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Using Drones in Internal and External Audits: An Exploratory Framework

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ABSTRACT: Recently the FAA relaxed restrictions on the use of drones or Unmanned Aircraft Systems (UASs) for commercial purposes. Markets for commercial drone use are in the technology trigger phase of the Gartner Group's Hyper Cycle, with developments occurring rapidly in real estate, agriculture (farming), the film industry, insurance, and other areas. Examination and inspection applications of drones have been proposed in heavy industry and cell tower inspection. Previous research suggests an incremental structure for implementing technological innovations such as continuous auditing (CA). In this paper these proposals are expanded to include the additional requirements to add drone technologies. This structure is extended here by (1) defining the use of drones in audit environments, with emphasis on the continuous versus occasional use of drone technologies, (2) extending the technical adoption architecture to include the use of drones, and (3) considering the types of drone usages amenable to both internal and external audits. A specific architecture is proposed here to prototype inventory counts in large warehouses or open-air inventories and that satisfies the suggested requirements. Additionally, this proposal adds value to the current research by extending the discussion of technology adoption in the Alles, Kogan, and Vasarhelyi (2008) paper to include the use of drones in many different audit environments by enumerating the usage types of drones in audit settings and by considering the prototype of such a system.

Keywords: audit evidence; drones; internal and external auditing; audit automation; continuous auditing.

INTRODUCTION

Recently the FAA relaxed restrictions on the use of drones or Unmanned Aircraft Systems (UASs) for commercial purposes, with some restrictions. Markets for commercial drone use are in the technology trigger phase of the Gartner Group's Hyper Cycle, with developments occurring in real estate, agriculture (farming), the film industry, insurance, and other areas. Inspections and examinations are conducted with the assistance of drones in agriculture, heavy industry, and communications. Currently in the U.S., commercial users are required to apply for and receive a Section 333 grant of exception from the FAA. The FAA has issued a blanket grant of exception for all commercial flights below 400 feet for those users who have been granted a Section 333 exception. Furthermore, commercial users of drones are required to obtain a drone pilot license and undergo continuing professional education course work. Drones that are less than 50 pounds are considered for personal or leisure use and do not require that the owners be pilots. However, these drones must be registered with the FAA and must be flown within sight of the drone navigator at all times. There are also numerous local ordinances and restrictions about drone use in various municipalities.

Heisey et al. (2013) propose an initial software architecture to support nationwide commercial drone use. Alles, Kogan, and Vasarhelyi (2008) propose a structure for implementing the technology of continuous auditing (CA). In this paper these proposed structures are combined and extended to consider the additional requirements when adding drone technologies to the audit. The Alles et al. (2008) structure focuses on adding CA software in ERP environments. This is extended by (1) defining the use of drones in traditional audit and CA environments, emphasizing the continuous versus occasional use of drone technologies; (2) extending the technical CA architecture to include the use of drones; and (3) considering the types of drone

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TABLE 1

The Six Principal Activities of DSR Applied to the Application of Drones in Audit Activities

Principal Activity of DSR	The Application of Drones in Audit Activities (as discussed in this paper)
Problem identification and motivation	Other domains are using drones for inspection and observation to reduce costs, improve efficiencies, and provide more efficient inspections. Why not the audit function?
Define the objectives of the solution	The objective is to see whether drones may be integrated in the audit, given current regulations.
Design and development of an artifact	A process is proposed based on extant research and that allows auditors to adopt drones to the extent desired (and allowed by the audit standards).
Demonstration of the solution	A demonstration is proposed—that of a warehouse inventory. A framework is provided to guide this future research application.
Evaluation of the solution	The performance of the drone(s) will be evaluated for cost efficiencies and benefits/drawbacks.
Communication of the results	As this project progresses, papers will result that motivate future research.

usages amenable to both internal and external audits. A specific architecture is proposed here to prototype inventory counts in large warehouses or open-air inventories and that satisfies the proposed requirements. This proposal adds value to the current research by extending the discussion in the Alles et al. (2008) paper to include the use of drones in continuous audit environments by enumerating the usage types of drones in audit settings and by considering the prototypes of such systems.

The methodology used in this paper is design science research (DSR), the science of the creation of information artifacts. The paper follows the design science approach introduced by Hevner, March, Park, and Ram (2004) and Peffers, Tuunanen, Rothenberger, and Chatterjee (2007). This paper also follows the discussion in Geerts (2011), which discusses the methodology and its six major activities. Not all six activities need to be included in a single proposal of research (Peffers et al. 2007, 73–74). DSR expands to fit research projects that can span many researchers, articles, and decades of development. The six principal activities are:

1. Problem identification and motivation.
2. Define the objectives of a solution.
3. Design and development of an artifact that meets (some of) the solution objectives.
4. Demonstration of the solution.
5. Evaluation of the solution.
6. Communication of the problem and the solution (usually an article).

This paper is mainly concerned with the first three activities of DSR; those of identifying the problem, defining the objectives, and developing and designing an artifact. Table 1 describes the six DSR activities as suggested in this paper for auditor drone use.

The paper is divided into sections as follows: First, problem identification and motivation are discussed in the literature review section. Defining the objectives of a solution are discussed in the sections on developing a framework for drone use in auditing and the use of drones in audit automation and continuous auditing (CA) environments. A general design and development of a solution is presented in the section on extending the technical/formal CA environment to include drones. Possible future demonstrations of the solution are described in the section on the warehousing drone architecture prototype. The paper then concludes and discusses future research.

LITERATURE REVIEW

When examining extant audit academic literature, it seems that there is no mention to date regarding the use of drones by the profession or in research. However, this paper while in process has stimulated discussion of drones in an Artificial Intelligence (AI) audit context (Issa, Sun, and Vasarhelyi 2016). A recent short AICPA blog discusses the potential use of drones by CPA firms given the new federal regulations (Morriss 2016). In the realm of audit or accounting practitioner publications, there appears to be one white paper about drones by PwC (2016a) in Poland and a short article in the *Journal of Accountancy* (Ovaska-Few 2017). Regarding practitioner articles, blogs, and popular press about drones in other industries, the coverage is extensive. This section begins by discussing the available practitioner publications on drone use that are relevant to the framework, and then continues with a review of the audit literature regarding newer forms of audit evidence and audit automation.

Publications on Drone Use

Nonmilitary drones have become quite popular for many industries where outdoor monitoring and surveillance are desired. In fact, some would claim that drones are the next disruptive technology (Christensen 2013) in business and could realize as much as $127 billion of savings for their adapters (PwC 2016b). Drones are used quite extensively in infrastructure, agriculture, transport, security, media and entertainment, insurance, photography, mining, and natural sciences (PwC 2016b). Drone use has seen the greatest impact in sectors that require mobility, flexibility, and a high quality of data. For example, Monsanto Company uses unmanned drones to spray its patented Roundup® on farmland (Benson 2015). The engineering firm McKim & Creed uses drones for surveying property (Mims 2016). The Chinese firm JD.com delivers packages to remote locations using drones (Crovitz 2016). State municipalities are experimenting with the use of drones for bridge inspections, which typically are quite manual. Finally, many real estate firms use drones to take pictures of their listings (Boughtin 2016).

The drone industry is growing quickly—some days the Federal Aviation Administration (FAA) receives 4,000 applications for small (50 lbs. or less) commercial drone use (Pasztor and Wells 2016). These small hobby drones are permitted to fly up to 400 feet above ground during daylight hours and must be in constant sight of either the trained Remote Pilot in Command (RPIC) or Visual Observer (VO). Larger commercial drones like those of Monsanto require extensive effort to be approved by the FAA (Benson 2015).

The financial industry is joining the ranks of drone users as well—PwC announced that it too will be deploying drones for surveillance tasks in Poland (Foy 2016; PwC (2016a). Poland is the only country other than South Africa that has completely developed drone regulations in place. In Poland, drones are being used for e-commerce deliveries, traffic monitoring, media reporting, critical medical supplies deliveries, and insurance risk monitoring (PwC 2016b). For its own use, PwC in Poland expects that drones will replace the audit examination of assets. Drones can replace humans who previously had to climb ladders or dangle from ropes to assess roof conditions or wind turbine integrity (Schutzer 2015). Furthermore, the "vision" of drones is more accurate than that of humans, with their high-resolution cameras, sensors, and geo-location guidance systems. Plus, the cost of a drone inspection is about half of that of an auditor (PwC 2016b).

Poland allows commercial drone flights that are either VLOS (visual line of sight) or BVLOS (beyond visual line of sight). For commercial flights, drone operators or pilots must be licensed and have undergone extensive training. In the U.S., commercial application permissions are difficult to obtain. For the smaller "residential" or "hobby" drone operator, pilot training is not required but there are many restrictions.

Most of the drone applications to date have been outside and under pilot or operator supervision with either direct or indirect (through a VO) observation. Geo-locational positioning is essential to avoid accidents and collisions. These trackers may not work as consistently indoors, although this situation is improving as GPS tracking signals become stronger. One area of concern for researchers is the development of an indoor geo-locational system for drones (Palazzi 2015). There are also extensive privacy and safety restrictions. For drones that will stray outside the property of the owner/pilot, stringent privacy and FAA regulations prevail, with stiff fines given if drones fly where they have not been granted permission (FAA 2016). General safety guidelines require that in public air space drones cannot fly over humans and suggest that in private contexts drones should not operate around people (Banker 2016).

Academic Literature on Video Imaging as Audit Evidence and Automation

The drones that are in heavy use by many industries are typically outfitted with cameras, video cameras, RFID trackers, sensors, and geo-locational devices. The pilot not only keeps the drone in visual sight (VLOS) but also in virtual sight via a continuous video/picture/sensor feed. As such, it is beneficial to search the audit academic literature regarding the use of video and sensor data as audit evidence.

Brown-Liburd and Vasarhelyi (2015) speculate on new forms of audit evidence in *Big Data and Audit Evidence*. Video feeds and RFID/sensor tracking are discussed as a form of automated data collection, depending on the audit objective. For example, while one inventory count using video feeds may suffice for the annual inspection by external auditors, internal auditors may want to measure or observe inventory every hour. The former could be directly controlled by the auditor in a real-time context, while the latter might be programmed into an automated and repetitive video application with embedded monitoring and auditing layers that formalize the audit objectives and assertions.

This discussion of Big Data is continued in *Big Data as Complementary Audit Evidence* (Yoon, Hoogduin, and Zhang 2015). Evidence may be categorized into three levels: financial statement, individual account, and audit objective (Yoon et al. 2015; Srivastava and Shafer 1992). RFID chips or video being used for inventory tracking verify the assertion of existence as an audit objective. Video tapes of difficult-to-reach components of assets, such as roof tops and fields of crops, may assist in verifying their conditions, assisting in the audit objective for the assertion of valuation.

Warren, Moffitt, and Byrnes (2015) expand on the use of video imaging in their discussion paper *How Big Data Will Change Accounting*. Video imaging is one of the more expansive areas of growth in Big Data, due to the prevalence of videos and cameras in smart phones and other personal devices. The technology of capturing the pixelated images and deriving objective value from them has been a recent focus of research (Metaxas and Zhang 2013). Algorithms can process and interpret dynamic and static images in an automated fashion. The field of image analysis has been exploding to address various business objectives. Interviews and observations may be video recorded and subsequently processed and analyzed for verbal and nonverbal clues.

FRAMEWORK FOR DRONE USE IN AUDITING

The stages of automation that were proposed by Parasuraman, Sheridan, and Wickens (2000) are expanded in the introductory article *Formalization of Standards, Automation, Robots, and IT Governance* by Vasarhelyi (2013). Human information processing and its evolution from man to machine is divided by Parasuraman et al. (2000) into four stages: (1) information acquisition, (2) information analysis, (3) decision selection, and (4) action implementation. This timeline is then expanded by Vasarhelyi (2013) to include the various levels of interaction in an audit context. Key attributes of audit automation would be the enormous volume of data, real-time information reporting, and the lack of direct observation. All of these would be part of the audit ecosystem. Vasarhelyi (2013) proposes that nothing short of full reengineering (Hammer 1990) of the audit process will ultimately be necessary.

However, this total reengineering may be best accomplished by incremental automation of manual steps (Alles et al. 2008). Not only should audit automation be undertaken methodically, it should reengineer these processes by first transforming the manual tasks to facilitate the transition to automation. That is, automation change is most likely incremental instead of disruptive.

This incremental approach may be observed in the audit profession—while some procedures have been automated, partly due to the prevailing digitization of business, other audit procedures have not. For example, many audit tests may be conducted on 100 percent of the audit population using Computer Assisted Auditing Techniques (CAATs) software packages. CAATs also automate the sampling process, as regulations still require this procedure. However, some areas of evidence collection such as inventory counts, observations, asset evaluation, and interviews are still nondigital.

RFID tagging is used for inventory tracking but might not be accepted as direct evidence for annual counts that require direct observation, unless best practices for controls have been established and verified (Swedberg 2014). With RFID tagging there exist two critical issues that can only be addressed by adequate internal controls: first, does each tag truly represent the item it purports to represent? And second, is every item represented or tagged?

Additionally, what seems highly unusual is the fact that the audit profession currently manually conducts observations, inventories, and valuations when many industries are turning to automation and drones for these tasks (Morriss 2016). Previous research proposes that manual repetitive tasks such as inventory taking and manual nonroutine tasks such as asset examination could be easily automated (Issa et al. 2016). However, even in this age of sensor and RFID tracking, auditors are still manually verifying electronic inventory counts and examining assets to determine economic value.

What follows is a discussion of the requirements for audit evidence and the possible role that drones could play in bridging this process from manual to automation in these few remaining areas of the audit. Audit evidence is "all of the information used by the auditor in arriving at the conclusions on which the audit opinion is based" (SAS No. 106, AICPA 2006; AS No. 15, PCAOB 2010). This information consists of the accounting records themselves and all other information obtained during the audit procedures performed during the engagement.

The financial statements presented by management implicitly or explicitly make assertions regarding the recognition, measurement, presentation, and disclosure of accounting information. Depending on the audit objective, the management assertions tested by the auditor could be occurrence, completeness, accuracy, cutoff, classification, existence, rights and obligations, and valuation and allocation.

Furthermore, this evidence should be sufficient, appropriate, and reliable. SAS No. 106.08 (AICPA 2006) clarifies that "the reliability of audit evidence is influenced by its source and by its nature and is dependent on the individual circumstances under which it is obtained." Generally, audit evidence is more reliable if it is obtained from sources external to the entity, if it is in documentary form, or if obtained directly from the auditor. SAS No. 106.20-.42 (AICPA 2006) describes the types of procedures that an auditor may undergo to obtain audit evidence, and these are illustrated in Table 2.

The audit procedures listed in SAS No. 106 (AICPA 2006) are static and backward-looking in nature, providing verification of a small snapshot of the entity's financial data. This small sample is then extrapolated across the dataset from which the sample was pulled. Although the audit procedure activity itself is current, the sample it is testing may include transactions that are a year old.

Continuous evidence gathering (Teeter, Alles, and Vasarhelyi 2010) enhances the audit by reducing the time span between the event occurrence and the audit procedure. Additionally, time series analyses may be readily performed, which allow for benchmarks and alert thresholds to be established (Vasarhelyi and Halper 1991). This process is more formalized and

TABLE 2

The Clarification of the Audit Procedures for Obtaining Audit Evidence Based on SAS No. 106.20-.42 (AICPA 2006)

Procedure	Method
Inspection of Records or Documents	Pull samples of records and trace/verify/match
Inspection of Tangible Assets	Physical inventory, walk through, open boxes
Observation	Stand/sit with worker(s) and observe
Inquiry	Written or oral interviews
Confirmation	Verify account balances
Recalculation	Extract and recalculate figures to verify
Re-performance	Re-perform procedures to verify
Analytical Procedures	Scanning and statistics

quantitative than the procedures in Table 2 and may require a reengineering of the audit evidence collection process (Alles et al. 2008). In a more electronic and continuous evidence collecting environment, the audit procedures stand in contrast to the earlier traditional approaches, as shown in Table 3 (adapted from Teeter et al. [2010]).

Although many of these continual evidence collection processes are in place at such firms as Siemens Corporation (Alles et al. 2006), physical observation and inquiry are still inferred processes in the continuous method. That is, the auditor is deducing and not observing the actual activities, inventory at hand, and asset condition. These areas of the audit evidence collection process, although enhanced by RFIDs and process flows, often require physical or manual observation to verify the relevant assertions of existence, occurrence, and valuation (SAS No. 106.08, AICPA 2006). Any process that would directly connect the auditor with the audit process is more reliable (SAS No. 106.08, AICPA 2006).

For *Inspection of Tangible Assets,* SAS No. 106.29 (AICPA 2006) declares that this process consists of a physical examination of the assets. It may provide appropriate audit evidence about their existence, but not the rights and obligations. It may assist in the determination of valuation by providing information about the asset(s') condition. This inspection, if involving actual inventory counts, requires observation or inquiry accompanying this activity. The auditor may want to open containers to ascertain the amount of goods or ensure that they are not empty.

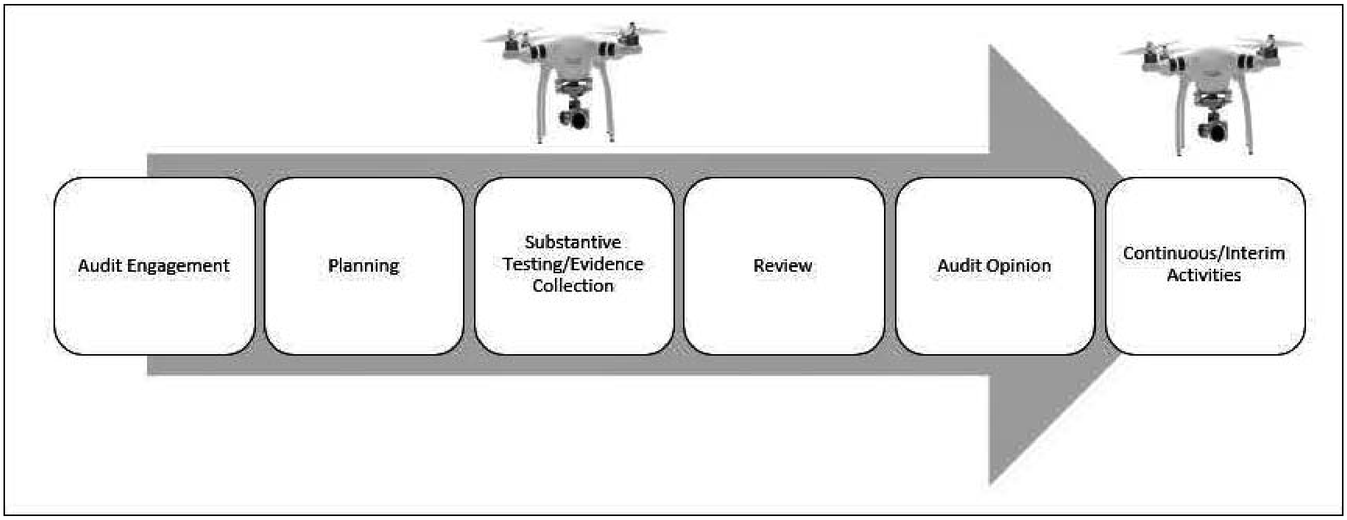
AU Section 331 (AICPA 1972) on *Inventories* provided similar guidelines regarding inventory procedures, whether to sample inventory count observations or to do a complete count. When inventories are conducted manually by the entity, the auditor should physically be there to observe, test, and inquire. If the entity has kept frequent perpetual inventory checks, the auditor's observations may occur either during or after the audit. Verification of automated inventory systems with RFID

TABLE 3

Audit Procedures Comparison Modified from Teeter et al. (2010)

Procedure	"Traditional" Method	Continuous Method
Inspection of Records or Documents	Pull samples of records and trace/verify/match	Evaluate entire datasets in ERP
Inspection of Tangible Assets	Physical inventory, walk through, open boxes	RFID tagging
Observation	Stand/sit with worker(s) and observe	Use process mining to verify work flows
Inquiry	Written or oral interviews	Monitor processes and controls, identify process violators for examination
Confirmation	Verify account balances	Link data streams
Recalculation	Extract and recalculate figures to verify	Monitor all data and run calculations automatically at intervals desired
Re-performance	Re-perform procedures to verify	Automatically replicate all transactions and identify exceptions
Analytical Procedures	Scanning and statistics	Filter real-time data with continuity equations and statistics

FIGURE 1
Phases of the Audit where Drone Usage Is Suggested with Minimal Infrastructure Change



tracking follows this guidance. For such automated inventory systems, often the auditor may observe a sample of the inventory count.

Observation (SAS No. 106.30, AICPA 2006) consists of looking at a process or procedure being performed by others. For example, watching the process of inventory counting or controls processing constitutes observation. However, the observation is only valid for the point in time that it occurs and is constrained by the fact that being observed may affect how the activities are performed.

The *Inventories* (AICPA 1972) guidelines and *Observation* (AICPA 2006) as audit procedures support the assertions of existence, occurrence, and valuation. Existence and occurrence are interchangeable and answer the questions if the assets really exist at the balance sheet date or did a transaction or physical control actually transpire. Valuation involves validating the condition of assets to substantiate their claimed economic value. For example, an auditor may want to observe the count of widgets to verify the claimed amount or ascertain the condition of the roof of an office building owned by the entity to substantiate its claimed economic value.

AU-C Section 501, *Audit Evidence—Specific Considerations for Selected Items* (AICPA 2015), expands on the process of inventory observation that was summarized in Section 331 (AICPA 1972) of the standards. The auditor is to evaluate the inventory procedures, observe the inventory, inspect the inventory, and perform test counts. If the physical inventory is conducted at a date other than that of the financial statements, the auditor should perform the observation on another date and then perform backtracking or forwarding audit procedures to calculate the inventory count. A similar process should occur if the count occurs at a time that the auditor cannot be physically present. If the inventory is held by a third party, the auditor should seek confirmations if physical inspection is not possible.

Based on the discussion in the "Literature Review" section and on the standards, drones appear to show promise in these two areas of evidence collection: physical inspection and observations. Note that physical inspection and observations are components of the larger audit process shown in Figure 1. In the typical engagement plan, drones could augment the audit team promptly with inspections and valuations at the substantive testing phase and reoccurring cycle inspections during the interim/continuous phase. Physical inspections consist of inventory verification and re-performance and asset evaluation. Observations consist of watching employees and areas of interest, and they are closely related to the use of video cameras/stationary cameras.

It is helpful to regard inspection and observation as they relate to earlier research of manual and cognitive tasks that are either routine or nonrepetitive (Issa et al. 2016). Tasks can be categorized as follows: routine manual, nonroutine manual, routine cognitive, and nonroutine cognitive. Routine tasks require little judgement or thought processes, whereas cognitive tasks require thought and analysis. Routine tasks are repeated frequently with little, or at least predictable, variation whereas nonrepetitive tasks may have variation and unpredictability. The simplest and most easily automated tasks are those considered to be manual-routine, and the most difficult to automate are the cognitive-nonrepetitive, as illustrated in Table 4.

TABLE 4

The Progression of Automation in the Context of Task Type Adopted from Issa et al. (2016)

Process Task Attributes	Manual	Cognitive
Routine	Easily automated	Moderately hard to automate
Nonrepetitive	Moderately hard to automate	Hard to automate

Those tasks undertaken by the auditor that are manual and routine could easily be automated to supplement the auditor in fulfillment of audit tasks. However, even though tasks such as inventory observation and verification may seem to be routine and ordinary, the auditor should verify the veracity and accuracy of the drone video feeds and subsequent software analysis. Ideally, the automation of these tasks could free the auditor to engage in more complex and challenging tasks that are cognitive and nonrepetitive (Oldhouser 2016).

Manned (piloted) drones could be considered initially as an extension of a physical auditor, with unmanned (autonomous) drones eventually assisting as continuous evidence collectors, pending audit standards revision—see Table 5. In this paper, a manned drone is a drone that is piloted by a person online either nearby or remotely. An unmanned drone is a drone that is not piloted at all—it is completely autonomous, a bot drone. If the standards would allow a bot drone to operate independently as an extension of the auditor, when reexamining AU-C Section 501 (AICPA 2015), the paragraphs that address when and where the auditor should be present for inventory observations will become superfluous, as either an unmanned or manned drone could be present as an extension of the auditor, regardless of the human auditor's location at that time.

Furthermore, auditor safety would cease to be an issue at observations, which could be regarded as manual-nonrepetitive tasks. Specifically, by using drones the auditor could feasibly never miss an inventory count—the auditor could be at two places at once, particularly if the site of the inventory count is unsafe.

TABLE 5

Physical Inspection Standards from AU-C Section 501. A20-30 (AICPA 2015) and Drones where "Manned" Drones Are Piloted and "Unmanned" Drones Are Autonomous

	Current Physical Audit Procedure	Audit Procedure with Manned Drone	Audit Procedure with Unmanned Drone
Physical Inventory:			
1. Evaluate	Verifying that certain procedures and controls are in compliance.	Drone could capture images of flow charts and read/analyze results.	Drone could capture images of flow charts and read/analyze results.
2. Observe	Observe/watch the procedure.	Drone could observe and watch the procedure, as directed or piloted by the auditor.	Drone could observe and watch the procedure based on video input and sensor tracking.
3. Inspect	Visually and/or physically inspect the inventory.	Drone could observe the worker physically inspecting or observe/view the inventory condition itself.	Drone could observe and watch the inspection based on video input and sensor tracking.
4. Perform	May need to recount inventory; re-perform inventory numbers.	Drone could recount inventory if needed—data feed automatically into audit app that re-performs the process.	Drone is recounting inventory all the time—data feed automatically into audit app that re-performs the process.
Occurrence:			
1. Observe	Watch process or control activity.	Drone may watch process or control activity.	Drone could watch and follow based on video input and analysis.
Valuation:			
1. Inspect	Visually inspect the asset for impairment.	Visually inspect the asset for impairment, safety is not an issue.	Drone could visually inspect based on video feed and GPS sensors.

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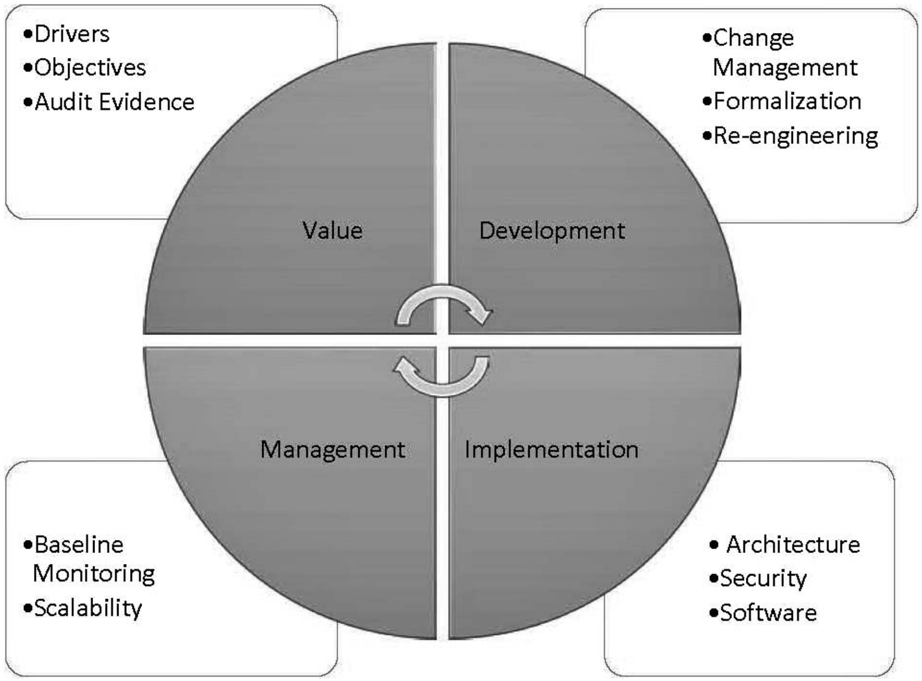
FIGURE 2
Audit Automation



Source: Alles et al. (2008)

Both external and internal auditors could advance the use of drones in inventory, observation, and valuation. These are the areas where drones may easily augment auditor tasks with minimal disruption and infrastructure development. The drones may be regarded as flexible and mobile cameras, not unlike those that are already mounted typically in numerous locations in most warehouses. Not all audit tasks can or should be assisted by drone evidence collection. The ease of drone adoption for an audit task would depend on the task type, with the cognitive-nonrepetitive tasks being the last to automate. The audit objectives may be different—the external auditor is merely verifying evidence to substantiate the eventual audit opinion, and the internal auditor is seeking evidence that will support an evaluation of operational efficiency.

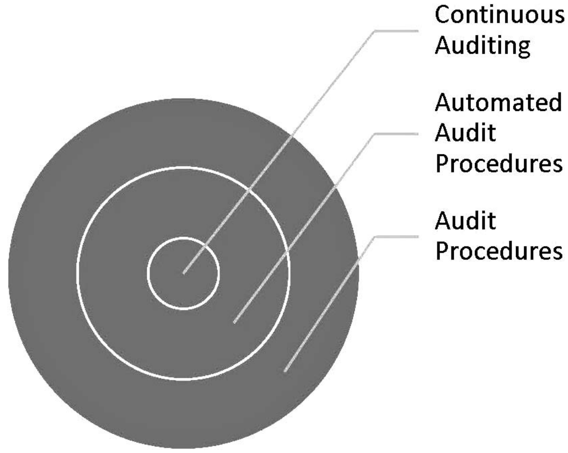
Drones could not only inspect inventory regarding existence and condition, they could also observe inventory processes. Video feeds could be processed with recognition software and be evaluated by the auditor (Issa et al. 2016). Requests for opening containers could be texted by the auditor or drone pilot who is guiding the drone. Observation could be continual for an automated drone, thereby expanding the scope of this examination to an automated routine task from a manual routine task (Issa et al. 2016). Both contexts for drone applications are expanded in the sections that follow.

THE USE OF DRONES IN AUDIT AUTOMATION AND CONTINUOUS AUDITING ENVIRONMENTS

The previous section discusses the uses of drones generally in the audit environment. This section will explore the possible uses of drones in both automated and continuous auditing (CA) environments. A modified framework for audit automation is adopted from a working paper by Alles et al. (2008). Figure 2 is a representation of a distillation of the framework presented by that working paper. As can be seen in the figure, the audit automation cycle is depicted as a cycle of activities starting with the primary phase in the upper left hand corner of the diagram. The cycle continues through development of audit automation solutions, implementation of those solutions and post-implementation management of the solution with an implied assessment of value beginning the cycle once more. This framework fits very well with the DSR methodology, since both approaches involve the development of information artifacts. In the next section, each quadrant is discussed in turn and is then investigated as to what ways the framework needs to be extended to include drones.

Beginning with the Value quadrant, Alles et al. (2008) consider drivers of audit automation to be external events that are pushing the audit profession to move toward considering automation as a potential solution to market place pressures. The drivers include the fact that most processing of the transactions that aggregate into the financial statements and other business

FIGURE 3
Audit Procedures, Audit Automation, and CA



reports are already captured and integrated in functions that are themselves already automated. Additional factors include the increasing complexity of business transactions and the increased emphasis on the risks associated with the use of information for strategic decision-making purposes across the enterprise. Value is also derived from the audit objectives themselves such as getting the audit procedure performed more quickly or being able to test entire populations thereby avoiding some of the pitfalls of sampling. Automation also adds value by allowing the use of real-time alarms that can be used to help mitigate audit risk. Automation also allows evidence to be aggregated across procedures to give a bigger picture view of the current sufficiency and competence of the evidence collected through the automated portion of the audit program.

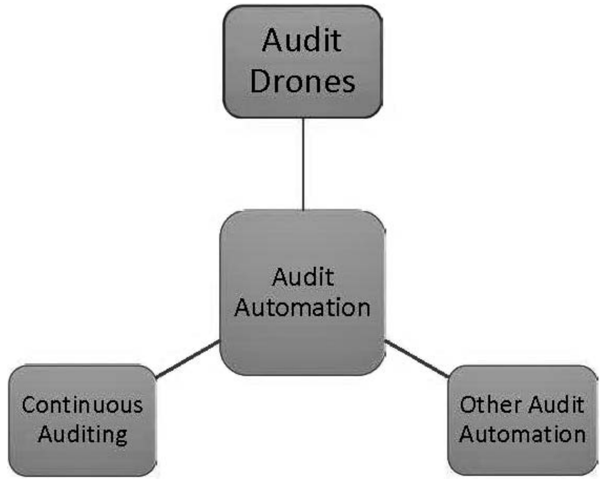
The next quadrant is the Development component of the Alles et al. (2008) framework. The first component in the framework in this quadrant is the use of senior executive champions or supporters to back the audit automation projects. These champions should identify and engage project stakeholders including business process owners, internal auditors, and IT personnel. Verification of the proposal should be completed by an audit professional who is external to the development team. The next two processes of the Development quadrant determine a critical divide between audit automation and continuous auditing. Formalization is a process by which audit procedures can be reduced to descriptions that are capable of automation. If these procedures are automated and are run in time to support audit decision making, then they are capable of being CA. To create as many opportunities as possible to develop a CA system, the audit process itself needs to be reengineered to collect formalizable procedures together and to separate them from the parts of the audit program that will remain manual.

The third quadrant is Implementation. The first component is the architecture that is further broken down into structure (integrated or distributed), access (direct or intermediated), and platform (common to the business or separate). Since the audit software is most likely going to be hosted on its own system and not the enterprise system, the audit hardware and software must be carefully secured. This includes security from super users at the business since the platform will likely be run by the business IT to reduce network bottleneck issues and network security concerns. Logical access will need to be carefully controlled and logged. The software will tend to fall either into the category of continuous control monitoring or continuous data assurance. Alles et al. (2008) clarify further that this union of the two software categories defines CA.

The final quadrant, Management, consists of baseline monitoring and scalability. Baseline monitoring develops a set of baseline measurement norms for the automated audit process that can then be used to check on changes in the underlying expected pattern. Scalability refers to the ability to design collections of parameters that are useful for many different audit automation uses and then leverage the generic collections in designing other audit automation solutions.

Before discussing an extension of the framework to include drone technologies, a few additional concepts should be introduced that are necessary for this process, Figure 3 clarifies the relationship between audit procedures as discussed in the previous section and audit automation (automated audit procedures) and continuous auditing. Audit procedures include both manual and automated procedures. Not all automated audit procedures rise to the level of continuous auditing. Figure 4 illustrates the relationship between audit automation, audit drone technologies, and CA. The figure depicts audit drone technologies and CA as subsets of audit automation, with other types of audit automation as a filler for areas that are neither drones nor CA, but are still classified as audit automation. Finally, Figure 5 illustrates the architecture and components of audit

FIGURE 4
Audit Drones and Audit Automation



drone technologies as used hereafter. They consist of a mandatory flight and maneuverability component, mandatory video or camera, mandatory data storage, the optional ability to manipulate objects, and other sensors.

EXTENDING THE TECHNICAL/FORMAL CA ENVIRONMENT TO INCLUDE DRONES

In this section, we modify the audit automation framework discussed and illustrated in Figure 2 to include the development of audit drone automation. Figure 6 depicts the modified framework for drone usage in the audit. The four quadrants remain the same, as well as some of the components of each quadrant. But the specifics of the components are customized for the specific use in drone automation.

Starting with the Value quadrant again, the drivers basically involve automation of additional auditor functions such as observation. Drones can extend the auditor's ability to observe clients' assets or processes. They also allow remote inspection and evaluation in dangerous, time consuming, or costly contexts. The use of drones can lever auditors' evidence-gathering capabilities using drone technologies. They also will enhance the realization of audit objectives by allowing quicker and more complete inspections, observations, and evaluations. In unmanned drone situations, they can also be used continuously to provide a platform for real-time alarms. Finally, audit drones increase the amount (sufficiency) and quality (competence) of audit evidence by allowing for more types of observations and inspections that collect fuller sets of data, for instance by recording video streams of processes that are considered risky from the auditor's point of view.

In the Development quadrant of the framework, the change management component remains the same. There will continue to be a need for senior executive champions and external verification of the audit drone components of the audit program. The senior executives, however, will be at the audit firm or in the internal audit department. This is because the rationale behind the

FIGURE 5
Drone Architecture

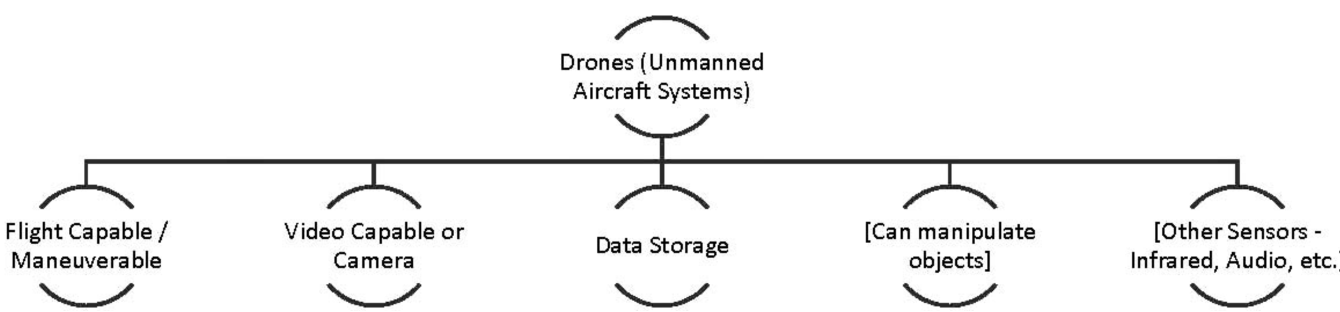
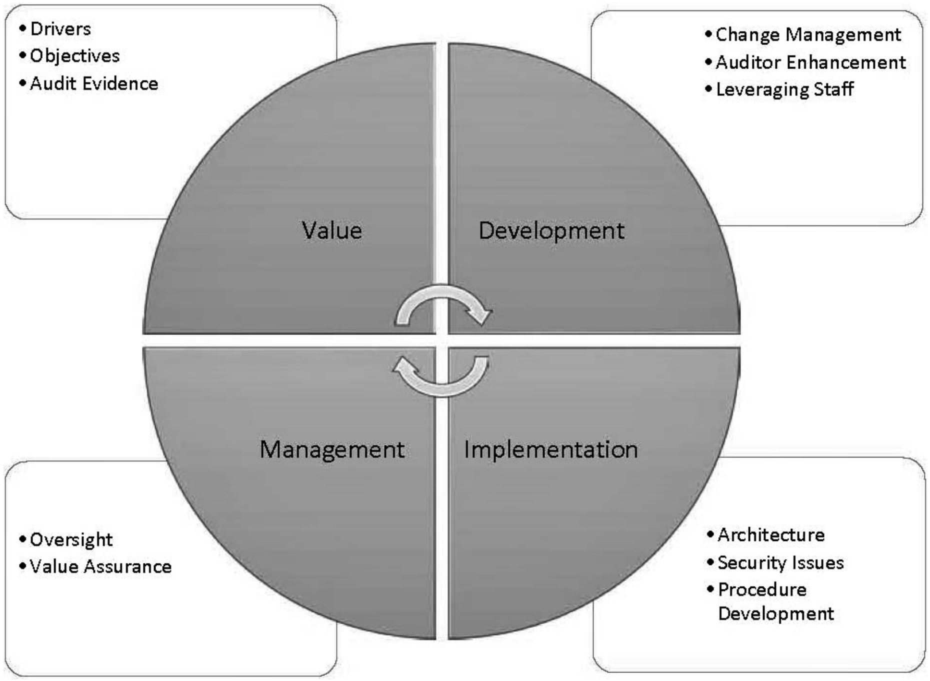


FIGURE 6
Audit Drone Automation



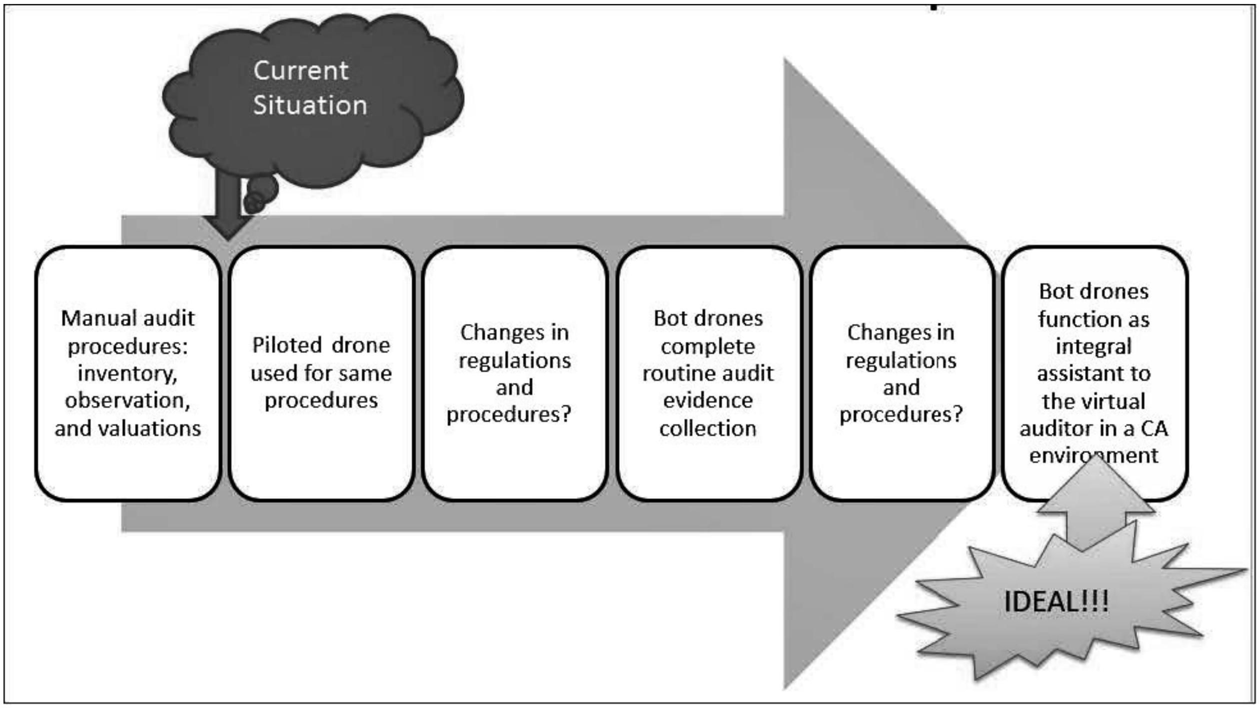
development of audit drone automation is more of realizing efficiencies of the internal resources. The drones are used to enhance and extend the auditor's ability to observe, inspect, and evaluate. Drones will be used in situations where this enhancement of auditors' abilities can be successfully leveraged to extend scarce audit staff and provide additional value to the enterprise from the extensions. Formalizations are embedded in the drone technology itself: stabilizers, video capabilities, storage, etc. At this level of drone implementation, reengineering of the audit plan is not necessary since only certain aspects of the audit processes are being automated.

In the third quadrant, Implementation, there are also some notable refinements of the original audit automation framework. The architecture is really the drone technology as a drone platform. Few audit firms or internal audit departments will be modifying, let alone building, their own drones. So developments in available drone architectures should be followed in a broad way by the audit function, but the auditor is generally more concerned with the available sensors on the drone since these are collecting the audit evidence. The sensors are the means for downloading or streaming the evidence.

Security issues are still important to follow, but the drone will be operated by or under the management of the auditor. Potential hijacking of the drone or interference with its data feed are possibilities but probably unlikely at present. The audit function must track emerging drone security issues nonetheless. The software component in the original framework becomes a procedure development component here. The audit procedure for using the drone in the specific audit situation needs to be developed in a careful and controlled manner. Discussion of this is deferred until the next section when we present a warehousing drone prototype.

The Management quadrant is also modified to a considerable extent. Baselining and scalability are not so important with drones because they are not operating as controls themselves but as audit procedures. An exception to this is possible if a continuous unmanned drone is deployed, in which case baselining of the situation in its normative state is still important. Scalability will also not be an issue in this paper in the way drones are deployed, since we are considering the use of individual drones for specific procedures. It is possible to develop concepts of deploying fleets of drones, but that is suggested for future research. One important component of managing audit drones is the overall oversight of the drone projects that are being developed and deployed. Here we consider oversight in the frame of a portfolio of audit automation development efforts and their implementation over time. Management controls from the COBIT framework are useful here where the audit function is managing its own audit operations. The other component here, which completes the framework, is assuring incremental audit value from the use of drones. This will require value metrics that again can be developed with insights from the COBIT framework. Finally, these modifications to the automation framework provide the objectives of a successful audit drone

FIGURE 7
Projected Steps toward Integration of Drones in the Audit



automation project solution in the sense of design science research. In the next section these objectives are used to construct an artifact, a warehouse drone architecture prototype.

WAREHOUSING DRONE ARCHITECTURE PROTOTYPE

In this section of the paper we outline the development and implementation of an audit drone automation project in which a warehouse inventory is performed to provide audit evidence for the existence and valuation of inventories. The audit drone automation framework of Figure 6 is followed, which is outlined in the previous section and illustrated here as Figure 7. Figure 7 expands on the discussion earlier about drones and task type. Each phase of drone automation for each task type undergoes a DSR adoption cycle.

For a specific automation project, some parts of the larger cycle can be assumed to be in place already. The value recognition and management functions would be in place for the portfolio of automation projects that the audit firm or audit function are in the process of developing. Only specific criteria for the warehouse inventory drone project are given here. We can therefore assume that the project passed the value enhancement test and is expected to add value to the audit. We also assume that the value metrics have been developed. These metrics would include measures such as the decrease in time an auditor spends on observing inventories. The objectives of the project are to provide evidence of existence and valuation of the client's inventory in a warehouse setting, which are objectives established by the standards. The drone will capture high resolution video in a warehouse fly-through. This video will be processed to estimate the size and condition of the inventory. The processing can be human viewing or automated evaluation.

In the Development quadrant, this drone automation project is championed through the project acceptance procedures in place to ensure a balanced portfolio of audit automation projects. The project is a straightforward enhancement of an auditor's ability to observe and thereby count and evaluate the condition of inventory in a warehouse. The leveraging of scarce staff is part of the value of this project, but it is here in the development of the project that the value will be either realized in the design or lost through ineffective design procedures.

In the Implementation quadrant, the various possible drones, their capabilities, and their costs should be considered. The initial purchase and use of drones for observation will be the riskiest aspect of a drone acquisition project. The audit function will have little to no prior experience in using drones for observation. Review of the professional literature is a good way of getting some insights on minimal drone capacities, video resolution, battery, control console characteristics, etc. With experience, the choice of the drone architecture will become more routine and predictable. The security issues should be minimal at this stage. The drone equipment must be physically secured when not in use. Procedure development will be matched to the extent of the video evidence that the auditor has planned to get from the use of the drone. The flight plan around and through the warehouse should be formulated, as well as procedures for collecting enough evidence to assess the condition of the inventory.

Because drones are flexible and scalable, the audit team could purchase or rent a limited number of drones and use them in a small, segregated portion of the warehouse, on an experimental or trial basis utilizing the framework processes suggested here. Or the audit team could contract a drone consultant to pilot the drones in the same experimental fashion. In any event, when this small trial succeeds in demonstrating the viability for using drones as an extension of the auditor for inspections, the audit team can then devote additional resources toward expanding their drone program. If the trial fails, the auditors may easily dispose of the drones at minimal expense and return to manual counts because they did not make huge infrastructure changes.

The Management quadrant includes the oversight of the warehouse drone project as part of the portfolio of projects that the audit function is managing. If the project is coming in over budget or the development time is more than planned, then there should be a mechanism to potentially end the project. Once the project has been implemented, the metrics designed to measure its value should be taken and assessed to see whether the project is delivering the value additions it was designed to deliver. Successes should be recorded in the audit knowledge base. Failures should also be recorded. Design changes to the procedures or changes in the value metrics can be considered in failure situations before a project is scrapped.

CONCLUSIONS AND FUTURE RESEARCH

In this paper, a framework is presented for designing and implementing audit drone automation in internal and external audit environments. The paper illustrates how drones fit into audits for some functions through their abilities to gather evidence to support specific assertions made by management and evaluated by auditors during the audit. Uses of drones in the audit are linked to the audit procedures used to collect evidence in support of specific assertions. We find that drones are not "generalists" in that they may be useful in a limited but not restrictive number of audit procedures. Drones are "specialists" in that they may be implemented in a targeted fashion to certain audit tasks that have yet to be automated and that are typically costly, difficult, and sometimes dangerous to complete. Drones may extend the auditor's abilities in observation, inspection, evaluation, and performance. This means that they can provide evidence about the existence and valuation assertions in certain circumstances.

Using the framework initially developed by Alles et al. (2008), we demonstrate from a design science perspective the problems that drones can help auditors resolve and motivate their use as a solution, namely adding value to the audit process. We show how the Alles et al. (2008) framework could be modified to provide the objectives of an audit drone automation project, one stage of a design science research project. We then design and develop a warehouse drone architecture prototype and demonstrate its usefulness in supporting the evidence-gathering procedures via the inventories and observation audit standards.

Drones are a rapidly developing technology. Rules and standards issued by the U.S. Department of Transportation and the Federal Aviation Administration are constantly evolving regarding the commercial use of small drones. Many different industry sectors are exploring ways to benefit from drone applications. In other countries, notably Poland, rules for drone use are more advanced than in the United States, and the use of drones has evolved to include the active deployment of drones in audits (PwC 2016b).

Future research should focus on the value of drone usage in auditing. Much of the value of drone usage will depend on supporting software applications, security applications, and the expanded functions of the drones. For example, one day drones might be able to open objects and move inventory around. In another instance, since most of the drones in use for cycle inventory counting are too bulky for maneuvering between boxes stacked in warehouse pallet racks, drones may have difficulty reading inventory that is more than one pallet deep. They cannot perform the full inventory count unless the deeper pallets are pulled out. It should be noted that this is an issue that faces manual inventories as well. However, in the future there could be drones the size of small insects or bees, and these could easily buzz or drone around between pallets and boxes and scan inventory (Banker 2016). However, it is generally felt that the greatest innovations will occur in supporting software development and less so on the drone hardware design (Banker 2016).

In another example, for audit risk assessment and regulatory compliance, the auditor should be present and in sight of the drone at all times, particularly in initial use. Reliability of auditor controls, auditor to drone connections, and software security must be maintained for drones to serve as either a tool of the audit process or as an enhancement of the auditor. Either situation could increase or decrease audit risk, depending on the degree of controls compliance. This issue is touched upon here in this paper but should be explored in future research.

It should be noted that when drones function as sensor or RFID tag readers, drones do not resolve the issues that plague sensor readings. That is, RFID tags may not be tagging everything and, also, they may not tag or correlate with the correct item. However, drones may ease the difficulty of verifying the RFID readings either at a first pass or at a confirmatory pass.

Additionally, the development of appropriate metrics to capture value gain is critical. Once many projects are implemented, testing the realization of the value gain is also critical. A broader exploration of the audit automation framework will also be necessary in a rapidly developing audit automation universe. Development of audit artifacts using the design science research methodology to guide project development will help assure a cohesive development process and a coherent discussion of developments across academic and professional fields. By observing these suggested best practices for adoption of automation, drones could really invade the audit profession.

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