

# Automated Laundry Processing System ALPS

Dr. Mark Austin ENPM 645  
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**Sulaimin Barrett**  
**Liyan Gu**  
**Henry Yi**

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## **I. Scope of Work**

Today's mom and pop dry cleaning business rely heavily on manual labor, especially the manual tagging, cataloging and searching of hundreds of customers' clothing. In a nutshell, a typical cleaner's business process consists of tagging the clothes, cleaning the clothes, cataloging and grouping the clean clothes based on the tags assigned to the clothes and to the customer, and searching for customer's clothes. Every step of the process involves manual cataloging and tracking of customers' clothes. These manual processes work well but are prone to errors and are taxing to dry cleaning staff. Computers have been introduced to the dry cleaning business to reduce errors, but there still exists a heavy reliance on manual labor in the cataloging and searching of clothes. As any manual process, human errors still exist in the process even with use of computers.

To show a case of dry cleaning mishaps, an article was taken from Smart Money magazine entitled Ten Things Your Dry Cleaner Won't Tell You. In this article, Daisy Chan talks about common consumer complaints against the dry cleaning business and how they handle these complaints. But placing emphasis on one of the topics in the article about clothing loss, Chan explains how a customer sent in three tablecloths worth \$800 to be cleaned and were lost and never located by the dry cleaner. In her article Chan states "According to the Council of Better Business Bureaus, lost items are one of the top three complaints consumers log against dry cleaners. Dry cleaners have a knack for losing your stuff."

There are many causes that may attribute to dry cleaners to lose items, with human error being one of them. In our effort we intend to address part of this issue by focusing on tagging and inventorying of clothes.

## **II. Project Objectives/Major Goals of ALPS**

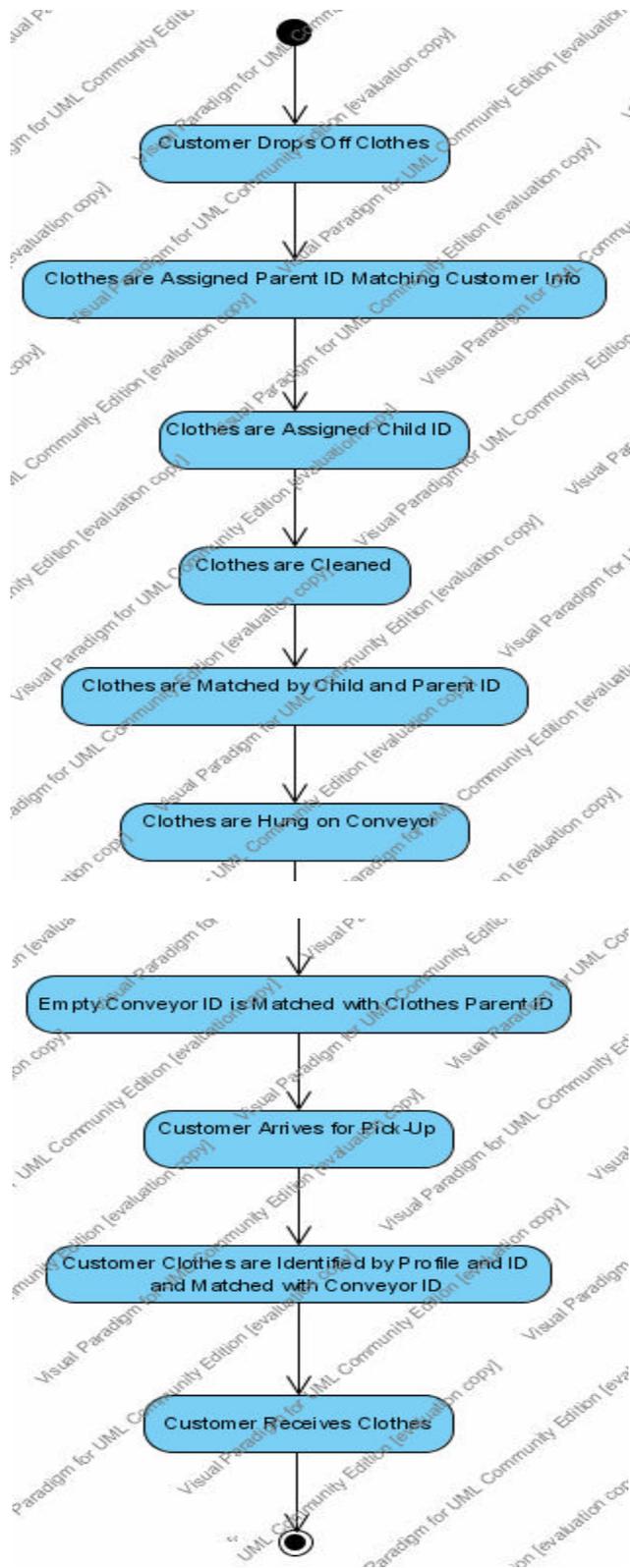
The major goals and objectives of ALPS include the following:

- Eliminate manual cataloging of clothes
- Eliminate manual searching for customer's clothes
- Eliminate such error as misplaced/miscataloged clothes
- Reporting of any missing or late clothes
- Must be safe for end users
- Have manual backup if the system fails

### **III. System Overview**

The overview of Automated Laundry Processing System (ALPS) consists of the same process of picking up, dropping off and cleaning clothes without the use of paper receipts. The normal process of picking up and dropping off clothes remains the same but once the customer leaves ALPS takes over to automate the logging process. As the customer drops off his or her clothes, instead of a paper ticket given out the clothes are scanned and input into the system matching the customer's personal information. The customer is assigned a unique ID given by ALPS for pick up of clothes. ALPS use Smart Tags and a sophisticated ID system to track clothes from laundering to pick up. It uses these Smart Tags to allow hands free control of the clothes conveyor allowing quick and easy clothes pick up by the customer.

ALPS begin with the tagging of the clothes and ends when the clothes are requested for pick up by the customer. By focusing in on this target region we are attempting to eliminate some of the manual labor that can introduce delay in customer pick up, misplacing of clothing items and improper inventorying. ALPS assume that all clothing received have an embedded RF chip in the material. ALPS do not install or supply RF chips or IDs for clothes identification. Current technology has already incorporated the use of RF IDs for merchandise tracking which includes clothes.



## **Operator/User Characteristics**

Typical operators or users of the system are expected to have at least a rudimentary education consisting of at least middle school education. The operators are required to read and understand written English language as well as be proficient in the usage of modern personal computers and its operations.

Definitions of terms related to our project and dry cleaning are as follows:

- **Laundry Transaction:** atomic action that starts with customer dropping off articles of clothes to be cleaned and ends with customer picking up the cleaned clothes.
- **Transaction id/Parent id:** an identifier associated with Laundry Transaction
- **Child id:** an identifier attached to each article of clothes in a laundry transaction
- **Tagging:** an act of attaching a unique child id to an article of clothing
- **Tag:** marker that can be identified with scanner
- **Abnormal child id:** all ids that does not belong to the laundry transaction id

The overall ALPS system consists of:

**Scanner Com:** communication module interfaces System Controller. All Scanners are attached to Scanner Com.

**Counter Scanners:** scanners that operators at the laundry counter uses to scan incoming and outgoing laundry

**Conveyor Scanners:** scanners that scan the laundry that is in the laundry conveyor

**Tagging Scanners:** scanners that operators at eh tagging counter/station tags received laundry

**Smart Tags:** tags that can be scanned remotely by Counter, Conveyor and Tagging Scanners

**System Controller:** the heart of the system that allows operators to interact with the system via the User Interface. Manages Data store which stores catalog of all the laundry/Smart Tags in the system.

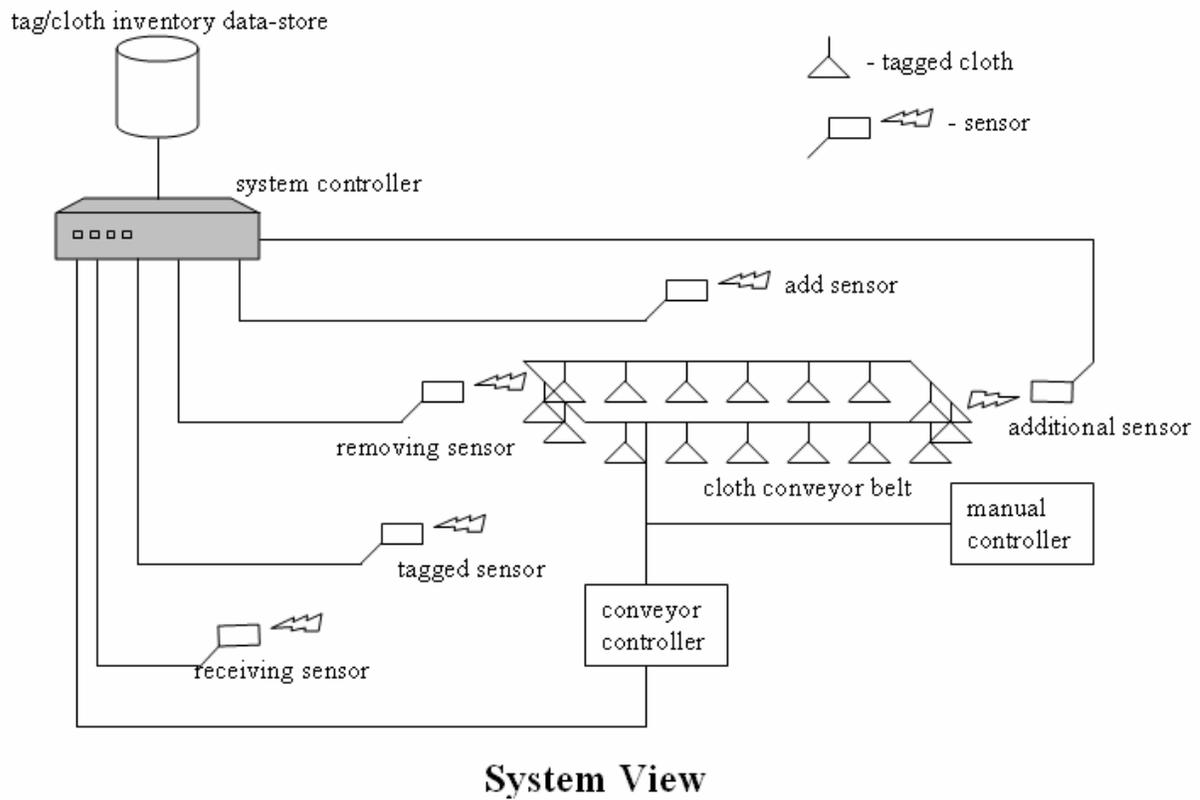
**Data Store:** storage medium that stores all the system data.

**User Interface:** subsystem that allows human interaction with the system

**Conveyor Controller:** received signal from System Controller to rotate the conveyor and stops when requested Smart Tag is found

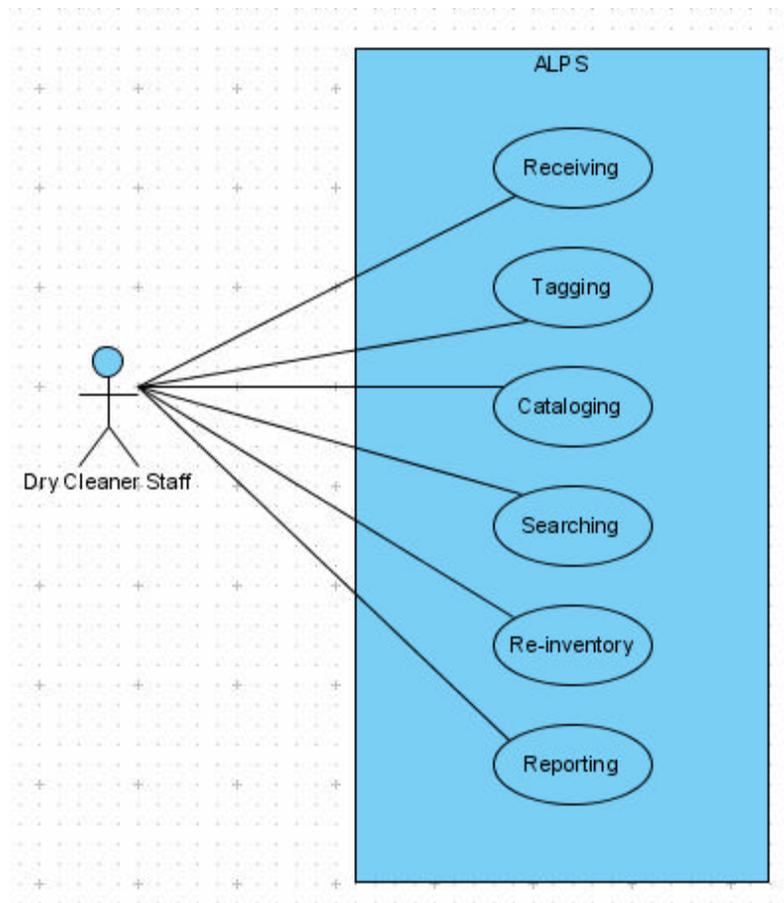
**Conveyor:** modified conveyor with smart tag embedded in the laundry slots to identify the location of the laundry slot.

**Manual Controller:** Allows manual control of the conveyor belt as in standard operation. Functions as a back up to ALPS.



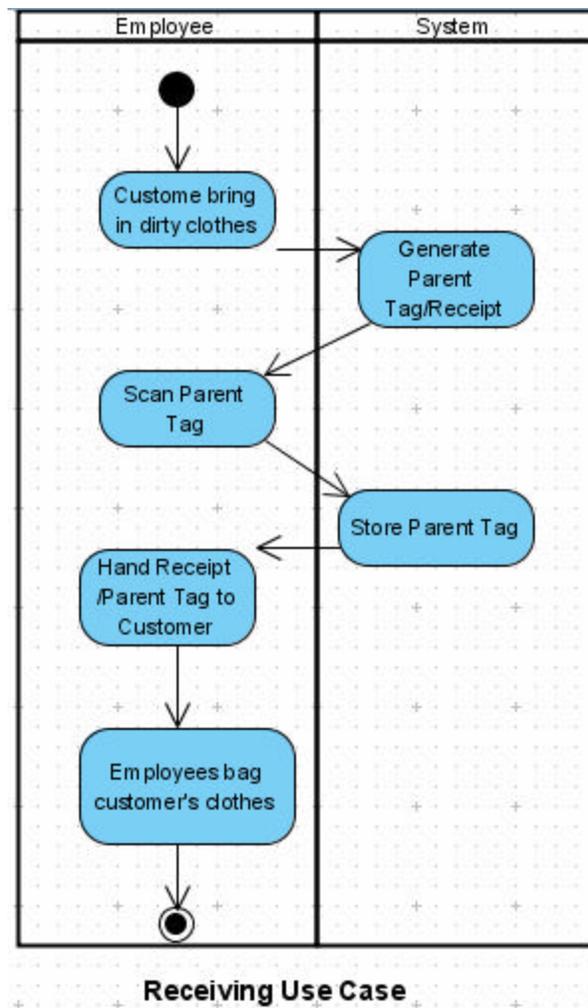
#### IV. Goals, Scenarios, Use Cases

Top level use case of ALPS is shown in the figure below. The Actor in this Use Case is the Dry Cleaner Staff. The Dry Cleaner Staff uses: receiving clothes, tagging clothes, cataloging clothes, searching clothes, re-inventorying clothes and reporting clothes. As stated earlier, ALPS takes over once the clothes are received by Dry Cleaners Staff.

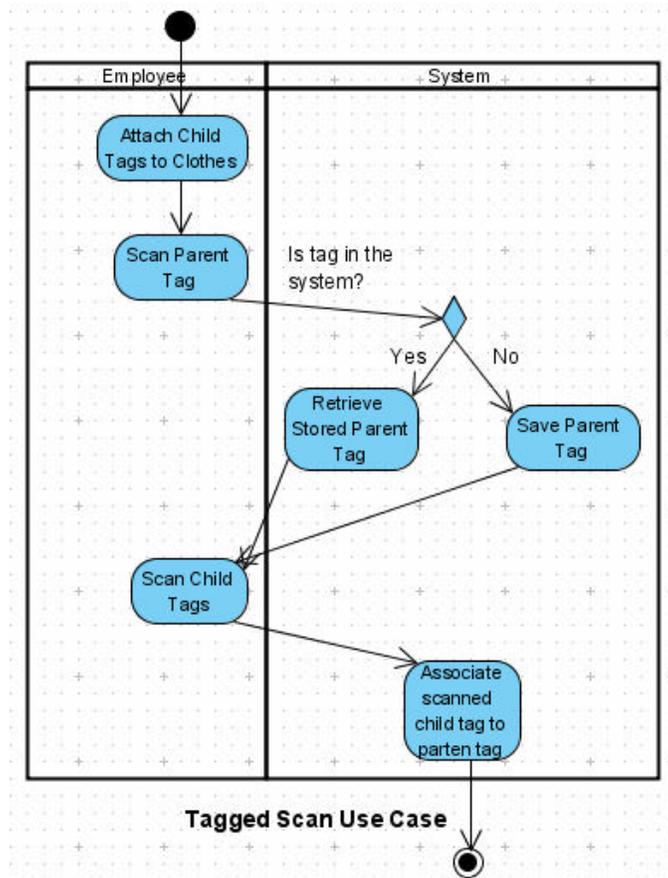


The Use Cases of ALPS is broken down into Use Case Scenarios to describe conditions and the flow of that particular part of ALPS.

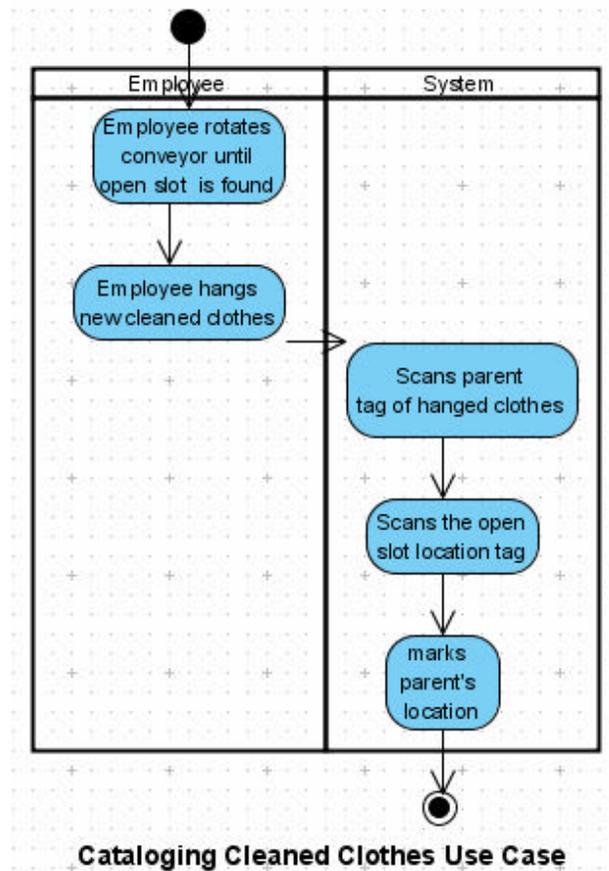
<b>Name:</b>	<b>Receiving Scan</b>
<b>Description:</b>	Customer brings in clothes to get them dry-cleaned. The employee takes the clothes and hands a receipt to the customer.
<b>Actors:</b>	Employee
<b>Trigger:</b>	Customer bring clothes to get cleaned
<b>Precondition:</b>	None
<b>Post-condition:</b>	System has the printed receipt in the system's data store.
<b>Normal Flow:</b>	<ol style="list-style-type: none"> <li>1. Employee prints a receipt and scans the receipt</li> <li>2. System stores the scanned receipt's id</li> <li>3. Receipt is handed to customer</li> <li>4. Employee bags the clothes and the receipt</li> </ol>
<b>Altemate Flow:</b>	None
<b>Notes:</b>	



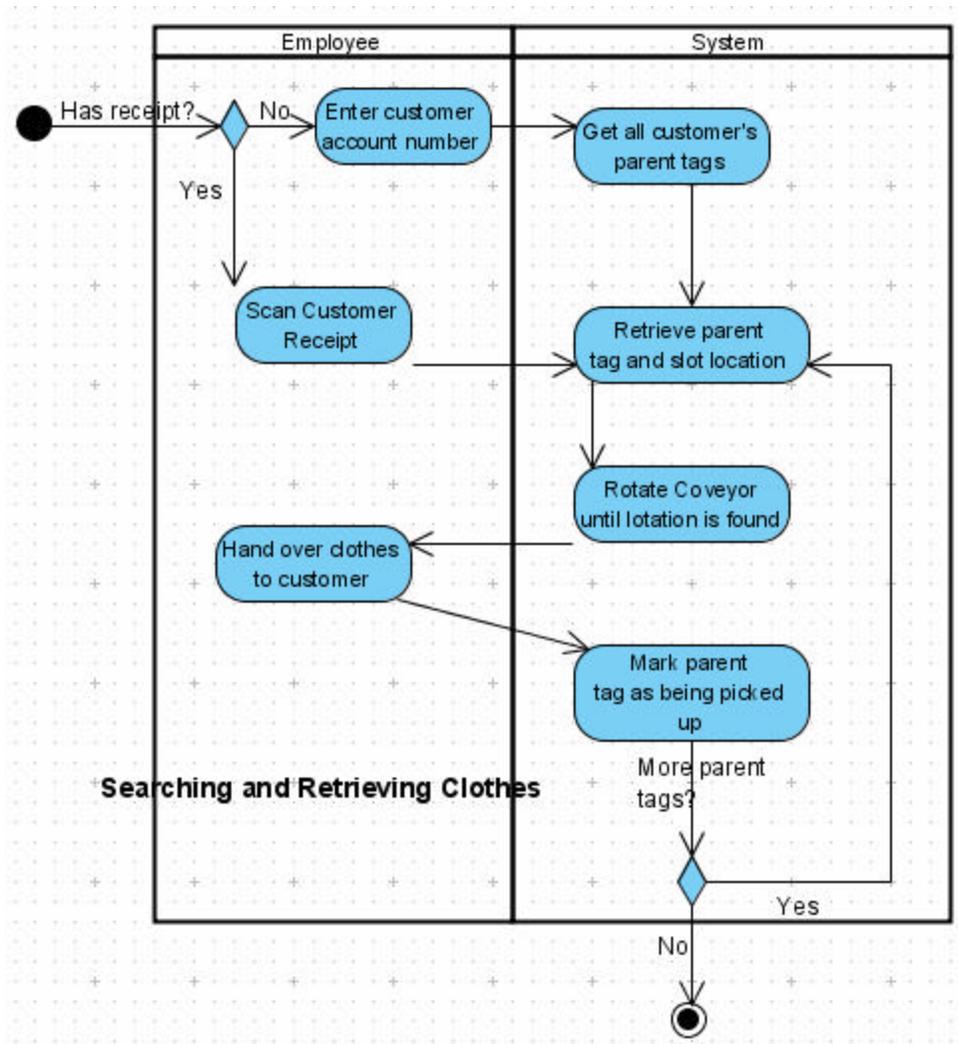
<b>Name:</b>	<b>Tagged Scan</b>
<b>Description:</b>	After the clothes are received, employee tags the bagged clothes. The tags are scanned into the system along with the parent tag, which is the receipt. The parent tag and the child tags on the clothes are linked.
<b>Actors:</b>	Employee
<b>Trigger:</b>	Bagged clothe arrives to tagging station
<b>Precondition:</b>	Parent receipt is created and scanned into the system
<b>Post-condition:</b>	Parent tag and child tags are in the system with established relationship between the parent and child tags.
<b>Normal Flow:</b>	<ol style="list-style-type: none"> <li>1. Bagged clothes are tagged.</li> <li>2. Parent tag is scanned</li> <li>3. Parent tag is retrieved from the system and displayed</li> <li>4. Tags attached to the clothes are scanned and these tags are defined as child tags</li> <li>5. Child tags are associated with the parent tag</li> </ol>
<b>Alternate Flow:</b>	<ol style="list-style-type: none"> <li>3.1 Parent tag is not found in the system</li> <li>3.2 Scan the parent tag in the bag and save it</li> <li>4. Flow of normal flow is followed from here on at step 4 of normal flow</li> </ol>
<b>Notes:</b>	



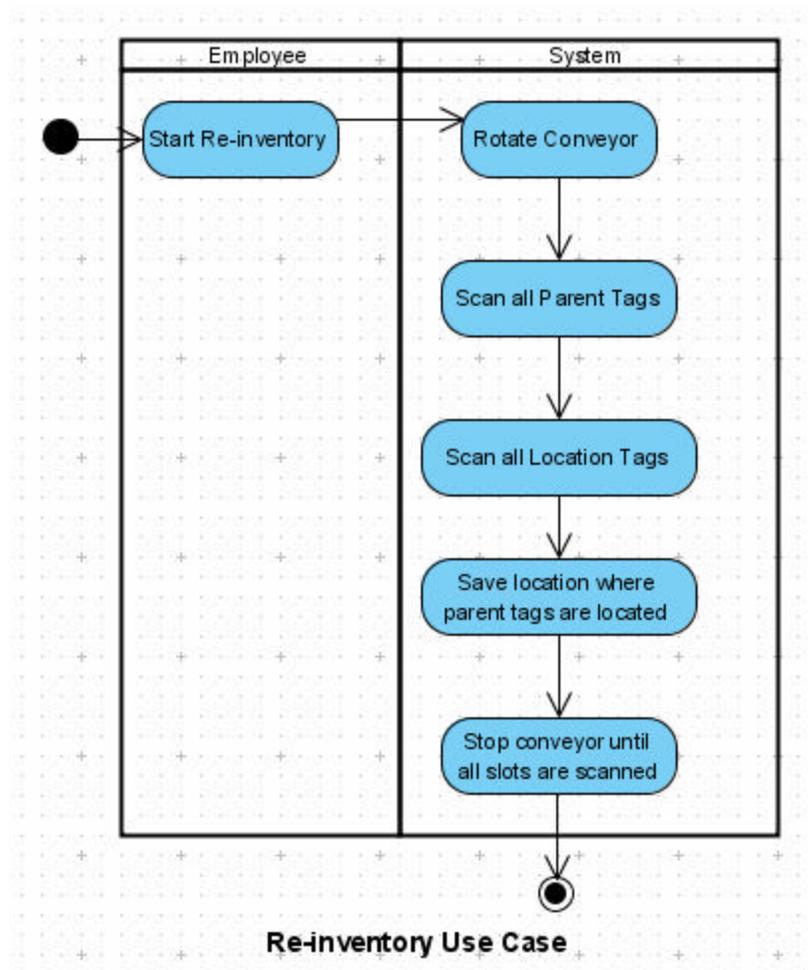
<b>Name:</b>	<b>Cataloging Cleaned Clothes</b>
<b>Description:</b>	After the cleaned clothes are returned from the cleaning facility or after cleaned on site, the clean clothes are hung on the conveyor belt and cataloged into the system.
<b>Actors:</b>	Employee
<b>Trigger:</b>	Cleaned cloth arrives and needs to be cataloged. Cleaned clothes are grouped as a bundle with their parent tag/receipt attached to the bundle
<b>Precondition:</b>	System has parent and child tag and its relationship stored in the data-store.
<b>Post-condition:</b>	System stores the location where the cleaned clothes/parent tag is hung.
<b>Normal Flow:</b>	<ol style="list-style-type: none"> <li>1. Employee rotates the conveyor belt until open slot is found</li> <li>2. Employee hangs the clothes on the open slot</li> <li>3. System scans the hanged clothes' parent tag</li> <li>4. System marks the location where of open slot and associates with the scanned parent tag</li> </ol>
<b>Alternate Flow:</b>	None
<b>Notes:</b>	None



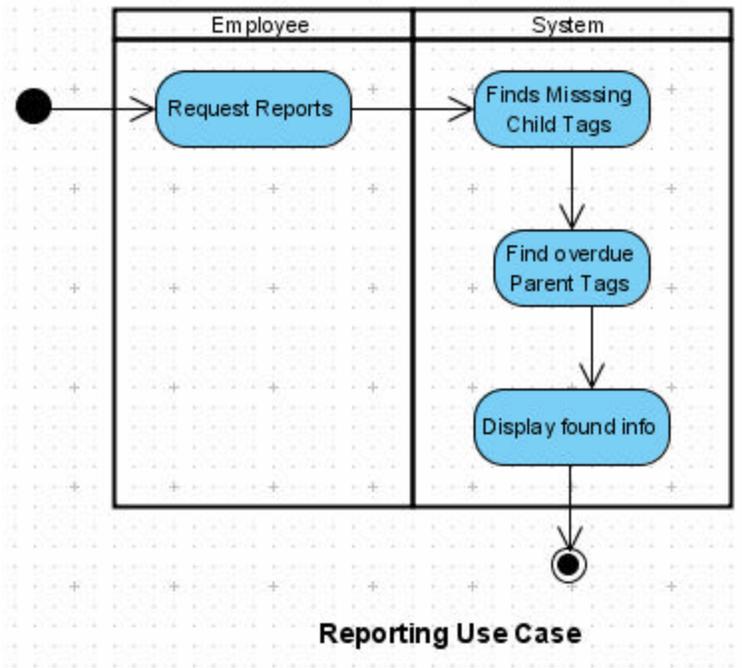
<b>Name:</b>	<b>Searching and removing Customer Clothes</b>
<b>Description:</b>	Customer comes in to pick up their cleaned clothes and system finds the clothes and rotates the conveyor belt and stop the conveyor belt where the cloths hangs
<b>Actors:</b>	Employee
<b>Trigger:</b>	Customer comes in the pick their cloth.
<b>Precondition:</b>	System has the location of the clothes stored in the system's data-store
<b>Post-condition:</b>	System marks the parent tag as being picked up and no longer in the system.
<b>Normal Flow:</b>	<ol style="list-style-type: none"> <li>1. Employee scans the customer's receipt</li> <li>2. System retrieves the scanned receipt's tag and location where the clothes are.</li> <li>3. System rotates the conveyor belt and stop on the location where the clothes are hanging</li> <li>4. Employee unhooks the clothes from the conveyor belt and hands the clothes to customer</li> <li>5. System marks the parent tag as being picked up</li> </ol>
<b>Alternate Flow:</b>	<ol style="list-style-type: none"> <li>1. Employee enters customer's account number</li> <li>2. System retrieves all the parent tags under the account number</li> <li>3. System finds first parent tag and rotates the conveyor belt</li> <li>4. System stops conveyor belt at the location where the clothes are hanging</li> <li>5. Employee unhooks the clothes</li> <li>6. System marks the unhooked clothes' parent tag as being picked up.</li> <li>7. Employee presses "Next" button</li> <li>8. Go to step 3 until all the clothes are marked as picked up</li> </ol>
<b>Notes:</b>	



<b>Name:</b>	<b>Re-inventorying</b>
<b>Description:</b>	At set time or when employee request re-inventory, system associates all the parent tags in the system with location of the slot where the clothes are hanging
<b>Actors:</b>	Employee or pre-determined time
<b>Trigger:</b>	Pre-determined time arrives or employee requests re-inventory
<b>Precondition:</b>	System is in working order
<b>Post-condition:</b>	All the clothes/parent tags in the conveyor belt are scanned and its location is logged.
<b>Normal Flow:</b>	<ol style="list-style-type: none"> <li>1. System rotates the conveyor belt</li> <li>2. Scans all the parent tags and associated slot number</li> <li>3. Saves the tag and slot number in the system</li> <li>4. System stops the conveyor belt until all the slots are accounted for</li> </ol>
<b>Alternate Flow:</b>	None
<b>Notes:</b>	



<b>Name:</b>	<b>Reporting</b>
<b>Description:</b>	System scans the data-store and report any missing clothes or overdue clothes
<b>Actors:</b>	Employee
<b>Trigger:</b>	Makes request for Report
<b>Precondition:</b>	System is in working order
<b>Post-condition:</b>	Report is displayed
<b>Normal Flow:</b>	<ol style="list-style-type: none"> <li>1. Employee request a missing/overdue report</li> <li>2. System scans the data-store for missing clothes</li> <li>3. System scans the data-store for overdue clothes</li> <li>4. System display missing clothes and overdue clothes with associated customer info</li> </ol>
<b>Alternate Flow:</b>	None
<b>Notes:</b>	



### Subsystem Interactions

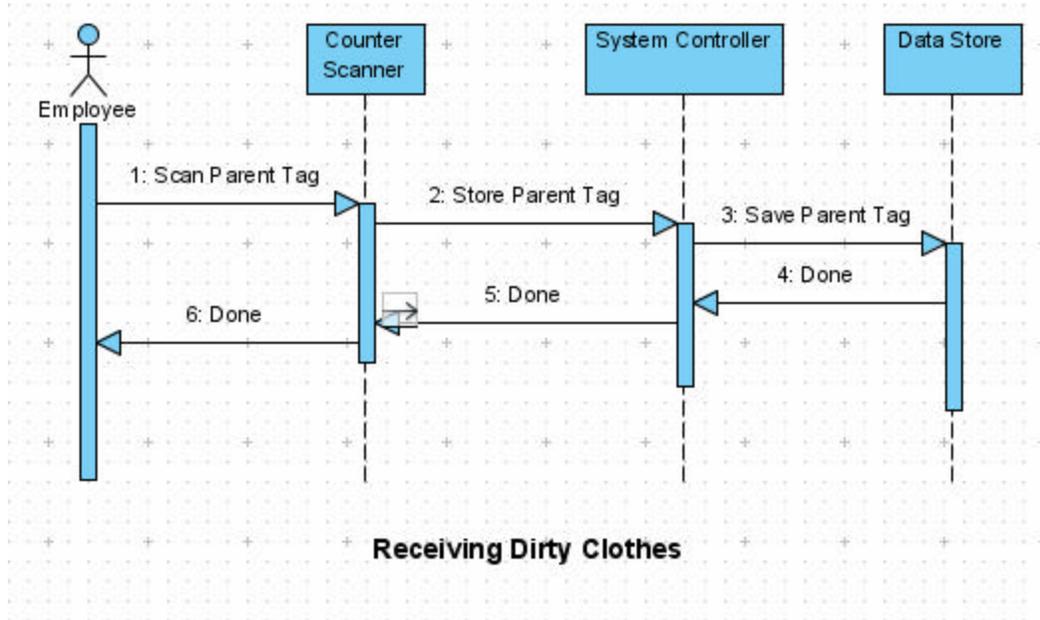
As identified in the Use Cases, ALPS need to perform 6 operational functions to support Dry Cleaning business process. They are:

- Receiving dirty clothes
- Tagging dirty clothes
- Cataloging cleaned clothes
- Searching and removing cleaned clothes
- Re-inventorying the clothes in the system
- Reporting

The following sequence diagrams illustrates interactions of ALPS subsystem to accomplish these 6 functions.

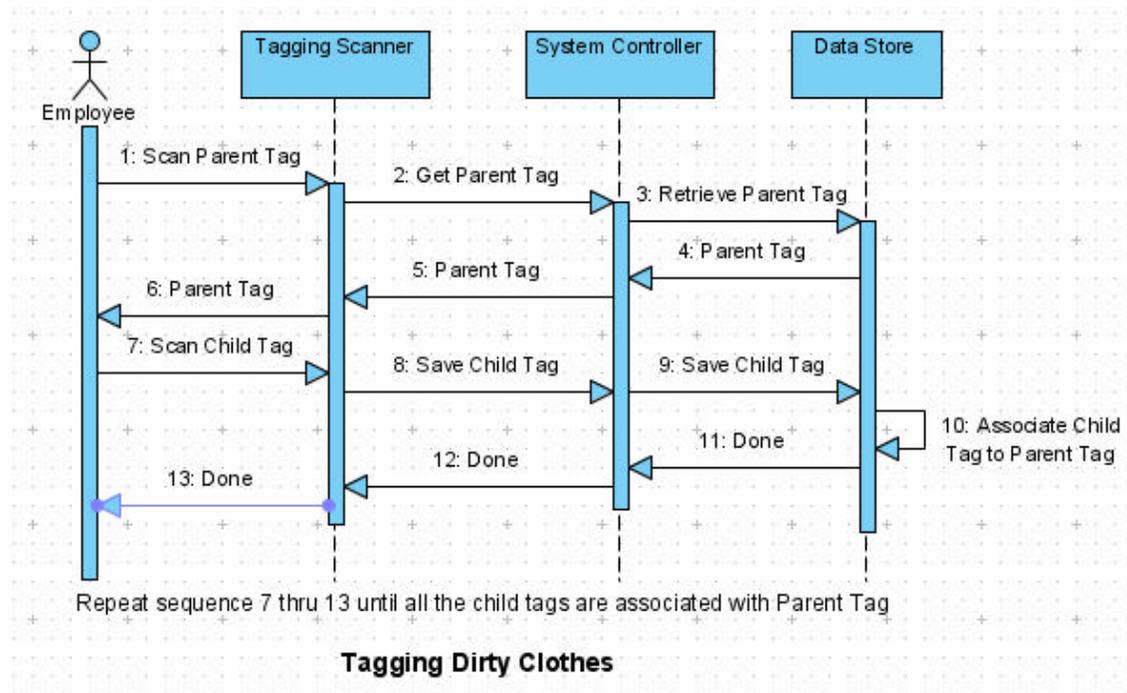
## Receiving Dirty Clothes

Whenever customers drop off their dirty clothes to get dry cleaned, ALPS will generate a receipt id/tag id, which is call Parent Tag Id. ALPS will store the Parent Tag ID for all laundry transactions.



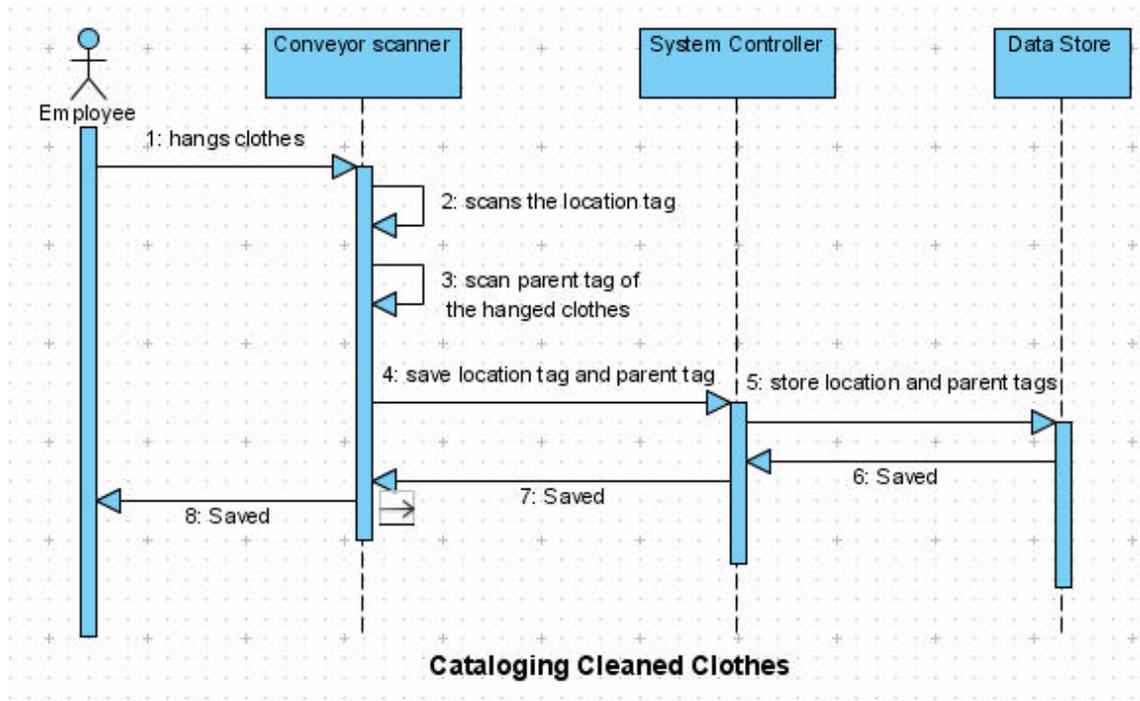
### Tagging Scan of Received Dirty Clothes

After the clothes are received, the employee attaches Child Tag Ids to the clothes and associate the Child Tag Ids to the Parent Tag Id that was assigned during the “Receiving Dirty Clothes” process.



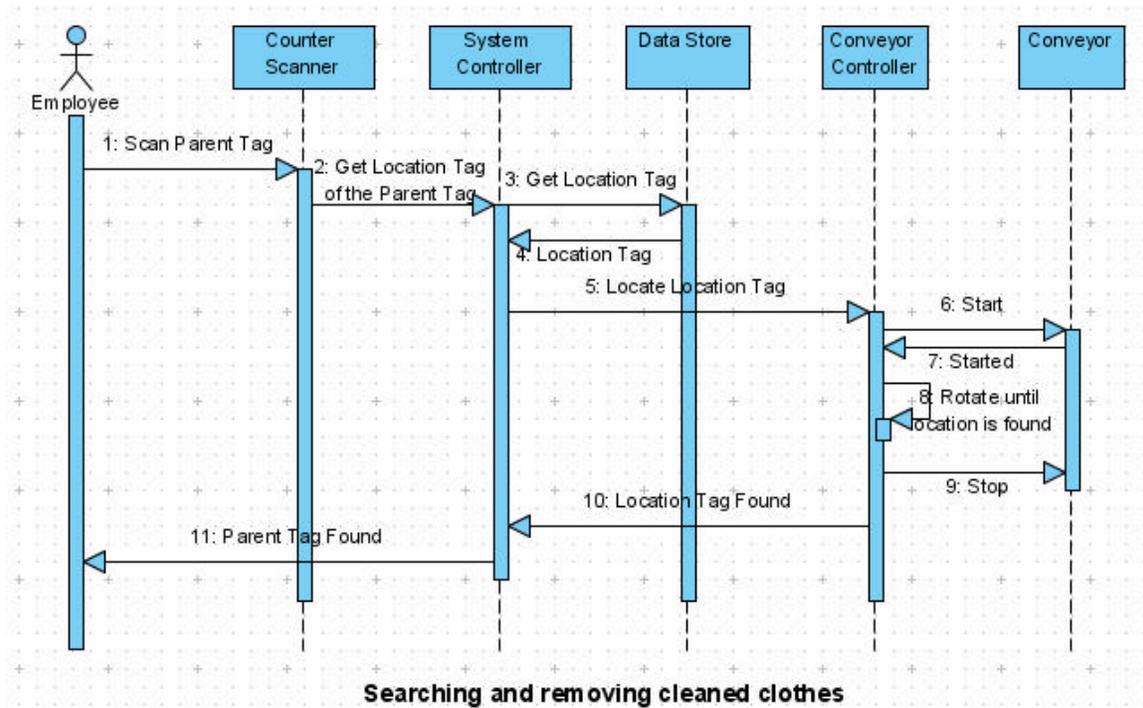
### Cataloging Cleaned Clothes

When cleaned clothes are returned from the cleaning process, they are hung on the conveyor.



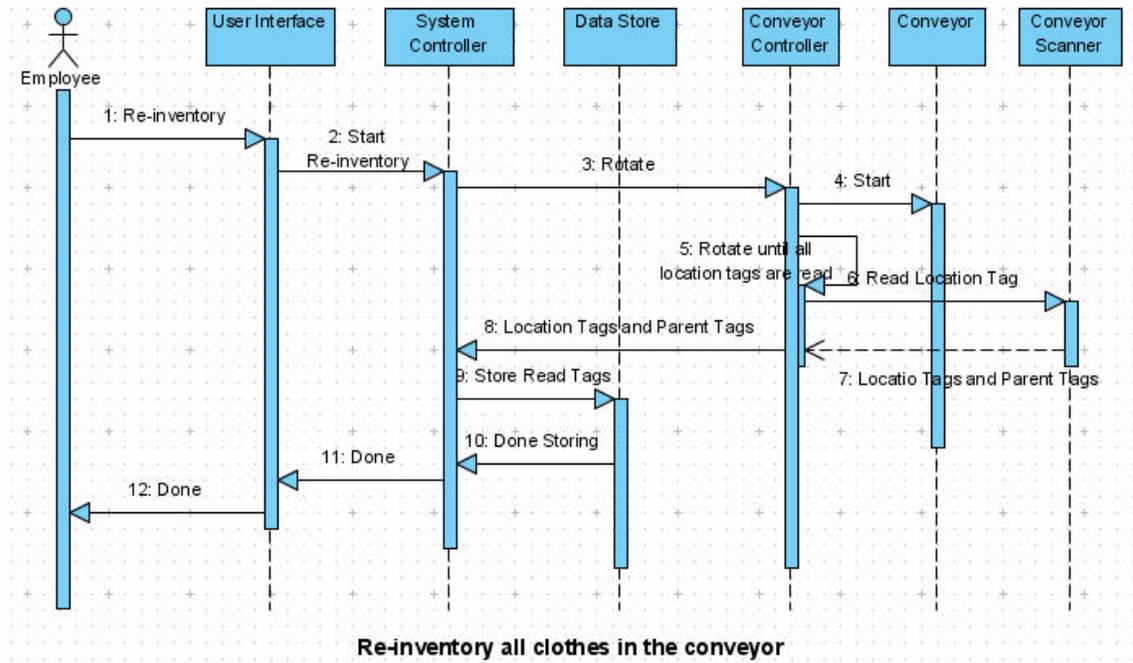
### Searching and removing cleaned clothes

When customer comes in to pick up their cleaned clothes, the employee scans the receipt customer has and APLS finds the clothes on the conveyor. The conveyor rotates and stops so that employee can unhook the clothes from the conveyor.



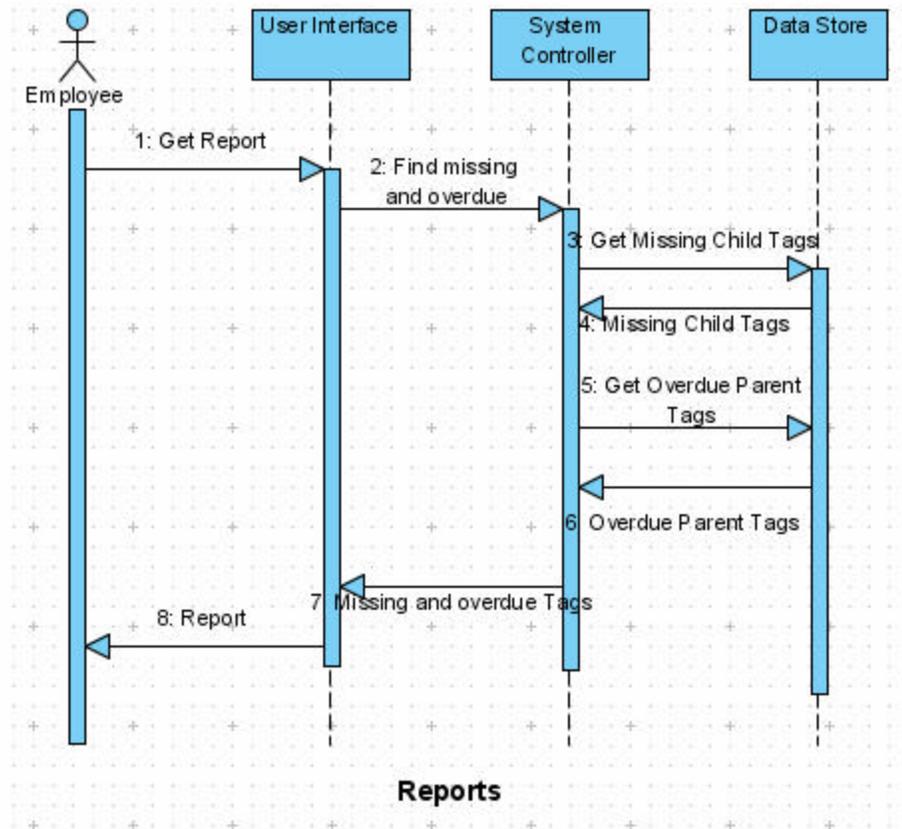
## Re-inventorying the clothes in the system

Periodically employee or at specified time intervals ALPS will re-scan all the clothes hanging in the conveyor belt to update the data store's inventory.



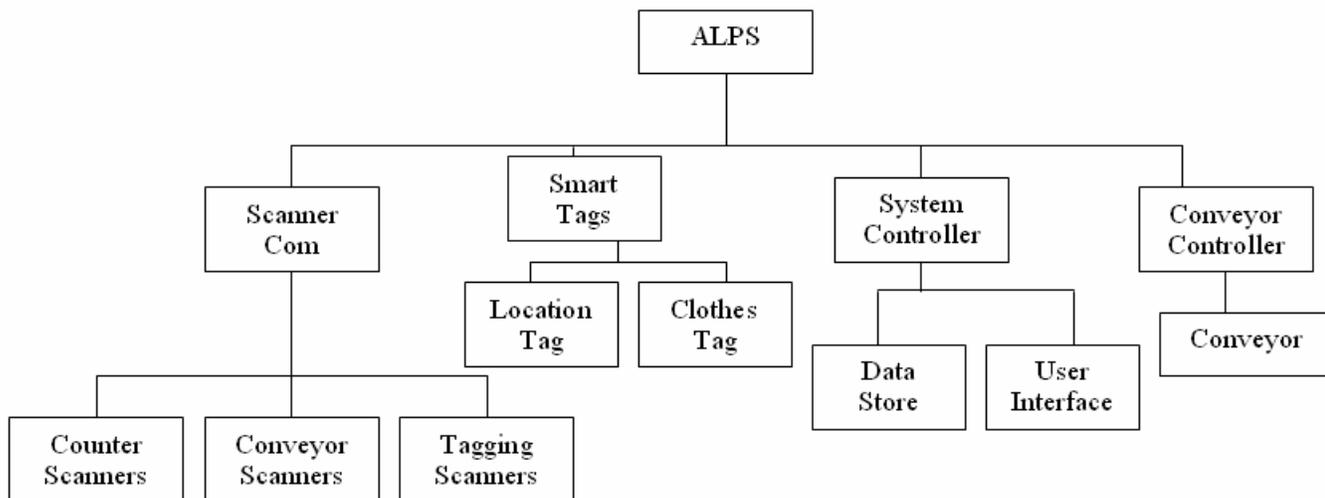
## Reporting

Upon employee's request, ALPS finds all the missing clothes and overdue cloths and displays as a list for employee's review.



## V. System Structure and Design

ALPS - Automated Laundry Processing System  
Subsystems Diagram



## VI. Requirements

The high level requirements, which are very general statements describing the customers use/need for the system, are then defined more specifically. The results are low level requirements which are traceable to the system objects and functional performance.

### Requirements Traceability Matrix

To develop a detailed requirements list for the Automated Laundry Processing System, the high level requirements must be broken down into subsystem and component level requirements that are useful to the design engineer. The low level requirements must contain details about subsystem interfaces, constraints such as size and power consumption, performance requirements, and details that are traceable to the specific system architecture and scenarios. The subsystem design engineer will use this information to develop components that will integrate with other subsystems to form a cohesive system functioning to meet the needs of the stakeholders.

### REQUIREMENTS TRACEABILITY MATRIX

Requirements	Goals	Scenarios	Verification
<b>1.1 Tags shall be capable of wireless, mid-range (at least ___ meters) radio-frequency communications.</b>			
1.1.1 The tag shall communicate with manual tag programmers (Employees).	1, 2	1.1/1.4	V_1.0
1.1.2 The Tag shall communicate with Sensors mounted in a laundry.			
1.1.2.1 Particular number of sensors should be installed in a laundry according to the laundry's area and size.	1	2.4/3.1/3.2/ 4.3/5.1/5.3	V_1.1.4 & V_1.1.5
1.1.2.2 Each Sensor shall be capable of sending and receiving radio frequency (RF) signals in a hemispherical pattern to communicate at a sepecific range.	3, 4, 6	5.1/5.3	V_1.6
1.1.2.3 Each tag only need to be automatically scanned once through Sensor.	1, 3	1.2/2.2/2.3	V_1.1.1 & V_1.1.2
1.1.2.4 All the communication history should be stored in the central database.	7, 8	1.3/1.5/4.6/ 5.4/5.5	V_1.1
1.1.3 The Tag shall be printed and processed through Controller.			
1.1.3.1 The front-desk machine should have control system installed.	1, 5, 6	2.5/3.3/3.4/ 3.5	V_1.2 & V_1.4
1.1.3.2 Printer should be connected with the front-desk machine.	1, 7, 8	8.2	V_1.1.6
<b>1.2 Tags shall be capable of being programmed with a unique ID.</b>			
1.2.1 Unique ID shall be capable of being recognized by sensor			
1.2.1.1 Both parent or child tag should only have one unique ID in a specific pattern.	2, 6	2.1/2.2/2.3/ 6.1	V_1.5
1.2.1.2 The sensor shall be capable of recognizing the unique ID and pass the information to central database.	all	1.2/3.2/3.4	V_1.6.1 & V_1.6.2
1.2.2 Each unique ID shall be linked to a Customer number.			
1.2.2.1 Each customer number shall have mutiple unique IDs.	2, 8	2.1/1.3/8.1	V_1.1.3
1.2.2.2 Each unique ID shall only be linked with one customer number.	7, 8	2.1/7.3/8.1	V_1.1.3
1.2.2.3 Customer number should be the primary key index in the data table of customer profiles..	6, 7	6.1/6.3	V_1.1.1

1.2.3 The tag shall only be either parent type or child type.	2, 3, 4	all	V_1.1
1.2.4 The tag shall be associated with quantity and time/date information.	1, 2, 7	1.5/5.5	V_1.1

**1.3 A control system with central database shall be installed in a laundry.**

1.3.1 Application Console

1.3.1.1 The application console shall have at least 1 MB of memory for tag and program data storage, and 512 kB of RAM memory.	4, 5, 6, 9	4.1/4.2/5.2/6.1/9.1	V_1.3
1.3.1.2 The application console shall have compiler software that will translate code written in a high level language.	4, 6	4.6/6.2/7.1/7.2	V_1.3.1 & V_1.3.2
1.3.1.3 The queuing software shall have a functional debugger.	5	5.2/9.1	V_1.2
1.3.1.4 The application console shall be capable of communicating with central database.	all	6.1/7.1/7.2/7.3	V_1.3.3

1.3.2 End User Machine shall be installed.

1.3.2.1 Front-desk desktop is needed for the end user to process the job and print the receipt.	1, 4	all	V_1.0 & V_1.1 & V_1.2 & V_1.3
1.3.2.2 Associated software shall be installed.	all	all	V_1.1.3
1.3.2.3 The front-desk desktop shall be capable of connecting to the central database.	1, 2, 4, 7	1.5/2.3/5.4/7.1/7.2	V_1.0 & V_1.1

1.3.3 Simple Network Device shall be installed.

1.3.3.1 The data between front-desk desktop and central database shall be transferred through network cable (RJ45).	1, 2, 7	1.5/2.3/5.4/7.3	V_1.0 & V_1.1
1.3.3.2 Firewall Hardware	9	9.1	V_1.0 & V_1.2

1.3.4 Central database shall be well designed.

1.3.4.1 Central database shall have separated tables to record associated information. (Current Transaction, Transaction History, Customer Profile, System Log, and Admin.)	7, 8	4.5/6.1/6.3/7.1/7.2/8.1	V_1.4.1 & V_1.4.2
1.3.4.2 The central database shall use proven technology to avoid duplicated records.	all	6.1/6.3/8.1	V_1.2
1.3.4.3 The central database shall have reporting function for enquire, package tracking, and inventory control.	6, 7	7.1/7.2/8.2	V_1.1.6
1.3.4.4 The central database shall be backuped every day.	9	9.1	V_1.2

1.3.5 The database shall use proven technology to store and process data in a predicable and repeatable manner.

9	9.1	V_1.6.3
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**1.4 Associated devices shall be installed.**

1.4.1 Cloth conveyor belt shall have sensor installed.	5	3.1/4.4/5.1/5.3	V_1.6
1.4.2 Slots on conveyor belt shall be cataloged in the database.	3, 4	3.1/3.2/4.4	V_1.4
1.4.3 Uninterruptible power supplies (UPS) shall be installed.	9	9.1	V_1.7
1.4.4 UPS shall have self error-detect and automatic alarm function.	1, 4	1.1/4.3	V_1.7.1 & V_1.7.2

**1.5 Sensor s/Scanners shall capable to withstand rigorous usage.**

1.5.1 Sensors/Scanners shall be housed in a waterproof enclosure.	all	all	V_1.6.4
1.5.2 Sensors/Scanners shall have self-debugger.	9	9.1	V_1.6.3

**1.6 Tags shall capable to withstand active and rigorous usage.**

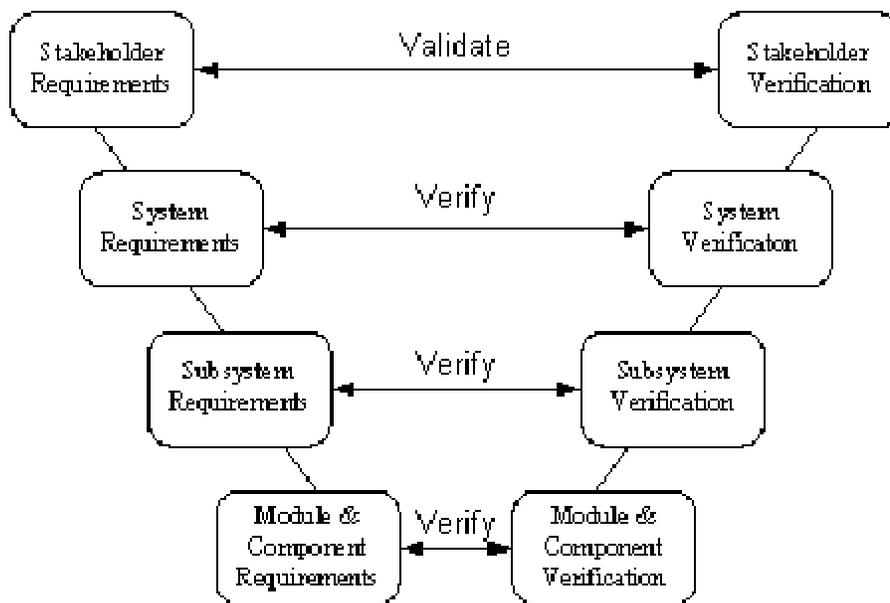
1.6.1 Tag dimensions shall not exceed (2" x2").	9	9.1	V_1.5 & V_1.5.2
1.6.2 Tags shall be housed in a waterproof enclosure.	all	all	V_1.5.1 & V_1.5.3

**1.7 The consumable products shall have low costs.**

1.7.1 The Tag shall cost no more than \$___ per tag to produce.	9	9.1	V_1.5.4
1.7.2 The Sensor/Scanner's weight shall no more than ___ oz.	9	9.1	V_1.6.5

**VII. Verification and Validation**

Referring to Figure 10, the V-Model of systems development, the process of requirements flow-down involves decomposition of the high-level stakeholder requirements into detailed subsystem and component specifications, which are used by component and subsystem designers to produce integral parts of a system from the bottom up. The task of system verification is to prove the system functionality concurrently as the design is trans-formed into functional component, module, subsystem, and system level objects and assemblies. At the highest level of verification, the system is tested against the stakeholder requirements, which is called validation. Once validation is complete, the system can be fully commissioned and turned over to its users.



<b>Verification ID</b>	<b>Verification Requirement</b>	<b>Level</b>
<b>V_1.0</b>	<p>Using a fully assembled Smart Tag, Sensor/Scanner, and desktop computer running conveyer belt controlling and logistics tracking software, perform the following functions:</p> <ol style="list-style-type: none"> <li>1. Enter Smart Tag I.D. number, type of ID, Customer account number, and time/date information into database. Send data to Tag, verify that tag responds with acknowledgment of received data. Response must occur in 2 sec. or less.</li> <li>2. Use logistics software to read tag data, data queried from tag must appear on computer screen within 2 seconds. Verify that data retrieved from tag matches the original data sent.</li> </ol>	System
<b>V_1.1</b>	<p>Perform the following tests: Scan the parent tag, compare the information pop-up on the screen and the records stored in the database.</p>	Sub-system
<b>V_1.1.1</b>	<p>Perform the test through the Front-desk Scanner. Connect a data recorder to Tag Transceivers to verify communications between Tag, Tag Transceiver, and Central Database:</p> <ol style="list-style-type: none"> <li>1. Check if the customer profile associated with that parent tag is correctly linked and updated.</li> <li>2. Check if the transaction ID associated with that parent tag is correctly linked and updated.</li> <li>3. Check if the user could retrieve the data of the customer transaction history through scanning the parent tag.</li> <li>4. Check if the database, desktop computer, and printer are connected properly.</li> <li>5. Check if the database stores the time and date correctly.</li> </ol>	Component

<p><b>V_1.1.2</b></p>	<p>Perform the test through the Conveyer Belt Scanner. Hang a cloth with tag on each slot of the conveyer belt respectively. Then rotate the conveyer belt 90 degree to the left and right respectively. Connect a data recorder to Tag Transceivers to verify communications between Tag, Tag Transceiver and Central Database:</p> <ol style="list-style-type: none"> <li>1. Check if the CLST (Conveyer Location Smart Tag) associated with that child tag is correctly linked and updated.</li> <li>2. Check if the transaction ID associated with that child tag is correctly linked and updated.</li> <li>3. Check if the user could retrieve the data of the customer transaction history through scanning the child tag.</li> <li>4. Check if the database stores the time and date correctly.</li> <li>5. Check if the all the CLST will be retrieved and updated under that particular customer profile.</li> </ol>	<p>Component</p>
<p><b>V_1.1.3</b></p>	<p>Perform a computer software simulation of the laundry process, results must show sufficient evidence that the database architecture satisfies Goal 1, 2, 3, 4, 6, and 7.</p>	<p>Component</p>
<p><b>V_1.1.4</b></p>	<p>Verify in CAD software that selected sensor/scanner design will cover within a quarter of conveyer belt enclosure and occupy no greater than 3 inch.</p>	<p>Component</p>
<p><b>V_1.1.5</b></p>	<p>Verify in CAD software that the major scanner and the front-desk scanner have the hemispherical coverage area and occupy no greater than 5 inch.</p>	<p>Component</p>
<p><b>V_1.1.6</b></p>	<p>Tap into the database and generate a sample report, verify the accuracy of the data report delivered by the database.</p>	<p>Component</p>
<p><b>V_1.2</b></p>	<p>Perform a software control simulation of the queuing mechanism, results must show sufficient evidence that the sensor/scanner processes the</p>	<p>Sub-system</p>

	signals respectively, once the controller is free, the next signal in line gets serviced.	
<b>V_1.3</b>	Use dummy data and schedule several time within a continuous 20 day period to re-inventory the clothes information.	Sub-system
<b>V_1.3.1</b>	Check if the database will catalog all the laundry transaction ids and associated child ids in the conveyer belt and compare with existing catalog to display any differences.	Component
<b>V_1.3.2</b>	Check after updating the re-cataloged information, if the sub-system will notifies the user of any differences in the re-catalog operation and current catalog.	Component
<b>V_1.3.3</b>	Check if the database will report any missing laundry transaction ids or any over due laundry transactions ids.	Component
<b>V_1.4</b>	Perform a computer software simulation of the Conveyer Belt Controller.	Sub-system
<b>V_1.4.1</b>	Test the algorithm used in the controller, randomly select the current CLST and desirable CLST, verifying the conveyer belt will rotate from current CLST to desirable CLST in a shortest way by applying the algorithm.	Component
<b>V_1.4.2</b>	Verify the conveyer belt behavior under “snap-shot” mode, results must show sufficient evidence that all the CLST on the conveyer belt will be scanned and recorded into the database.	Component
<b>V_1.5</b>	Using a Manual Tag Programmer, perform the following operations on Tag: clear data, download data, upload data. Verify that uploaded data matches downloaded data. Downloaded data shall include a sample I.D. number, type, and time/date information.	Sub-system
<b>V_1.5.1</b>	Verify Tag functionality in a dusty, dirty environment (cloth) for a continuous 6 day period.	Component

<b>V_1.5.2</b>	Measure tag enclosure with standard dial caliper, dimensions shall not exceed 2" on any long side, and 2" on any short side.	Component
<b>V_1.5.3</b>	Test Tag functionality for at least 120 hours in machine wash cold/hot modes, Tumble dry low/high modes, and dry clean mode.	Component
<b>V_1.5.4</b>	Verify the cost of tag, which is no more than the specification of the corresponding requirement.	Component
<b>V_1.6</b>	Using a testing tool, perform the following operations on Sensors/Scanners: receive information, compress information, and send out information. Verify that uploaded data matches downloaded data. Downloaded data shall include a sample I.D. number, type, and time/date information.	Sub-system
<b>V_1.6.1</b>	Verify that receive data matches send-out data. Compressed data shall include a sample I.D. number, type, and time/date information.	Component
<b>V_1.6.2</b>	Verify the PLS (Pick-up Location Scanner) and ISS (Inventory Snap-shot Scanner) are properly installed on the right position.	Component
<b>V_1.6.3</b>	Perform test with sensor/scanner self-debugger. The alarm light will flash automatically when error within the sensor/scanner is detected.	Component
<b>V_1.6.4</b>	Perform test with sensor/scanner's waterproof property. Reposition sensor/scanner enclosure every four hours to expose all six sides to spray. At end of test, open enclosure and verify that it is moisture free.	Component
<b>V_1.6.5</b>	Place sensor/scanner on calibrated scale, it must weigh no more than 20 oz. + 5%	Component
<b>V_1.7</b>	Perform test with uninterruptible power supply (UPS).	System

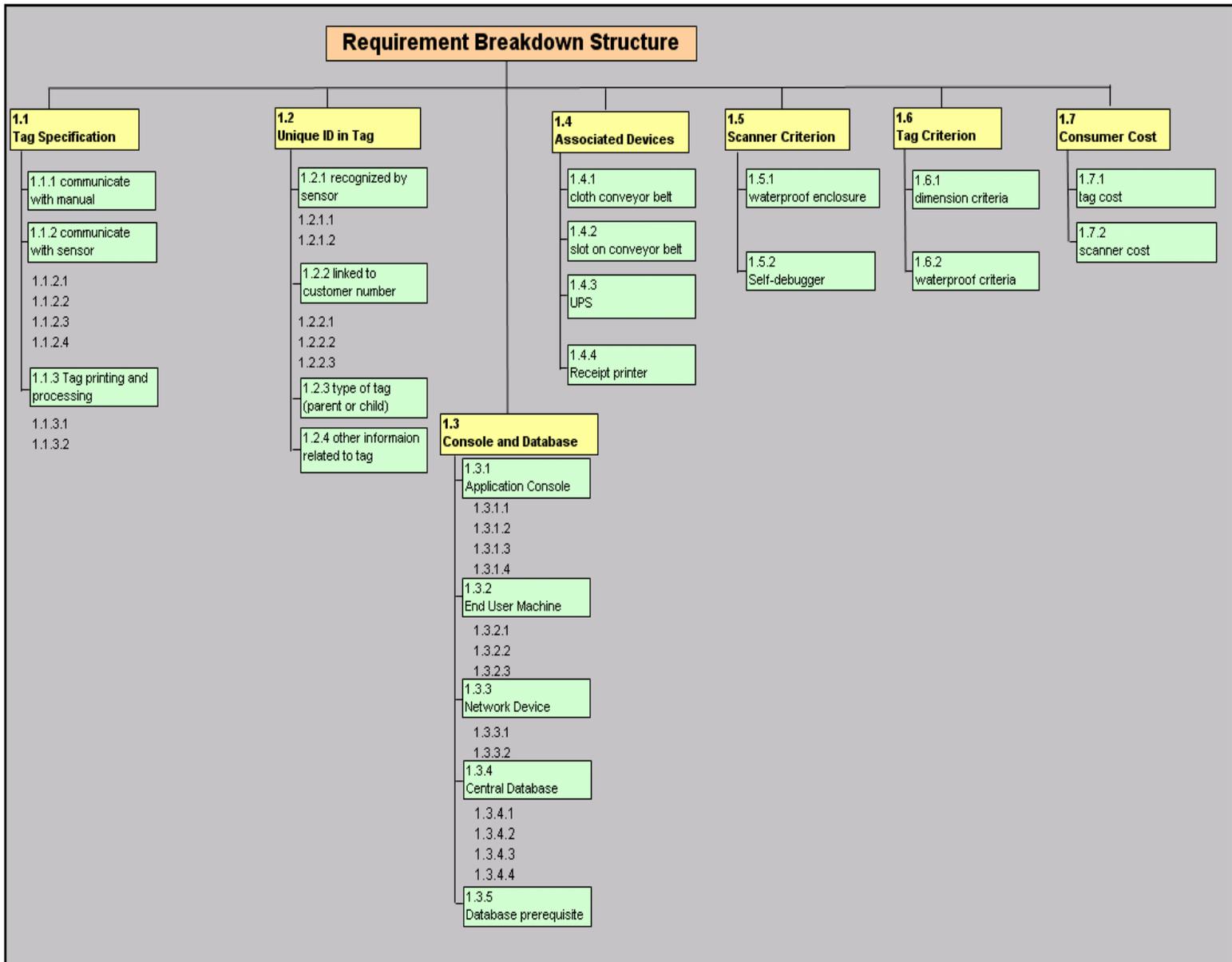
V_1.7.1	Verify the time limit that the uninterruptible power supply can support the system without out side power.	System
V_1.7.2	Energize components and observe that "low-voltage" trouble signal is sent from UPS. After trouble signal is verified and time limit reached, send "fault signal received" signal and observe that LED on power supply flashes, and system goes into sleep mode.	System

### Top-down and Bottom-up Verification

A requirement breakdown structure is used for the top-down and bottom-up verification.

First, the bottom-up verification will be performed. Start verification on the lowest level of requirement elements, verifying if the requirement specification is satisfied. Then gradually trace up to the upper level requirement elements, verifying them until reach the highest the level.

Second, the top-down verification will be performed. Start verification on the highest level of requirement elements, verifying if the component or sub-system's functionality satisfies the specification of the high level requirements. Then trace down to the lowest level.



## VIII. Tradeoff Analysis

In design and specification of the system, it is necessary to consider both sides of the situation. For the scanner problem of the system development, a multi-objective optimization is necessary. Due to the multiple subsystem constituents, and varying specification ranges, as described under the system structure heading, tradeoff is necessary to optimize performance variables and cost. The following section describes our tradeoff analysis, aided by the use of Excel, conducted in order to find optimal design parameters.

## Problem Background

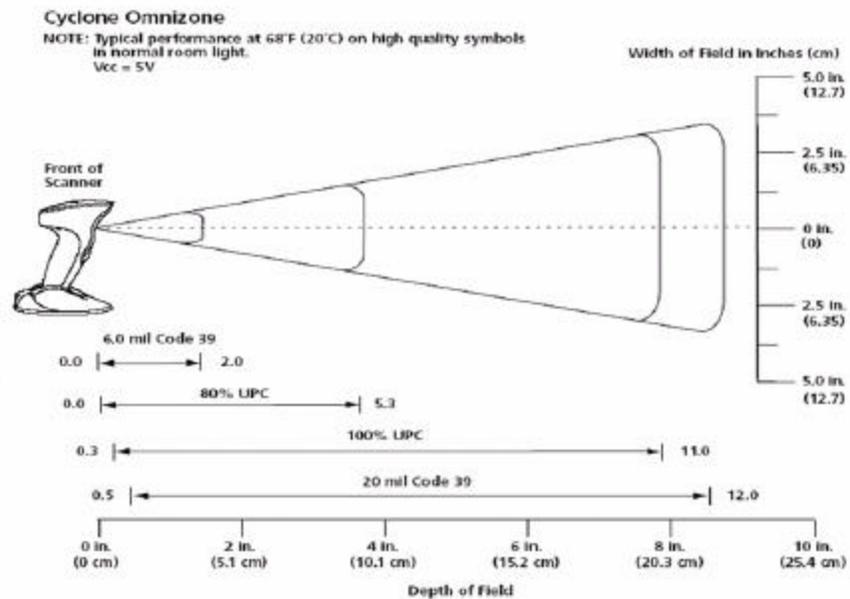
### - Cyclone M2000 Scanner Specification \$499



M2004-I400-0600ZN

Standard Applications,  
Synapse Adapter  
Cable-6 foot, Straight  
Cable-25-32463-20,

Single Line: 590 x 22  
frames/sec.



### - LS 2200 Series Scanner Specification \$204



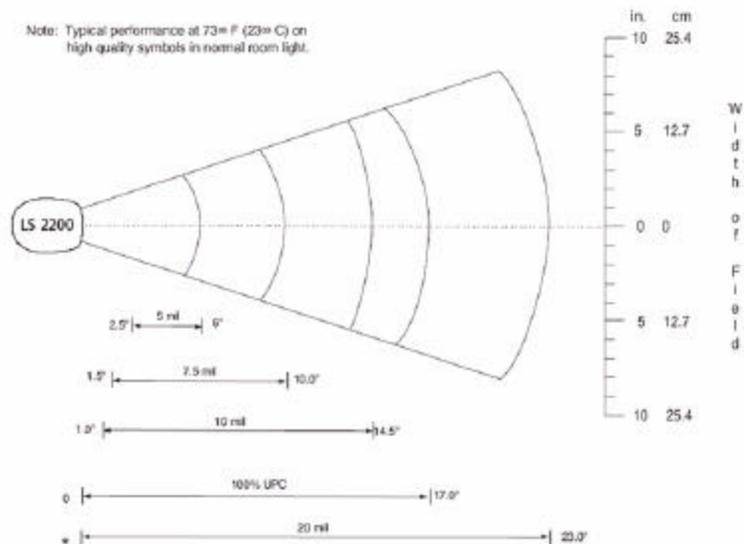
LS2208-1AZK0100S

Multiple Interface  
Scanner: Includes 25-  
62417-20 Keyboard  
Wedge PS/2 6 Foot  
Straight Cable, 20-  
61019-01 Intellistand,

Scan Rate: 100 scans  
per second typical

Scan Angle: 23 degrees  
nominal

LS 2200 Series Decode Zone



- WS 1200-LR Scanner Specification \$999



**WS 1200-LR Decode Zone**

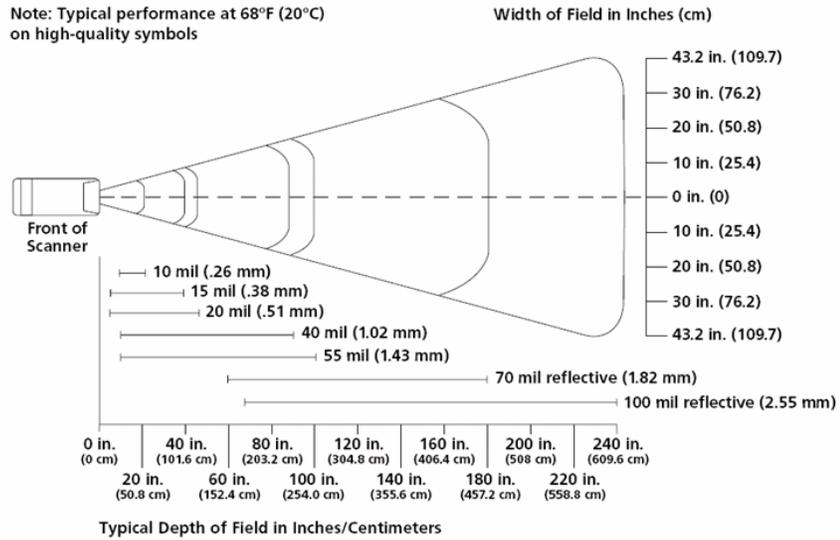
Note: Typical performance at 68°F (20°C) on high-quality symbols

WS1200-LR00

Long Range Scanner:  
with Plastic Cap,  
Trigger, Cable and  
Glove

Scan Rate: 35+5 scans  
per second

Scan Angle: 33 degrees  
nominal



**Decision Variables**

- C1 = cost of Cyclone M2000 Scanner
- X1 = number of Cyclone M2000 needed
- C2 = cost of LS 2200 series Scanner
- X2 = number of LS2200 series needed
- C3 = cost of WS 1200-LR Scanner
- X3 = number of WS 1200-LR needed
- C4 = potential cost saving, including labor cost and compensation cost
- FC = fixed cost of Tag and Controller / Printer

**Design Objectives**

Minimize the cost of implementing the system.

Min:  $(C1 * X1 + C2 * X2 + C3 * X3 + FC) - C4$

Subject to:

- $C4 - (C1 * X1 + C2 * X2 + C3 * X3 + FC) > 0$ ;
- Pattern of (X1, X2, X3) satisfy the conveyer specification;  
four conveyer size: Straight, inline, L, and wide U;  
length of garment up to 60".

## Feasible Solution Set

(X1, X2, X3) =

Feasible Solution Sets	Pattern of X (X1=, X2=, X3=)	Result
1	2, 8, 3	-573
2	3, 4, 2	-2289
3	0, 6, 4	-1380
4	2, 2, 3	-2397
5	3, 2, 2	-2897
6	2, 8, 1	-2971

## Optimal Solution

X1 = 2;

X2 = 8;

X3 = 1;

We have concluded that the use of the 2 Cyclone M2000 Scanner, 8 LS 2200 Series Scanner, and 1 WS 1200-LR Scanner with the cost at \$3629 is most feasible. The total implementation cost will be \$2,2029. And the total cost saving will be \$2,971.

In ALPS it is necessary to compare wired and wireless installation four key areas:

- installation
- total cost
- reliability
- performance

Some sub-components of ALPS do not have the option to be wireless, such as the system controller and conveyor controller whereas others do. Sensors and scanners have the option to be wireless. For both cases installation will require an electrician but with a wired network more time will be spent placing and locating wires in an orderly fashion along with ensuring proper electrical code standards are being followed. In a wireless system, which ALPS focuses on, hardware installation does not have the constraints as a wired system. For example relocating wires, running wires through difficult areas and having enough wire length does not hinder the installation. The prices of wireless components have been dropping steadily in recent years making wireless a better option. Running cable through floors or walls may not be feasible or may even be impossible due office or warehouse setup. Cost for both setup types are dependant upon electrician or a hired contractor. For a wireless setup majority of the time will be attributed to software setup. For a wired installation most of the time will be performing wire installation.

With the given technology we have today wireless is an easier and cleaner option. Reliability of wireless has improved greatly over the past few years and will continue to

improve as the technology improves. With wired components in a dry cleaning environment, special precautions must be taken to avoid damage. The introduction of noise can cause sensor components to react in an abnormal function. Objects in past years that posed a threat to wireless have been removed. In today's society wires are the new threat as far as flexibility is concerned. In brief, wireless is no less reliable than a wired network.

## **XI. Conclusion**

In concluding our project, it can serve as a feasible solution to combat common problems that customers and dry cleaners face together. ALPS does allow dry cleaning businesses to increase their profit margin in the long run by being more efficient and not having as many processing errors due to manual labor. By advancing to a wireless network, dry cleaners can introduce other wireless component and devices such as internet to communicate with customers or cleaning warehouses. It is necessary for ALPS to continue through a testing phase to ensure reliability and quality for creating a more efficient and improved customer friendly process.

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