



The Global Language of Business

# Auto-ID Labs Research Projects Summary Report

May 2019



# About the Auto-ID Labs and their projects

The Auto-ID Labs network was originally created to foster foundational research in the area of open standards for supply chain visibility. These six internationally renowned research institutions continue to push the boundaries of exploration into areas like machine learning, sensors and the Internet of Things (IoT). Additionally, they support collaborative programmes to apply GS1 standards in new applications, through public and private partnerships.

GS1 Global Office supports the cutting-edge research of these Auto-ID Labs, which includes many collaborators from industry, government and not-for-profit agencies around the world.

Read and learn about some of the key projects from this past year.

## 1. Massachusetts Institute of Technology (USA)



The Massachusetts Institute of Technology (MIT) Auto-ID Lab focuses on low-cost, pervasive sensing for a variety of applications in IoT and the application of blockchain technology in digital commerce. The lab has strong expertise in the electromagnetic characterisation of smart materials—a fast-growing area of research in IoT development. It also leverages world-class facilities in digital manufacturing to develop non-conformal RFID (Radio Frequency Identification) tags that can be embedded in challenging applications. Key collaborators for its work include GS1 US, Massachusetts General Hospital, Target, Intel and Capgemini.

» **Pervasive Sensors for Value Creation in IoT** aims to use RFID tags as sensors by interfacing them with electrically responsive smart materials. This year, a new food safety temperature sensor was developed with a customisable temperature threshold in the minus 20 degrees Celsius range. Also developed was an RFID alarm sensor that increases its range fourfold when in the presence of a toxic gas or liquid—so that emergency events (such as toxic spills) can be communicated over long distances.

This work impacts GS1 in two ways: enables **RFID** technology to gain deeper adoption in diverse applications beyond **retail**, and positions technology and applications that leverage GS1 standards at the forefront of **IoT** development.

» **Embedded ID for Product Digitisation** helps realise the vision of IoT by embedding tracking and sensing capabilities into everyday objects. Advances in digital manufacturing are already being applied to embed tags into challenging objects such as golf balls. This year, the range of these tags was enhanced by incorporating low-cost photovoltaic cells as a power source for the chips.

This demonstrates how advancements in manufacturing and battery technology can be leveraged to help make passive and semi-passive **RFID** a compelling **technology for identification**, and bridge the digital and physical worlds.

» **Synergistic Opportunities for Data Fusion in IoT** explores ways to make use of technologies like Augmented Reality (AR), to better perceive sensor data. The MIT Lab has developed xVision—a technology that fuses AR and RFID sensor data. xVision highlights everyday objects, such as coffee cups, and augments the object with contextual data, like the volume or temperature of the fluid within.

By tying xVision’s capabilities to **GS1 product identifiers**, this research can extend into applications, such as worker training and maintenance work.

» **Passive Actuator Design for Voltage-Based Stimulation of Materials** investigates ways to use RFID tag-integrated circuits to trigger physical or colour changes in a tagged object. This project seeks to enhance the scope of the use of **RFID** in healthcare devices—particularly in the area of medical implants. For example, the technology could be used to stimulate muscle movement in physiotherapy, using voltage impulses transmitted by an embedded tag.

Another area of application is for rapidly identifying objects in **transport and logistics**, where colour changes can be used to visually mark certain objects on warehouse shelves.

» **Voice Name System (VNS)** is a new architecture being designed to route smart speaker voice requests to third-party services in a “neutral” way. The idea is to enable consumers to connect with the brand or retailer of their choice, in the same way that the Domain Name System (DNS) allows lookup and connection to companies on the internet. Current research activities include the collection of voice samples to design “wake engines” (algorithms that activate smart speaker actions based on what the consumer says); the exploration of ways to firewall off personally identifiable information; and the prevention of phishing attacks.

The project is exploring the role that GS1 standards can play as brands, retailers and marketplaces increasingly look to connect with consumers around **conversational commerce**.

## 2. Keio University (Japan)



The Auto-ID Lab at Keio University is actively exploring Automated Identification and Data Capture (AIDC), RFID, wireless communications, and the use of internet technology for service discovery. Additionally, Keio University is playing an important role as a collaborator for GS1 Japan and as an expert advisor to the Japanese initiative to achieve item-level tagging in convenience stores by 2025.

» **Lifecycle Information Management of Source-Tagged Items** is looking for ways to establish and connect services associated with trade items that are tagged with unique serialised identifiers at the point of production/manufacture. This research explores the use of robotics to automate asset management, and checkout and return operations to optimise the use of tagged products in a retail environment.

All stakeholders in the **retail** supply chain can benefit from additional information—traceable from the manufacturer to the consumer. Consumers get product traceability information, while retailers improve their inventory management capabilities and brands collect product usage data (with the consent of consumers).

» **Barcode Fingerprinting** leverages computer vision and image processing to enable the unique identification of trade items for enhanced lifecycle management. While RFID or other tagging technology can enable unique serialised identification of products, this project investigates the feasibility of using print irregularity of item-level barcodes to identify unique products.

The research explores automatic identification technology based on computer vision and image processing.

» **Distributed Query Choreography EPCIS** seeks to manage information flows when different supply chain stakeholders use distributed EPCIS repositories. Linking and connecting different EPCIS repositories could hinder increased adoption as demand for greater transparency and traceability increases. The project takes advantage of source/destination lists by creating a link to the next (or previous) EPCIS end points. A prototype is being developed to allow for distributed queries of EPCIS systems between 5 retailers, 3 logistics companies and 17 suppliers.

This work explores the data choreography challenges of implementing full traceability between partners that use distributed EPCIS repositories.

## 3. Fudan University (China)



The Fudan University Auto-ID Lab focuses specifically on IoT circuit and system design and is devoted to promoting GS1 and EPC (Electronic Product Code) standards in China. Special areas of interest include IoT technology for food and drug traceability, healthcare and smart cities. Fudan University designed the first “contact-less” smart card chip in China in 1999. Collaborators include GS1 China, National Medical Product Administration (NMPA), Alibaba, SF Express, China Academy of Information and Communications Technology (CAICT), Zhuhai Government, J&J China, Shanghai Jmars Co. Ltd, Shanghai Free Trade Zone United Development Co. Ltd, and others.

» **Automated Identification based on Wide Area Networks (WAN)** is a research effort designed to explore a coding scheme and low-power solutions that can extend communication distances up to 1,000 metres. The outcome can enable low-cost IoT applications that require device connection and communication across long distances and can simplify the infrastructure compared with the near-field communication systems.

This research can impact a number of industries to extend AIDC communication over longer distances, including warehouse management in **transport and logistics**.

» **Towards One-Cent RFID Tags** pushes the limits in further reducing the cost of EPC-enabled RFID tags in order to expand the field of item-level tagging. Solutions to reduce the cost of tags include on-chip CMOS antenna fabrication and printable graphene antenna technology.

These efforts support a broad push to expand item-level RFID tags in retail by researching more cost-effective tag manufacturing techniques.

» **Tracking and Tracing System based on Blockchain** aims to study a food and drug electronic traceability system that leverages blockchain technology and EPCIS. A goal of this project is to provide a harmonised on-chain and off-chain solution for a traceability system that offers transparency, integrity and privacy protection, and allows for the sharing of permissioned data among the stakeholders of the food and drug supply chains.

The research explores ways to combine blockchain technology and understand the architecture to integrate EPCIS event information into a **retail/food** and **healthcare** traceability system.

## 4. University of Cambridge (UK)



The Cambridge Auto-ID Lab is based in the Institute for Manufacturing within the Engineering Department of the University of Cambridge. The lab focuses specifically on industrial applications of AIDC, sensing, IoT, data analytics, machine learning and automation. Sector experience includes aerospace, construction, automation and logistics. Recent research collaborators have included Boeing, Rolls Royce, Y H Global, Siemens, Exxon-Mobil and Procter & Gamble.

» The **ID System Development in Manufacturing** project is investigating ways to incorporate tracking and analytics of aerospace raw materials between suppliers and manufacturers. The project piloted the deployment of AIDC techniques in a commercial production line.

Ongoing work examines ways that **technical industries** companies can leverage AIDC standards in a manufacturing operation and how this can be integrated into existing systems to improve business optimisation.

» Research on hidden patterns in the **Supply Chain Data Analytics** project can provide useful insights to identify supply chain disruptions and improve supply chain visibility. Software prototypes have been completed.

This research demonstrates the integration of machine learning, big data and predictive analytics to improve and optimise supply chains across both **retail** and **technical industries**.

» **Dynamic and Adaptable Supply Chain Logistics** explores strategies to improve and stabilise performance of warehouse and logistics operations for e-commerce. This is important help for **transport and logistics** companies to better manage high-volume order and delivery periods, especially in omni-channel commerce. One example is “Singles Day” in China—the world’s largest shopping holiday.

» **Digital Manufacturing on a Shoestring** leverages off-the-shelf components to provide Industrial IoT capabilities at a low cost. Using inexpensive computer web cameras, parts were tracked through a production warehouse, demonstrating the integration of low-cost systems to improve **manufacturing, logistics and other industrial operations**—even for small manufacturers and logistics providers.

» **Integrated Warehouse & Logistics Automation and Tracking** explores ways to improve automation through the use of robotics and smart systems. The Cambridge lab is working with manufacturers, retailers, logistics providers and warehouses to adopt autonomous robotics and other systems to automate picking, depalletising and sorting operations.

This research explores new approaches to automation that can leverage automatic scanning of GS1 identifiers on products, cases and pallets.

» **Social Networked Smart Infrastructure Assets (SoNIA)** is a collaborative project that takes a digital approach to the way assets—owned, managed and used by different parties—are monitored and maintained. This project has secured £677,000 in funding from Innovate UK.

## 5. Korea Advanced Institute of Science and Technology (South Korea)



The Korea Advanced Institute of Science and Technology (KAIST) is the top science and engineering university in South Korea. The Auto-ID Lab at KAIST is specifically focused on scalable IoT platforms and applications. The lab has developed an open-source IoT system (OLIOT) that leverages GS1 standards and has resulted in more than 10,000 downloads from 103 countries. Collaborators include numerous Korean companies such as Hyundai Autron, PINE C&I and Korea Telecom. Using OLIOT and GS1 standards, the Auto-ID Lab at KAIST is exploring use cases involving healthcare, smart agriculture and smart cities.

» **City-hub** is a core technology platform being developed to drive smart city applications in South Korea. The goal of this project is to develop an open data platform to collect and share data for various demonstration projects focused on energy, environment and other city services, centred around Siheung City and Daegu City. The project aims to integrate various standards and platforms, including GS1, oneM2M, Open Connectivity Foundation (OCF) and FIWARE. GS1 identification keys will be used to identify physical city resources; however, the project is also expected to explore other use cases where the GS1 system of standards, including EPCIS, is applied to a smart-city environment.

» **Internet of Food and Farm (IoF2020)** is a multi-organisational European initiative with collaboration by 16 European countries and 71 companies and organisations, including KAIST. KAIST is working to leverage GS1 standards in meat traceability along with Artificial Intelligence (A.I.), big data and IoT techniques. A main contribution of KAIST is to create interoperability of EPCIS with other IoT standards, specifically FIWARE.

This research supports the **fresh foods** and **foodservice** sectors by exploring the application of GS1 standards in the agriculture and food industries.

## 6. ETH Zürich and University of St. Gallen (Switzerland)



The Auto-ID Lab in Switzerland is a joint initiative of the Institute of Technology at University of St.

Gallen and the Information Management Group at ETH Zürich. A key area of research focus is the exploration of the digital transformation of the retail industry—specifically how consumer behaviour can be influenced through access to richer product information. Key collaborators include GS1 Switzerland, Swiss Society for Nutrition, Valora, Aduno, and the Swiss Federal Food Safety and Veterinary Office.

» **Object Recognition of Products** aims to use machine learning and computer vision to predict product categories—or missing values—for nutrients from product master data such as images. Through this research, image data was used to predict the product category and ingredient data was used to predict nutrients. High accuracy rates were achieved using a small product set (e.g., vending machine) and nutrients from ingredient data.

This project illustrates a way to leverage computer vision technology to address **data quality** challenges where data may be missing or incorrect.

» **Digital Receipts Pipeline Exploration** explores the growing interest in digital receipts from retailers and payment providers, especially in regions with high shares of non-cash payments (e.g., Sweden and the UK). Together with Aduno (largest credit card issuer in Switzerland) and Swisscom (largest telecommunication operator in Switzerland), the lab is assessing the regulatory, technical and societal prerequisites for mass adoption of digital receipts in Switzerland and Europe. The lab has also developed its own digital receipt infrastructure with Receipt2Nutrition, which is piloting interoperable digital receipts across multiple retailers.

This project looks to advance new standardisation opportunities in **retail** for digital receipts.

» **Food Literacy and Healthy Nutrition** focuses on building digital health interventions based on product master data and digital receipts. In the past few years, multiple health applications have been built and tested that connect to Eatfit, the lab's own research database of product data. This past year, **Receipt2Nutrition** was launched, integrating the two largest loyalty card systems in Switzerland and enabling consumers to automatically receive a nutritional assessment of their shopping baskets after each store visit.

This work exemplifies how regulatory frameworks such as the EU's Food Information Regulation 1169/2011 (EU1169) or its General Data Protection Regulation (GDPR) 2016/679 can lead to new health applications that leverage **GS1 identifiers and product master data** to further bridge the gap between consumers, brands and app developers.

» **Financial Literacy and Smart Spending** explores the use of mobile apps to provide insights to consumers on their purchases made through credit cards and other digital payment channels. The Walter Finance App has been used by over 1,000 consumers. A study this year showed that with app-based interventions, consumers can reduce their credit card spending by 13 percent.

This research demonstrates how data from standardised APIs can be leveraged to inform customer decision-making, which could benefit **retail** operations for enhanced engagement with consumers.

» The **Scan & Go** project—a self-checkout app that explores consumer behaviour—led to the launch of the first autonomous stores in Switzerland in April 2019. Initial findings from the work with their research partner, Valora, Europe's largest convenience retailer, led to the opening of 24/7 self-service kiosks without a point of sale (POS). Similar to other self-checkout systems, consumers enter the store by scanning a user-specific QR code and purchase products via product barcode scanning, using the store's mobile app.

This example illustrates how Auto-ID Lab collaboration with industry can accelerate the implementation of new **retail** advances and create new consumer experiences.



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## Learn more about the GS1 Auto-ID Labs Programme

For questions or more information about research of the Auto-ID Labs, contact the GS1 Global Office Solutions & Innovation team at [innovation@gs1.org](mailto:innovation@gs1.org).

### About GS1

GS1 is a neutral, not-for-profit organisation that develops and maintains the most widely used global standards for efficient business communication. We are best known for the barcode, named by the BBC as one of “the 50 things that made the world economy”. GS1 standards improve the efficiency, safety and visibility of supply chains across physical and digital channels in 25 sectors. Our scale and reach – local Member Organisations in 112 countries, 1.5 million user companies and 6 billion transactions every day – help ensure that GS1 standards create a common language that supports systems and processes across the globe. Find out more at [www.gs1.org](http://www.gs1.org).

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