



Create a Wearable Device with a Hybrid Architecture

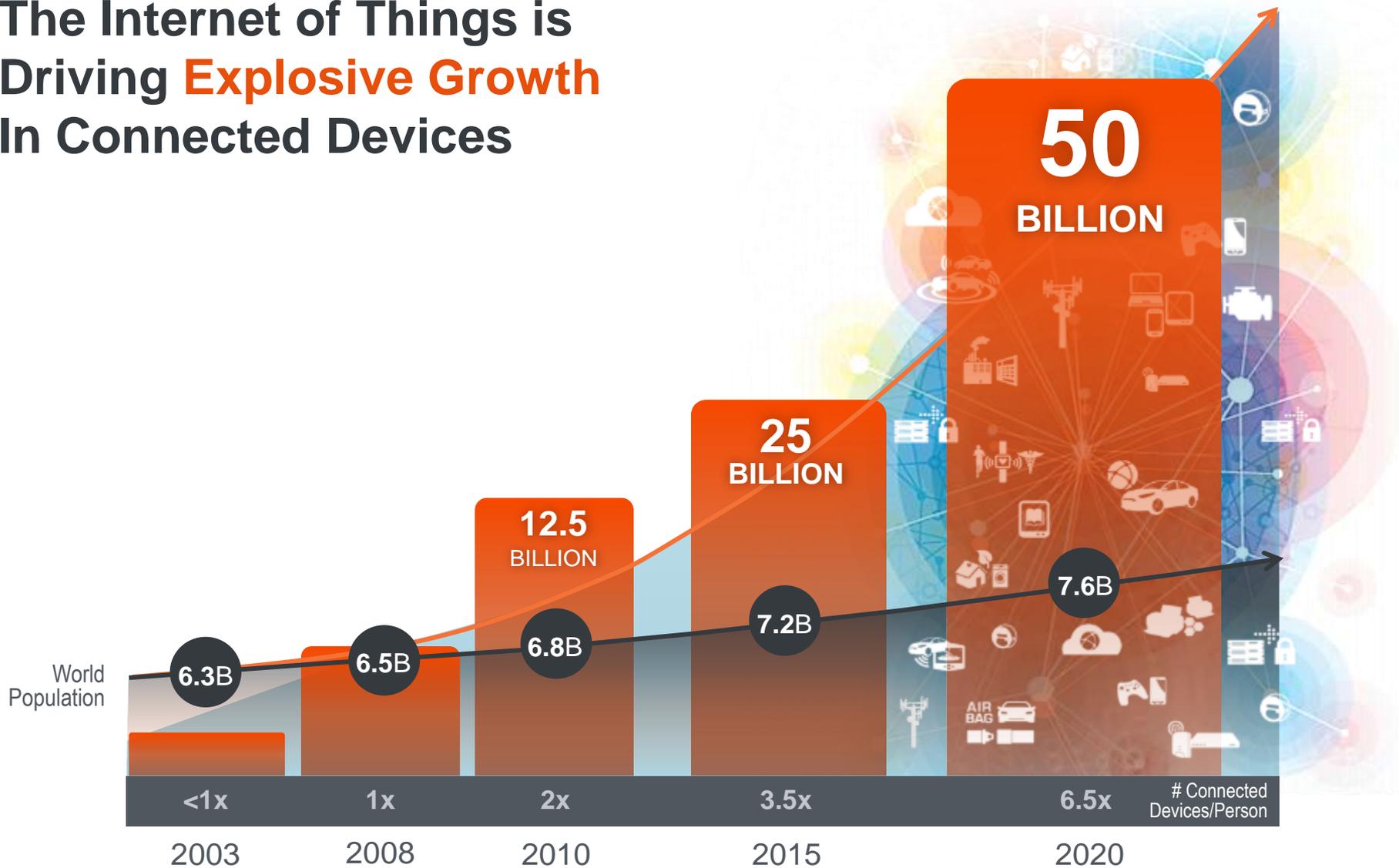
WaRPboard.org

KT Ahn | Business Development Manager

Oct. 2014



The Internet of Things is Driving Explosive Growth In Connected Devices



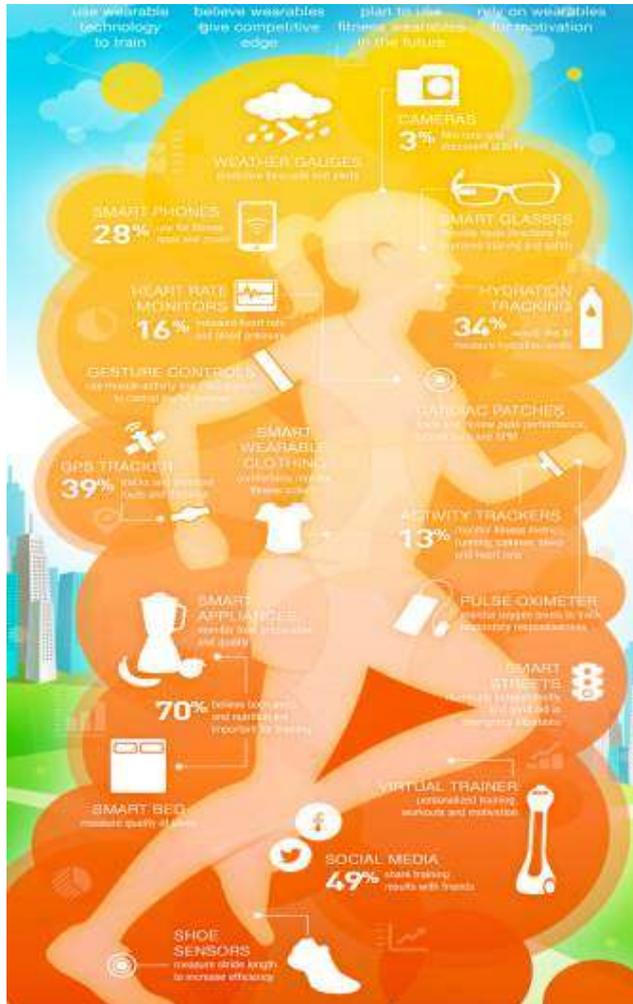
What Is A Wearable Device?

- 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

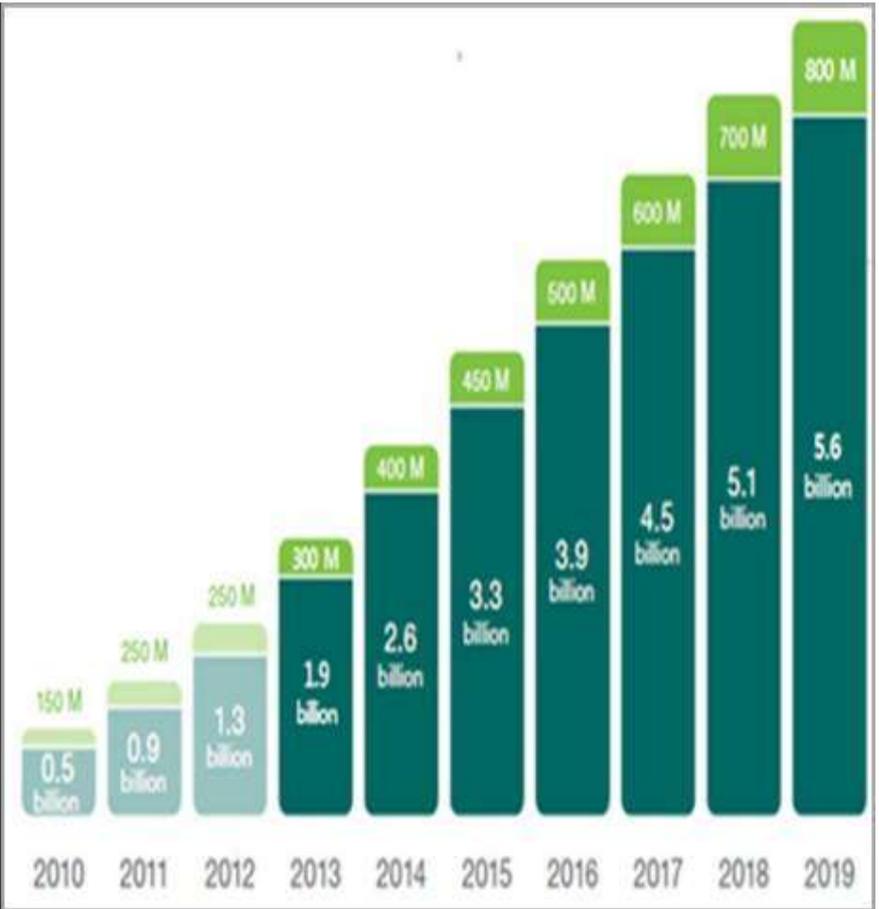
Smart Device Market Trend

Smart phone growth Trend



Source : Flurry Analytic & KT E&M Research

Smart device market forecast



Source : Ericsson Mobility

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

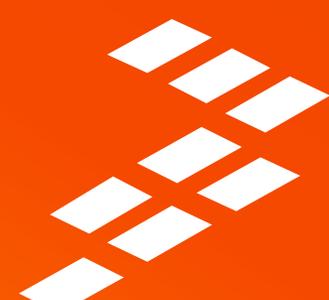


Wearable's Challenge

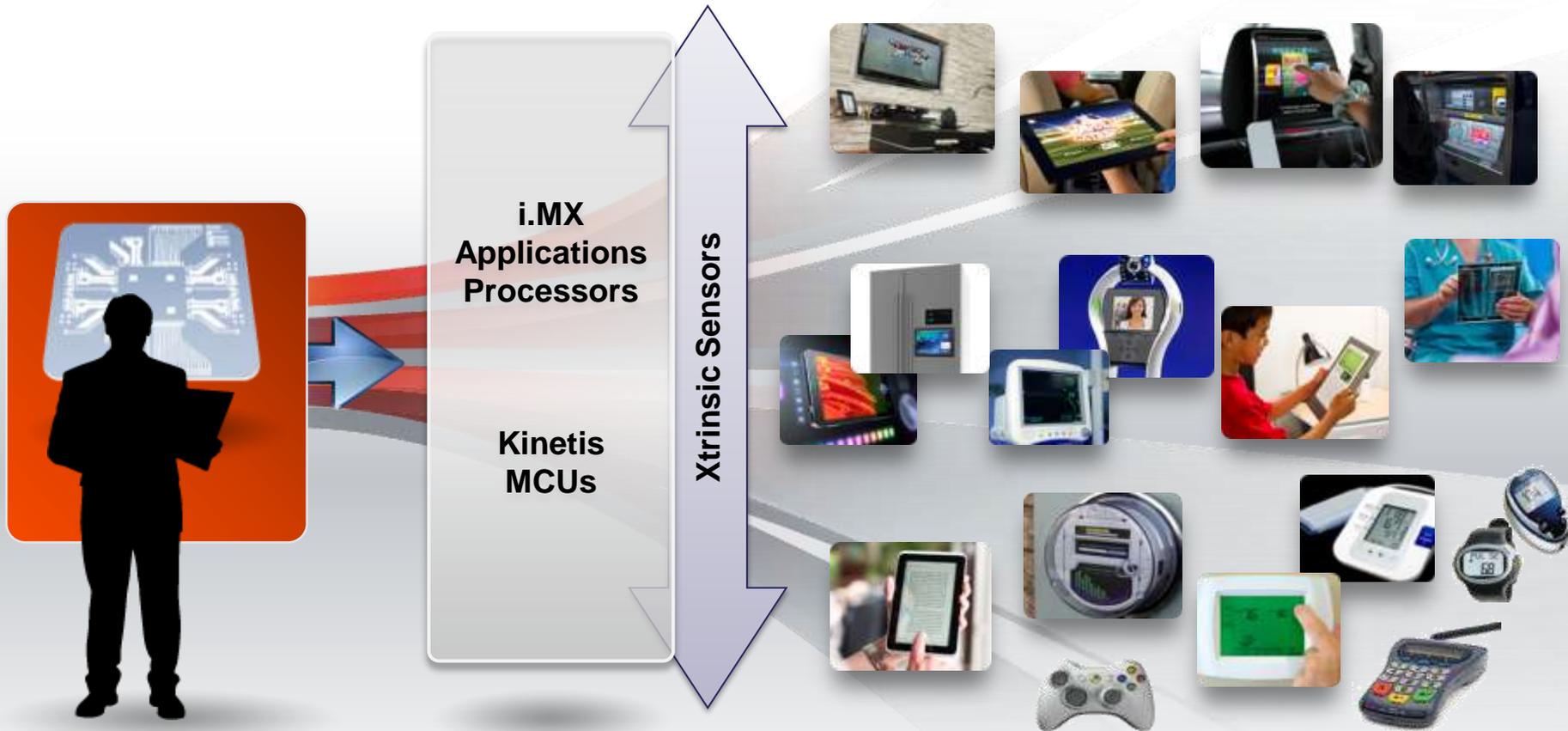
“Stickiness” of the wearable device: Must drive long-term engagement and impact behavior

- ✓ 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



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



WaRPboard.org



WaRP Architecture



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



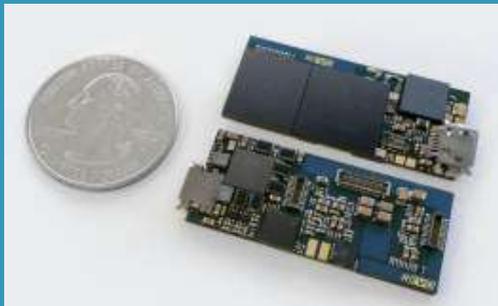
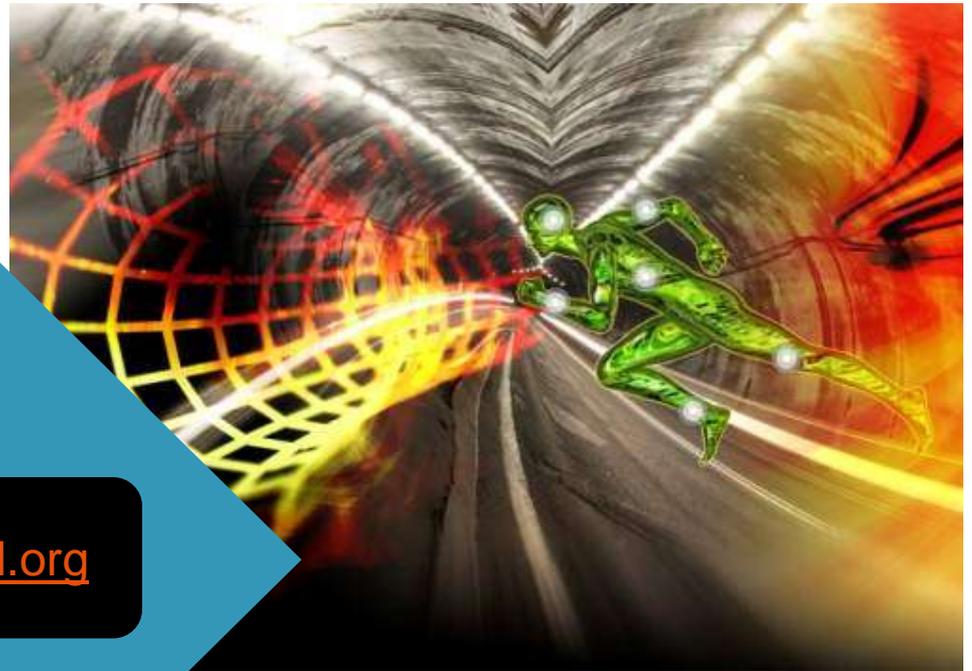
WaRPboard.org



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



WaRPboard.org

Bill of Materials – Open Source

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	GRM188C80G226MEA0 D
CapacitorSM	Capacitor	C2, C8, C9, C13, C18, C20	CapacitorSM	22	4.7uF	0402 (1005) Cap High Density	C1005X5R0J475M050BC
CapacitorSM	Capacitor	C3, C5, C6, C10, C12, C14, C16, C17, C19, C22, C23, C25, C26, C28, C29, C30, C31, C37	CapacitorSM	18	0.22uF	0201 (0603) Cap High Density	C0603X5R0J224R050BD
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

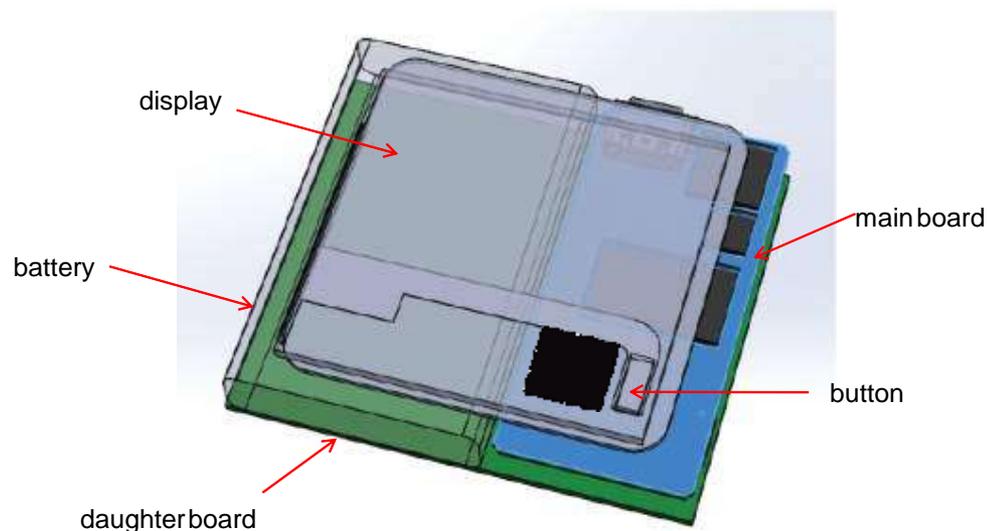
MPUs provide higher performance, ability to run a full operating system and an SDK for applications development .

A hybrid approach addresses:

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

Application Examples

- 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

WaRP

Wearable Reference Platform

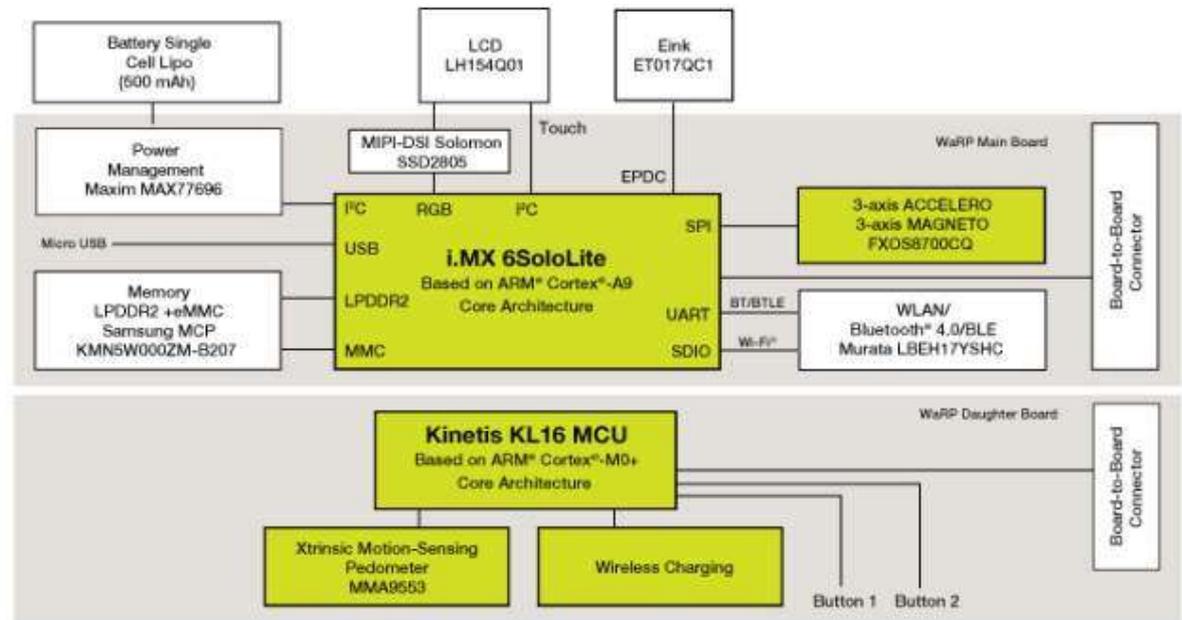
WaRPboard.org

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

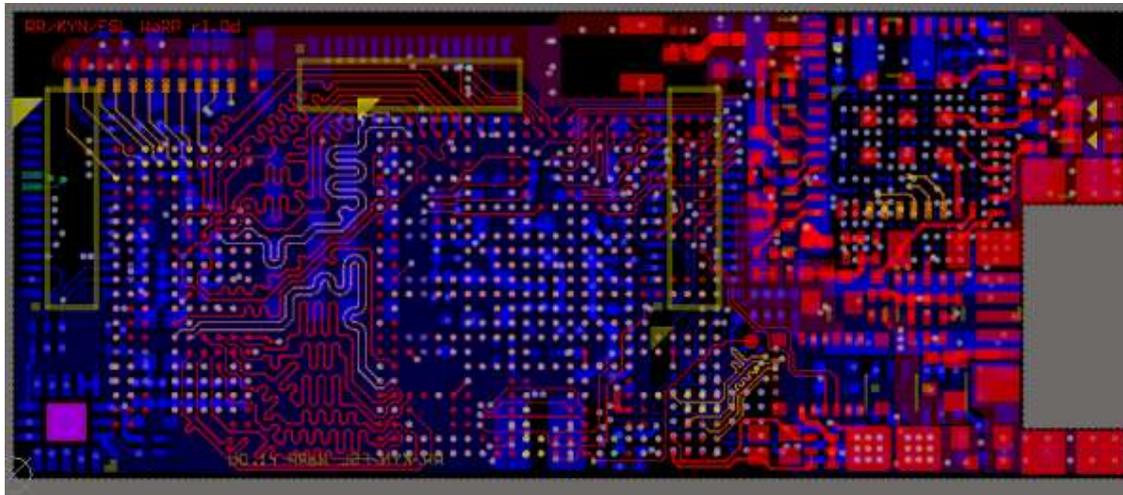




Main Board

Main Board PCB Design

- 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.



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 <math><5^\circ</math> absolute heading accuracy and $\pm 0.1^\circ</math> resolution performance$
Single cell lipo battery	Power source	Provides highest energy density

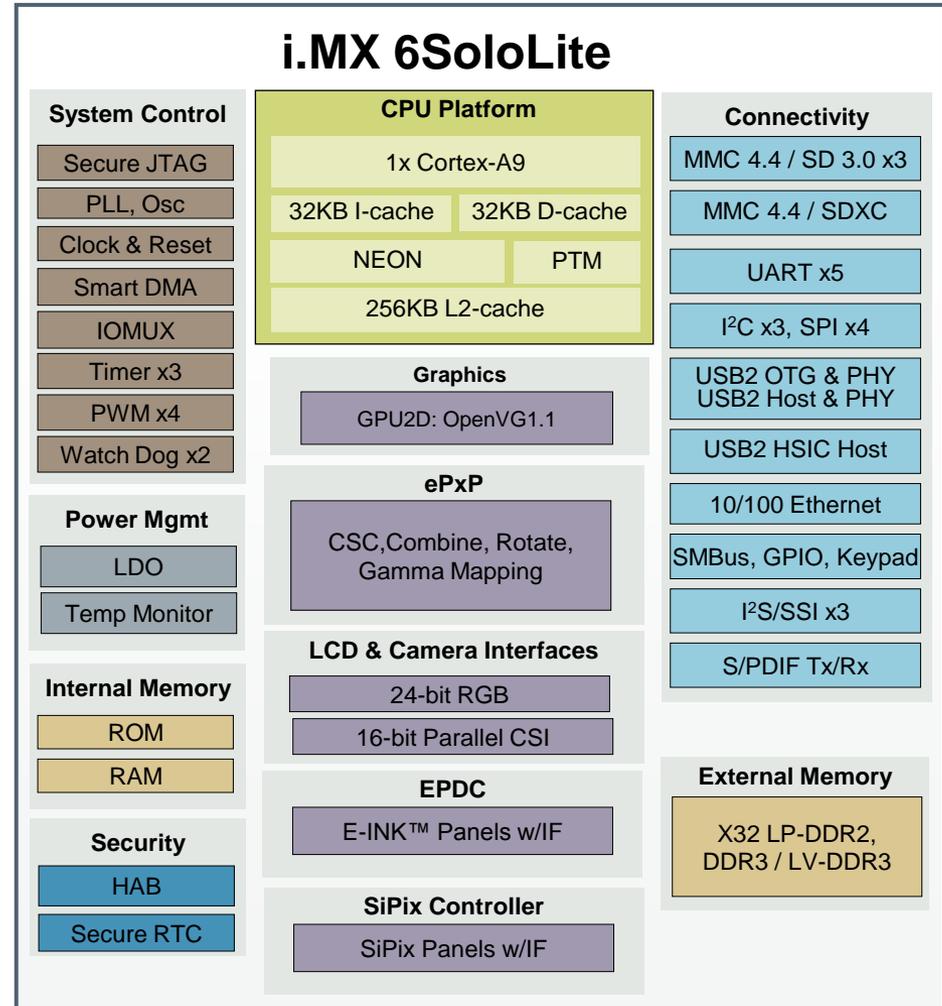
i.MX 6SoloLite Multimedia Processor

• 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

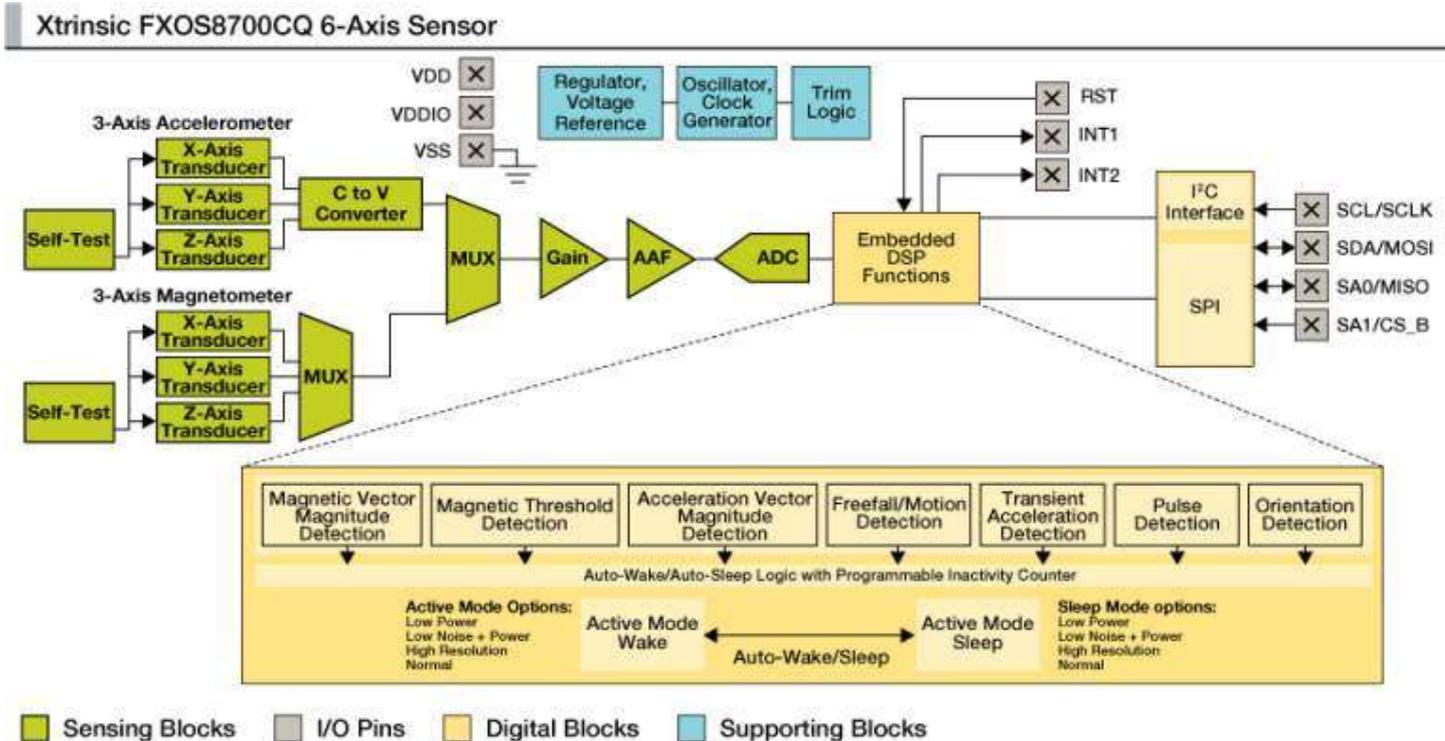


Xtrinsic FXOS8700CQ 6DOF eCompass Sensor

Low noise, low offset 3-axis accelerometer + magnetometer eCompass sensor enabling <math><5^\circ</math> absolute heading accuracy and $\pm 0.1^\circ$ 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

Daughter Card PCB Design

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

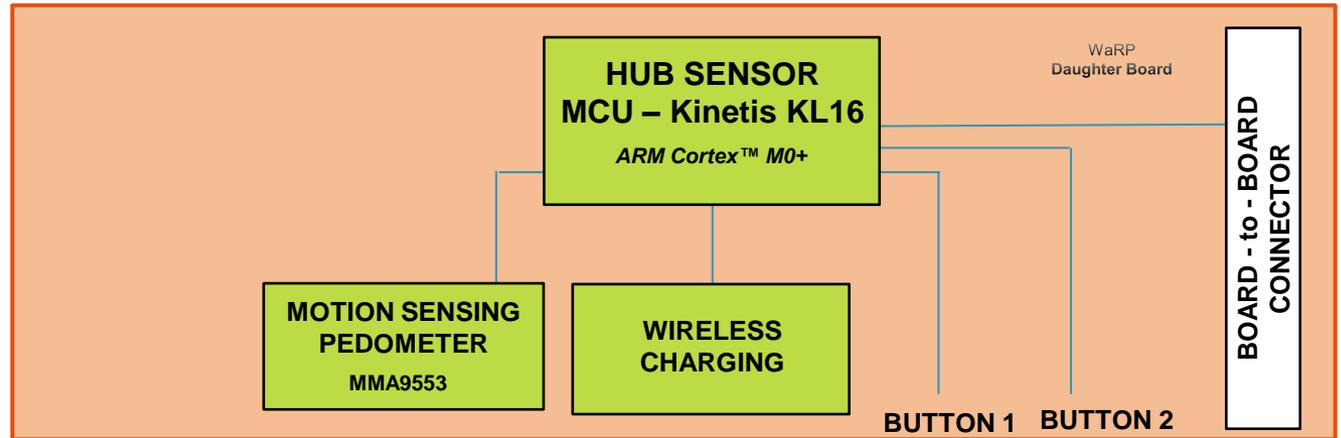


WaRPboard.org

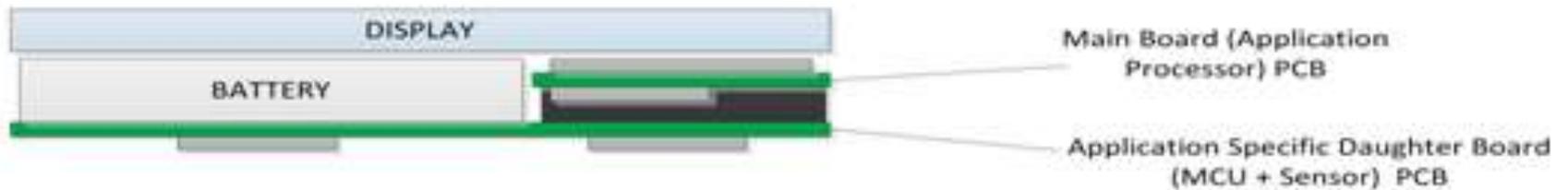




Daughter Board PCB size:
42 mm x 42 mm
(1.65" x 1.65")



- 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

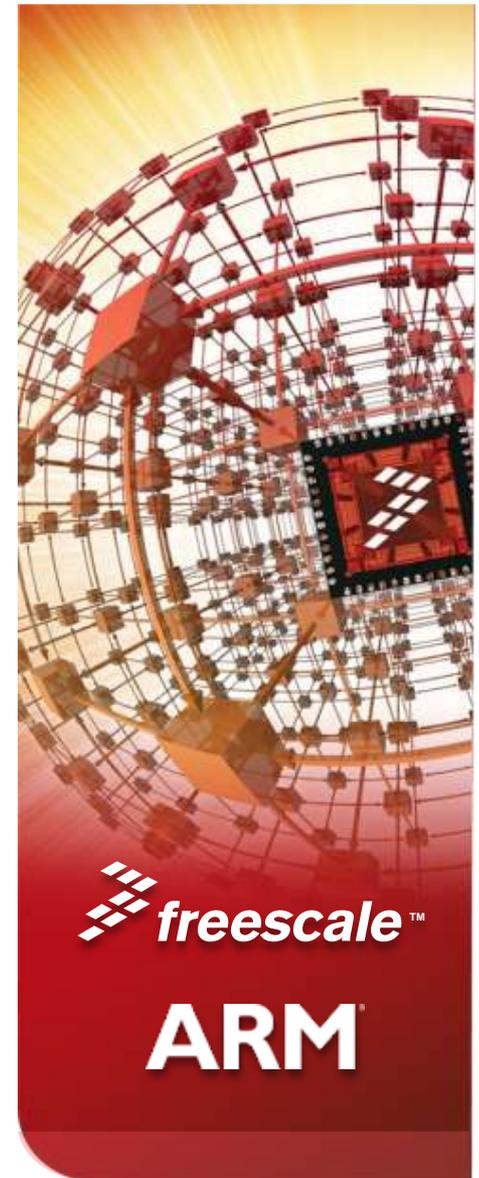
- Optimized for low power with 90nm TFS technology, clock and power gating techniques, and highly efficient platform featuring a low power boot option, bit manipulation engine, peripheral bridge crossbar and zero wait state flash memory controller

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



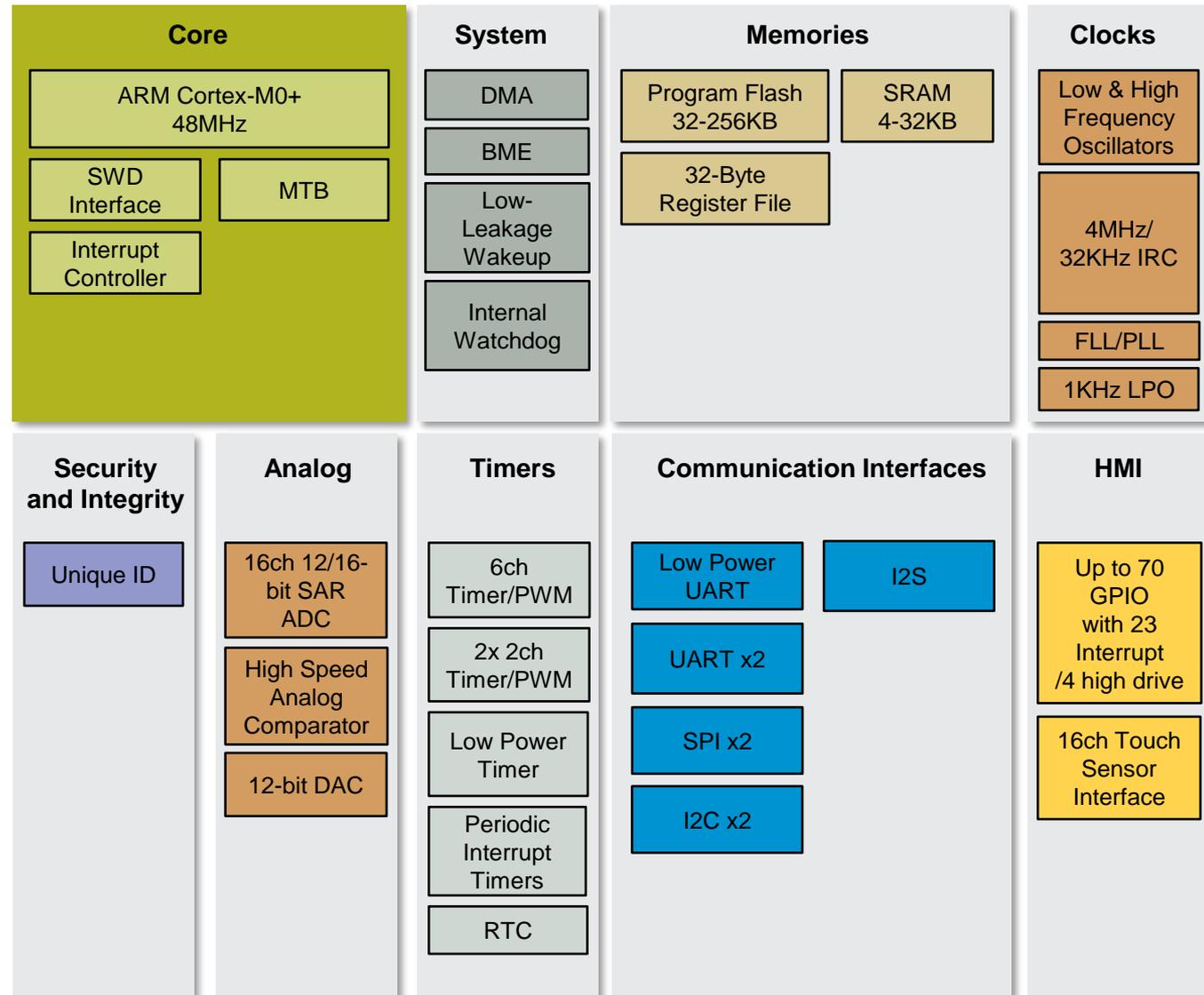
Kinetis L Series MCUs: KL16 Block Diagram

Specifications

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

WaRP Use Case

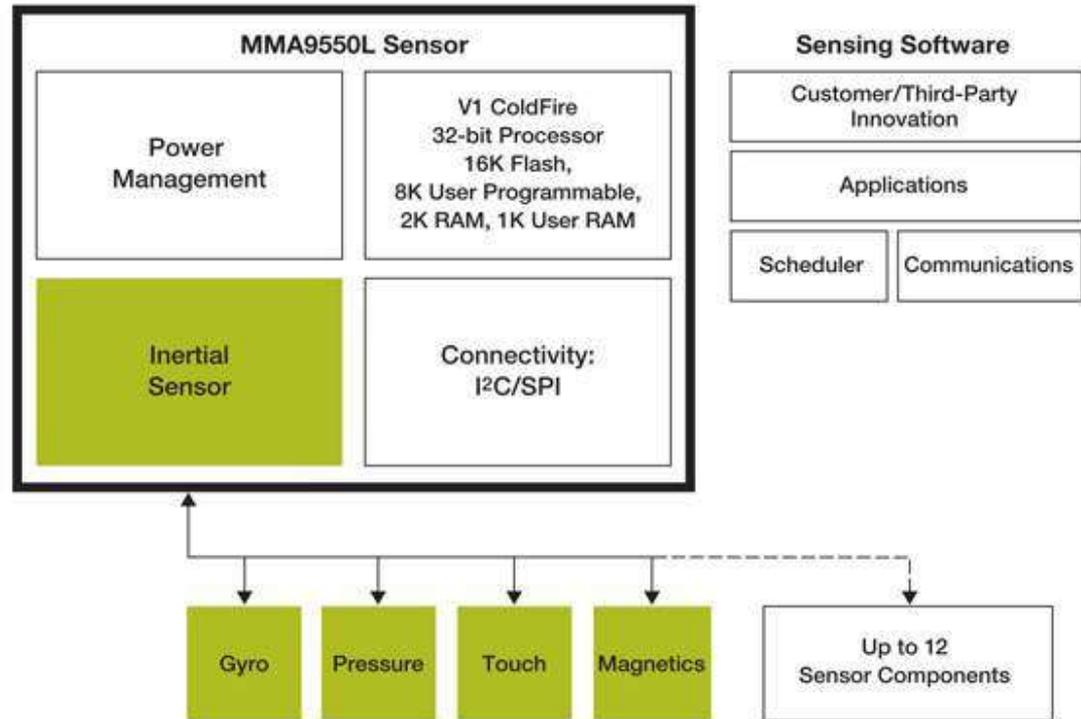
- UART for communication to the main board
- PWM for buzzer (notifications)
- I2C to motion detector sensor
- SPI to E-Ink display for power management
- GPIO for buttons



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

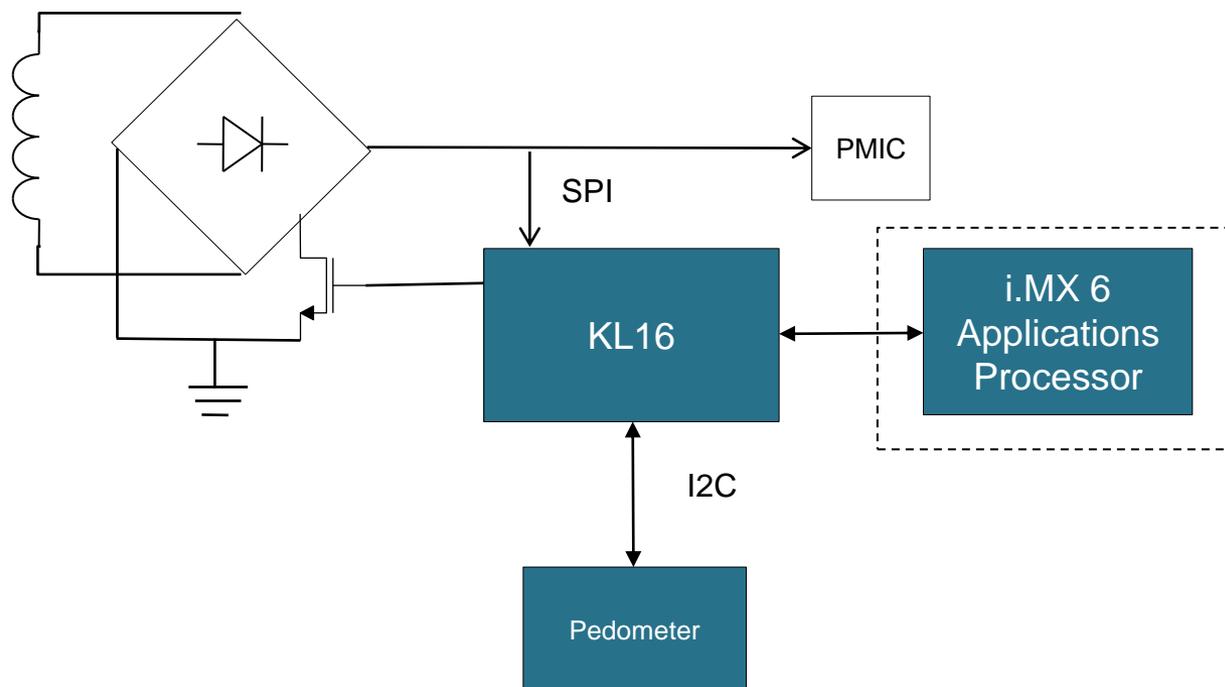


Software

- 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

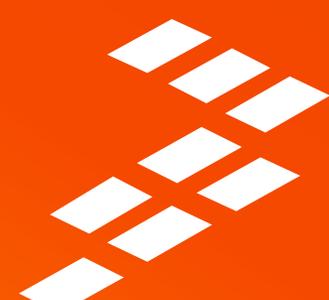
Wireless Charging Receiver

- 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

Applications

<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="background-color: #666; color: white; padding: 5px 10px; border-radius: 5px;">UI</div> <div style="background-color: #666; color: white; padding: 5px 10px; border-radius: 5px;">Apps</div> <div style="background-color: #666; color: white; padding: 5px 10px; border-radius: 5px;">Launcher</div> </div>	 
--	---

Segment Specific

<table border="0" style="width: 100%;"> <tr> <td style="width: 33%; vertical-align: top;"> Infotainment <ul style="list-style-type: none"> Smart watch Wearable gaming Music Video </td> <td style="width: 33%; vertical-align: top;"> Fitness <ul style="list-style-type: none"> Pedometer Compass Motion Sensing Body Activity Monitor </td> <td style="width: 33%; vertical-align: top;"> Medical <ul style="list-style-type: none"> ECG/HR Glucometer Skin thermometer Data Aggregation </td> </tr> </table>	Infotainment <ul style="list-style-type: none"> Smart watch Wearable gaming Music Video 	Fitness <ul style="list-style-type: none"> Pedometer Compass Motion Sensing Body Activity Monitor 	Medical <ul style="list-style-type: none"> ECG/HR Glucometer Skin thermometer Data Aggregation 	  
Infotainment <ul style="list-style-type: none"> Smart watch Wearable gaming Music Video 	Fitness <ul style="list-style-type: none"> Pedometer Compass Motion Sensing Body Activity Monitor 	Medical <ul style="list-style-type: none"> ECG/HR Glucometer Skin thermometer Data Aggregation 		

API

<ul style="list-style-type: none"> Android Standard API Daughter Board API Bluetooth Profiles Custom Third Party API 	  
--	---

OS Layer

<ul style="list-style-type: none"> Power Management Bluetooth Core Stack Video Codecs Kernel 3.0.35/3.5.x Device Drivers Microcontroller Access Protocol 	<table border="0" style="width: 100%;"> <tr> <td style="background-color: #00A0C0; color: white; padding: 5px 10px; border-radius: 5px;">Bootloader</td> <td style="background-color: #00A0C0; color: white; padding: 5px 10px; border-radius: 5px;">Core stacks</td> </tr> <tr> <td style="background-color: #00A0C0; color: white; padding: 5px 10px; border-radius: 5px;">Kernel</td> <td style="background-color: #00A0C0; color: white; padding: 5px 10px; border-radius: 5px;">Drivers</td> </tr> </table>	Bootloader	Core stacks	Kernel	Drivers	      
Bootloader	Core stacks					
Kernel	Drivers					

Hardware

<p>Application Processor: i.MX 6SoloLite Microcontroller: Kinetis KL16</p>	 
--	---

WaRP Android Software Implementation



WaRPboard.org

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

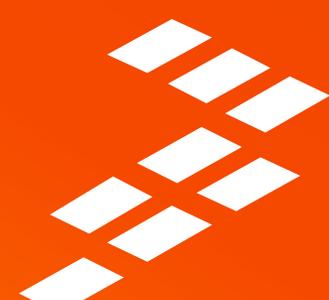
Android is only OS with an optimized & lightweight surface renderer & advanced touch human interface

Context Awareness

Extension of SDK used simple messaging system to interface with daughter card & access data from sensors



Launch & Community



WaRP

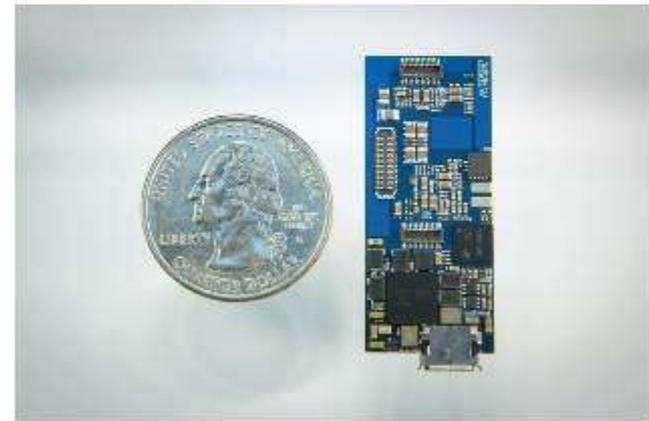
Wearable Reference Platform



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

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



Technical Features

Community driven by Circuitco



WaRP Timeline Calendar



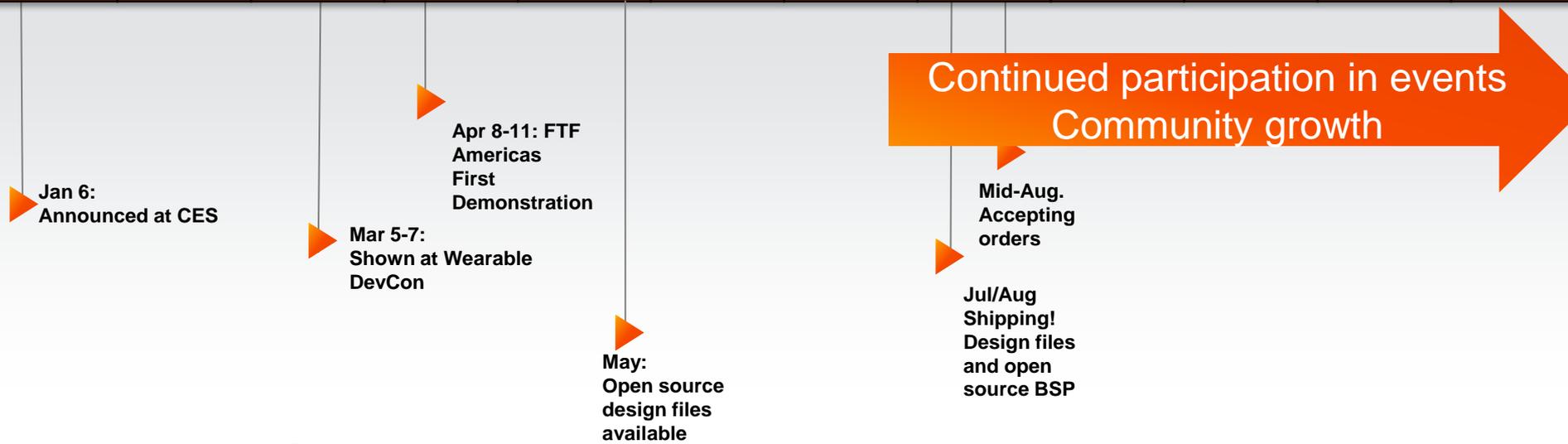
- **Available Now**

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

- **Ordering**

- WaRPboard.org
- Distributors – Arrow and Avnet

WaRPboard.org



Wearables Summary



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 Freescale, Kynetics, Revolution Robotics and Circuitco that will evolve with market and enable innovation.



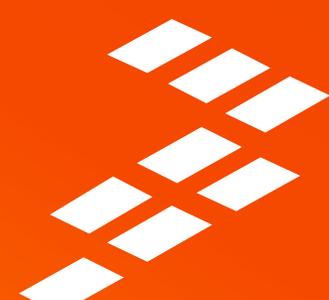
Productizable

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



Growth Opportunities

Growing market covering multiple vertical segments





www.Freescale.com