Create a Wearable Device
with a Hybrid Architecture

WaRPboard.org

KT Ahn | Business Development Manager

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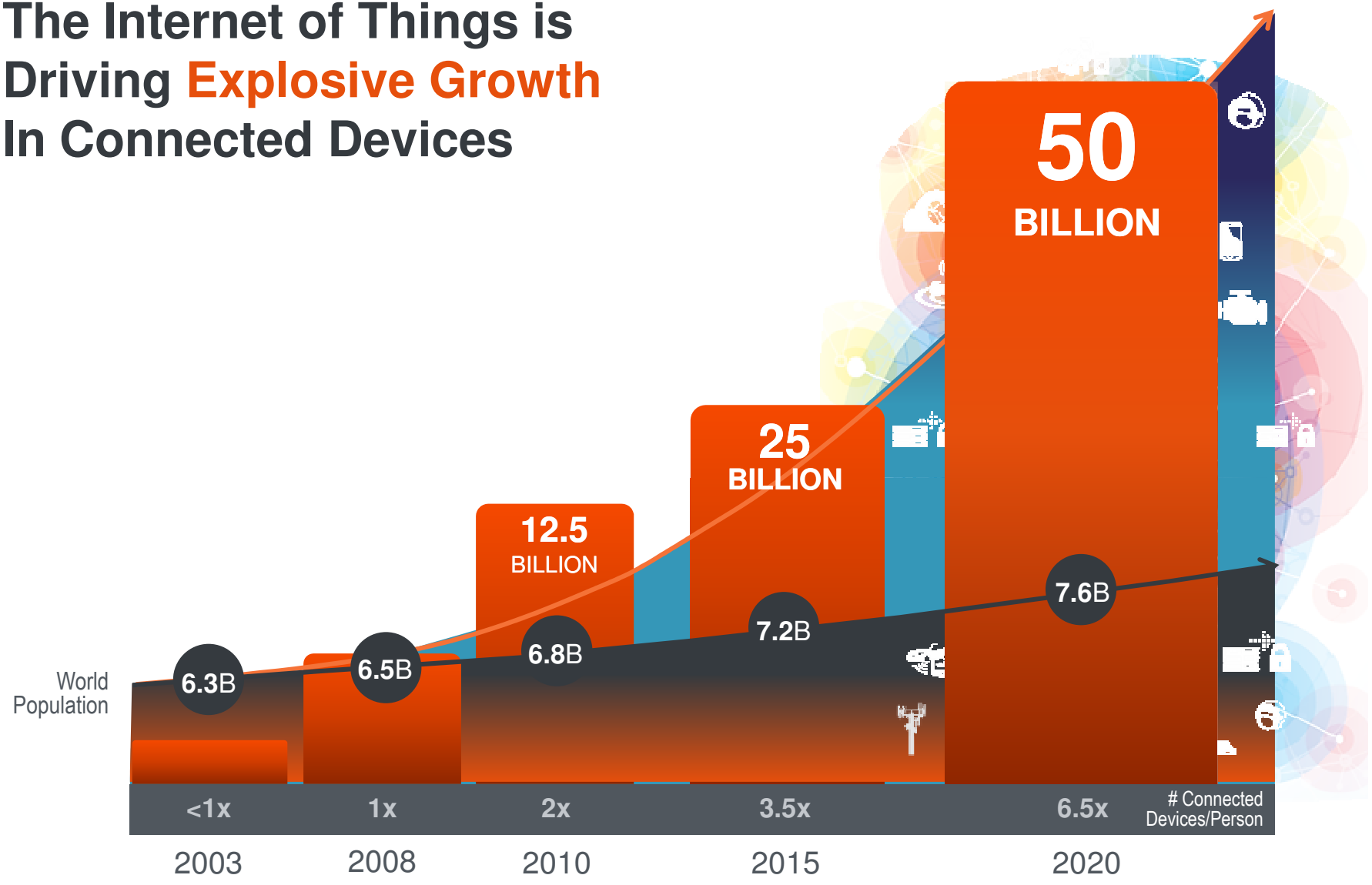
freescale™

The Internet of Things is Driving Explosive Growth In Connected Devices



* Sources: Ericsson, February 2011; Cisco Internet Business Solutions Group (IBSG), April 2011

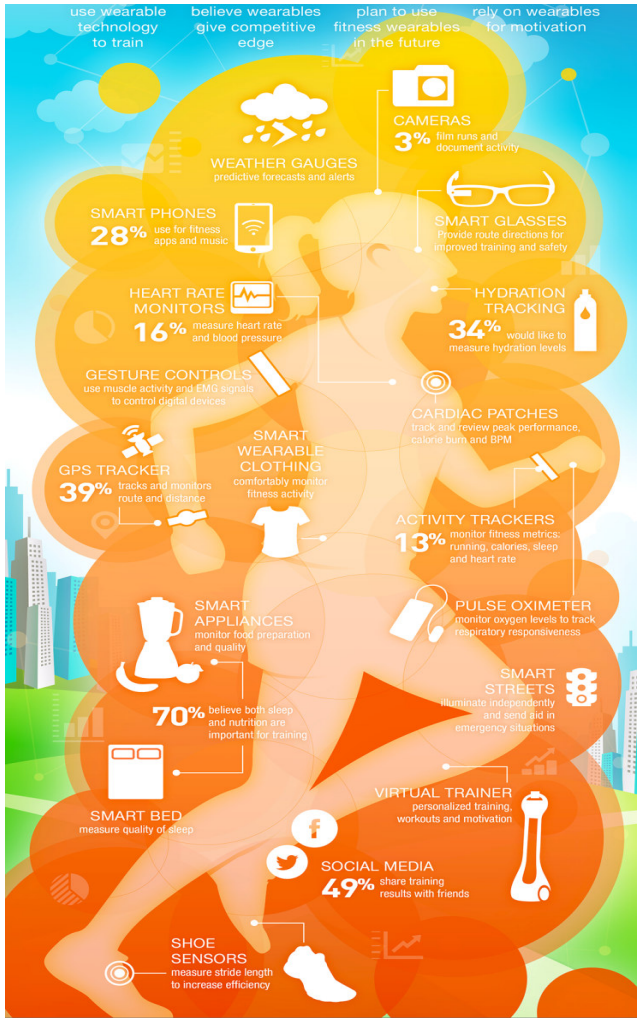
What Is A Wearable Device?

- Products that enhance the user's experience as a result of the product being worn through sensing, connectivity and processing of data

Key Technology Market Trends for Wearables:

- Miniaturization
- Low power
- Connectivity
- Multiple sensors

Austin Marathon – Freescale Survey



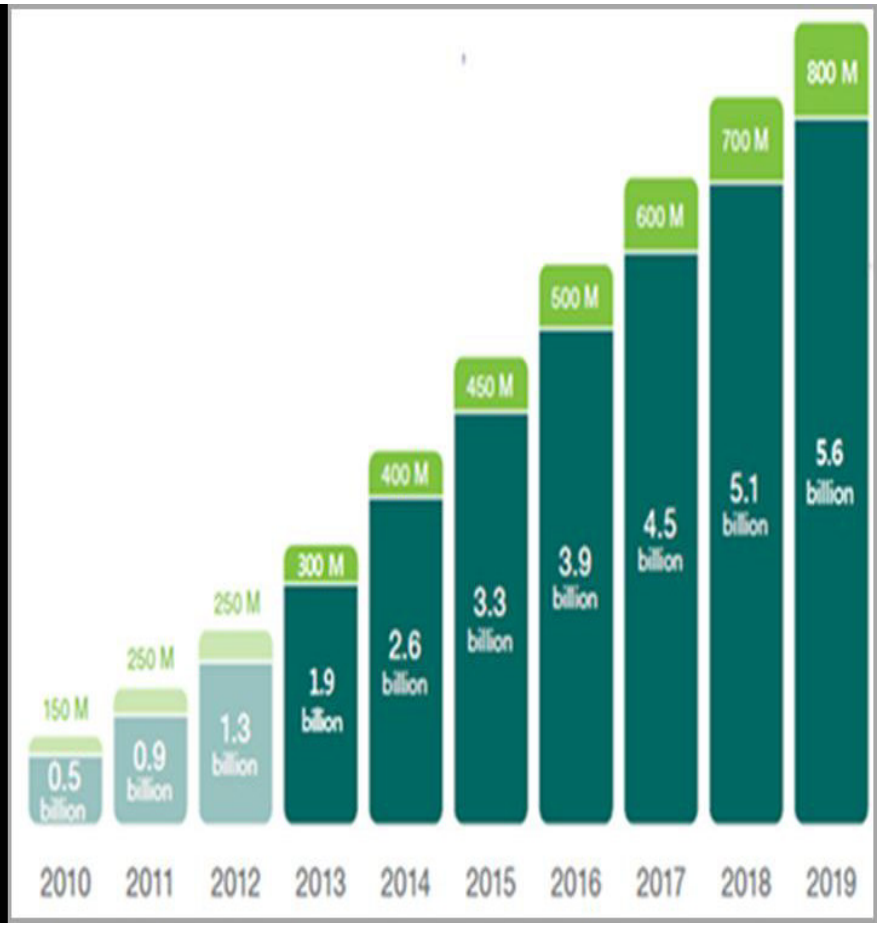
- 74% use wearables to train
- 88% of people surveyed said they rely on wearables for motivation similar to a coach
- 78% believe wearables give them a competitive edge
- 88% plan to use fitness wearables in the future

Smart Device Market Trend

Smart phone growth Trend

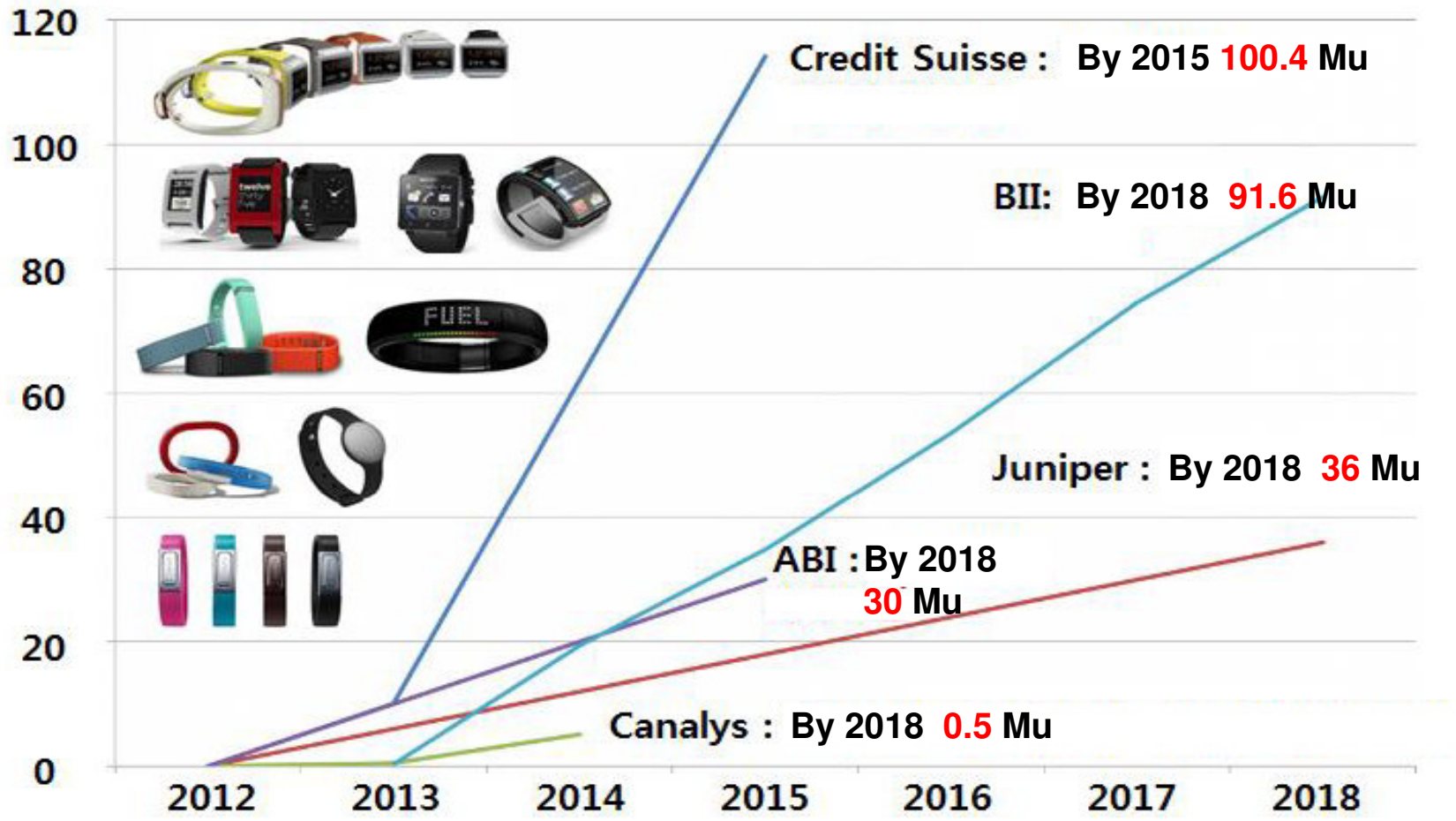
Source : Flurry Analytic & KT E&M Research

Smart device market forecast



Source : Ericsson Mobility

Smart Watch Unit Forecast by Researchs



Source : BI Intelligence

•Smart Watch would be the most fast growing wearable device in near future

Wearable Market: Segmentation

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

Wearable Market: Diverse Usage Models

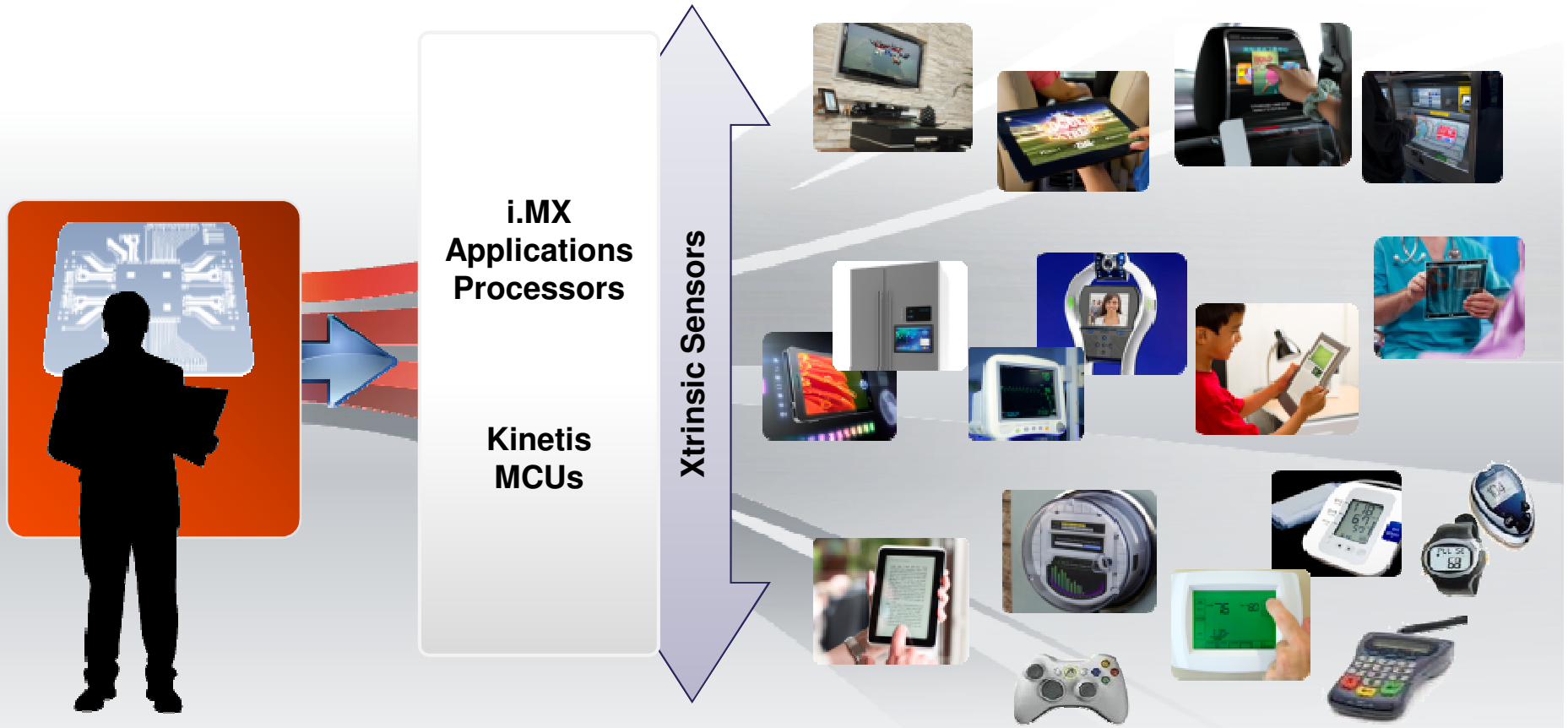
Wearable's Challenge

"Stickiness" of the wearable device: Must drive long-term engagement and impact behavior

- **Space**
- **Power Consumption & Charging**
- **Usability**
- **Cost**

WaRP – WearAble Reference Platform

Freescale: Broadest Portfolio to Support IoT Applications



Freescale serves more markets than any other supplier

- Broadest portfolio of ARM-based products in the industry
- World-class scalability and flexibility within product portfolios
- Products aligned with development needs for Internet of Things (IoT)
- Supported by Freescale Sensors

Creating Wearable Innovation

WaRP
Wearable Reference Platform

Key development challenges	• Form factor, battery life, cost and usability
Ecosystem	• Over 15 partners
Scalable	• Modular architecture to enable rapid platform evolution
Open Source	• Community drives innovation

Kynetics
Doers for Innovation

REVO
Revolution Robotics

WaRPboard.org

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WaRP Architecture

WaRP
Wearable Reference Platform

Small Form Factor	• Main board 38 x14 mm
Battery Life	• Key components selected for power mgmt capabilities • Hybrid Architecture: ARM® Cortex®A9 main compute engine and Cortex-M0+ sensor hub • Wireless Charging
Usability	• Hybrid architecture to allow improved user experience • Flexibility: LCD & E-Ink displays, Wi-Fi & BT 4.0 module • Android 4.3 for ease of development
Cost	• $149 sales price for the WaRP kit • Low cost BOM • Open Source Hardware & Software: BOM and design files available

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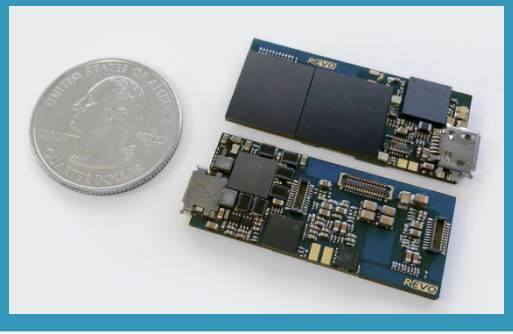
Wearable Reference Platform

- Speeds and eases development for creating wearable devices by addressing key technology challenges which frees developers to focus on creating differentiated features

WaRP

Wearable Reference Platform



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Bill of Materials – Open Source

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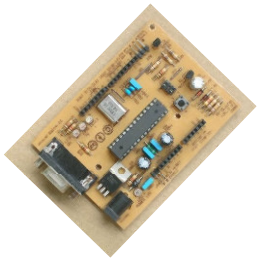
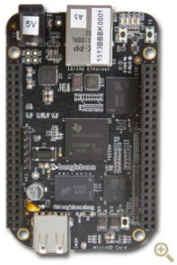
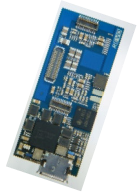
Wearable Reference Platform

Comment	Description	Designator	LibRef	Qty	Value	Footprint	Part No.
2450AT07A0100	Johanson Technology Inc 1mm x 0.5mm 2.4GHz Ultra Mini Chip Antenna	ANT1	2450AT07A0100	1		2450AT07A0100	2450AT07A0100
Coax RF		ANT2	Coax RF	1		W.FL-R-SMT-1	W.FL-R-SMT-1
Header 2	Header, 2-Pin	BAT	Header 2	1		Small Solder Pads	
CapacitorSM	Capacitor	C1, C4, C7, C11, C15, C56, C61, C75, C76, C77, C81	CapacitorSM	11	22uF	0603 (1608) Cap High Density	GRM188C80G226MEA0D
CapacitorSM	Capacitor	C2, C8, C9, C13, C18, C20, C16, C17, C19, C22, C23, C25, C26, C28, C29, C30, C31, C37	CapacitorSM	22	4.7uF	0402 (1005) Cap High Density	C1005X5R0J475M050BC
Capacitor	Capacitor	C34, C35, C119, C120	Capacitor	4	8pF	0201 (0603) Cap High Density	C0603C0G1E080D030BA
CapacitorSM	Capacitor	C38, C39, C40, C41, C44, C46, C47, C48, C52, C53, C54, C57, C58, C59, C62, C63, C64, C65, C68, C70, C91, C94, C95, C109, C110, C111, C113, C114, C116, C121, C134	CapacitorSM	31	0.1uF	0201 (0603) Cap High Density	GRM033R60J104ME19D
CapacitorSM	Capacitor	C42, C55, C60, C66, C67, C69, C71	CapacitorSM	7	0.01uF	0201 (0603) Cap High Density	GRM033R70J103KA01D
CapacitorSM	Capacitor	C50, C51, C79	CapacitorSM	3	4.7uF	0603 (1608) Cap High Density	GRM188R60J475ME19D
CapacitorSM	Capacitor	C74, C82, C84, C85, C87, C88, C93, C106, C107, C123, C124, C126, C127, C131, C132	CapacitorSM	15	1uF	0201 (0603) Cap High Density	C0603X5R0J105M030BC
CapacitorSM	Capacitor	C78, C80, C86, C122, C133	CapacitorSM	5	2.2uF	0402 (1005) Cap High Density	LMK105BJ225MV-F
CapacitorSM	Capacitor	C83, C96, C98, C102, C104, C125	CapacitorSM	6	1uF	0402 (1005) Cap High Density	C1005X5R1V105M050BC

A full bill of materials will be provided on WaRPboard.org for product development

Reference Design Comparison for Wearable projects



	Raspberry Pi	Arduino	Beagle Bone Black	ToQ	WaRP
Wearable Form Factor	No Wi-Fi or BT			Yes – Smart Watch	
Battery Life	DC power	DC or Battery	DC Power or USB	Mirasol Display	
Scalability	Arduino compatible			None	
Cost	$25	$110	$45 -$89	$399	$149
Open Source		Creative Commons			
Productizable					

Processor selection: MCUs vs Apps Processors

MCUs optimized for simple, single function solutions

MPUs provide higher performance, ability to run a full operating system and an SDK for applications development .

A hybrid approach addresses:

- The diversity of the wearable's market
- Optimized, scalable power management
- Small footprint

Application Examples

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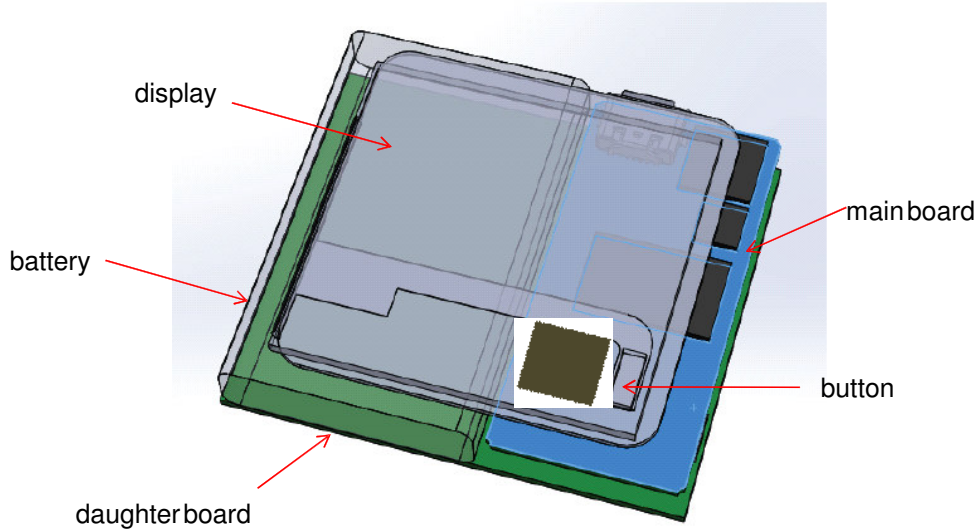
- Time, chrono, lap time, alarms
- Smart music player with audio streaming to headset
- Photo gallery and video player
- Bluetooth Smart Pairing with Android Device
- Wi-Fi connectivity
- Compass
- Free fall detection
- Pedometer / activity monitor
  - Distance traveled
  - Calories
- Wake up on motion
- Charging over USB
- Wireless charging
- Phase 2: ECG & Heart Rate Monitoring



Block Diagram

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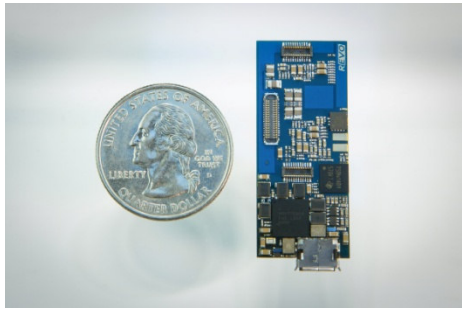
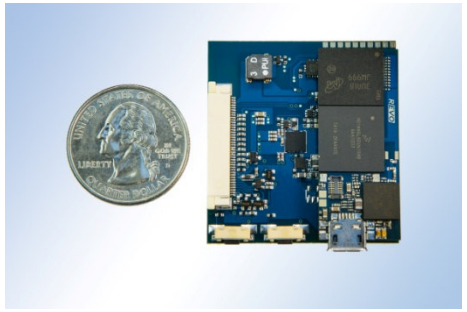
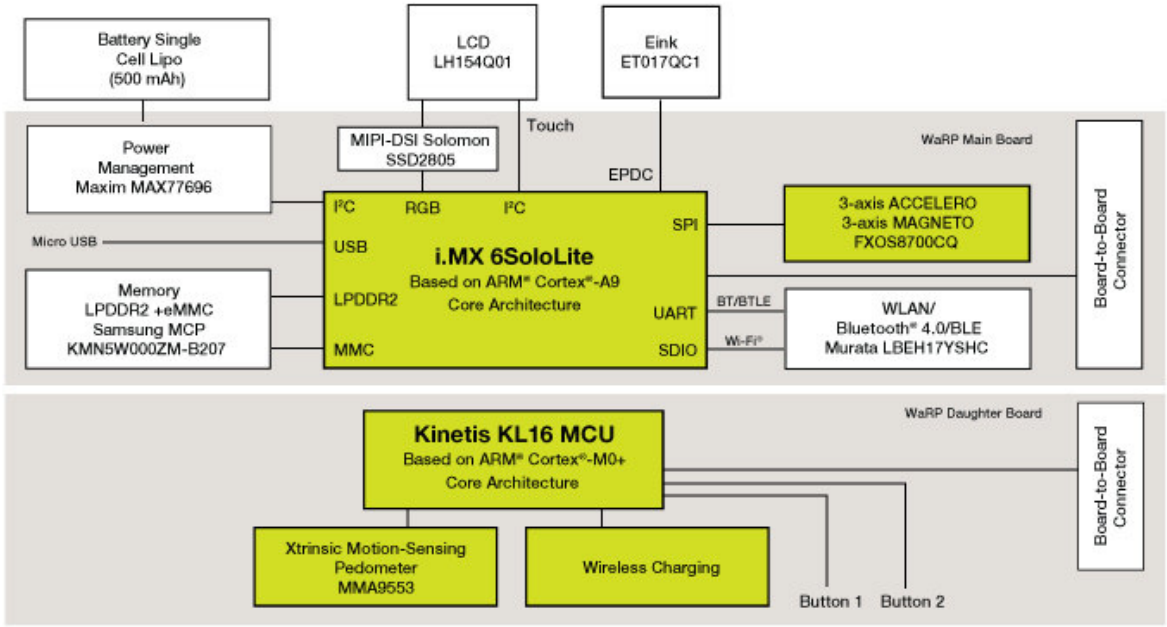
Main Board PCB size:
38 mm x 14 mm
(1.49”x 0.55”)





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

Wearable Reference Platform (WaRP) with Standard Daughter Board



Freescale Technology

Designed to be able to productize

Main Board

Main Board PCB Design

Wearable Reference Platform

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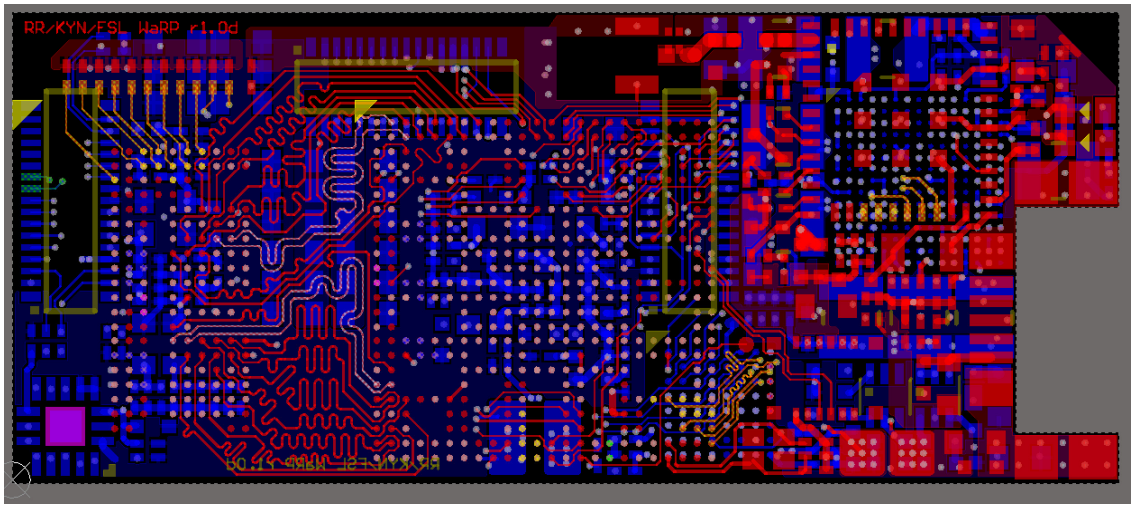
- Small form factor through tight design
  - The hard work of integrating hardware into small form factor is done by WaRP so you can focus resources on the application.
- Main Board PCB Specifics
  - 16 x 38mm footprint for main board which includes all critical functions.
  - 10 layers
  - Blind/Buried vias using HDI (high density interconnect) PCBs - same/similar tech used in mobile phones.



Main Board

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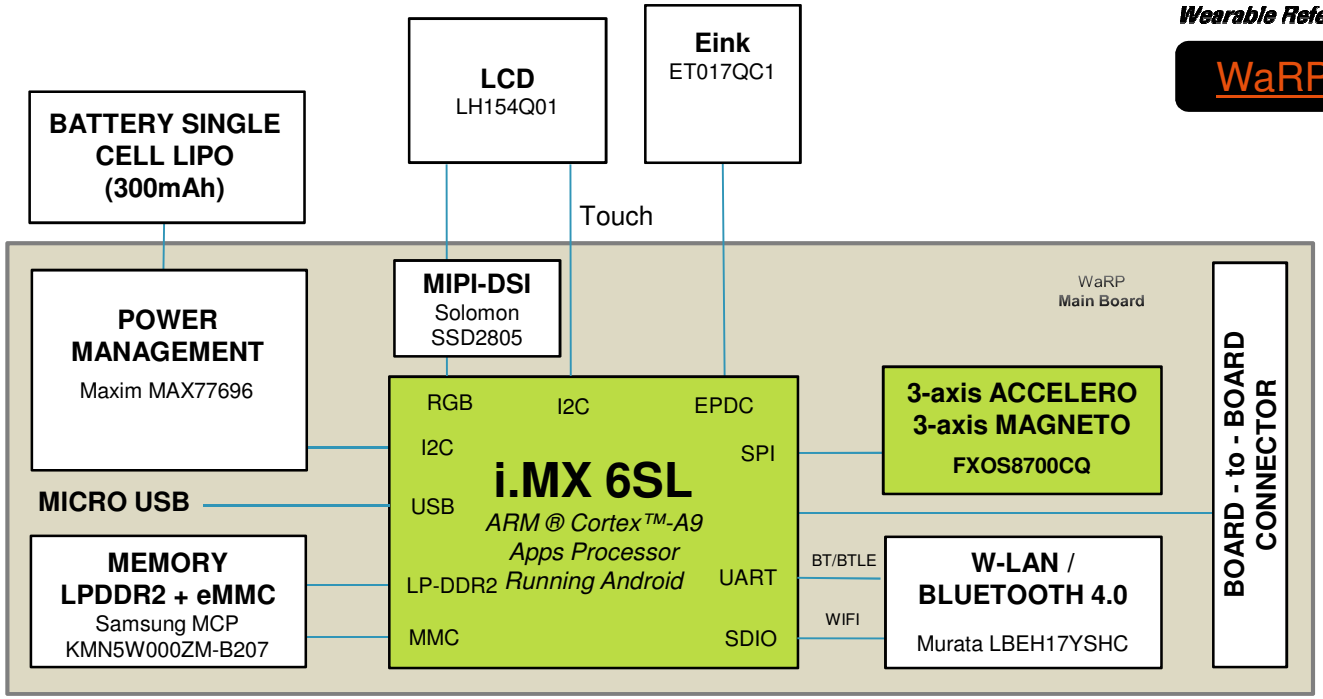
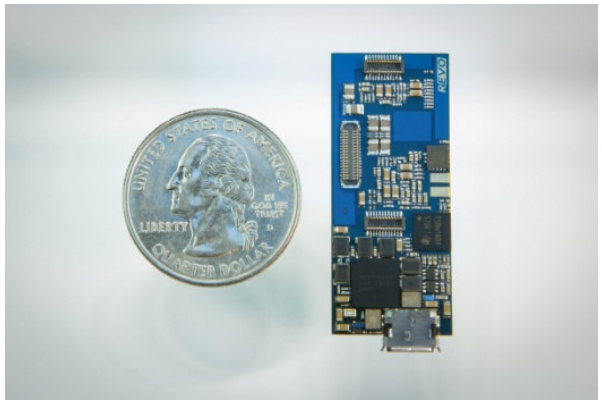




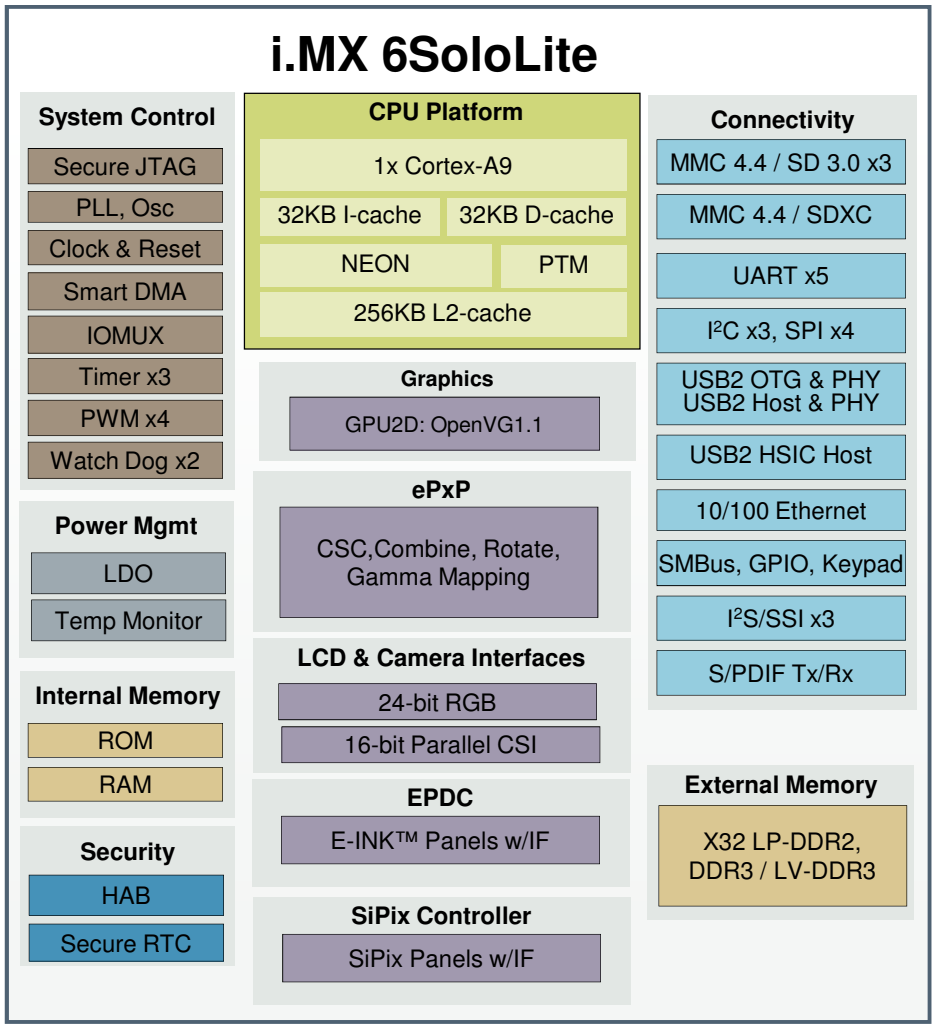
Main Board PCB size:
38 mm x 14 mm
(1.49”x 0.55”)

WaRP Main Board Components

Component	Use Case	Reason Selected
Freescale MCIMX6L7DVN10AB	Main compute engine – connectivity, data processing, user interface. Runs Android.	Small footprint (13x13mm), eInk display support, low power apps processor
Murata LBEH17YSHC Wireless Module	Wi-Fi® (802.11 b/g/n) – connect to cloud Bluetooth® – tether to smartphone/tablet	Small form factor (7x7mm) single module. market tested (cell phones), low power
Samsung MCP KMN5W000ZM-B207	LP-DDR2 – low power system memory 4GB eMMC for storage	Small tightly coupled design, saves up to 40% board space, consumes less energy
Eink EPD (ET017QC1) and LCD (LH154Q01) display options	Graphic User Interface - options for both interactive highly visual displays (LCD) to constant always-on notification displays using monochrome e-ink	E-Ink panel - lowest power display technology, LCD panel – most broadly used 1.5” high density display with touch in wearables
Maxim MAX77696 PMIC	System Power Management IC	Regulators from 2.6V to 5.5V Dual Input Battery Charger Supports both E-Ink and LCD displays
Xtrinsic FXOS8700CQ 6DOF eCompass Sensor	Direction awareness & Motion detection – included on main board to allow it to be a standalone wearable compute platform	Low noise, low offset 3-axis accelerometer + magnetometer eCompass sensor enabling <5º absolute heading accuracy and ±0.1º resolution performance
Single cell lipo battery	Power source	Provides highest energy density

i.MX 6SoloLite Multimedia Processor

- **Specifications**
  - CPU: 1x ARM® Cortex®-A9 @ 1GHz
  - Core Voltage: 1.1V
  - Package: 0.5mm 13x13 MAPBGA
- **WaRP Use Case**
  - Lower active & stand by power via:
    - Clock/power gating
    - Dynamic voltage & frequency scaling
  - x32 LP-DDR2 & managed NAND
  - EPD /LCD Controller & 2D GPU
  - USB OTG 2.0 for charging and for updates to the end device
  - Interfaces: UART for BT, SDIO for Wi-Fi, SPI for the accelerometer

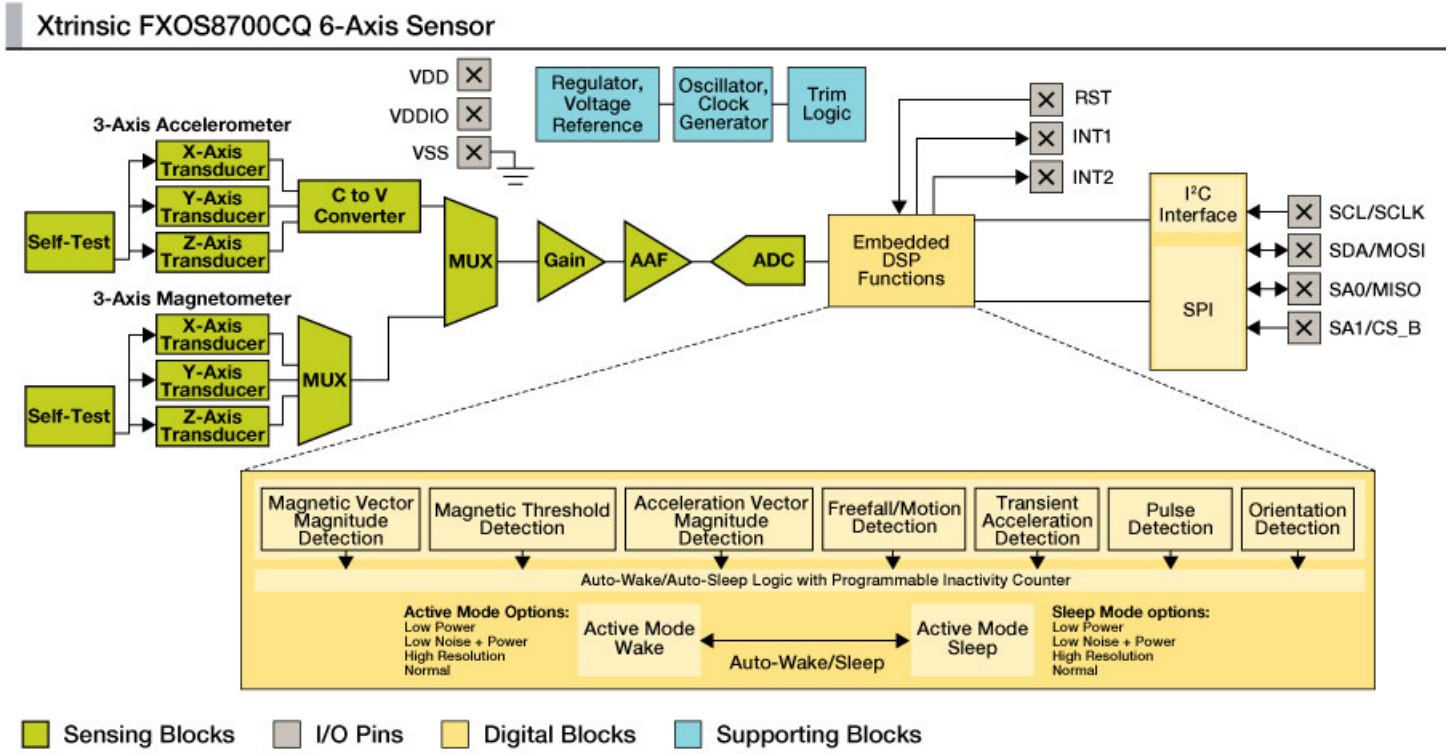


Xtrinsic FXOS8700CQ 6DOF eCompass Sensor

Low noise, low offset 3-axis accelerometer + magnetometer eCompass sensor enabling <5º absolute heading accuracy and ±0.1º resolution performance

Differentiating Points

- 14b data gcell ADC with 33% lower noise and 3x lower offset
- 16b data mcell ADC with 0.6 uT-rms noise density
- Vector magnitude change detection for faster system response and lower power
- Autonomous hard iron calibration
- Production-ready calibration and award winning eCompass software
- Pin compatible with Freescale accelerometer portfolio



Daughter Board

Daughtercard PCB Design

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- Optimized for low cost
- Daughtercard PCB Specifics
  - 42 mm x 42 mm footprint
  - 2 layer board
  - No blind vias
  - Easy to manufacture

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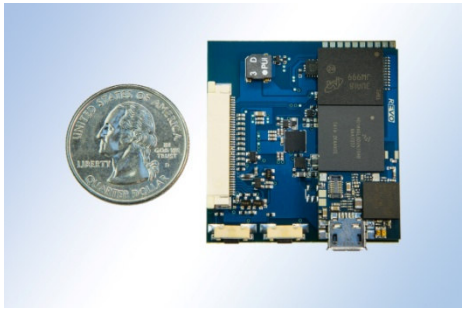

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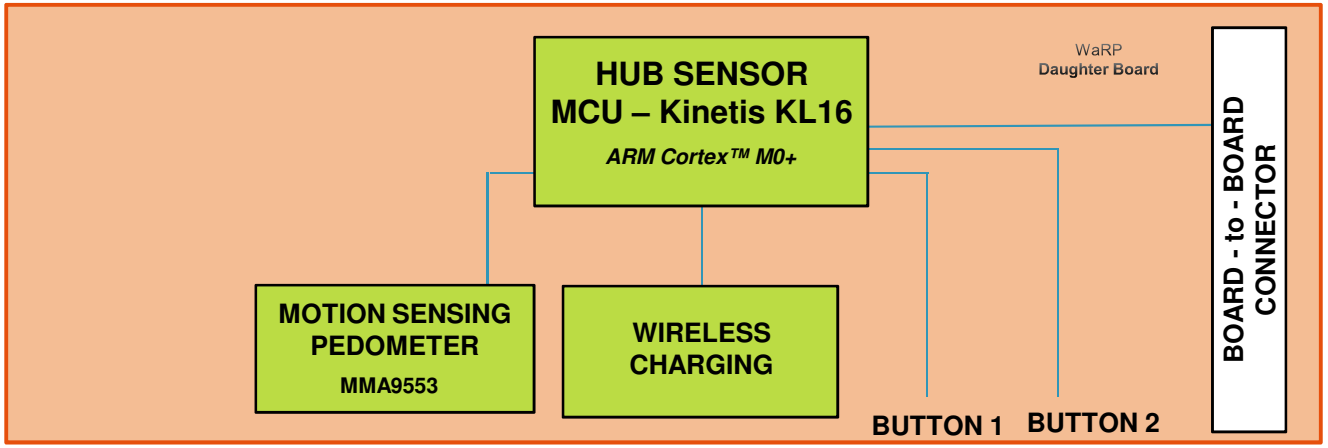
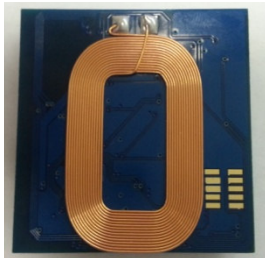
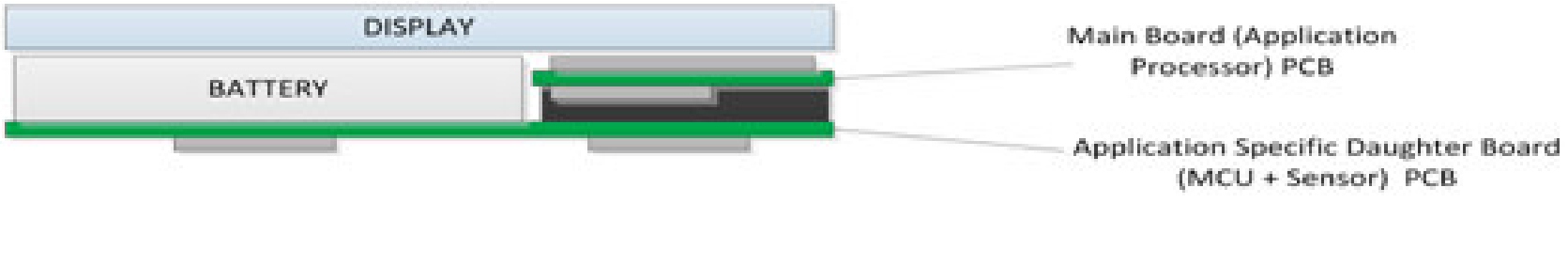




- Top view with battery attached
- Bottom View – Charging Coil



Daughter Card Components

Component	Use Case	Reason Selected
Kinetis KL16 - MKL16Z128VFT4	Sensor Hub, system power and application manager to maximize battery life and hosts wireless charging.	Always active so needed low power MCU. Scalability to add or change function of daughtercard
Xtrinsic MMA955xL 3-Axis Accelerometer	Pedometer features	Intelligent Motion Platform with embedded libraries for pedometer. Power management features and low power modes
Vishay 5W Charging Coil	Charging	Supports Chi standard, small size and is broadly available
Wireless Charging Software	Innovative charging technologies are critical to the adoption of wearables	Chi compliant wireless charging embedded software for 5Watts – configurable

Kinetis L Series: Low Power Pillars

Ultra-efficient Cortex-M0+ processor

- Most energy-efficient 32-bit processor on the market with industry leading throughput/mA

Energy-saving architecture

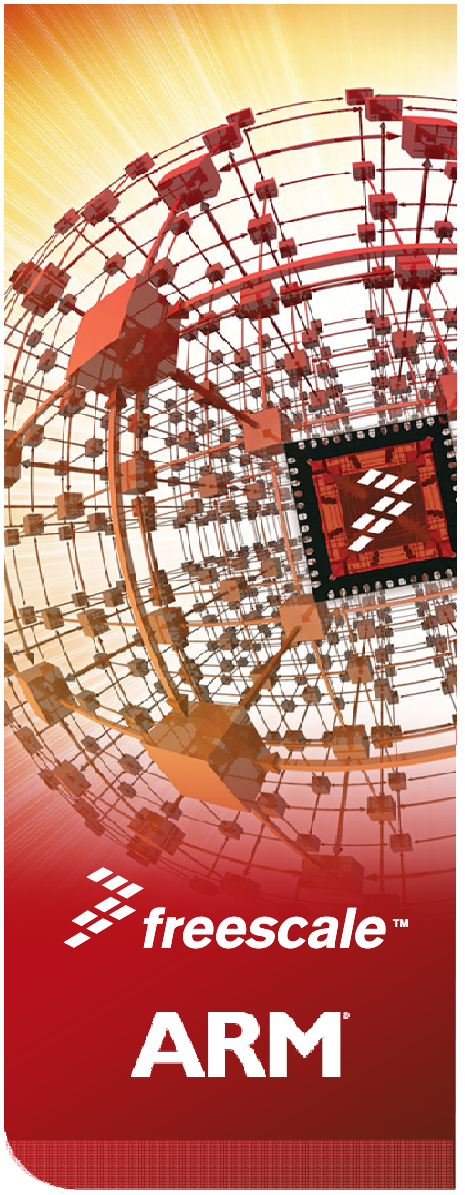
- Optimized for low power with 90nm TFS technology, clock and power gating techniques, and highly efficient platform featuring a low power boot option, bit manipulation engine, peripheral bridge crossbar and zero wait state flash memory controller

Ultra-low power modes

- Several, flexible power modes fit for different application use cases designed to maximize battery life

Energy-saving peripherals

- Smart peripherals with functionality in deep sleep modes can make intelligent decisions and process data without waking up the core



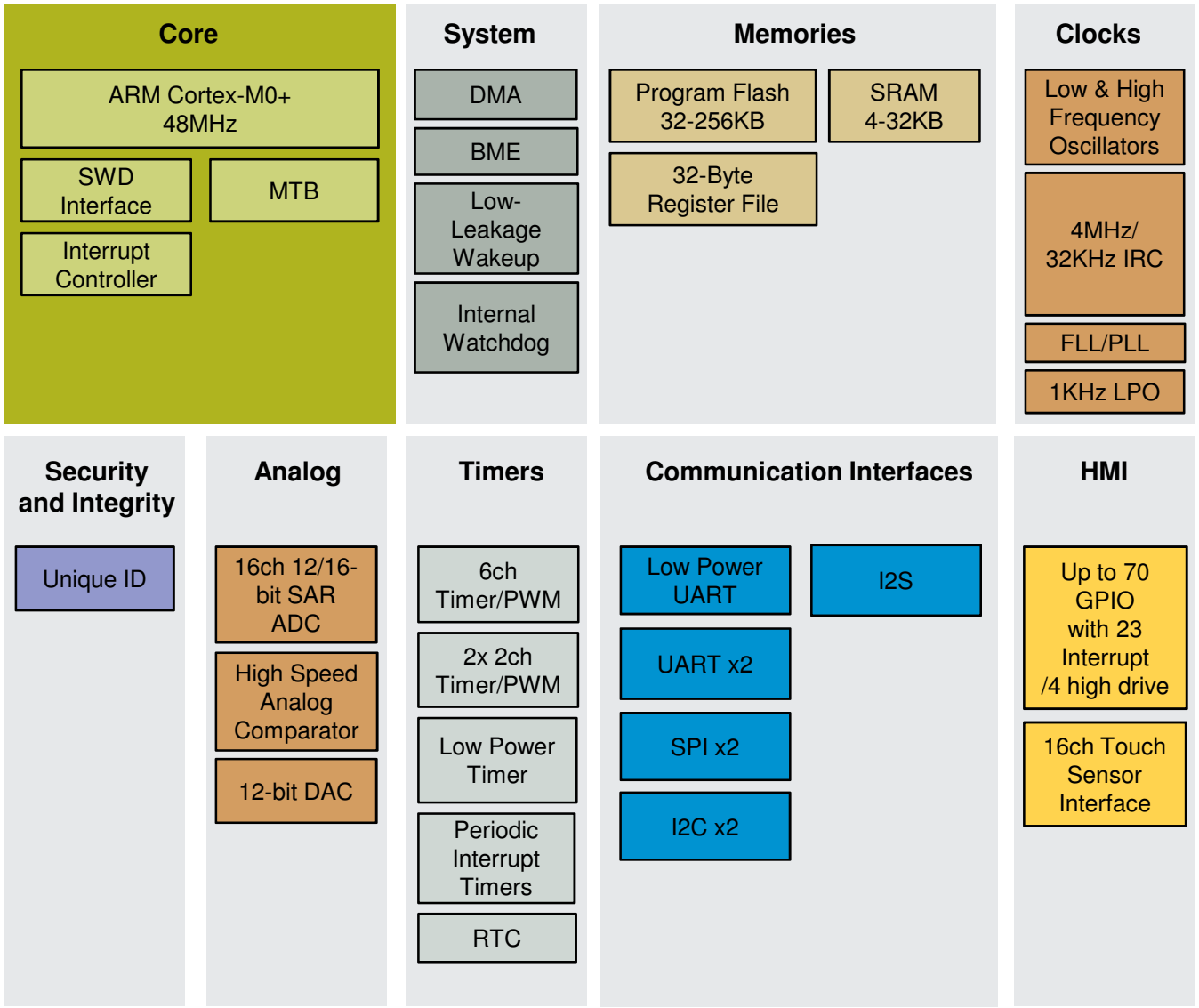
Kinetis L Series MCUs: KL16 Block Diagram

Specifications

- CPU: 1x ARM Cortex-M0+ @ 48MHz
- 32QFN 5x5x1/0.5mm

WaRP Use Case

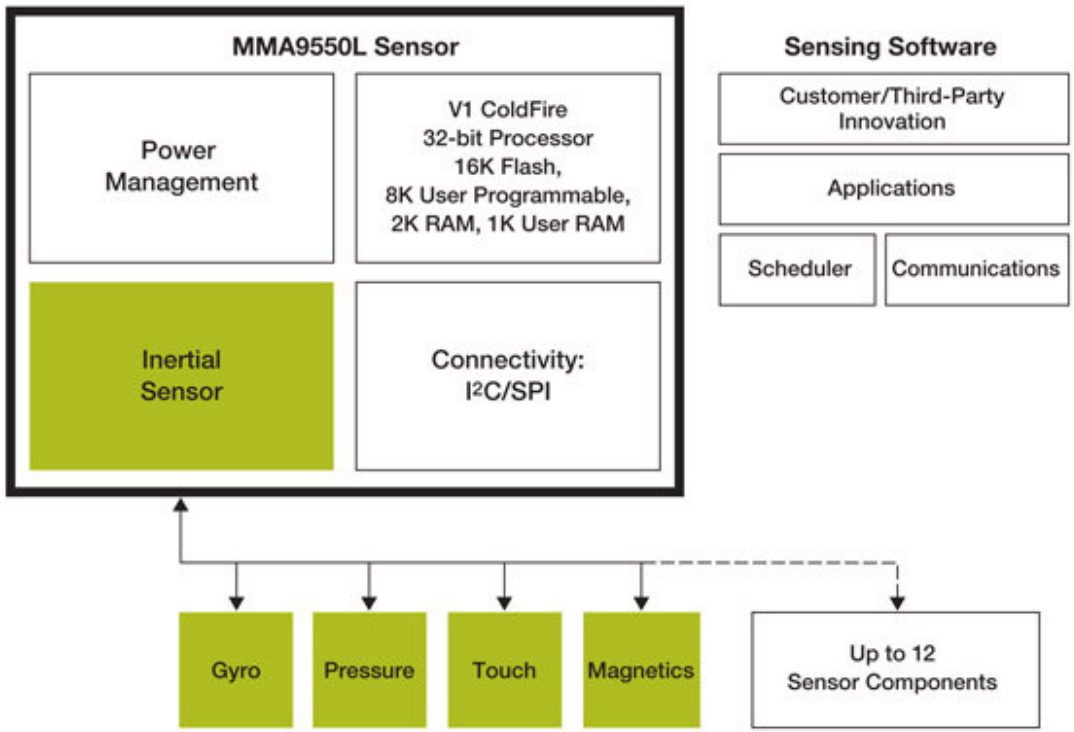
- UART for communication to the main board
- PWM for buzzer (notifications)
- I2C to motion detector sensor
- SPI to E-Ink display for power management
- GPIO for buttons



Xtrinsic MMA955xL Variations

- MMA9550L
  - Infrastructure only functions
  - User Flash: 6.5 Kbytes
  - User RAM: 576 bytes
- MMA9551L
  - Infrastructure plus gestures
  - User Flash: 4.5 Kbytes
  - User RAM: 452 bytes
- MMA9553L
  - Infrastructure plus pedometer
  - User Flash: 1.5 Kbytes
  - User RAM: 200 bytes
- MMA9559L
  - Lightweight Infrastructure
  - User Flash: 14 Kbytes
  - User RAM: 1.5 bytes

MMA9550L Block Diagram

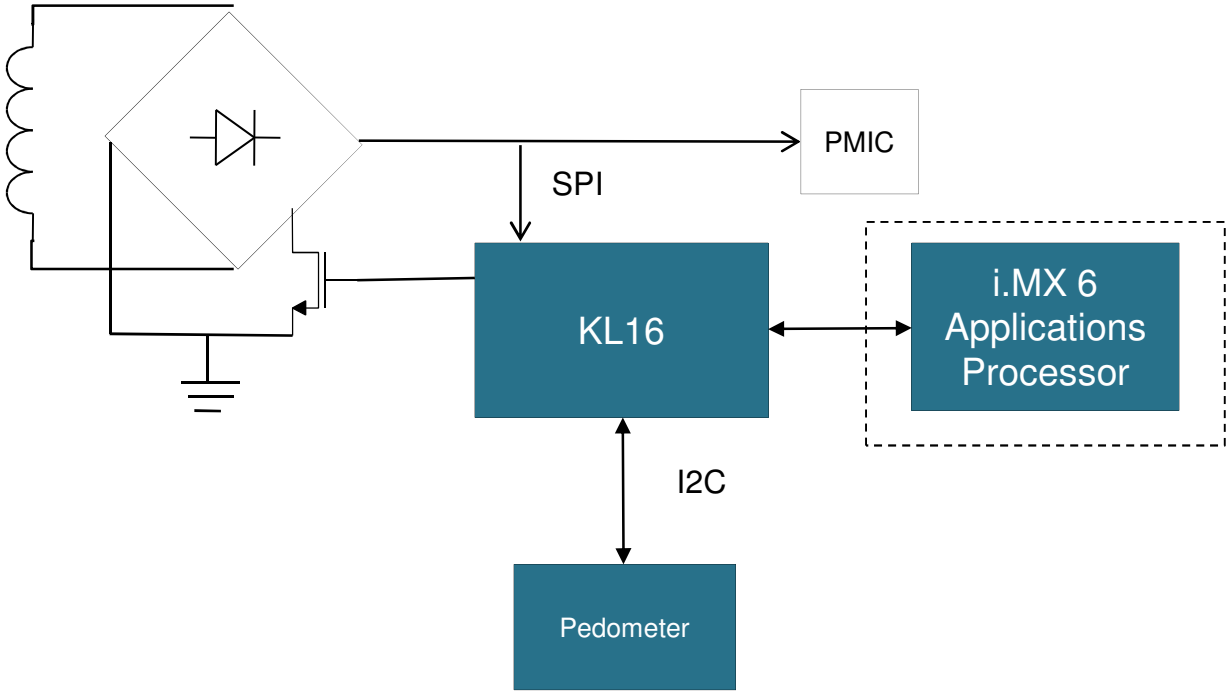


Software

- Full enablement suite of tools including Freescale CodeWarrior
- Project Wizard creates project in as few as nine clicks
- CodeWarrior optimizing C/C ++ compilers for ColdFire included
- Integrated support for hardware background debugger

Wireless Charging Receiver

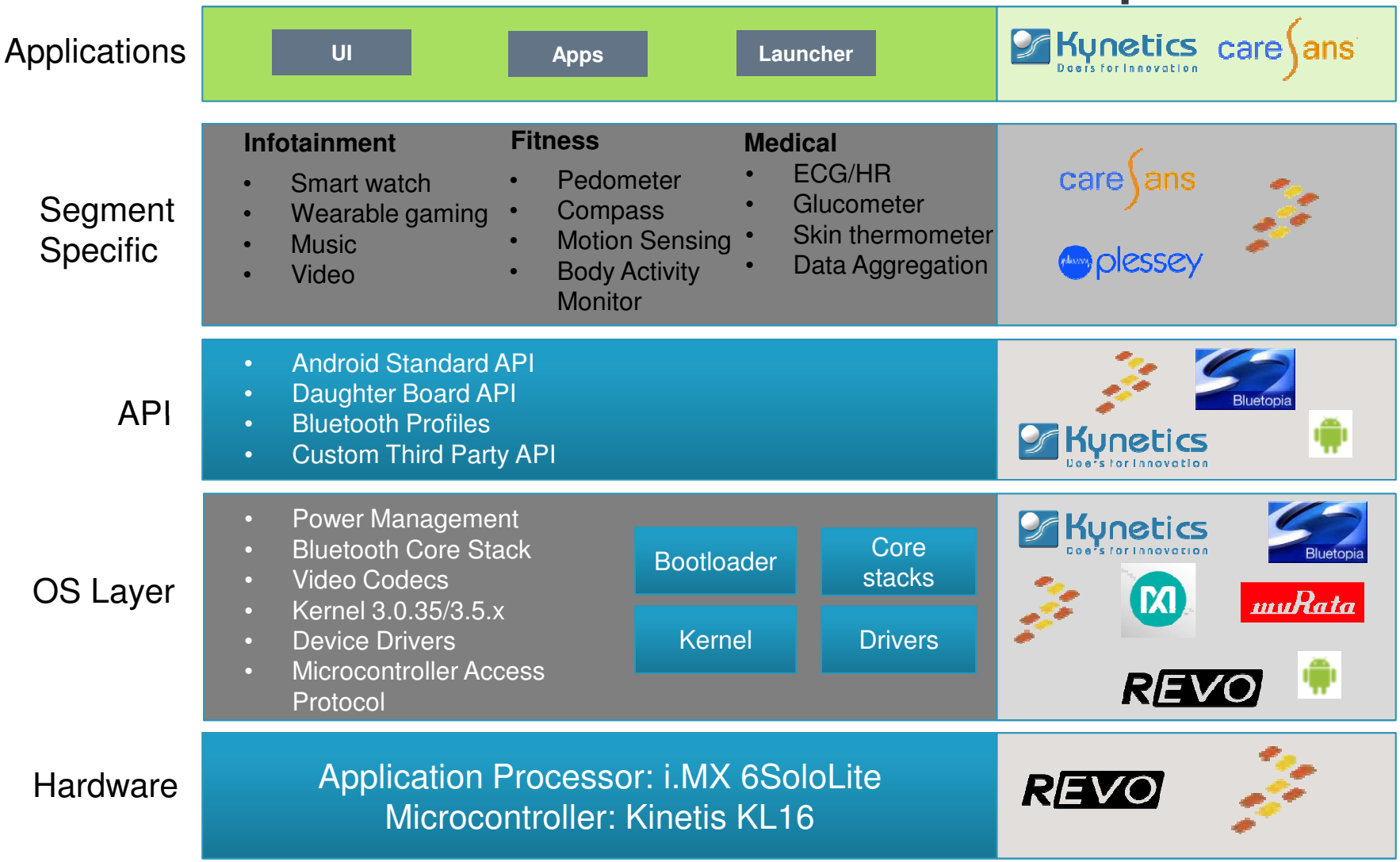
- Uses the latest industry standard – Chi standard
- Charge without the bulky micro-USB connector to create a true connector-less device and minimize form factor
- Implements a discrete topology to offer ultimate flexibility over ASIC solution
- Uses commercially available components - no special components required
- Provides ease of implementation with software provided in library format



WaRP

Software Details

WaRP: Software Architecture and Completeness



What is Android?

Connectivity	LTE to NFC On-demand and autonomously
Context Awareness	System capable of higher-level concepts, functions, and behaviors
Interactive and Intelligent	Learn behaviors based on user's response. Natural user interface: Spoken, gestures.
Extensible	Application Framework capable of performing a combinatorial set of tasks

WaRP Android Software Implementation

Connected	Fully connected stack accessible via Java SDK Flexible recovery system for OS updates
Extensible	Large developer community can leverage full standard Android SDK & standard dev tools Open platform – two BSP versions, full open source & advanced optimized via click through license
Interactive & Intelligent	Android is only OS with an optimized & lightweight surface renderer & advanced touch human interface
Context Awareness	Extension of SDK used simple messaging system to interface with daughter card & access data from sensors

Android Wear – What's The Impact

What it is

- The released SDK includes API libraries & dev tools to build, test & debug apps for devices running Android Wear.
- Similar to the GDK for Google Glass – The Glass OS can be installed only on Google Glass and is solely owned by Google
- **Google have not released the source code** therefore cannot be ported to the WaRP board or any third party platform at this time.

What it's not

- NOT Open Source
- NOT Applicable to all wearable's – currently just Smart Watches
- NOT a stand alone OS – Android Wear still requires interoperability with phones and tablets

Launch & Community

Community

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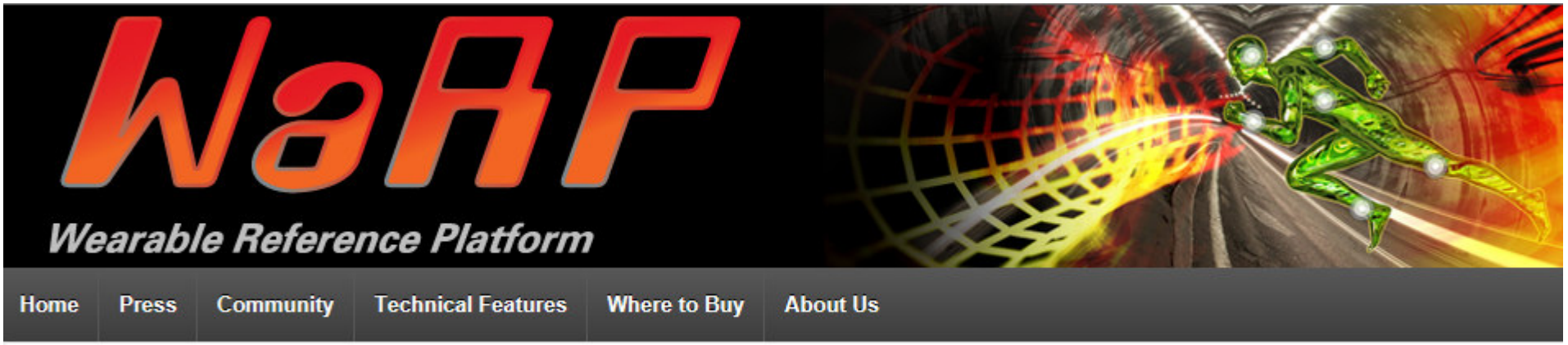
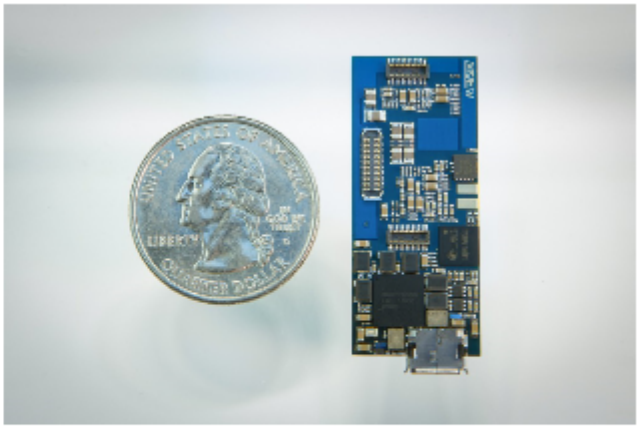


WaRP community can help you tackle challenges, develop quickly and innovate!

- Includes main board, sensor hub daughtercard, LCD display, battery and mini-USB cable
- Target MSRP $149



Community driven by CIrcuitco

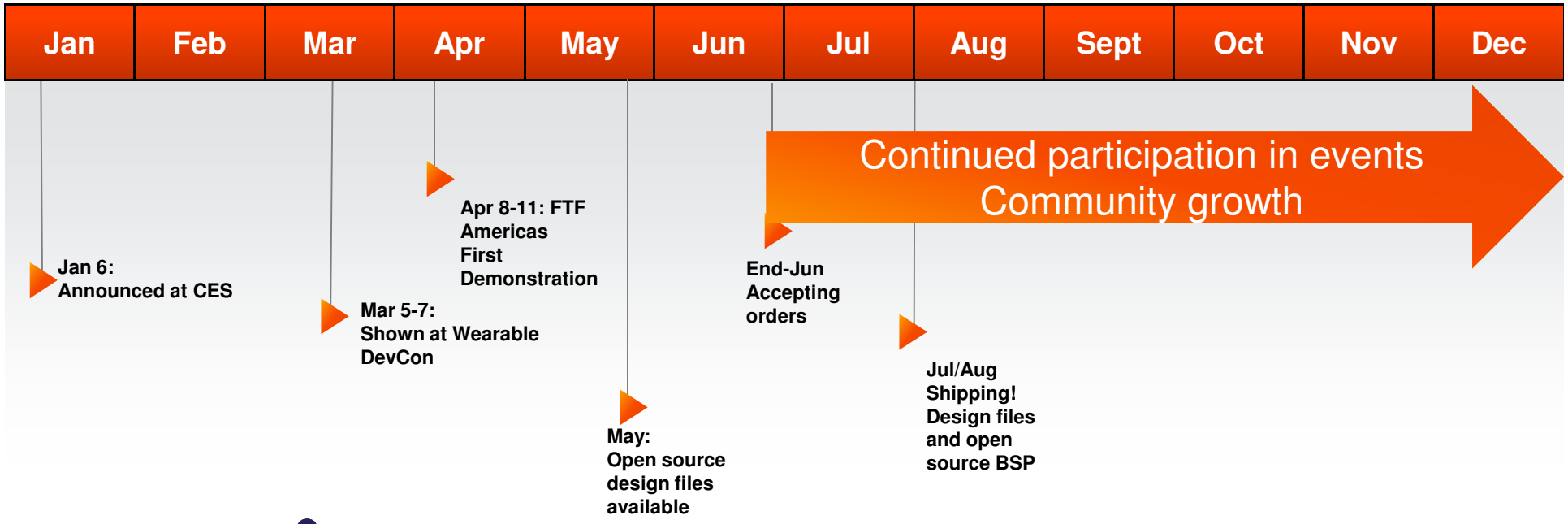
Technical Features

WaRP Timeline Calendar

- **Available Now**
  - WaRPboard.org Website
  - Block Diagram
  - WaRPboard Google Group

- **Ordering**
  - WaRPboard.org
  - Distributors – Arrow and Avnet

WaRP
Wearable Reference Platform
WaRPboard.org



(A) Announcement, (L) Launch, (FML) Full Market Launch

Wearables Summary

WaRP
Wearable Reference Platform

Versatile Applications
More than just smart watches! The possibilities are endless.

Scalable, Modular and Open Source
WaRP is a scalable, modular, and open source reference platform provided by Freecale, Kynetics, Revolution Robotics and Circuitco that will evolve with market and enable innovation.

Productizable
Form factor board that can be productized because components are all readily available

Growth Opportunites
Growing market covering multiple vertical segments

www.Freescale.com