



Perspective and Plans for Flexible Electronics

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Imagination at work.

Outline

Past and present research at GE GRC

Flexible Electronics technology development path



GE Products, Systems, Technology

PRODUCTS



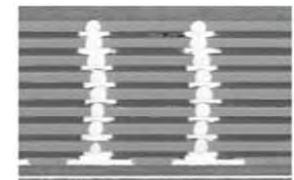
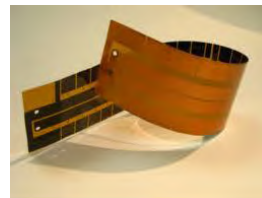
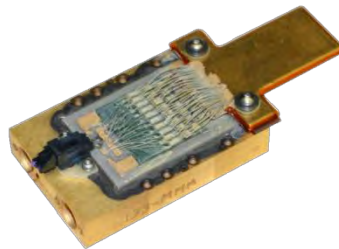
Customer CTQ's, \$\$, etc.

SYSTEMS & COMPONENTS



CTQs: Efficiency, Torque, etc.

PACKAGING TECHNOLOGY



CTQs: Size, Heat Flux Density, etc.

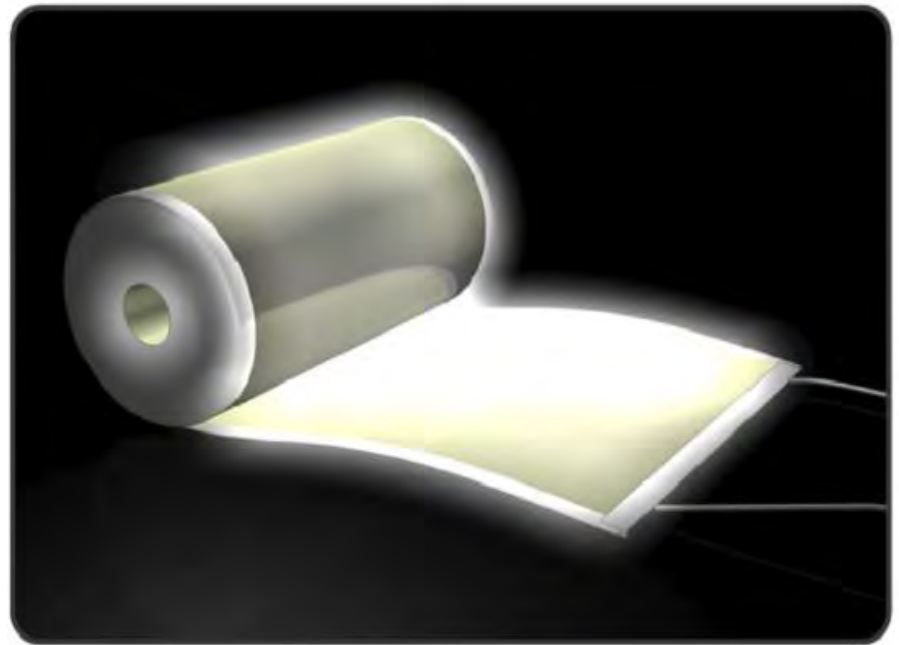
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2000 - GE OLED Vision

“Lighting Wallpaper”

- Energy Efficient
- Low Cost
- Thin and Flexible



New design possibilities could change the way we think about lighting!

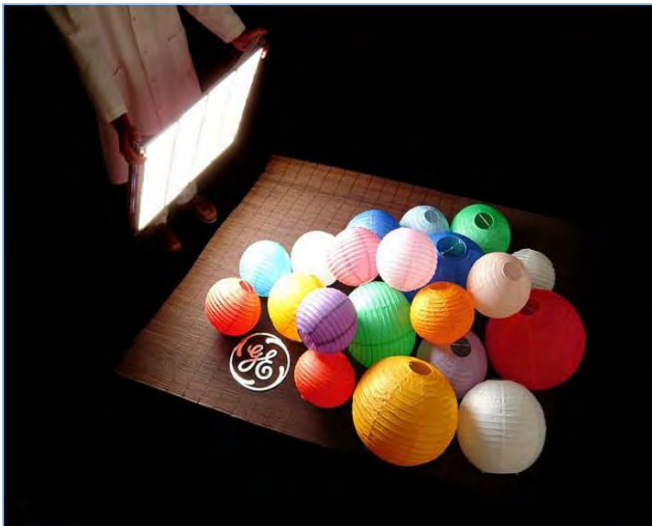


OLED Development at GE

2000-2003 – Scoping Technology

Incandescent Milestone

- 4000K on BB
- 88 CRI
- 15 LPW, 1200 Lumens



2003-2007: Roll-to-Roll Process Feasibility

First Working Output



Research Partner: Energy Conversion Devices



New Markets for X-Ray: Mobile & Portable

*Trends in display industry
similar to X-Ray*

Phase 1: Lightweight, Rigid, Unbreakable,
thin, low power

Phase 2: Curved, Rigid, Unbreakable, low
power

Phase 3: Flexible, Roll-able

Today's X-Ray

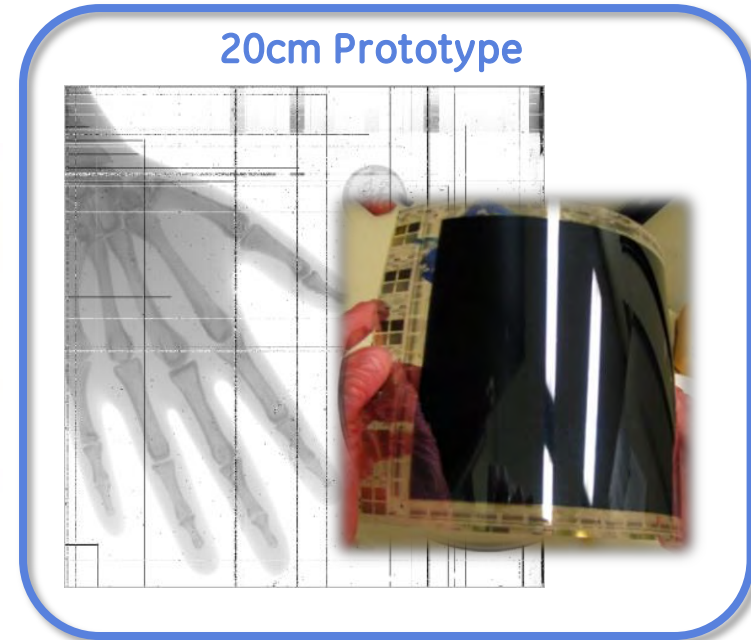
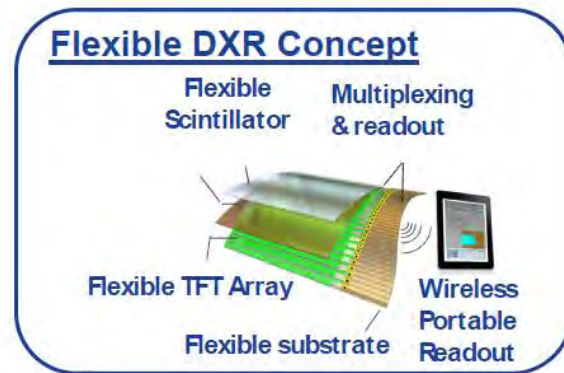
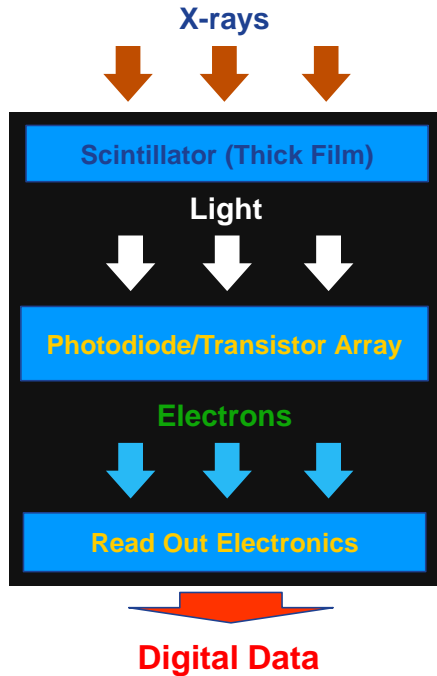


Future X-Ray ?



New DXR Technologies in Development at GE

Rugged/Flexible Digital X-Ray Detector



Raw image: no bad pixels/line correction

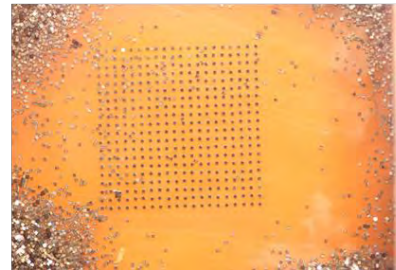
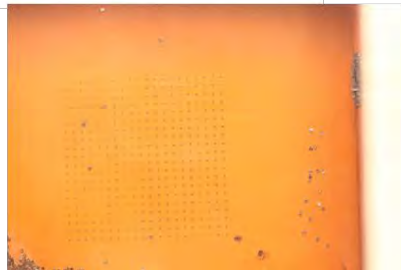
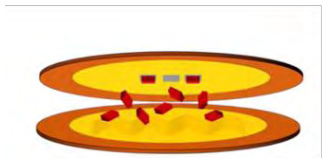
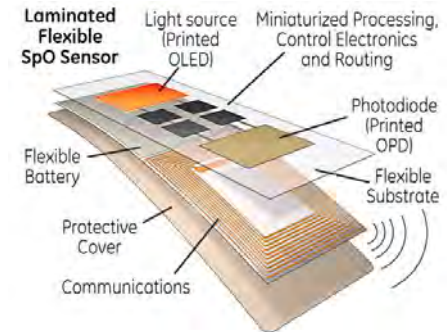
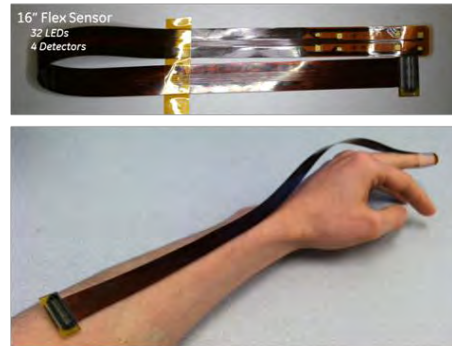
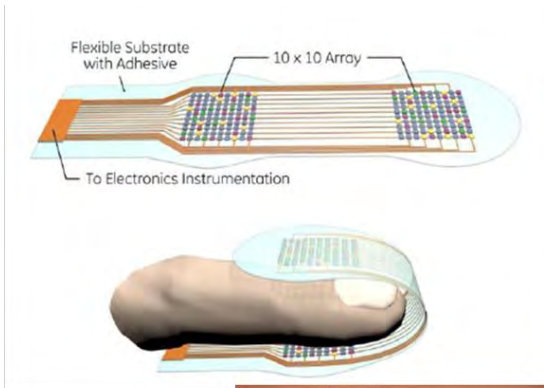
Applications in medical imaging and nondestructive testing.

Research Partner: Flexible Display Center

ARL Contract W911NF-13-2-0011



New Pulse Oximeter Concepts



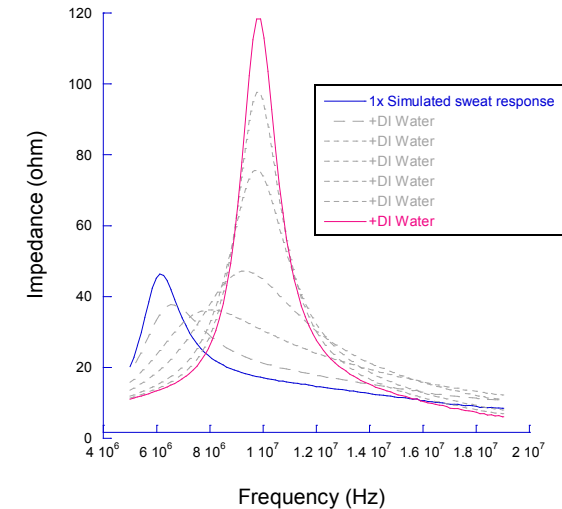
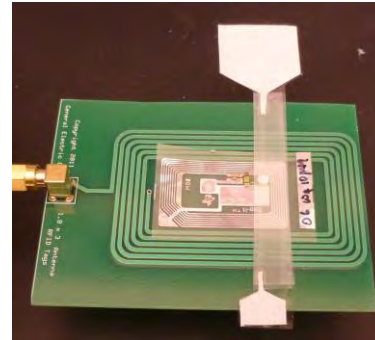
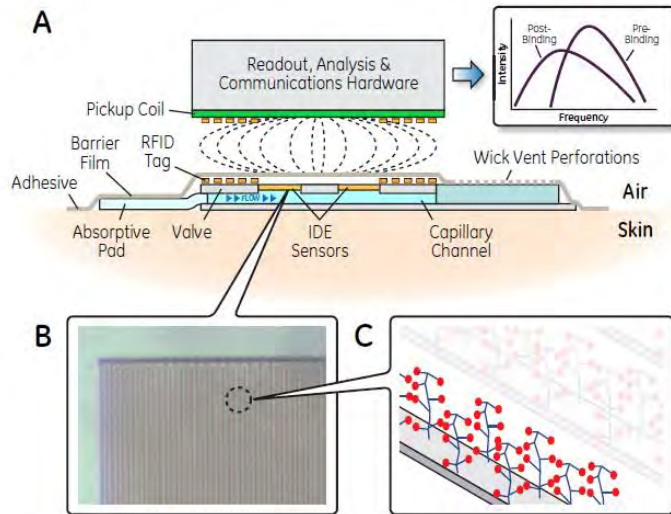
Multi-wavelength for better diagnostic capability.

Self-assembly concepts for cost.

Large area OPD for better signal/noise.



Wearable Impedance RF Sweat Sensors



Continuous measurement of biomarkers from sweat

- Hydration (electrolytes eg. Na, K)
- Stress (cortison, Orexin A)
- Inflammation (IL6, NPY, TNF- α)



Research Partners: UMass/AFRL



SiC for Power Electronics Enables New Product Capabilities

GE SiC MOSFET



1/2

Space & weight, or

2x

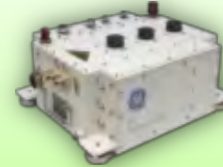
Power Density

2x

Reliability

+50°C

Higher temperature capability



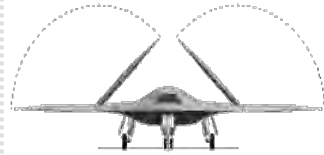
Generation



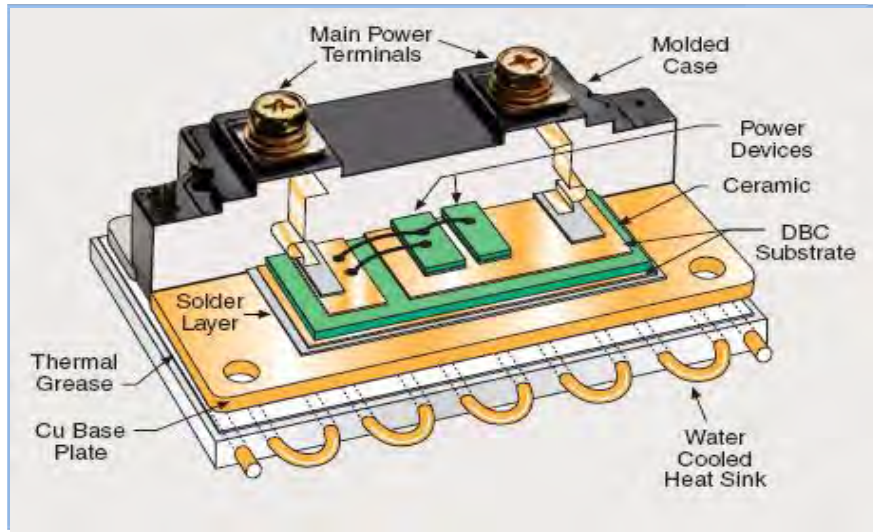
Conversion



Distribution



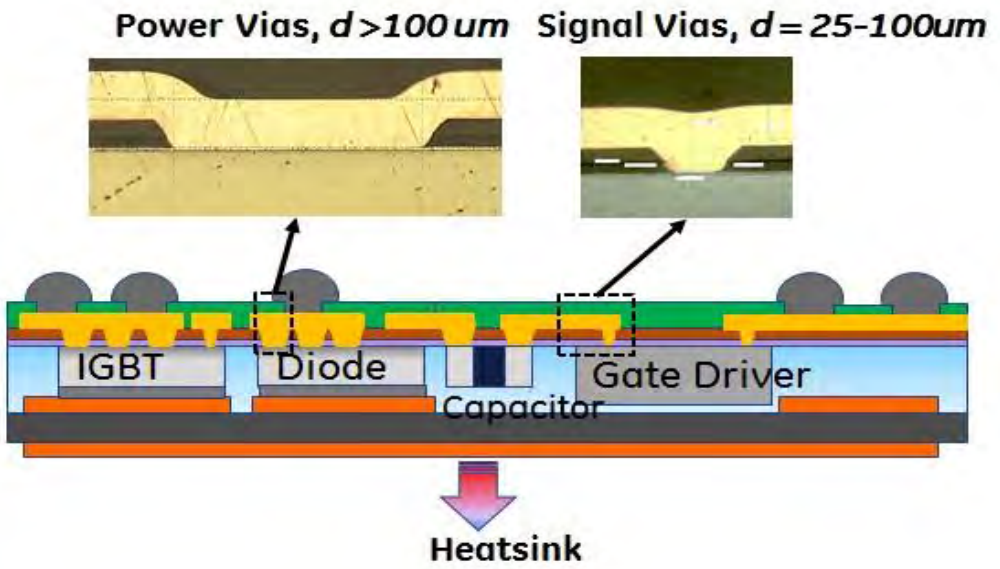
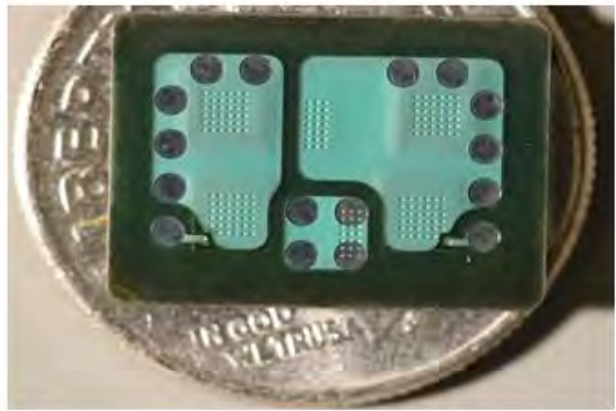
Limitations of Standard Power Module



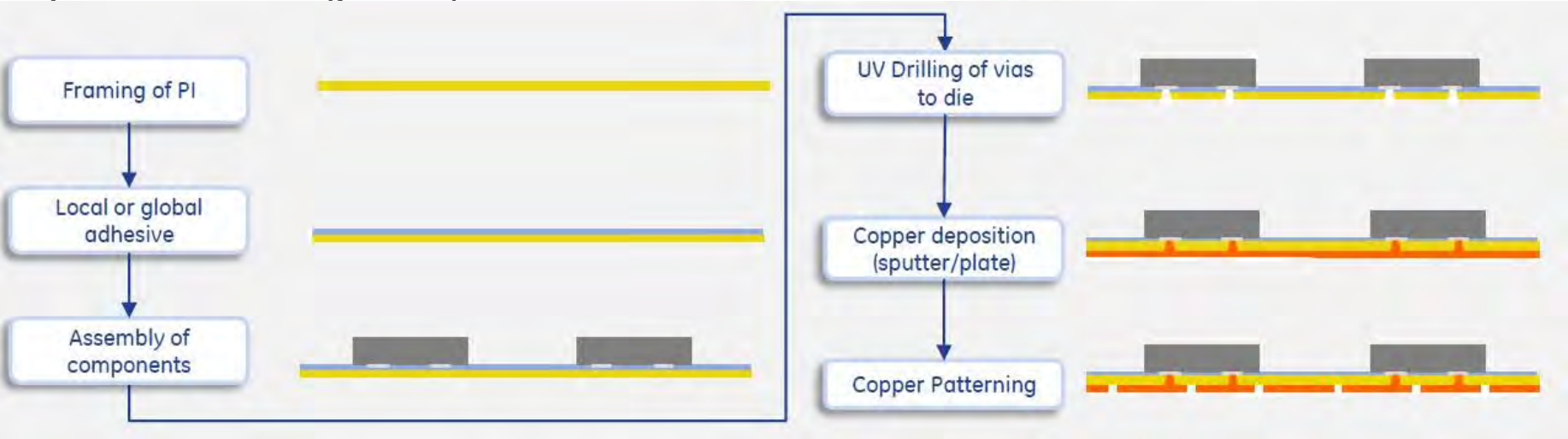
- Electrical limitations
 - Package inductance too high
 - Wirebond current handling
- Thermal limitations
 - Baseplate-to-heatsink thermal resistance
 - Low power density (including heatsink)
- SiC module power limitations
 - Yield and cost challenges associated with wirebonding many small SiC devices



Power Overlay (POL) Platform: Realizing the full benefit of SiC power electronics



Direct copper interconnect
Polyimide based integration platform



Flexible Electronics Development at GE

“Technology Push” is hard!
Where is “Market Pull”?



GE Healthcare



Monitoring Solutions



- **Wearable & wireless**
- **Medical body area networks**
- **Multi-parameter systems.**

GE already has business in “wearables” for hospital.
Large market pull to reduce size and cost.



Wearables Market Segmentation

Sports/Fitness

- Calorie tracker
- Vital signs
- Motion tracker
- Temperature regulation

Wellness

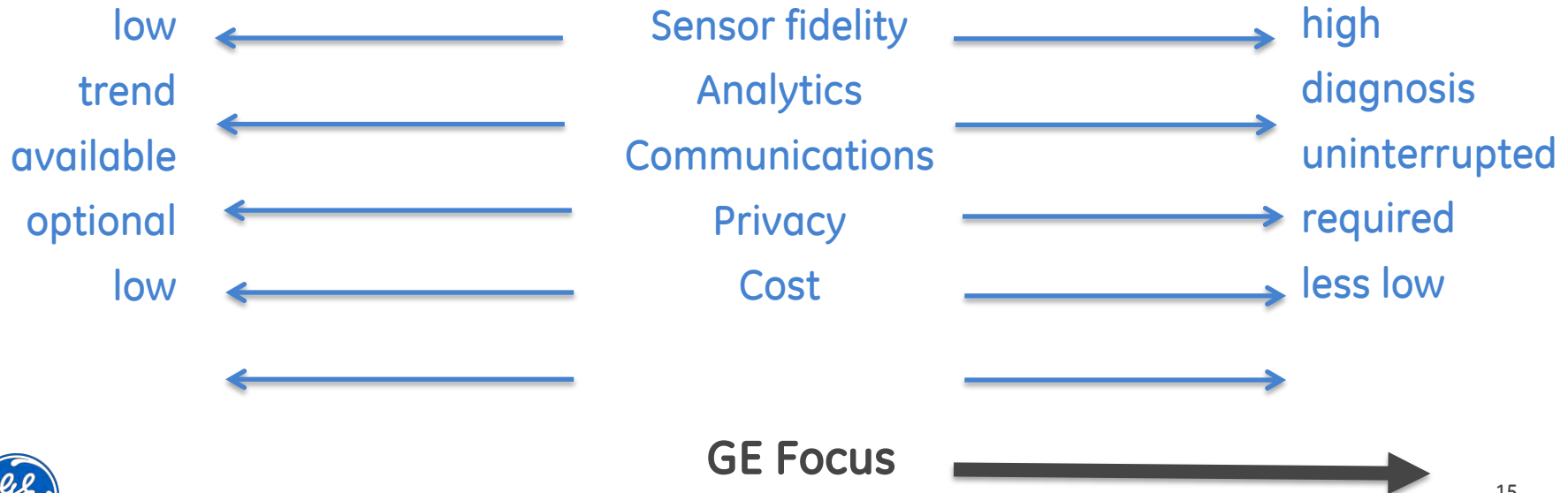
- Physiological
- Stress
- Weight
- Ergonomics

Home Health

- General
- Chronic
- 30-day re-admissions

In-Hospital

- General hospitalization
- Critical care
- Neonatal



GE Technology Plans for Wearables

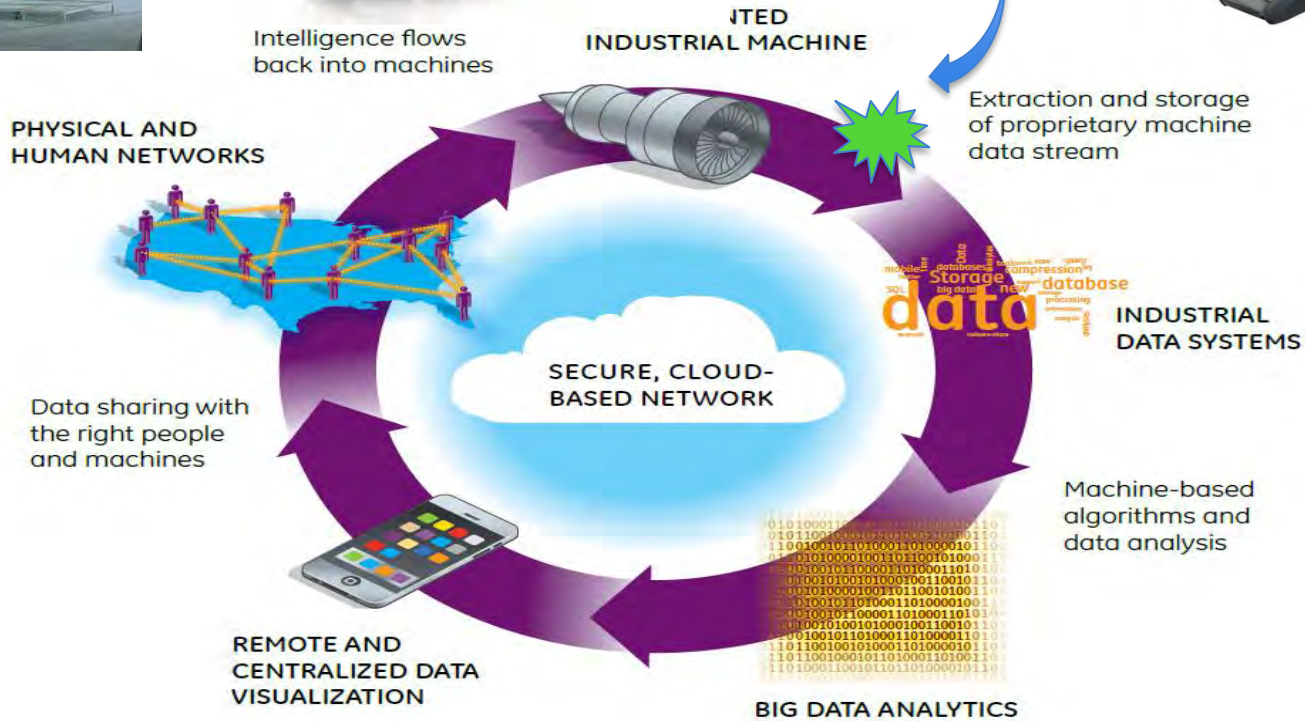
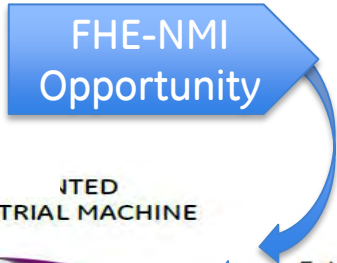
Focus is on developing system solutions that integrate with healthcare infrastructure.

- Evaluate and implement new sensors as they become available.
- Partner to develop new flexible electronics-based sensor technologies where GE brings unique capability.
- Develop advanced algorithms for existing sensors.
- Collaborate with clinicians to develop new tools and analytics.

External collaboration is critical to success.



GE Context : The Industrial Internet



From: P. C. Evans and M. Annunziata, Industrial Internet: Pushing the Boundaries of Minds and Machines



Industrial Internet Consortium



- Need similar ecosystem for healthcare.
- Flexible electronics will be a key technology element.



Conclusions

GE has rich history in flexible electronics technology.

Future focus is on system solutions for healthcare.

GE welcomes partnerships in wearable sensor technology.

Acknowledgements

GRC Advanced Technology Team

- Department of Energy
- National Institute of Standards and Technology
- United States Display Consortium
- Army Research Laboratory
- Defense Threat Reduction Agency
- Air Force Research Laboratory
- Nano-Bio Manufacturing Consortium



