America's Flexible Hybrid Electronics Manufacturing Institute

NextFlex Flexible Hybrid Electronics Manufacturing Roadmap Summary

March 2023

Rev. 1.0

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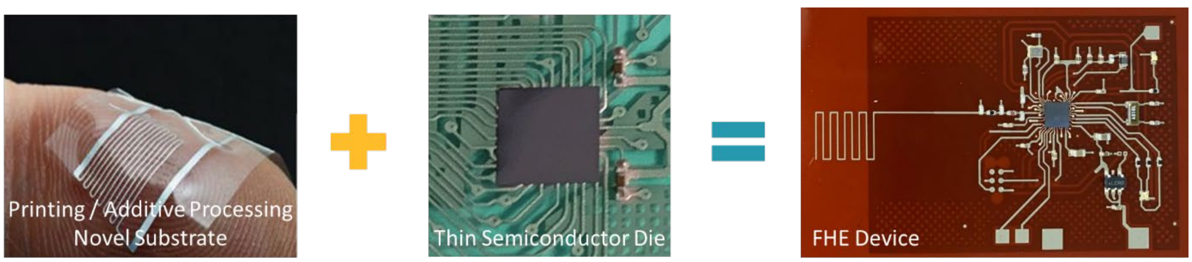
ABOUT NEXTFLEX

NextFlex is a consortium of American electronics companies, academic institutions, non-profits, state, local and federal government partners with the shared goal of advancing U.S. manufacturing of Flexible Hybrid Electronics (FHE). Since its formation in 2015, the NextFlex community of technologists, educators, problem solvers, and manufacturers have come together to collectively facilitate FHE innovation, narrow the advanced manufacturing workforce gap, and promote sustainable electronics manufacturing ecosystems.

WHAT IS FHE?

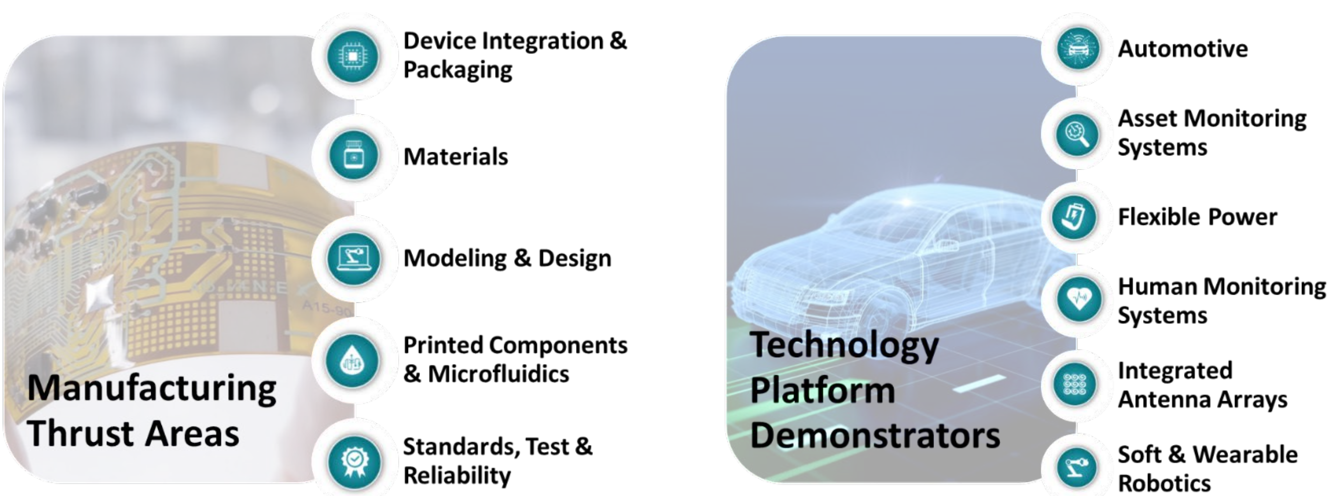
Flexible Hybrid Electronics (FHE) as defined by NextFlex is the field that exists at the intersection of printed and additively manufactured electronics with conventional semiconductor devices and discrete components. FHE is broader, though, than is sometimes interpreted from this description, as FHE also includes electronics that can stretch, bend and twist, those which are conformally built onto surfaces in three dimensions, and those which are additively manufactured in three dimensions, regardless of mechanical flexibility. Advanced semiconductor packaging and additive printed circuit board (PCB) manufacturing are areas of growing focus for NextFlex as novel additive techniques provide distinct capabilities on both flexible and rigid substrates.



Graphical representation of the field of Flexible Hybrid Electronics

TECHNICAL WORKING GROUPS

NextFlex Technical Working Groups (TWGs) are a devoted group of subject matter experts who collaborate through NextFlex on establishing FHE manufacturing technology roadmaps to identify key technology gaps and technology planning requirements to advance the manufacturability of flexible hybrid electronics. There are currently eleven TWGs. These include six application areas called "Technology Platform Demonstrators," and five that are called "Manufacturing Thrust Areas,". Each TWG is led by a small team of "co-leads" from a balance of academia, government, and industry. Including the 35 co-leads, there are 250+ subject matter experts regularly convening to develop, expand, and refine the FHE Technology Roadmaps.



FHE TECHNOLOGY ROADMAPS

The FHE Technology Roadmaps are narrative documents developed by the TWGs in each eleven of the technical areas of emphasis. These roadmaps are a critical asset to NextFlex members and contain significant detailed information on the current state of the art, market opportunities and needs, key stakeholders, a five-year forward-looking development roadmap, and prioritized technical gaps for each TWG.

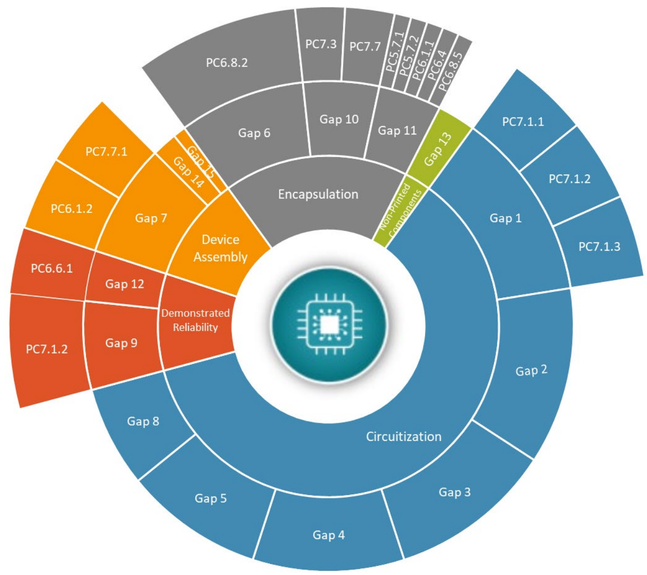
The following pages present single-page summaries of the full FHE Technology Roadmaps available to NextFlex members.

DEVICE INTEGRATION & PACKAGING

SCOPE The focus of the Device Integration and Packaging Technical Working Group (DIP-TWG) is to establish manufacturing methods for preparation, placing, interconnecting, and protecting circuit components onto flexible substrates for the fabrication of fully flexible and/or conformal electronic circuits. The DIP-TWG plans integration methods for sensing, communication and computational elements that can adapt to a multitude of geometric and environmental constraints.

STATE OF THE ART

Component / Element	SOTA Specs
Circuit Layers	8
Via Diameter	100-250 µm
Dielectric Thickness	≥25 µm
Bend Radius	>6x thickness
Sheet-to-Sheet Lines & Spaces	50-200 µm
Roll-to-Roll Lines & Spaces	250 µm
Printed conductors	3-20x bulk resistivity
Components	SMTs with solder attach
Printed Resistors	±20% tolerance
Flip-Chip Attach to Flex	100 µm pitch
Die Size	<5 mm^2
Die Thickness	<250 µm
Die I/Os	<100
Pad Area	>75µm sq
Pitch	>150 µm



Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

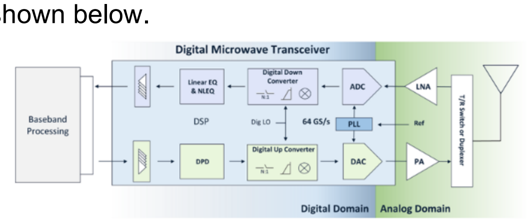
- Printed passives using inkjet, aerosol-jet and direct-write
- Semiconductor packaging and heterogenous integration
- Fully and semi-additive PCB manufacturing
- Printed structures for RF and mm-wave comms
- Device preparation including thinning and bumping
- Thin die handling and placement
- Double-sided component assembly on flex
- Reliable rigid-to-flex and flex-to-flex interconnect

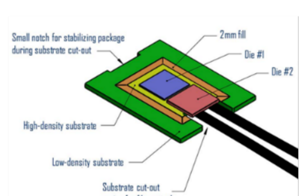
TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS

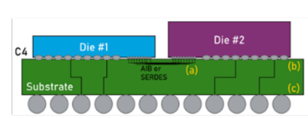
Circuitization	Encapsulation	Device Assembly	Non-Printed Components	Demonstrated Reliability
Embedded components with interconnects	Reliablity of encapsulated bare dies	Heterogeneous integration	Thin die flip-chip bonding	Understanding failure modes
Flex circuit transition to multi-layer	High volume encapsulation / overmolding methods	Flexible interposers	Bare & thin die supply chain	Modeling FHE system life
Coplanar waveguides and differential pairs	Extreme environment protection	All additive PCB manufacturing	Defect-free thinning & dicing	Demonstrated thermal managment

PROJECT CALLS

To date, NextFlex has funded 34 projects that align to the Device Integration & Packaging Working Group, including PC7.1.1 shown below.







Conceptual drawings of fiber optic MCM using a high-density interposer for chip-to-chip interconnects. C4 die bumping pitch 55µm and interposer BGA pitch 1.0mm.

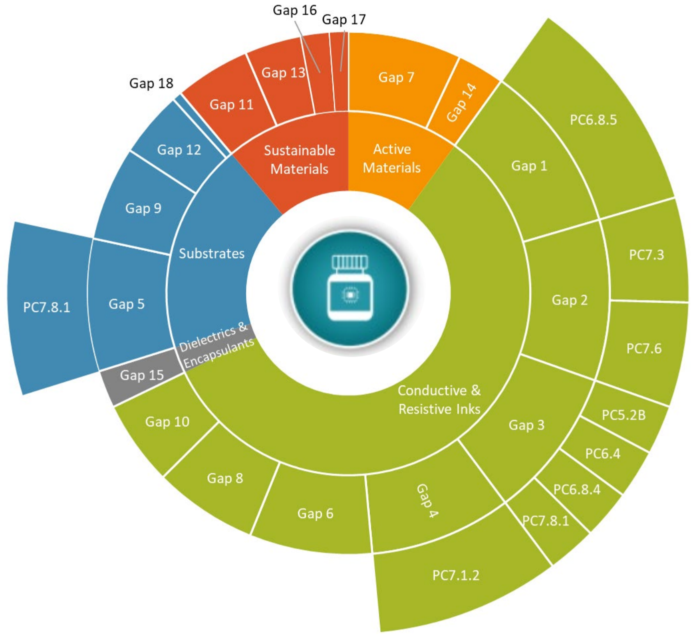
PC7.1.1: FHE Interposer for heterogeneous integration of a high-density Fiber Optic Multi-chip module led by Lockheed Martin

MATERIALS

SCOPE Material properties and functionality are critical drivers for the technological development and performance of flexible hybrid electronic devices. Materials development is driven by the needs of the NextFlex community, but also by cross-fertilization from materials developments outside NextFlex.

STATE OF THE ART

Category	SOTA Materials
Substrates	Polymers, Glass, Thinned Silicon, TPUs, LCPs
Active Materials	Doped amorphous silicon, electro-fluorescent inks, doped CNTs, magnetic films, electro-active materials, PZTs
Passive Conductors	Ag inks (10-20% higher than bulk), Cu inks and pastes, graphene inks, highly doped carbon inks
Dielectrics & Encapsulants	Polymers with non-conjugated carbon backbone, metal-oxide, ceramic-bearing materials
Materials Processing	Photonic curing, magnetically aligned ECAs



Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

- Stretchable substrates and inks
- Printed passives components
- Active semiconductor materials
- Interconnect materials and processes
- Improved consistency/reliability of individual inks

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS

Substrates
- Stretchable substrates with low hysteresis
- Low temperature die attach materials
- Interposer materials for strain relief and heat transfer

Dielectrics & Encapsulants
- High dielectric breakdown
- High protection from moisture & oxygen
- Improved surface dielectric breakdown

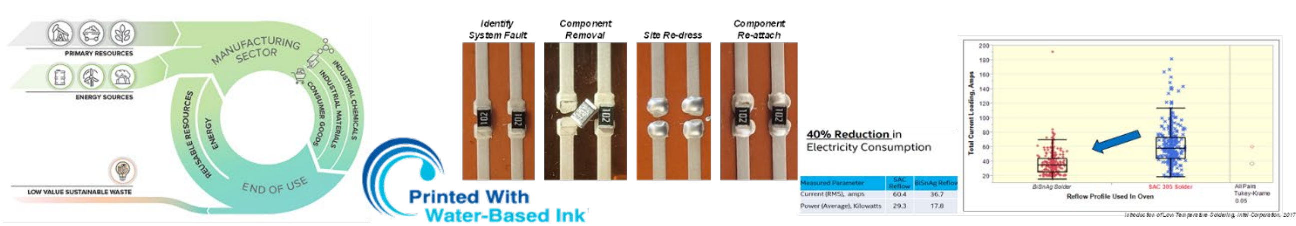
Active Materials
- Printed transistor technologies
- Printed ICs in multilayer electronics
- Radiation effects on passives and digital electronics

Conductive & Resistive Inks
- Particle-free Inks
- Higher conductivity inks
- Ink shelf life / stability

Sustainable Materials
- Reduced manufacturing waste streams
- Biodegradable substrates / materials
- Life cycle assessment

PROJECT CALLS

To date, NextFlex has funded 11 projects that align to the Materials Working Group, including PC7.3 shown below.



PC7.3: Sustainable Additively Printed Electronics through Water-Solvent Inks-FHE Repairability-Low Temperature Processing led by Auburn University.

MODELING & DESIGN

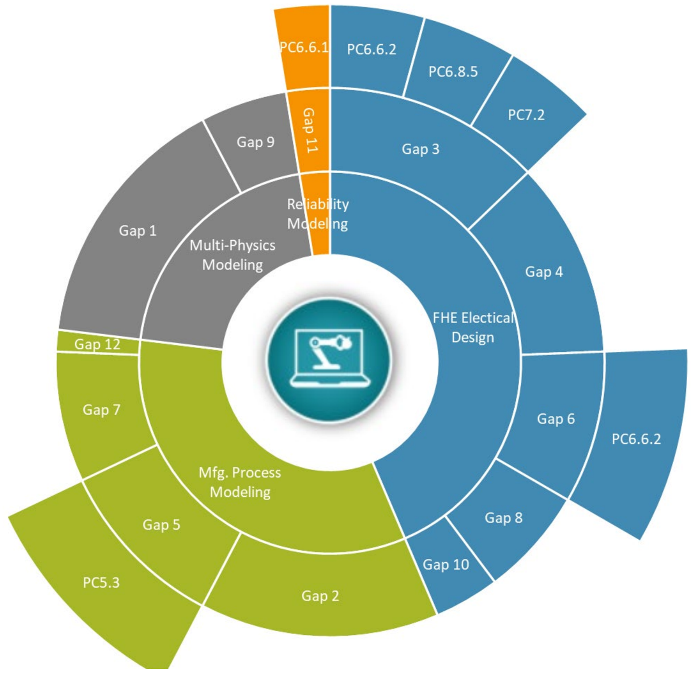
SCOPE The objective of the Modeling & Design Technical Working Group is to identity the key gaps in computational methods and tools for flexible hybrid electronics product design and analysis. The technical fields include but are not limited to FHE electrical design, manufacturing process modeling, reliability modeling, multi-physics modeling, and FHE material database integration. Simulation software or computer-aided design tools to support the FHE modeling and design needs are indirectly related to M&D-TWG roadmap.

STATE OF THE ART

- Existing process simulation and modeling software for 3D printing such as Additive Works and Simufact can possibly be used for FHE additive-printing processes, although the simulation accuracy and compatibility with various FHE printing processes are yet to be investigated.
- NextFlex has invested in an initial phase of FHE-PDK development which lays the foundation of FHE electrical simulations and device models based on actual FHE device characterizations.

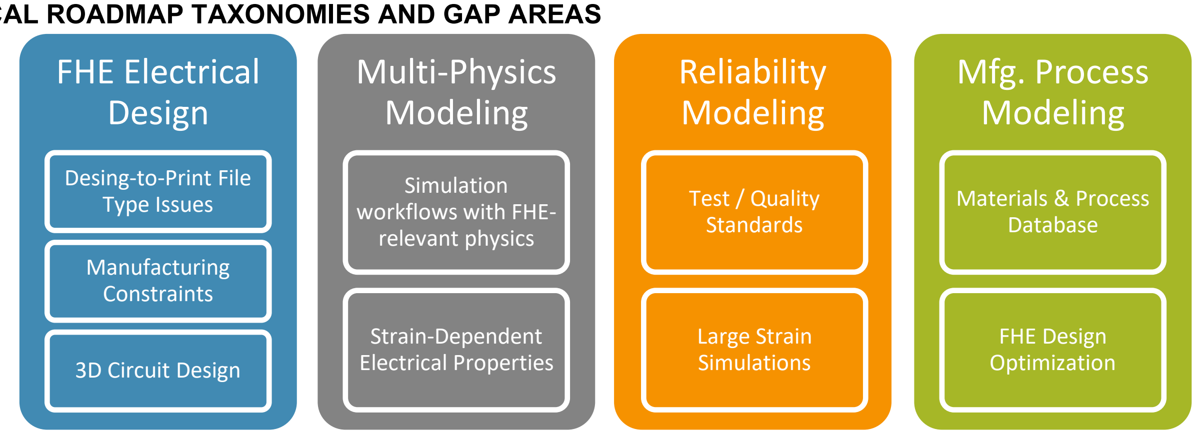
KEY OPPORTUNITIES

- Wide adoption of FHE design tools and PDK by NextFlex members
- Statistical analysis for manufacturing process yield and analysis capability to improve the yield
- Predictive modeling for FHE failure modes
- Validated multiphysics models and simulation tools for FHE applications
- Accelerate FHE design process via cloud-based workflows and ML-driven design suggestions



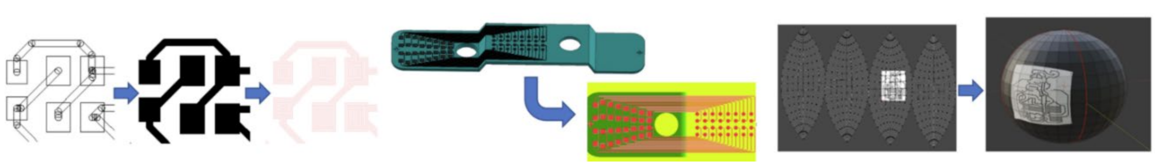
Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS



PROJECT CALLS

To date, NextFlex has funded 9 projects that align to the Modeling & Design Working Group, including PC6.6.2 shown below.



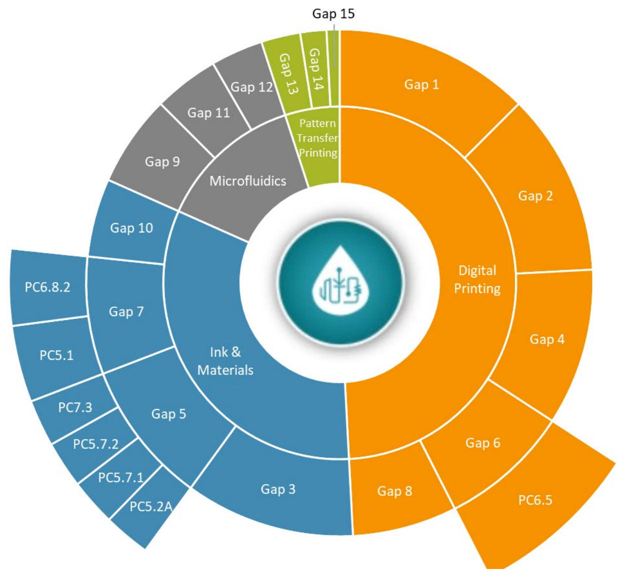
PC6.6.2: Design Tool Development for Printing Conformal Circuits led by Integrated Deposition Solutions.

PRINTED COMPONENTS & MICROFLUIDICS

SCOPE The development of flexible hybrid electronic devices is dependent on material properties, printing processes, and microfluidic components. The materials primarily include functional inks and NextFlex is focused on (a) defining material properties to enable FHE at low- and high-volume manufacturing, (b) expand material database inputs to include “real-world performance” data and (c) developing product design guides which define materials, printing processes, post-processing, and assembly methods.

STATE OF THE ART

	MRL 3	MRL 4	MRL 5	MRL 6	MRL7
Ink & Materials	Stretchable inks, washable inks	Conductive inks (Cu) Semiconductor inks	Dielectric inks	Substrates (Paper, TPU), Encapsulant inks	Substrates (Kapton, PET, textile) Conductive inks (Ag)
Printing	Via printing, High-speed insertion of components	In-line metrology, precise layer registration	R2R integration with controlled atmosphere	Multi-layer structures; Inline insertion of components	Printers with multiple deposition modes
Direct Writing	Design-to-Toolpath Generation	Single / Multi-material printing of devices	Single material printing at low-volume	-	-
Microfluidics	Hybrid FHE/MF component, Stretchable microfluidics	Rigid MF elements for FHE	Rigid MF elements	Rigid MF systems	Screen-printed, laminated materials for test-strips



Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap.

KEY OPPORTUNITIES

- High-volume printing processes capable of high-resolution features (<20 µm)
- Identify equipment with precision layer-to-layer registration capability (<10 µm)
- Roll-to-roll process integration of validated off-line process technologies with controlled atmosphere
- In-line metrology and component attach

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS

Ink & Materials
- Materials & Process Database
- Stretchable conductive inks
- Printed dielectric inks for multilayer printing

Microfluidics
- Flexible active fluid control
- Integration of MF sub-components
- FHE lab-on-a-chip

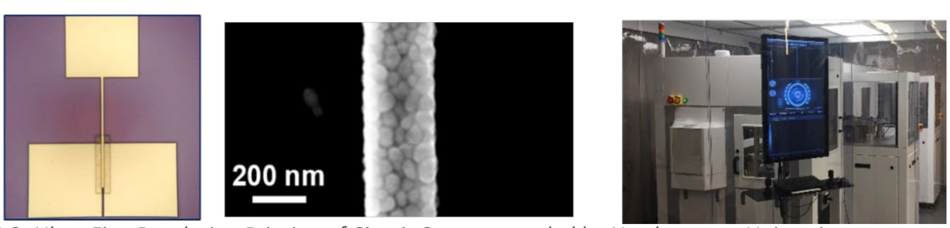
Digital Printing
- Addressing scalability
- In-situ process monitoring and feedback loop
- Design rules

Pattern Transfer Printing
- Layer-to-layer registration
- High volume techniques at high resolution
- In-situ processing & Metrology

PROJECT CALLS

To date, NextFlex has funded 23 projects that align to the Printed Components & Microfluidics Working Group, including PC6.8.2 shown below.

Printed silver with a 2 um minimum feature size with 2 um alignment accuracy



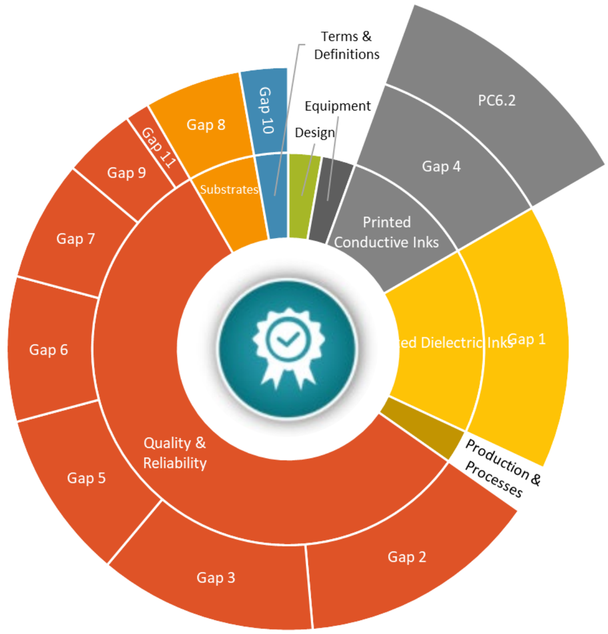
PC6.8.2: Ultra-Fine Resolution Printing of Circuit Components led by Northeastern University.

STANDARDS, TEST & RELIABILITY

SCOPE The NextFlex Standards, Test & Reliability Technical Working Group (STR-TWG) establishes key goals with needs relevant to standards, test methods, guidelines and qualification programs for flexible hybrid printed electronics. The STR-TWG establishes these goals based on needs demonstrated by the other TWGs, thus making the STR-TWG a responsive group. Additionally, the STR-TWG will identify appropriate standards development organizations to address specific gaps.

EXISTING STANDARDS

Area	Standard
Term & Definitions	IPC-6903A, SEMI 3D1-0912
Printed Conductive Inks	IPC-4591A
Substrates	IPC-4921A
Design	IPC-2292
Quality & Reliability	MIL-STD-810G, IPC-9204, ASTM D522-03a
Printed Dielectric Inks	-
Equipment	IPC-2591
Production & Process	IEC 62899-401

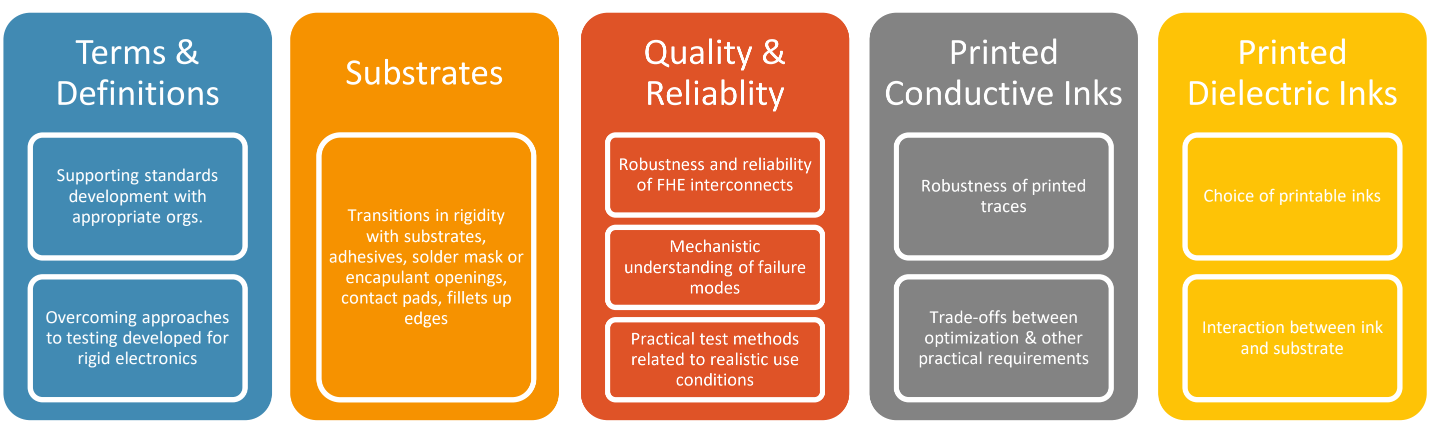


Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

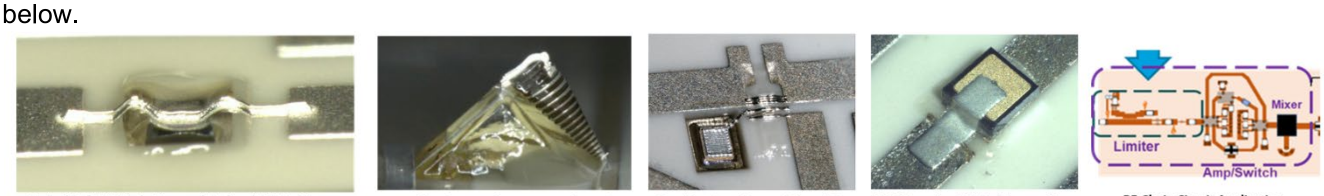
- Developing FHE-specific standards
- Standard for dielectric inks
- Quality and reliability standard
- Validated independent test methods
- Materials database of consistent information and reflective of industry standards
- Validate equipment communication standard

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS



PROJECT CALL

To date, NextFlex has funded 9 projects that align to the Standards, Test & Reliablity Working Group, including PC6.2. shown below.



Embedded PIN Diode Encapsulated and Printed Traces | Broadband Bias Inductor Printed Windings | Coupling Transformer Printed Core | MIS-Capacitor Printed Connection | RF-Chain Circuit Application

PC6.2: Reliability Validation and Sustainment of Direct-Write Printed RF Devices led by Lockheed Martin.

ASSET MONITORING SYSTEMS

SCOPE Asset Monitoring System (AMS) devices enable monitoring of performance, status, and health of any item of interest for a user. AMS devices can provide functional capabilities such as condition-based maintenance, time critical monitoring, monitoring for compliance actions, anti-counterfeit, cyber security, active feedback for closed loop control to maximize performance, efficiency, life, remaining useful life and environmental status, as well as improvements in manufacturing quality, and throughput.

STATE OF THE ART

- Current AMS devices are predominately fabricated on rigid printed circuit boards and housed in assemblies connected to higher level systems through wired or wireless interfaces.
- Some RFID systems use printed antennas and interconnects, thinned components, flexible batteries, and integrated sensors, depending on type and number of sensors, power budget, and application.
- The COVID-19 pandemic and associated supply chain disruptions have illustrated the importance of critical asset monitoring systems.

Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

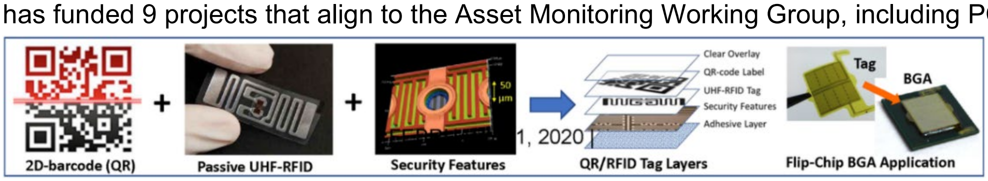
- Asset Tracking for Logistics Items
- Environmental Monitoring of Products and Foods
- Process Control Monitoring of Factory Equipment
- In-situ Performance Monitoring of Components in Machinery
- Sensing for Closed Loop Control of Equipment
- Structural Health Monitoring of Buildings, Infrastructure, Vehicles, or Aircraft
- Distributed Sensor Networks for Security Status and Agricultural Monitoring
- Health Monitoring and Control for aerospace, underwater and harsh terrestrial environments
- Anti-Tamper or Anti-Counterfeit

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS

Safety & Security	Algorithm Development	Asset Health Monitoring	Asset Status Monitoring	Extreme Environment	Others
Chain of Custody	Monitored parameter algorithms	Industrial systems health awareness	Excessive environmental awareness	Underwater	Wearables
Man-Machine Interaction	Dimensionality reduction	Transport systems	Degraded electronics	Extreme industrial	Consumer Handhelds
Safety of Asset/Person	Point-of-application assessment	Remaining useful life determination	Status tags for industrial / transport	Aerospace	Residential applicaques

PROJECT CALLS

To date, NextFlex has funded 9 projects that align to the Asset Monitoring Working Group, including PC5.5 shown below.



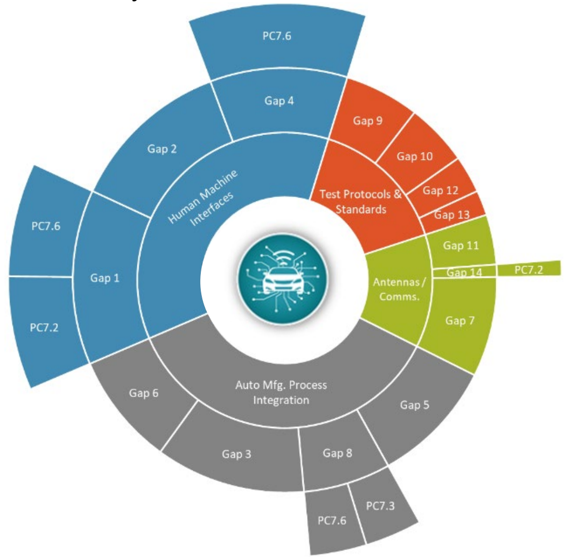
PC5.5: Passive UHF-RFID Tag with Encrypted Security Features for Authentication and Tamper Resistance led by Lockheed Martin

AUTOMOTIVE

SCOPE The scope of the Automotive TWG includes Human Machine Interfacing (HMI), Antennas/Communications, Sensors, In-Mold Electronics (IME), Testing/Standards. Future scope of the automotive TWG may include Shape-Morphing and Adaptive Surfaces. Automotive platforms increasingly use electronics for several function-critical and safety critical functions including touch surfaces, acquisition of signals from sensors and systems, guidance, navigation, control, charging, sensing and operator interaction. The use of FHE and additive technologies creates an opportunity to reduce the weight of the automobile through the use of printed electronics on structural plastic and flexible hybrid electronics.

STATE OF THE ART

Function	Where in vehicle?	What is being done?	Current Status	SOTA
Human Machine Interface	Console	Display	Commercial	Touchscreen With Display, ITO
	Console	Non-Display Touch, Backlight, Fingerprint Sensor	Commercial	Capacitive Touch, LED Lamination, PDOT/PSS, Silver Traces
Connectivity	Vehicle to reader (toll/RFID)	Tag / Windshield	Commercial	Silicon with etched aluminum
External	Windshield	De Ice Heater	Commercial	Copper Traces
	Headlamps Rear Lights	De Ice Heater	Prototype	Direct Printed Heater, In-mold

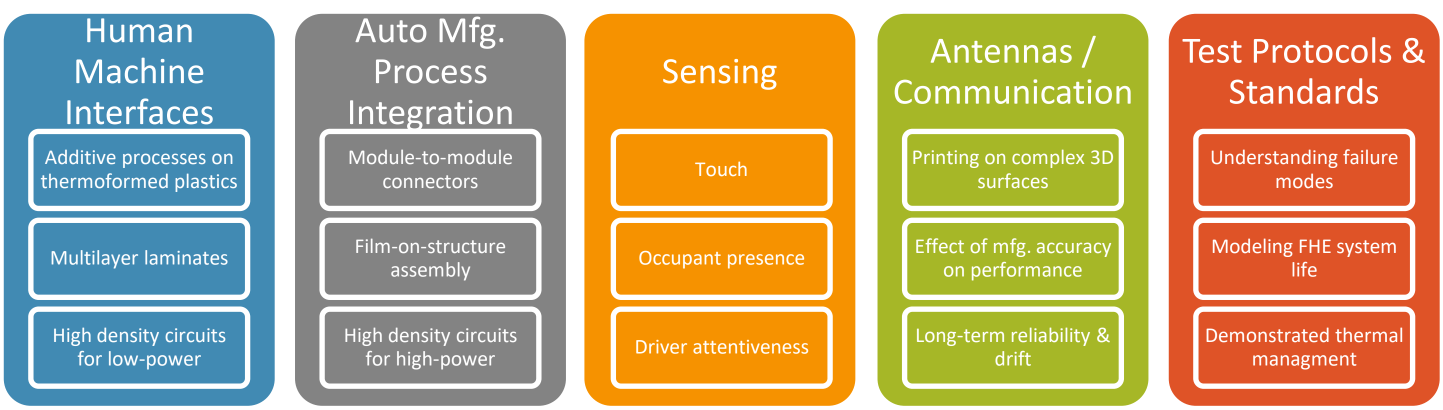


Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

- HMI controls on steering wheel, interior / exterior doors
- Integrated heaters in seats, arm rests, interior body panels for comfort
- Lidar / camera heaters for deicing and startup warming
- Integrated startup warmers and health sensors for EV batteries

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS



PROJECT CALLS

To date, NextFlex has funded 1 project that aligns to the Automotive Working Group since launching it in late 2021; PC7.6 is shown below.

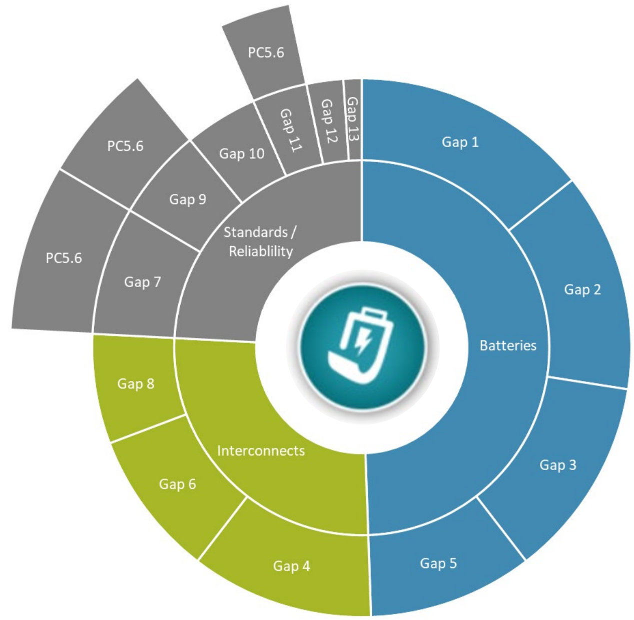
PC7.6: In-Mold Electronics interconnection and thermoforming for 3D-integrated applications led by Auburn University

FLEXIBLE POWER

SCOPE The Flexible Power TWG scope covers energy supply for FHE and the integration of power systems with TPDs and FHE products. Power and energy supply are at the core of all FHE product functionality. Capabilities such as wireless communication or information display are power-intensive and combined with use case needs such as continuous sensor data recording or long sleep times, means that the power system can limit a product's usable lifetime.

STATE OF THE ART

- Capacity/area acceptable given large areas available for most applications
- Peak power/area acceptable for some technologies
- Flexibility (dynamic cycling): insufficient relevant data
- Thickness is a fundamental limit for flexibility and integration in many FHE applications
- Interconnects and integration achieving electrical and mechanical reliability: insufficient data
- Environmental testing: insufficient data
- EH&WC cycle lifetime combined with flex: insufficient data



Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

- Mechanical and dimensional constraints
- Peak power requirements
- Energy and power budget
- Integration and interconnect of flexible power

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS

Batteries
- Thinner flexible batteries
- Higher Capacity
- Higher Power Density

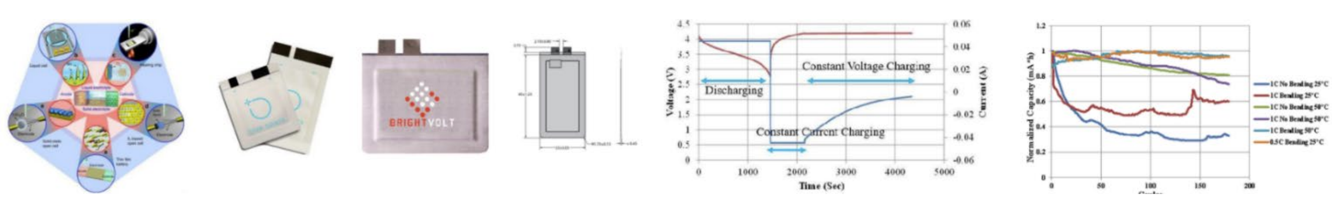
Standards / Reliability
- Flexiblity above 10k cycles
- Coupling flexiblity and environmental / electrochemical testing
- Thermal cycling reliability

Power Management / ULP
- Flexible Power Management Units
- Improved power management schemes for ultra long-duration use

Interconnects
- Scalable Manufacturing Approaches
- Interconnects and integration processes with high reliability

PROJECT CALLS

To date, NextFlex has funded 1 project that aligns to the Flexible Power Working Group; PC5.6 is shown below.



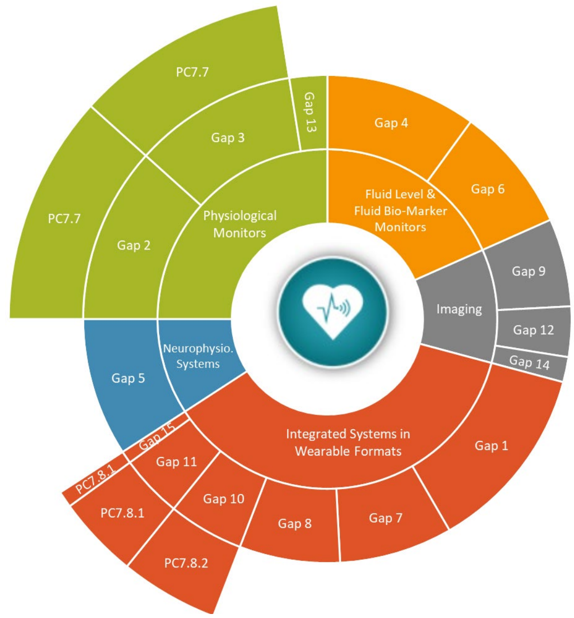
PC5.6: Accelerated Testing and Degradation Mechanisms for Flexible Batteries to Enable Selection-Guidelines Comparing Performance and Reliability led by Auburn University.

HUMAN MONITORING SYSTEMS

SCOPE Human monitoring systems (HMS) are emerging technologies that allow for on-demand and often wireless tracking of information of physiological, cognitive, biological, and situational states of humans with the objective of providing new capabilities, such as medical diagnosis and therapy, increased safety, injury prevention and performance augmentation capabilities.

STATE OF THE ART

- Proliferation of tattoo-like bio-electronic devices that exhibit similar mechanical compliance as the human tissue
- Wearable non-invasive / minimally invasive fluid-based biomarker sensing devices, particularly for electrolyte and metabolite monitoring
- Environmentally friendly biodegradable/transient electronics
- Broader acceptance and real-world implementations of flexible wearable and implantable electronics devices
- Advances in scalable and low-cost manufacturing to simultaneously achieve wearable high performance, low footprint, low power consuming devices with strong connectivity



Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

- Remote patient monitoring
- Wellness monitoring for diagnosing and treating chronic diseases
- Wearable for worker safety and performance enhancement
- Defense and commercial cognitive state monitoring and augmentation

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS

Neurophysiological Systems
- EOG/EEG/EMG
- Stimulation / augmentation
- High mobility / low profile wearables

Integrated Systems in Wearable Formats
- Textile-integrated electronics
- Long-duration wear electronics

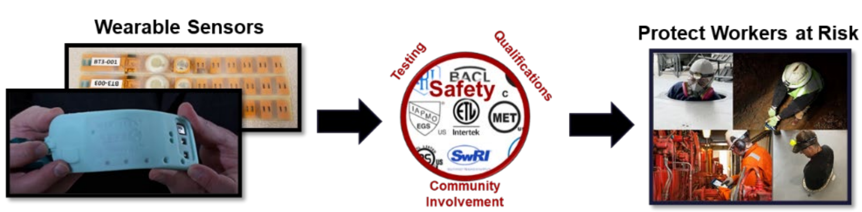
Imaging
- Flex / stretch medical imaging systems
- Large area ultrasound arrays

Fluid Level & Fluid Bio-Marker Monitors
- Interstitial fluid
- Sweat
- Breath

Physiological Monitors
- Disposable vital sign monitors
- Biodegradable flexible electronics

PROJECT CALLS

To date, NextFlex has funded 14 projects that align to the Human Monitoring Systems Working Group, including PC7.8.2 shown below.



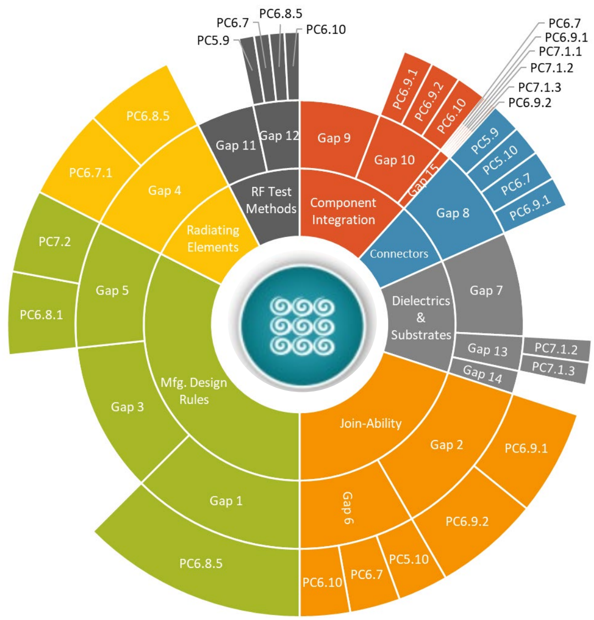
PC7.8.2: Safety Assessments of FHE & Enhancements for Tough Environments led by Sentinel

INTEGRATED ANTENNA ARRAYS

SCOPE An Integrated Antenna Array (IAA) is defined as the combination of (a) physically reconfigurable flexible antennas, and/or (b) the processing of conformal (non-planar) antennas, (c) through the support of RF compatible materials and the integration of electronics. The IAA working group seeks to demonstrate manufacturing capability rather than develop new antennas. The three types of IAA systems that have been defined to demonstrate the FHE technologies are (a) 2D Flex Hybrid Array Antenna, (b) 2.5D Conformal, High Performance Phased Array with Integrated Electronics, and (c) 3D Integration of 2D/3D Antenna Systems with Embedded Electronics and Sensors.

STATE OF THE ART

- A number of conformal / flexible antenna architectures have been developed and are well documented in the literature. Typical examples are patch antennas and arrays, printed dipoles, wraparound antennas and arrays, substrate integrated waveguide antennas, spirals, and others.
- Recent advances in additive manufacturing technology have enabled new means to produce conformal antennas. Enabling technologies include 2D, 2.5D, and 3D printing.
- Truly flexible antenna systems have been produced using modified inkjet printers to deposit flexible conductive inks on flexible substrates such as Kapton and Corning Willow Glass

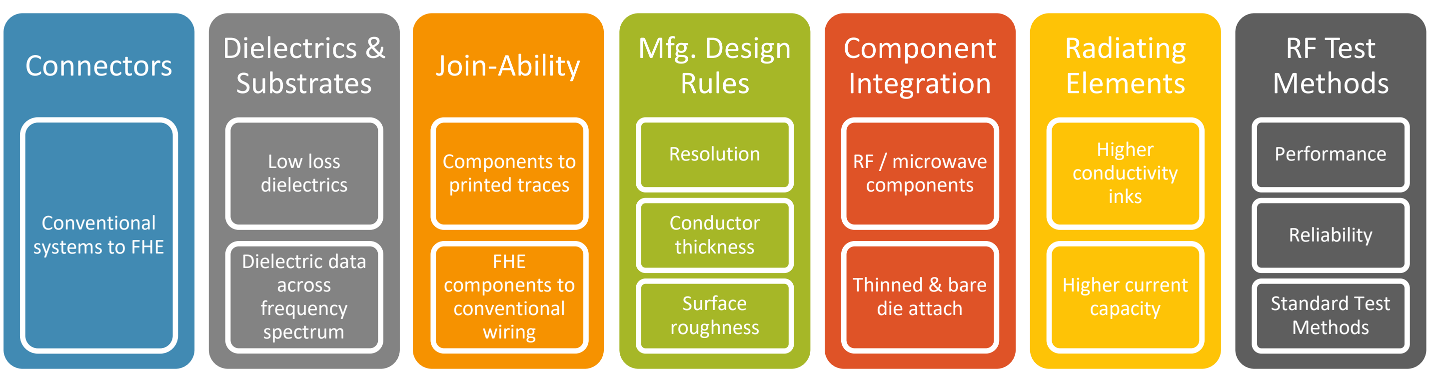


Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

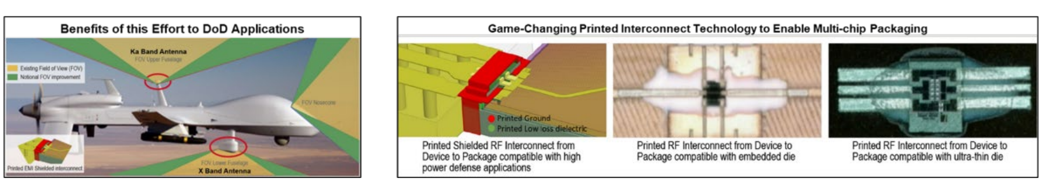
- Communication - defense and commercial
- Navigation - defense and commercial
- Intelligence, Surveillance, Reconnaissance (ISR) - defense
- Electronic warfare - defense
- Radar - defense and commercial
- Sensor - defense and commercial
- Automotive – body panel integration

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS



PROJECT CALLS

To date, NextFlex has funded 17 projects that align to the Integrated Antenna Arrays Working Group, including PC7.1.3 shown below.



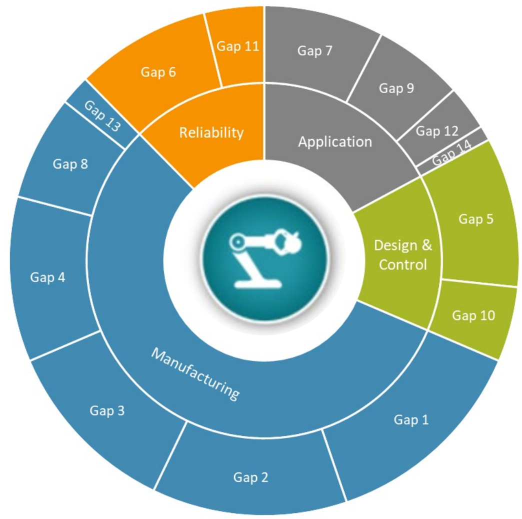
PC7.1.3: Printed Interconnect Solutions for microwave multichip packaging led by Raytheon and UMass Lowell

SOFT & WEARABLE ROBOTICS

SCOPE Soft and wearable robotics considers technologies comprised of composites of soft materials that, when integrated as a system, perform at least two of the basic functions of a robotic system at TRL 3/4: 1) “sense,” measure or detect some salient characteristic or aspect of the operating environment; 2) “decide,” make decisions based on that sensed information; and 3) “act,” physically modify its own state or the environment in some manner based on the decision.

STATE OF THE ART

	Pneumatic Artificial Muscles	Electroactive Polymers	Shape Memory Polymers
Component Assembly	MRL 5	MRL 4	MRL 3
Molding	MRL 6	MRL 4	MRL 3
3D Printing	MRL 5	MRL 3	MRL 3

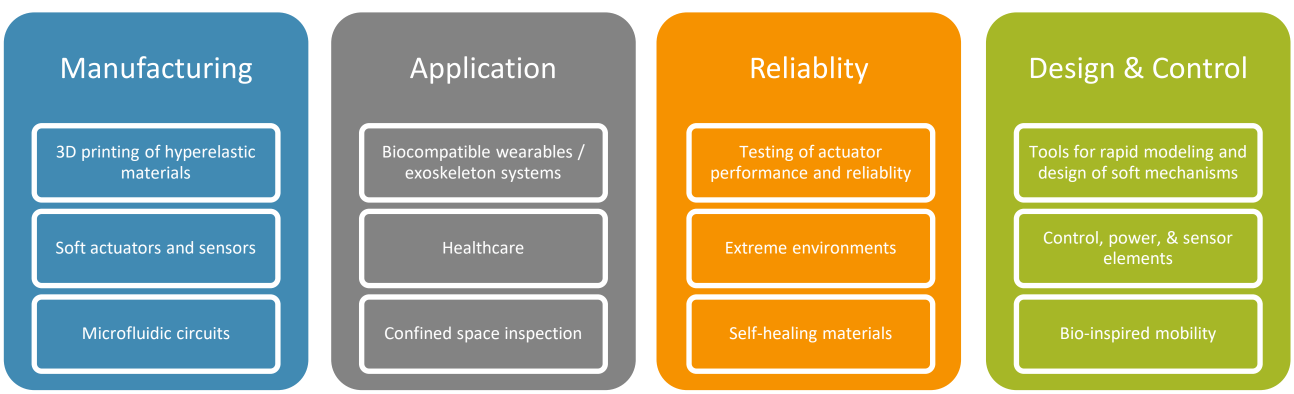


Roadmap taxonomies (inner ring), identified technical gaps (middle ring), and recent NextFlex-funded projects that align with solving a technical gap (outer ring).

KEY OPPORTUNITIES

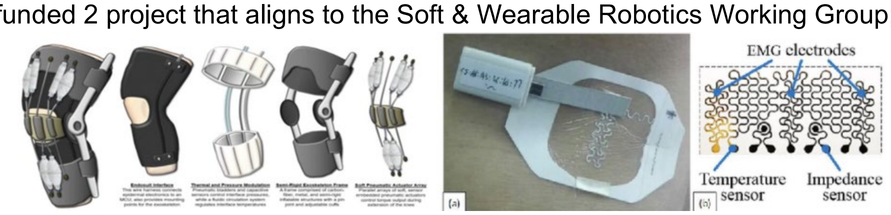
- **Defense**: robots for rescue and recovery and active exosuits for human capacity augmentation.
- **Healthcare**: minimally invasive surgery, remote physical examination, targeted drug delivery, rehabilitation, personal assistance, and prosthetics.
- **Industrial Services & Manufacturing**: maintenance, inspection, repair and overhaul for critical machinery and structures such as power turbines, marine vessels, aircraft engines, industrial pipelines, and subsea oil & gas platforms.
- **Food and E-Commerce**: Automation for e-commerce order fulfilment could be done cost-effectively and productively via a robotic solution that can adapt to a variety of tasks, such as handling packages and food products of a range of irregular shapes and sizes without reconfiguration or retraining.

TECHNICAL ROADMAP TAXONOMIES AND GAP AREAS



PROJECT CALLS

To date, NextFlex has funded 2 project that aligns to the Soft & Wearable Robotics Working Group; PC3.6 is shown below.



PC3.6: Flexible Skin Sensing for Soft Robotic Exoskeleton Knee led by Lockheed Martin & Georgia Tech.

For More Information

To learn more about FHE, the full FHE Technology Roadmaps, NextFlex, and becoming a NextFlex Member, please visit www.nextflex.us or email info@nextflex.us.

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