



The Global Language of Business

Auto-ID Labs Research Projects Summary Report

May 2018



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 pushed the boundaries of exploration into areas like machine learning, sensors and the Internet of Things (IoT). Additionally, they supported collaborative programs to apply GS1 standards in new applications through public and private partnerships.

GS1 Global Office supports their cutting-edge research, which includes 100 collaborators from industry, government and non-profit agencies from around the world.

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

1. Massachusetts Institute of Technology (USA)



The MIT Auto-ID Lab focuses on low-cost, pervasive sensing for diverse applications in IoT and the application of blockchain technology in digital commerce. The lab has strong expertise in the electromagnetic characterisation of smart materials, which is 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. Lab personnel are at the forefront of blockchain technology application development – particularly in e-commerce and online retail. Key collaborators for their work include GS1 US, Massachusetts General Hospital, Target, Intel and Capgemini.



Pervasive Sensors for Value Creation in IoT aims to extend RFID tags as pervasive sensors by interfacing the tag with electrically responsive smart materials. Through this work they have developed low-cost sensors for applications in indoor air-quality sensing and glucose monitoring.

This work impacts GS1 in two ways: first, it can allow RFID technology to gain deeper adoption in diverse applications beyond **Retail**, and second, it positions technology that leverages GS1 standards at the forefront of IoT development in these applications.



eyeDNA: Analytics for Machine Monitoring seeks to build a knowledge base of analytics for the condition monitoring of industrial machinery. They developed machine learning analytics to successfully quantify the sharpness degradation of a milling machine drill bit using low-cost accelerometers and infra-red thermometers.

This research demonstrates predictive monitoring to support the growth of Industrial IoT applications in **Technical Industries**.



Embedded ID for Product Digitisation leverages advancements in digital manufacturing to seamlessly embed RFID tags into everyday objects. They developed an RFID-augmented gold ball with more than a six-metre read range, as well as RFID-enhanced medical instruments to enable automated inventory counting. The vision of IoT will be realised by embedding tracking and sensing capabilities into everyday objects.

This project seeks to fulfil that vision using RFID, ensuring that the technology bridging the digital and physical worlds continues to leverage GS1 standards.



Bridging the Physical and Digital Divide demonstrates how advancements in augmented and virtual reality (AR and VR) can enhance the shopping experience by allowing consumers to virtually view products in their homes. AR has been a hot topic for retailers to develop apps for convenient, virtual shopping, and MIT's work includes the exploration of image processing needed for 3D object rendering as part of a smartphone or VR headset.

This work can leverage trusted product information for future AR-based **Retail** shopping experiences.



Cyber Security of Autonomous Vehicles research focuses on the analysis and design of control architecture, detection mechanisms, and mitigation solutions to cyber attacks on autonomous vehicles.

This project can provide a framework for performing architectural analyses to identify vulnerabilities of sensor networks and mechanisms for planning, mitigating and defending against cyber attacks.



Conversational Commerce is a new initiative to explore the rapid consumer adoption of voice assistants and the role they play in changing e-commerce. This work also includes research into the role of underlying technologies such as artificial intelligence (AI), blockchain and IoT.

The impact of conversational commerce will extend beyond simply voice-activated shopping, and will enable the creation of new shopper-centric **Retail** experiences.

2. Keio University (Japan)



The Auto-ID Lab at Keio University is active in Automated Identification and Data Capture (AIDC), RFID, wireless communications and 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.



Life Cycle Information Management of Digitally Fabricated Products

is exploring ways of providing identification management of products, which are fabricated with modern manufacturing machines such as 3D printers. The goal is to authenticate, identify and track individually fabricated items to allow product information and other services (such as warranty or product recall) to be digitally attached to these small batch products.

The research explores the challenges of unique product identification against the future trend of greater mass customisation of **Retail** products.



RFID Interrogation Zone Filtering investigates the challenge of having clusters of many RFID-tagged items in a single warehouse, but not being able to effectively distinguish between the tags of interest and reading unintended tagged objects (such as when multiple shipping containers each have tagged items). The goal is to provide smart filtering of the RFID signals within a specified zone, and ignore signals from the undesired tagged objects with machine learning techniques.

As increased adoption of EPC/RFID tags become more prevalent, this research will become important to optimally manage inventory systems, especially for **Retail** industries.



Robust Filtering and Collection Platform aims to provide high-speed filtering during the reading of RFID tags to match many heterogeneous subscription requests. In this way, the reader can filter out only the events of interest based on the application at speeds over 10,000 tags per second.

As increased adoption of EPC/RFID tags becomes more prevalent, this research will become important to properly process physical world events in **Retail** and **Transport & Logistics** industries.



Source Tagging Every Item in Japanese Convenience Store Chains by 2025 is expected to require deployment of 100 billion RFID tags

per year. Keio University is playing a pivotal role in providing guidance to the large ecosystem of convenience store retailers, technology suppliers and system integrators to prepare for this challenge. Additionally, they collaborate with other organisations to reduce the cost of RFID tags.

This is a major effort that benefits the entire convenience store **Retail** enterprise across Japan. Additionally, this work will provide an opportunity to learn about challenges and solutions for both broad-scale RFID adoption and EPCIS.

3. Fudan University (China)



The Fudan University Auto-ID Lab focuses specifically on Integrated Circuit (IC) and RFID chip design and is devoted to promoting GS1 and EPC standards in China. Special areas of interest include 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, Information Center of China Food and Drug Administration (CFDA), Shanghai Quanray Electronics, Nanjing Weigang Dairy Co. Ltd, Shanghai Free Trade Zone United Development Co. Ltd, and others.



Automated Identification based on Wide Area Networks (WAN)

is a research effort to explore a coding scheme and air interface protocol 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 & Logistics**.



Moving Towards One-Cent RFID Tags

pushes the limits in further reducing the cost of EPC/RFID tags in order to expand the field of item-level tagging. Solutions to reduce the tag cost 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 cost-reducing tag manufacturing techniques.



Food Tracking and Tracing System based on Blockchain

aims to study a food safety, electronic traceability system that leverages blockchain technology. The goal of this project is to provide discovery services for a traceability system that offers transparency and integrity protection and allows for permissioned data sharing among the stakeholders of the food supply chain.

This research explores ways to combine blockchain technology and understand the architecture to integrate EPCIS event information into a **Retail** or **Food** 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 Cambridge Lab has a specific focus on industrial applications of AIDC, sensing, IoT, data analytics, distributed decision-making and automation. Sector experience includes Aerospace, Construction, Automation and Logistics. Recent research collaborators have included Tesco, Boeing, British Telecom, Laing O'Rourke, Y H Global, Siemens and P&G.



Smart Waste Management of Food Items has focused on exploring food inventory tracking in the home in order to monitor and reduce food waste. The research included trials with Tesco to demonstrate the use of a consumer app and a smart fridge to record lot and sell-by date from the expanded GS1 DataMatrix barcode. Additionally, a camera was used to identify objects using image recognition models.

This research demonstrates ways to utilise additional product information from **Fresh Foods** to create a digital home inventory database that can create new consumer opportunities to learn how to manage food usage and reduce food waste in the home.



ID System Development in Manufacturing is investigating ways to incorporate tracking and analytics of materials between suppliers and the manufacturer. Example materials include composite sheets, which may include barcode identification when they arrive at the manufacturer. However, the identification is potentially lost in processing when the material is cut, heated and shaped during production. The project looks at tracking the materials that are used to make a final part with its own identification. The goal is to pilot the deployment of AIDC techniques in a commercial production line. The project also explores the tracking infrastructure needed to support manufacturing operations.

The 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.



Customer-Oriented Logistics for Omni-Channel Retailing examines how to develop and deploy different warehouse and transport strategies during high-volume promotion days or holidays. The methodology creates different modes that can be easily switched to quickly ramp-up demand for logistics suppliers.

This ongoing work helps explore ways that **Transport & Logistics** companies can evolve IT system development to better manage high-volume order and delivery periods, especially for omni-channel commerce.



Various Supply Chain Analytics projects are being explored to research ways that hidden patterns in data can provide useful insights to identify supply chain structures and improve supply chain operations.

The research demonstrates the integration of machine learning, big data and predictive analytics to improve and optimise supply chains across both **Retail** and **Technical Industries**.

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



While the Korea Advanced Institute of Science and Technology (KAIST) is a relatively young institution, it is now considered the top science and engineering university in South Korea. The Auto-ID Lab at KAIST is specifically focused on scalable IoT platforms and applications, and has developed an open-source IoT system (OLIoT) that leverages GS1 standards and has resulted in more than 9,000 downloads from 100 countries. Collaborators include numerous governmental industry and trade organisations in Korea, as well as companies such as Hyundai Autron and Ericsson.



The GS1 Connected Car Project has been an effort to utilise the open-source IoT system to integrate vehicle information, user infotainment and mash-up services into a single, in-car dashboard. Of particular interest is how the system has integrated a number of different communication protocols, from voice recognition to barcode scanning, CAN, Wi-Fi, NFC, LTE and others.

The project has demonstrated a prototype connected car that uses a personal digital assistant to connect the driver to the car and capture all information using EPCIS and other GS1 data standards. This can impact both consumer-IoT systems as well as **Transport & Logistics** operations.



Internet of Food and Farm is a multi-organisation European initiative with collaboration from 16 European countries and 71 companies and organisations, including KAIST. KAIST is working to leverage AI, big data and IoT techniques to integrate sensor data to support the program.

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 the access to richer product information. Additional activities include participation in hackathons. Key collaborators include GS1 Switzerland, Valora, Aduno and the Swiss Health Ministry.



Novel Loyalty Schemes and Actionable Analytics in Physical Retailing

explores the use of apps to foster customer loyalty and provide insights into customer behaviour. Their Scan&Go Self-Checkout app has been used for more than 1,000 transactions in a field study. The results indicate that such apps can positively impact purchase frequencies and customer share of wallet. Furthermore, using methods from econometrics and machine learning, they have developed models providing customer share-of-wallet estimates, finding first evidence for the positive impact of novel loyalty schemes on retailer loyalty.

This research contributes towards designing novel, mobile-mediated loyalty schemes and measuring consumer behaviour in the absence of complete information that could benefit **Retail** operations for enhanced customer analytics.



Financial Literacy and Credit Card Spending

Control 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. Early research investigating consumer behaviour has shown that app-based interventions can help consumers reduce their credit card spending.

This research demonstrates how data from standardised APIs (in this case PSD2 Account Information Service API data) can be leveraged to inform customer decision-making and ultimately persuade behaviour, which could benefit **Retail** operations for enhanced engagement with consumers.



Secure Data Sharing (Open Algorithms – OPAL – for GS1)

aims to unlock the potential of private data for public good in a privacy-conscious, scalable, and socially and economically sustainable manner. The core idea is to ship code instead of data, thereby empowering consumers to keep control of their data, yet allowing decentralised machine learning in a privacy-preserving way.

They believe that there is huge potential for GS1 and its **Retail** clients since data exchange in a privacy-preserving and standardised way is essential for GS1's future business activities.



Food Literacy and Healthy Nutrition

focuses on building mobile health interventions based on product master data and digital receipts. They have built and tested multiple mobile health applications such as FoodQuiz, SaltTracker, FoodTracker, AllergyScan, BetterChoice and NutritionAvatar. These apps tailor relevant information to their users through the processing of purchase history and ingredient data, thereby offering a novel, tailored and scalable alternative to contemporary apps. In addition, they have built Eatfit, their own GS1 Source database, enabling integration of additional data assets and research on machine learning-based improvements of data quality.

This work exemplifies how regulatory frameworks such as EU1169 or Data Portability can lead to new health applications. They believe that, through the provision of enablers such as GS1 Cloud, GS1 can bridge the gap between developers, consumers and brands.



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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.

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.

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