We are devoted to the betterment of human health and well-being through applied medical device innovation

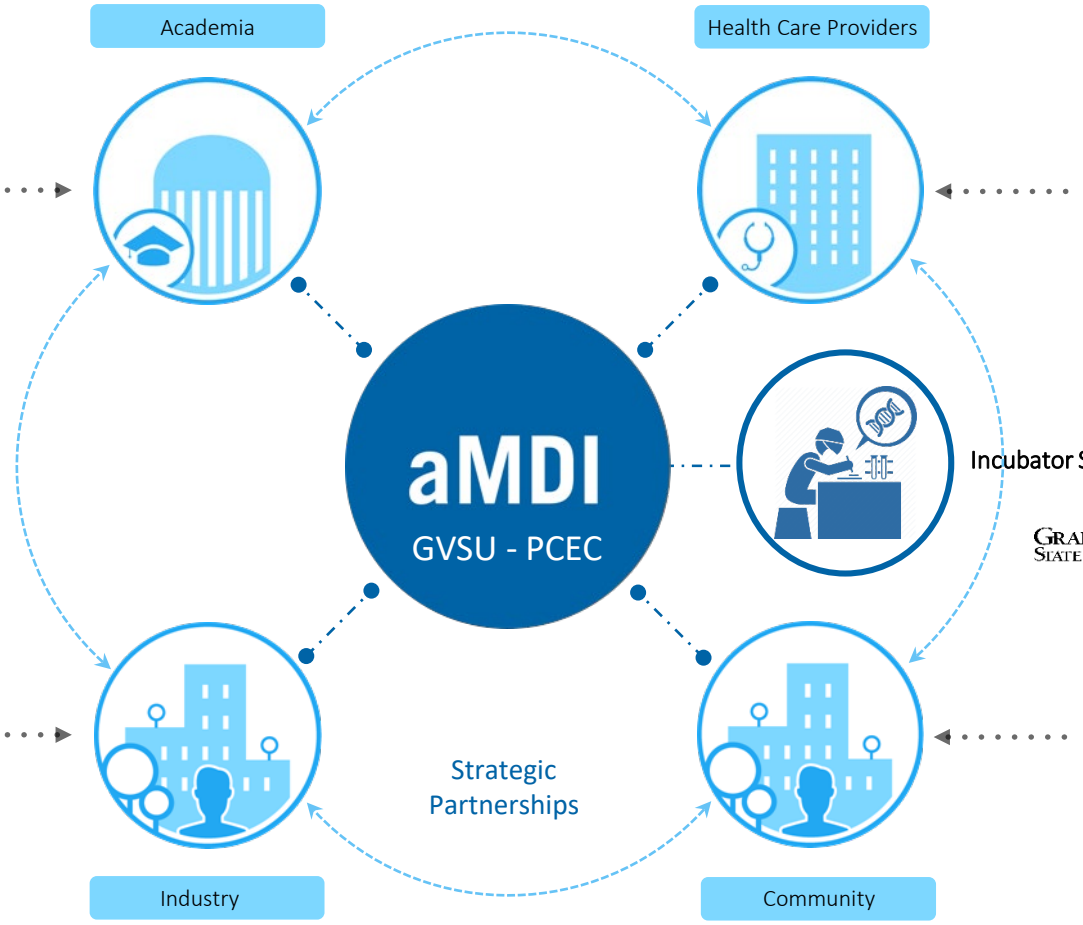
Internet of Medical Things

Thoughts of a practitioner

Enhancing student learning experiences, engaging faculty and our community to bring novel medical devices to market.

Grand Valley State University
Applied Medical Device Institute

Serving a gap between education, health care, industry, & community



Calvin College 1876

Hope College

University of Michigan

Wayne State University

Michigan Technological University

Michigan State University

Faculty
Scholarly works

Students
Immersive education

Encoris

MTEC Medical Technology Enterprise Consortium

SURGE Cardiovascular

Spectrum Health Innovations

MEDISURGE An ISO 13485 Certified Contract Manufacturer

Sterilogy for Life

Manufacturing

Sales & Distribution

Packaging & Labeling

Engineering

Industry Associates 11

Clients 15

Spectrum Health

Borgess

Bronson

Beaumont

Henry Ford Health System

Mercy Health

Trinity Health

Providence Health Plan

Cleveland Clinic

McLaren Health Care

Nurses & Staff

Surgeons

Physicians

Clinicians

Administration

STEM Programs

Incubator Space

- Mini-lab space and office space options
- Ideal for grants through (SBIR), (STTR), or (SCIP)
- Commercialization, Concepts and Connections
- Access to medical / wet lab equipment

Grand Valley State University

MBIA

MEDC Michigan Economic Development Corporation

City of Grand Rapids

Government Sponsors

Government Agencies (MEDC, SCIP)

Inventors

Entrepreneurs

W.K. Kellogg Foundation

OUR Grand Rapids Community Foundation

MichBio

MD Medevice

MVCA Michigan Venture Capital Association

Start Garden

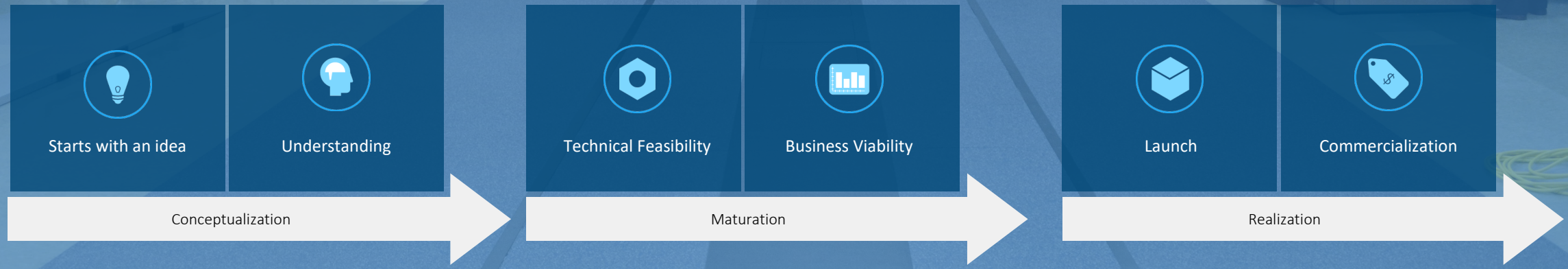
SmartZone Business Accelerator

MCRN Michigan Corporate Relations Network

The Right Place

Our process and services

- Product conceptualization
- Root cause analysis
- Project Management
- Requirements Definition
- Opportunity Identification
- Applied Computing Institute
- Electromagnetic Compatibility Testing
- Engineering
- Manufacturing
- Prototyping
- Testbed Development
- Validation
- Verification
- Detailed Design

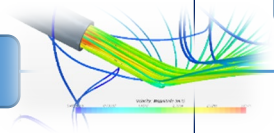


2015 | 2016 | 2017 | 2018 | 2019 | 2020

Spectrum HVI
Remote Robotic Surgery

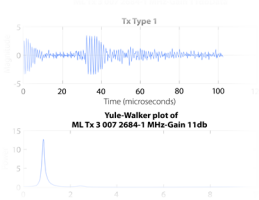
NIH/NSF
Automated Surgical Bed

Surge Cardiovascular, Inc.
Cannula Design CFD

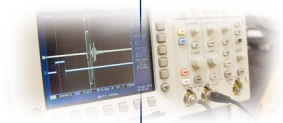


Run Form Labs
Biomechanics

Visualhero
GVSU Community College



OrthoForge
Signal Analysis



Spectrum HVI
Remote Robotic Surgery

Inspired Biometrics
Device Prototype

Surge Cardiovascular, Inc.
Cannula Fab & Test

Sterilogy
Proof of Principle

Spectrum HVI
Aortic Arch CFD

eVideon
Design

Orthoforge
Testing

Test 4 Time
Application Development

Encoris
Spine Surgery

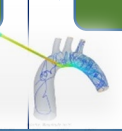
SHI uCol
Proof-of-Principle

Airway Innovations
FEA

NIH/NSF
Image Compression

Inspired Biometrics
Device Prototype

Sterilogy
Device Development



Spectrum HVI
Aortic Arch CFD

eVideon
Device Development

Sigvaris

OST
Marketing

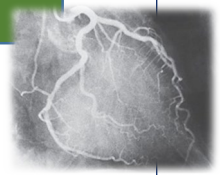
Test 4 Time
Retainer Service

Encoris
Jamshidi Imaging

SHI uCol
Manufacturability

Airway Innovations
FEA

NIH/NSF
Force Control



MediSurge, Inc.
Additive Manufacturing

Packaging Compliance Labs, Inc.
Nested Packaging Development

MediSurge, Inc.
Additive Manufacturing

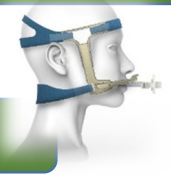
Packaging Compliance Labs, Inc.
Nested Packaging Development

Sterilogy
Testing

Ontilogics

Ontilogics

Encoris
Lateral Surgery



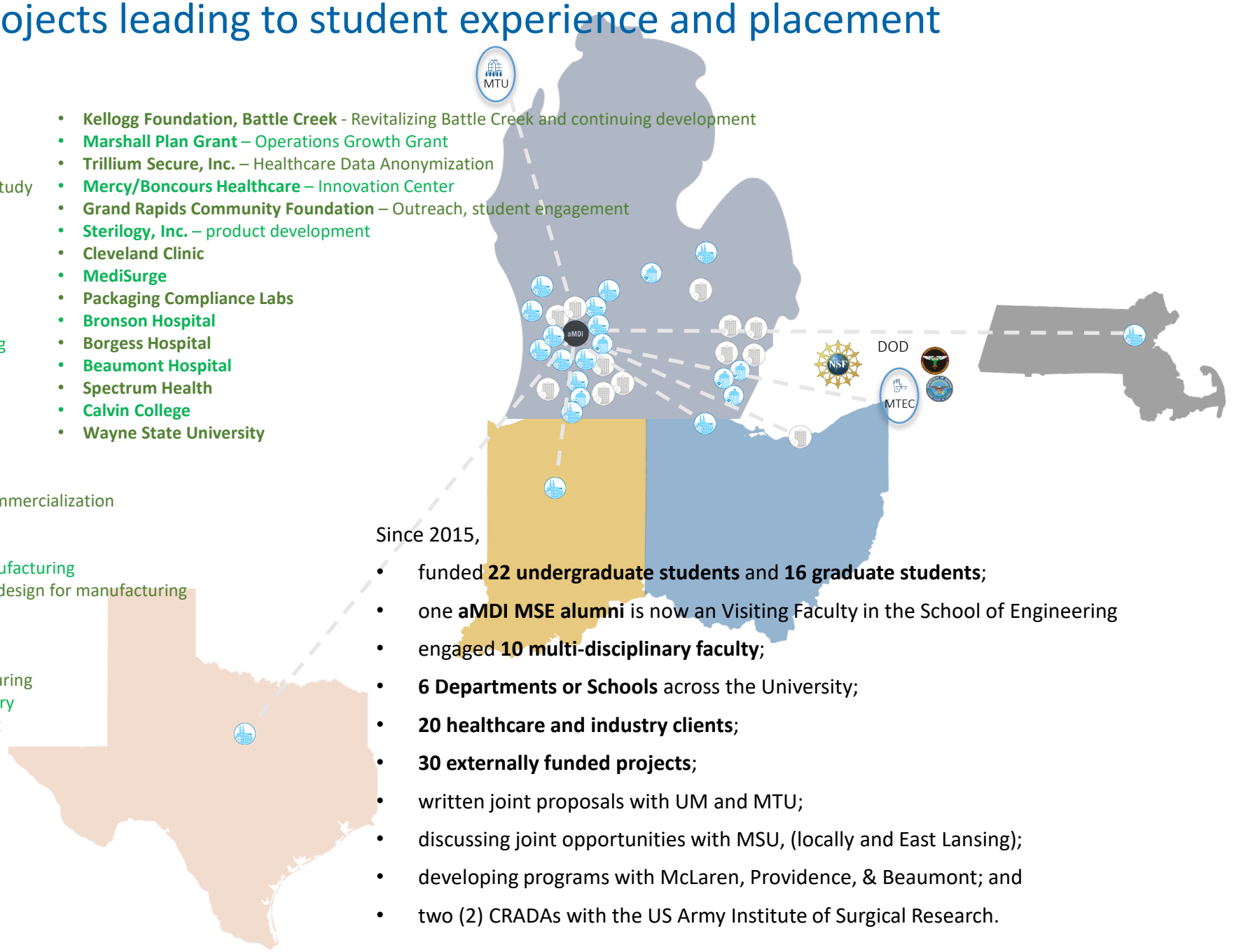
SHI uCol
Clinical Trial Engineering

Airway Innovations
Fab & Test

Impact- Client Sponsored Projects leading to student experience and placement

- **Surge Cardiovascular**- Aortic Arch Cannula CFD
- **Spectrum Heart & Vascular Institute** - Remote Robotic Surgery
- **OrthoForge** - Orthopedic Sensor Validation
- **Spectrum Health Innovations** - Female Urinary Catheter Value Study
  - Phase 1a uCol Replication
  - Phase 2a Design and Validation
- **RunForm Labs** - Biomechanics Comparison Measurements
- **Trinity Health** - Esophageal Tracheotomy Device
- **eVideon** - NextGen Patient Experience Med Device
- **Test 4 Time** - Learning Application Development & Testing
- **Spectrum Heart & Vascular Institute** - LVAD Aortic CFD Modeling
- **Encoris** - Spine Surgery Trainer Enhancements
- **Grand Valley State** - aMDI Public Relations Campaign CAP 495
- **Grand Valley State** - Pedestrian/Cyclist Protective Wear
- **Grand Valley State** - Running Dynamics
- **Grand Valley State** - Astronaut Hand Exoskeleton
- **Beaumont Research Institute** - Pain Measurement Device
- **Airway Innovations** - product development, testing, support commercialization
- **Inspired Biometrics** - product development
- **Sterilogy Phase 1b** – Beta-site ready development
- **Distal Perfusion** - product development, testing, design for manufacturing
- **Surge Cardiovascular (MTRAC)** - product development, testing, design for manufacturing
- **uCol Phase 2b** - design, support commercialization
- **MTEC - Vascular/Arterial** - research, experimental development
- **AIRS Med App** - opportunity identification, customer discovery
- **AIRS Filter** - product development, testing, design for manufacturing
- **The Right Answer** - opportunity identification, customer discovery
- **Orindi** - product development, testing, design for manufacturing
- **Sigvaris** - Adaptable pressure socks for vascular diseases
- **Ontologics** - Machine learning patent classification
- **Applied Mobility, LLC** - Physical Therapy device

- **Kellogg Foundation, Battle Creek** - Revitalizing Battle Creek and continuing development
- **Marshall Plan Grant** – Operations Growth Grant
- **Trillium Secure, Inc.** – Healthcare Data Anonymization
- **Mercy/Boncours Healthcare** – Innovation Center
- **Grand Rapids Community Foundation** – Outreach, student engagement
- **Sterilogy, Inc.** – product development
- **Cleveland Clinic**
- **MediSurge**
- **Packaging Compliance Labs**
- **Bronson Hospital**
- **Borgess Hospital**
- **Beaumont Hospital**
- **Spectrum Health**
- **Calvin College**
- **Wayne State University**



Since 2015,

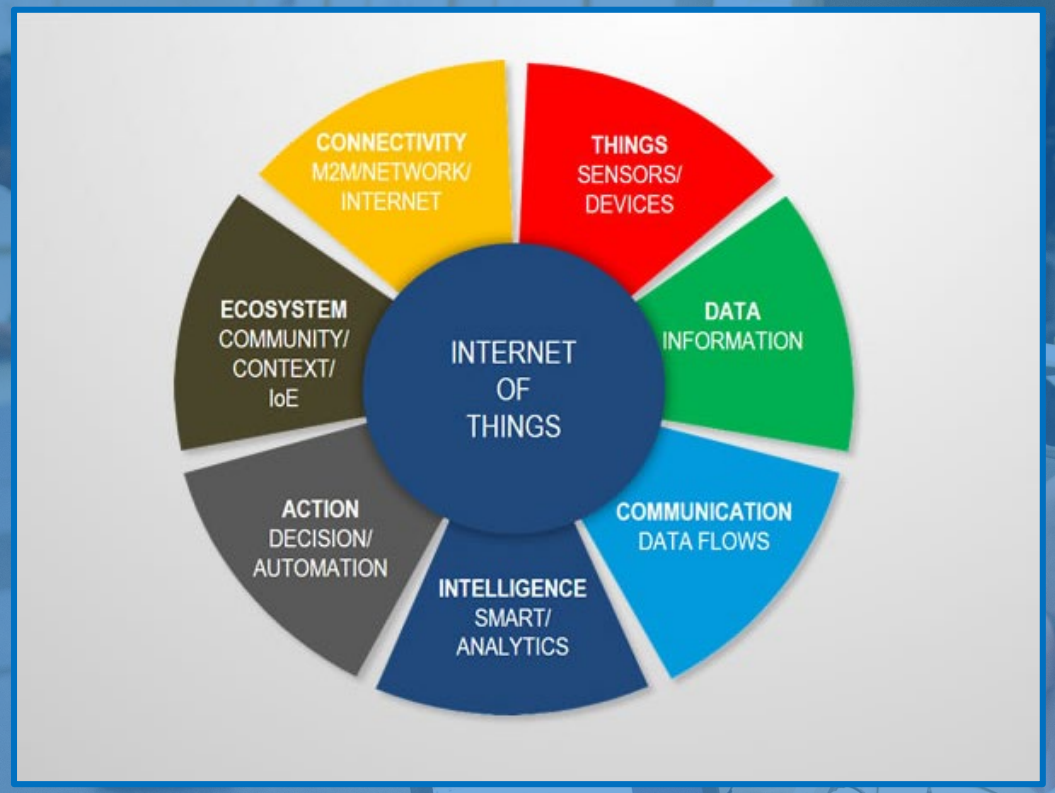
- funded **22 undergraduate students** and **16 graduate students**;
- one **aMDI MSE alumni** is now an Visiting Faculty in the School of Engineering
- engaged **10 multi-disciplinary faculty**;
- **6 Departments or Schools** across the University;
- **20 healthcare and industry clients**;
- **30 externally funded projects**;
- written joint proposals with UM and MTU;
- discussing joint opportunities with MSU, (locally and East Lansing);
- developing programs with McLaren, Providence, & Beaumont; and
- two (2) CRADAs with the US Army Institute of Surgical Research.

IoMT, I am your biggest fan!

The story of the temperature measurement as an indicator for health and wellness:

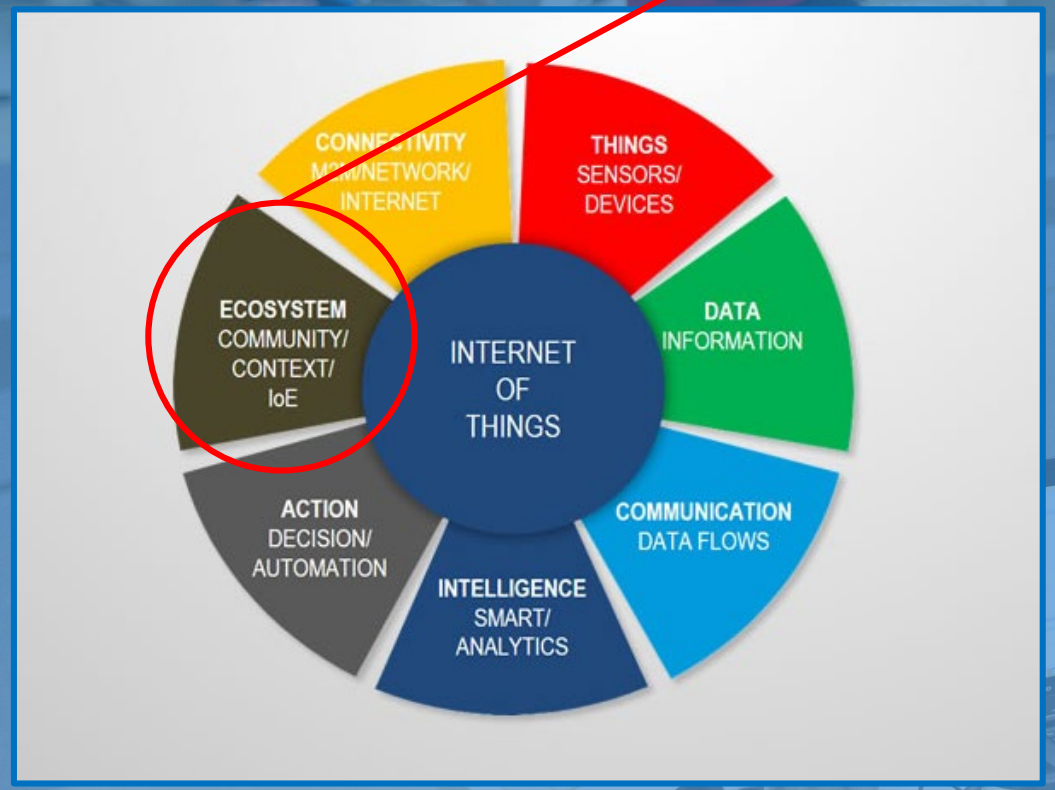
- Heuristics
  - 460 BC – Hippocrates: fever and chills were considered a morbid process.
  - 476 AD – 1492: In the Middle Ages health was defined using four humors: hot, cold, dry, and moist.
- Science
  - 1592 – Galileo Galilea invented a crude temperature measurement device without a scale.
  - 1654 - Ferdinando II de' Medici, Grand Duke of Tuscany created an enclosed thermometer that used alcohol.
  - 1714 – Gabriel Fahrenheit invented the first mercury thermometer with scale referring to his last name.
  - 1742 – Alders Celsius defined the scale that refers to his last name.
- Application
  - Circa 1760 - Dr. A. De Haen (1707 – 76) used the thermometer bedside to study illness progression. Viennese School of Medicine colleagues were unimpressed.
  - 1866 - Sir Dr. Clifford Allbutt invented the 6” clinical thermometer that read the temperature in 5 minutes. He practiced for 28 years and published extensively in 1871, 1892, and 1915.
  - 1868 – Dr. Carl Wunderlich published > 1M readings of 25,000 patients using a foot-long axilla thermometer that took 20 minutes to stabilize the temperature reading.
- 1964 – Dr. Theodor H. Benzinger invented the ear thermometer

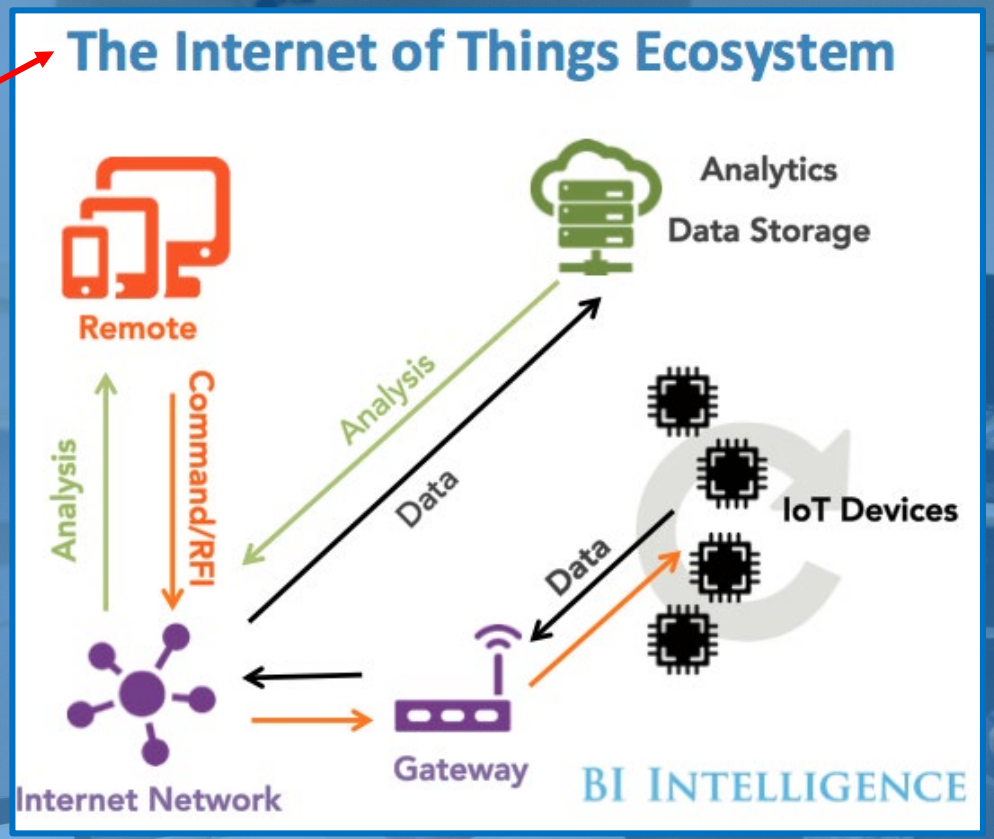
The defining characteristics of IoMT



GRAND VALLEY STATE UNIVERSITY
APPLIED MEDICAL DEVICE INSTITUTE

Think of the challenges in context of the Ecosystem





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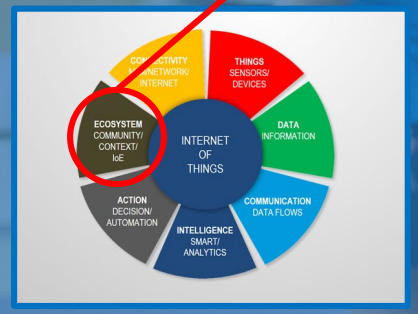
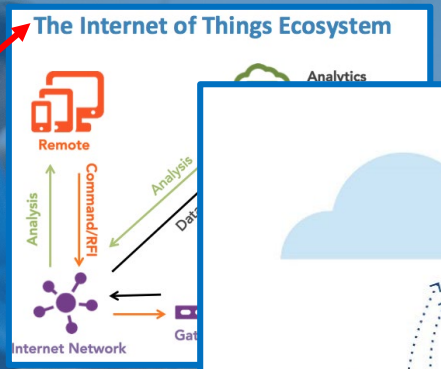
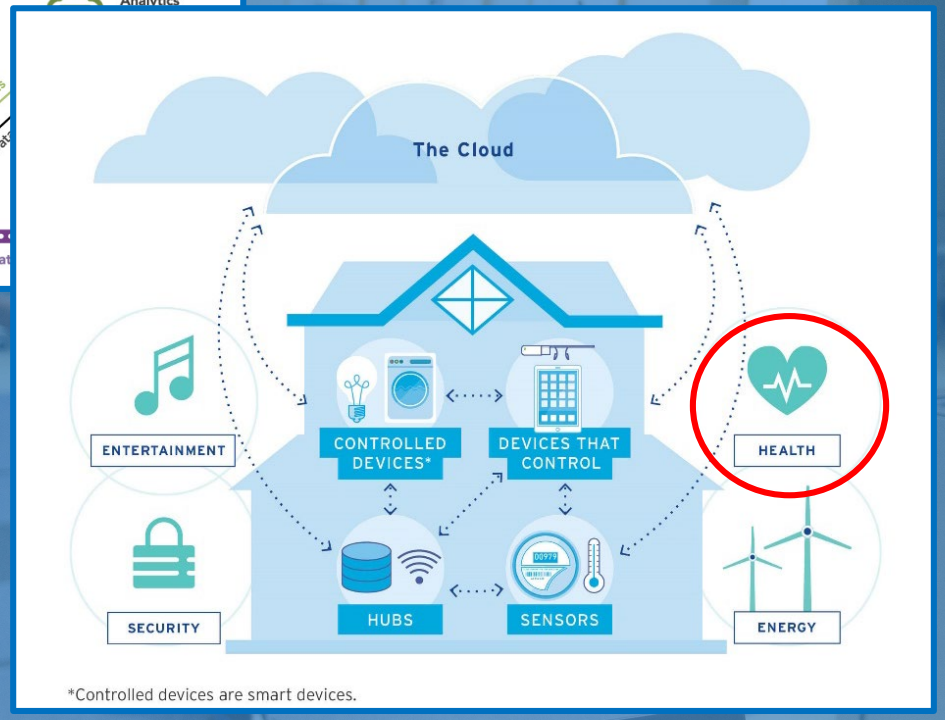
Let’s bring this home!







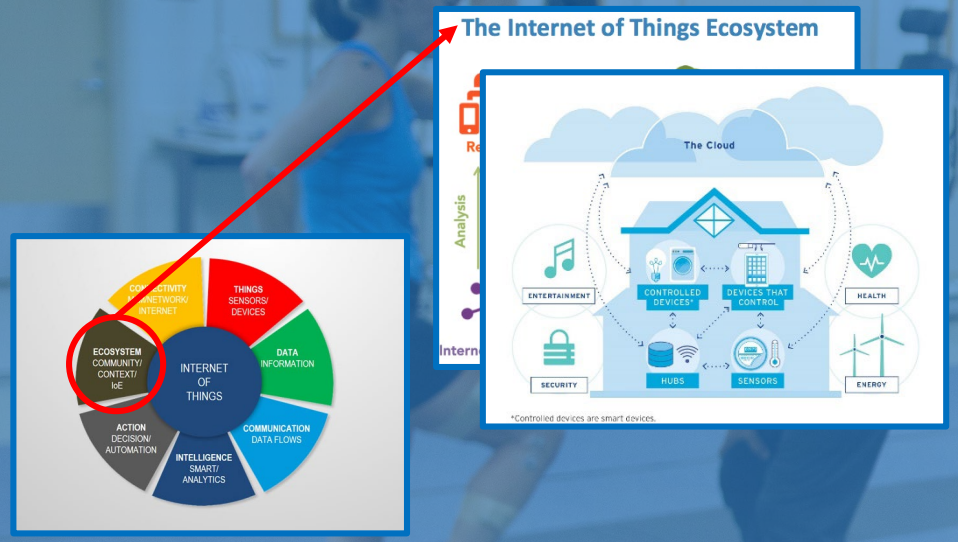
1. Fitness wearables
2. Clinical grade wearables
3. Remote patient monitoring devices
4. Smart pills
5. Point of care devices and kiosks
6. Clinical monitors
7. Hospital devices

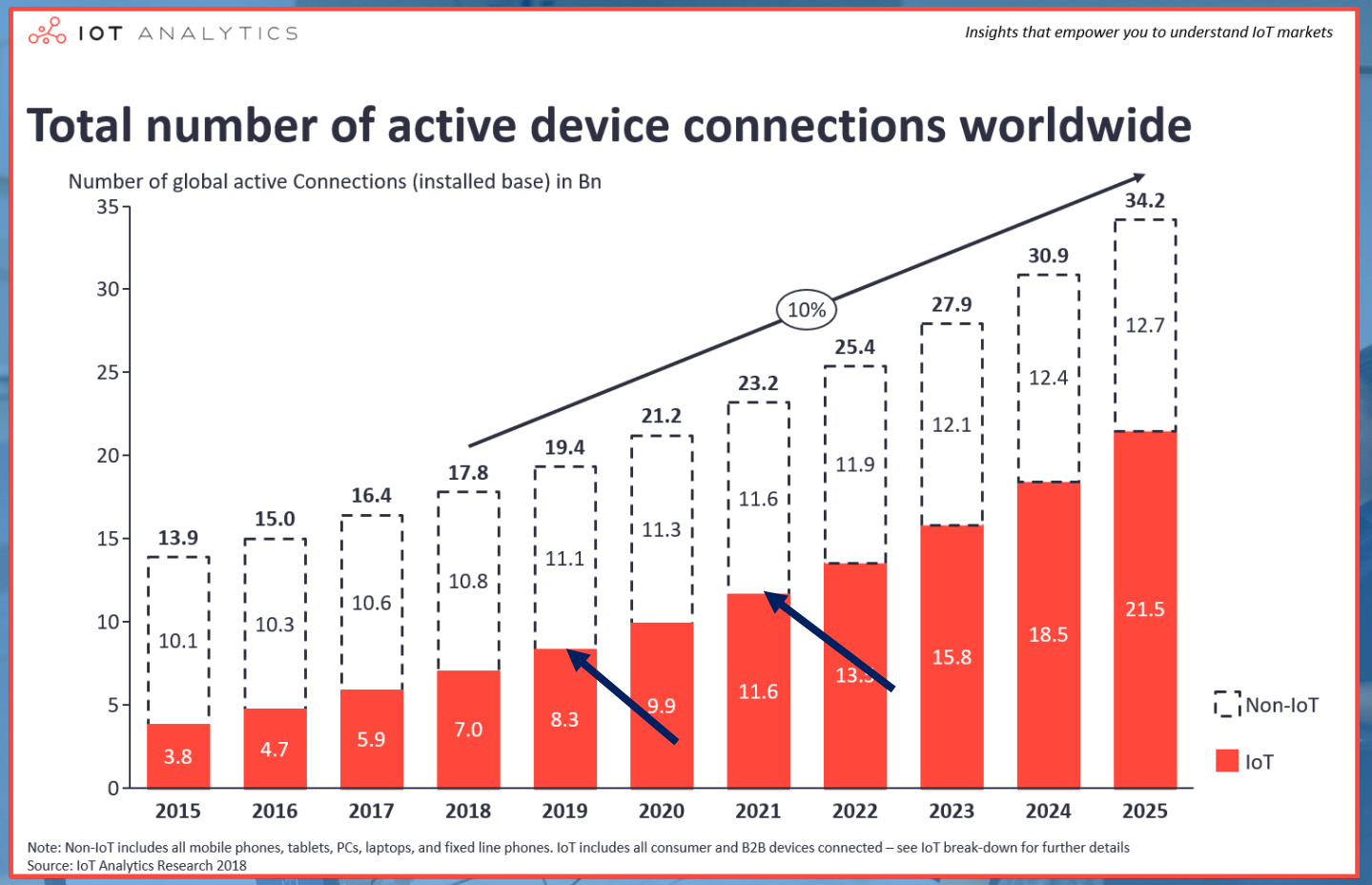
Features of the connected home include:

- Smart appliances
- Smart meters and advanced metering infrastructure
- Smart grid
- Cloud computing
- Mobile
- Touch screen
- Sensor networks
- Controls
- Hubs
- Home automation
- Smart thermostat
- Health (elderly monitoring, home care, health & wellness, etc.)
- Security systems

Grand Valley State University
Applied Medical Device Institute

Think of the challenges in context of the Ecosystem





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APPLIED MEDICAL DEVICE INSTITUTE

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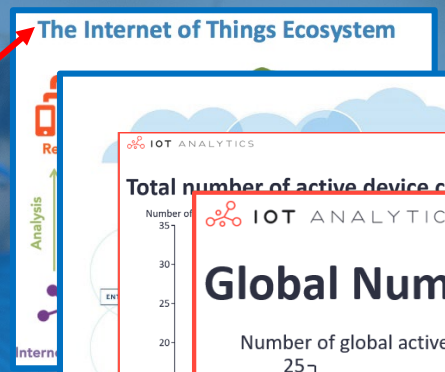
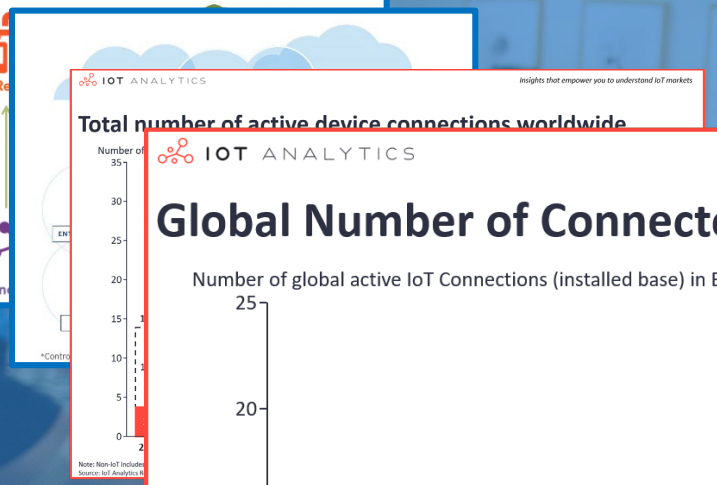


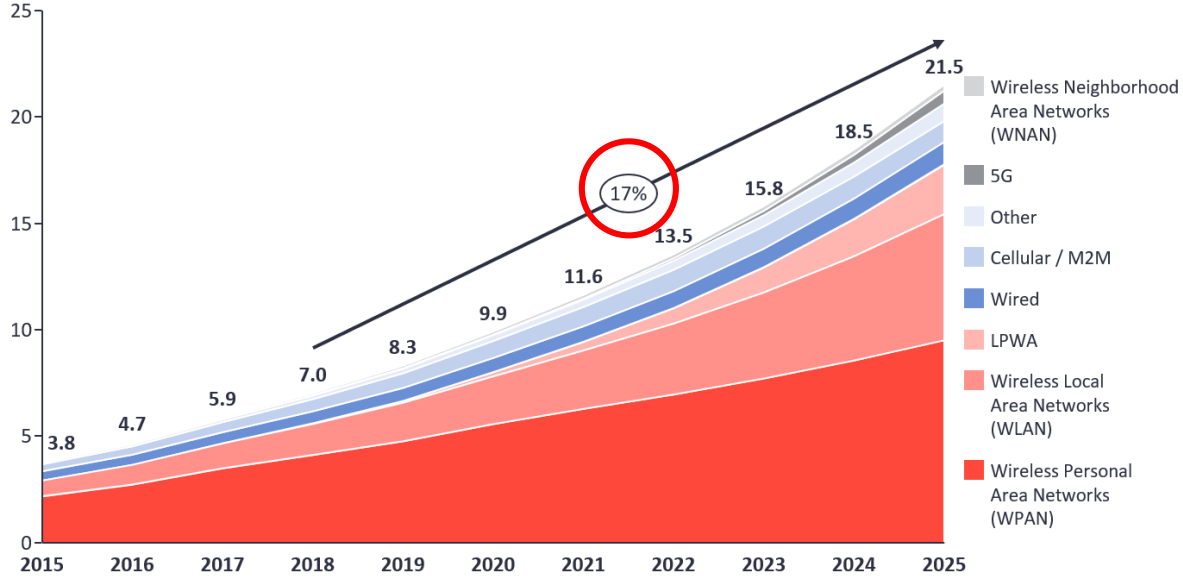


IOT ANALYTICS

Insights that empower you to understand IoT markets

Global Number of Connected IoT Devices

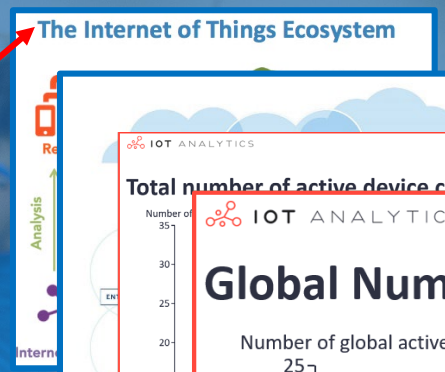
Number of global active IoT Connections (installed base) in Bn

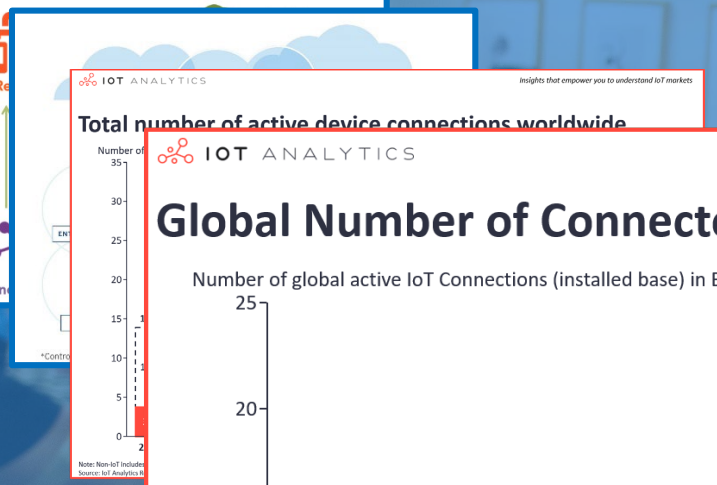


Note: IoT Connections do not include any computers, laptops, fixed phones, cellphones or tablets. Counted are active nodes/devices or gateways that concentrate the end-sensors, not every sensor/actuator. Simple one-directional communications technology not considered (e.g., RFID, NFC). Wired includes Ethernet and Fieldbuses (e.g., connected industrial PLCs or I/O modules); Cellular includes 2G, 3G, 4G; LPWAN includes unlicensed and licensed low-power networks; WPAN includes Bluetooth, Zigbee, Z-Wave or similar; WLAN includes Wi-fi and related protocols; WNAN includes non-short range mesh; Other includes satellite and unclassified proprietary networks with any range.
Source: IoT Analytics Research 2018

GRAND VALLEY STATE UNIVERSITY
APPLIED MEDICAL DEVICE INSTITUTE

Think of the challenges in context of the Ecosystem





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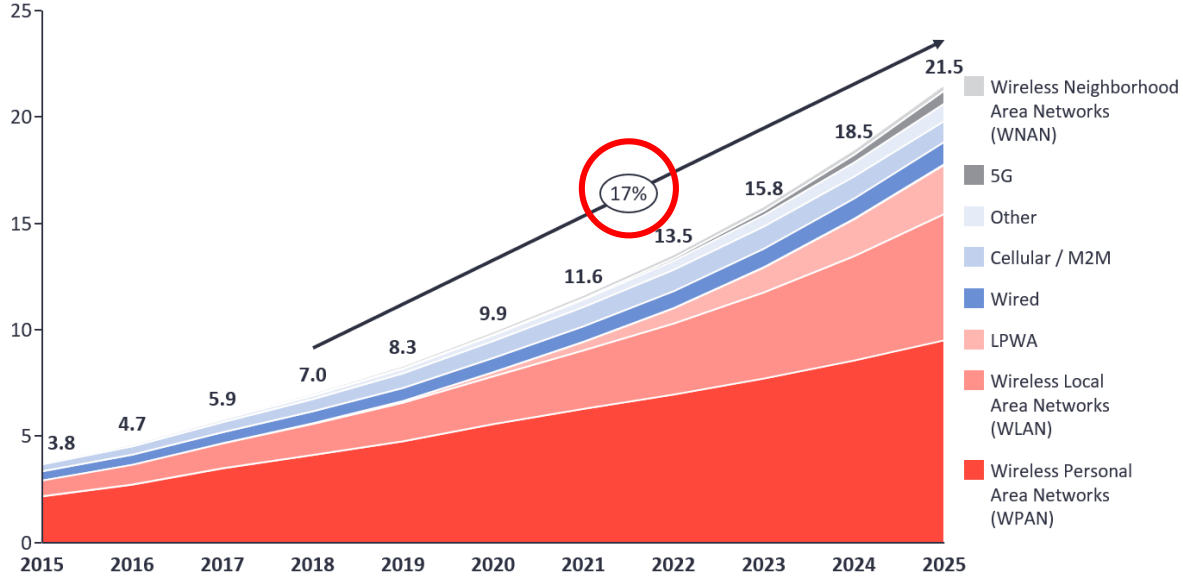

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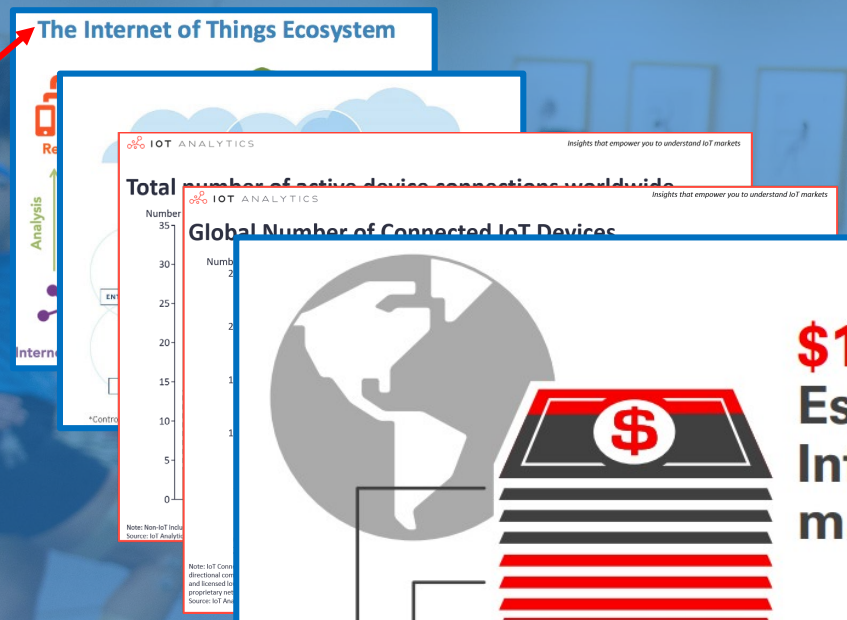

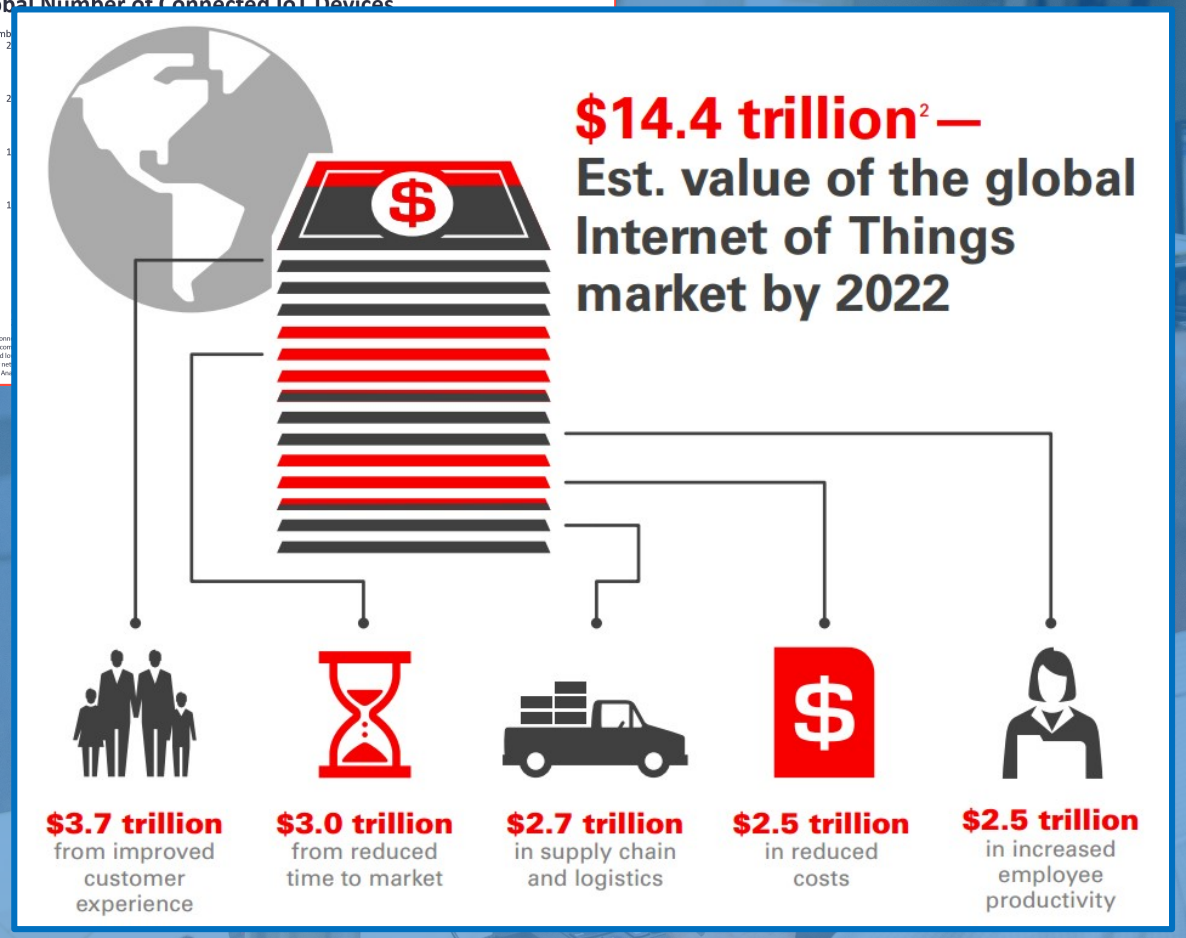

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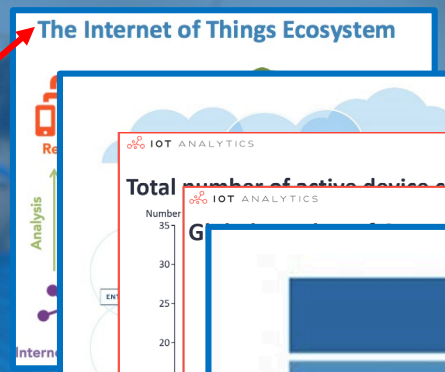
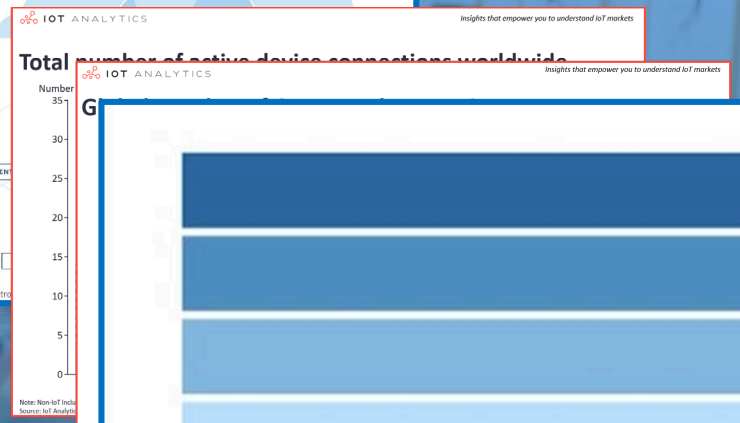
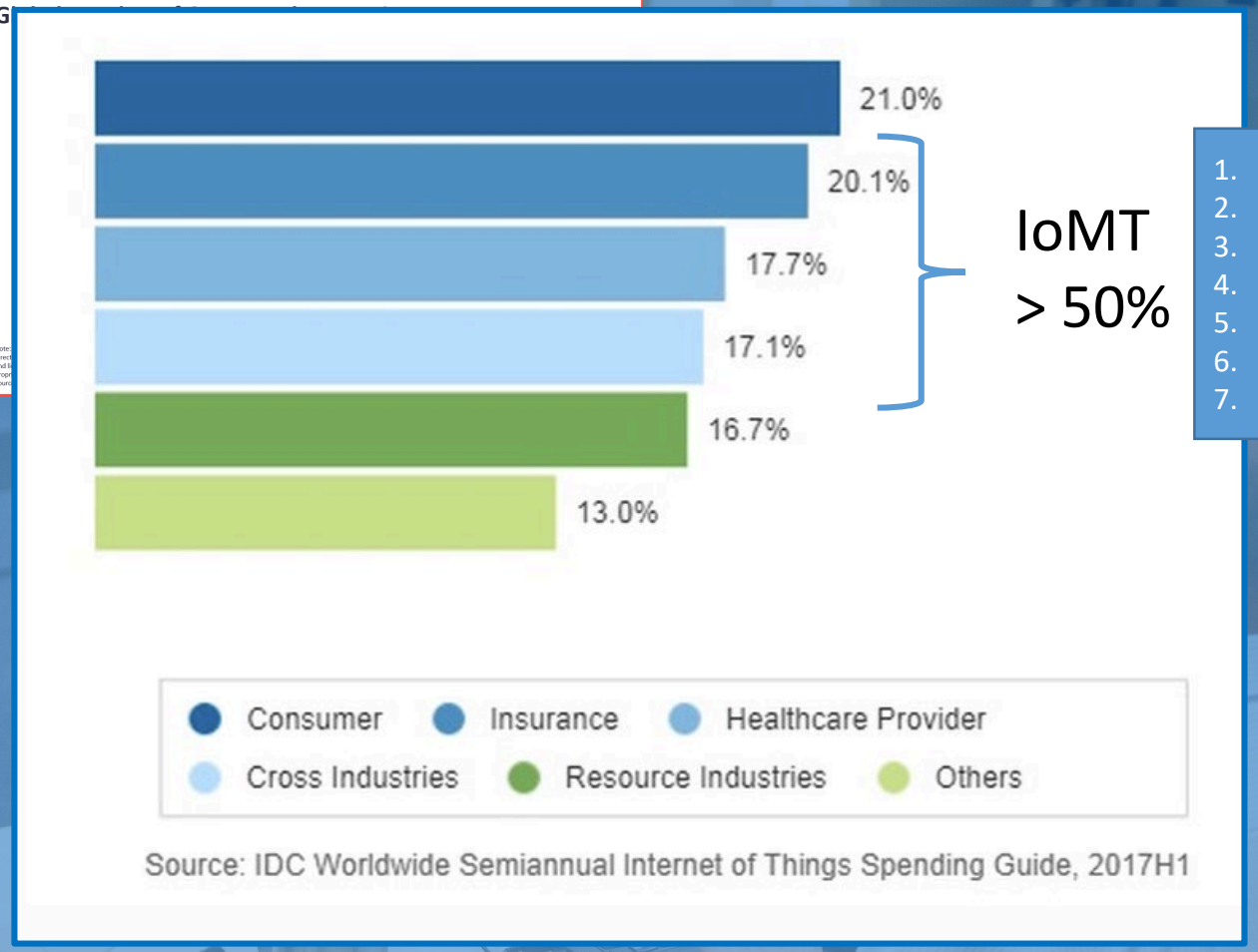
Think of the challenges in context of the Ecosystem







IoMT
> 50%

1. Fitness wearables
2. Clinical grade wearables
3. Remote patient monitoring devices
4. Smart pills
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7. Hospital devices

GRAND VALLEY STATE UNIVERSITY
APPLIED MEDICAL DEVICE INSTITUTE

IoMT, I am your biggest fan…

a couple of quick case studies.

Grand Valley State University
Applied Medical Device Institute

PCEC aMDI Sterilogy

Encourage hand sanitizing by alerting health care workers

Starts with an idea

Developing the concept

Understanding

Creating a development infrastructure

Technical Feasibility

Business Viability

Demonstrating *in simulation* feasibility

Build Understanding

Health Care workers should sanitize their hands every time when they approach a patient bed and again when they walk away from a patient bed after tending to a patient, to avoid spreading infections.

Understanding Infrastructure

The system needs three components: a Personal Sanitizer Unit (PSU) to be carried by the worker, a Zone Alarm Emitter Unit (ZAEU) to be placed under the patient bed, and a Base Station Unit (BSU) at the nurse's sanitation to track sanitizing activity.

Sterilogy Simulation

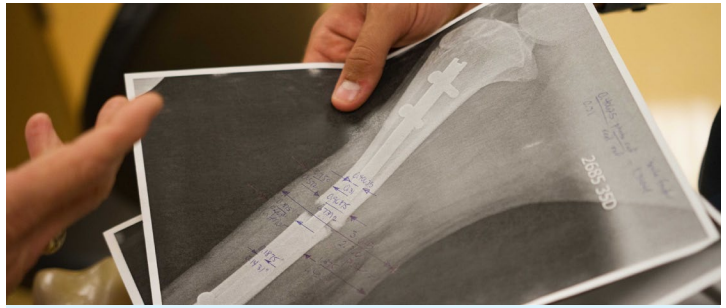
A demo was executed in a hospital simulation lab. When the PSU entered the range of a ZAEU, it alerted the health care worker to sanitize his/ her hands. The PSU recorded if he/ she had complied or not. When the health care worker walked by the nurse's station, the PSU uploaded the data on the number of times the he/ she has complied to sanitizing alerts to the BSU, where it was stored in a database.

Case Study: Faculty research, founding **OrthoForge***

Remote monitoring of bone healing with personalized results

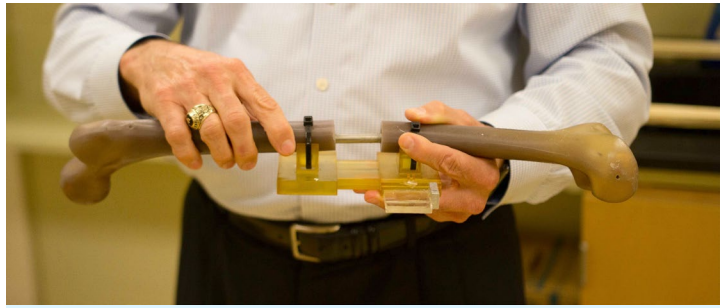
Starts with an idea | Understanding | Technical Feasibility | Business Viability | Launch | Commercialization

Development | Vet | Solutions



Build Understanding

Traditional bone re-growth methods rely on osseous healing approximations, overcompensate on recovery time, and suffer chances of re-fracture due to improper healing. Measuring the progress of soft and hard bone growth can ensure proper healing and full recovery.



Technical Feasibility

aMDI tested and prototyped multiple methods of measuring bone density and distance, with sub-millimeter accuracy.

Business Viability

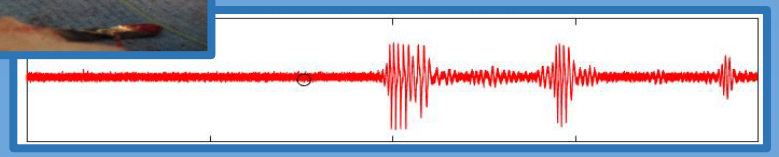
aMDI's device allows physicians to understand detailed bone growth statistic, patients can monitor from home, which reduces costs.

Build Solutions

The technology has been scaled down from standardized lab equipment to proprietary handheld devices. Small sensors are implanted, and a skin patch for communication with a dongle that attaches to smartphone devices is currently in development.

* The author and presenter is the inventor, co-founder, majority equity owner of OrthoForge, Inc.

Development Timeline



Bone & Soft Tissue Acoustic Definitions

Algorithm v1.0

Pre-Clinicals (Live Sheep)

Orthoforge, Inc. Founded

2011-2015 | **2016** | 2017 | **2018** | 2019

Computational Modeling

Prototype v1.0 & 2.0

Bone Composite Healing Analysis

Development Timeline

Bone & Soft Tissue Acoustic Definitions

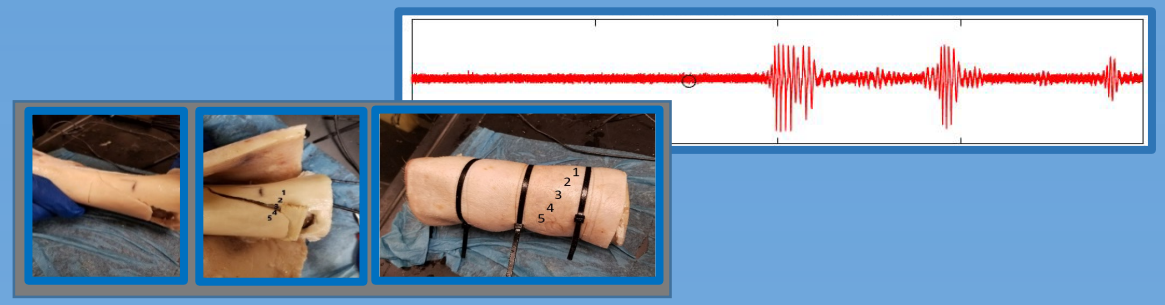
Algorithm v1.0

Pre-Clinicals (Live Sheep)

Orthoforge, Inc. Founded

Fracture Gap Analysis

Fracture Gap Characterization



2011-2015 | **2016** | 2017 | **2018** | 2019

Computational Modeling

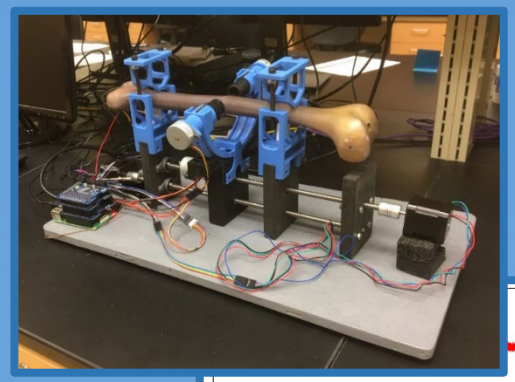
Prototype v1.0 & 2.0

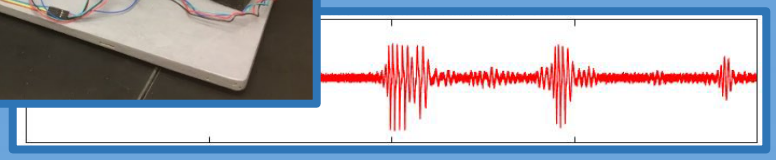
Bone Composite Healing Analysis

Algorithm v2.0

Bone Composite Healing Analysis

Development Timeline





Bone & Soft Tissue Acoustic Definitions

Algorithm v1.0

Pre-Clinicals (Live Sheep)

Orthoforge, Inc. Founded

Fracture Gap Analysis

Fracture Gap Characterization

AFAS Study

Algorithm v4.0

2011-2015 | **2016** | **2017** | **2018** | **2019**

Computational Modeling

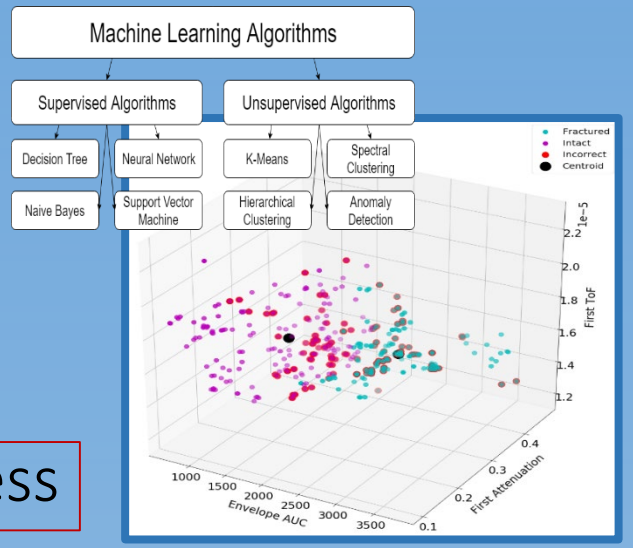
Prototype v1.0 & 2.0

Bone Composite Healing Analysis

Algorithm v2.0

Bone Composite Healing Analysis

Algorithm v3.0



From science to use in a decade … or less

IoMT, I am your biggest fan… but

Big Data Dimensions

1. Volume
2. Variety
3. Velocity
4. Veracity
5. … some say 42!

"75% of businesses believe their customer contact information is incorrect. If you've got a database full of inaccurate customer data, you might as well have no data at all."
https://www.piesync.com/blog/top-5-problems-with-big-data-and-how-to-solve-them/

Grand Valley State University
Applied Medical Device Institute

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Machine Learning/AI

1. Weird Correlations
2. Inaccurate conversions create loops in logic (language sematics)
3. Outliers
4. Biases
5. … learning how to learn

"The 'Smart Kitchen' Is Very Stupid"
https://www.wired.com/story/smart-kitchen-failures-rants-and-raves/

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67 studies on Fitbit's movement tracking concluded that the device worked best on able-bodied adults walking at typical speeds.

- … within 10 % of the actual number of steps a person took half of the time
- … even less accurate in counting steps when someone was resting their wrist on a walker or stroller, for example.

https://www.wired.com/story/telltale-heart-fitbit-murder/

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IoMT, I am your biggest fan!

"IoMT is disruptive and transformative. It should be understood that IoMT is nothing more than a tool as much as the early thermometer.

Learning from history, the healthcare professional is critical and irreplaceable in the use, interpretation, and verification of the data. "

Circa 2010 - Brent M. Nowak, PhD

Grand Valley State University
Applied Medical Device Institute

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Thank you

We're excited about the things we can build together.

Visit our website gvsu.edu/amdi

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