

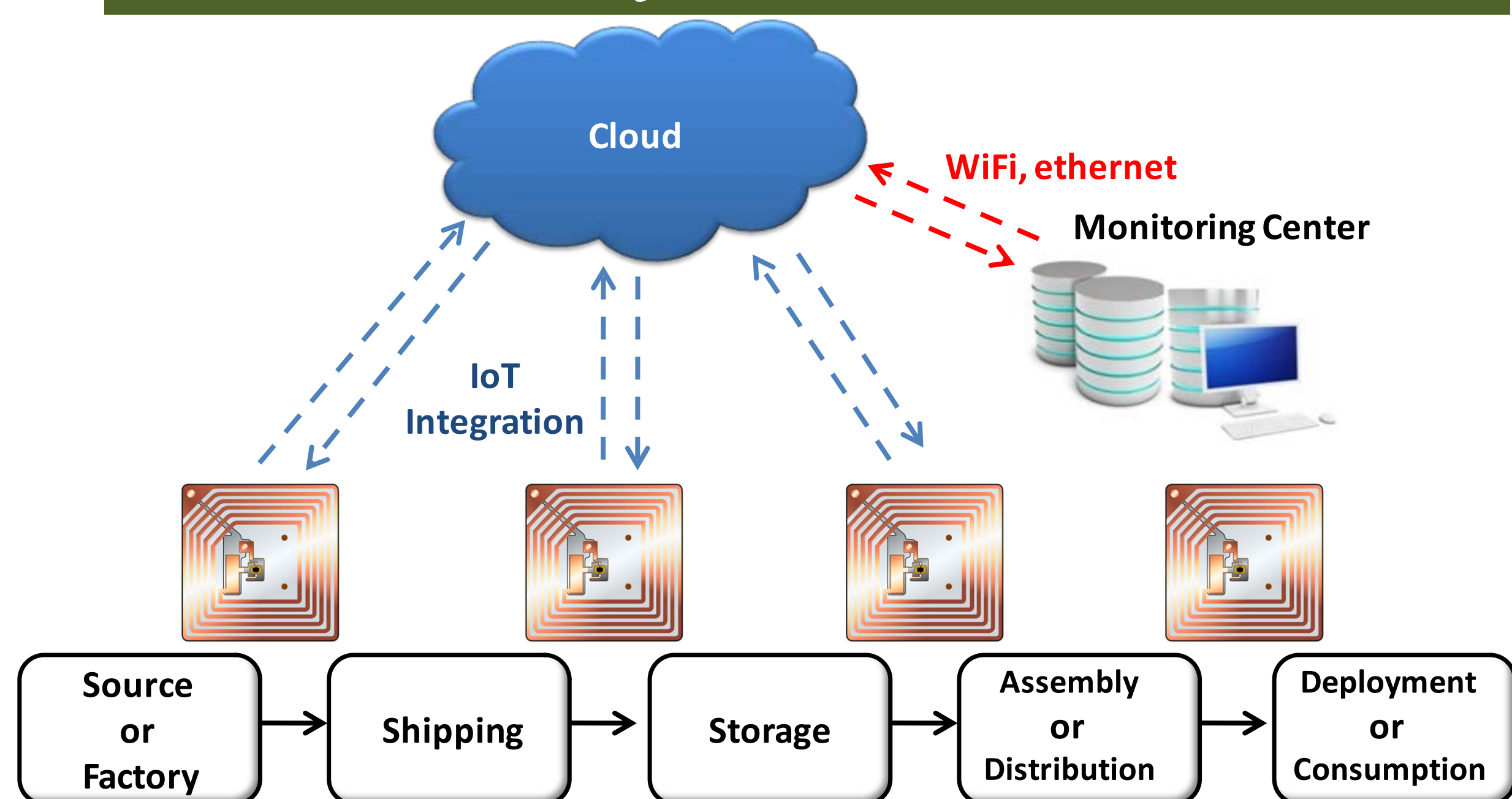


# Passive RFID Sensing Technology for Monitoring of Complex Product Supply-Chain

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## 1. Research Project & Axia Institute Theme

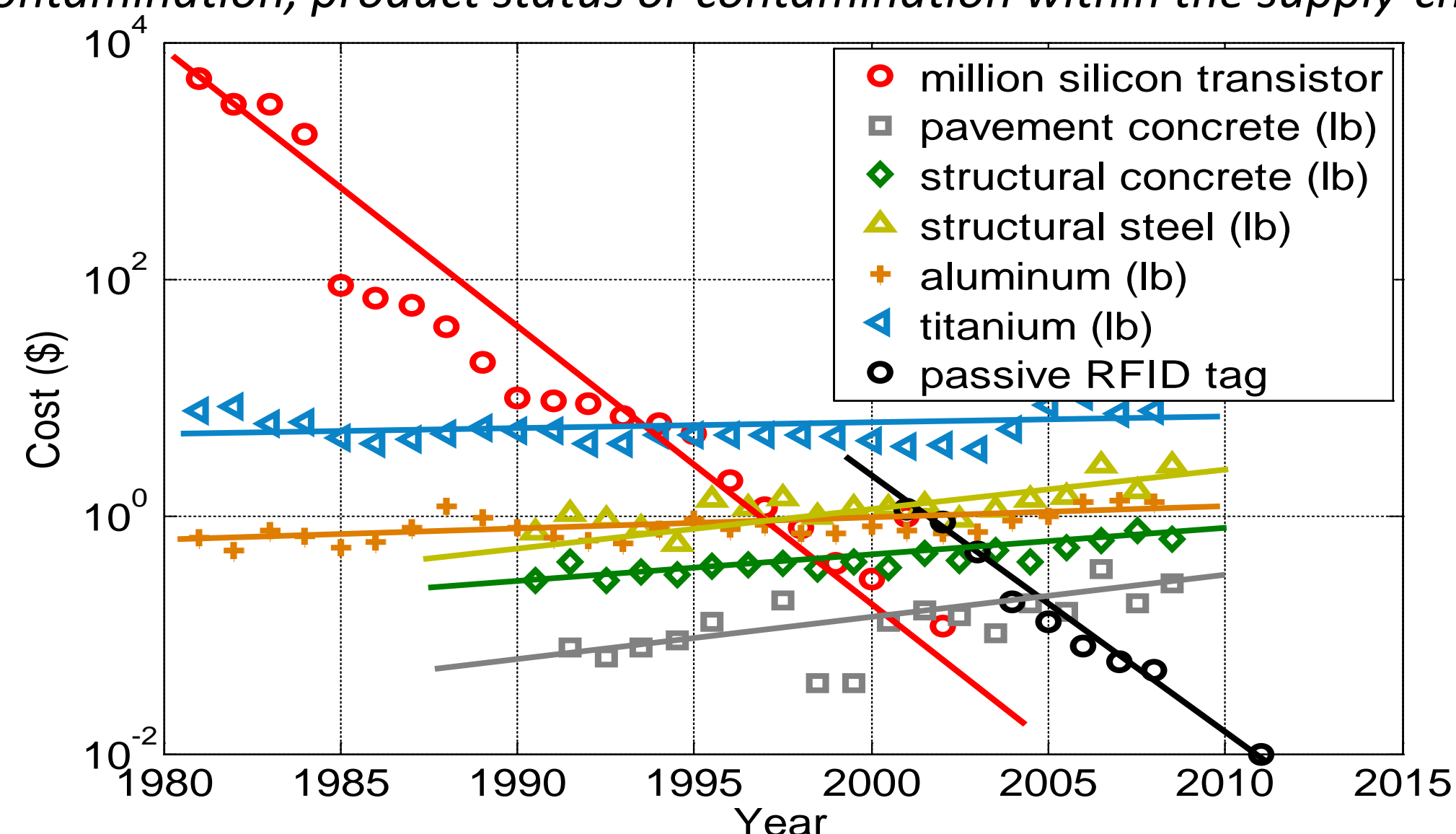


### ➤ Complexity of modern product supply-chain

Encompasses multiple geographical location manufacturing, multi-site storage and the use of third-party shipping channels - practically impossible to completely isolate and optimize.

### ➤ Leveraging advances in radio-frequency identification (RFID) technology

Integrate sensors directly onto an RFID tag to convey either the source of contamination, product status or contamination within the supply-chain.



### ➤ Leveraging MSU's expertise in passive sensing, packaging and supply-chain management.

Large portfolio of passive sensing technologies that do not require any batteries or any external power to operate. Expertise in packaging materials and infrastructure for supply-chain monitoring and education.

**Project theme:** Combine passive sensors, packaging materials and radio-frequency identification within the existing commercial infrastructure. Make RFID sensors integral part of packaging.

## 2. Value Created

➤ Size of RFID market anticipated to reach \$23.4 billion by the year 2020. Some of the key impact areas of RFID integrated with sensors being investigated for supply chain include:

### ➤ Monitoring tampering and contamination.

Applicable to other tamper-sensitive and contamination-sensitive products like cosmetics, pharmaceutical and construction materials.

### ➤ Markers for buried pipes

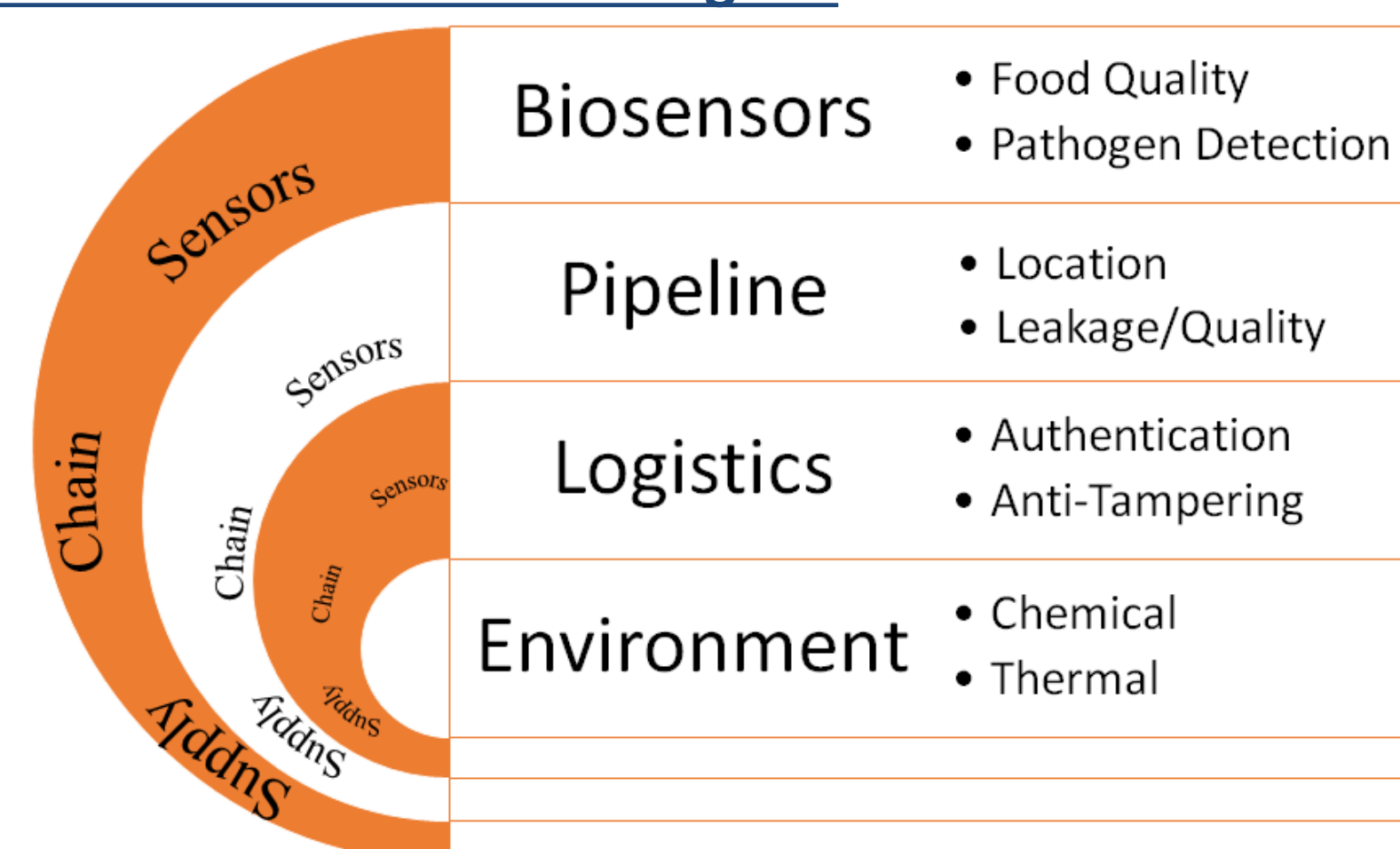
Pipeline infrastructure is an important area in supply chain. Applying the proposed sensors with tags as surface markers enables indicating the location and orientation of pipes. For example, Leak or corrosion detection will ensure safety of gas and oil pipelines.

### ➤ Monitoring of perishable product supply-chain

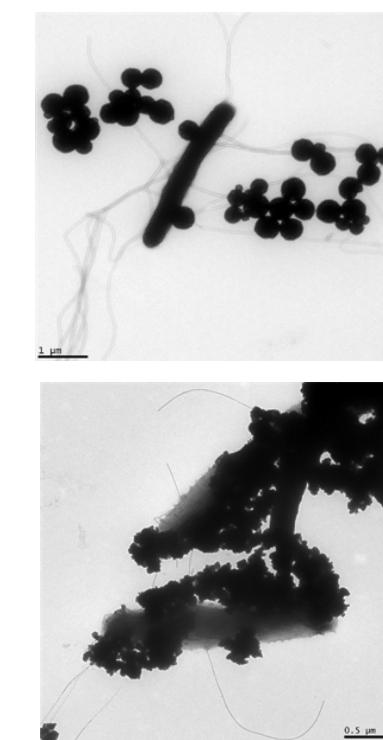
Monitoring of food-product supply chain is important towards preventing food-borne outbreaks and product recalls which account for approximately \$6.9 billion in losses annually. As an example, monitoring of milk products will reduce waste and benefit globally.

## 3. Results and Future Directions

➤ Different sensing elements integrated with commercial RFID antenna - modulates the reflected signal.



<b>Biosensors</b>	<ul style="list-style-type: none"> <li>• Food Quality</li> <li>• Pathogen Detection</li> </ul>
<b>Pipeline</b>	<ul style="list-style-type: none"> <li>• Location</li> <li>• Leakage/Quality</li> </ul>
<b>Logistics</b>	<ul style="list-style-type: none"> <li>• Authentication</li> <li>• Anti-Tampering</li> </ul>
<b>Environment</b>	<ul style="list-style-type: none"> <li>• Chemical</li> <li>• Thermal</li> </ul>



Sensing different targets using harmonic antenna based sensors as an integral part of a UHF Gen-2 RFID antenna.

RFID based sensing can be made integral part of packaging and structure for improved supply chain.

RF tags developed under this project

Different sensing modalities are being investigated. In parallel, studying manufacturing of RFIDs on a host of substrates utilizing inkjet printing.

➤ **Future direction 1:** Investigate passive sensors that can directly modulate the electrical impedance of the RFID antenna. Incorporate sensors within the antenna element.

➤ **Future direction 2:** Integrate sensors, taggants and antenna with the packaging material – piezoelectric fibers or fouling substrates.

## 4. Project Plan

**Milestone 1:** Standardization of the RFID sensing platform to support multiple types of passive sensors. Investigate the integration of RFID with different packaging materials and substrates. Completion Date: 1 year from the start of the project.

**Milestone 2:** Proof-of-concept integration of different types of passive sensors (biosensor, logistics sensor) on the RFID platform. Completion Date: 2 years from the start of the project.

**Milestone 3:** Top-down analysis and sensing optimization based on risk assessment and mitigation strategies on an existing product supply chain. Completion Date: 3 years from the start of the project.