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WORK SMARTER, NOT HARDER:

RFID-DRIVEN CODE CART MANAGEMENT

EXECUTIVE SUMMARY

Crash cart management is one of the most critical inventory management components for a healthcare facility. Access to the right medications in crash carts can be the difference between life and death. However, historically, staff have relied on an archaic process to replenish, manage, and control the inventory in crash carts with paper records and manual medication inspections. In parallel, healthcare organizations have been asked to do more with less, with the rising cost of care and declines in reimbursement for the services provided. Many have been left wondering how to leverage technology to achieve greater efficiency with less and still maintain quality standards. RFID technology used within crash cart management has done just that! It moves the process from "paper and plastic lock practices" to digital quality control and replenishment.

RFID technology has demonstrated the capability to ensure near-100% replenishment accuracy, significantly outperforming manual and barcode-based processes.[1]

The ASHP Foundation convened a group of early adopters to explore expanding the current and implementing new uses of RFID technology in medication-use systems, share insights, and develop white papers outlining key considerations and strategies for evaluation and implementation in practice. Additional details about the project and participants are listed in Appendix A. This white paper presents the business case for RFID in crash cart management and provides an implementation playbook for those evaluating an investment. For organizations that have already embedded RFID into their crash cart management process, the paper offers guidance on overcoming physical barriers and addressing data-driven operational considerations to help elevate their program to the next level.

For more advanced users, the white paper explores the future state of connected inventory and what it will offer. Additional use cases and the creation of the future state are included in the second white paper, "Building an Agile RFID System: A Future-Forward Approach for Health-System Pharmacy." Finally, as George Santayana once said, "hindsight is always 20/20", this paper shares lessons learned from participants as they reflect on what they wish they had known at the outset.

THE BUSINESS CASE: ROI

The first step in investing in RFID and crash cart management is to make your case to your healthcare facility for why it should invest. To promote adoption, participants have cited the following returns on investments (ROI) for RFID and crash cart management: safety, efficiency, and regulatory readiness.

SAFETY

The most frequently discussed topic was the business case for RFID, particularly the balance between safety and efficiency. Every participant was able to cite tangible examples—whether related to preventing expired medication use or achieving time savings through automation. This dual benefit made the business case the easiest concept to quantify and the primary driver behind initial purchase decisions.

The number of medication units (vials, bags, or syringes) contained in a crash cart can be as high as 50 or more, which each require an individual check for formulation, concentration, and expiration during each replenishment. With RFID, crash cart vials and trays can be checked in seconds, nearing 100% accuracy. The replenishment accuracy ensures that no cart is replenished with the incorrect medication, the incorrect quantity, or expired inventory. In hospitals with pediatric and/or neonatal crash carts, where patient vulnerability is highest, adding RFID to workflows provides an essential safety net by verifying the accuracy of specialized medication inventory. Participants in the focus group report that the system is working so well that they are actively seeking other high-use mobile kits that could benefit.

One site reported reducing their daily tray checking time from 102 minutes to 27 minutes, effectively repurposing 75 minutes of pharmacist time per day.

EFFICIENCY

The efficiency mentioned above is the second-most-cited ROI for RFID in crash cart management. Participants compared the efficiency gained with RFID in crash cart replenishment to a “pit stop” in a Formula One race. One site reported reducing its daily tray-checking time from 102 minutes to 27 minutes, effectively repurposing 75 minutes of pharmacist time per day. The system has shifted pharmacy from a manual counting shop to a high-speed replenishment center. While efficiency is gained during tray checking, time and labor must be invested in and considered for upstream tagging and the encoding required for all medications used within the RFID system. Although not all medications commonly stored in crash carts come pre-tagged, the supply chain is evolving quickly, with manufacturers continually expanding their pre-tagged portfolios. As a participant noted, “The improvements in preventing wrong product selection and ensuring kit accuracy have far outweighed any risks, and the technology has delivered meaningful gains in both safety and efficiency for technician roles.

REGULATORY READINESS

Regulatory readiness is also a noteworthy ROI for RFID in crash cart management. The target for health care facilities is to stand “regulatory ready” at all times. This includes chasing zero events, and when it comes to crash carts, that refers to perfect replenishment and flawless expiration date management. Most healthcare facilities that have crash carts have a daily inspection of the unit, in which the expiration date for the medications and supplies is checked. With RFID crash cart management, the facility can rely on the data to proactively know when items are expiring rather than relying on manual inspections and alerts. The system is described by a participant as “invaluable” for meeting the needs of regulatory auditors, as it enables crash cart management by providing readily retrievable data in minutes.

IMPLEMENTATION PLAYBOOK

Once you have the support of your healthcare facility, the next step is to develop your implementation strategy. Keys to implementation include, but are not limited to, the design of the environment, staffing, defining a tagging strategy, and developing your standard works with interprofessional partners.

STANDARDIZATION BEFORE AUTOMATION:

You cannot automate a mess. Before applying a single tag, the most critical step is formulary standardization. As a participant noted, attempting to launch RFID across too many variations of tray layouts ("Start broad") can dilute success. Successful sites leveraged the transition to RFID to drive clinical consensus, reducing multiple similar tray variations into a standardized, streamlined set. This "clean up" must happen *before* the technology is deployed.

THE DESIGN OF THE ENVIRONMENT

Establishing a dedicated workspace is a critical foundational step. Segregating the RFID workspace helps prevent mix-ups between tagged and untagged inventory and supports cleaner, more reliable workflows. Without this separation, teams reported increased confusion and inventory integrity risks. In addition, dedicated data, an adequate number of power ports, and a workstation will be needed to house the hardware and software of the RFID system.

STAFFING

RFID responsibilities cannot be viewed as "other duties as assigned." Participants recommend a dedicated expert. One key lesson learned was that when staffing was tight, RFID work was frequently deprioritized in favor of more urgent operational needs. As one participant noted, "Anytime we were short-staffed, we found ourselves prioritizing other work over RFID operations…sometimes we had no one working that knew how to function in the RFID space." This reinforced the importance of establishing an expert or dedicated RFID champion to avoid last-minute scrambling—particularly at the start of the week.

DEFINING A STRATEGY FOR TAGGING

There was a strong consensus in favor of pre-tagged inventory from manufacturers. Wholesaler tagging was viewed as an easier transition for organizations with limited internal IT or operational resources. The topic of tagging and encoding medications generated a high volume of discussion and was widely described as a major pain point, with participants openly sharing challenges related to staffing limitations, resource constraints, and real-world operational demands.

Facilities must have clear definitions of who and what will be tagged, by whom, and by when, to ensure the inventory needed for expedited replenishment is available at the right times. In addition, staff involved in the tagging process need to understand the proper placement of tags to ensure no essential medication information is inadvertently blocked. Tagging and encoding privileges vary significantly by state; therefore, each facility must individually interpret its local laws to determine appropriate user roles. For example, some facilities interpret state statutes to require pharmacist approval for all tagged inventory, while others allow advanced technicians to manage critical tasks such as adding new lots and National Drug Codes (NDCs). Given the safety risks associated with incorrect encoding, leadership must clearly define these privileges to ensure RFID practices align strictly with their specific regulatory and policy requirements.

DEVELOPING STANDARD WORKS

The design of standard works for program maintenance was found to be just as important as an implementation plan. One key interprofessional partner involved in crash cart standard work is central supply, or those who manage the supplies within the crash carts. Key standard works include, but are not limited to, used crash cart processing, expiration management, and recall response.

A key part of cart maintenance in all routine standard works is visual inspection for used items that remain in the tray, as RFID technology cannot differentiate between a used RFID-tagged item and an unused tagged item. There was a recurring discussion centered on how organizations define “consumed” items. Participants questioned whether “consumed” referred to removing an item from a tray or kit, or only after the product was opened and used. The ambiguity of a consumed item highlighted the need for clearer shared definitions and standardized practices across RFID.

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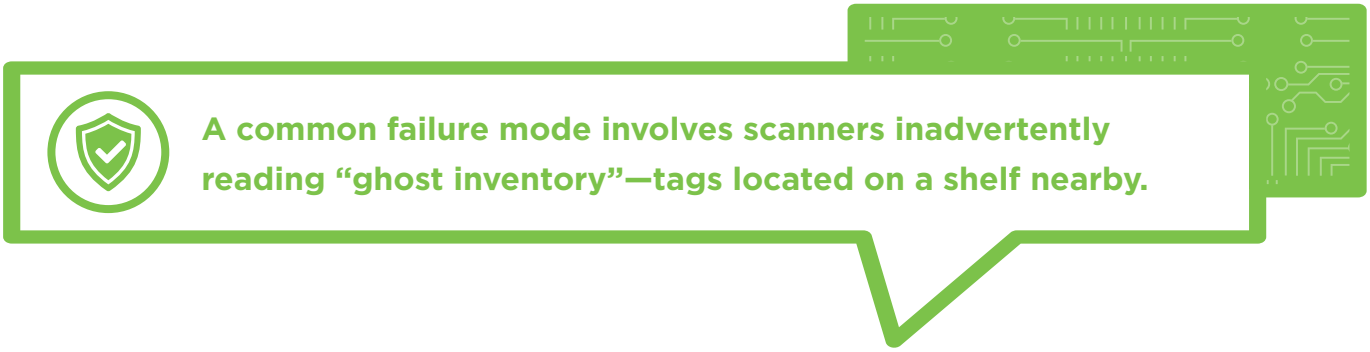
NAVIGATING PHYSICAL BARRIERS: WORKFLOW AND INFRASTRUCTURE

Understanding the physical limitations of RFID technology is a key consideration during vendor selection. A successful rollout must account for the physical ecosystem: the crash cart material, the operation's location, and drug packaging.

THE REALITY OF EQUIPMENT (THE CART)

Many directors assume RFID signals will penetrate all standard hospital equipment. However, the material composition of crash carts creates unexpected barriers. One participant noted that the metal structure of their carts blocked signals from active real-time location systems (RTLS) tags, causing carts to be "lost" in the system.

To mitigate these barriers, rigorous validation is required before purchase. If a vendor claims their handheld scanner functions effectively through metal carts, require a live proof-of-concept using your specific crash carts and medication configuration. Similarly, if implementing active tracking, conduct collaborative testing with your IT team to ensure the cart's metal structure does not block communication between active tags and ceiling receivers. If any issues are identified, establish a pre-defined mitigation plan, such as mounting tags externally or installing additional network repeaters, to address signal disruption before go-live. Regarding daily operations, achieving near-100% accuracy typically necessitates a "Tray-Out" workflow, where the plastic medication tray is removed from the metal cart to eliminate the variable entirely.



MANAGING “CROSS-TALK” (THE ENVIRONMENT)

RFID readers are hypersensitive. A common failure mode involves scanners inadvertently reading “ghost inventory”—tags located on a shelf nearby—causing a tray to pass or fail inspection erroneously because the highly sensitive scanner reads a tagged medication sitting on a desk three feet away. Signals can bleed if a reader is placed too close to stocked, tagged inventory. To manage this, designs may need to include physical shielding (such as metal-lined partitions) if creating a “quiet zone” initially is not possible, and standard operating procedures must enforce a strict “one tray at a time” policy to ensure data integrity.

TAGGING “DIFFICULT” INVENTORY (THE MEDS)

Not all medications are RFID-friendly. Fluid bags and foil-wrapped vials (e.g., norepinephrine and dopamine bags) present physics challenges: fluid absorbs signals, while foil reflects them. If a standard tag is placed flush against a foil wrapper, readability can drop significantly. Technicians must be trained on the “flagging” technique—adhering only part of the tag to the vial so the antenna protrudes into the air gap like a flag. Staff competency in these nuances is critical for system reliability. As one discussion participant noted, the process is “incredibly dependent on having proper, protected resources” who understand *how* to tag complex items, rather than relying on rotating staff who may not understand the correct process.

ADVANCED OPERATIONS: DATA-DRIVEN OPTIMIZATION

For a health system implementing RFID, the immediate value is visibility. You are suddenly provided with a reliable source of data that simply did not exist in the manual era, where inventory levels were often a “black box” until a tray was physically opened.

For sites that have matured past the initial rollout, the goal shifts from counting to optimizing. The focus is no longer just “Do we have the meds?” but “Do we have the right amount of meds in the right places?

One participant highlighted this shift from simple tracking to active management: “Analytics have been the most useful to more accurately, without manual processes, identify usage to modify kit contents and adjust PARs.”

INTEGRATING RTLS

Standard passive RFID tells you what is in the cart. Active RTLS tells you where the cart is. For health systems managing hundreds of crash carts, integrating these two technologies in tandem changes the standard of care for product recalls and monthly crash cart maintenance.

To implement this successfully, the baseline requirement is ensuring your vendor can link a specific "Cart ID" (Active Tag) to the "Tray Inventory" (Passive Tags) housed within it. In a manual environment, a Class I recall requires physically searching every cart to find the specific lot. With integration, pharmacy staff can run a single query across the software platforms to identify the precise room number of every cart containing the affected medication. One participant shared the operational reality of this integration, noting that their team no longer sends staff out to search during a recall. Instead, they "simply run a report… and use the RTLS to see the precise, real-time location of every affected cart," effectively removing the manual search component entirely.

RIGHT-SIZING PAR LEVELS

Code carts are historically overstocked "just in case," leading to significant financial waste. RFID generates an "Items Consumed or Removed" report that tracks exactly what clinical staff use and what they do not, providing the objective evidence needed to challenge historical PAR levels.

To implement a right-sizing strategy, pharmacy leaders should utilize consumption reports to identify high-cost items with zero utilization over a 12 to 24-month period. This data can then be presented to the appropriate committee with oversight over crash cart inventory to recommend evidence-based par reductions or the complete removal of unused inventory.

The process is "incredibly dependent on having proper, protected resources" who understand how to tag complex items.

One participant highlighted that this data goes beyond simple restocking, noting that identifying product removals—whether used, partially used, or returned—is a huge safety and efficiency win that can also help drive improvements in charge capture.

PROACTIVE EXPIRATION MANAGEMENT

Advanced users in the focus group report utilizing data to prevent waste through "Proactive Rotation." By generating reports of critical medications expiring in 30–60 days, technicians can retrieve items from low-volume crash carts and rotate them to high-volume areas (like the OR) where they will be consumed before expiration. While this workflow may not be active at go-live, evaluating a vendor's ability to capture this information should be part of the selection criterion.

CHECKLIST FOR SUCCESS

"WHAT WE WISH WE KNEW"

A recurring theme throughout the participant discussion was the critical importance of protecting dedicated resources. Participants emphasized that RFID success is highly dependent on having properly allocated and protected staffing and time. Operational reality—specifically staffing—ranked as a top item on the checklist for success. Participants resonated deeply with the practical challenges of maintaining RFID systems day to day, including tagging labor, training gaps, and ongoing coverage needs.

Another key lesson focused on tag quality and procurement. Organizations reported the need to ensure vendor contracts clearly address acceptable tags and defect rates, particularly when in-house tagging is used. Finally, while users expressed overall satisfaction with the technology, frustration emerged over system silos and a lack of interoperability, highlighting the need for future-state interoperability planning and integration with RTLS systems for complete visibility.

The panel created this checklist to serve as a resource for readers to validate their planned investment in an RFID solution and/or their current RFID operation, based on the real-world experiences of health systems that have already been through the implementation and growing pains of RFID. Additionally, readers are encouraged to review the Foundation's previous research white papers for additional guidance on evaluating and implementing (see references).

RESOURCE PROTECTION

The Lesson: RFID cannot be treated as "other duties as assigned." If the technician responsible for crash carts is distracted, accuracy can decrease, increasing process errors.

- ☐ **Protected Time:** Have you designated specific hours and/or a shift assignment where the technician focuses only on tray management without interruption?
- ☐ **Physical Environment:** Have you decided if you will segregate tagged inventory from non-tagged inventory? If yes, verify that you have the physical space and a process to monitor compliance.

STAFFING

The Lesson: A common failure mode is relying on a single super user. If that person calls out sick, the crash cart process can grind to a halt. Successful operations depend on having an adequate number of staff trained to operate in the RFID space to support your RFID needs on weekends, holidays, and during unexpected absences.

- ☐ **Adequate Coverage:** Do you have enough trained technicians and pharmacists to ensure the workflow can continue if your primary RFID champion calls out?
- ☐ **Competency Assessment:** Do you have a standard training module to ensure a baseline level of knowledge before working in the space? Does your training require staff to demonstrate they can handle complex scenarios (i.e., "flagging" a foil vial or troubleshooting a reader error) before working independently?
- ☐ **Role Definition:** Have you clearly defined (and configured in software) who has the security privileges to encode new drugs (i.e., pharmacist only) versus who can approve tagged inventory and trays?

TAG QUALITY & PROCUREMENT

The Lesson: As the market matures, your inventory will become a mix of items you tag in-house and items that arrive pre-tagged from the wholesaler. Your staff (and your buyers) need to know the difference. One source of waste occurs when technicians unknowingly apply a new tag to a vial that already has a manufacturer's RFID tag.

Conversely, procurement teams may accidentally order an item that your system cannot read or a nontagged item when tagged options are available.

- ☐ **Buyer Education:** Does your purchasing team understand the difference between tagged and non-tagged NDCs? Do they know if your system has limitations on certain tag types, and is there an ordering "exclusion list"?
- ☐ **Defect Monitoring:** Do you have a process to identify if tag failure rates exceed a specific threshold? Does your vendor contract address acceptable tag defect rates and purchase requirements for in-house tagging?
- ☐ **Root Cause Analysis:** If a threshold is exceeded, is there a process designated to determine if it is a user error (technique) or a technical error (hardware)?
- ☐ **Visual Management:** Are there clear visual aids at the tagging station to help technicians identify pre-tagged vials to prevent "double-tagging"?

IMPLEMENTATION & HARDWARE

The Lesson: Physics matters. Metal carts and mobile scanners do not always mix. While mobile scanning sounds appealing, the physics of metal carts often necessitate a "Tray-Out" workflow.

- ☐ **Workflow Validation:** If utilizing mobile scanners, have you verified staff understand the need to fully expose the tray or tune the reader's power settings as appropriate?
- ☐ **Space Planning:** Have you accounted for the physical footprint of shielded box readers and accessory hardware in your RFID-designated area design?
- ☐ **Keep the Future in Mind:** The vendor(s) you start with matter, but they don't have to be forever. As the ecosystem evolves, new technologies and vendors will continue to emerge, giving you opportunities to improve and expand over time. For more on this topic, see the *Building an Agile RFID System* white paper.

INTEGRATION WITH RTLS

The Lesson: Combining passive RFID (what is in the cart) with active RTLS (where the cart is) transforms recall management and routine maintenance from a manual, time-consuming process into a streamlined, data-driven workflow.

- ☐ **RTLS Vendor Capability:** Confirm your vendor can link a specific cart ID (RTLS) to a tray (RFID) inside the cart.
- ☐ **Signal Validation:** If using RTLS, have you tested designated locations of an RTLS tag on your carts to ensure consistent communication with software?
- ☐ **System Interoperability:** Ensure software platforms can run a single query to identify all carts containing affected medications. If not integrated, build an internal method to combine the two data sources.
- ☐ **Operational Workflow:** Train staff to use RTLS reports for real-time cart location rather than manual searches.
- ☐ **Validation & Testing:** Conduct a mock recall and/or monthly expiration inventory exchange to verify integration accuracy and speed.

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APPENDIX A
ABOUT THE PROJECT AND PARTICIPANTS

18 participants were involved in this ASHP Foundation project, supported by Fresenius Kabi. The group included four advisory committee members and two facilitators (Table 2). Advisory committee and focus group members all had experience in RFID technology in medication-use systems. Project activities occurred between Aug. and Nov. 2025 (Table 1).

Table 1: Project Activities

 **Pre-work and Convening**	 **Focus 1: Code Carts**	 **Focus 2: Towards an Agile RFID System**	 **Dissemination Activities**
• Survey of past research participants to prioritize focus • Prior research papers, podcasts, webinars shared **Advisory committee and participants:** convened and engaged	1. **Live Virtual Meeting:** Oct. 23 **Format:** Presentation and Discussion **Topics included:** getting started, switching, expanding—opportunities, challenges, lessons learned. 2. **Discussion Board:** Oct. 24–28 **Topics included:** RFID implementation, staffing, evaluating ROI, other uses of RFID data, and interoperability	1. **Live Virtual Session:** Nov. 4 **Format:** Presentation and Discussion **Topics included:** explore the need for agility, current gaps, and the role of interoperability along with future use applications. 2. **Discussion Board:** Nov. 5–7 **Topics included:** data integration across systems, expanding uses/vendors, safety/risk mitigation, and next steps.	**Two white papers** written by advisory committee members based on discussions, presentations and expertise **Presentations** from two virtual meetings **Actionable insights podcast**

Table 2: Project Participants	
Advisory Committee	
David Aguero, PharmD, MSTL, FASHP, FAMIA Director, Medication Systems and Informatics Division of Pharmaceutical Services St. Jude Children's Research Hospital	**Ryan Cello, PharmD, FASHP** Pharmacy Manager-Automation, Informatics, Analytics & Diversion Detection Volunteer Assistant Clinical Professor UCSF School of Pharmacy
Amanda Beck, PharmD, MS Director of Pharmacy Houston Methodist Cypress Hospital	**Arpit Mehta, PharmD, MPH, MHA, CPEL, FASHP** Director of Pharmacy HSPAL Residency Coordinator AHN Allegheny General Hospital
Virtual Focus Group Participants	
Yang C. Fan, PharmD Pharmacy Manager New York-Presbyterian Brooklyn Methodist Hospital	**Christa Miller, PharmD, MBA** Senior Pharmacy Manager Advent Health
Catherine Floroff, PharmD, BCPS Pharmacy Director, Inpatient Pharmacy Sentara Norfolk General Hospital	**Kathryn F. Schwartz, RPh** Pharmacy Operations Manager Penn Medicine Doylestown Hospital
Matthew G. Gimbar, PharmD Sr. Assoc. Director of Pharmacy Operations University of Illinois Hospital	**Blake D. Shay, PharmD, MS, BCPS** Pharmacy Manager BayCare Health System Tampa, FL
Barbara A. Higgins, PharmD Director of Pharmacy University of Michigan Health Academic Med. Ctr.	**Tyler Tomasek, PharmD, MS, BCPS** Senior Director-Pharmacy Information Technology Cleveland Clinic
John D. Hill, PharmD, MS, BCPS, BCSCP, CPEL, FASHP Pharmacy Executive Pharmacy Enterprise Solutions at Vizient, Inc.	**Jeffrey Wagner, PharmD, MPH, BCPS** Vice President Texas Children's Hospital
Ann E. McKinstry, RPh Performance Improvement Pharmacist Rady Children's Health	**Steve Wenger, BS Pharm, RPh–Retired** Pharmacist Rady Children's Health
Facilitators	
Angela T. Cassano, PharmD, BCPS, FASHP President Pharmfusion Consulting, LLC	**Barbara B. Nussbaum, BSPharm, PhD** Vice President for Research and Education ASHP Foundation

About the ASHP Foundation

The ASHP Foundation was established in 1968 by ASHP as a nonprofit, tax-exempt organization. As the philanthropic arm of ASHP, the Foundation shares ASHP's vision that medication use will be optimal, safe, and effective for all people all of the time. Our mission is to support ASHP by advancing the professional practice of pharmacists and the pharmacy workforce by funding research and education that improves health outcomes through optimal, safe, and effective medication use. To learn more about the Foundation's programs, visit **ashpfoundation.org**.

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4500 East-West Highway, Suite 900
Bethesda, Maryland 20814

ashpfoundation.org

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