Drug Security Supply Chain Act (DSCSA) and the Pharmaceutical Supply Chain

A Pilot Study to Demonstrate the Feasibility of Radio Frequency Identification (RFID) for Traceability "Pharma Supply Chain End-to-End Pilot"

The Axia Institute, September 2023 | By Bahar Aliakbarian, Ethan Claucherty, and Danielle Cummins

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Summary

This comprehensive whitepaper addresses the results of a collaborative pilot project led by Michigan State University's Axia Institute. The primary objective of this endeavor conducted within the Axia Lab, was to assess the potential of Radio Frequency Identification (RFID) technology in establishing an end-to-end traceable pharmaceutical supply chain, all while adhering to GS1 standards and the interoperability requirements outlined by the Food and Drug Administration's (FDA) Drug Supply Chain Security Act (DSCSA). A crucial aspect of this project involved conducting site visits to key points along the pharmaceutical supply chain, which provided invaluable insights into real-world workflows and helped identify areas where RFID technology could offer the supply chain substantial benefits. These site visits played a pivotal role in shaping the pilot's strategy and approach. The industry stakeholders "Pilot Advisory Group" played an invaluable role in providing insights and expertise, further enriching the project's outcomes. The culmination of this initiative underscores the immense value of RFID technology as a complementary asset for traditional barcoding methods, affording the pharmaceutical supply chain unparalleled visibility and seamless interoperability. Notably, the integration of RFID demonstrated substantial time savings and a marked reduction in errors, particularly within the intricate landscape of diverse product environments.

Section 1: Introduction

1.1. Drug Supply Chain Security Act

With the gradual implementation of the Drug Supply Chain Security Act (DSCSA) by the Food and Drug Administration (FDA), pharmaceutical supply chain visibility has become paramount. The DSCSA imposes several requirements on pharmaceutical supply chain participants in the United States to enhance drug safety and traceability. These requirements aim to prevent the entry of contaminated, stolen, counterfeit, or otherwise unsafe prescription drugs into the supply chain [1]. Based on the DSCSA mandate, pharmaceutical manufacturers are required to serialize prescription drug packages at the unit level. By November 27, 2023, full unit level traceability, including aggregation, is required. This means that each individual package or container must have a unique identifier, often in the form of a 2D barcode, to allow for traceability. Though the legislation was initially signed into law on November 27, 2013, with the Drug Quality and Security Act (DQSA) [2], the complexity of the subject matter delayed the execution of initial phase requirements until 2018. Again, on August 30, 2023, the FDA announced a one-year extension for the enforcement of the electronic tracking requirement under the DSCSA. This means that the FDA will not take enforcement action against companies that are not yet able to electronically exchange transaction information (TI) and transaction statements (TS) until November 27, 2024. There is an intention to develop a centralized system to securely store pharmaceutical data, provide a full history of transactions, and any other information to verify the authenticity of any unit sold. The intent of this system is to be a secure place for actors in the pharmaceutical supply chain to communicate and confirm the legitimacy of the prescription drugs within the United States [3]. The database would also aid in identifying and handling suspicious, counterfeit products. A collaborative effort has been made between the FDA, manufacturers, re-packagers, wholesale distributors, dispensers (pharmacies), and third-party logistics providers to effectively and efficiently comply with the requirements of the DSCSA through the organization of the Partnership for DSCSA Governance (PDG) [4] which intends to support the efforts of the DSCSA requirements of electronic, interoperable tracing and verification of prescription drugs within the United States [5].

1.2. Possible Enablers toward DSCSA Interoperable Tracing Requirement

Interoperable tracing is a way to track products and materials throughout the supply chain using machine-readable labels or tags. This makes it easier to identify and locate products and materials, and to track their movement through the supply chain. This can help to improve the safety, security, and efficiency of the supply chain. Interoperable tracing is achieved using a data carrier, which is a machine-readable label or tag that can be attached to products or materials. Common types of data carriers include barcodes, QR codes, and radio frequency identification (RFID) tags [2]. For reference, barcodes and QR codes must be individually scanned with a device, while RFID tags provide more flexibility and can be read without being in direct line of sight of the reader. This makes RFID ideal for tracking products and materials that are inside containers or boxes. Passive Ultra High Frequency (UHF) RFID tags, also known as RAIN RFID chips, are a type of RFID tag that does not require a battery. They have limited storage capacity but can be encoded with important information such as lot number, batch number, and expiration date [6-8]. Interoperable tracing is important for several reasons. It can help to improve the safety and security of

the supply chain by making it easier to track and trace products and materials in the event of a recall or contamination. It can also help to improve efficiency and reduce costs by making it easier to track the movement of products and materials through the supply chain.

1.3. Igniting Industry-Academia Collaboration: The Inception of Axia's Pilot Project

Under mounting pressure from the FDA to enhance end-to-end traceability and recognizing the paramount significance of improving patient safety and operational efficiencies, healthcare leaders are actively exploring the potential advantages offered by EPC-enabled RFID technology. To facilitate this journey, Michigan State University's Axia Institute and Zebra initiated a pivotal event in August 2022, marking the commencement of their Pharma Supply Chain End-to-End Pilot. Over the course of two days, this collaborative effort united various stakeholders from the healthcare industry "Pilot Advisory Group" to collectively deliberate on the framework and logistics of a pilot (see Figure 1) initiative. During the first day, eAgile hosted the group at their impressive facilities in Grand Rapids, Michigan. They provided firsthand insights into their RFID tags, software solutions, and cutting-edge hardware. Participants were afforded a close-up look at the technological components that underpin RFID traceability and packaging systems. The diversity of equipment configurations essential for executing the pilot was also highlighted. Subsequently, the following day featured a tour of the Axia Lab, where attendees were treated to live demonstrations showcasing RFID traceability and packaging technologies. This immersive experience allowed participants to grasp the nuances of equipment setups critical to the success of the pilot. During a productive session at The Axia Institute, key challenges came to the forefront of discussions. Topics of concern included the implementation of the DSCSA, the need for interoperability, the existing disconnect in unit-of-measure standards within the healthcare industry, and the benefits and challenges of RFID technology. Participants expressed that, "*RFID is an unfamiliar technology in pharma but increasing adoption in retail and other verticals (Walmart) could facilitate its adoption*." They also highlighted the fact that, "*An automated sensor-based approach yields fast and accurate business outcomes due to a reduction in human error and an increase in efficiency*." All participants concurred that, "*RFID requires new capital and ongoing investments across the supply chain. However, prevention of counterfeit and diversion as a result of an automated sensor-based system justifies the capital*." The session concluded with the identification of actionable items, setting the stage for the development of a pilot engagement aimed at addressing these pivotal challenges head-on.

Figure 1. Axia's First Brainstorming Session Participants in August 2021

1.4. Exploring Real-world Workflows: Identifying RFID Benefits

The pharmaceutical supply chain is an intricate and multifaceted process that involves a multitude of stakeholders, each with distinct roles and responsibilities (see Figure 2, Upper Level). This expansive network comprises manufacturers, wholesalers, distributors, dispensers (such as pharmacies), and regulatory bodies, each entrusted with specific tasks, including drug production, storage, transportation, and the assurance of product safety and authenticity.

In our pursuit of designing a comprehensive pilot engagement, site visits emerged as indispensable components. These visits were strategically aimed at immersing ourselves in the tangible realities of each segment within the pharmaceutical supply chain. By doing so, the Pilot Advisory Group gained an invaluable opportunity to observe and meticulously document the intricate processes and procedures executed by each stakeholder across the pharmaceutical value chain.

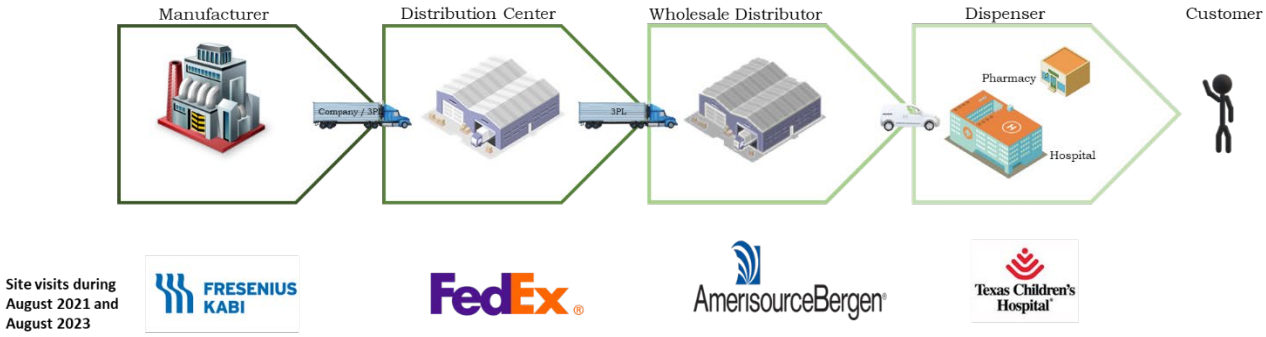


Figure 2: Major Nodes of the Pharmaceutical Supply Chain and Site Visits Performed by the Pilot Advisory Group

Over the course of the 12-month project duration, the Pilot Advisory Group visited at least one site for each pivotal point (refer to Figure 2, Lower Level). This firsthand exposure and knowledge acquisition proved paramount in the identification of potential vulnerabilities and risks lurking within the supply chain. Furthermore, it enabled us to craft effective strategies for their mitigation.

The data garnered from these site visits served as a cornerstone for replicating real-world scenarios within the laboratory setting. For instance, our visit to a wholesaler's facility shed light on the manual efforts involved in loading, unloading, scanning, and tracking products within the premises. This insight was instrumental in designing a process that could faithfully emulate the real-world scenario on a smaller scale in the lab, obviating the need for substantial investments or alterations in the facility's operational flow. After the site visit, the Pilot Advisory Group concurred that, "*There are many models for successful implementation of new technologies. Invariably, the most open and standards-based implementations win in the long run*." It was evident to the participants that, "*RFID is positive for patient safety and for reducing healthcare costs, but only if it works well. This study proves it works*."

This whitepaper offers a comprehensive insight into a collaborative pilot project undertaken by Michigan State University's Axia Institute, in partnership with industry stakeholders called “Pilot Advisory Group”. This initiative carried out in the Axia Lab aimed to evaluate the potential of RFID technology in establishing an end-to-end traceable pharmaceutical supply chain while adhering to GS1 standards and the interoperability mandates outlined by the DSCSA.

Section 2: Research Framework and Execution Plan

2.1. RFID Tags

Three passive UHF RFID tags from tag manufacturers CCL, eAgile, and Zebra were used. All three tags (Tag 1, 2, 3) were of a similar size and were equipped with the optional user memory bank on the integrated circuit to allow for additional information to be encoded. Two of the tags were pre-encoded by the manufacturers to include the lot/batch number and expiration date, and one was encoded in the Axia Lab using GS1's EPC and User Memory Encoders/Decoder tool. The encoding scheme followed GS1's serialization standard [9].

2.2. Pharmaceutical Products

Three products from three independent pharmaceutical manufacturers were used to build test formulations. The products used were Leflunomide ("ARAVA®" by Apotex) (oral tablets in plastic bottles), Avapro® irbesartan by Sanofi-Aventis (oral tablets in plastic bottles), and Diprivan® propofol box by Fresenius Kabi (liquid in glass vials with metal caps for intravenous administration). Each Diprivan box contained ten RFID-tagged vials of 20mL Diprivan. Products were mounted in a small-sized standard pharmaceutical tote provided by pharmaceutical distributor Amerisource Bergen. RFID effectiveness is notably averse to the presence of liquid and metal; thus, a preliminary study was executed using a similar size UHF RFID tag without the user memory bank to determine the maximum number of products that could fit in a tote aiming to obtain a 100% RFID readability. Based on the preliminary results, two separate tote formulations were created: one with more solid oral tablets (Figure 3A) and one with more liquid vials (Figure 3B). Both formulations are based on our site visits inspired by real-world situations occurring within wholesaler distribution and dispensing.

A B

Figure 3: Formulation A (Left) with a total of 54 sellable units (24 Leflunomide, 24 Avapro, and 6 boxes of Diprivan) And Formulation B (Right) with a total of 36 sellable units (12 Leflunomide, 12 Avapro, and 12 boxes of Diprivan)

2.3. Equipment to Encode RFID tags and Measure RFID Readability

Software and hardware provided by separate solution providers Zebra, Printronix, and ACSIS were used. RFID printers to encode and print RFID labels (Figure 4A), an RFID-enabled tunnel (Figure 4B) to measure RFID readability at the tote level, and an RFID transition portal to test the RFID readability at the pallet level (Figure 4C) were employed in this project.

A B C

Figure 4: RFID tag encoding printers (A), RFID enabled tunnel (B) and RFID transition portal and pallet wrapper (C)

When using the RFID tunnel and the RFID transition portal at the pallet wrapper, Zebra's 123 RFID software settings were modified to ascertain the appropriate results. The adjusted settings are listed in Table 1 and Table 2.

Table 1. RFID Tunnel Settings

Antenna Port Settings			Trigger Settings		Advanced Settings				
Antenna 1,2,3,4 Power (dBm)	RF Mode	Dwell Time (ms)	Start Read When…	Stop Read After (s)	Antenna Singulation	State Aware	Inventory State	Flag State	Tag Population
20, 20, 24, 25	Maximum Data	200	Start + GPI goes high	2.5	Session 1	Active	A	All	150
20, 20, 24, 25	Maximum Data	200	Start + GPI goes high	1.5	Session 1	Active	A	All	150

Table 2. RFID Transition Portal Settings

Antenna Port Settings			Trigger Settings		Advanced Settings				
Antenna 1,2 Power (dBm)	RF Mode	Dwell Time (ms)	Start Read When…	Stop Read After (s)	Antenna Singulation	State Aware	Inventory State	Flag State	Tag Population
30, 30	Maximum Data	200	Start	15	Session 1	Active	A	All	540

The settings seen in Table 1 and 2 were optimized to read the maximum number of sellable unit tags in each formulation. The settings changed included Antenna Port Settings, Trigger Settings, and Advanced Settings. The types of antenna settings changed were Antenna Power, The Radio Frequency (RF) Mode and Dwell Time. The Antenna Power is the output power of the antenna (dBm). The RF mode used was "Maximum Data Rate" which is designed for maximum tag readability in low interference environments and was selected because the radio frequency interference was low and allowed for better tag readability. The Dwell Time specifies when the inventory would switch from one antenna to another.

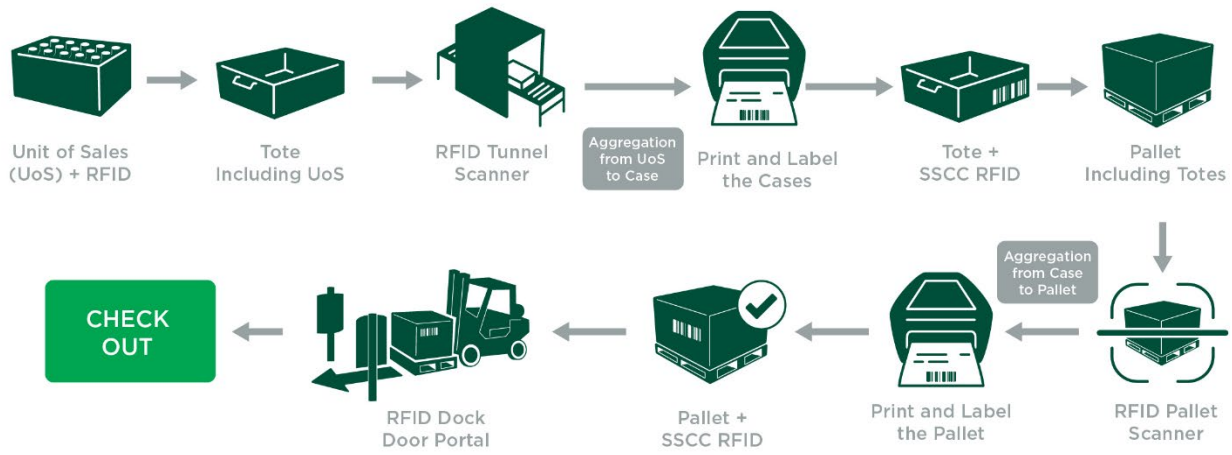
Trigger settings activate an antenna to read and define what conditions halt reading. For Phase 1, this also involved a General-Purpose Input (GPI), which would be triggered when the user presses start, and the GPI accessory photo eye is triggered by an object moving through its threshold. For Phase 1 and Phase 2, reading was halted after either 1.5, 2.5 or 15 seconds.

The advanced reader settings were altered to optimize antenna singulation which refers to the method of identifying an individual tag in a multiple-tag environment. The specified reader session was Session 1. State Aware Singulation was activated, and Inventory State A was selected to specify the inventoried flag value of the session. The flag state was set to SL ALL and the overall expected tag population was defined as either 150 or 540 tags. The expected tag population is larger than the results as it includes item-level tagged Diprivan vials, which come in a box of ten, that are then filtered out and aggregated as a sellable unit.

2.4. Experimental Procedure

To investigate the feasibility of RFID technology and to demonstrate end-to-end pharmaceutical traceability, the following testing procedure (Figure 5) was performed. Initially, a preliminary test was performed using the RFID tunnel to determine the maximum number of each prescription drug formulation that could fit in a tote with 100% readability. All products were manually tagged with a UHF RFID tag with a similar size and shape to those used in the pilot, however the tag did not have the additional extended user memory built into the tag's integrated circuit. After three rounds of testing (N=100 times), the optimized A and B formulations were created.

A



B

Define Best Drug Formulation	Manually tag items at their sellable unit using commercially available RFID tag without user memory feature	Fill totes with the maximum number of drugs	Adjust tunnel antenna settings to reach 100% readability	Create formulations A and B based on results	
Phase 1: RFID Readability for a Mixed Tote	Manually tag items with tags 1,2,3	Create 10 totes for each tag with formulations A&B	Pass each tote through the RFID tunnel (3 tags, 2 formulations, 2 read times, N=100)	Report Readability (Average + % CV)	Create an association for each tote and print a label with the SSCC
Define the Pallet Wrapper Configuration	Create a pallet of 10 totes for each tag and formulations A&B with SSCC tags	Turn on the pallet wrapper at 12 rpm	Determine the time to stretch wrap the pallet for two layers (N=5)	Record the speed and time	
Phase 2: RFID Readability for Pallet of Totes	Create a pallet of 10 totes (Repeat for 3 tags and 2 formulations)	Read RFID tags using the pallet wrapper while shrink wrapping	Filter out all other RFID tags besides SSCC tags using 123RFID	Repeat 100X for each of the tags and formulations	Report Readability (Average + % CV)

Figure 5: Graphical (A) and Descriptive (B) Procedures Used for this Project.

2.4.1 Sellable Unit to Tote Level Aggregation using RFID Tunnel (Phase 1)

After preliminary testing, three series of tests were conducted at two separate time points, each using a different RFID tag: Tags 1, 2, and 3. In each series of testing, the products were manually tagged and placed into ten totes. Each tote was placed on a gravity conveyor and released through the tunnel. This process was repeated ten times for each tote. The RFID software output was cataloged, then cleared following each conveyor run. On the final run of each formulation, the ACSIS software was used to aggregate the items in each tote into a corresponding tote level tag with a SSCC (Serialized Shipping Container Code) number encoded based on GS1's encoding scheme [10]. Figure 6 shows a representation of the product aggregation including tag information in the tote (Figure 6).

AggregationViewer

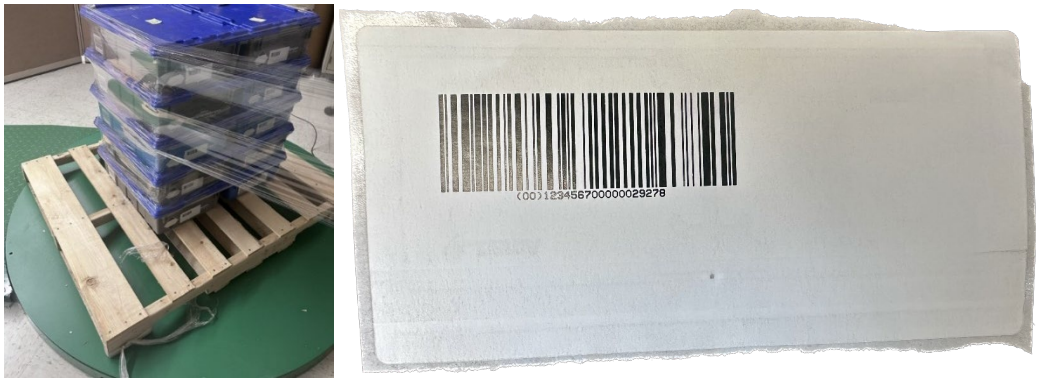
(00)123456700000029278 | 8/30/2023 10:36:33 A | Print SSCC | Print Aggregation

EPC ID	Date /Time	PeakRSSI	User Memory
30564530B815B3800000011A	8/30/2023 10:36:33 AM	-60	892A465D3873F06115C0FC0000000000
30564530B815B3800000019E	8/30/2023 10:36:33 AM	-63	892A465D3873F06115C0FC0000000000
30564530B815B38000000167	8/30/2023 10:36:33 AM	-63	892A465D3873F06115C0FC0000000000
30564530B815B38000000149	8/30/2023 10:36:33 AM	-65	892A465D3873F06115C0FC0000000000
30564530B815B38000000147	8/30/2023 10:36:33 AM	-61	892A465D3873F06115C0FC0000000000
30564530B815B38000000153	8/30/2023 10:36:33 AM	-50	892A465D3873F06115C0FC0000000000
30564530B815B380000000B5	8/30/2023 10:36:33 AM	-63	892A465D3873F06115C0FC0000000000
30564530B815B3800000020C	8/30/2023 10:36:33 AM	-65	892A465D3873F06115C0FC0000000000
30564530B815B38000000193	8/30/2023 10:36:33 AM	-59	892A465D3873F06115C0FC0000000000
30564530B815B380000001A6	8/30/2023 10:36:33 AM	-65	892A465D3873F06115C0FC0000000000
30564530B815B380000000BA	8/30/2023 10:36:33 AM	-57	892A465D3873F06115C0FC0000000000
30564530B815B380000000EE	8/30/2023 10:36:33 AM	-59	892A465D3873F06115C0FC0000000000
30564530B815B380000001A2	8/30/2023 10:36:33 AM	-58	892A465D3873F06115C0FC0000000000
30564530B815B380000001BF	8/30/2023 10:36:33 AM	-64	892A465D3873F06115C0FC0000000000
30564530B815B38000000050	8/30/2023 10:36:33 AM	-56	892A465D3873F06115C0FC0000000000
30564530B815B38000000117	8/30/2023 10:36:33 AM	-61	892A465D3873F06115C0FC0000000000
30564530B815B38000000259	8/30/2023 10:36:33 AM	-54	892A465D3873F06115C0FC0000000000
30564530B815B38000000078	8/30/2023 10:36:33 AM	-62	892A465D3873F06115C0FC0000000000
30564530B815B380000001B4	8/30/2023 10:36:33 AM	-62	892A465D3873F06115C0FC0000000000

Figure 6: Demonstration of the aggregation of products from sellable unit to tote unit using ACSIS software. The results show relevant information including EPC ID, Date/Time, Received Signal Strength Indicator (RSSI) and User Memory with Encoded Lot and Expiration Date.

2.4.2 Tote to Pallet Level Aggregation using RFID Transition Portal and Pallet Wrapper (Phase 2)

A preliminary test was performed using an RFID transition portal and pallet wrapper to determine the average time to wrap the pallet by two layers at a speed of 12 rpm [11]. After five replicates, it took an average of 14.68 seconds for the pallet wrapper to wrap ten totes. Based on the results, 15 seconds was selected for wrapping the pallet. After the preliminary testing, each tote formulation (six total) was tested on the pallet wrapper and the readability ratio was analyzed by filtering out irrelevant EPC's so that only the tote level SSCC tags were read. Each pallet contained ten totes corresponding to one of the six formulations. In Phase 1, the sellable unit tags were aggregated into each tote and a corresponding tote level SSCC tag was printed, which was then adhered to the tote. Thus, one pallet would only have ten responsive tags. The pallet wrapper was turned on and spun continuously for 15 seconds through each round of testing. Readings were repeated N=100 times. The RFID software output was cataloged, then cleared following each conveyor run (Figure 7A). Figure 7B shows an SSCC tag that incorporates a single sellable unit to tote with all the information from the aggregated sellable units in a tote.



A B

Figure 7: Representation of ten aggregated totes on the pallet wrapper (A) and a tote-level SSCC tag (B).

Section 3: Results and Discussion

3.1. RFID Performance to Aggregate from Sellable Unit to Tote Level (Phase 1)

The results from the first level of aggregation (sellable unit to tote) are presented in Table 3. Formulation A, which contained more oral tablets than liquids and more sellable unit tags, had a slightly lower readability across both time points when compared to Formulation B, which had equal numbers of sellable units, but significantly more liquids in terms of volume and items. The highest readability of 99.67% was seen using Tag 1 in formulation B during the 2.5-second read time, with the lowest readability of 96.50% was seen using Tag 3 over a 1.5-second read time. Overall, the 2.5-second read time performed better than the 1.5-second read time for both formulations A and B, as well as across all three tags. In all cases readability was greater than 96.5% and 97.25% at 1.5 and 2.5 seconds, respectively. All reads include the relevant information including EPC ID, date/time, EPC ID, and user memory with encoded Lot and Expiration Date.

Table 3. RFID Readability for Different Tote Formulation at Different Read Time (Sellable Unit to Tote)

Formulation*	RFID Tag	Read Time (s)	Avg. Read Ratio (%) ± SD	CV (%)
A	1	1.5	99.28 ± 0.95	0.95
		2.5	99.61 ± 0.76	0.76
	2	1.5	97.96 ± 1.83	1.87
		2.5	99.07 ± 1.10	1.11
	3	1.5	96.50 ± 2.82	2.92
		2.5	97.74 ± 2.07	2.11
B	1	1.5	99.14 ± 1.48	1.49
		2.5	99.67 ± 0.91	0.91
	2	1.5	98.56 ± 2.03	2.06
		2.5	99.36 ± 1.24	1.25
	3	1.5	97.25 ± 2.54	2.62
		2.5	97.78 ± 2.16	2.21

**Formulation A has a total of 54 sellable units consisting of 48 oral tablet pill bottles and 6 boxes of ten liquid filled glass vials. Formulation B has a total of 36 sellable units consisting of 24 oral tablet pill bottles and 12 boxes of ten liquid filled glass vials.*

3.2. RFID Performance to Aggregate from Tote Level to Pallet Level (Phase 2)

The results from the transition portal testing on the pallet wrapper are presented in Table 4. The results show that 100% readability is achieved over the course of 15 seconds for all tags and formulations tested.

Table 4. RFID readability for different tote formulation (Tote to Pallet)

Formulation*	RFID Tag	Read Time (s)	Avg. Read Ratio (%) ± SD	CV (%)
A	1	15	100 ± 0.00	0.00
	2	15	100 ± 0.00	0.00
	3	15	100 ± 0.00	0.00
B	1	15	100 ± 0.00	0.00
	2	15	100 ± 0.00	0.00
	3	15	100 ± 0.00	0.00

** Formulation A has a total of 54 sellable units consisting of 48 oral tablet pill bottles and 6 boxes of ten liquid filled glass vials. Formulation B has a total of 36 sellable units consisting of 24 oral tablet pill bottles and 12 boxes of ten liquid filled glass vials.*

Section 4: Conclusion and Looking Ahead

This journey through the realms of UHF RAIN RFID technology in supply chains has been a compelling one. While the retail sector, with its well-established history and mandates from giants like Walmart, has stood at the forefront of RFID integration, adoption has lagged in other industries. The slow adoption across diverse sectors is a striking contrast to RFID's well-documented prowess in delivering precise, efficient, and frictionless traceability within the retail sector. Yet, within this landscape of cautious adoption, there is a shifting tide. Sectors such as pharmaceuticals, food, and healthcare are beginning to recognize the multitude of advantages offered by RFID technology over other data carriers, spurred in part by regulatory mandates like the FDA's Drug Supply Chain Security Act (DSCSA) and the Food Safety Modernization Act (FSMA). As the undeniable benefits of UHF RAIN RFID become increasingly apparent, we anticipate a growing acceptance of this transformative technology across industries, ultimately enhancing supply chain operations and ensuring the safety and authenticity of products on a broader scale.

Our pilot project, conducted under the guidance of Michigan State University's Axia Institute, was a pivotal step in this journey. It aimed to explore the potential of RFID in creating a traceable pharmaceutical supply chain, all while aligning with GS1 standards and DSCSA interoperability requirements. The strategic site visits, which offered a firsthand understanding of real-world workflows, played an instrumental role in shaping our approach. We are immensely grateful to the "Pilot Advisory Group", composed of industry stakeholders, for their invaluable insights and expertise. Our findings firmly establish that RFID technology is not only efficacious, but also holds the potential to revolutionize the pharmaceutical supply chain, providing a high degree of readability in remarkably short timeframes. While these results are promising, they are only the initial steps on the path to widespread adoption. Extensive future research and experimentation will be essential to fully validate RFID's feasibility on a larger scale.

In conclusion, this whitepaper is a testament to the collaborative spirit of industry and academia, working hand-in-hand to unlock the full potential of RFID technology. Despite the promising outcomes of this pilot project, the relative scarcity of university-based research in this field is worth noting. This clearly underscores the need for further academic exploration and collaboration to delve deeper into the potential applications and benefits of RFID technology within the pharmaceutical sector.

To advance this research, future steps should include developing stronger ties between academia and industry, and expanding the pilot project to involve a wider network of pharmaceutical supply chain partners, potentially including more manufacturers, wholesalers, distributors, and dispensers. Looking ahead, Axia sees the need to develop educational resources, workshops, and training programs to help industry professionals better understand the benefits and implementation processes associated with RFID technology in supply chains. The Axia team envisions a future where RFID seamlessly integrates into supply chains across various sectors, optimizing efficiency and security for the benefit of all stakeholders across the value chain. Axia also believes that continuous feedback from industry stakeholders and subsequent implementations to identify areas for improvement and refinement of RFID systems are necessary to reach the future RFID-based pharmaceutical supply chain.

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- CCL/eAgile – Provider of tags for testing and host of facility visit from Pilot Advisory Group
- FedEx – Host of visit from Pilot Advisory Group.
- Fresenius Kabi – Provider of pharmaceuticals for testing and host of two warehouse visits from Pilot Advisory Group
- GS1 US – Influencer
- Sanofi-Aventis – Provider of pharmaceuticals for testing
- Seagull Scientific – Provider of the software for testing
- Texas Children's Hospital – Host of visit from Pilot Advisory Group
- Zebra Technologies – Provider of tags and instruments for testing

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About the Organization

The Axia Institute® is a premier research and education center dedicated to developing effective and sustainable solutions to improve public and private value chains. Established by Michigan State University in 2013 with initial grant support from the Dow Chemical Company, the Dow Chemical Foundation, Dow Corning, the Herbert H. and Grace A. Dow Foundation, the Rollin M. Gerstacker Foundation, the Charles J. Strostacker Foundation and the MSU Foundation, Axia partners with industry to solve grand challenges and conduct cross-disciplinary research in areas of value chain digitization, optimization, the circular economy, packaging design traceability solutions and talent development.

A member-driven organization providing research-based solutions across the healthcare, food and agriculture, and advanced manufacturing industries, the Axia Institute also operates the Axia Lab, an independent third-party Radio Frequency Identification (RFID) testing laboratory. The Axia Lab offers fee-for-service testing of RFID-tagged items, including pharmaceuticals and other consumer products.

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