

Designed to be able to productize

Overview of the Challenges of Wearable Design


Size Constraints
Power Management
Security
Connectivity
Sense and Interface

Market Segmentation

Multi Function

Type 2
High Performance, multiple usage models

HLOS based
Android, Android Wear

Connectivity
BLE

4G

Type 1
Always On, specific usage

RTOS based
ThreadX, Free RTOS

Fixed Purpose

MCU vs. MPU: Approaching the Design

Activity Tracker	Smart Watch
• MCU performs all functions • Integrated memory & PM • Standard Batteries	• SoC specific functions • Advanced memory & displays • Discrete PMIC • Combo RF modules • Rechargeable batteries

MCU Up Approach	System Level Down Approach

Kinetis K64F/K24F

(up to 1 MB Flash)

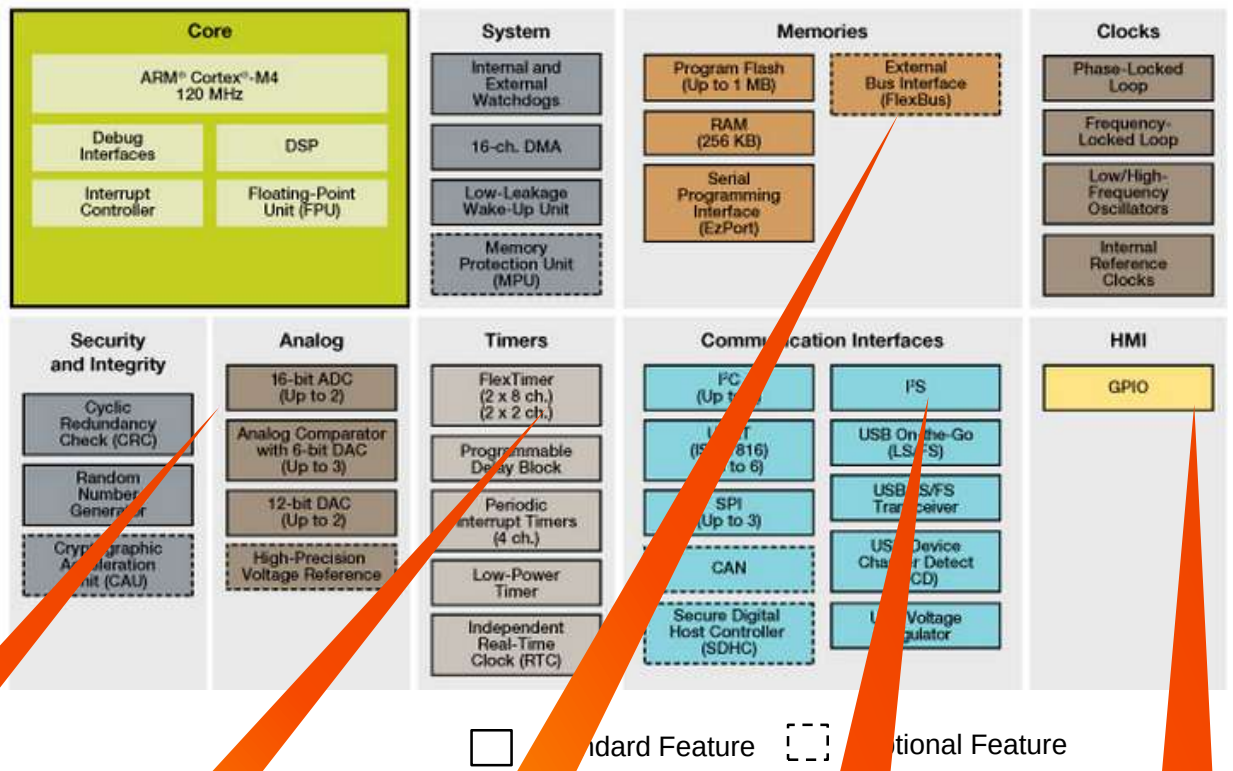
Learn More: Kinetis K2x Fact Sheet | K24 120MHz Public Website | Kinetis K Selector Guide

Key Product Features

- Portfolio Scalability
- CPU Performance
- Static/Dynamic Low Power
- Crystal-less USB
- FlexIO
- Tamper Detection
- LP Trusted Crypto
- Memory Interfaces
- Extended SRAM
- Asynchronous DMA
- Smarter Peripherals
- FlexMemory / EEPROM
- Program Flash Security
- Boot ROM
- Quad SPI XIP
- Separate Voltage Domain
- Large I/D Cache
- VBAT Voltage R
- Enablement To

Links to:

Block Diagram



Analog Inputs and outputs

PWMs for interface to Piezo

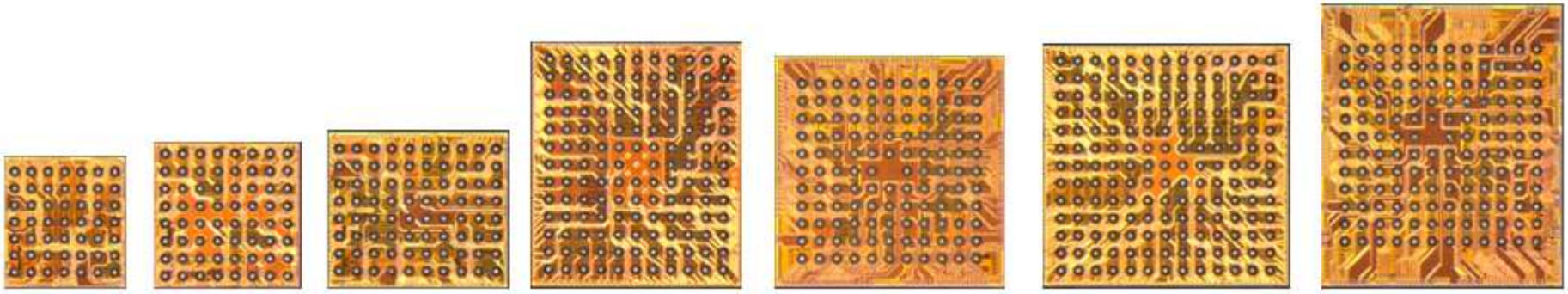
Memory and memory interfaces for displays

I2S for interface to Audio Codec

IO pins for buttons

Kinetis WLCSP – SIZE CONSTRAINTS

K Series (Cortex-M4)



49WLCSP
2.92 x 3.14 mm

64WLCSP
3.35 x 3.32 mm

80WLCSP
4.12 x 3.55 mm

142WLCSP
4.83 x 5.58 mm

120WLCSP
5.29 x 5.28 mm

169WLCSP
5.63 x 5.49 mm

143WLCSP
6.44 x 5.55 mm

L Series (Cortex-M0+)

20WLCSP
1.99 x 1.6 mm

20WLCSP
1.99 x 1.94 mm

36WLCSP
2.37 x 2.46 mm

35WLCSP
2.53 x 2.98 mm

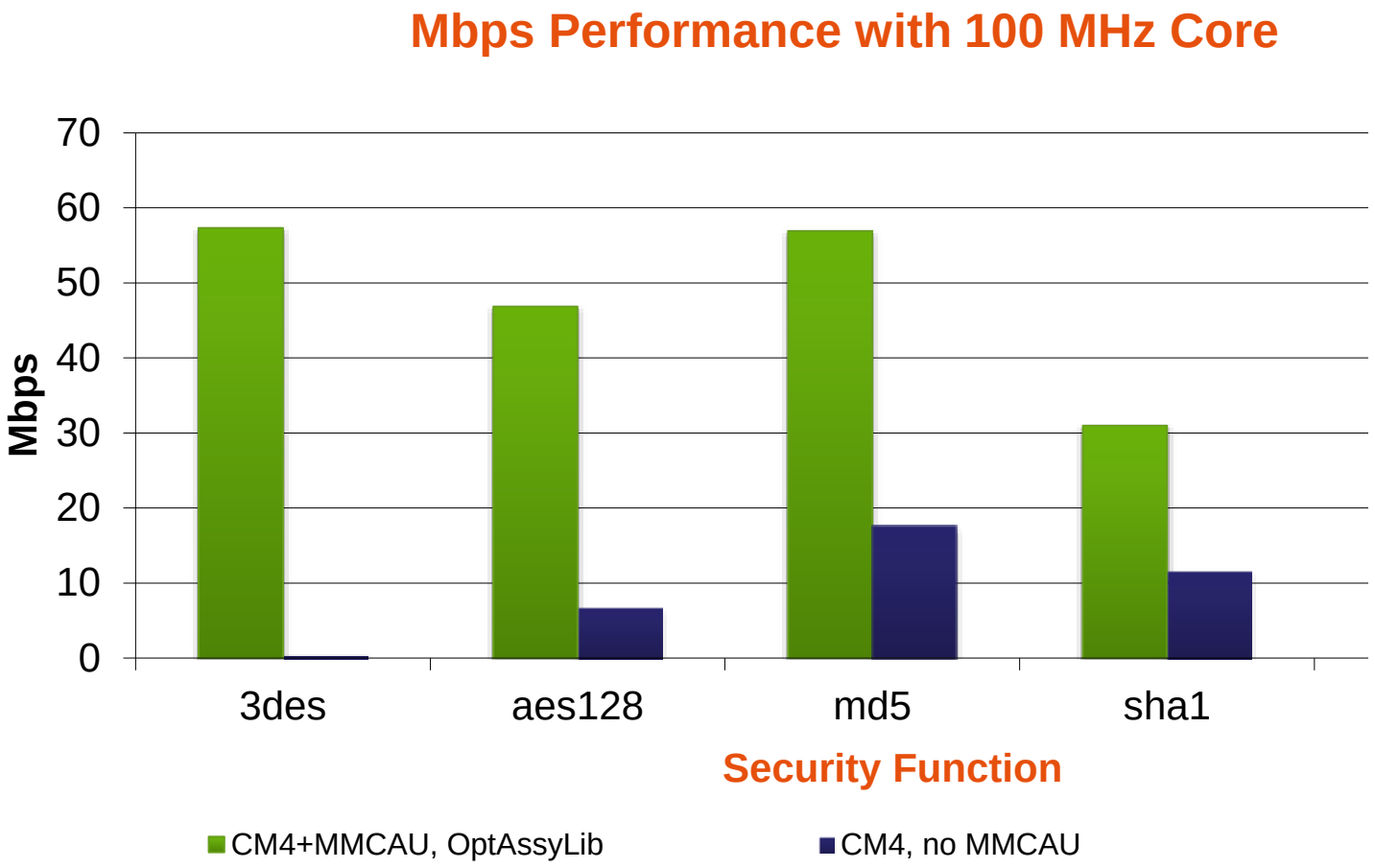
Refer to Technical Documentation

Kinetis L Power Consumption – POWER MANAGEMENT

Core Mode	Device mode	CPU/BUS Frequency	Description	Peripheral Clocks	Typical IDD @3V, 25C	Recovery Time
Run	RUN	48/24 MHz	Full speed RUN mode with specified CPU/BUS frequency, flash cache enabled, clocked by 48MHz IRC, with Compute mode and peripheral clocks on/off options	Enabled	5.62mA (117uA/MHz)	-
		48/24 MHz		Disabled	4.04mA (84uA/MHz)	-
		48/- MHz		Compute Mode*	3.39mA (70uA/MHz)	-
		24/24 MHz		Disabled	2.99mA	-
	VLPR	4/1 MHz	Very Low Power RUN mode with specified CPU/BUS frequency, flash cache enabled, clocked by 8/2MHz IRC, with Compute mode and peripheral clocks on/off options	Enabled	329uA (82uA/MHz)	-
		4/1 MHz		Disabled	253uA (63uA/MHz)	-
		4/- MHz		Compute Mode	229uA (57uA/MHz)	-
		2/- MHz		Compute Mode	101uA (50uA/MHz)	-
Sleep	WAIT	48/24 MHz	Full CPU/BUS frequency with CPU in SLEEP mode	Disabled	1.79mA	-
	VLPW	4/1 MHz	Restricted CPU/BUS frequency with CPU in SLEEP mode	Disabled	218uA	-
Deep Sleep	STOP	OFF	MCU in static state with full retention, CPU clock is off, energy-saving peripherals functional with Asynchronous DMA, Asynchronous Wake-up Interrupt Controller detects wake-up source for CPU, LVD ON	OFF	160uA	7.5us
	VLPS	OFF	Same as STOP with LVD OFF, lowest mode with ADC and pin interrupt functional	OFF	2.09uA	7.5us
	LLS	OFF	MCU in low-leakage state with full retention, Low Leakage Wake-up Unit detects wake-up source, lowest mode with full RAM and I/O retention and fast wake-up, Asynchronous DMA in static state	OFF	1.58uA	7.5us
	VLLS3	OFF	Similar to LLS mode with wake-up following reset flow	OFF	1.35uA	93us
	VLLS1	OFF	Similar to VLLS3 mode with SRAM OFF, REGFILE retained for critical data	OFF	700nA	152us
	VLLS0	OFF	Similar to VLLS1, with REGFILE OFF, LPO OFF, optional POR ON/OFF, shelf mode	OFF	76/252nA	152us

*Compute Operation shuts off bus and system clock for lowest power core processing. Peripherals with an alternate asynchronous clock source can continue to operate.
Test result from MKL27Z64VLH4 with code in flash and flash cache on

MMCAU Performance: SECURITY (crypto-acceleration)



CONNECTIVITY

The Kinetis W series of MCUs is optimized for low-power wireless communication and integrates class-leading sub-1 GHz and 2.4 GHz RF transceivers, providing the right mix of performance, integration, connectivity and security.

Wireless Connectivity Microcontroller Solutions

RF Integration	Integrating RF functionality to the Kinetis MCU portfolio
Flexibility	Ability to integrate the right combination of memories and peripherals to meet a variety of customer demands
Enablement	Part of the Kinetis MCU ecosystem including KSDK environment using MQX and third-party support from IAR, KEIL or other ARM ecosystem providers

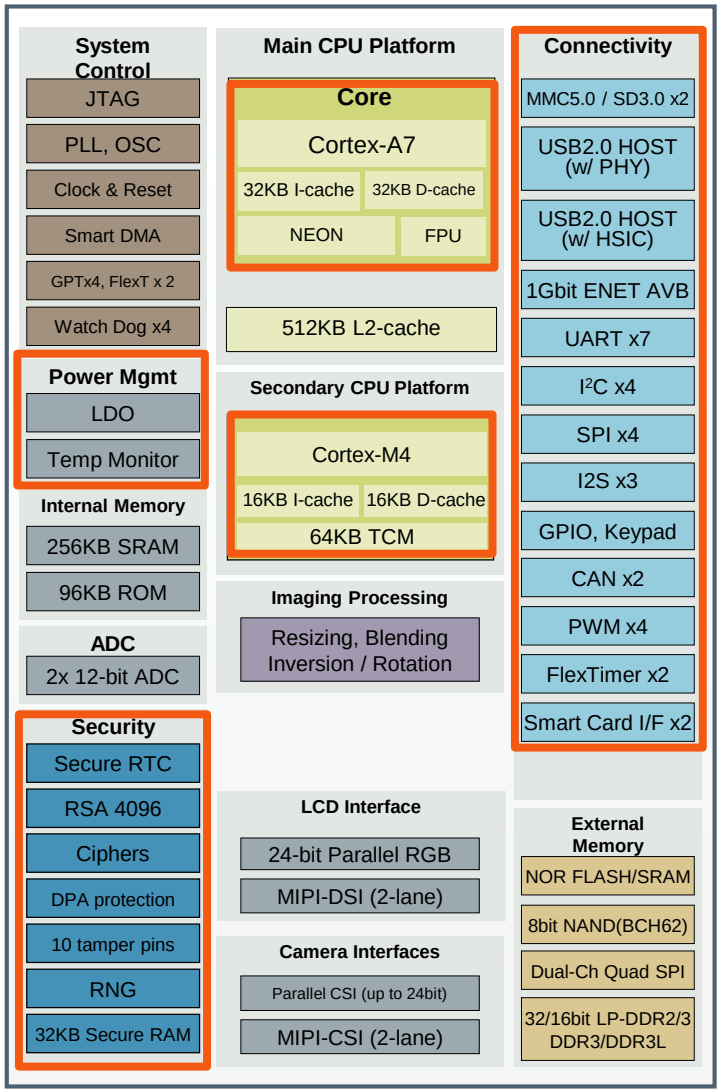
Energy-Saving Peripherals: SENSOR INTERFACE

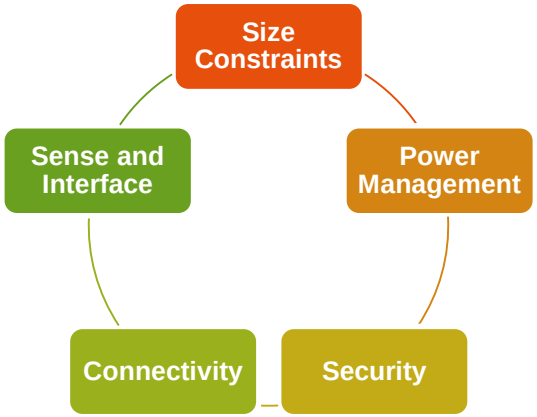
Intelligent peripherals maximizing time in deep sleep modes with no CPU intervention

Peripheral	Low Power Functionality
DMA	Allows energy-saving peripherals (ADC, UART and Timer/PWM) to trigger asynchronous DMA request in STOP/VLPS modes to perform DMA transfer and return to current power mode with no CPU intervention
UART	Supports asynchronous transmit and receive operations to the bus clock supporting communication down to STOP/VLPS modes. Configurable receiver baud rate oversampling ratio from 4x to 32x allowing higher baud rates with lower clock sources
SPI	Supports slave mode address match wake-up function and first message capture down to STOP/VLPS modes
I2C	Supports multiple address match wake-up function down to STOP/VLPS modes
USB	Supports asynchronous wakeup on resume signaling down to STOP/VLPS
LPTPM (Timer/PWM)	Supports 16-bit timer input capture, output compare and PWM functions down to STOP/VLPS modes
LPTMR (Timer/Pulse Counter)	Supports 16-bit timer and pulse counter functions in all power modes
RTC	Supports 32-bit seconds counter with seconds interrupt and programmable alarm in all power modes with include temperature and voltage compensation

Enhanced SPI, I2C and USB Low Power Features Coming Soon!

i.MX 7Solo Applications Processor





- **Package:**
  19x19@0.75mm BGA

  12x12@0.4mm BGA*

* Feature limited (1 ADC, 4 tamper pins)

Pi is the Answer?

Great tool but…

- Not open source
- Subsidized
- Limited ability to productize

Wearable Reference Designs?

Raspberry Pi

ToQ

Intel Curie

Udoo Neo

Arduino

WaRP

Intel Edison

RioT

Beagle Bone

Ingenic
Newton 2

SensoPlex
SP-10C

Pico

Wearable Reference Designs- Key Features

First decision: Microcontroller or Application Processor?

Key Features
1. Wearable Form Factor
2. Battery Management
3. Ease of Use/Scalability
4. Open Source - Community
5. BOM Cost and Availability

Faster time to final product

Wearable Reference Designs

	Raspberry Pi 2	Arduino Uno	WaRP	Ingenic Newton 2	SensoPlex SP-10C	Intel Edison	Intel Curie	UDOO Neo	Pico
Wearable Form Factor	3.4” × 2.2 ”	2.7” x 2.1”	1.4” x 0.6”	1.2” X 0.6”	1.4” x 1.0”	1.4” x 1.0”	0.7” diameter	2.2” x2.7”	2.1” x 2.8”
Battery Life									
Scalability	Arduino compatible	Shields	Daughter cards	External boards	Daughter boards	Arduino compatible		Arduino Compatible	Edison Compatible
Open Source									
BOM Cost / Availability									

Design with the Right Components

Components make up over 60% of your entire business costs

The Good

- Small Footprint
- Low Power

The Bad

- Price increases dramatically for small quantities

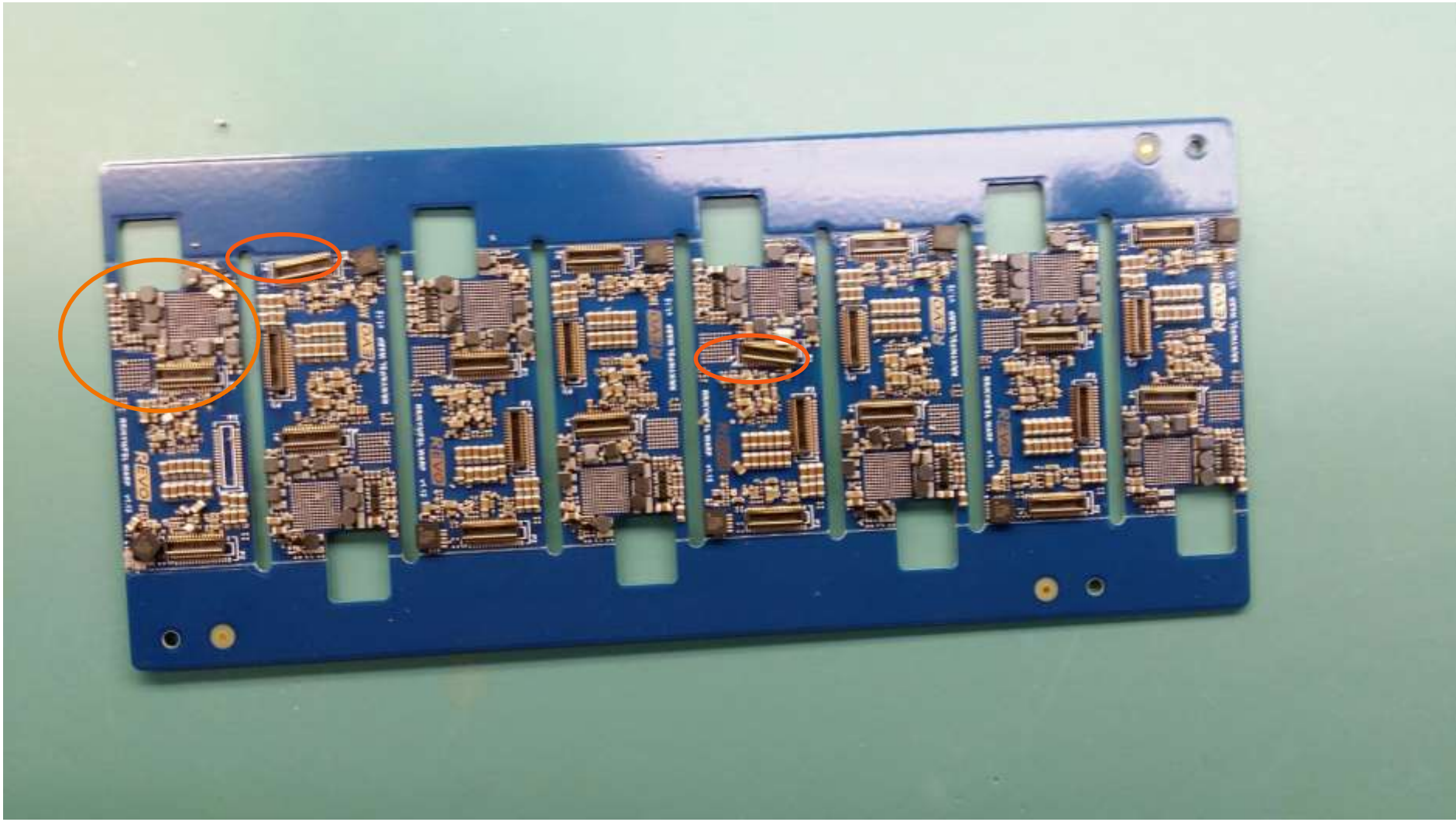
The Ugly

- Short life cycles
  Limited availability (distribution)

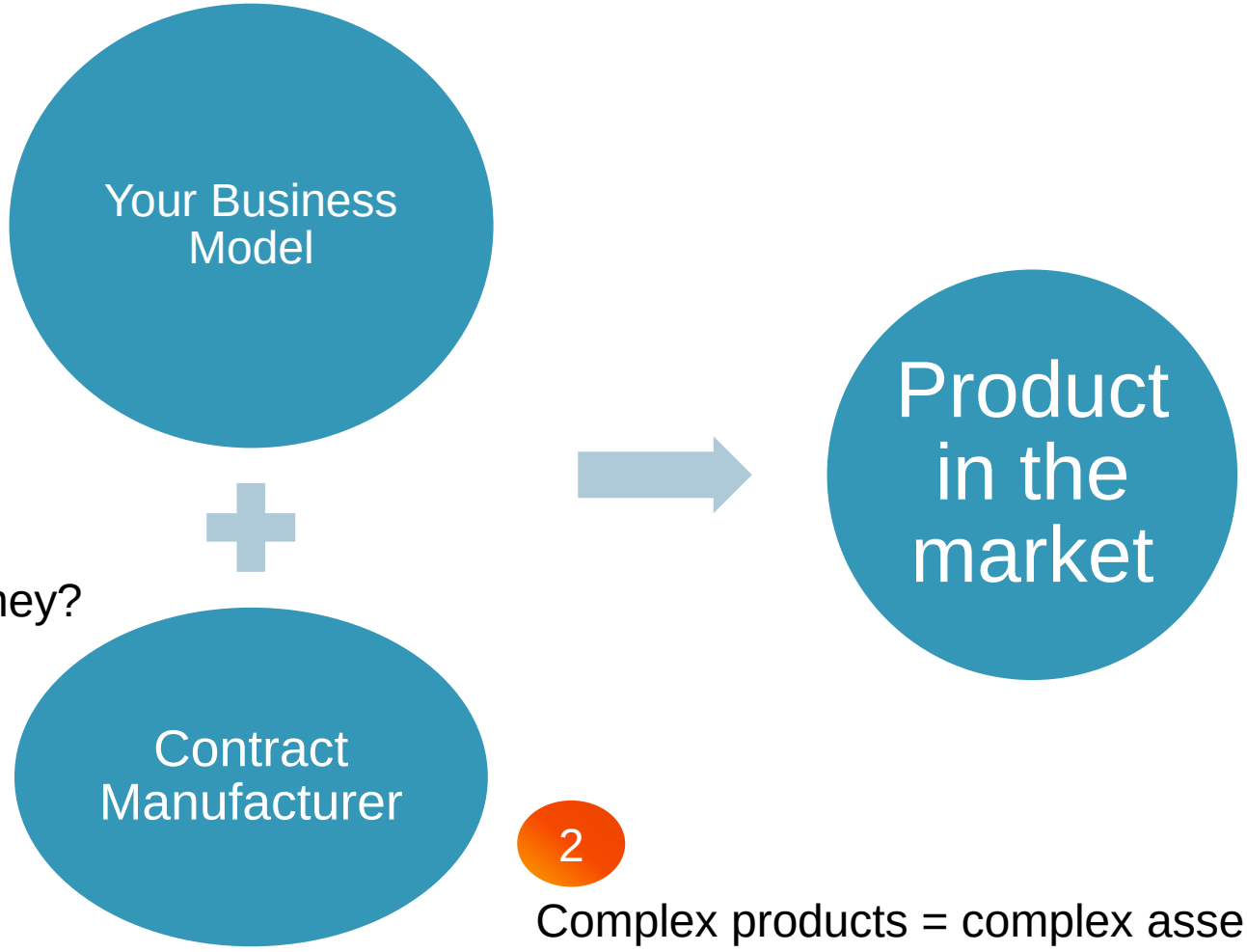
“No hardware plan survives contact with a factory.”

Cyril Ebersweiler, Founder of HAXLR8R

A Prototype is Ready…..When It Can be Manufactured



Your Factory is Your Most Important Partner



1

How do they make money?

2

Complex products = complex assembly = lower yield

3

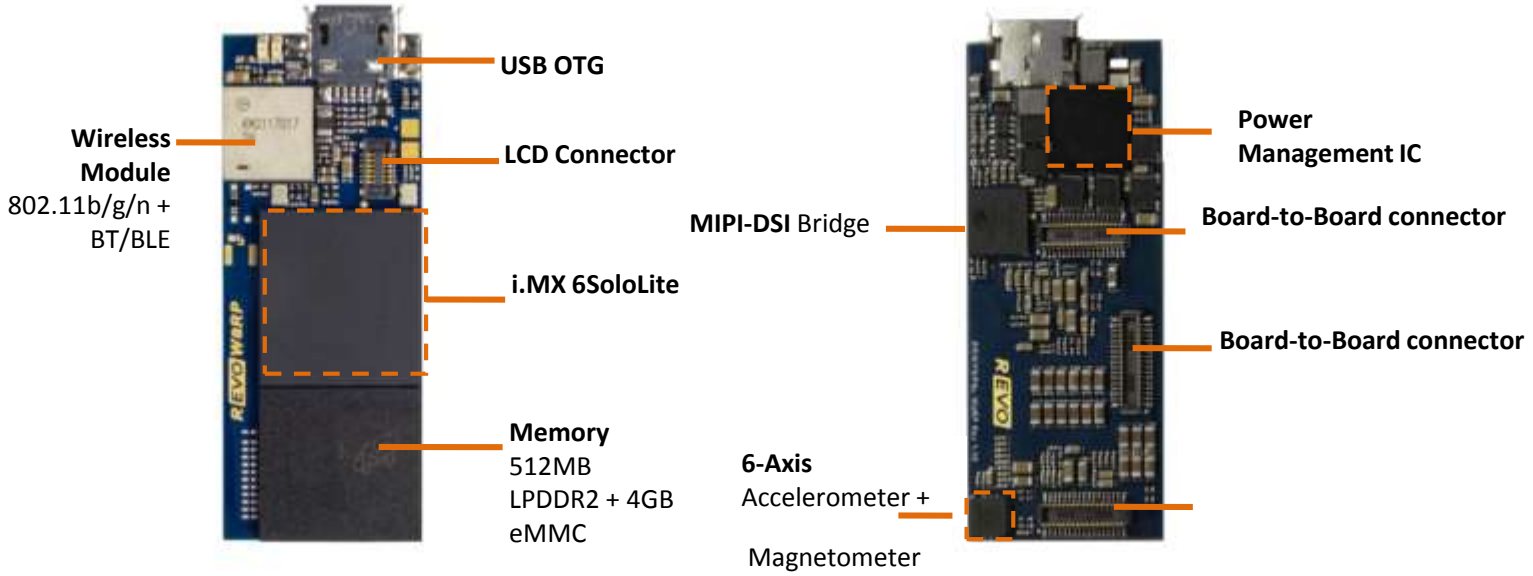
Component sourcing/financing

Enablement

- MPU: Freescale and Partner Reference Designs
- MCU: SDK and HW board ecosystem

Wearable Form Factor...WaRPboard

- Main Board PCB size: 38 mm x 16 mm (1.4” x 0.6”)

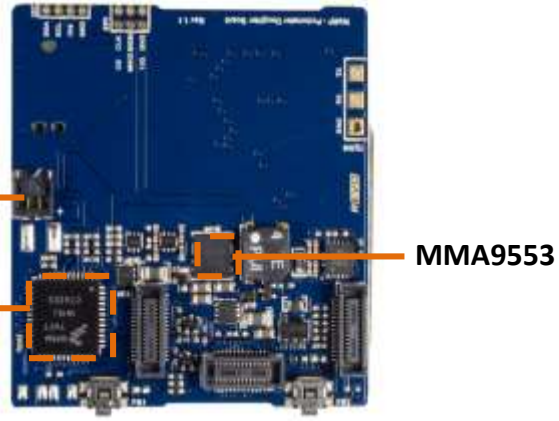


Battery Management / Scalability

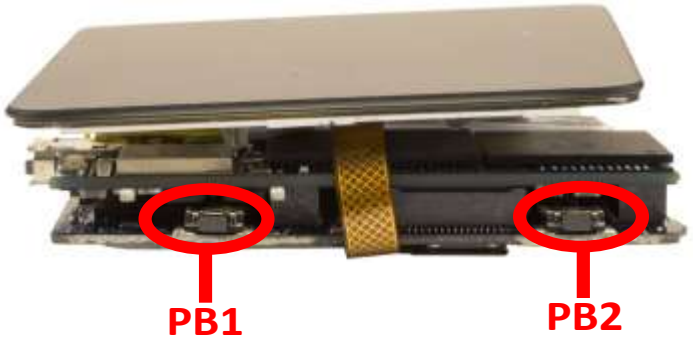
Top view

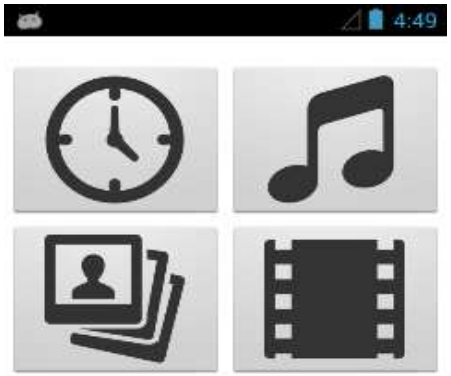
Bottom View

Daughter Board PCB size:
42 mm x 42 mm
(1.65” x 1.65”)



Usability


PB1
PB2


4:49


1:00


1:11
Settings
WIRELESS
Wi-Fi
Bluetooth
DEVICE
Sound

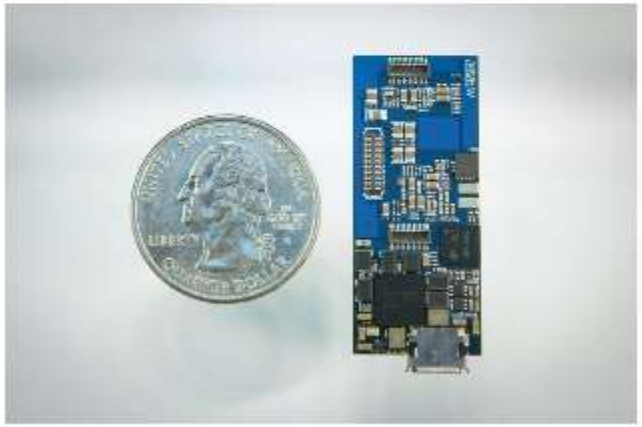
Open Source/ Community

Home | Press | Community | Technical Features | Where to Buy | About Us

WaRPboard.org is a nonprofit community based organization providing service and support for the wearables reference platform (WaRP). The solution's hardware and software will be open sourced and community driven. No closed development tools or licensing fees are required when used in conjunction with open source resources.

WaRPboard implements a hybrid architecture to address the evolving needs of the wearables market. The platform consists of a main board and an example daughtercard with the ability to add additional daughtercards for different usage models. In this hybrid architecture, the guts of the design is done on the main board with Freescale's i.MX 6SoloLite applications processor, and a secondary microcontroller, Freescale's Kinetis KL16 MCU, is implemented on the daughtercard, which is used as a sensor hub as well as a wireless charging MCU.

Technical Features



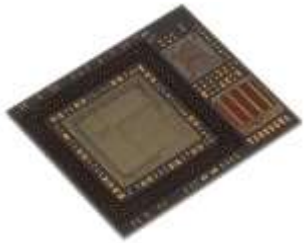
See the Technical Features page for additional board photos.

Wearables…One Size Does Not Fit All

UDOO – Neo

DART – MX6

PICO –i.MX6-S

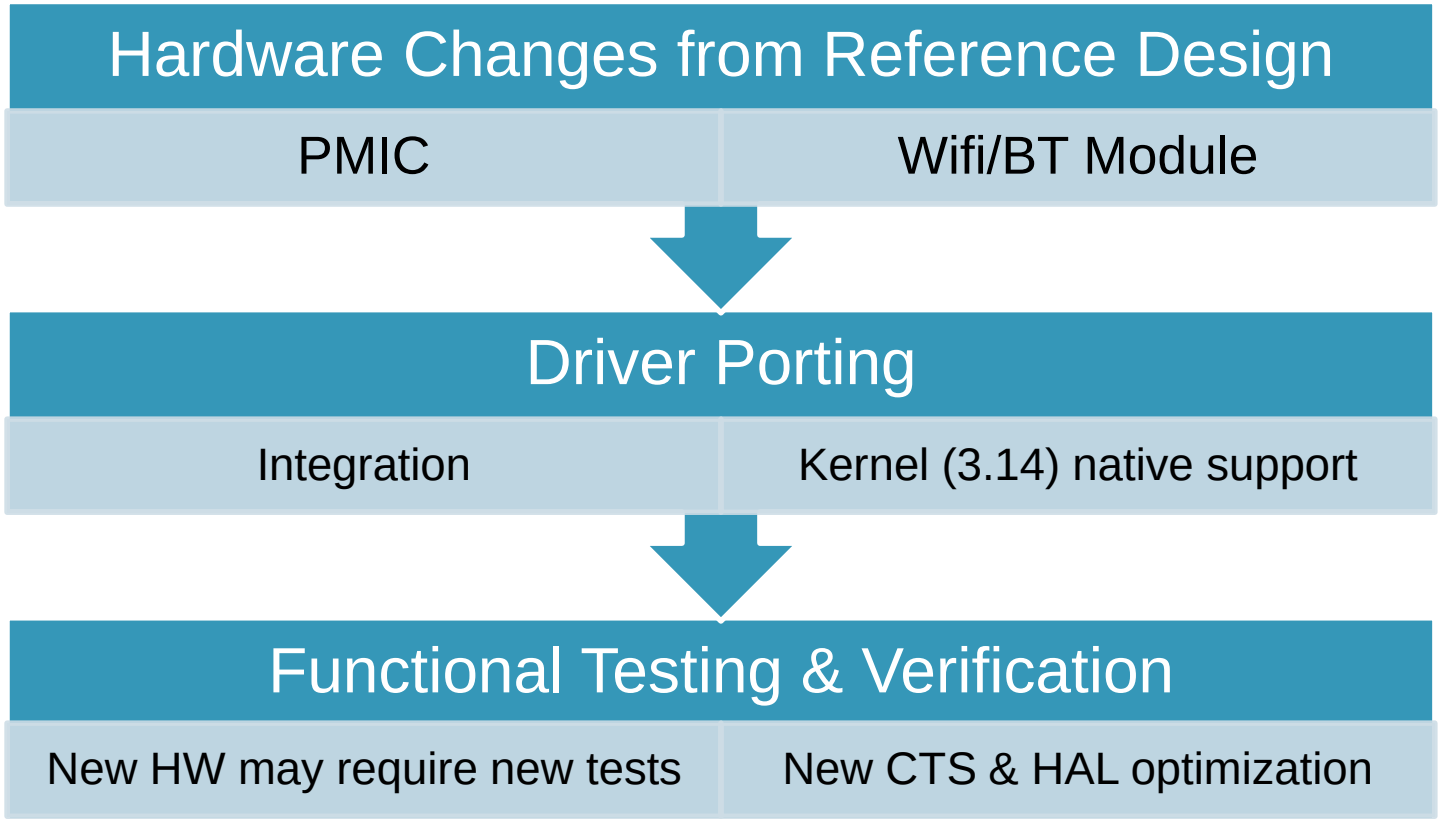


Single Chip Solution Module

Software: From Reference Design to Production

About half the way there…

- Android is a framework it takes a considerable effort (develop and test) to deliver a system!

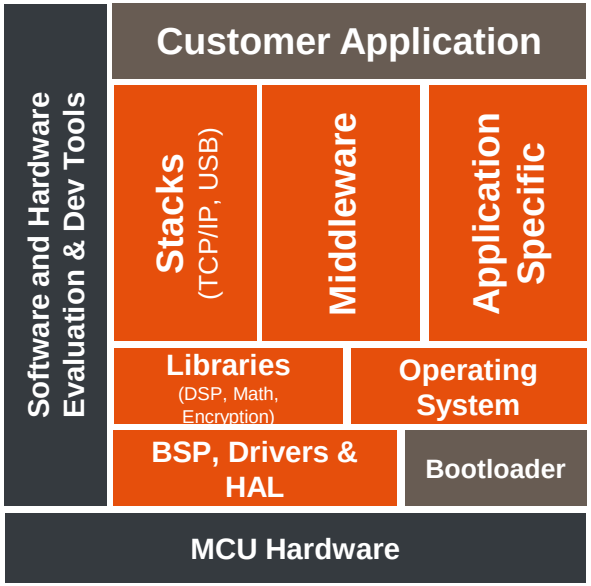


Kinetis Software Development Kit (SDK)

SDK

A complete software framework for developing applications across all Kinetis MCUs

HAL, peripheral drivers, libraries, middleware, utilities, and usage examples; delivered in C source



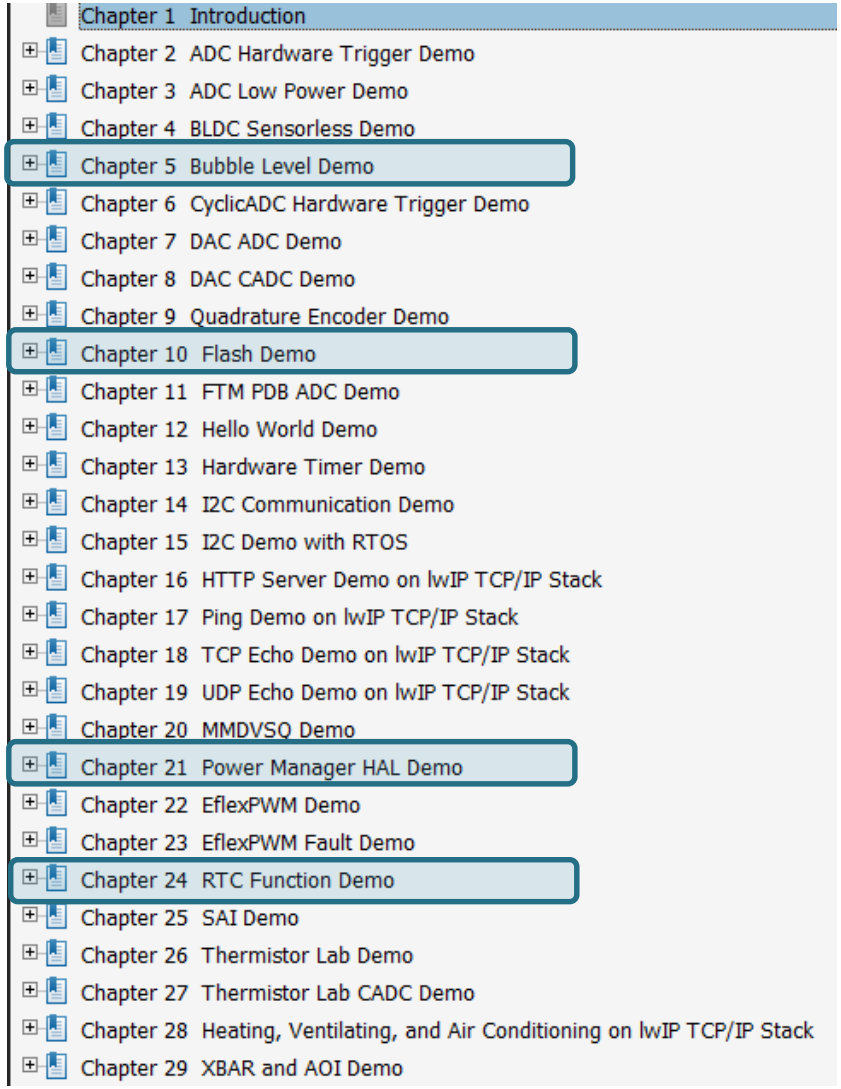
Open Source Initiative

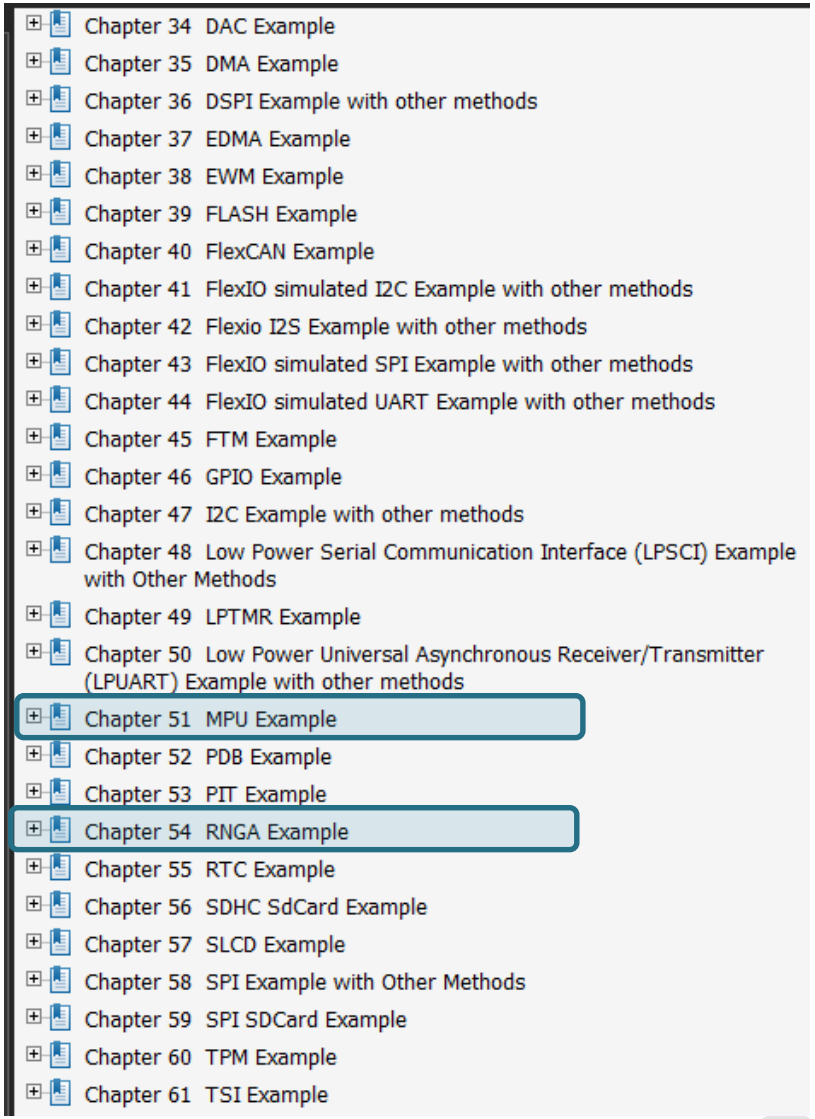
CMSIS COMPLIANT

Product Features

- Open source Hardware Abstraction Layer (HAL) provides APIs for all Kinetis hardware resources
- BSD-licensed set of peripheral drivers with easy-to-use C-language APIs
- Comprehensive HAL and driver usage examples and sample applications for RTOS and bare-metal.
- CMSIS-CORE compatible startup and drivers plus CMSIS-DSP library and examples
- RTOS Abstraction Layer (OSA) with support for Freescale MQX, FreeRTOS, Micrium uC/OS, bare-metal and more
- Integrates USB and TCP/IP stacks, touch sensing software, encryption and math/DSP libraries, and more
- Support for multiple toolchains including GNU GCC, IAR, Keil, and Kinetis Design Studio
- Integrated with Processor Expert

SDK Demonstrations & Examples





What is the SDK Power Manager?

- A high-level API that allows an application to easily manage and utilize its supported power modes
- Support for application
  - Provides the ability to execute application-defined callbacks before and/or after power mode transitions
- Works with MCU peripherals
  - Enables agreeable or forcible transition between power modes, allowing peripherals to hold-off transition requests or the application to force transition

How to Engage with Sensor Fusion

- **freescale.com/sensorfusion**
  - Contains the latest sensor fusion information
  - Downloadable SW and demos
  - Blogs and app notes
- Sensor fusion development kits
  - Available November 2014
  - Combination of FRDM-MULTI-B and FRDM-K64F boards
  - Part numbers
    - **FRDM-SFUSION-S** with 50 hours of commercial support
    - **FRDM-SFUSION** with community support
- Factory contact
  - **SFSW@Freescale.com**
  - Email alias includes sensor and MCU teams

ISF 2.1 for Kinetis MCUs

ISF 2.1 for Kinetis MCUs allows you to write an embedded sensor application in less than 30 minutes without writing a single line of code using Processor Expert technology.

Differentiating Points

- Sensor application code auto-generation using Processor Expert technology
- Deployable across entire line of Kinetis MCUs
- Sensor Fusion library has been integrated as an “Orientation” sensor
- Register Level Interface allows low-level access to sensor registers

Product Features

- Projects available for **FRDM-KL25Z, FRDM-K22F and FRDM-K64F**
- Supports a broad set of Freescale sensors including MMA8652/8653, MAG3110, FXOS8700, FXAS21002, FXLS8471, MPL3115 and others
- Example projects available for both CodeWarrior 10.6 and Kinetis Design Studio 2.0 Integrated Development Environments

Applications

- Sensor Data Analytics
- Internet of Things
- Consumer Electronics
- Wearable Electronics
- Medical Devices

Sensor Fusion Development Kit

Development Kit

- Enables quick development and prototype of sensor fusion applications
- Includes
  - Kinetis FRDM-K64F Freedom board
  - Freedom Development Platform for Freescale Sensors with Bluetooth®
- Part numbers
  - FRDM-SFUSION with community support ($170)
  - FRDM-SFUSION-S with 50 hours commercial support ($10K)

Commercial Support

- Reduces project risk, accelerates time to market
- Prioritized and dedicated access
- Guaranteed response time
- Senior level developer access
- Private portal with customer reporting and dedicated escalation path
- Annual Subscription

Future Predications….

In 2017, a third of all wearables will come from…

- Companies that don't exist today

www.Freescale.com