Lecture 06
Warehouse Activity Profile

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OUTLINE

1 Concept of Warehouse Activity Profiling

2 Master Data for Warehouse Activity Profile

3 WAP Processes & Examples

4 Case Study: Construction Material

5 Overview of Key Performance Index

source: General references [BH09, Mul94, Fra02]
**What:** improving warehouse by understanding *natures* & exploring *patterns*

**Idea:** *data mining* with database program
INVESTIGATION = WAP

<table>
<thead>
<tr>
<th>Crime Investigation</th>
<th>Warehouse Activity Profiling</th>
</tr>
</thead>
<tbody>
<tr>
<td>• gathering evidences &amp; witnesses</td>
<td>• gathering data</td>
</tr>
<tr>
<td>• understanding motivates</td>
<td>• understanding patterns</td>
</tr>
<tr>
<td>• selecting suspects</td>
<td>• selecting causes &amp; solution</td>
</tr>
<tr>
<td>• capturing murder</td>
<td>• improving efficiency &amp; productivity</td>
</tr>
</tbody>
</table>

Questions & Data ⇒ Information ⇒ Success of profiling
Benefits of Warehouse Activity Profiling

- Understand demands & patterns → layout, picking policy, labor management
- Calculate Key Performance Index (KPI) → snapshot of warehouse
- Managing SKU → select suitable equipment, package, *slotting*, default pick path
- Gather data for design
**Master Data**

- **Item Master:** database related to SKUs
- **Location Master:** database of inventory at all storage locations
- **Order Master:** database of sale in-out to warehouse (100+MB)

**Questions**

- What is **data**? → obtaining data, **time horizon**, meaning of each column, wired data
- How each data set related? → understanding big picture by interaction
- What is **primary key** of each set of data? → understanding big picture by interaction
**Profiling Data: Item Master**

- **General:** SKU ID, description, vendor ID
- **Bulk break:** break SKU, box per pallet
- **Physical:** volume, width (length × height × weight)
- **Time:** received date, expired date
- **Ordering:** min-max, response person
- **Other:** picking note, shipping note, lot #, equipment

**Example**

<table>
<thead>
<tr>
<th>Sku ID</th>
<th>Vendor ID</th>
<th>Description</th>
<th>Unit length</th>
<th>Unit width</th>
<th>Unit height</th>
<th>Unit weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAG47294</td>
<td>AAG</td>
<td>PLNR,'FAT LITTLE',BK</td>
<td>6.2</td>
<td>6.1</td>
<td>1.7</td>
<td>0.9</td>
</tr>
</tbody>
</table>

**Source:** Warehousing Science [http://www2.isye.gatech.edu/jjb/wh/book/profile/activities/profilingexercise.html](http://www2.isye.gatech.edu/jjb/wh/book/profile/activities/profilingexercise.html)
Profiling Data: Location Master

- **Header**: date-time that data are retrieved
- **Address**: zone, aisle, section, position
- **Unit**: quantity, case, pallet

**Example**

<table>
<thead>
<tr>
<th>Sku ID</th>
<th>Zone</th>
<th>Aisle</th>
<th>Bay</th>
<th>Level</th>
<th>Position</th>
<th>Qty</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPRSP2-4915</td>
<td>A</td>
<td>102</td>
<td>A</td>
<td>2</td>
<td>B</td>
<td>20</td>
<td>Case</td>
</tr>
<tr>
<td>AVE05731</td>
<td>A</td>
<td>102</td>
<td>A</td>
<td>5</td>
<td>B</td>
<td>12</td>
<td>Case</td>
</tr>
<tr>
<td>WLJ36610</td>
<td>A</td>
<td>102</td>
<td>B</td>
<td>1</td>
<td>B</td>
<td>30</td>
<td>Case</td>
</tr>
<tr>
<td>SPR5084SP</td>
<td>A</td>
<td>102</td>
<td>B</td>
<td>3</td>
<td>B</td>
<td>10</td>
<td>Piece</td>
</tr>
</tbody>
</table>

Typical Warehouse Address
**Profiling Data: Order Master**

- **Header**: order ID, customer ID,
- **Detail**: SKU ID, date, time, quantity (Qty), unit
- **Note**: largest database (200+MB)

### Example

<table>
<thead>
<tr>
<th>Sku ID</th>
<th>Order number</th>
<th>Customer number</th>
<th>Order qty</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRTTN460</td>
<td>23926870</td>
<td>615413</td>
<td>4</td>
<td>2004-01-12</td>
<td>17:01:00</td>
</tr>
<tr>
<td>CMC5810-BE</td>
<td>23559658</td>
<td>10135</td>
<td>8</td>
<td>2004-02-08</td>
<td>14:45:00</td>
</tr>
<tr>
<td>KOK00172</td>
<td>23840414</td>
<td>614283</td>
<td>1</td>
<td>2004-01-11</td>
<td>10:41:00</td>
</tr>
<tr>
<td>SOF1500</td>
<td>23926870</td>
<td>615413</td>
<td>20</td>
<td>2004-01-12</td>
<td>17:01:00</td>
</tr>
</tbody>
</table>

**Processes in WAP**

- **Define questions:** What do you plan to improve (Pro VS Con)?
- **Gather data:** meaning of data & finding related data:
  - **Static:** SKU related, layout-zone, std. time, cut-off time
  - **Dynamic:** picker related, plan, OT, schedule
- **Import data:** 'connect with database', basic statistic analysis
- **Check data:** inconsistency, outlier → clean-up data
- **Analysis data:** create & explain distribution (figure)
- **Implementation:** gap analysis, saving analysis
SKU Related Statistic

- **# active SKU each month:** → difficulty & nature of warehouse
- **# pallet receiving each day:** → workload from receiving
- **Volume of SKU shipping each day:** → material handling
- **# line per order:** → warehouse characteristics & channel
- **Seasonality index:** → balance of workload

Facility Related Statistic

- **# new SKU each month:** → stability of warehouse
- **Avg. inventory per SKU:** → workload, inventory policy
- **# workers in each activity:** → division of labor
**Examples of WAP**

- **Order mixed distribution:** moving partial warehouse, re-range zone
- **Channel mixed distribution:** business analysis, outsourcing, direct shipment,
- **Line per Order distribution:** batch picking,
- **Pallet order incremental distribution:** requirement of equipment, sub-pallet
- **Item popularity distribution:** storage location, fast picking area,
  ABC analysis by 'pick'
- **Family pair analysis:** SKU in same order → zoning
**Construction Material: Products**

- **Category:** roof (↑ labor), cement (time limit), paint (flammable)

- **roof tile**
- **grey cement**
- **home paint**
**Construction Material: Sale**

- **Channel:** retail (↑ margin), whole sale (↑ qty), project (know in advance)

- homemart retail
- wholesale
- construction project
WAREHOUSE LAYOUT

- never enough space $\rightarrow$ space?, qty?, SKU?
- high labor turnover $\rightarrow$ mgt?, worker?, task?, policy?, equipment?
- layout suck $\rightarrow$ design?, inventory?, slotting?
Which category should be re-located?
**Direct Shipment?: Cement or Roof**

![Bar chart showing the percentage of volume for Roof, Cement, and Paint in different channels: Retail, Whole Channel, Project. The chart indicates that Ceramic has the highest percentage in the Project channel, followed by Whole Channel, and then Retail.](chart)

Warehouse v2.0: Activity Profile

18/ 34
Number of Line for Batch Picking

- 50% for 1 line
- 55% for 2 lines
- 15% for 3-5 lines
- 10% for 6-9 lines
- 10% for 10+ lines

Percentage distribution of lines per order for batch picking.
Roof problems

- **Roof problems:** require high labor, small order qty, easy damage
- **Question:** should do sub-pallet? & how much
ABC analysis by total sale

![Graph showing ABC analysis by total sale](image-url)
ABC Analysis by Handling

ABC analysis by handling is a method used to prioritize and manage inventory. It categorizes items into three groups based on their value in order to optimize inventory management. The categories are:

- **A** items: High-value, high-demand items that require tight control and frequent monitoring.
- **B** items: Medium-value, medium-demand items that need moderate control.
- **C** items: Low-value, low-demand items that can be managed less strictly.

The diagram illustrates the relationship between the order of SKU and total pick, showing how different handling methods (unit vs. pallet) affect these metrics. The curve indicates that as the order of SKU increases, the total pick also increases, with some differences in how quickly this occurs between unit and pallet handling methods.
Equipment Selection

- Floor Stack
- Flow Rack
- Storage Drawer
- Bin Shelving
- Carousels

Adopted from Frazelle, E. 2002
Cycle of inventory
## Common Questions for WAP

<table>
<thead>
<tr>
<th>Area</th>
<th>Questions</th>
<th>Profiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order picking &amp; shipping process</td>
<td>• batch size</td>
<td>• order mix dist.</td>
</tr>
<tr>
<td></td>
<td>• picking tour</td>
<td>• line/order dist.</td>
</tr>
<tr>
<td></td>
<td>• shipping mode separation</td>
<td>• line/order dist.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• cubes/order dist.</td>
</tr>
<tr>
<td>Receiving &amp; put-away</td>
<td>• receiving mode separation</td>
<td>• order mix dist.</td>
</tr>
<tr>
<td></td>
<td>• put-away batch size</td>
<td>• lines/receipt dist.</td>
</tr>
<tr>
<td></td>
<td>• put-away tour</td>
<td>• lines/receipt dist.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• cube/receipt dist.</td>
</tr>
<tr>
<td>Slotting</td>
<td>• zone definition</td>
<td>• popularity dist.</td>
</tr>
<tr>
<td></td>
<td>• storage selection &amp; size</td>
<td>• cube volume profile</td>
</tr>
<tr>
<td></td>
<td>• item location</td>
<td>• popular/volume dist.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• order completing dist.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• demand correlation</td>
</tr>
</tbody>
</table>

*Adopted from Frazelle, E. 2002*
**Warning on WAP**

- **Yielding unexpected turns:** profiling results ≠ general believes validate date & analysis → new information & fact

- **Spending too much time:**
  - **Unavailable data:** e.g., volume
  - **Over analysis:** e.g., questions & profiling

- **Profiling periodically:** Data is inconsistency & dynamic → WAP is non-stationary
**What is KPI?**

- **What:** a way to measure performance of organization/activity
- **Important:**
  - indicate success of each activity
  - evaluate main objectives
  - measure progress of implementation (historical comparison)
  - measure productivity & efficiency
- **Issues:** data collection, measurement, **consistency**
**WHAT ARE CHARACTERISTICS OF GOOD KPI?**

- related to the organization objective & mission
- accepted by everyone (supervisor, customers, industry)
- historical comparable & controllable → \( \frac{\text{output}}{\text{resources}} \)
- logical & suggesting solution
- required minimal of works for collecting & analyzing

**Type of KPI?**

- **Financial related KPI:** % warehousing cost per total cost, cost per shipped SKU
- **Non-Financial related KPI:**
# KPI for Every Activity & Aspect

<table>
<thead>
<tr>
<th>Activity</th>
<th>Financial</th>
<th>Productivity</th>
<th>Utilization</th>
<th>Quality</th>
<th>Cycle-Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receiving</td>
<td>receiving-cost per line</td>
<td>receipts per man-hour</td>
<td>% utilization of dock</td>
<td>% receipts accurate</td>
<td>receipts CT</td>
</tr>
<tr>
<td>Put-away</td>
<td>put-away cost per line</td>
<td>put-away per man-hour</td>
<td>% utilization of labor</td>
<td>% perfect put-away</td>
<td>put-away CT</td>
</tr>
<tr>
<td>Storage</td>
<td>storage cost per item</td>
<td>inventory per square foot</td>
<td>% utilization of cubic</td>
<td>% available location</td>
<td>inventory days on hand</td>
</tr>
<tr>
<td>Picking</td>
<td>picking cost per line</td>
<td>lines per man-hour</td>
<td>% utilization of labor</td>
<td>% perfect picking lines</td>
<td>warehouse order CT</td>
</tr>
<tr>
<td>Shipping</td>
<td>shipping cost per order</td>
<td>order prepared for shipment</td>
<td>% utilization of dock</td>
<td>% perfect shipments</td>
<td>total warehouse CT</td>
</tr>
<tr>
<td>Total</td>
<td>total cost per order</td>
<td>shipped lines per man-hour</td>
<td>% utilization of capacity</td>
<td>% perfect order</td>
<td></td>
</tr>
</tbody>
</table>

*Adopted from* Frazelle, E. 2002
Example of Non-Financial KPI

- **Service Customer View:** response time (order cycle time), shipment accuracy (correct qty/total qty), fill rate (qty shipped/ordered qty)

- **Service Warehouse View:** dock-to-stock time, inventory accuracy, % cross-docking order

- **Productivity:** lines per man-hour, cases per person-hour, cubic space utilization, equipment up-time

- **Situation:** lines shipped per SKU, inventory turnover, investment pick accuracy, % of new SKUs, % active SKUs, labor turnover, lines per order, total lines shipped per day

## Rating of Selected KPIs

<table>
<thead>
<tr>
<th>KPI/Rating</th>
<th>Poor</th>
<th>Sub-Par</th>
<th>Par</th>
<th>Superior</th>
<th>Outstanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>responding time (hrs)</td>
<td>&gt;48</td>
<td>24-48</td>
<td>12-24</td>
<td>4-12</td>
<td>&lt;4</td>
</tr>
<tr>
<td>dock-to-store time (hrs)</td>
<td>&gt;48</td>
<td>24-48</td>
<td>8-24</td>
<td>2-8</td>
<td>&lt;2</td>
</tr>
<tr>
<td>lines per man-hour</td>
<td>&lt;5</td>
<td>5-10</td>
<td>10-20</td>
<td>20-50</td>
<td>&gt;50</td>
</tr>
<tr>
<td>cases per man-hour</td>
<td>8-25</td>
<td>25-50</td>
<td>50-100</td>
<td>100-250</td>
<td>&gt;250</td>
</tr>
<tr>
<td>cubic utilization (%)</td>
<td>&lt;65</td>
<td>65-75</td>
<td>75-85</td>
<td>85-95</td>
<td>0.95</td>
</tr>
<tr>
<td>annual lines per SKU</td>
<td>&lt;50</td>
<td>50-100</td>
<td>100-250</td>
<td>250-400</td>
<td>&gt;400</td>
</tr>
<tr>
<td>inventory accuracy (% qty)</td>
<td>&gt;5.0</td>
<td>1.0-5.0</td>
<td>0.5-1.0</td>
<td>0.05-0.5</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>inventory turn</td>
<td>&lt;1.0</td>
<td>1.0-3.0</td>
<td>3.0-6.0</td>
<td>6.0-10.0</td>
<td>&gt;12.0</td>
</tr>
</tbody>
</table>

Using KPIs

Project comparison:
- **Idea:** verify success of project with KPIs
- **Limitation:** 'wired' KPI, standardization, spilling effect

Historical comparison:
- **Idea:** compare KPIs across period e.g., month-by-month, year-by-year
- **Limitation:** situations (e.g., no picking, disruption), improving area

Benchmark comparison:
- **Idea:** compare KPIs across organization
- **Limitation:** type & scale of warehouses, confidentiality, interpretation
- **Method to compare:** To-Be-Continue
1. In warehouse activity profile, why do we prefer **Database software** (e.g., MS Access) rather than **Spreadsheet software** (e.g., MS Excel)?

2. Based on WPA workshop, how many SKUs in Zone A/ Aisle 145?

3. Based on WPA workshop, what is the average line/order of SKU located in zone A?


[**BH09**] J. J. Bartholdi and S. T. Hackman.  
*Warehouse & distribution science.*  
Supply chain and logistics institute, Georgia institute of technology, 2009.

[Fra02] E. Frazelle.  
*World-class warehousing and material handling.*  

*Warehouse distribution and operations handbook.*  