InvenSense Wearable Market

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Sr. Director Wearable/IoT
Market Drivers and Success Stories
Wearable Tech Applications

- **Smart Glasses/HMD**
  - Google, Vuzix, Oculus, Epson

- **In-Ear**
  - Sony, Bragi

- **Necklace**
  - Misfit

- **Wrist Worn**
  - Fitbit, Jawbone, Polar, Samsung, LG, Sony, Motorola, Asus

- **Ring**
  - Nod, Logbar

- **Hip Worn**
  - Omron, Fitbit, Fitbug,

- **Smart Clothes**
  - Citizen Science
Wearable Success Stories (within last 6 months)

Zepp ITG-3701
Octonion MPU-9250
Bragi MPU-9250 MPU6500
Sony MPU-6500
Mattel ICS-43434

FireFly SoC + Audio Mics + 6/9-Axis

Intel/Fossil ICS-43432
LG Urbane 2 Watch MPU-6515
Qiwo Smart Watch ICM-30630
Fitbit Surge MPU-9250
SK Telecom MPU-6555
Zikto MPU-6555
Wearable Business Model

- **MEMS SoC**
- **Consumer Devices** (Watch, Band, HMD, Tracker, etc.)
- **Apps**
- **Cloud Data/Analytics**
- **Access & Services**
Wearable Sensor Platform System Solutions
Wrist Worn Health/Fitness Feature Set

Activity/Context
Steps, Activity, Sleep

Vital Signs Monitoring
PPG Motion Artifact Correction
HRV

Sensor Assisted GNSS
Running: Speed/Distance/Route
Biking: Speed/Distance/Route

Barometer Support
Floors Climbed

OEM Health/Fitness Cloud

Green – Available Now

InvenSense
Context Awareness/Activity Recognition
Step Count isn’t Enough

Wearable Market Today is Pedometer Only:

- Step Count isn’t valuable after a while
- Hard to deliver Cloud Services on Step Count only
- Calorie info is not accurate

Wearable Market Moving to Context/Activity:

Android Wear Requirement (Since Android-L release)
Better Data Analytics to Deliver Targeted Services
More Accurate Calorie Count
Low-Med-High End Solutions

6-axis Raw Sensor Sensor
ICM-20602 or ICM-20690

Activity-Classifier B2S

6/9-axis “Smart” Sensor
ICM-20648 or ICM-20948

Wearable FireFly™- ICM-30631
Heart rate (PPG based) Problems

**Problem:** Heart rate measurement is not reliable when body is in motion

**Solution:** Remove motion artifact from the PPG light signal

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**PPG Sensors Supported**

<table>
<thead>
<tr>
<th>HRM Algo</th>
<th>MIPS</th>
<th>Size</th>
<th>HRM Tracking Performance [bpm 1σ]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Code</td>
<td>Data</td>
</tr>
<tr>
<td>InvenSense (Cortex M4 Lib)</td>
<td>1</td>
<td>15KB</td>
<td>17KB</td>
</tr>
</tbody>
</table>

PAH8001
PAH8002
PPS960 (includes AFE4404)
ADPD174
INVN Performance: High Pulse → Low Pulse Transitions

INVN HRM algorithm able to RELIABLY conduct motion artifact removal resulting in good BPM tracking.
Speed/Distance/Route w/ GNSS Duty Cycle
GPS is a Wearable Battery Killer

Problem: GPS Usage Kills Battery Life

- **Fitbit Surge**: 7 day Battery life, 5hr GPS Battery life
- **TomTom GPS Watch**: 17 day Battery life, 10hr GPS Battery life
- **Strava Fitness Apps**: 4-6hr Battery life with GPS

Solution: Coursa Sports

Use Less GPS and Keep Accuracy of Speed/Dist/Route

- Sensors + GNSS Integration
  - **Low Power Mode**: 50% Lower Power than GPS
  - **OpenSKy**: Similar speed/distance Accuracy
  - **MultiPath**: Improved speed/Dist Accuracy
  - 100% Coverage in Denied Environments
  - Improved Workout Credit

- Available Wrist Worn Wearable and Mobile Fitness App
Coursa Sports vs. Strava

Coursa Sports vs Strava vs Reference

GPS used for Coursa Sports

Conclusion
IPL Sports can deliver the same accuracy as Strava (who uses 100% GPS) but with only 25% GPS
Coursa Sports – for OEMs

- Eliminate GPS route outages
- More accurate speed/distance
- Improved elevation accuracy
- Extend Battery life

Realtime

GPS Device (with Coursa Sports)

Coursa Sports
Speed/Dist/Route Service

GNSS, Motion Speed/Distance

Route + More Accurate Speed/Distance

+ More Accurate Speed/Distance

Customer Cloud
Wearable
Go-To-Market Strategy
Wearable SoC
FireFly™: ICM-30630

- **Hierarchical Tri-Core Processing**
  - ARM M0: Open Platform
  - DMP4: Android L offload (Fusion, BAC, Pedo)
  - DMP3: FFT
- **Low Power Processing (M0+DMP < M4)**
- **Available/Free resources – Open Sandbox**
  - Memory: ~32KB SRAM (incl FIFO) + ~32KB Flash
- **Complete Wearable SW Features**
  - See Next Slide

<table>
<thead>
<tr>
<th>Test Condition</th>
<th>Current (µA)</th>
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<tbody>
<tr>
<td>Standby (No functionality)</td>
<td>52</td>
</tr>
<tr>
<td>SMD only</td>
<td>210</td>
</tr>
<tr>
<td>Pedometer only</td>
<td>215</td>
</tr>
<tr>
<td>Activity only</td>
<td>202</td>
</tr>
<tr>
<td>HRM (PPG Sensor not included)</td>
<td>605</td>
</tr>
</tbody>
</table>

"Master" – Required to boot up 30630
"Slave" – Processes Wearable Sensor Features at Low Power
High-End Wearable Offering:
Complete Wearable SW Stack

<table>
<thead>
<tr>
<th>Category</th>
<th>SW Feature/Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware Sensor</td>
<td>Accelerometer</td>
</tr>
<tr>
<td></td>
<td>Gyro</td>
</tr>
<tr>
<td></td>
<td>Pressure (BMP280)</td>
</tr>
<tr>
<td></td>
<td>Mag (AKM09911)</td>
</tr>
<tr>
<td></td>
<td>Proximity (CM36671)</td>
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<tr>
<td></td>
<td>PPG (PAH8001/8002, ADPD174, PPS960)</td>
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<tr>
<td>Health/Fitness</td>
<td>Activity: Walk, Run, Bike, Still, Transport</td>
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<tr>
<td>Features</td>
<td>Walk/Run Step Counter</td>
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<tr>
<td></td>
<td>Walk/Run Time Accrual</td>
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<tr>
<td></td>
<td>Stand/Sit Time Accrual</td>
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<tr>
<td></td>
<td>HRM Motion Artifact Correction</td>
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<tr>
<td></td>
<td>Heart Rate Variation (HRV)</td>
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<td></td>
<td>All Day Heart Rate Tracking</td>
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<td>Sleep Analysis (manual entry)</td>
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<tr>
<td></td>
<td>Calorie Counter</td>
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<tr>
<td></td>
<td>Distance (Based on Stride Length)</td>
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<tr>
<td></td>
<td>Floors Climbed (Floors climbed and descended)</td>
</tr>
<tr>
<td>Gestures</td>
<td>Bring-To-See, Shake, Double-Tap</td>
</tr>
<tr>
<td>Android Sensors</td>
<td>Android FusionGravity, Linear Accel, Orientation (RV, GRV, GEOMAG)</td>
</tr>
</tbody>
</table>

ICM-3063x SW Features

Smart Watch/Fitness Tracker

- Display
- BLE
- GPS
- Touch

MCU or AP (Display Driver/Graphics, etc)

- Sensor Framework
- Steps, Activity, Stairs
- HRM, HRV, Sleep
- Sensor Fusion

ICM-30631

- PPG
- Pressure
- Mag
Thank you!