



Emerging Applications of Integrated MEMS Sensors

Jay Esfandiyari

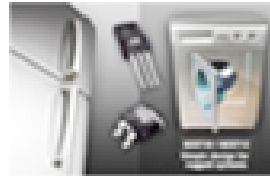
MEMS Product Marketing Manager

Sensors Conference

March 6, 2013, Santa Clara CA



In the home: entertainment, comfort, security, appliances, energy savings ...



Our health:

medical imaging, telemedicine, fitness aids, portable diagnostics, DNA analysis, defibrillators, implantable devices, prosthetics...



In the car:

engine control and powertrain, car body and safety, navigation and other infotainment ...



life.augmented

At work or school:

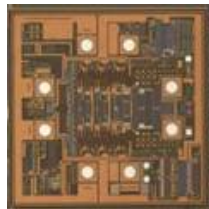
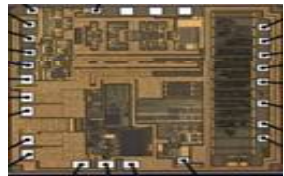
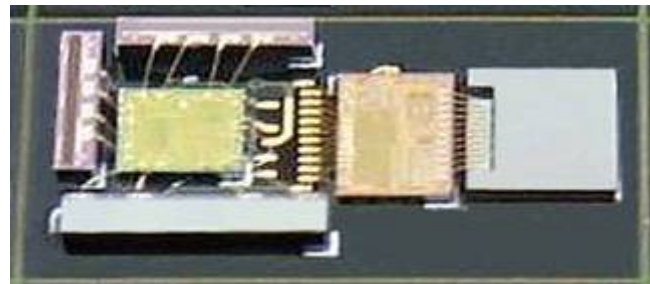
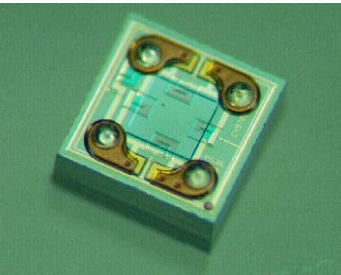
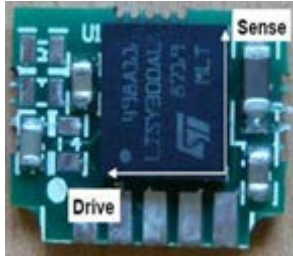
printers, PCs, climate control, energy savings ...



On the go: mobile phones, PDAs, MP3 players, bank cards ...



Our planet: energy-saving solutions, solar power, greener cars, smarter transportation ...



Low Power 3-Axis Linear Accelerometer

Orientation (Functional) Sensors

Multiple-axis Gyroscopes

Ultra-miniaturized Pressure Sensor

Magnetic Sensors

High-performance Digital Microphone

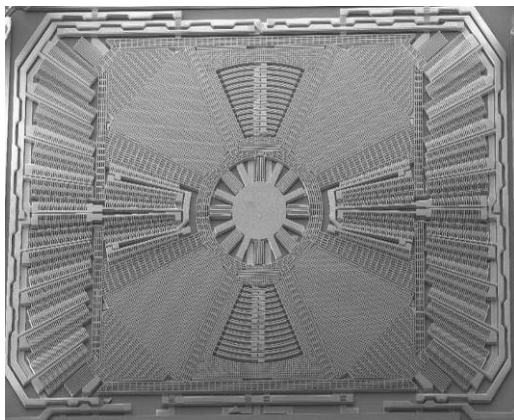
Humidity

Biosensors

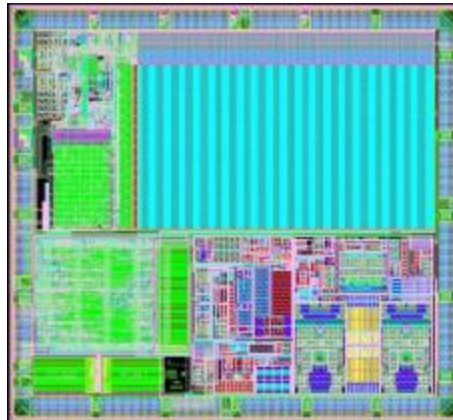
MEMS are Extreme Analog Products

- **MEMS** means **M**icro **E**lectro **M**echanical **S**ystems ... taking advantage of the mechanical AND electrical properties of silicon
- Three key elements:
 - **Micron-sized Transducer** realized through a specific process called Micro-Machining (THELMA)
 - An **Extreme Analog Chip** with embedded smart functionalities
 - Dedicated **package** and **calibration** features

THELMA @ 1 um



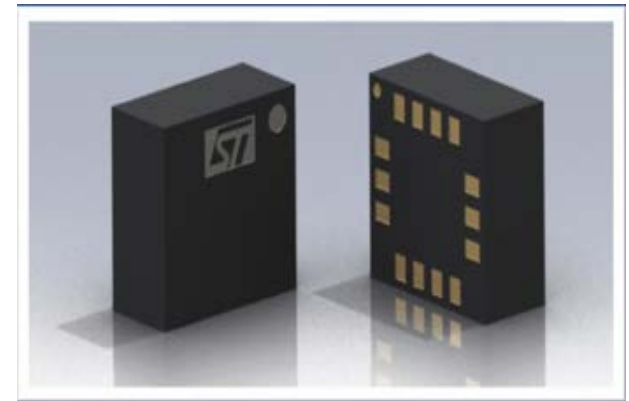
ASIC @ 130 nm



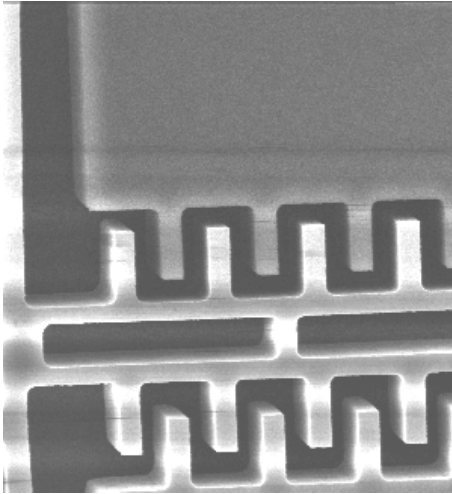
+

=

3 Axis Gyroscope



- Accelerometer is a system based on **silicon mechanical structure** able to sense **motion**



Vibration
(dynamic measurement)



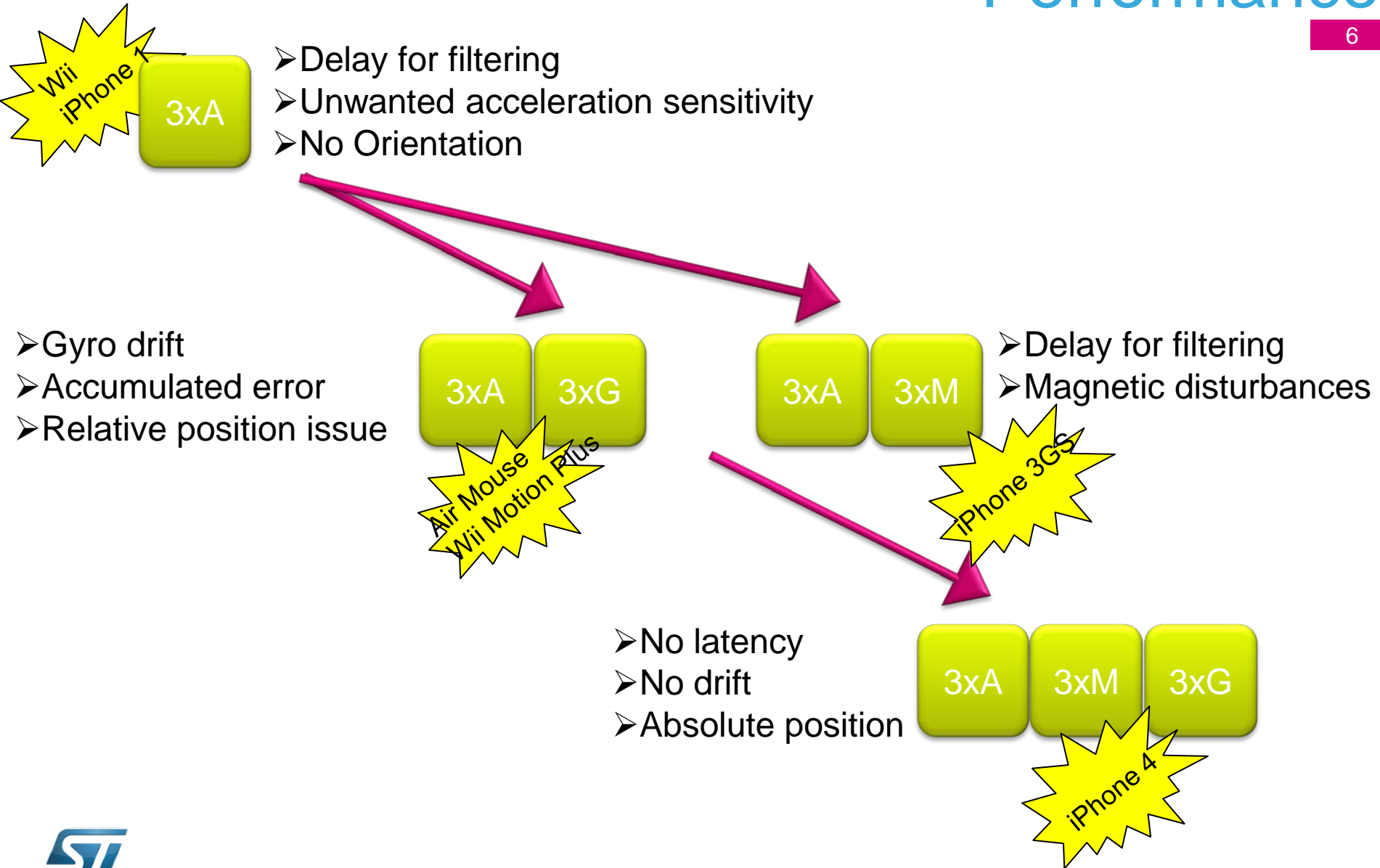
Inclination
(static measurement)



Acceleration
(dynamic measurement)

- Step Counting, Pedometer, Image Rotation
- Activity monitoring
- Motion Detection

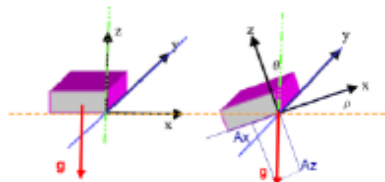
Sensor Integration for Enhanced Performance



Sensor Integration: High Performance

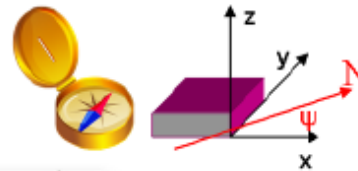
10 DoF

7



Accelerometer

- Senses the linear acceleration.
- In **static** conditions, the projection of gravity on the three axes allow to compute **tilt angles**



Magnetometer

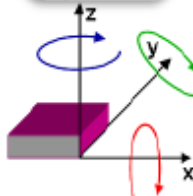
- Senses the magnetic field.
- In **static** conditions, the projection of geomagnetic field on the three axes allows to compute heading angle



10 DOF through complementary sensors

Gyroscope

- Measures the angular rate
- In **dynamic** conditions, the integration of the angular rate along the three axes allow to determine the 3D orientation



Pressure Sensor

- Measures the absolute and relative pressure (
- In **dynamic** conditions, it allows to calculate the delta altitude



Rise of MEMS Consumerization Wave

Optical Image Stabilization



Location Based Services



Indoor navigation



Advanced User Interface & Gaming



Augmented Reality



Fitness/Wellness & In-House Tele-health



MEMS for Indoor Positioning Applications

10

➤ Handsets and tablets

- Search, map, navigation
- Tracking
- Social networking

➤ Cameras

- Geotagging

➤ Fitness devices

- Speed, altitude, track
- Context recognition

➤ Asset tracking

- Low-power tracking
- Geofencing
- Alerts



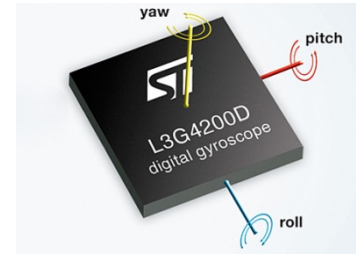
MEMS + GPS + WI-FI enable Indoor Navigation

Accelerometer, Gyroscope, Magnetometer, Pressure Sensor for Indoor Navigation are available today at low cost .

MEMS Pedestrian Dead Reckoning

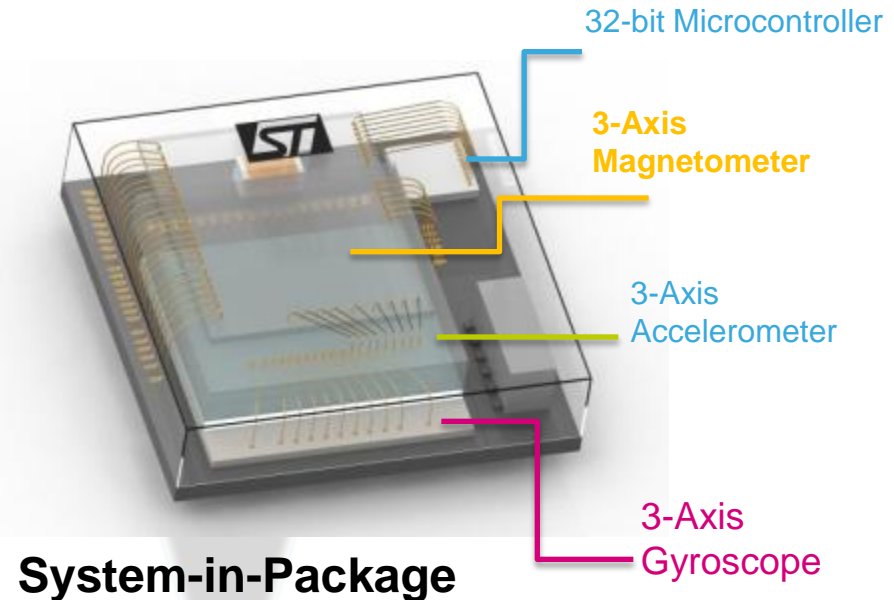
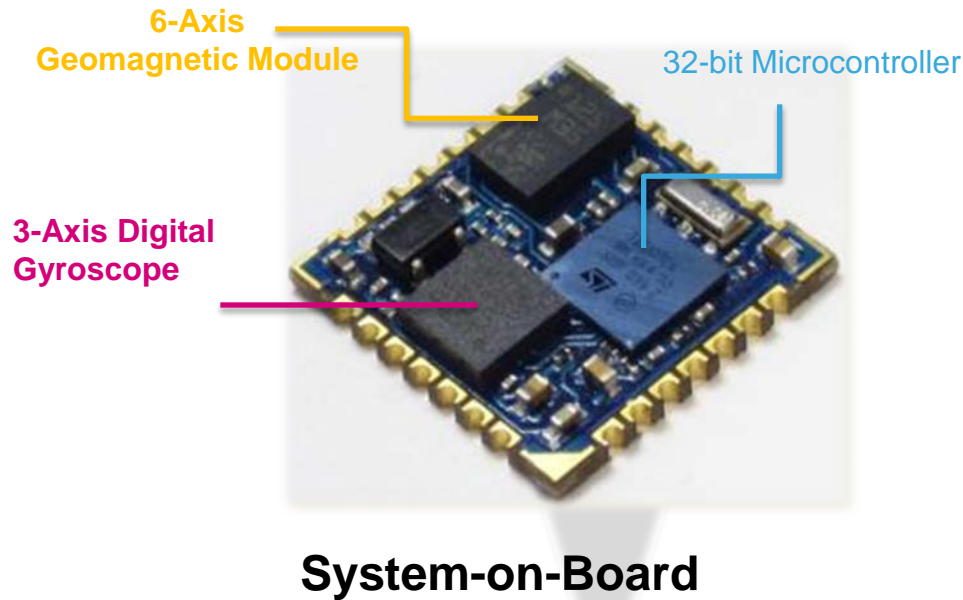
➤ 10-axis MEMS:

- 3-axis accelerometer
- 3-axis magnetometer
- 3-axis gyro
- Barometer



- Input signals are synchronized and buffered
- Continuous calibration employed
- Context detection used to determine when to invoke pedestrian mode
 - Walking, running, standing, stairs, escalator, elevator, etc.
- Pedestrian dead reckoning used to determine path and speed by step counting rather than integrating acceleration
- Error growth with no absolute position is about 10% of distance traveled
- Suitable for smoothing and bridging between absolute fixes

Current Trend of Sensor Integration

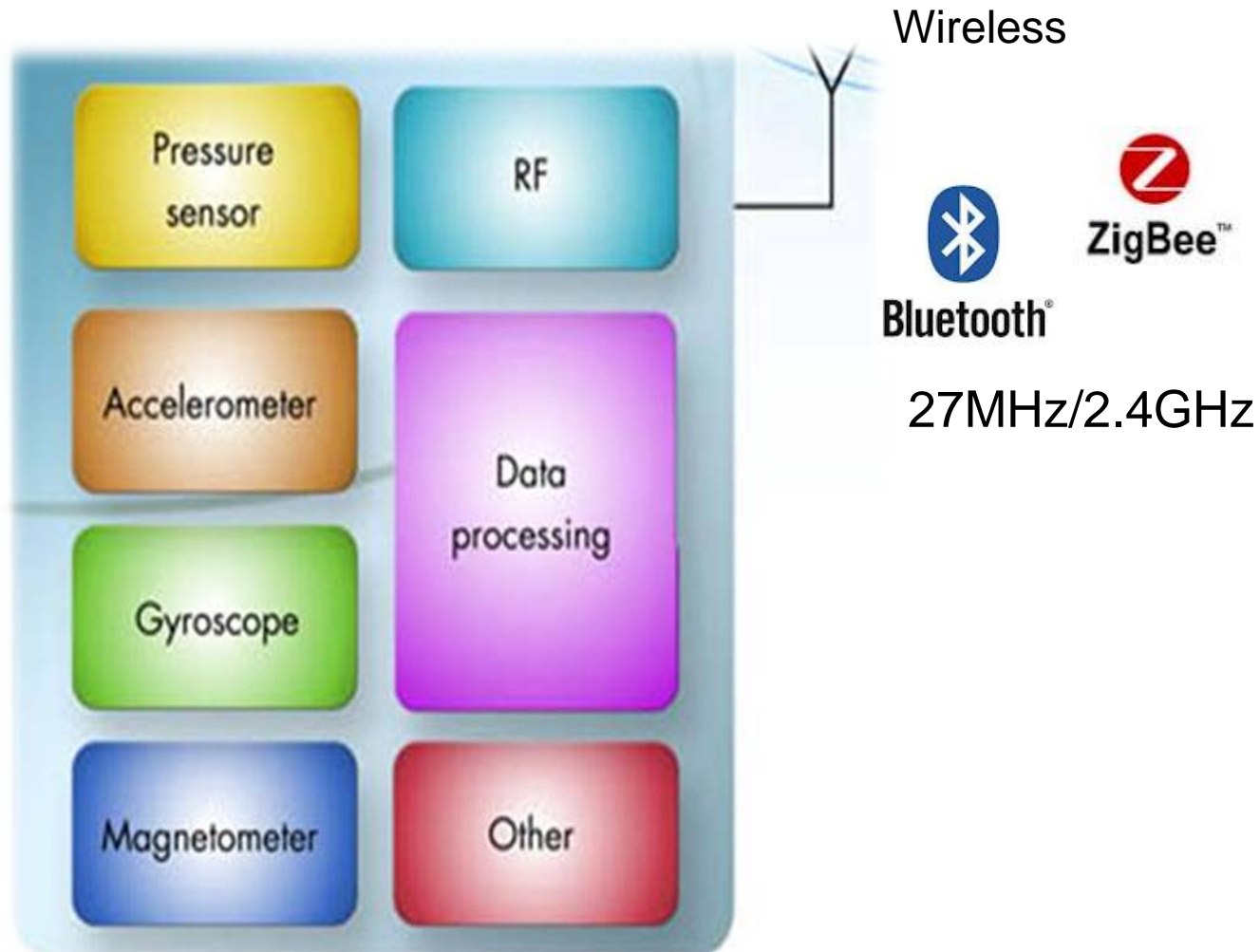


iNEMO-M1
System-on-Board
9-Axis plus 32-Bit MCU
13x13 mm in a Board

iNEMO®
System-in-Package
9-Axis plus 32-Bit MCU in
small footprint

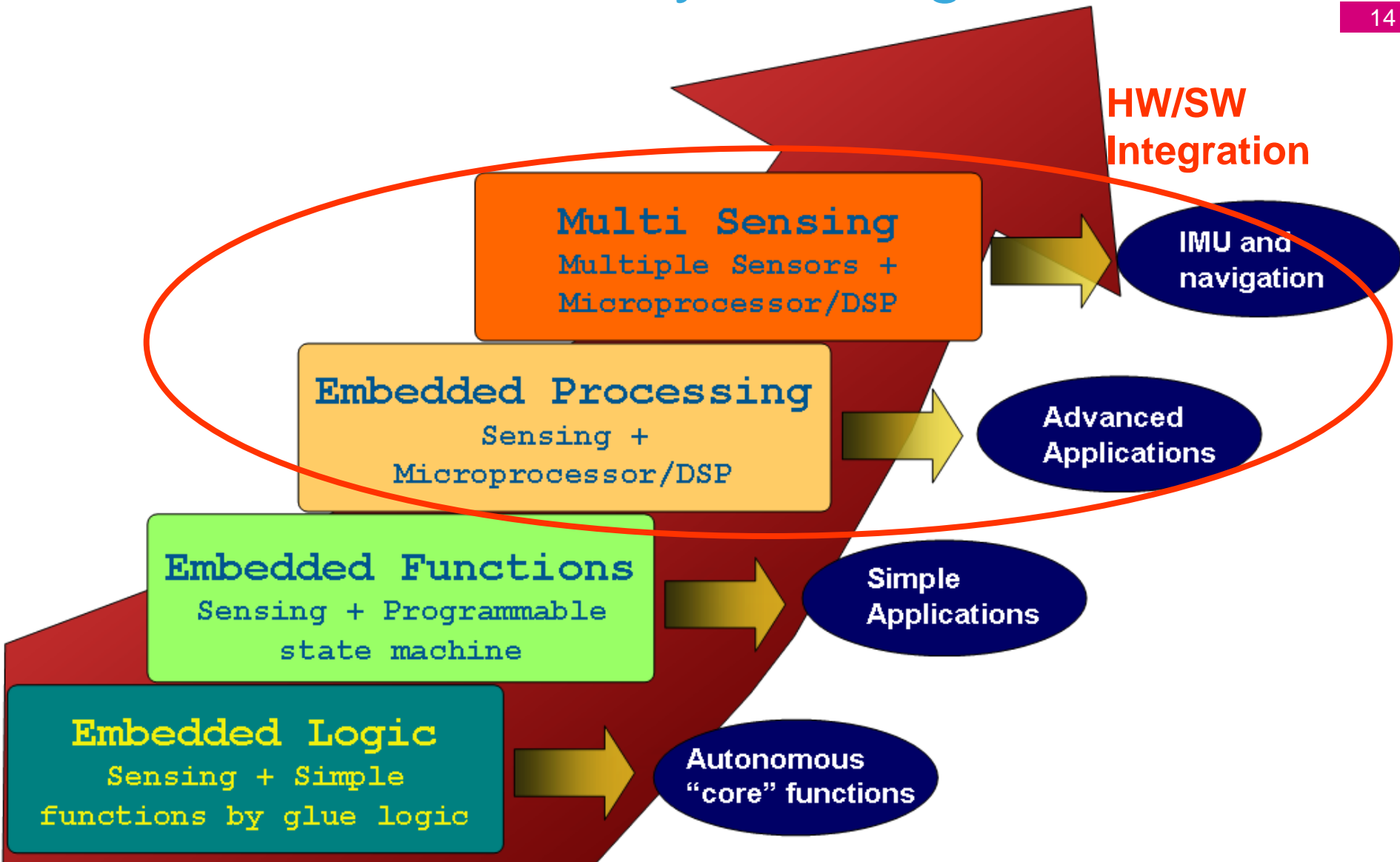
Components of Future Sensor Modules

13



The Way to Integrated Sensors

14



MEMS will continue to grow fast and enable new innovative applications



THANK YOU