Case Study

Colorado License Plate Factory

Version 1.0

Compiere, OSI (Open Source Initiative)

June 17, 2003

Final Draft

For Public Consumption

Juniper Valley Products • Business Technologies
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Date	Description
[redacted]	

2.

Introduction

2.1 System Overview

Compiere Manufacturing (MFG) is a planned extension of the Compiere Enterprise Resource Planning (ERP) and Customer Relations Management (CRM) enterprise-level software package. The intent of the MFG extension is to provide manufactures with an open source alternative that enables them to produce goods in a controlled environment using embedded Compiere software planning and control tools – thereby streamlining the manufacturing organization, thereby maximizing sales and profitability.

2.2 Project Scope

The Compiere Manufacturing Open Source Initiative will be developed with two primary areas of focus: 1) the control and planning of "*Material"* and 2) control of manufacturing *"Operations"*. With these capabilities, the resulting software will enable manufacturers to effectively plan raw material purchases and to execute a manufacturing plan in the most efficient and predictable manner possible.

"The Control of Material", will utilize or extend Compiere components, such as: Products, Pricing, Purchasing, and Material Management, which are necessary conduct scheduling, warehousing, procurement, and material transport operations. The goal, in controlling material, therefore, is to create manufacturing orders, purchase the least quantity of raw materials necessary for the manufacturing run and to track inventory levels as they migrate through the manufacturing process from raw materials to work-in-process, to shipping.

"*The Control of Operations"* will utilize or extend existing Compiere components, such as Project Scheduling and Workflow to drive the shop-floor process. The goal in controlling operations is to develop software that defines manufacturing in terms of process steps and work efforts. This will allow the manufacturing organization to plan, schedule, and monitor production that occurs on the shop floor.

2.3 About this Document

The Compiere Manufacturing Case Study provides a detailed analysis for developing a manufacturing system in Compiere. Contained within this document is a case study of the Colorado License Plate Factory, the basic components of manufacturing. The License Plate Factory implements a relatively simple and repetitive manufacturing process. With this in mind, the primary intent of this document is to formulate a basis for developing the first release of the Compiere manufacturing system.

While some manufacturing components in Compiere, like Material Management, are already firmly established, other components, like Routing and Work Centers will need to be developed and will therefore extend Compiere functionality.

This document provides a case study of a relatively simple manufacturing process that is ongoing at the Colorado License Plate Factory. The goal is to provide a baseline for discussion on developing a simple manufacturing system and the basic components needed to plan and run production lines.

The material contained in this document comprises of the author's practical experience with manufacturing organizations, personal research, reference material, and a fundamental understanding of Compiere. All material has also been reviewed and approved by the License Plate Factory Supervisor.

It is important to note that this is document is a living document, meaning that it is highly anticipated that various revisions will be applied after all interested parties have been provided with the opportunity to review and respond to its contents. Once the document has been reviewed and subsequently has reached its final form, it will be frozen to establish the project scope for Version 1.0, thereby allowing the Compiere development process to enter the *Detailed Design* stage of development.

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Case Study

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4.1 Case Study Overview

The case study presented in this document centers on the day-to-day operations conducted at the Colorado State License Plate Factory. The License Plate Factory organizationally belongs to Colorado Correctional Industries, which in turn belongs to the Colorado State Department of Corrections.

The mission of Correctional Industries (trade name Juniper Valley Products) is to "reduce idleness by working as many inmates as possible". It's obvious to realize, therefore, that the vast majority of labor is performed by inmates; state employees are responsible for managing the day-to-day operations.

While the License Plate Factory is a state entity that employs inmates, it also operates in the same manner as typical manufacturing organizations: product is ordered, raw materials are obtained, production runs are executed, and the end product is shipped.

Producing embossed license plates is a relatively simple endeavor as opposed to, let's say, an airplane. The back office ordering and shop floor operations are relatively simple because there are a limited number of raw materials and work stations to manage.

4.2 Running The License Plate Factory

By interviewing personnel at the License Plate Factory, the staff identified six key tasks involved the processing of manufacturing *embossed license plates* (please see table 2-1 below). While some of these tasks are automated, others are not. In either case, the following sections to explain the current workflow process of the Colorado License Plate Factory as it relates to the embossed license plate manufacturing process.

Table 2–1 License Plate Factory Order Processing

Rudimentary Task	Brief Explanation
Planning	Accept Sales Orders and Plan for Manufacturing Run
Purchasing	Purchase of Materials
Inventory Control	Movement and Management of Inventory
Manufacturing	Work Centers and Procedures Involved in Manufacturing
Shipping	Ship Orders to Counties
Invoicing	Invoicing and Accounts Receivable

4.2.1 Planning

Quarterly orders are initiated by the Department of Motor Vehicles. These orders contain manufacturing requests for any county whose inventory levels of any plate type (or other related material) has fallen below a minimum inventory level. It is important to note that, while the License Plate Factory receives a single quarterly order request for the entire state; the request is broken down by county and therefore contains multiple shipping locations – one for each county.

Emergency Orders, likewise, are exceptions to Quarterly Orders and are filled on demand.

Note (Ordering Software Exclusion)

The "ordering" software for the License Plate Factory is currently handled by another package. It will not be necessary, therefore, to replicate that software in MFG Version 1.0. Instead, manufacturing orders, which are part of the Compiere Manufacturing System, will be generated using an automated interface.

The manufacturing process actually begins after the Department of Motor Vehicles (DMV) has forwarded a Purchase Order Number to the License Plate Factory. Once this occurs, the following actions are taken: 1) a summary of the order request is created in the form of an internal sales order, and 2) the planning process for the manufacturing run begins.

4.2.1.1 Planning for Material

In addition to license plates, the License Plate Factory (or more generally called the Tag Plant) produces additional products like license plate tabs and handicap stickers. In the beginning stages, therefore, one task is to separate product by type (embossed plates, digital plates, tabs, etc…).

Specifically for embossed plates, raw materials that include: aluminum rolls, vinyl sheeting, ink, solvents, and packing material and are ordered based on *current inventory levels and lead-time*. While some raw materials can be quickly obtained like packaging, others, like vinyl sheeting can take months to receive into the warehouse.

The License Plate Factory maintains reorder points and lead-times. In addition, when a new manufacturing order is received, current inventory levels for unallocated inventory are weighed against the new manufacturing order determine any purchasing requirements. So when inventory item reaches a minimum threshold or when a manufacturing order is received, either case can trigger a purchasing event.

Listed below in Table 2-2 are the raw materials needed to produce embossed license plates.

Table 2–2 Inventory Plannign Table

Item	Calculated Need
Ink (Paint)/Solvents	30,000 Plates Per Gallon
Aluminum Rolls	3000 lbs Rolls; 4.3 Plates Per Pound; 3000 * 4.3 = Number of Plates Per Roll
Vinyl Sheeting	1800 Plates Per Roll (ordered in four colors, based on the need)
Packing Material	Based on Inventory Min/Max Levels

4.2.1.2 Planning the Manufacturing Run

Next, a *Manufacturing Log* is created by grouping an entire order by county and plate type. The Manufacturing Log is used by Shop Floor Supervisors as the overall blue print for production. Because the Manufacturing Log contains the "County" ordering sequence, it becomes evident that the production floor typically flows accordingly, by county.

As plates for one county have been completed and shipped, plates for another county are in the process of being manufactured. There are exceptions to this rule, however, because emergency orders, county reprioritizations, or generation of plate types can take precedence over the initial plan.

With rescheduling being an issue, plant managers track production on the manufacturing log. Once a series of license plates are completed, the completed work is signed off on the log and work continues to the next task. Listed below in Table 2-3 and Table 2.4 is the data tracked in the Manufacturing Log and its explanation:

Table 2–3 Manufacturing Log Information

Job	County	Plate Type	Beginning/Ending	Sets Ordered	Singles Ordered	Status	System No
100629	Adams	M/C-REG	001-IWI / 348-IWI	0	453	NEED	TAA03-134
100629	Adams	PAS-DES	348-IWI / 999-IWI	651	1,302	NEED	TAA03-134
…							
100629	Denver	PAS-REG	001-IWT / 999-IWT	999	1,998	NEED	TAA03-134
100629	Denver	PAS-REG	001-IWU / 999-IWU	999	1,998	NEED	TAA03-134

Table 2–4 Manufacturing Log Explanation

Item	Description
Job	System Assigned Job Number – relates to a system number (see below)
County	County – Manufacturing runs are typically run by county
Plate Type	Type of Plate. E.g. M/C-REG. Motor Cycle Regular
Beginning/Ending	Start and End of Plate Series
Sets Ordered	Number of plate singles to be produces – applies to passenger cars, for example. Doesn't apply to singles, like motorcycles.
Singles Ordered	Number of plate singles to be produces – applies to both passenger car sets and motor cycle singles.
Status	Current status of line-item
System No	Relates to the Job Number – Is also used as the internal Sales Order Number

Serialization for all license plates is determined in the planning phase. Given a predefined number of plates in a manufacturing run, the serialization generator assigns the appropriate alphanumeric numbers from 000-AAA through 999-ZZZ depending on where in the series in previous manufacturing run ended.

Additionally, determining how the order will be packaged is another task in the planning process. For not only is it necessary to procure the correct amount of packing materials, but each box will be stamped with the county name, plate type, and series weeks in advance of the plate's planned manufacture date. Given a specific number of plates and boxes, the current manufacturing system calculates the size and content of each box that will be shipped.

Note (Problems in Preplanning the Shipping Process)

The practice of preplanning the shipping containers has historically caused problems because it does not easily allow for any modifications in the order during the manufacturing process. Manufacturing orders, therefore, are usually executed with very few exceptions, thereby causing minor problems in customer relations.

4.2.2 Purchasing

Purchasing materials needed in the embossed license plate manufacturing process originates in the planning stages as explained above in section 2.3.1.1. As the items needed are identified, the License Plate Factory generates *Purchase Requests,* which are forwarded to the State buying agency for processing. After the State commits to a purchase, a Purchase Order is generated, and copy is returned to the License Plate Factory for inventory control purposes as explained in section 2.2.3 below.

Note (Purchasing Overview)

The above paragraph is a very brief overview of the purchasing process because the act of purchasing is performed by another organization. If needed, more detail can be added upon request.

4.2.3 Inventory Control

The License Plate Factory maintains four primary categories of inventories as listed in Table 2-3 below. The process of inventory control begins at the receiving dock when supplies and raw materials are received and brought into inventory. This is done by cross-referencing shipments to packing slips, and purchase orders to receiving documents. For in doing so, this ensures that all materials ordered are received and that nothing is paid for that wasn't ordered.

After inventory is received, it is then moved to various locations both on and off site. Once in inventory, material will remain until needed by the manufacturing process. As expected, monetary values for inventory are closely tracked and used in monthly profit/loss reports. Items such as aluminum rolls contain serial numbers and weight to determine values. Other items, such as packing, maintain value based on quantity and material type. Supplies, are not included in the profit/loss reports.

Table 2–5 Types of Inventory

Material Category	Brief Description
Raw Materials	Materials used to begin the manufacturing process
Work In Progress	Materials produced during the manufacturing process
Finished Goods	The end product of the manufacturing process
Supplies	Materials needed to support the manufacturing process

Due to the limited number of raw materials and the bulk in which they're packaged, the License plate factory does not utilize *Pull Lists* (list of various parts taken from inventory to produce a product) to build its product. When a roll of aluminum, vinyl sheeting or paint is needed, it is simply retrieved from inventory and used. In fact, it isn't until the monthly reconciliation process that inventory levels for all raw materials are recounted and adjusted accordingly in the current inventory system. It was assumed throughout the month that certain amounts of raw materials would be utilized based on the number of plates produced.

4.2.3.1 Use of Raw Materials

There are four raw used to produce embossed license plates: 1) rolls of sheet aluminum, 2) rolls of reflective graphic vinyl, 3) paint, and 4) packaging. At the start of the manufacturing process, the vinyl is laminated onto the sheet aluminum and the aluminum is stamped into a license plate; this process is called *blanking*, all blanks are transferred to a holding area until they are *embossed* (stamped) and *painted*. Finally, the plates are *packaged* and set on pallets for shipment.

So as rolls of aluminum and vinyl sheeting, paint, and packaging leave the inventory, raw materials are being expended and transformed into work-in-progress and finished goods, depending on the manufacturing phase.

The planned inventory amounts for each manufacturing order request are determined from the information contained in Table 2-6 – Raw Materials (also, please refer to Figure 2-1 below for a schematic of the entire manufacturing process).

Table 2–6 Raw Materials

Item	Usage
Aluminum Rolls	Stamped into correct dimensions to serve as the plate backing
Vinyl Sheeting	Laminated onto the aluminum and contains the plate frontal design.
Ink (Paint)/Solvents	Used to paint the raised (embossed) areas of the license plate
Packing Material	The bags and boxes in which the plates are housed and shipped.

4.2.3.2 Work In Progress

Once the roll of vinyl is joined to the aluminum, and the aluminum is stamped into its correct shape, the status of the material has changed from raw materials to work-in-progress, as blanks are created in this initial process.

As license plates move from one work station to the next, inventory is removed from one work station to the next. This action occurs with production is *posted* in the system to signify the completion of a task. For example, once the aluminum/vinyl sheeting lamination process is completed, a supervisor will post the completed work, thereby reducing aluminum and vinyl sheeting inventories and adding license plate blanks to inventory.

Table 2–7 Work In Progress

Item	Usage
Blank Plates	Created after the aluminum and vinyl sheet lamination
Embossed Plates	Created after the embossing (stamping) process
Completed Plates	Created after the painting process

4.2.3.3 Finished Goods

After an embossed plate has been blanked, embossed, and painted, it is considered to be a finished good once it is packaged for shipping.

Ideally, finished goods do not remain in inventory very long before being shipped. There are exceptions, however, because occasionally, finished goods stay long enough to be included in monthly or quarterly inventory reports. This is undesirable, though, as finished goods in inventory negatively affect the profit and loss statement.

4.2.3.4 Supplies

An adequate inventory of supplies is maintained at the License Plate Factory to support the manufacturing process. For example, while not part of the actual license plate, certain quantities of packaging and shrink wrap are needed to properly protect and ship the finished goods.

Inventory levels for these materials are relatively easy to order and maintain because of quick turn-around times. So in maintaining inventory levels for shipping and shrink wrap materials, the License Plate Factory maintains minimum reordering levels used to trigger a purchasing event. Additionally, inventory is ordered based on expected expenditures during a quarterly manufacturing run.

4.2.4 Manufacturing Work Centers

There are seven work centers associated with the production of *embossed* license plates. Table 2-3 below outlines the predefined steps in the manufacturing process. As the process begins with the raw materials, the work-in-process flows sequentially through the various workstations until the final product is packaged and ready for shipment. The only exception to the process flow is in the Final Inspection work stations where defective products are remade – starting production again at the embossing station. Please refer to Figure 2-1 - Manufacturing Activity Diagram, which flowcharts the entire process.

Table 2–8 Processing Steps

Step	Process	Description
1	Blanking	Laminate graphic vinyl to aluminum backing
2	Separation	Inspect for flaws and separate into plate sets or singles
3	Embossing	Press the desired alphanumeric lettering onto the plate
4	Painting	Paint the raised portion of the plate – caused by embossing
5	Final Inspection	Inspect the plate for errors in the painting process; remake defective plates

6	Packaging	Package the plate into its predefined box; place the box on a predefined pallet
7	Shipping	Shipping Material to the Counties

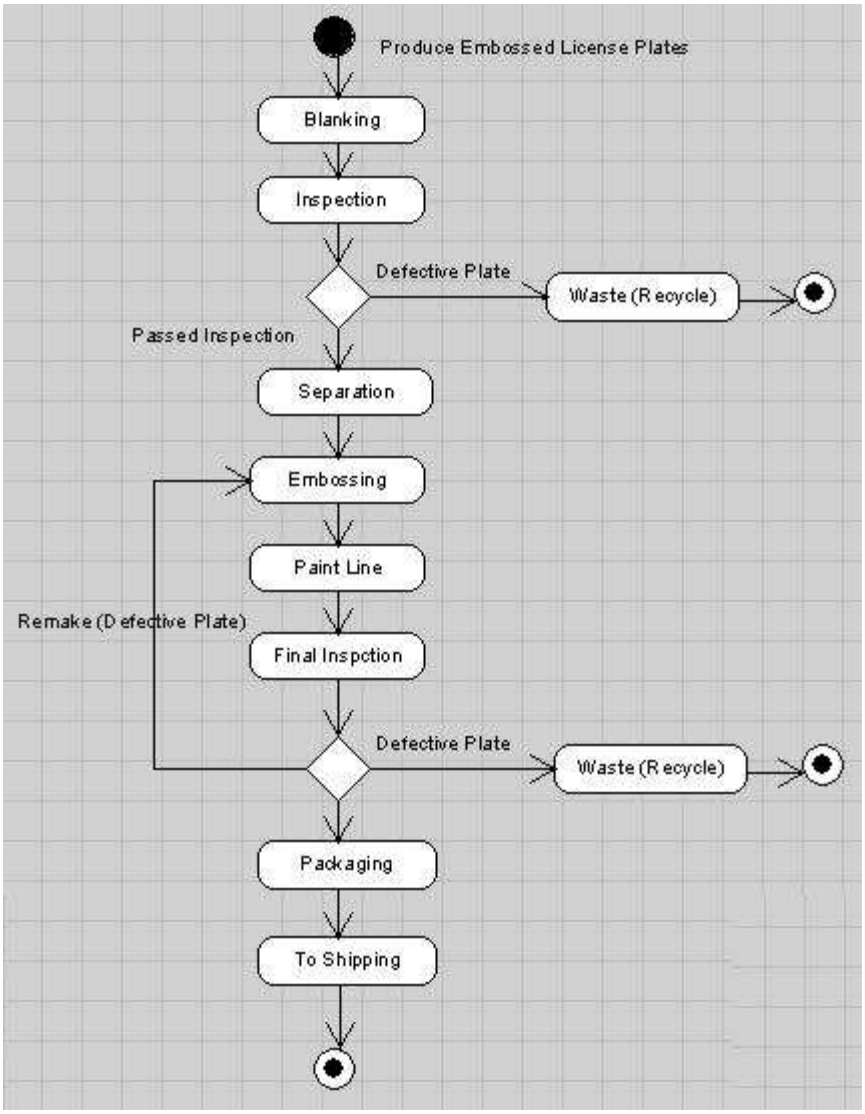

Figure 2–1 Manufacturing Activity Diagram

Manufacturing Logs for quarterly orders are created in the planning process. Each floor supervisor covers one or more work centers and utilizes a Manufacturing Log to determine the daily allotment of work. As the manufacturing order progresses, the supervisor simply highlights completed work and continues down the list. Recounting, Manufacturing Log is ordered by *county*, Emergency Orders, reprioritizations, or various plate types in the queue can modify the sequence in which the order is processed and shipped.

4.2.4.1 Blanking

Embossed plates are produced from *blank plates* produced on the *Blanking Line*. Blanks are produced when a roll of graphic vinyl material is laminated onto a roll of sheet aluminum, and then ran through a cutting die, which cuts the plate at the specified dimension, and simultaneously punches holes in the plate's corners.

If there is any raw material waste, the aluminum is sent out to the recycling center, but is otherwise considered waste material. The waste produced in the blanking process is not accounted for in planning for aluminum because less than 1% of the aluminum used is wasted.

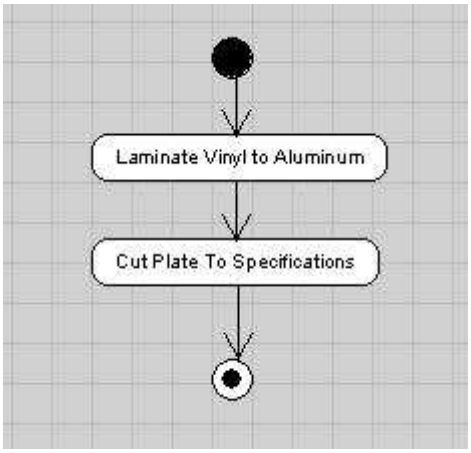

Figure 2–2 Blanking Activity Diagram

4.2.4.2 Separation

After a predefined number of blank plates are produced, they are sent to the Separation Work Center and inspected for flaws. All defective plates are considered waste; and are logged for inventory purposes prior to leaving the factory. After inspection, all plates are separated into singles (e.g. for trailers) or sets (e.g. for automobiles) and placed into specialized racks. This process prepares blank plates for embossing.

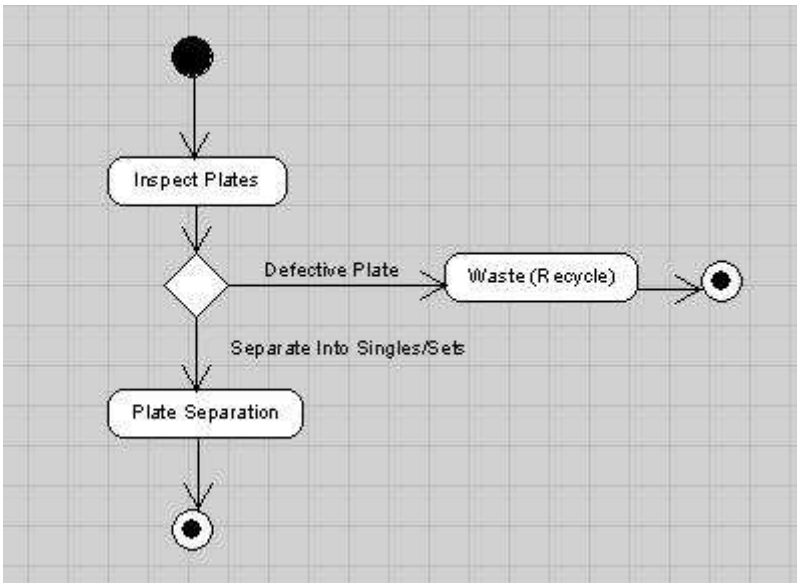

Figure 2–3 Plate Separation Activity Diagram

4.2.4.3 Emobossing Station

A *Runlist for Embossers* originates from the Manufacturing Log and is used to assign work and track the embossing process. Each line item in the Runlist for Embossers is identical to the Manufacturing Log except that it does not contain the Status column. Each runlist contains the county, plate types, alphanumeric series that assigned to each embossing crew on a daily basis. Listed below in Table 2-9 and Table 2.10 is the data tracked in the Runlist for Embossers and its corresponding explanation:

Table 2–9 Runlist for Embossers Information

Job	County	Plate Type	Beginning/Ending	Sets Ordered	Singles Ordered	System No
100629	Adams	M/C-REG	001-IWI / 348-IWI	0	453	TAA03-134
100629	Adams	PAS-DES	348-IWI / 999-IWI	651	1,302	TAA03-134
…						
100629	Denver	PAS-REG	001-IWT / 999-IWT	999	1,998	TAA03-134
100629	Denver	PAS-REG	001-IWU / 999-IWU	999	1,998	TAA03-134

Table 2–10 Runlist for Embossers Explanation

Item	Description
Job	System Assigned Job Number – relates to a system number (see below)
County	County – Manufacturing runs are typically run by county
Plate Type	Type of Plate. E.g. M/C-REG. Motor Cycle Regular
Beginning/Ending	Start and End of Plate Series
Sets Ordered	Number of plate singles to be produces – applies to passenger cars, for example. Doesn't apply to singles, like motorcycles.
Singles Ordered	Number of plate singles to be produces – applies to both passenger car sets and motor cycle singles.
System No	Relates to the Job Number – Is also used as the internal Sales Order Number

Embossing occurs when blank plates are placed in a hydraulic press, and compressed between heavy iron jaws unto a series of tempered steel dies that produces the desired alphanumeric sequence into the plate. Plates are embossed in either sets or singles, depending on the plate type. After the plate is pressed, it is ejected from the press, and the dies are manually changed to produce the next alphanumeric number.

Every time plates are ejected from the hydraulic press, they are placed on a pallet. This process continues until all plates in the plate type or county series has been embossed. Upon completion, the pallet is then moved to the Paint Line Holding and the embossing crew will begin on the next series. Depending on varying factors, such as mixing singles with sets, as a rule of thumb, pallets can hold a maximum of 4000 sets (8000 plates) or 3000 singles.

The License Plate Factory has three hydraulic presses that can operate simultaneously. In full production, 20,000 plates can be embossed in a single day.

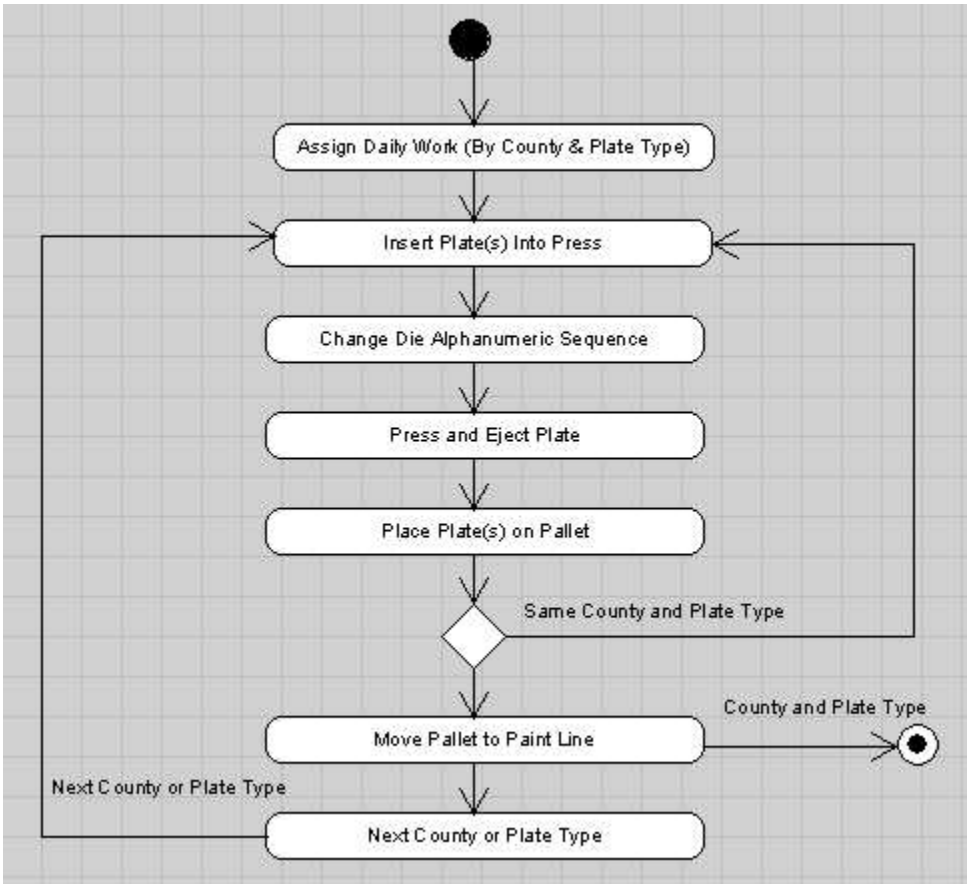

Figure 2–4 Embossing Process Activity Diagram

4.2.4.4 The Paint Line

As a result of the embossing process, plates are placed on pallets by county and plate type and moved to the *paint line holding area* prior to being painted. Plates remain at the holding area until the Paint Line Supervisor determines that enough plates of the same color can be painted, thereby saving time in the setup process. At the appropriate time, plates are individually removed from the pallets and fed into a machine that applies the paint (ink), bakes it, and cools each plate prior to final inspection.

To maximize shop floor efficiency, Paint Line Supervisor reviews the Manufacturing Log and compares it inventory in the holding. The daily run is created weighing the following factors: 1) emergency requests, 2) county prioritizations, 3) the Manufacturing Log, and 4) the different colors that need to be applied.

Note (Paint Line Run Lists)

The daily run is also given to the packaging area on a daily basis so workers know in advance which plates will be packaged throughout the day. Additionally, all plates produced in a day are also packaged.

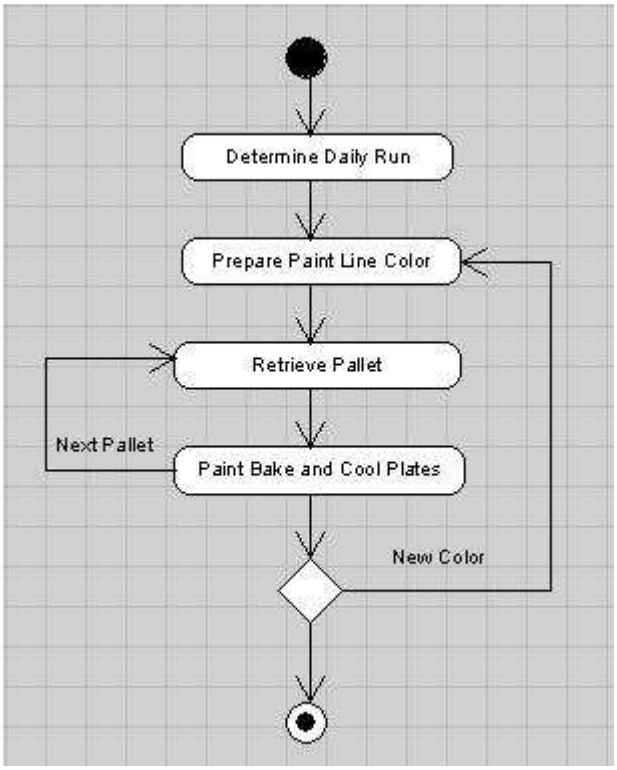

Figure 2–5 Paint Line Activity Diagram

4.2.4.5 Final Inspection and Remakes

After the painting process, each plate is inspected for flaws that were introduced either during the embossing or painting process. Defective plates are logged by plate type and number and thrown into the recycling bin. Once an adequate number of plates are logged, the list is sent to an embossing crew where they will be quickly embossed and resent through the Paint Line. The entire remake process takes approximately 20 minutes. The short timeframe is necessary because, as illustrated below, plates are packaged in series, and a bottleneck occurs in the packaging work station remakes were not done post haste.

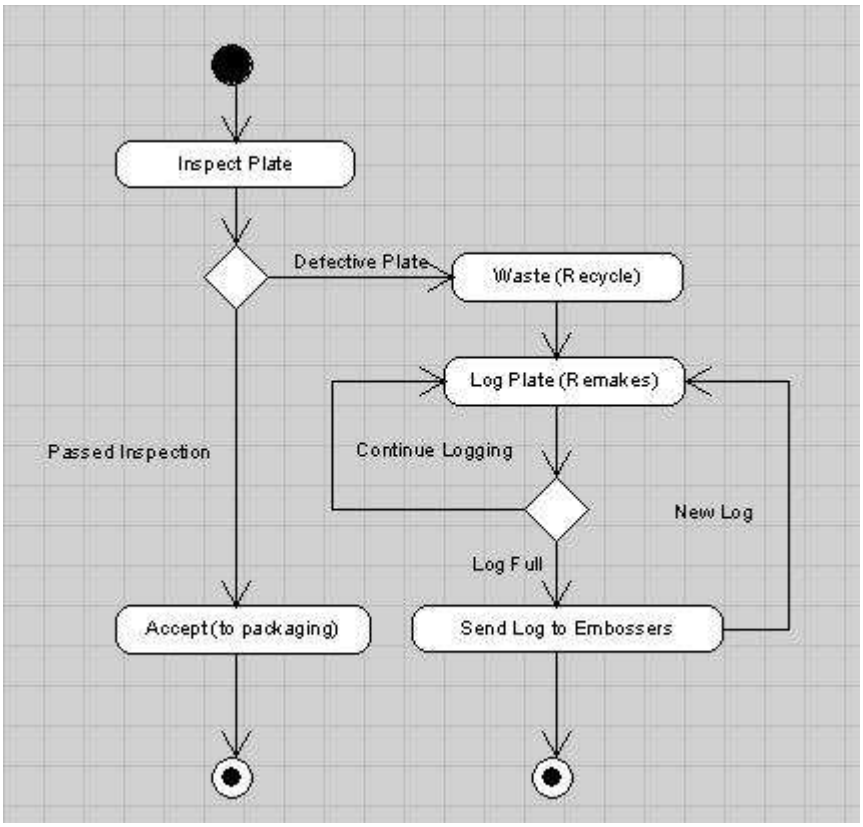

Figure 2–6 Final Inspection and Remakes Activity Diagram

4.2.4.6 Packaging

After final inspection, plates arriving in the packaging area are placed in alphanumeric order and stacked in groups of specific quantities as determined by type of plate. For instance, passenger plates are grouped into stacks of 50 sets. Trailer plates, being singles, are placed into stacks of seventy-five. The stacks of plates are then transferred to the bagging machines where they are sealed in clear plastic bags and then placed in a pre-assigned box for shipping.

To hasten the packaging process, each box is made up well in advance. Boxes are prepared by manually by stamping the *county name*, *plate type*, and *plate series* on the outside of each box. It is important to note that each of the same type of box can contain any variation of quantities depending on the plates unit of measure (single/set). As each plate is passed through the shipping line, it is placed in a plastic bag and into the appropriate box. Once the box is completely filled the box is sealed and placed on an assigned pallet for shipping. While there are minor exceptions when dealing with small quantities of license plates in a single box, Table 2-10 contains the number of plates that are planned for each box:

Table 2–11 Plates Per Box

Plate Types	Quantities
Sets	50 Sets Per Box (e.g. Passenger Car Plates)
Singles	75 Singles Per Box (e.g. Trailers)
Motor Cycle	100 Plates Per Box

During the packaging process, remakes for each box are tracked by dog-earing the box with the appropriate license plate number. Remakes are identified when the next sequential number in a plate series doesn't appear in the stack. Boxes that have not been completed will remain open and available until all remakes manufactured and placed in the box.

Note (Handling Remakes)

It is important to note that shipping boxes are earmarked with any plates being remade as a result of the final inspection process. Shipping boxes will remain open until all plates are remanufactured, pass final inspection, and are placed in the box.

In the final stage of packaging, pallets, which contain products for a single county, are stacked and inventoried. Once a pallet is full, it is shrink-wrapped and moved to a standby area to await shipment.

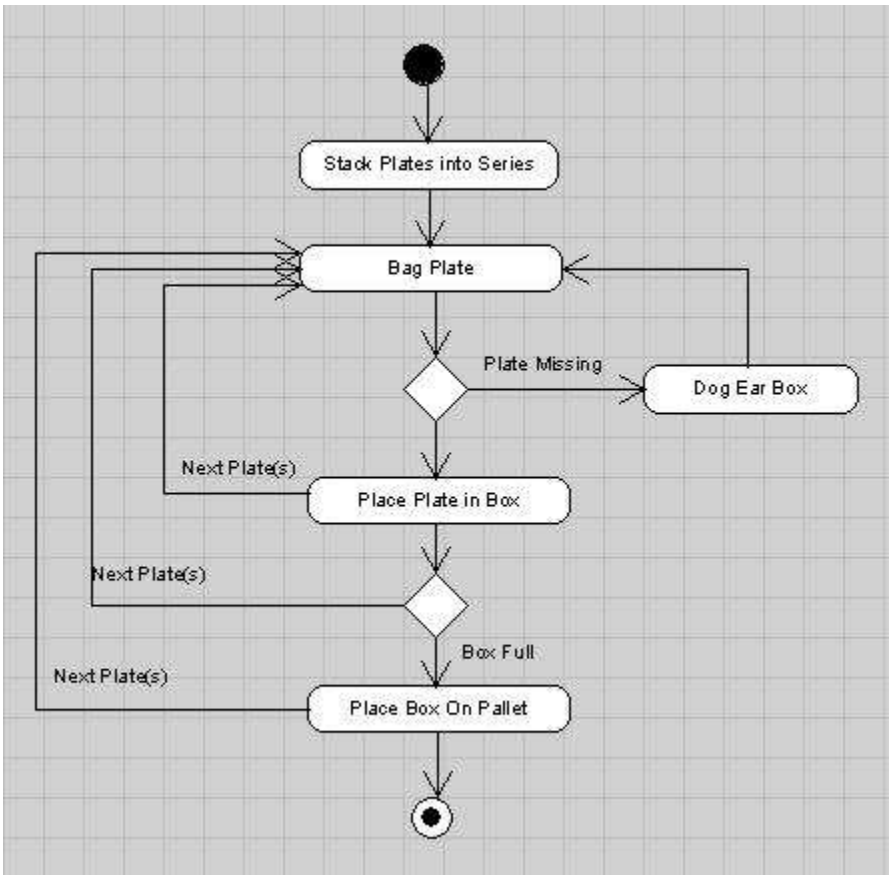

Figure 2–7 Packaging Activity Diagram

4.2.5 Shipping

The shipment of license plates is either handled by UPS or Correctional Industries. The actual trucking assignment depends on the amount being shipped. Typically, smaller shipments of less than 20 boxes sent through UPS, whereas all others are shipments are handled by Correctional Industries.

Shipping is usually performed by county after the all plates related to a single order have been manufactured and packaged. There are exceptions, however, because sometimes a county will have an immediate for a particular plate type, so that plate type will be shipped – leaving the remaining order for a later date. Emergency orders typically contain one plate type for one county, so they are naturally shipped in their entirety.

Packing slips are created to identify each item in a particular shipment. Additionally, the packing slips are used as proof of delivery for the order. The shipping crew, therefore, reconciles/inventories the packing slip to the actual product to ensure that all items are

present. Additionally, the shipping crew is responsible preparing each pallet prior to shipment by shrink-wrapping all boxes to the pallet accordingly.

4.2.6 Invoicing

Invoice packages are generated and mailed to the DMV monthly. Typically, an invoice package is a compilation of all products shipped to all the counties during a monthly timeframe. Enclosed in the package, is the invoice, pertinent excerpts from the sales order, and all packing slips that were used to ship the product. So in sending out such a package, the DMV is capable of reconciling and tracking all products shipped. This is necessary because of the large number of counties and license plates involved in each Quarterly Request.

Note (Invoicing Overview)

The above paragraph is a very brief overview of the invoicing process. If needed, more detail will be added upon request.

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