Indoor Autonomous Drones for Inventory Management

Presented by:
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Indoor Autonomous Drones

- Mines
- Warehouse
- Tanks
- Homes
Technical Challenges

- No/Weak GPS
- Static/Dynamic Obstacles
- Flight Stability
- Size & Weight

**Solution:** ArUco Markers + Simultaneous Localization and Mapping (SLAM)

**Types of SLAM:** Visual, Inertial, LiDAR, ...
Operational Challenges

Degree of Autonomy
- Drone flights
- Data collection
- Battery charging

Degree of Customization
- UI/UX
- System integration
- Cloud connectivity

Solution: Full Autonomy + Mass Customization
Indoor Autonomous Drones For Warehouse Inventory
Inventory Counting

Rack Pallet Storage

Cycle Counting

Warehouse Management System

<table>
<thead>
<tr>
<th>Level</th>
<th>Digital Twin</th>
<th>Real World</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>i8</td>
<td>i7</td>
</tr>
<tr>
<td>L2</td>
<td>i5</td>
<td>i6</td>
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<td>L3</td>
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<td>i4</td>
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<tr>
<td>L4</td>
<td>i2</td>
<td>i1</td>
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</tbody>
</table>
Inventory Counting Frequency

Δ Gap

Time

W1  W2  W3  W4  W5  W6  W7  W8  W9  W10  W11  W12  W13  W14  W15  W16

M1  M2  M3  M4
Inventory Counting Context

- Full Pallets
- Case Reserve
- Audits / 3PL SLAs
- Very Narrow Aisles
Inventory Counting Challenges

- Poor Efficiency
- Lack of Auditability
- Time Consuming
- Risk of Worker Injury
Aerial Inventory Scans
Success Factor: Full Autonomy

- Autonomous navigation - no reliance on skilled human pilots
- Automatic, precise take-off & landing from home location
- Autonomous charging - resume mission after battery charge
- Automatic barcode scans, powered by AI/ML
Success Factor: Ease of Use

- Operator-friendly dashboard
- Plan/execute/analyze/repeat inventory missions, on-site or remotely
- Live video feeds, location-wise images, mission archives
Success Factor: Safety

Obstacle Detection
Sense & Avoid
SOS Alert
Success Factor: Inventory Data

- Live video feed
- Location-wise images
- Date-wise image archives
- Location-wise barcodes
- Live drone telemetry
- Mission history
- Drone & battery health
- On-premise/cloud storage
Success Factor: Integration

- Automatic data push into WMS
- Automatic mission triggers from WMS
- API-based system integration
- Remote/centralized mission planning, monitoring & reporting
Workflow for Aerial Inventory Scans

Drone follows the predefined path to navigate.

Drone scans the barcode at each palette and sends to ground station.

Scanned data report available on the dashboard.

Drone lands back precisely at the charging station after scanning.

Drone takes off at a scheduled time.

Drone flies over the top of the warehouse aisle to enter next aisle.
# Aerial vs. Manual Counts

<table>
<thead>
<tr>
<th>Sources of Inventory Inaccuracy</th>
<th>Manual Cycle Count</th>
<th>Drone Cycle Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Hard-to-reach locations inaccessible by a person</td>
<td>😞</td>
<td>😊</td>
</tr>
<tr>
<td>2 Scanning of an incorrect (item or location) barcode by a person</td>
<td>😞</td>
<td>😊</td>
</tr>
<tr>
<td>3 Intentional skipping of an item or location by a person</td>
<td>😞</td>
<td>😊</td>
</tr>
<tr>
<td>4 Theft by a person during stock takes</td>
<td>😞</td>
<td>😊</td>
</tr>
<tr>
<td>5 Errors in manual entry of cycle count data into WMS</td>
<td>😞</td>
<td>😊</td>
</tr>
<tr>
<td>6 Unreadable (damaged, plastic-covered, etc.) or missing barcode</td>
<td>😞</td>
<td>😊</td>
</tr>
</tbody>
</table>
Estimating the Return on Investment

How many racks have items (full pallets / cases) stored one-deep with front-facing bar codes?

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How many racks have items (broken pallets / cartons / cases) stored multi-deep?

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On average, how long is each aisle?

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On average, how tall is each rack?

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On average, how often do you currently complete a full cycle count of all the racks?

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Ideally, how often would you like to complete a full cycle count of all racks?

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On average, how many full time resources (across all shifts) are engaged in inventory counts?

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On average, how many hours each week (including weekends) do you allocate for counts?

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Business Value from Drone Cycle Counts

- More than 3x faster & up to 3x cheaper versus manual counts
- Repeatable, fully traceable, quickly auditable cycle counts
- Payback period as short as 1 year, IRR potential of > 30% over 3 years
- Amortization of UAV investments across multiple sites, use-cases

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Applicability of Inventory Drones

**DCs & Large Warehouses**
Save labor, equipment & time by integrating robotic scans of pallets into inventory operations.

**Fulfillment & Sorting Facilities**
Improve fulfillment metrics by aerial search & detection of critical items, empty & full slots.

**Cargo & Freight Forwarding**
Adapt to higher supply chain velocity by deploying UAVs for faster, high frequency cycle counts.

**Retail Stores & Warehouse Clubs**
Minimize stockouts & pilferage by counting bulk storage, every single day, in warehouse stores.
Challenges for Aerial Counts: Broken/Partial Pallets
Challenges for Aerial Counts: Bulk Storage
Aerial & Manual Counts: Complementary, Safe, Scalable

- Humans plan & schedule missions; drones execute them during off-hours
- Drones scan full pallets; humans count partials (usually stored on the ground)
- Drones collect video & images; humans count items remotely
- Drones identify location inaccuracies; humans analyze root-cause
- Drones identify unreadable barcodes; humans read/replace them
- Drones collect top-view of bulk storage; humans move honeycombed items

Drones do the dull, repetitive, dangerous work;
Humans focus on higher-value tasks!
Thank You
For more information:

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