Aligning the MEMS and Sensors Ecosystem For the Transition to the TSensors Era

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November 12th, 2014 TSensors Summit, La Jolla, CA
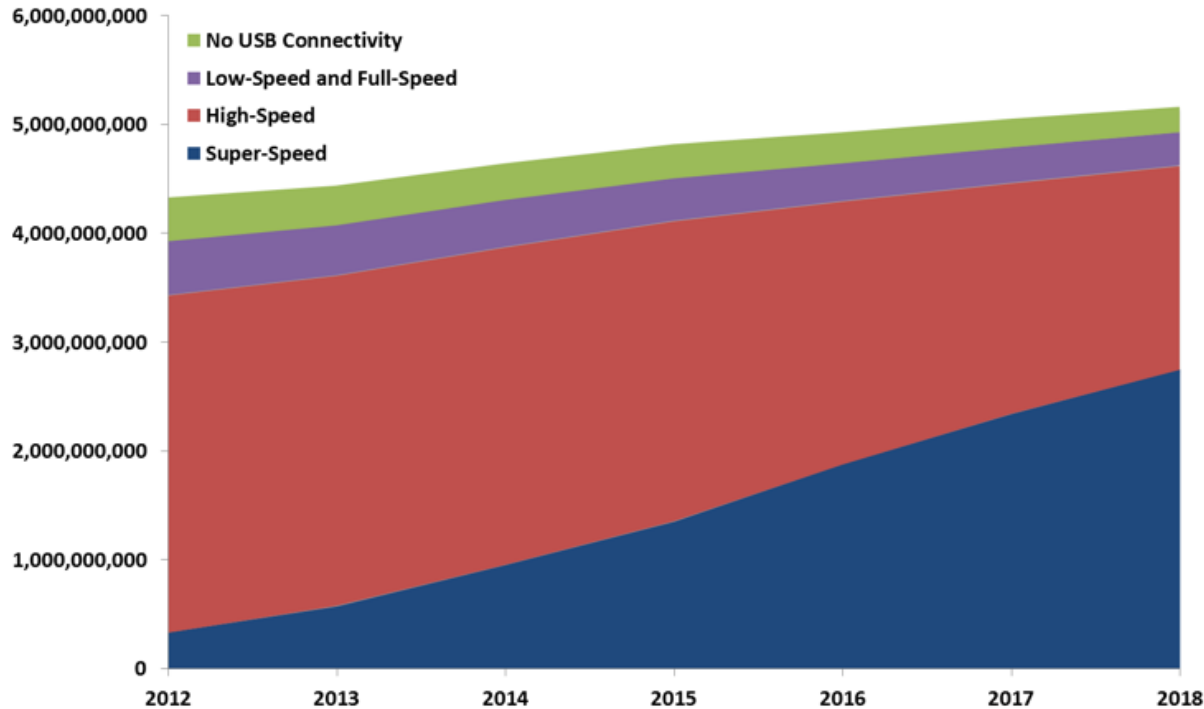
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Worldwide Shipment of USB-enabled Devices

- USB is the most successful interface in the history of PC
- Device charging over USB has become a major consumer feature
- USB installed base is 10+ billion units and growing at 4+ billion units a year
- Shipments will reach roughly 5.1 billion devices by 2018, an increase of over 19% from 2012

Device Shipments by USB Type, 2012-2018

Legend:
- No USB Connectivity
- Low-Speed and Full-Speed
- High-Speed
- Super-Speed

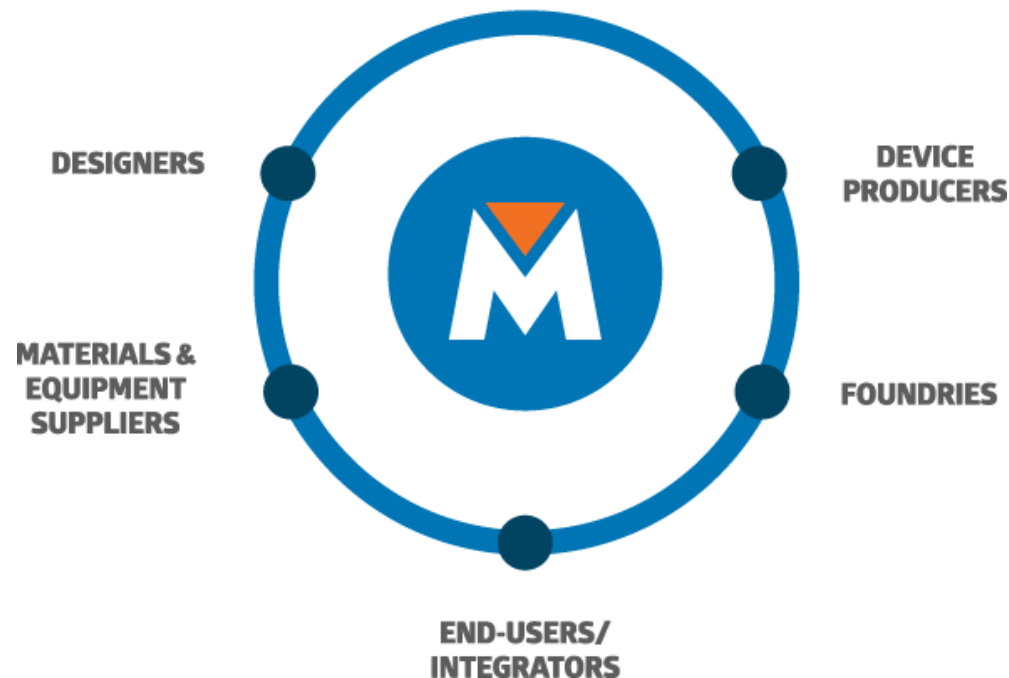Source: Multimedia Research Group, February 2014

Agenda

- **MEMS Industry Group**

- **Opportunities and Challenges**

- **TSensors – is it inevitable?**

- **Collaboration to co-creation**

- **Solving World Hunger**

About MEMS Industry Group®

- **Established in 2001, MEMS Industry Group (MIG) is a trade association advancing MEMS and sensors across global markets.**

- **Connects and champions the MEMS and sensors supply chain in established and emerging markets**

- **Enables the commercialization of MEMS and sensors – helping overcome technology and manufacturing hurdles**

- **170+ member companies and partners**

Connecting the MEMS & Sensors Supply Chain

DESIGNERS
DEVICE PRODUCERS
MATERIALS & EQUIPMENT SUPPLIERS
FOUNDRIES
END-USERS/ INTEGRATORS

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Opportunities and Challenges

but…

EVERYTHING WILL BE CONNECTED

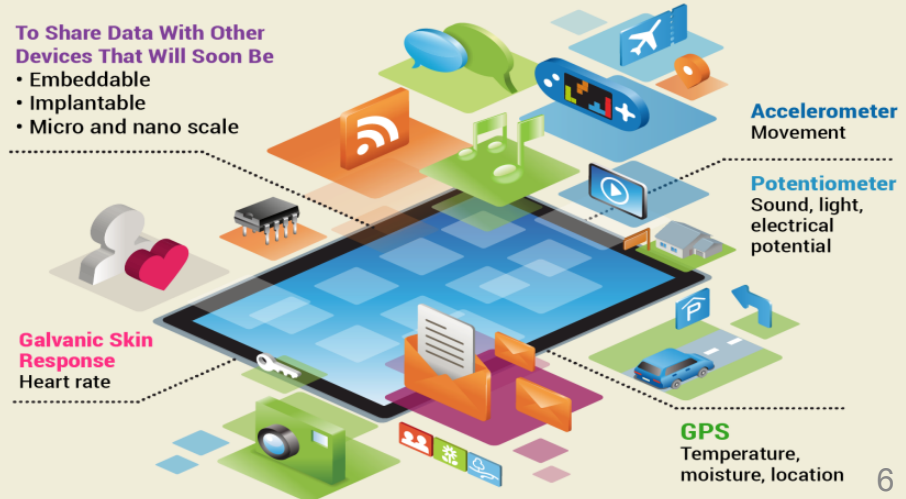Billions of wirelessly interconnected devices will communicate directly

Smart Phones · Smart Glasses · Smart Cars · Drones · Smart Textiles · Smart Watches

Smart Homes   Autonomous vehicles   Agriculture   Machine to Machine   Smart Buildings   mHealth   Augmented Reality   Smartphones   Printed Electronics   IOT

Drones   Consumer Electronics   Tablets   Smart Cities   IOE   Environmental   Automotive   Wearables   Gaming Consoles   Flexible Electronics

Infographic courtesy of Jabil

CONNECTED THROUGH SENSORS

One of the biggest drivers of the IOT is the increasing number of low-cost sensors available for many different kinds of functionality

To Share Data With Other Devices That Will Soon Be
- Embeddable
- Implantable
- Micro and nano scale

Accelerometer Movement

Potentiometer Sound, light, electrical potential

Galvanic Skin Response Heart rate

GPS Temperature, moisture, location

To Manage, Connect, Control & Measure Things We Care About

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What Stands in the Way?

Consumer MEMS challenges

(Source: Status of the MEMS Industry 2014, Yole Développement, August 2014)

New MEMS design
Above IC
SIZE REDUCTION
3D integration
New wafer bonding

Closer integration with processing
Better performance
Sensor fusion   Software
MORE INTELLIGENCE
Stronger RF specifications
Data discrimination

Mobility
Connectivity everywhere
LBS   E-Health
Social networking
NEW APPLICATIONS
Internet of Things

High volume production
Shared fab infrastructure
PRICE PRESSURE
Fabless model
MEMS across multiple markets

No shortage of business and technology challenges across the supply chain

Is the MEMS and sensors industry positioned to effectively address them?

Yes. But can we do more?
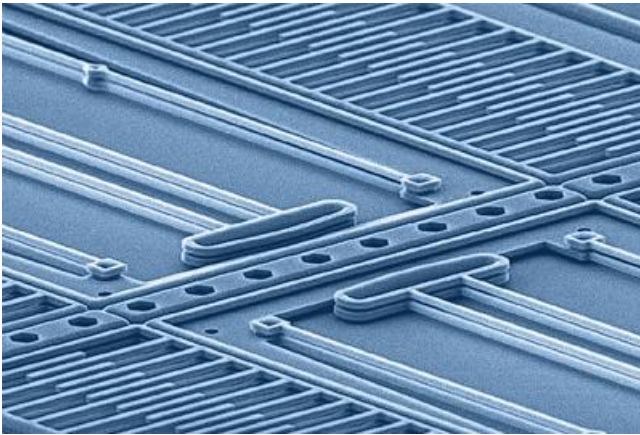
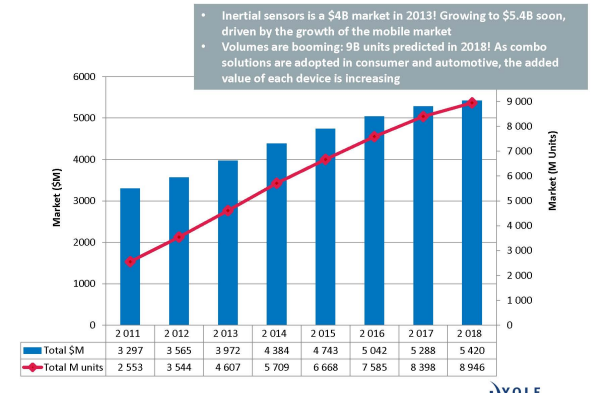**Steady advancements in MEMS and sensor technology being made across academia and commercial enterprises**

MEMS & SENSORS

Global MEMS inertial sensor market – From 2011 to 2018
(Source: Inertial MEMS Manufacturing Trends 2014 - Volumes 1 & 2 , Yole Développement, March 2014)

- Inertial sensors is a $4B market in 2013! Growing to $5.4B soon, driven by the growth of the mobile market
- Volumes are booming: 9B units predicted in 2018! As combo solutions are adopted in consumer and automotive, the added value of each device is increasing

Future demand is strong

|	2 011	2 012	2 013	2 014	2 015	2 016	2 017	2 018
Total $M	3 297	3 565	3 972	4 384	4 743	5 042	5 288	5 420
Total M units	2 553	3 544	4 607	5 709	6 668	7 585	8 398	8 946

© August 2014

YOLE Développement

What else can be done though to foster accelerated growth and innovation for Abundance?

It starts with you and me

Objective: acceleration of historically long new sensors development cycles for sensors supporting Abundance/Impacting the World.
Strategy:
1. Ultrahigh volume applications
2. Emerging sensor technologies
3. Encourage Supply Chain support
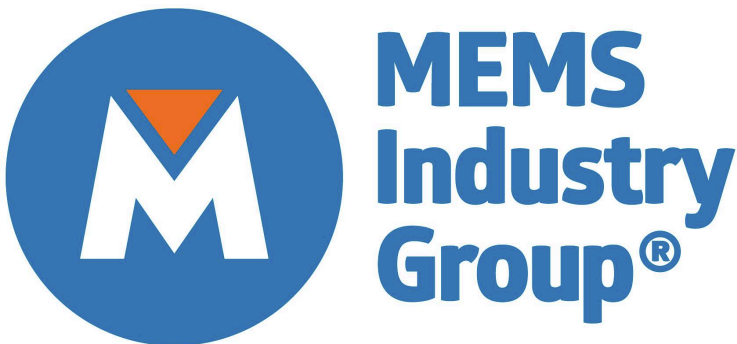
- Partnerships – TSensors, MIPI, SEMI, IEEE, NIST...
- Working Groups – standards, test, healthcare...
- Open Source Algorithm Development

- **The MIPI I3C specification is a two-pin interface that is backward compatible with I2C**
- **Reduces device pin count and facilitates incorporation of more sensors in a device**
- **Supports a minimum data rate of 10 Mbps with options for higher performance high-data-rate**
- **Scheduled for Working Group completion Q4'14 and publication Q1'15**

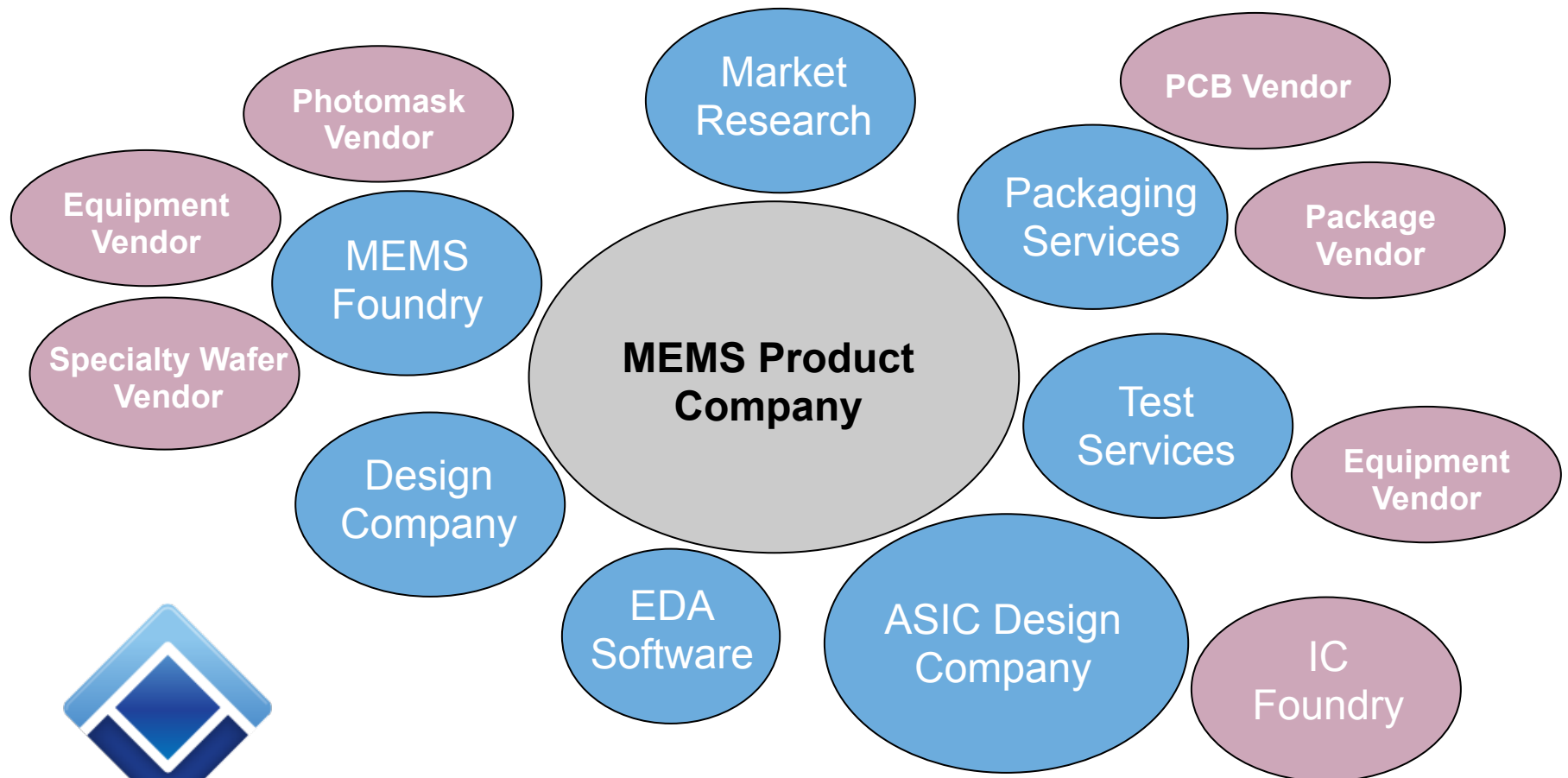*MIPI® I3C℠ Offers a Substantial Leap in Performance and Power Efficiency*

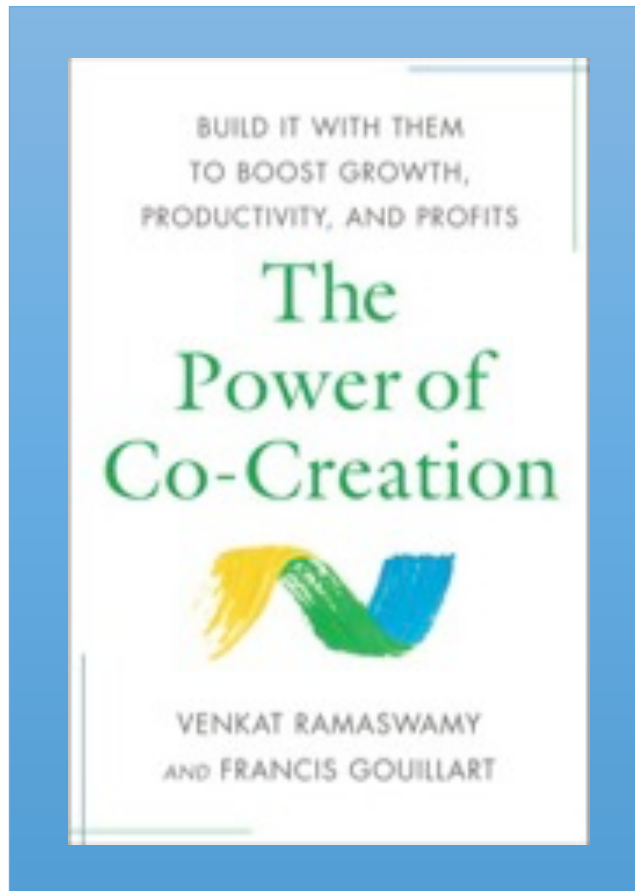# Accelerated Innovation Community (AIC)
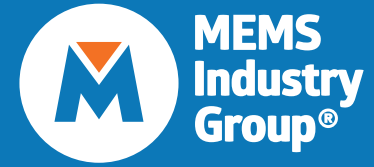
- **Open-source introductory sensor algorithm community**

- **Intent is to reduce time-to-market, development costs, risk and increase supply chain collaboration and innovation**

- **Initial supporting partners with MIG are Analog Devices, Berkeley Sensor & Actuator Center (BSAC), Carnegie Mellon University, Freescale, Kionix, NIST and PNI Sensors**

More Information at MEMSINDUSTRYGROUP.ORG/AIC

But Are We Really Working Together?

MEMS Industry Group®

BUILD IT WITH THEM TO BOOST GROWTH, PRODUCTIVITY, AND PROFITS

The Power of Co-Creation

VENKAT RAMASWAMY AND FRANCIS GOUILLART

By working together, innovating faster and _co-creating_, could we solve…

World Hunger?
Healthcare for all?
Clean Energy?
Clean Water & Air?

Following slides in conjunction with Francis Gouillart

MEMS Industry Group®

1. Identified some passionate runners (*lead users*)

2. ... and developed with them a *sensor-based engagement platform* ...

3. ... that mobilized a growing *community* of people around them ...

4. ... that allowed members of the community to exchange *data* ...

5. ... that allowed the structuring over time of new *interactions* between them ...

6. ... that drove new *experiences* for members of the community ...

7. ... and created new *value* for the companies in the ecosystem.

Together, Nike+ ran 297,402,060 mi
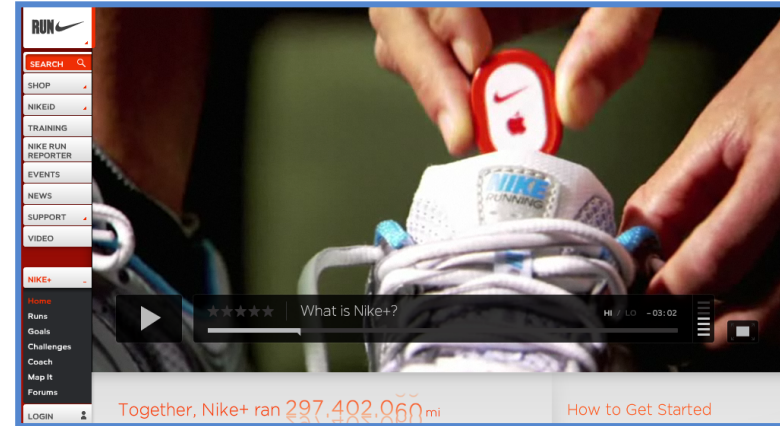
Nike gained 10% market share over Adidas in year 1 and reduced its advertising expenses by 55%

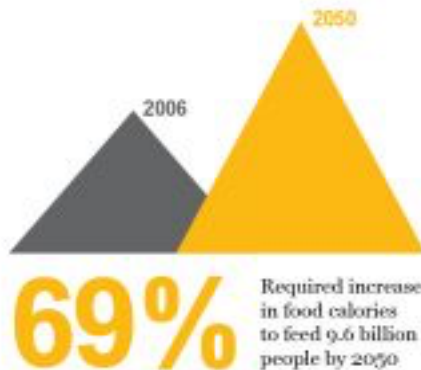*This process is what we call co-creation*
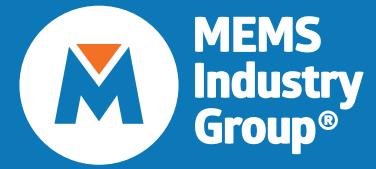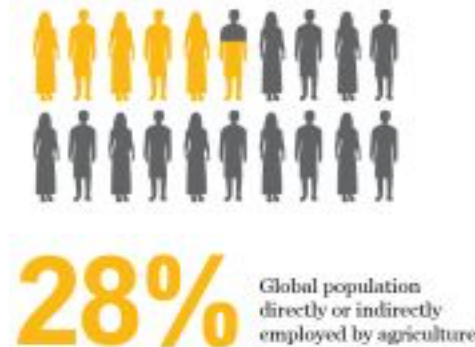
Example: Solving World Hunger

THE GREAT BALANCING ACT

The world must achieve a "great balancing act" in order to sustainably feed 9.6 billion people by 2050.
Three needs must be met at the same time.

CLOSING THE FOOD GAP

2050
2006

69% Required increase in food calories to feed 9.6 billion people by 2050

SUPPORTING ECONOMIC DEVELOPMENT

28% Global population directly or indirectly employed by agriculture

REDUCING ENVIRONMENTAL IMPACT

24% Global greenhouse gas emissions from agriculture and land use change
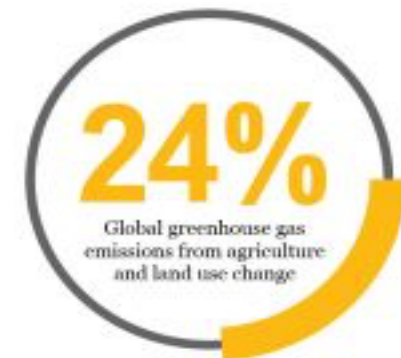
WORLD RESOURCES INSTITUTE

In the Americas and Europe, the problem is transforming the quality of the Ag-Food chain; in Africa and most of Asia, the problem is raising yield

Technology Has Created a 67% Yield Increase in Corn in the Last 47 Years in the US and Precision Agriculture is Just Getting Started

Figure 1. U.S. average corn yields (1965 to 2012) and the stream of technological advancements supporting productivity (modified with permission. Cassman et al., 2006).
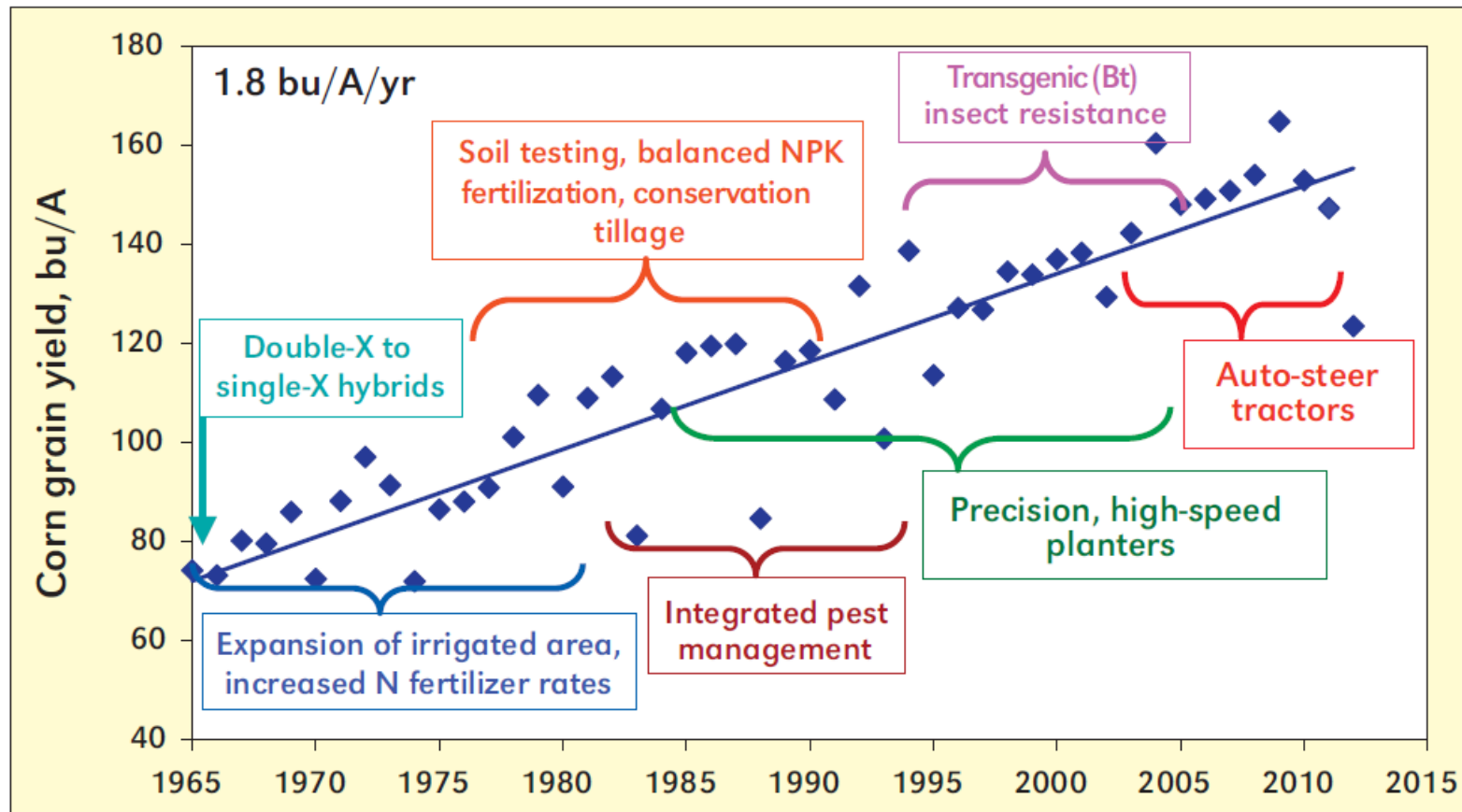
MEMS sensors and devices are central to the future of precision agriculture

Every Industry Has (Positive) Activists You Can Engage in Co-Creation

QUANTIFIED SELFERS (for wearables)
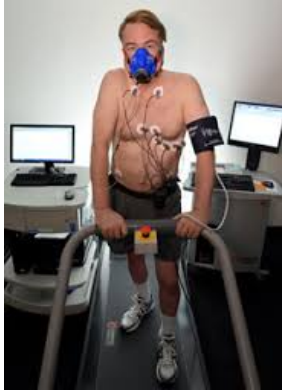
GEEKS WHO ASSEMBLED COMPUTERS IN THEIR GARAGE (early computer industry)

"PROGRESSIVE SUSTAINABLE" FARMERS

FOOD REBELS, GUERRILLA GARDENERS, AND SMART-COOKIN' MAMAS

FIGHTING BACK IN AN AGE OF INDUSTRIAL AGRICULTURE

MARK WINNE

CHEFS AND FOODIES

Start with a handful of farmers, celebrity chefs and foodies in one place (say Boston or San Francisco) and hypothesize what the MEMS industry could provide them

Today, the System is Largely a Company-Centric Push System with Lots of Weak or Missing Links (Example using Meat)

CONSUMERS

RESTAURANTS

MEAT RETAILERS

FOOD SERVICE PROVIDERS

MEAT DISTRIBUTORS

MEAT PROCESSORS

SLAUGHTER HOUSES

CATTLE RANCHERS

MEMS CONTROLLERS MANUFACTURERS

DEVELOPERS OF ALGORITHMS AND SOFTWARE

DEVICE MANUFACTURERS

MEMS FABs

MEMS SENSORS MANUFACTURERS

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Knowledge

- stunning of animals before slaughter
- animal-friendly conditions at farm
- course of chilling
- animal-friendly transportation
- meat not fatty, lean
- slaughter weight
- farmers own feed
- age of pig at slaughter
- not fed gmo feed
- maturation of meat
- temperature distribution
- no pesticide residues in meat
- Increase in growth
- breed
- date of slaughter
- date of cutting
- low use of energy and water in production
- uniformity of meat cut
- low ph-value of meat
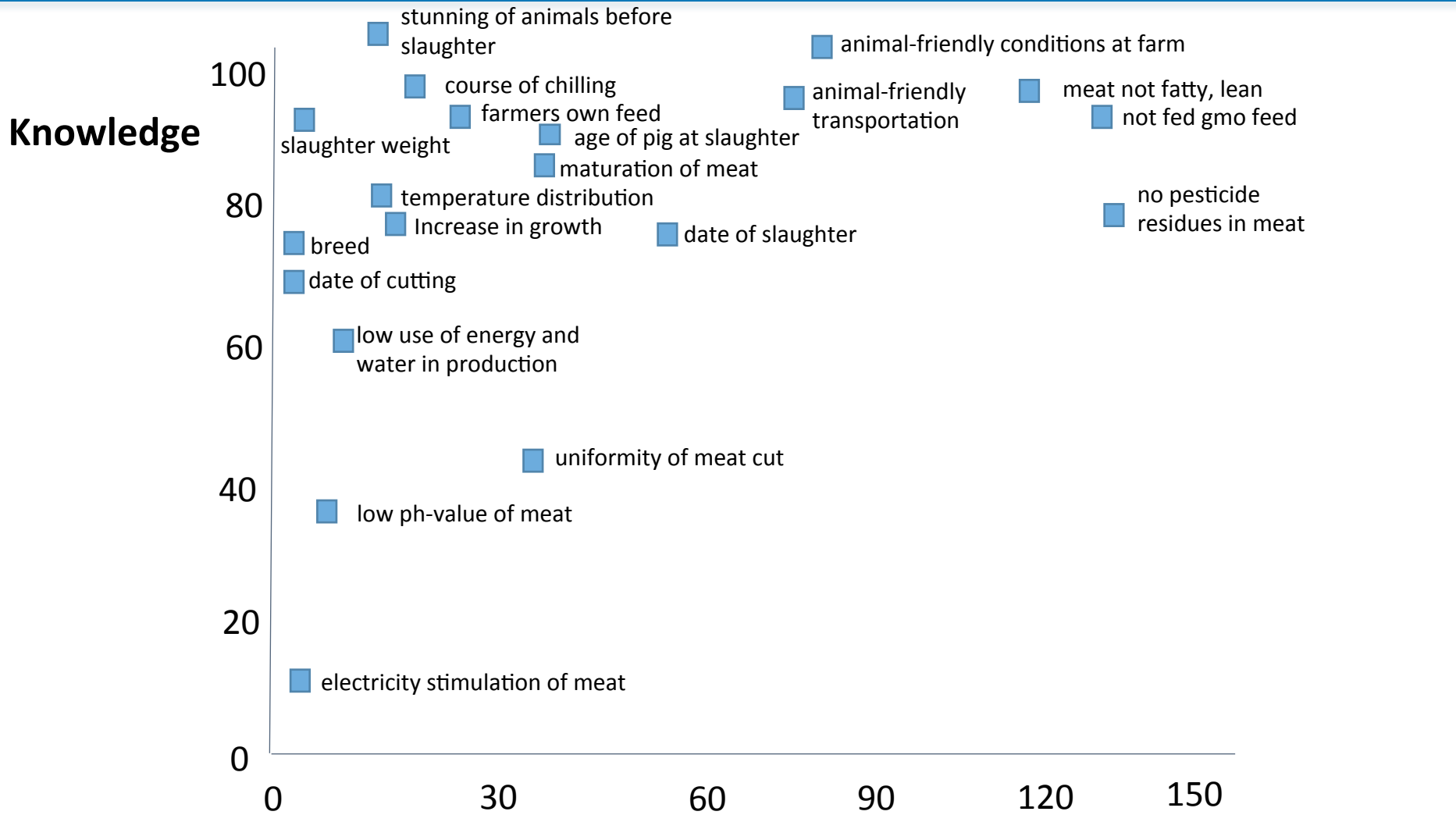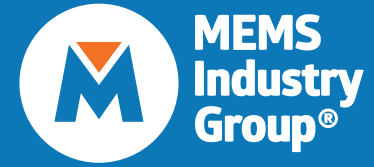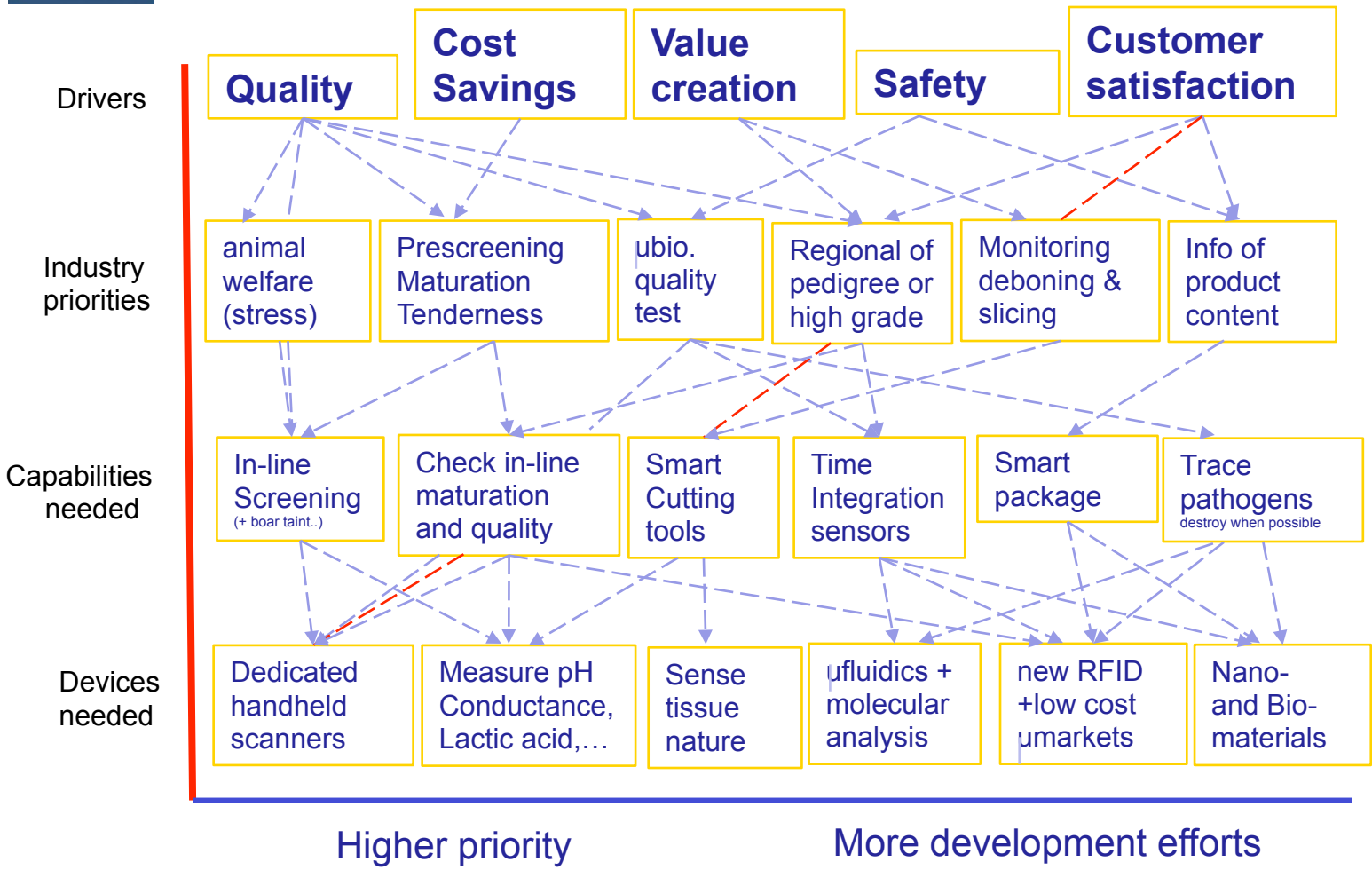- electricity stimulation of meat

Importance

Figure 3.1.1.1 Those characteristics which consumers both believe they understand and which they regard as important are in the upper right corner of the diagram.
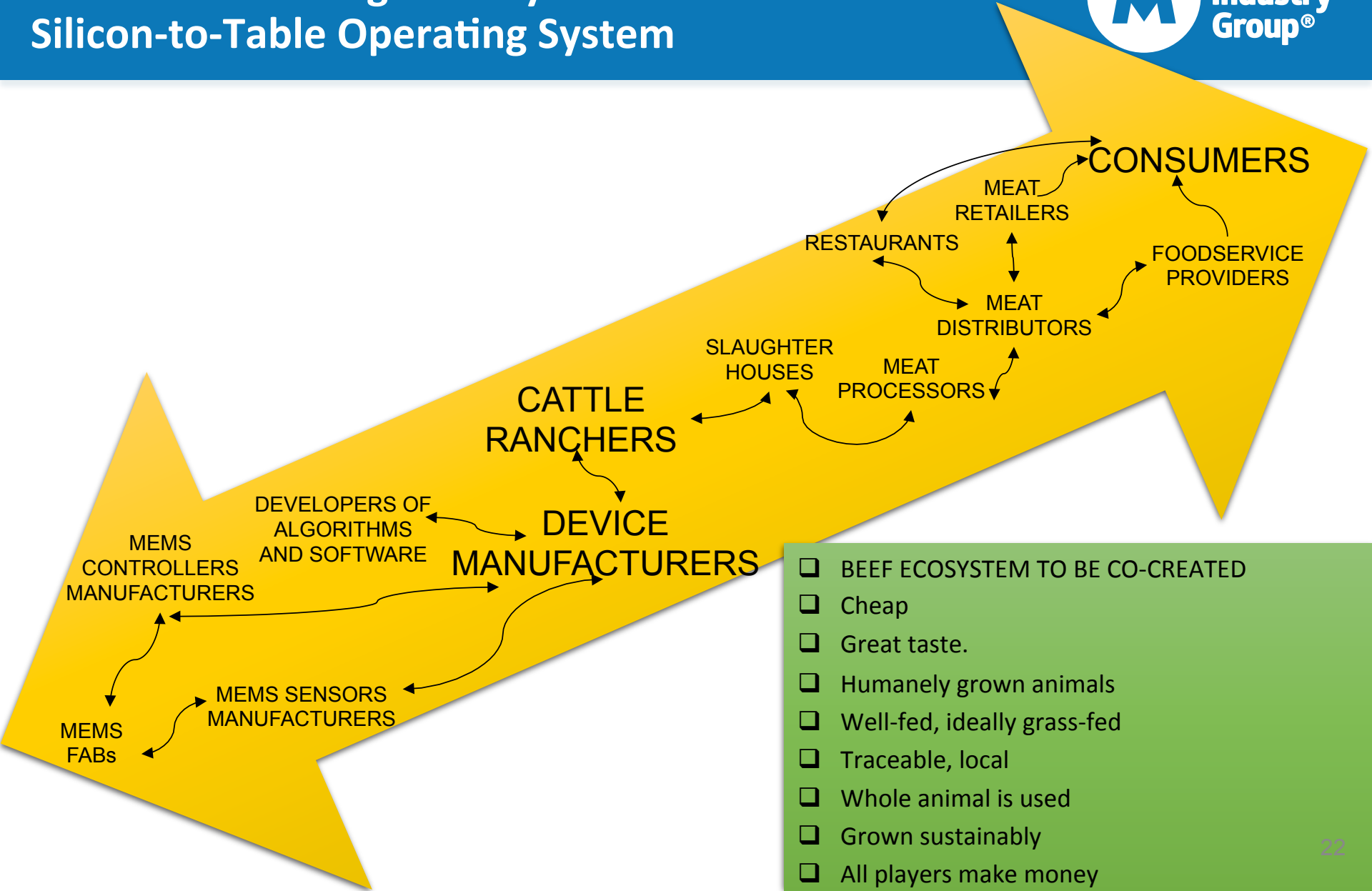
Source [Grunert et al., 2004]

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This Could Drive a MEMS Technology Agenda That Would Transform the Whole Meat Ecosystem

Meat technology: unprocessed meats

Drivers

| Quality | Cost Savings | Value creation | Safety | Customer satisfaction |

Industry priorities

- animal welfare (stress)
- Prescreening Maturation Tenderness
- ubio. quality test
- Regional of pedigree or high grade
- Monitoring deboning & slicing
- Info of product content

Capabilities needed

- In-line Screening (+ boar taint..)
- Check in-line maturation and quality
- Smart Cutting tools
- Time Integration sensors
- Smart package
- Trace pathogens destroy when possible

Devices needed

- Dedicated handheld scanners
- Measure pH Conductance, Lactic acid,…
- Sense tissue nature
- µfluidics + molecular analysis
- new RFID +low cost µmarkets
- Nano- and Bio-materials

Higher priority   More development efforts

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MEMS SENSORS MANUFACTURERS

MEMS FABs

- ❑ BEEF ECOSYSTEM TO BE CO-CREATED
- ❑ Cheap
- ❑ Great taste.
- ❑ Humanely grown animals
- ❑ Well-fed, ideally grass-fed
- ❑ Traceable, local
- ❑ Whole animal is used
- ❑ Grown sustainably
- ❑ All players make money

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Interested?

- **Great opportunities ahead**
- **Challenges are being addressed**
- **Co-creation will help realize better product and ecosystem solutions**
- **Engage us!**

Thank you!

www.memsindustrygroup.org

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