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Berger



AIMS value proposition assessment

REPORT



The warehousing and logistics industry is looking for automation solutions and inventory monitoring is priority #1.

In this survey, we asked them why.

Nokia’s Autonomous Inventory Monitoring Service (AIMS) uses smart drone technology to transform warehouse inventory counting using autonomous drones. Offering a true snapshot of actual inventory, empty bins and inventory analytics, it transforms productivity and efficiency while offering an indicative 40%+ ROI over three years of operation.

We asked Roland Berger, a leading international management consulting firm, to study the warehousing and logistics industry to better understand what would make an autonomous inventory monitoring service attractive. The results are based on interviews with global warehousing and logistics industry experts and managers; a selection of the personnel interviewed is represented to the right.

The study first looked at the pain points related to warehouse inventory counting. Then we explored what the fundamental components

of a competitive value solution for automated inventory could look like. Finally, the key purchasing criteria they would use to evaluate a solution are evaluated.

The results presented in this report reflect a strong interest by survey participants in a solution like AIMS. In the final pages of the report, we put together an indicative business case to help warehouse and logistics leaders calculate what an indicative ROI of AIMS might be for their business.

If you’d like to learn more about these findings or explore how Nokia AIMS can help your warehouse operations, please reach out to Paul Heitlinger, General Manager at paul.heitlinger@nokia.com

Selection of subject-matter expert (SME) interviewed

Role (current and former)	Perspective
Manager – Inventory Field Services	Retail
Director of Automation and Innovation	3PL
Head of E-commerce Logistics and Operations	Retail
Former SVP	3PL
Former Hub Operations Manager	3PL
Former SVP – Supply Chain Operations	Retail
VP Strategic IT Planning	3PL
Director of Flows	Retail
Former Head of Digital Innovation	3PL
Head of Sales	Competitor
Head of Sales	Competitor
Head of Sales	Competitor
VP, Technology Solutions B2B	Retail
General Manager, Canada	Industrial
Regional Director, Operations & Distribution	Retail
Manager, Supply Chain and Distribution	3PL
Director, Distribution and Warehousing	3PL
Director	3PL/Shipping

Roland Berger sources

- Past project experience
- Interviews with RB experts globally
- Interviews with RB clients

External sources

(non-exhaustive)

Market reports & databases

- Oracle Netsuite
- RFID in retail market study

Table of contents

Executive summary

Pain points related to traditional inventory counting

Fundamental components of a competitive value proposition

KPC and pricing scenarios



Warehouse managers are highly interested in inventory count automation, and autonomous drones fulfil the requirements

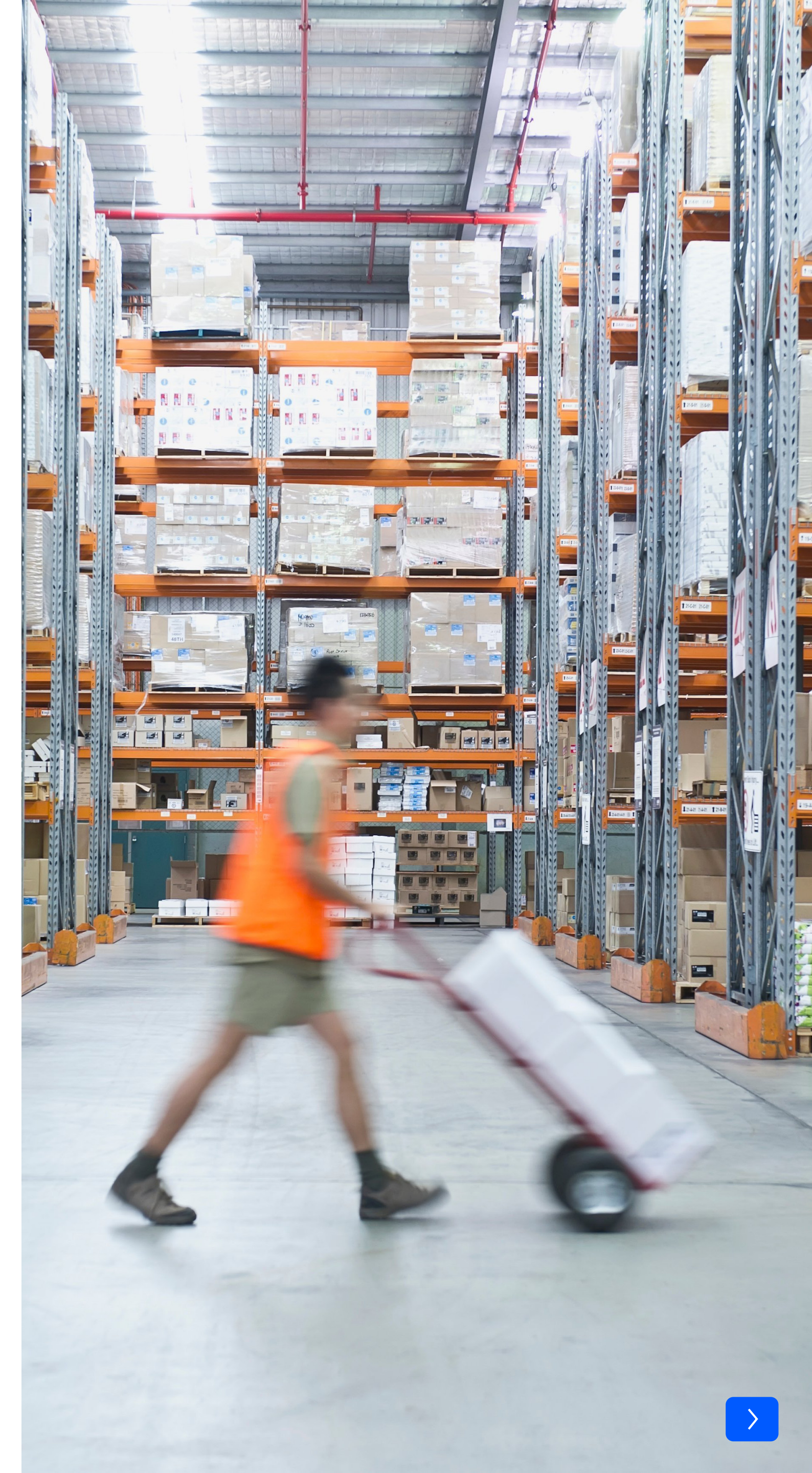
Executive summary

1 The most prevalent pain points to inventory counting are related to labor

- Movement of inventory inevitably results in accumulation of mismatches between actual inventory and book record – periodic inventory counting is essential to control gaps between actual and book to reduce impact of inaccuracies
- Attracting and retaining employees to perform simple repetitive tasks related to inventory counting are a major pain point for warehouse managers, especially during labor shortages – greater automatization is desirable
- Large companies make a trade-off between the cost of inventory counting and the cost of stock inaccuracies – reducing the cost of labor and improving the accuracy of inventory counting with automation improves that trade-off
- Automatic counting with drones could help alleviate those pain points, without creating new significant pain points

2 Automatic pallet counting in free aisles is an appealing proposition for customers

- Autonomous drones that scan single pallet depth in a defined aisle configuration is an attractive proposition for large warehouses, even if scanning does not cover the whole inventory
- Meeting minimum performance metrics (e.g., scanning productivity, integration with WMS, precision of mismatch analysis, etc.) are expected by customer to build a compelling value proposition
- A productivity of 150-200 pallet counts per hour per drone (including charging time) compares favorably to employee productivity (highly variable, ~10-50 pallets/hr using scissor lift in 4-5 stories depending on configuration and equipment)



Savings on labor and impact of stock inaccuracies justify investment in autonomous drones in large warehouses

3 Savings generated by automatic counting mainly come from reduction of labor and impact of stock inaccuracies

- Primary purchasing criteria for all customers is the return on investment (ROI)
- Main cost savings come from the reduction of labor and impact of inaccuracies. Reduction of equipment generates minor savings while other operational warehouse improvements exist, but are highly variable and hard to quantify
- Savings are highly variable depending on the warehouse configuration (size, rack height, aisle width), the warehouse operation (count frequency, human count productivity, count accuracy) and inventory properties (value, turnover, product type (e.g., bulk vs. pallet))
- Based on pilots and at current level of development, players such as 3PL typically see an attractive business case starting for warehouses of 150k sqft., but aforementioned factors remain influential. Retail warehouses generally see more benefit from higher inventory accuracies and sometimes have higher turnover. Their business case could be attractive for smaller warehouse sizes if item counts are available
- Savings are skewed towards lower labor costs or lower impacts of stock inaccuracies, depending on existing operations
 - Large inventory count workforce provides higher stock accuracies – Savings will come from labor cost reductions
 - Lower workforce generates lower labor cost, but leaves more stock inaccuracies – Savings will come from improved stock accuracies
- Customers typically expect an ROI of 20–30% for a successful automation business case
- Savings are highly variable. Taking, as a business case, a warehouse of 200,000 sqft with 20,000 pallets where 60–80% are countable by drone using typical ABC cycle counts, the recurring annual saving expected are \$187,000 to \$273,000. Savings would be higher with higher turnover (currently 3) or more improvement in inventory accuracy (from 97% to 98%)
- Customers favor automated solutions as a service to reduce upfront capital outlays and ensure ongoing service support.



Pain points related to traditional inventory counting



Periodic inventory counting is essential to control gaps between actual inventory and book record and to reduce the impact of inaccuracies

1

Mismatch building between actual inventory and book record

- Constant inflows and outflows of inventory lead to an **accumulation of mismatches** between **physical goods** in stock and **expected goods** in WMS
- Counting inventory reduces these inaccuracies and avoids their financial impacts

“We increased the frequency of our inventory counts because in our worst sites we used to have an accuracy count of only 80%”

Director of Automation and Innovation, 3PL

2

Revenues, profitability and customer satisfaction

- Understanding the location and quantity of inventory on hand helps **avoid stockouts** and reduces **labor costs** associated with inventory localization once orders are placed — it also streamlines **shipment deliveries** and eliminates unsuccessful sales from impacting customer satisfaction

“Not knowing where your inventory is leads to spending time finding it, delaying fulfillment for the customer and creating second shipments costing you a lot from your own dime”

SVP – Supply Chain Operations, Large retailer

3

Cycle counts due to stockouts

- In retail, **stockouts** trigger **cycle counts** in locations with identified issues to avoid further damages

“We tried reducing the count to every two weeks, but the cost of stockout was too high, and it triggered cycle counts too often”

Head of e-commerce logistics & operations, Large retailer

4

Mandated count by management and audit

- Company policies often **mandate** inventory counts by either internal teams or external third parties for **asset management** and **audit** motives

“We were mandated to have third-party vendors doing the inventory count with their unique processes to validate our internal numbers”

Manager – Inventory field services, Retail

Physical counting method used most extensively – several strategies such as cycle count and sampling are also used to optimize inventory tracking

	Physical counting		Cycle counting	Inventory sampling
	Manual completion	Electronic counting	ABC method	
Description	Counting all stock available in warehouse using paper count cards, sheets and pencils	Counting all stock available in warehouse using scanners, RFID, barcodes or mobile devices	Counting inventory in cycles, with higher frequency of count for important stock: higher value, higher turnover etc.	Counting inventory via sampled inventory process that uses statistical methods to predict actual inventory levels
Advantages	- Actual inventory data for inventory in warehouse - Lower cost for materials	- Actual inventory data for inventory in warehouse - Lower potential errors	- Continued partial operations throughout count process - Time and resources optimization allocated to inventory count - Increased focus on key products, improving forecasting, pricing, supplier relations, etc.	- Continued partial operations throughout count process - Lower time and resources needed to complete - Doable periodically or on ongoing basis
Disadvantages	- Higher potential rate for errors - Extended time and resources needed to complete - Restrained or halted operations during count	- Higher cost for equipment - Extended time and resources needed to complete - Restrained or halted operations during count	- Higher risk of obsolescence or loss for “lower value products” sitting in warehouse - Lower available statistical details - Lower compatibility over time due to parameter instability	- Inaccurate and estimated overall inventory count - Lower detection of theft, damage or incompetence issues - Higher change of redoing count due to statistical errors

The inventory counting procedure varies greatly according to needs and warehouse practices – it can be divided into approximately 15 steps

High-level steps for physical inventory counting



Before count start, steps such as training (step 3) can often be done on an on-going basis and in parallel After count start Source: Oracle Netsuite, SME interviews, desk research

The major inventory counting pain points are attracting and retaining staff and finding an optimal balance between accuracy and count costs

Ranking of inventory count pain points and addressability by AIMS (1/2)

				Importance		Solution by AIMS	Feedback
		Description	Steps impacted ¹	Low	High		
1 Labor related pain points	Attracting labor	Difficulty attracting labor for inventory counting due to the unattractive working conditions (schedule, lack of career dev.)	All steps related				“The main advantage we see from drones is the headcount replacement, as finding workers is becoming more and more difficult” Director of Automation and Innovation, 3PL
	Retaining labor	Struggle retaining employees in inventory counting arising from tough working hours and mundane tasks	All steps related				“Turnover is quite high and entails high risks of experience loss related to knowledge of equipment and processes” Manager – Inventory Field Services, Retailer
	Human error	Inaccuracy in the inventory counts resulting from human errors throughout the counting process	11 12			“The main pain point we face is the accuracy that comes with our employees, and drones address this concern thoroughly” Hub Operations Manager, 3PL	
2 Warehouse operation related pain points	Accuracy-cost trade off	Struggle to find optimal counting frequency due to draw on resources on one hand and faulty counts on the other	All steps related				“Increasing counting frequency to improve accuracy is too costly, drones cover ground in shorter time with no excessive costs” Distribution centre general manager, Retailer
	Preparation for count and shutdown	Waste of time, resources and profitability from warehouse clean-up, arrangement and shutdown prior to inventory count	7 8				“Fully counting inventory will require a lot of preparations and a full shut down of operations which is problematic” Former SVP, 3PL
	Operational inefficiencies	Inefficiency in warehouse count process arising from limited automation regarding inventory counting	8			“We currently see difficulties regarding warehouse management like safety, ergonomics and warehouse flow that drones can improve” Operations manager, Large retailer	
	External audits	Complicated to effectively introduce external audits due to differences in equipment, staff and processes	10 to 15				”Two problems arise with external audits: turnover and rotation of staff amongst third parties is high, and our workers have to adapt to new teams and processes” Manager, Retailer

✓ AIMS able to address pain point ~ AIMS somewhat able to address pain point ✗ AIMS unable to address pain point

Inventory counting pain points arising from equipment represents only minor inconveniences from glitchy or faulty technologies

Ranking of inventory count pain points and addressability by AIMS (2/2)

				Importance		Solution by AIMS	Feedback
Description		Steps impacted ¹	Low	High			
3 Equipment related pain points	Technological inefficiencies	Inefficiency in counting arising from unexpected faulty or glitchy equipment	4 11			~	“As a specialist in automation, being self-sufficient to avoid potential issues is the most important factor to consider” Plant Operations Supervisor, 3PL
	Equipment expenses	Trouble overcoming recurring direct and indirect expenses on equipment from the inventory counting process	5 10 11 14			X	“Some of the equipment we would buy to lift our workers to the top shelves would cost us over USD 50,000 per unit, on top of maintenance” SVP Supply Chain, Large retailer
	Digital literacy	Reluctance from employees to use advanced technologies — learning curves are too steep	3 11			~	“In our more tech-savvy warehouses, people refuse to use technology because it is seen as complicated” Director of Automation and Innovation, 3PL
✓ AIMS able to address pain point ~ AIMS somewhat able to address pain point X AIMS unable to address pain point							

AIMS enables employees in warehouses to undertake higher value tasks and minimizes human-generated counting errors

Pain point	Description and rationale	AIMS ability or inability to solve situation
Attracting labor	- Existing labor shortage for inventory management and counting jobs due to: - Limited appeal of the job and responsibilities - Challenging working conditions regarding scheduling - Minimal career prospects	Improving inventory counting conditions with drones has the potential to improve the attractiveness of the job profile, with higher focus on value-add tasks
Retaining labor	- High employee turnover — reluctant to count inventory because they: - Find working hours challenging with late nights and counting on weekends - View inventory counts as mundane and repetitive - Prevented from working on other tasks deemed of higher value	- Realizing inventory counts remotely during non-operational hours without the need for employees' presence - Reducing turnover issues and allowing employees to focus on other more appealing and higher value tasks
Human error	- Increased chance of errors during manual counts because of miscounts, missing products or faulty data entry - Significant loss of efficiency and failure to follow best practices due to constant turnover of employees or rotation on count-duty - Greater risk of mistakes by count teams tempted to speed up the process	- Minimizing human intervention in counting process, thus reducing and even eliminating human-induced mistakes - Speeding up counting process without loss of efficiency or at the expense of more frequent errors

AIMS lessens operational pain points by reducing count preparation, eliminating inefficiencies and ensuring frequent counts at little incremental cost

Pain point	Description and rationale	AIMS ability or inability to solve situation
Accuracy cost trade-off	Challenging trade-off between accuracy and cost: accurate counting requires frequent counts, which draws on resources (FTEs and costs) and is time consuming; whereas infrequent counts lead to inaccurate counts, stockouts and need for costly emergency deliveries	Improves accuracy as increased frequency of counts comes at little incremental cost by using AIMS
Preparation for count and shutdown	- Need to prepare aisles by removing obstacles to perform the count - Need to shut down aisles or entire facilities for long periods to complete the inventory count	- Eliminates the need to shut down warehouse because inventory counts can be done after hours - Reduces long clean up and preparation time in aisles with drones’ ability to maneuver in small areas (limited impact due to drone’s width)
Operational inefficiencies	- Safety concerns due to height of pallets and inventory to be counted - Further steps deemed unnecessary such as quality check counts in case of subpar accuracy results - In some facilities, highly cumbersome manual counting and data entry (e.g., utilization of pen and paper for counting)	- Improves safety conditions — no need to physically reach inventory on higher shelves - Ensures first-time accurate counts with precise technology, thus eliminating unwanted steps and streamlining process
External audits	Must use outsourced third-party vendors for inventory audits, which introduces new equipment, processes and team, often with high turnover levels	n/a

Simplicity and reliability of AIMS makes it easy to implement compared to traditional inventory counting technologies

Pain point	Description and rationale	AIMS ability or inability to solve situation
Technological inefficiencies	- Unexpected technological malfunctions and defects during the inventory counting process such as: - Scanning guns lag/not fast enough collecting and transferring data - Connectivity limited or weakened in certain areas of warehouse - WMS system fails to connect due to maintenance or server issues	- AIMS ability to operate independently of network connectivity while flying [coming later] Nokia’s private network ensures strong connectivity for entire warehouse for failure-free inventory counting by the drone
Equipment expenses	- Direct recurring equipment expenses for inventory count including scanners, batteries/charging and, for a limited number of warehouses, count tags, pen and paper - Indirect expenses for large equipment such as lifts includes increased wear and tear costs for maintenance/replacement and unavailability for performance of other tasks	- Reducing use of traditional equipment lowers recurring costs for warehouses - However, AIMS will involve adoption of new equipment in the warehouse
Digital literacy	Common reluctance amongst warehouse employees to use advanced automation technologies for warehouse tasks, especially inventory counts, seen as complicated to use	- Nokia installs and trains workers on AIMS in client warehouse, which eliminates the most complex technological aspects of the solution - AIMS provides a simple solution (press of a button), thus addressing technological reluctance of employees – however, some warehouse workers may still refuse to adopt it

Autonomous drone-based counting expected to generate only minor pain points—Largely compensated by reducing current manual count pain points

Overview of potential pain points associated with autonomous drone-based counting

Pain point	Description and rationale		
1 Dependency on supplier	In case of drone malfunction, warehouses are unable to scan inventory and revert to manual counts until supplier restores service	Likelihood and impact of pain point	
2 Drone data and WMS integration	Drone software might not integrate with all existing WMS software		
3 Safety	- Safety risks related to drones if operating in same aisles as workers - Risk seen as lower than workers reaching top shelves via lifts and pickers		
4 Network investments	- Existing warehouse networks (Wi-Fi) are unreliable — can't ensure constant drone autonomy - Some locations in the warehouse unable to reach network due to weak coverage		
5 Inoperable conditions	Challenging operating conditions, such as extreme temperatures, lack of lighting and obstacles placed in front of bins, may prevent drone from successfully scanning inventory		
6 Downtime and battery replacement	- Downtime needed to recharge/replace drone battery will hinder count process - Thus, need to invest in multiple drones to keep operations running 24/7		
7 Labor union pushback	- Tensions with labor union fearful that members may lose employment - Industry experts highlight that workers are willing to automate count task — seen as mundane and dull - It is also seen by employees as way to reduce the workload in understaffed warehouse		

“When we tested drones, there was no real pushback because you automate boring tasks. It is often seen as a way to address understaffed warehouse.”

Former Head of Innovation
- Global Transport and Logistics, 3PL

Fundamental components of AIMS value proposition



Nokia AIMS uses autonomous inventory-scanning drones to improve the inventory counting process for warehouses

Nokia’s autonomous inventory monitoring service (AIMS) overview

Autonomous inventory-scanning drone

- Customized off-the-shelf drone
- Fully autonomous flight software developed internally by Nokia

Full-fledged solution

- Drone, cameras and sensor hardware
- Autonomy and payload software includes flight scheduling, collision avoidance and localization
- Integrates with existing WMS and includes UI
- Installation of solution requires some weeks

Inventory scanning mechanism

- Advanced barcode detection using computer vision

Inventory reporting and analytics

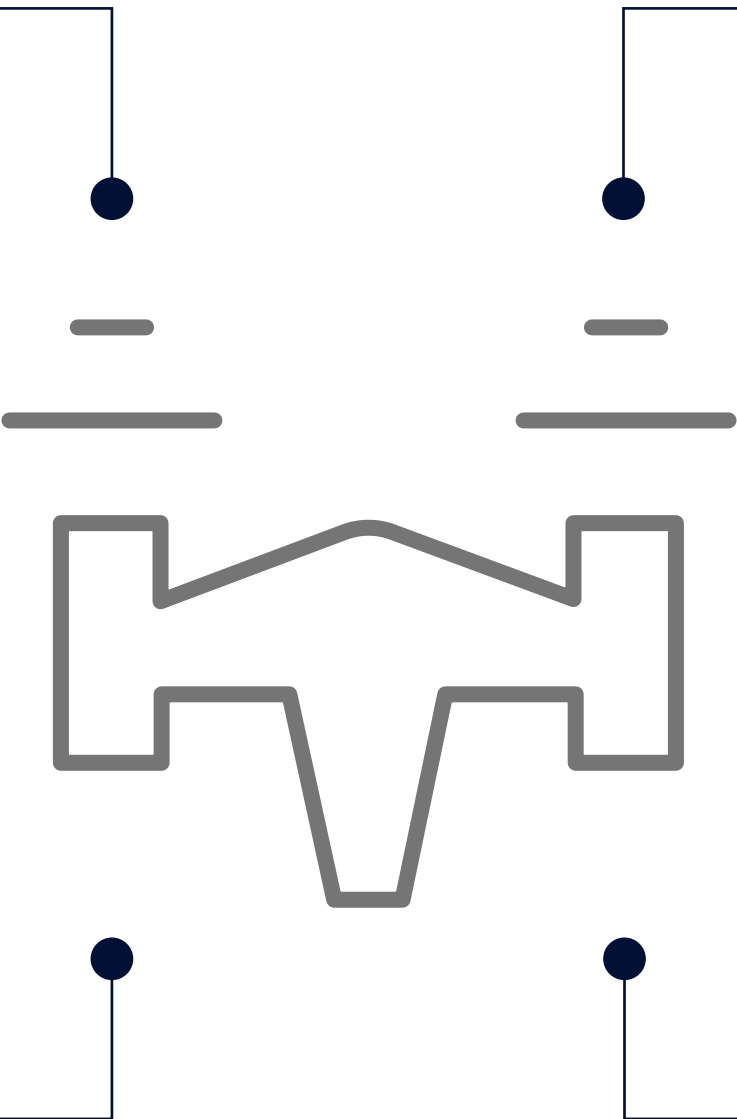
- Runs on cloud
- Inventory reports processed with algorithms to develop insightful analytics
- Easy to use UI

Connectivity

- Works with existing on-prem Wi-Fi network
- Other future connectivity capabilities supported include 4G, 5G

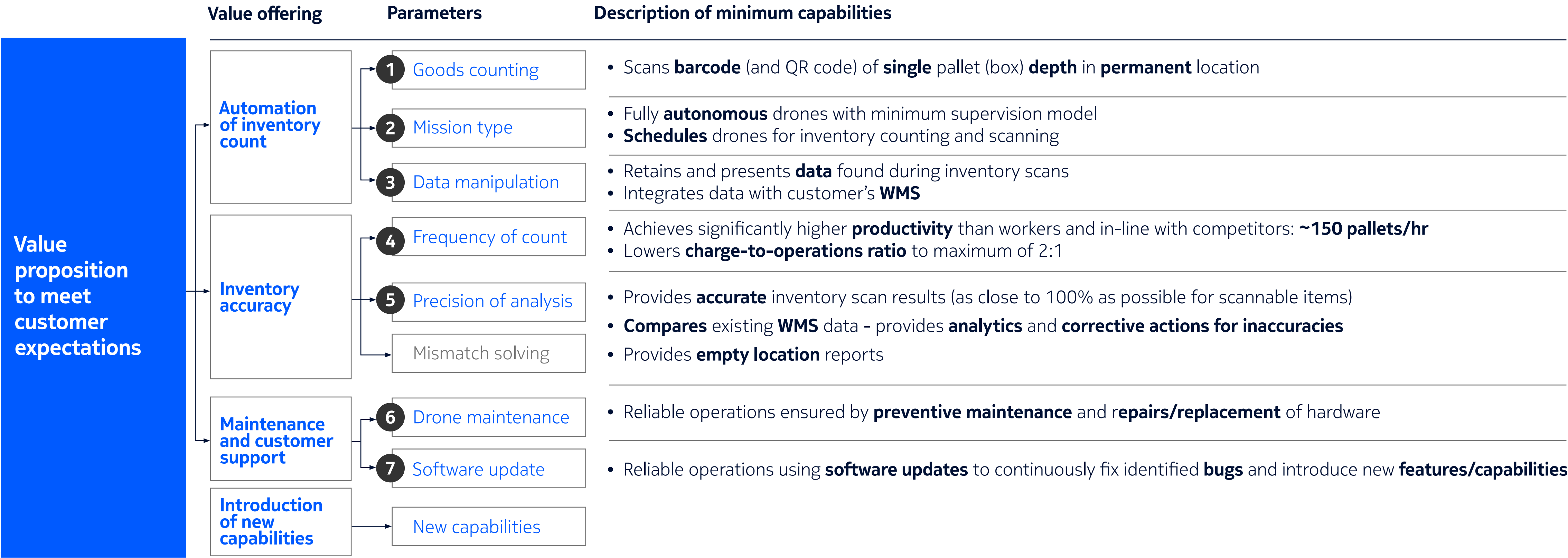
Other potential features

- 2D and 3D digital twins of scanned warehouse
- Warehouse/pallet damage, leakage, theft and danger alerts



Key capabilities must be implemented for solution to be considered viable by warehouse customers

Overview of the minimum capabilities required for a viable drone solution



Scanning barcodes of pallets is acceptable to address a significant portion of the market

Overview of capabilities required for goods counting

Description of capability required for basic solution

- **Ability to scan barcodes (and potentially QR codes) facing aisles on pallets stored in permanent locations**
- **Operational conditions:**
 - Scanning in aisles with width as narrow as four feet
 - Sufficient lighting inside warehouse for drone to pick up barcodes
- **Potential for failure:**
 - Barcodes can be placed below 1.5 feet
 - Potential for misplacement of barcodes on sides or back of pallets may prevent drones from counting successfully (operation can typically be adjusted to address this potential issue)



Drones need to be autonomous and scan pallets in permanent locations

Overview of capabilities required for mission type

Description of capability required for basic solution

- Autonomy of drones is a must have for warehouses to adopt the technology, with little to no interest shown in pilot-driven drones

“If the drone is not autonomous, we don’t see a large value add and will not implement the solution in our warehouses.”

Former Head of Innovation - Global Transport and Logistics , 3PL

- Capability to schedule drone for inventory counting and scanning in obstacle free, pre-arranged standard aisles
 - Ability to instantly use drone without prior scheduling seen as interesting feature
 - However, possibility to use this feature during working hours seems unlikely due to worker safety concerns

“We don’t think we can ever have drones flying in aisles where workers are operating due to the associated safety issues.”

Director of inventory flows, Large retailer

- Successful scanning of closed pallets in their permanent locations is the primary need of warehouses currently



Seamless data integration with existing WMS required by customers and advanced analytics are value-added enhancements

Overview of capabilities required for data manipulation

Description of capability required for basic solution

- Ability to retain and present all the data from complete inventory scan
 - Through API and cloud applications
 - Through Excel or CSV documents for most basic form
- Integration with warehouse management software (WMS) to ensure accurate comparison between stored data and actual content found
 - Minimum solution requires extraction of WMS data to compare with data provided by drone
- Wide array of software exists for managing warehouses making it difficult for drone software to be compatible with all providers of WMS
- Risk of future WMS software upgrades puts pressure on drone suppliers to remain constantly compatible with existing software

Additional capabilities create additional value

Advanced analytics

- Analyze data collected from drones to develop informative insights and recommendations for warehouse managers (e.g., heat map of mismatch)
- Analytics of gaps between actual inventory and WMS data as well as space utilization (empty) appeared to be the highest value add. Additional features appeared interesting but not critical as customers are already getting some analytics capabilities for their management of inventory
- Customers interested in obtaining analytics for the maintenance and repair of the drone such as battery health, identified issues and damages

“Following the inventory count process, I only want the data of what the count is, the analytics can be done by our individual teams and existing software. But we do want the analytics about the drone itself.”

Hub Operations Manager, 3PL

Maximizing scanning productivity is key and productivity needs to be between 100–200 pallets/hr

Overview of capabilities required for frequency of count

Description of capability required for basic solution

- Boost in scanning productivity (pallets per hour) significant enough compared to human workers to encourage adoption of drones in warehouses
 - Human workers productivity: 10–50 pallets/hr
 - Influenced by height of racks, equipment used, automation level in scanning process
 - Drone productivity needs to be 100–200 pallets/hr
- Drone productivity highly dependent on flight autonomy versus charging time
 - 1:1 or 2:1 charging vs. operational time splits required



Inventory mismatch analysis—a must have

Overview of capabilities required for precision of analysis

Description of capability required for basic solution

- Ability to provide accurate inventory scan results concerning visible, missing and damaged barcodes, and empty locations
- Comparability with existing WMS data to find products not matching with data scanned by the drone
- Provision of corrective actions and recommendations such as moving wrong inventory to correct bins

Example of analysis to be delivered post scanning

	WMS data	Scan result	No issue	Issue identified
MATCH	Empty	Empty	✓	None
MATCH	1 Barcode 123456	1 Barcode 123456	✓	None
MISMATCH	EMPTY	1 Barcode 987654	✗	Non-empty
MISMATCH	1 Barcode 345678	Empty	✗	Empty
MISMATCH	1 Barcode 123456	1 barcode 987654	✗	Barcode mismatch
MISMATCH	Empty	Non-empty (no barcode)	✗	Barcode missing
INCONCLUSIVE	Empty	Inconclusive	?	Inconclusive

- Presentation of empty location reports to maximize warehouse utilization
- Provision of pictures of scanned pallets (especially damaged ones)

Additional capabilities create additional value

Detailed goods specifications retention

- Able to save/report important data regarding product’s size, expiry, etc.
- Facilitates compatibility between inventory management model selected (FEFO, LIFO, FIFO, etc.) and operations in warehouse
- Helps identify and outflow inventory with limited shelf life first, reducing shrinkage

Damaged goods identification

- Determine goods and pallets with limited sale capability due to physical damages
- Offers possibility to replace products before an order from a customer, avoiding stockouts and customer dissatisfaction

Video streaming of inventory scanned

- Provide videos of scanned goods as advanced feature vs. photos

Must offer maintenance services and continuous software updates

Overview of capabilities required for drone maintenance and software update

Description of capability required for basic solution

Drone maintenance

- Offer continuous customer support through preventive maintenance and repairs/replacement of hardware
 - Customers appear to prefer subscription-based pricing as it ensures they will receive maintenance support (seen as a key purchasing criteria)
- Leveraging drone-generated data for hardware predictive maintenance is an appealing feature

“When ranking the key purchasing criteria, having the maintenance of the hardware continuously offered to us is critical in choosing the solution we would implement.”

Manager – Inventory Field Services, Retailer

Software update

- Continuous software updates via cloud to fix identified bugs and introduce new features
 - Important to update software continuously to ensure constant compatibility of solution's software with customer's WMS updates



Use of drones to build a digital twin of the warehouse would be valuable for warehouse operations simulations

Overview of digital twins capabilities requirement

Digital twins

- Minimum functionality of a digital twin is a 3D representation of the **aisles with pallets** allowing for:
 - Visualization of analytics such as shelf occupancy, scan mismatches, movements, etc.
 - Optimization of warehouse footprint
- **Highest value** of digital twin comes when you can **simulate the complete operations and movement in the warehouse**
 - Some customers operating large warehouses with high turnover would use digital twins to optimize their warehouse operations
 - Simulating workflow and movement can optimize the footprint, reduce forklift mileage, identify movement bottlenecks, etc.
 - Note that less sophisticated clients may see value of digital twins only at the design phase of their warehouse

“If I had a digital twin of the warehouse, I estimate that I could reduce the warehouse footprint required by 10% by reducing the empty space.”

Manager – Inventory Field Services, Retail

“A 3D static model is insufficient. I need a complete 3D dynamic model to conduct analysis of goods movement, usage of space, movement of worker, etc. in order to optimize my operations.”

SVP Innovation & Strategic Growth, 3PL

“Lot of customers use digital twins only at the design phase and see less value to use it once operations start.”

Account Manager, Network infrastructure



KPC and pricing scenarios

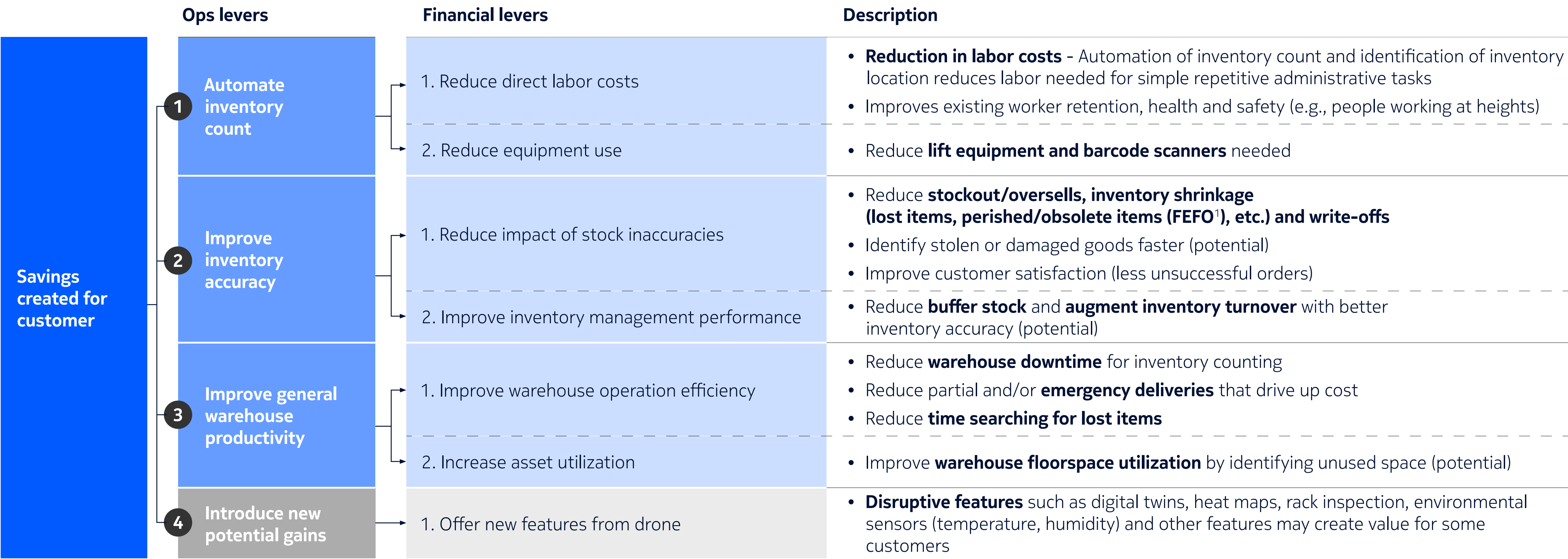


The main purchasing criteria includes ROI, adequate solution performance and aftersales support, integration and low risk of implementation

Key purchasing criteria (KPC) description

	Key purchasing criteria	Description	Importance
Return on investment (ROI)	Switching cost	Deployment cost of drone system (dedicated private network, dedicated space for drones, etc.)	
	Cost saving to perform the inventory count	Savings directly linked to inventory count: labor, equipment, reduction of accuracies, etc.	
	Other saving opportunities	Indirect savings such as reduced downtime of operation, better floorspace utilization, etc.	
Solution performances	Technical specifications meeting internal threshold requirements	- Solution performances surpassing current inventory count method: scanning productivity, precision of scanning, etc. Needs vary per warehouse manager - Enhance features such as item counts, picture or digital twin of facility (3D replication) are of interest, depending on the application, but seen in a next-generation development	
Aftersales support	Maintenance and long-term support	Aftersales customer support critical — preference for a subscription fee to ensure prompt response	
Integration to existing management tools	Smooth integration into current warehouse operation	- Simple and efficient interface with other management tools (e.g., WMS) - Limited disruptions to the other aspects of operations (e.g., installation of private network, space for drone maintenance, etc.)	
Low risk of implementation	Proven solution	- Proven concept in similar environment increasing trust in the product - Alternatively, pilot test for a subset of the warehouse to prove the benefit of the solution	

The savings created for customers comes from reduction of direct counting cost, improved inventory accuracy and warehouse productivity



1 - First expired first out
Source: SME interviews, competitor website, Roland Berger

The savings created by AIMS will increase with higher inventory values and count frequency, and decrease with higher worker productivity

Ranking of factors impacting the potential for value creation by AIMS (1/2)

			Importance							
Description			Direction of impact	Low	High	Levers impacted				Caveats and additional comments
Inventory properties	Inventory value	Higher value goods favor more frequent and accurate inventory counts as each lost item has larger financial impact	+							
	Inventory turnover	Higher inventory turnover represents risk for product loss, theft or damage as this occurs predominantly during inventory movement	+							Inventory lost during product inflow and outflow is traditionally written-off, presenting an opportunity for drones to reduce losses
	Product type	Non-palettized items including raw materials and bulk products and “open” pallets can’t be counted by drones with the current technology	na							Development of ML and computer vision models will enable this later
Warehouse operations	Count frequency	Higher count frequency increases accuracy but yields substantially larger labor and equipment expenses	+							Automation of count process improves the accuracy-cost trade off highlighted in pain points section
	Human count productivity	Faster counting processes by workers will reduce the need for drones due to their ability to work efficiently	-							Fast pallet counting done manually can come at the expense of inventory count accuracy
	Accuracy level desired	Greater accuracy required by warehouses will substantially favor drones compared to human workers	+							If the current accuracy level is high, drone use primarily creates labor cost savings (task automation)
Directly proportional			Inversely proportional	Labour cost	Equipment cost	Inventory accuracy cost	Warehouse efficiency cost			

The savings created by AIMS will also increase with the size of the warehouse, measured in terms of square footage and pallet quantity

Ranking of factors impacting the potential for value creation by AIMS (2/2)

		Importance					
		Description	Direction of impact	Low	High	Levers impacted	Caveats and additional comments
Warehouse configuration	Warehouse size	Larger warehouses whether by square footage or number of pallets/products require more labor and equipment when counting inventory	+				Large warehouses are either very expensive to operate efficiently or have high inaccuracies
	Rack heights	Taller racks reduce scanning productivity of workers due to the need to use machinery, thus increasing labor and equipment costs	+				Value created by AIMS is amplified with rack heights due to quicker time for drone to navigate heights versus scissor lift
	Aisle widths	Narrow aisles are harder to navigate for vehicles, especially upon entry and exit; drones have very few limitations	Minimum aisle width required				Aisles still need to be wide enough for drone to get good field of view of pallets

+

Directly proportional

-

Inversely proportional

Labour cost

Equipment cost

Inventory accuracy cost

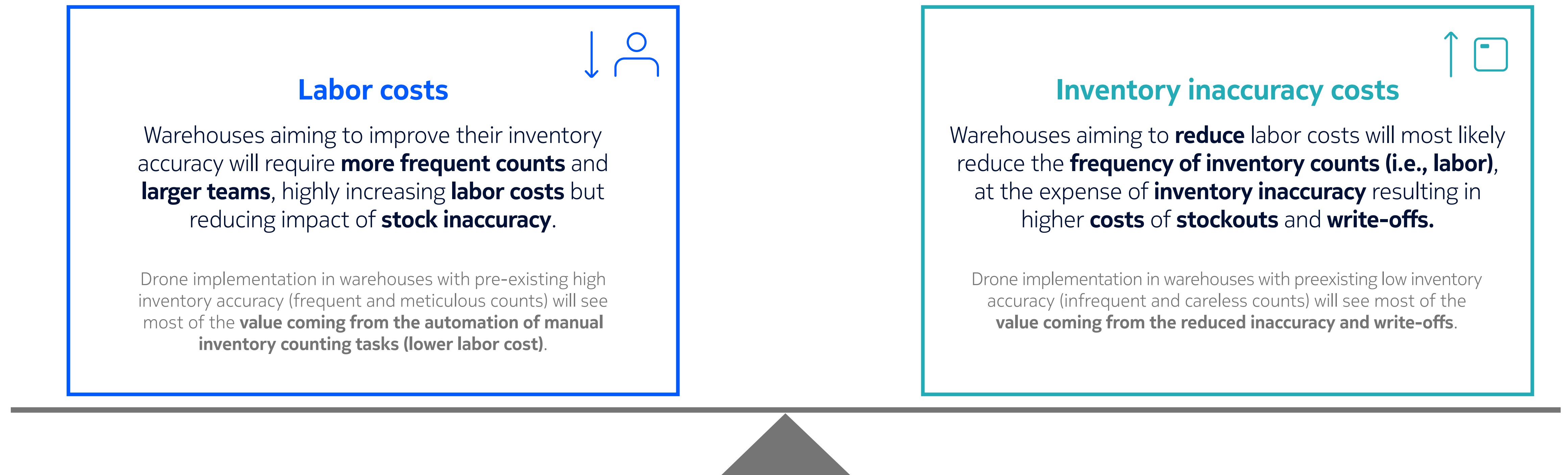
Warehouse efficiency cost

“We started seeing the benefits of automating our counting process with drones in facilities of around 250k square feet.”
VP Strategic IT Planning, 3PL

“The drones we deployed in our warehouses showed good returns for facilities starting at 150k square feet.”
Former Head of Digital Innovation, 3PL

In practice, savings are driven by labor costs and/or inventory inaccuracy costs — Exact split depends on warehouse's operational conditions¹

Value creation through sources of savings easily quantifiable



¹ - Refers to the conditions on p XX-XX

Warehouse managers ranked their innovation project based on payback and return on investment - ROI between 20% and 30% is typically an attractive investment

Desired return on investment (ROI) by warehouse managers on automation solutions

“Whenever we implement a new automation solution, the objective is to have an ROI of around four years.”

Head of E-commerce, Logistics and Operations, Retail

“For low-risk projects we look for an ROI of two to three years, higher ones we are good with five years. This is based on a typical 3PL contract.”

Director of Automation and Innovation, 3PL

“To determine what our desired ROI would be, I believe we would need to assess the efficacy of the solution to determine our interest in the initial investment, and once the solution has proven to be effective, I can think of what I want my return to be.”

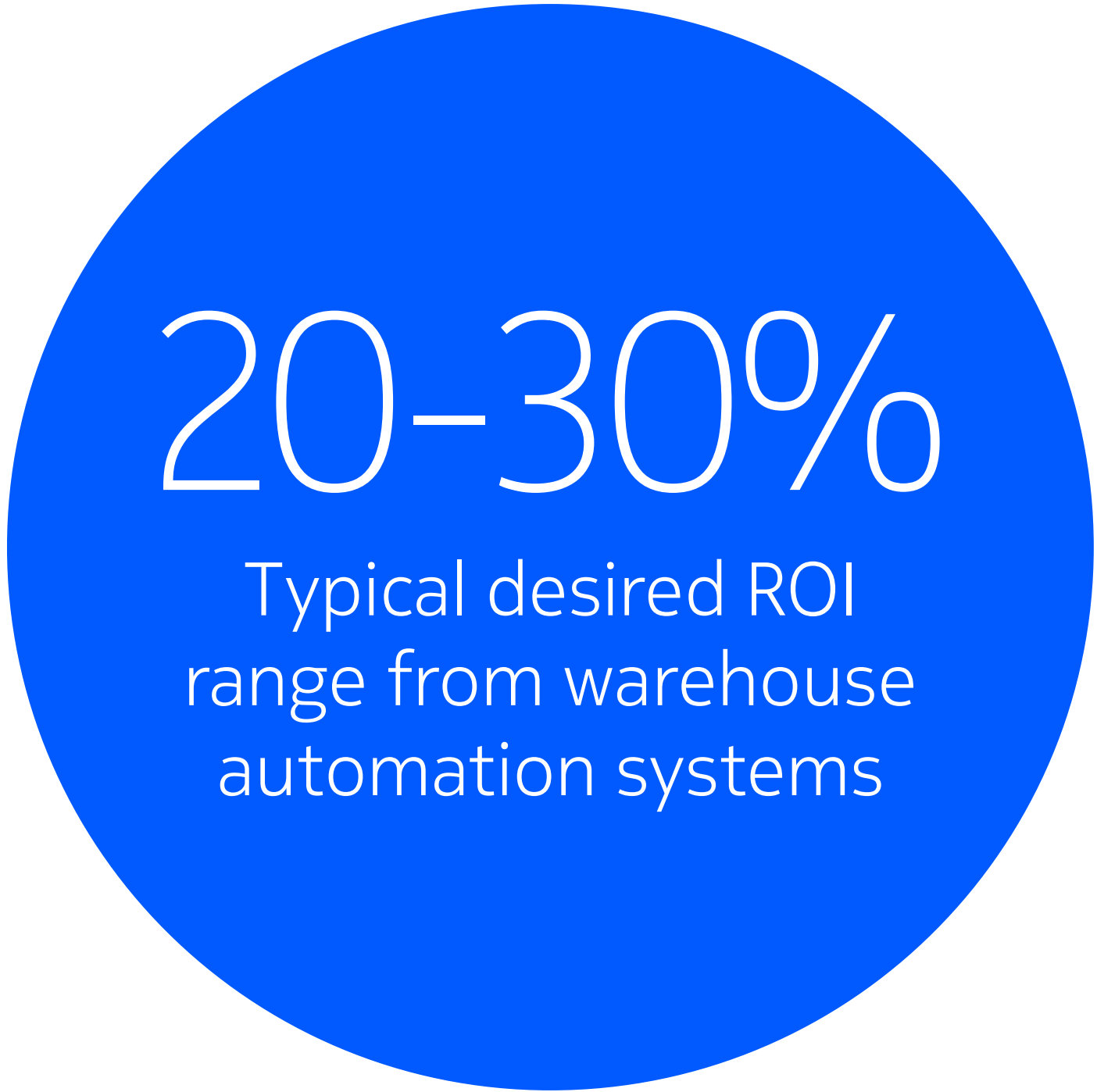
Former Hub Operations Manager, 3PL

“We need an ROI of 15-30% on our investments, and it depends on a lot of different factors such as investment length, upfront costs etc.”

Manager – Inventory Field Services, Retail

“We have a preferred payback of 18 months, with a maximum of three years for our investment.”

Former SVP – Supply Chain Operations, Retail



A 200,000 sq ft warehouse represents a typical case where the AIMS solution shows potential savings

Inputs of case study for pricing of value proposition



Warehouse

Square footage:

200,000

Clear height:

32 feet

Aisle width:

108 inches

Pallet occupancy of total square footage:

60-80%



Pallets

Length:

48 inches

Width:

40 inches

Height:

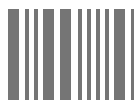
60 inches

Total amount:

20,000

Scannable pallets as % of the total:

60-80%



Inventory

Inventory value:

USD 25 million

Average yearly turnover: **3**

Goods classification and % of total pallets:

- Class A: high value: **60%**
- Class B: medium value: **30%**
- Class C: low value: **10%**

Inventory accuracy (item):

99% (A)

95% (B&C)

(97.4% weighted avg)



Labor

Frequency of cycle counting per year:

A > 12, B > 3, C > 1

Frequency of full physical year:

1 counting per

Number of full-time counters:

3.0

Count productivity:

25 pallets per hour

Hourly wage:

USD 20

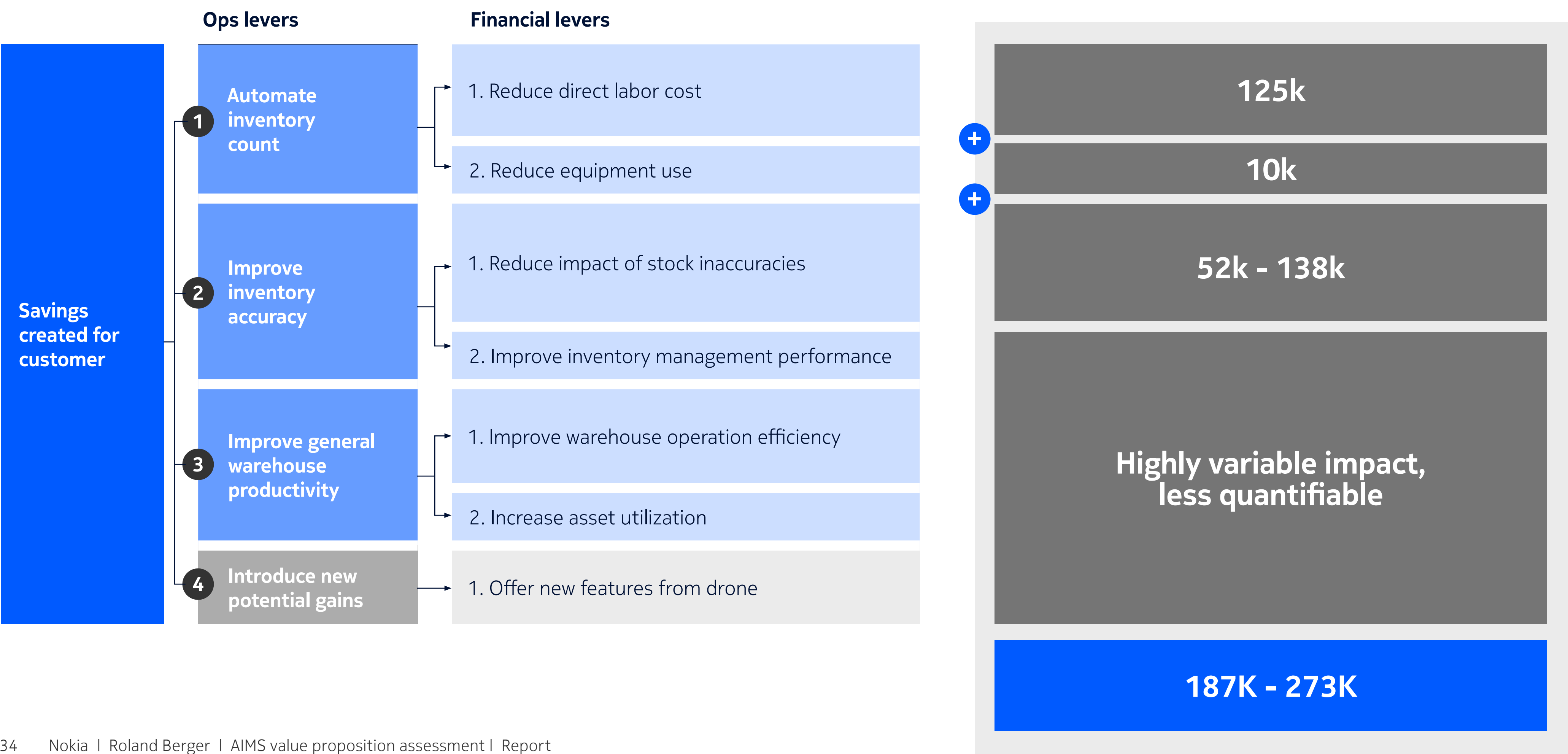
Additional employee benefits:

20% of salary



Customer operating our case study warehouse can save between USD 187k and 273k p.a. with the AIMS solution

Total value creation from AIMS solution



Realizing a monthly cycle count and yearly full physical count at a rate of 25 pallets / hour will necessitate around 2.5 – 3.5 FTEs for case study warehouse

FTE calculation for inventory count

Class A 60% of inventory	Cycle counts ¹ Class B 30% of inventory	Class C 10% of inventory
Scannable pallets as % of the total: 60% - 80%		
7,200 – 9,600 pallets Count frequency p.a.: 12	3,600 – 5,400 pallets Count frequency p.a.: 4	1,200 – 1,600 pallets Count frequency p.a.: 1
Human pallet count productivity: 25 / hour		
Total time spent counting inventory per inventory class:		
3,456 - 4,608 hrs 1.66 - 2.22 FTEs	576-768 hrs 0.28 - 0.37 FTEs	48-64 hrs 0.02 - 0.03 FTEs
Σ= 2.0-2.6 FTEs		

Yearly full physical count¹

Total scannable pallets: 12,000 – 16,000
Human pallet count productivity: 25 / hour

Initial estimate: 0.23 - 0.31 FTEs

Adjusted estimate for off-hours work and incremental spending necessary: 2

=

Σ= 2.0-2.6 FTEs

Note thant external audits (generally annual) might still be required, thus reducing replaceable FTEs

Total FTEs only affected to count: ~3 FTEs

1 - Only counting full pallets displayed on permanent rack locations

Eliminating 2.5 FTEs through the use of drones would yield a direct labor expense saving of around USD 125k for the case study warehouse

 **Direct labor cost savings =** Total FTEs eliminated **x** average wage x working hours **x** adjustment for benefits **x** % of pallets with no issues or damages

Labor cost saving inputs



Total FTEs eliminated: **2.5** (out of 3) – assuming 0.5 FTEs support drone operations and other tasks

X

Average wage: **USD 20**

=

Total yearly salaries: **USD 104,000**

- Adjusting for off-hours work premiums, work benefits such as insurance and pensions etc. **> 20%**

New total yearly salaries saved: **USD 124,800**

X

Percentage of scannable inventory with no defects and obstacles preventing drones from successfully counting: **>99%** (negligible)

- Pallets with barcodes put sideways or missing barcodes, workers identifying and solving miss matches, etc.

Total yearly savings on direct labor costs

USD 125,000

Removing warehouse equipment needed for inventory counts such as barcode scanners and lifts can reduce expenses by USD 10k


Equipment use cost savings =

Total lifts and pickers used **x** % lifts eliminated due to drones **x** yearly costs (purchase/lease + maintenance)
 + scanning guns per FTE eliminated **x** yearly expenses

Equipment cost saving inputs



Total pickers used in warehouse: 3
 Percentage of pickers eliminated by drone usage:¹ 33%
X _____
 Average yearly cost of a picker (including maintenance): USD 9,000
= _____
 Total lift-related cost savings: USD 9,000

Number of scanners per FTE: 1.2x
 Number of scanners purchased for eliminated FTEs: 3.0
X _____
 Yearly cost for scanner: USD 360
= _____
 Total scanner-related cost savings: USD 1,080

Total yearly savings on equipment costs
USD 10,000

1- For the case study, cycle counting expected to be completed only during working hours, thus the need to have pickers attributed specifically to counting process

Inventory counting with autonomous drones is expected to reduce inventory inaccuracies, primarily reducing shrinkage and losses

Reducing impact of stock inaccuracies through drones

Inventory shrinkage

- Reducing the likelihood of inventory write-offs and stockouts, leading to significant financial losses, operational complexities and missed sales
- Shrinkage due to:
 - Lost inventory during inflow, outflow and storage in warehouse
 - Perished items
 - Obsolete or “out of season” inventory

Customer satisfaction

- Improving customer satisfaction by ensuring availability of products and avoiding cancelation/delay of orders already placed

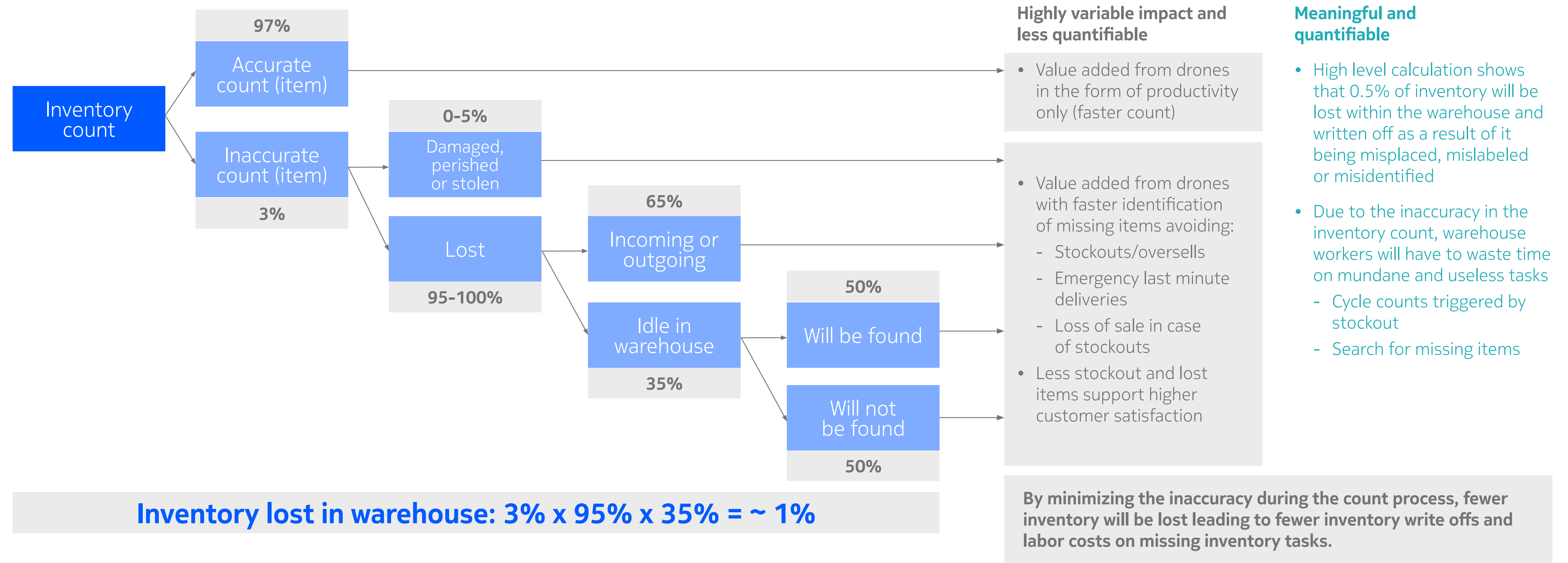
Meaningful and
quantifiable
(see next page)

Highly variable
impact and less
quantifiable



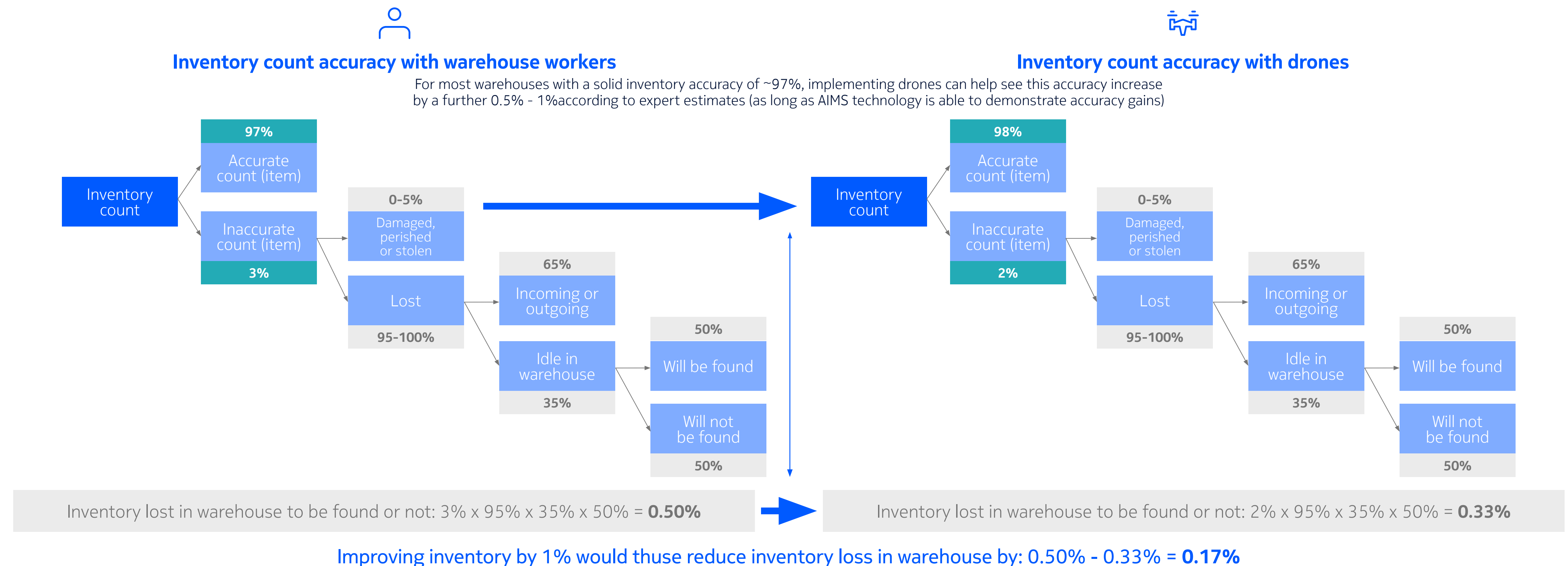
In case study we estimate that ~1% of inventory will be lost within the warehouse, eventually leading to write offs, stockouts and customer dissatisfaction

Drones value add for inventory counting accuracy



Implementing autonomous drones could lead to an improvement of inventory accuracy of 0.5% – 1%, which could save roughly 0.2% of total inventory

Inventory inaccuracies cost savings



An estimated savings of USD 52,000 to USD 138,000 could be achieved by improving the inventory accuracies by 0.5 to 1.0% in the case study inventory

Inventory inaccuracies cost savings

Inventory inaccuracy
cost saving

=

(Inventory written off prior to drones in USD - inventory written off post drones in USD) + (labor costs on finding missing pallets prior to drones - labor costs on finding missing pallets post drones)

Inventory inaccuracy cost saving inputs:

Total pallets: 20,000 X yearly inventory turnover: 4 = Total flow of pallets: 80,000

X

Scannable pallets as % of the total: 60% – 80% Total flow of scannable pallets: 48,000 – 64,000

Lost pallets in warehouse not to be found prior to drones: ~240 – 320

-

Lost pallets in warehouse not to be found post to drones: ~200 – 213

X

Average pallet value: USD 1,250

=

Inventory accuracy improvement savings: USD 50,000 – 133,000

Time spent looking for missing pallet: 60 minutes

X

(Total lost pallets in warehouse prior to drone: ~480 – 640

-

Total lost pallets in warehouse post drone: ~400 – 426

X

Average wage: USD 20 + 20% benefits

=

Labor expense savings: USD 1,900 – 5,100

Total yearly savings on inventory inaccuracy

USD 52,000 – 138,000

Additional cost savings exist but are difficult to quantify unless specific details are known in the business case

Additional cost saving potential from drone use in inventory counts

Inventory management

- Higher inventory accuracy and visibility could translate into **reduced** needs for **inventory buffers** on hand and **better** turnover of inventory due to **increased availability** of products

“You obviously don’t want more buffer stock than you must, because if you don’t turn it, it becomes obsolete. If you improve count accuracy, you could definitely reduce your buffer stock.”

Hub Operations Manager, 3PL

Warehouse downtime

- Drones will **eliminate** need to **shut down** warehouses for counts, though most counts now are done during weekends and off-hours

“We could not count every item we had in all warehouses because we didn’t want to be shutting down all our locations from operations. We would instead extrapolate based on samples.”

Manager – Inventory Field Services, Retailer

Emergency deliveries

- More efficient inventory management should lead to **fewer stockouts**
- Eliminate costly **emergency deliveries** in case **inventory** is finally **not found**
- Get rid of **secondary shipments** to customers once **inventory** is actually **found**

“Around 5% of all our shipments ended up costing us tens of millions of dollars we could have avoided that were due to inventory inaccuracy and unavailability in our warehouses.”

SVP – Supply Chain Operations, Large retailer

Utilization rate: visualize empty spaces to improve bin occupancy

- 3PL:** increase space availability for further inventory and **customers**, thus increasing revenues
- Retail/industrial:** maximize asset **occupancy** with potential to carry more SKUs

“Our willingness to pay for a visualization of the warehouse and where to fit in additional inventory is very high, but I’m unsure about how to quantify it.”

Director of Automation and Innovation, 3PL

Customers favor the subscription model with recurring fees to ensure better after-sale services and to reduce initial capital expenditure

Preferred pricing model

1 Subscription-based model

“We will always go for the subscription model because of the maintenance and other services that come with it.”

Director of Automation and Innovation, 3PL

2 Upfront cost for hardware + subscription for software model

“We prefer to pay for the hardware up front to amortize it, then pay the monthly subscription for maintenance.”

Head of E-commerce Logistics and Operations, Retail

3 Upfront cost model

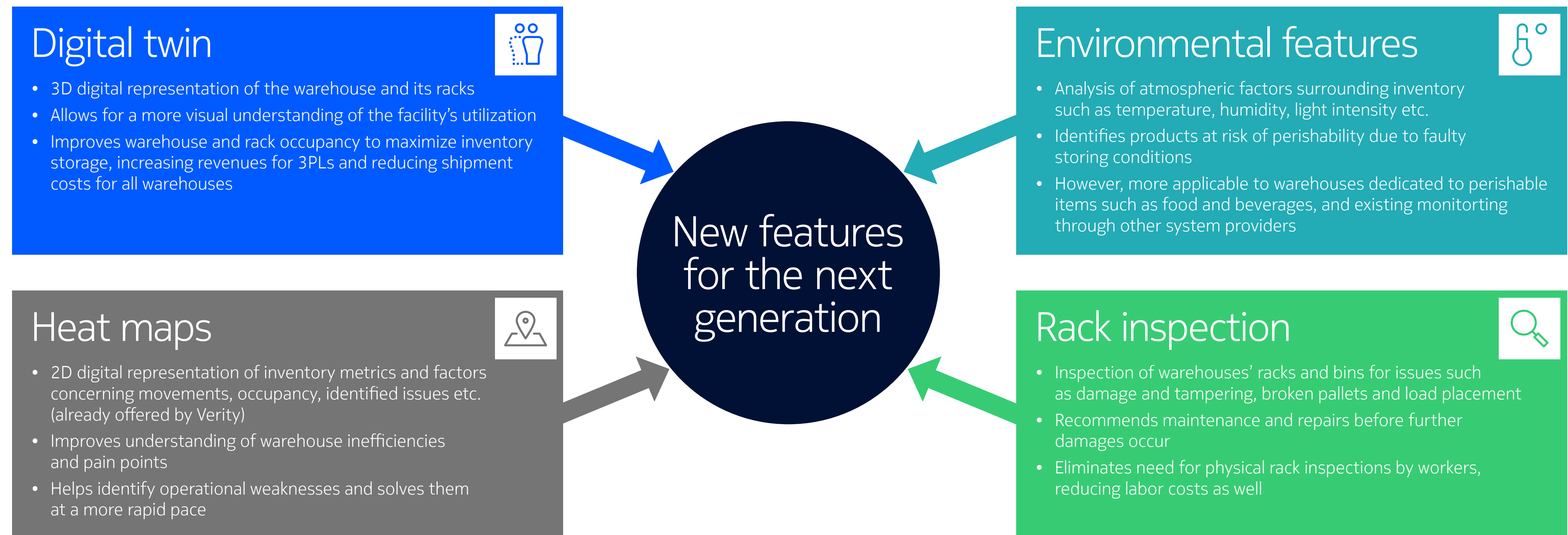
“We usually prefer to pay on a subscription basis, but would consider paying up front if price difference is big enough.”

Manager – Inventory Field Services, Retail

- Customers generally prefer the subscription-based model to ensure better maintenance and support services associated with it and would only consider switching to an upfront cost model if significantly cheaper
- Pricing can include initial set-up costs to cover system installation as seen in competitors’ pricing models

AIMS can provide further value creation to warehouse manager through new features regarding warehouse operations, utilization and safety

Incremental new features to be introduced by AIMS



Summary

This study, commissioned by Nokia and conducted by Roland Berger, focused on addressing pain points related to warehouse inventory counting, particularly major labor challenges like attracting and retaining staff and striking the right balance between accuracy and counting costs.

Drones emerged as a solution by automating routine tasks such as inventory counting and scanning, significantly expediting warehouse operations. When equipped with advanced computer-vision-based scanning technology, drones can efficiently scan inventory at any time within the warehouse, including areas not accessible by humans and not in direct line of sight.

This automation eliminates the need for employees to engage in long hours of simple and repetitive tasks, and enhances the attractiveness of the job profile, leading to improved worker retention, health and safety. Beyond labor considerations, this service addresses operational pain points by

streamlining count preparation, eliminating inefficiencies, and facilitating more frequent counts at little incremental cost.

In conclusion, the study uncovers that Nokia Autonomous Inventory Monitoring Service AIMS is a transformative solution, able to bridge the gap between efficiency, cost-effectiveness, and technological innovation in the ever-evolving landscape of warehouse management. The evidence lies in its potential to elevate service levels for warehouse operators, distributors, third-party logistics, equipment manufacturers and retailers.

Contact us directly to calculate your ROI:

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www.nokia.com/industries/manufacturing-and-logistics/aims/



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