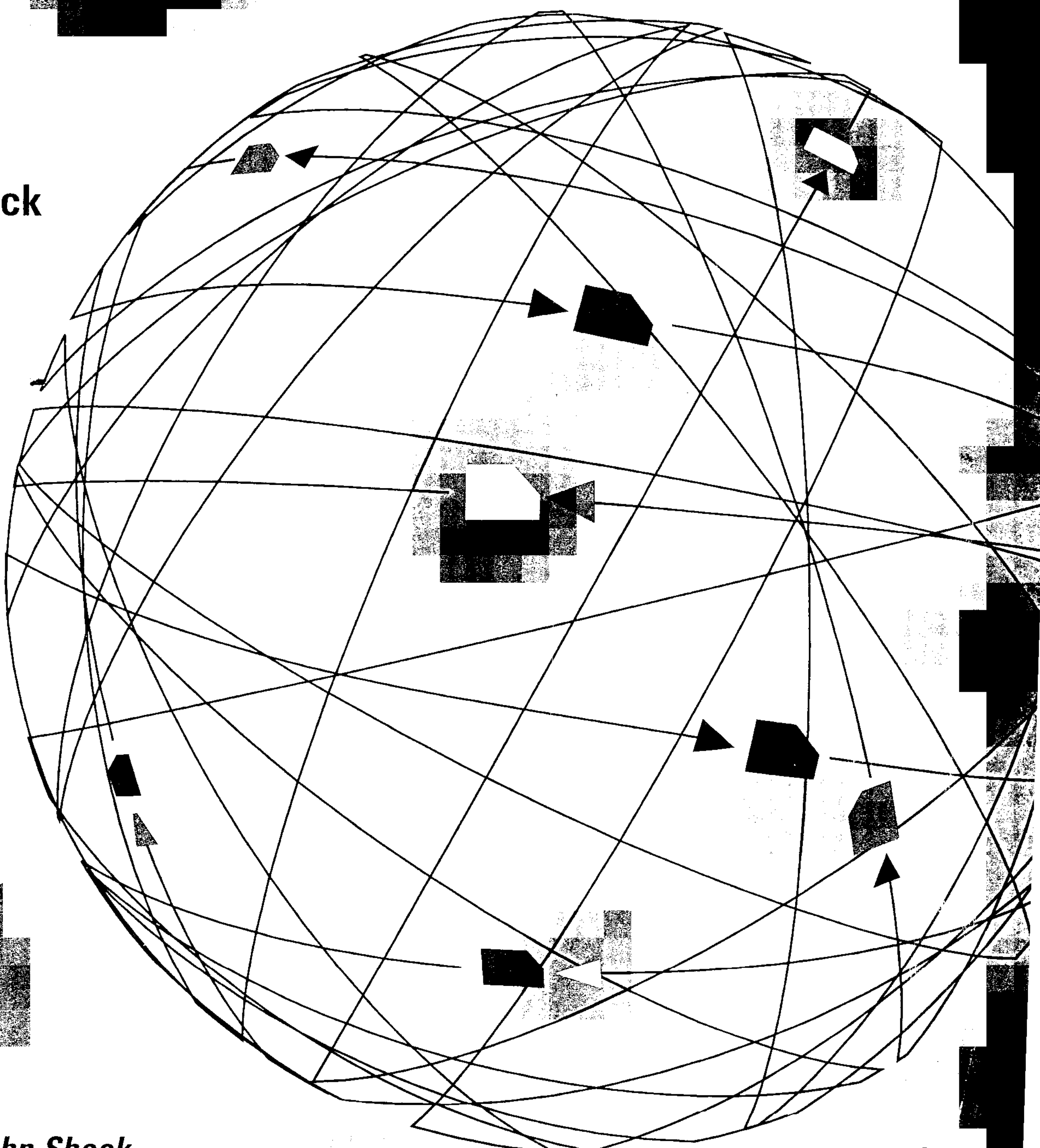
Seeing the Whole

mapping the extended value stream

by

Dan Jones

Jim Womack



foreword by ***John Shook***

Objectives of Mapping Extended Value Streams

1. Raise consciousness in every firm and function touching the value stream of the enormous waste of time, effort, and movement in the Current State — where 9 out of 10 steps and 99 percent of elapsed time are typically waste.

2. Raise consciousness in every firm and function of the effect of its actions on every other firm and function touching the value stream.

3. Learn how a value stream team with representatives from every firm can envision a series of Future States and an Ideal State for their shared value streams.

4. Learn how the team can progressively implement:

   - A Future State 1 in which smooth, leveled pull and flow are introduced *within* every facility touching the value stream.

   - A Future State 2 in which smooth, leveled pull and frequent replenishment loops are introduced *between* every facility touching the value stream (eliminating warehousing and cross-docking in the process.)

   - An Ideal State (providing a North Star for collectively steering toward the perfect value stream with zero waste) by compressing the value stream and introducing right-sized technologies.

5. Learn how value stream teams can share costs and gains to create win-win-win outcomes for every value stream participant.

Seeing the Whole

Mapping the Extended Value Stream

By Dan Jones and Jim Womack
Foreword by John Shook

An LEI Breakthrough Guide

THE LEAN ENTERPRISE INSTITUTE
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Version 1.0
March 2002

GETTING STARTED
CURRENT STATE MAP
THE EXTENDED VALUE STREAM
FUTURE STATE 1
FUTURE STATE 2
IDEAL STATE
ACHIEVING FUTURE STATES

With gratitude to Dan Jones's colleagues at the Lean Enterprise Research Center, Cardiff University, in particular Nick Rich, Dave Brunt, Dave Simons and Matthias Holweg, who helped pioneer extended value stream mapping.

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Whenever there is a product for a customer, there is a value stream.
The challenge lies in seeing it.

— Mike Rother & John Shook, *Learning to See*

When you have learned to see value streams in individual facilities,
it's time to see and then to optimize entire value streams,
from raw materials to customer.

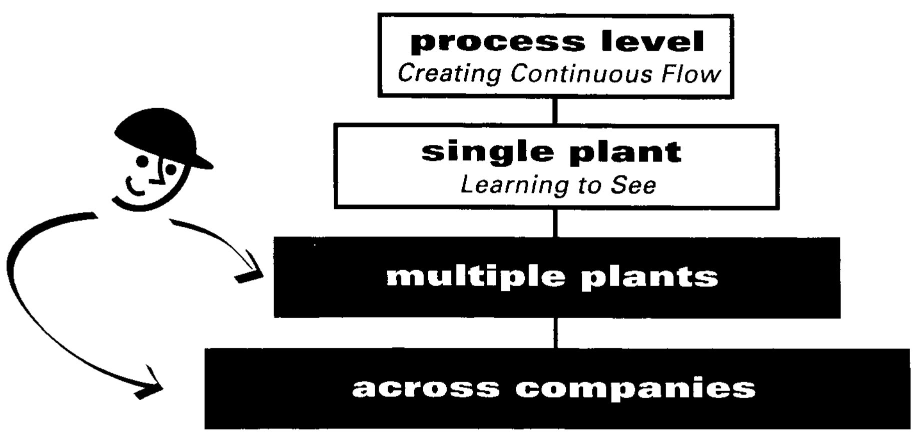
FOREWORD

When the first item in the Lean Tool Kit, *Learning to See*, was launched in June of 1998, we at LEI began to hear from managers in many industries that "this is the tool we have been looking for." Readers quickly realized that the great power of *Learning to See* lies in focusing attention on the value stream for individual product families within plants. Rather than concentrating on isolated processes along the value stream or aggregated activities serving many value streams, readers could suddenly see how to optimize the flow of each product from receiving to shipping. This insight was breathtaking for many managers caught up in narrow techniques or looking at only one activity in a complex system.

As more and more people heard about *Learning to See* and began to practice value stream mapping, we began to hear of additional needs. "How can we introduce continuous flow at the process level within facilities?" And, "How can we expand the scope of value stream mapping beyond individual facilities to the extended value stream from raw materials to the end customer?" Many readers suspected that if there was vast *muda* within the walls of each facility there was even more *muda* between facilities and firms.

We had been thinking about this issue long before June of 1998. Indeed, the initial outline of *Learning to See* devoted equal attention to mapping the extended value stream. However, we knew that extended mapping is more challenging than facility-level mapping and we soon concluded that we would need several publications. In addition, we realized that managers would do well to hone their skills by "learning to see" within a limited area before venturing forth to "see the whole".

We therefore included a diagram in *Learning to See* illustrating different levels of mapping. We've recently addressed the process level with Mike Rother and Rick Harris' *Creating Continuous Flow*. In *Seeing the Whole* we tackle the higher, extended levels.



Why is an extended map harder to draw? It's not because the fundamental concept is different. At every level of mapping, we are simply observing and writing down every step in information processing and physical transformation for individual product families. We observe the flow of customer desires moving up the value stream, in the form of orders or schedules, and then observe the progress of products moving downstream in response to this information, from raw materials to finished items.

Extended mapping is harder because we need to map across plant, divisional, and company boundaries. In addition, we must pay careful attention to the variability in order and materials flows. Finally, we need to think about untangling, simplifying, and "right sizing" complex logistics and information systems, large facilities, and high-scale processing technologies serving many value streams and operated by many firms.

Conducting extended mapping requires the cooperation of many departments and divisions within firms and between firms. These entities rarely think about the total flow of individual products and often hide information from each other while pushing in opposite directions. In addition, extended mapping requires that line managers devote hard-to-spare time to direct observation of each product family's value stream. Failing this, higher-level mapping easily becomes a staff exercise (or a consulting project) yielding only another report that's soon forgotten.

These additional dimensions of extended mapping truly are challenges. However, we have had considerable success in overcoming them, including recent instances during the preparation of this workbook. We now are certain that change-agent managers can meet these challenges and we know that time already devoted to learning to see at the process and the facility levels will prove invaluable as you expand your field of view.

As with *Learning to See*, we hope users of *Seeing the Whole* will tell us how to improve this tool and will be willing to share their experiences with the lean community. Numerous user suggestions, based on hands-on experience with value stream mapping at the facility level, have permitted us to improve *Learning to See* several times since its first publication. We look forward to an intense and continuing dialogue with the lean community on *Seeing the Whole* as well.

John Shook
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March 2002

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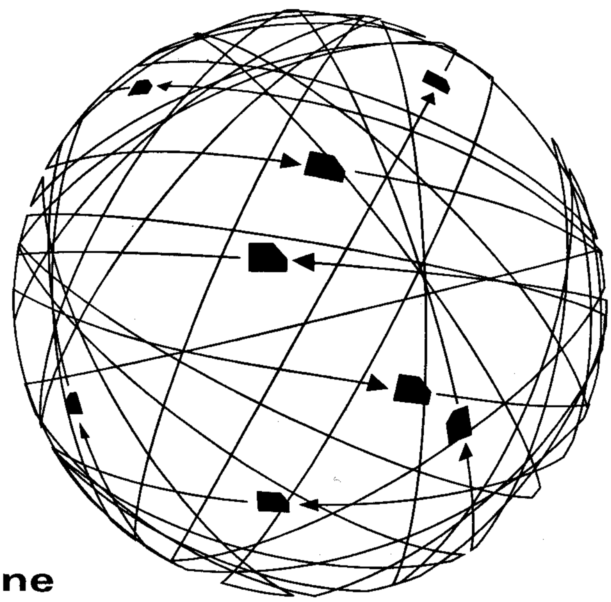


INTRODUCTION

Changing Your Focal Plane

For years now we have loved to "take a walk" along the entire value stream for a given product, looking for value and waste. We've done this for dozens of products in many industries and followed streams across the world. We presented our first example in *Lean Thinking* (1996) when we drew the path of a humble cola can. This simple product with only three parts (barrel, top, and "pop-top") traveled 319 days through nine facilities owned by six companies in four countries to progress from ore in the ground into the hands of the customer. Yet during this long march only three hours of value creating activities were performed and the great majority of the steps — storing, picking, packing, shipping, unpacking, binning, checking, reworking, and endless movements of information to manage the system's complexity — created no value at all.

Looking at the whole has always seemed natural to us and doing so will always suggest ways to slash costs while dramatically improving responsiveness and quality. Yet most managers we have encountered on our value stream walks want to stand in one place and look at only one point — their machine, their department, their plant, their firm. Often, the machine, the department, the plant, and the firm are performing well on traditional measures — high labor and machine utilization, low defects, on-time shipments — and the managers are pleased with their achievements.

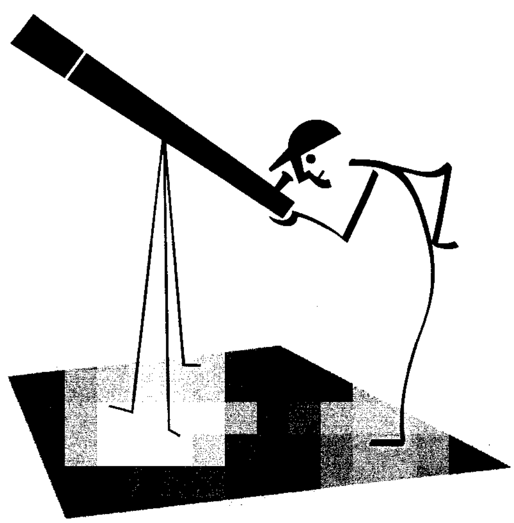
However, when we get managers to change their focal plane from their assets and their organization to look at the product itself and what is actually happening on its long journey, they immediately realize that the performance of the entire value stream is abysmally sub-optimal. Indeed, most wonder how they have worked for years in traditionally compartmentalized operations and somehow failed to notice the waste everywhere. Then they wonder what they can do about the mess.

And that is the big challenge. Managers find it easy and fun to draw extended current state maps. And this is a critical first step because it raises consciousness. But providing a management tool that permits the waste to be removed permanently by achieving successive future states has been much harder. It was only when we first saw Mike Rother and John Shook drawing future state value stream maps at the facility level and coupling these maps to an action plan for implementation that we begin to see how we might guide groups of managers — for all extended value streams are shared across many departments and firms — toward similar results for entire streams.

In this breakthrough guide we present our method. It proposes a progression through two "future states" to an "ideal state" after the current state is jointly identified and agreed. The first future state will be relatively easy and creates the setting for the second. The second future state is considerably harder and reaching the ideal state will require a major commitment by all the firms touching the product. Yet we believe that the savings in time and effort and the improvements in quality at every step will encourage teams to keep going once they learn how to jointly optimize the shared stream.

Eventually, with some creative thinking about process and information technologies, we believe that most value streams can be compressed and smoothed to a point where a large fraction of the original steps and practically all of the throughput time are eliminated. This will be a true revolution and the value stream team getting there first will have an overwhelming competitive advantage. More important in most cases, the team getting started first and making the quickest progress along the path will have a *continuing* competitive advantage.

The key is to summon your courage, form your cross-department and cross-company team, and change your focal plane to focus on the product. Then learn to see the whole and … get going to take out the waste! We will be urging you on and waiting to hear about your problems and successes.



Dan Jones and Jim Womack
Ross-on-Wye, Herefordshire, UK
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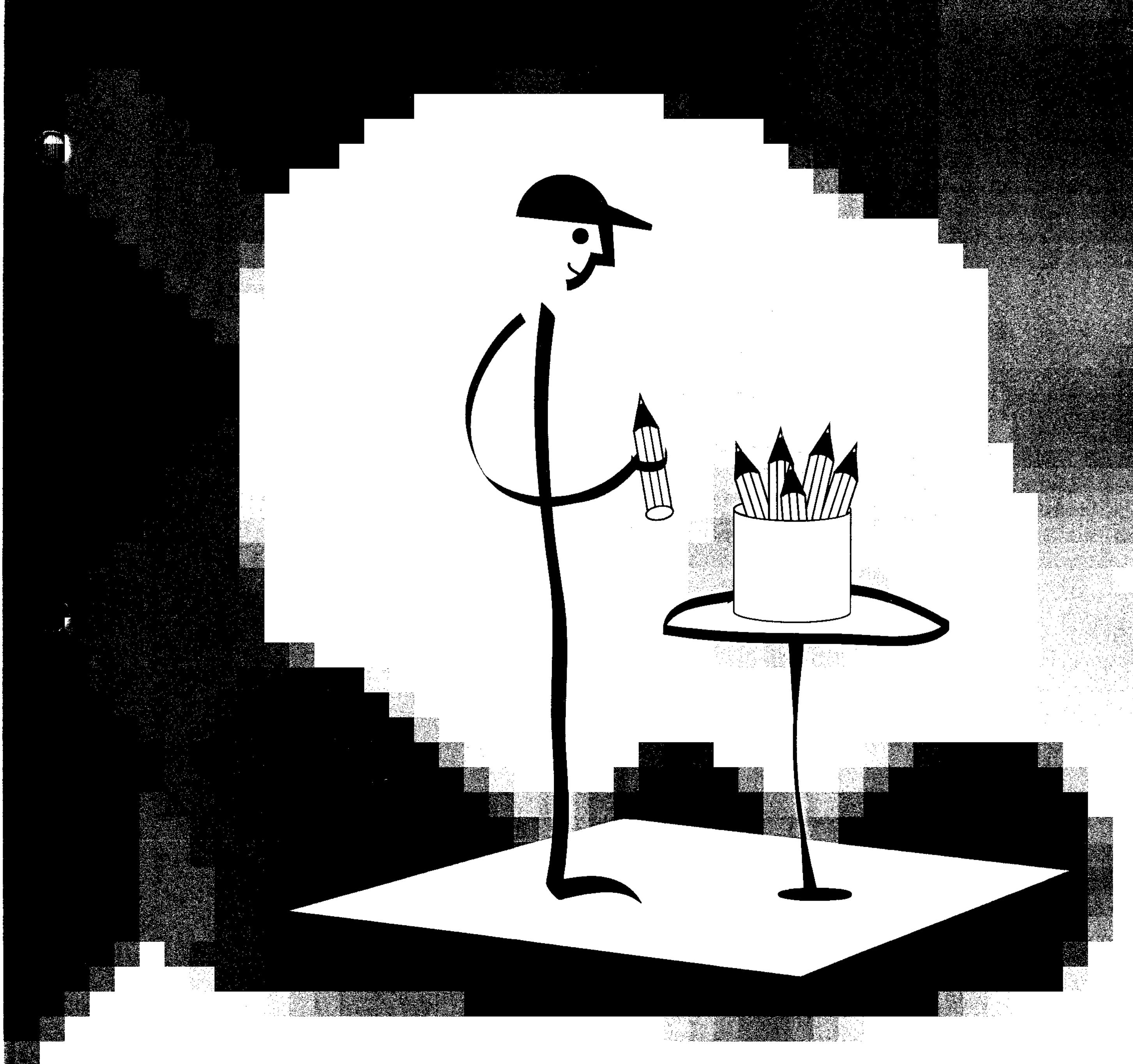
March 2002

PART I: GETTING STARTED



PART I: GETTING STARTED

What is Extended Value Stream Mapping?

Selecting a Product Family

Determining a Manageable Field of View

Choosing a Leader and a Value Stream Team

Taking a Walk

A Final Benefit: A Diagnostic for the Functions

What is Extended Value Stream Mapping?

An extended value stream is simply all of the actions — both value-creating and wasteful — required to bring a product from raw materials into the arms of the customer. The relevant actions to be mapped consist of two flows: (a) orders traveling upstream from the customer (or from the sales department when forecasts substitute for confirmed orders) and (b) products coming down the value stream from raw materials to customer. Together these constitute a closed circuit of demand and response.

Value stream mapping is the simple process of directly observing the flows of information and materials as they now occur, summarizing them visually, and then envisioning a future state with much better performance.

Maps of the extended value stream can be drawn for products currently in production or for future products being planned. The only difference is that the "current state" map for a product in production shows conditions as they exist today while the "current state" map for a new product shows the "business as usual" approach to making the product compared with alternative "future states" and "ideal states" with less waste and greater responsiveness.

Selecting a Product Family

The whole point of value stream mapping is to disaggregate operational issues to the level of specific products, where they can be more easily acted on by managers. To do this you need to start at the furthest point downstream (toward the customer) to be mapped and to define product families at that point. Typically a product family will include a group of product variants passing through similar processing steps and using common equipment just prior to shipment to the customer. For example:

- In a power tools business, a product family might be medium-sized electric drills utilizing a common chassis and passing through a common assembly cell as the last manufacturing step, even though the finished product has many different features and customer labels. Alternatively the mapping team might define the product family as the motor going into the medium drills and map back upstream from that point.

- In the auto industry, a product family might be a car platform (e.g., Ford Explorer and Mercury Mountaineer) produced in an assembly plant. Alternatively it might be a major component supplied to auto assemblers — let's say an alternator — using a common design architecture and assembled in a cell, but with varying power outputs and with different attachment points for different vehicles.

Where Should I Start?

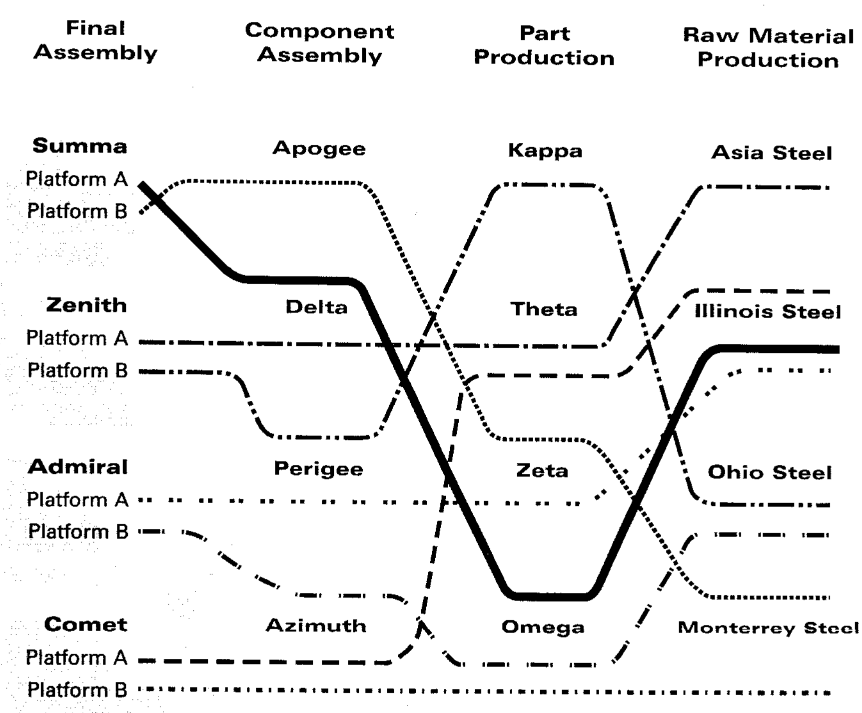
Because products not yet in production seem easier and cheaper to rethink than products already in production, we often hear that extended or macro-mapping should focus on new products. And it is certainly an excellent idea to create "business as usual" and alternative "future state" and "ideal state" maps for every new product family as a core part of the product development process.

However, we do worry that concentrating on ideal states for products entering production at some point in the future will remove the pressure to improve stagnant value streams for current products that will continue in production for years to come. It's our belief that organizations truly committed to value stream thinking will tackle both their existing value streams for current products and those envisioned for new products.

- In the aerospace industry, a product family might be an entire airframe (e.g., the Boeing 737 or Airbus A320). Alternatively, it might be a major sub-assembly, for example the vertical tail. The sub-assembly may have many variants for different buyers of the completed aircraft. For example the tail structure might incorporate different aerials and fairings for navigation and communication equipment. And the products within the family chosen for mapping might differ slightly in dimensions. For example, the basic tail design might be slightly longer for use on a stretched airframe. However, the vertical tail clearly constitutes a product family because all variants follow the same manufacturing path and have no commonality with tails for other aircraft, even if they are made in other areas of the same facilities by the same firm utilizing parts from the same suppliers.

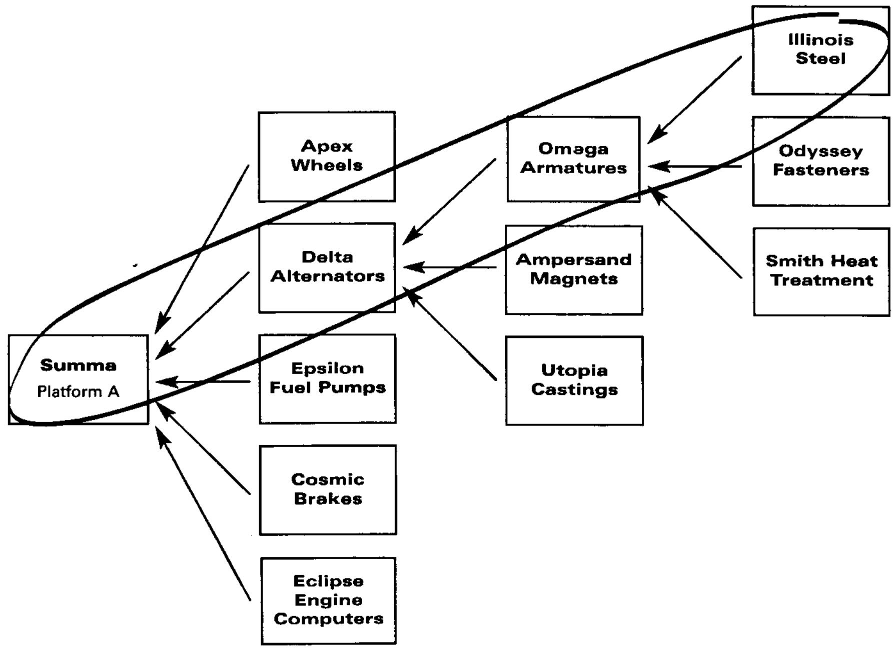
Note that the same product family may be supplied to a number of different end customers and have cosmetic differences causing the casual observer to overlook product commonality. Nevertheless from the standpoint of the firm or facility at the downstream end of the map, the product is clearly a family.

Note also from the chart below that firms along similar value streams often have complex relations with each other. Delta supplies similar components to both Summa and Zenith; Omega fabricates similar parts for Delta and Azimuth; and Illinois Steel supplies materials to Theta and Zeta as well as Omega. Extended mapping cuts through this clutter to focus on just one stream in order to think of improvements that can eventually apply to all streams.



Firms along similar value streams often have complex relations with each other.

Product Families from Summa's Perspective



Because the product family is defined from the vantage point of the final step mapped, the concept is essentially "fractal". That is, you can define product families from many starting points and map backward up value streams of varying lengths. For example, what appears to be a product family for an armature manufacturer (large armatures for alternators) is simply one of many component parts for an alternator producer (who might define a product family as large alternators). And the large alternator is just one component among many from the standpoint of the auto assembler who defines product families in terms of vehicle platforms.

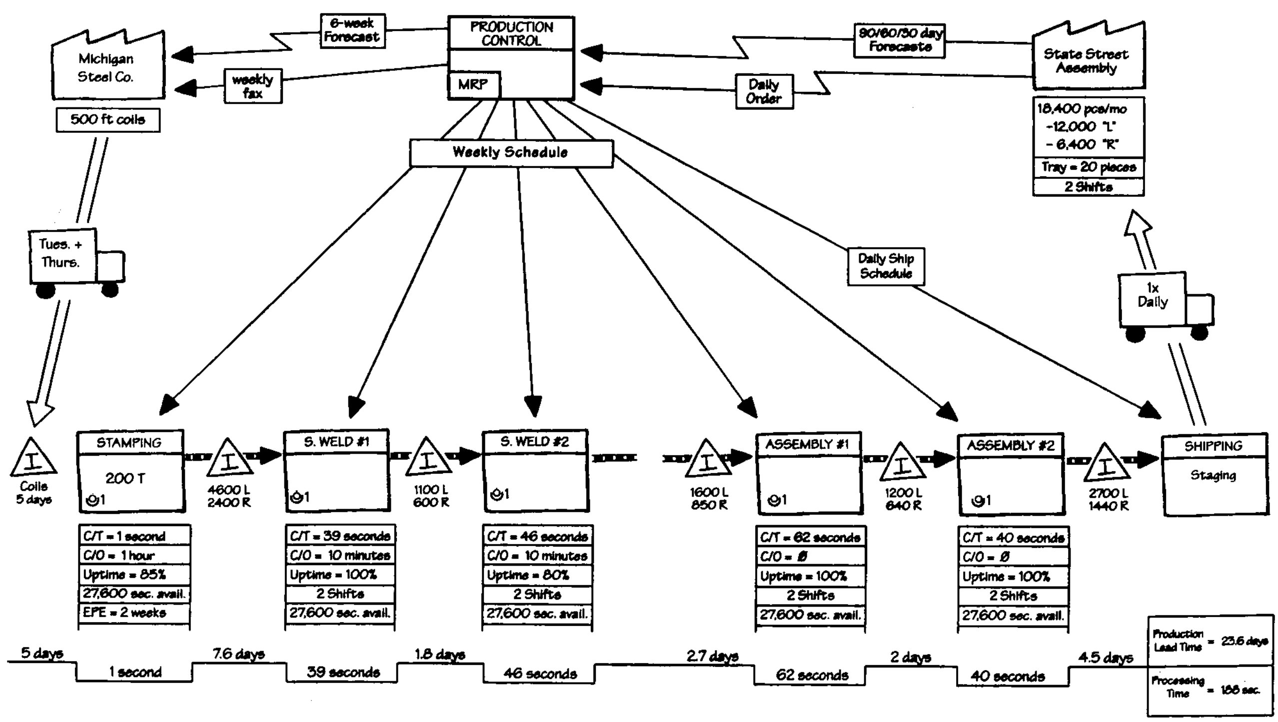
As you select your start point and move back upstream, it is best for your first map to follow the path of a single family and a single component in the product. *This is because the first objective of extended mapping is to achieve a breakthrough in shared consciousness of waste and to identify systematic opportunities for eliminating the waste.* It is highly likely that the wastes identified by following one component back upstream will occur in roughly equal measure in every component going into the finished product. The alternative approach of mapping the value stream of every component going into the product is time consuming and costly and we have found that it overwhelms managers with too much data.

In subsequent rounds of mapping — if the collaborators in the mapping process find ways to work together and achieve useful results — additional maps can be created for many or all of the components and parts going into a finished product. But to get started, keep it simple and focus first on achieving a breakthrough in raising your team's consciousness!

Determining a Manageable Field of View

The ideal map would truly show the whole. That is, it would start with the end customer who uses or consumes the product. The map would then follow the product all the way up the value stream to molecules in the ground (or in the recycling bin), showing all the wasted actions and information loss en route. However, just as trying to map all of a product's parts back upstream is overwhelming, trying to see too far with your current vision may be fruitless. We advise novice mappers that a lot can be learned by looking one or two facilities and firms upstream from wherever you start. This is the minimum scope of extended mapping.

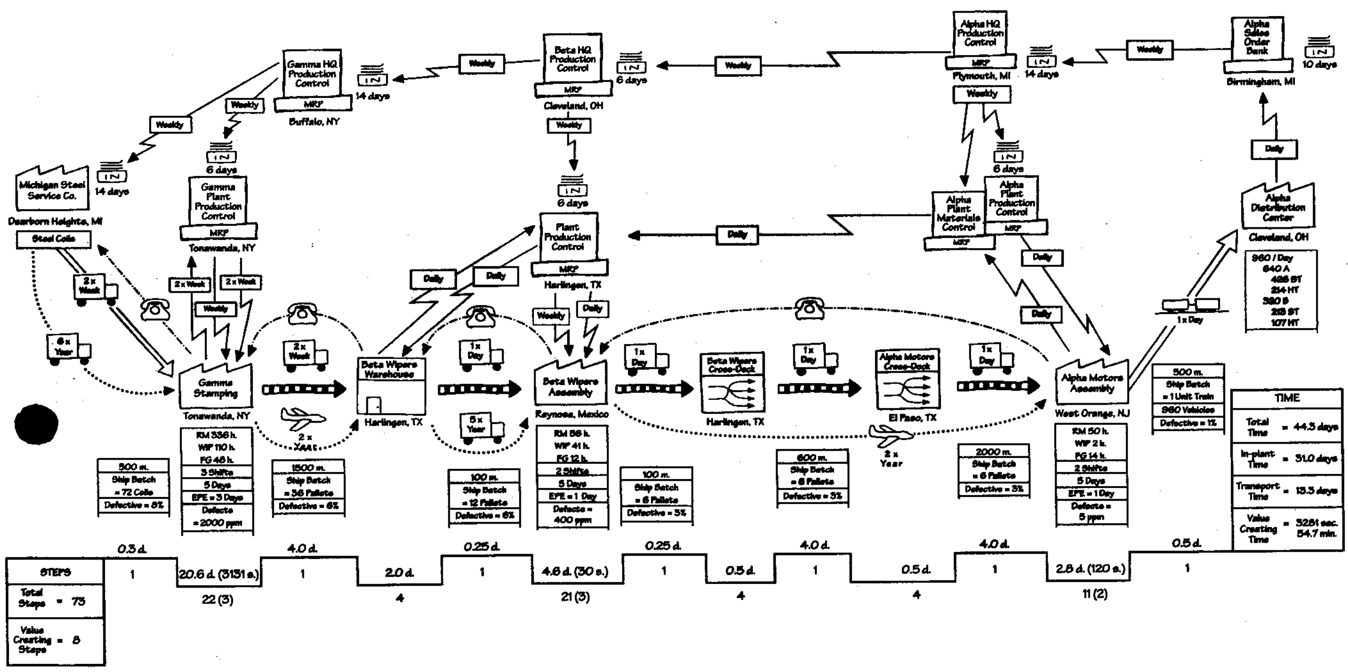
Single Facility Field of View – *Learning to See*



Even at this minimum scope, note that the scale of maps changes dramatically between *Learning to See* (facility-level maps) and *Seeing the Whole.* The facility boxes that are the primary units of analysis in this breakthrough guide are the same size as the individual process boxes ("stamping", "welding", "assembly") in *Learning to See.* Vast expanses of people and equipment within facilities have been shrunk into tiny boxes so we can see the big picture!

In this guide, we will draw maps with an intermediate field of view, starting at the distribution center for the completed product and proceeding upstream to raw materials (e.g., rolls of steel). For those with more ambition and with full cooperation from upstream facilities and firms, it is both possible and desirable to start near the end customer and work far back upstream toward raw materials.

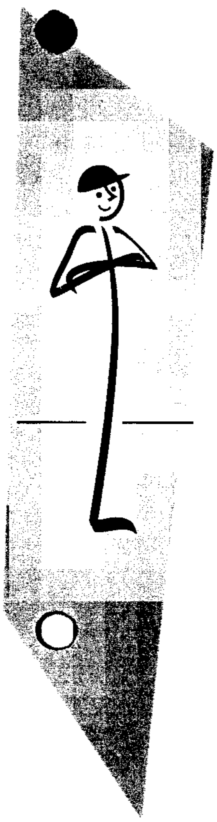
Multiple Facilities Field of View — *Seeing the Whole*



Choosing a Leader and a Value Stream Team

We hope that you are experienced with facility-level mapping as described in *Learning to See* and have appointed value stream managers for all of the value streams within your facilities. We are convinced that this is critical to gain the full benefit of mapping at the facility level. What's more, the knowledge of facility-level value stream managers will be invaluable for quickly drawing accurate maps of the extended value stream.

However, by their nature, extended maps cross facilities and firms. Suppose managers are in place for the segments of the stream within each facility. Who has the responsibility for directly managing the total stream across firms, to connect the maps and lead the improvement process? The reality in most cases will be "no one". So there is a need for a new type of manager who we will call the "Product Line Manager" (PLM).



The Product Line Manager

This individual in the most downstream firm needs to be much more than a technician concerned with one facility. Indeed, for optimal results the Product Line Manager needs to be a <u>business manager</u>. This means "business" in the sense of taking responsibility for making money and growing market share with the product family in question. And it means "manager" in the sense of looking concretely at the precise actions that need to be taken all along the value stream to remove waste and cost while improving quality and responsiveness.

The most successful firms we have encountered using these techniques have Product Line Managers who think about product marketing and engineering as well as production and purchasing. With all the elements of marketing, design, production, and supply chain under his or her oversight, this individual is in a unique position to judge the performance of the many functions touching the product. Indeed, as we will see in a moment, a continuing assessment of functional performance along with precise prescriptions for improvement is one of the most important benefits of product line management.

However, we do not usually recommend what is sometimes called a "product team" structure in which all of the engineering, operations, purchasing, and marketing employees supporting the product are put on a dedicated team. Doing this causes a large amount of organizational disruption during the transition and this structure still does not address the behavior of upstream partner firms. What's more, it is really not necessary in most cases if the PLM takes an energetic approach to the job.

Perhaps the best known example of what we are talking about in the manufacturing world today is the Chief Engineer for a car platform at Toyota (a job position also called the *shusa*). This individual is widely known by everyone in the company and takes responsibility for the success of the product in terms of return on investment and market share. Yet the Chief Engineer, like our proposed PLM, actually has no direct authority over marketing (which is done by a large marketing department), over engineering (which is done by the various parts of the large engineering department), over production (which is done by the operations department), and over suppliers (who are managed by the purchasing department, and the production control and logistics department.) Instead the Chief Engineer, working with a tiny group of assistants, is the one person who can "see the whole" and think about the necessary contributions from every functional activity and every upstream firm to create and deliver a successful product as judged by the end customer.

The PLM in the most downstream firm will be even more effective if there are similar individuals in each of the upstream firms so that for any product a quick evaluation can be conducted by a small group composed of one PLM per firm.

But this is not likely to be the case. Indeed, in today's world very few firms have true PLMs. (One of our concerns in preparing this breakthrough guide has been that the very managers most able to benefit from it don't currently exist in many firms!) Thus to get started, someone from one of the functional areas in the most downstream firm will probably need to take the lead and aim to achieve a breakthrough in consciousness. This individual probably will have little formal authority for overseeing the value stream and will therefore need to lead by example and by raising hopes about possible joint gains.

We can't guarantee that anyone anywhere along a value stream can succeed in raising every participant's consciousness to transform the entire stream. We can guarantee that anyone anywhere can raise the important issues and make constructive change a possibility where it was previously impossible ... if they have the courage to act.

Anyone Can Start Anywhere

One of our most surprising experiences in developing this breakthrough guide was encountering the general manager of a supplier firm who had read *Learning to See* and then approached his OEM customers and his upstream suppliers proposing to jointly map their shared value streams.

Needless to say, the customers were a bit surprised at first because suppliers are rarely proactive about anything but selling their latest products. And the suppliers were surprised because they had previously only heard from this firm in the context of price negotiations. A proposal to jointly discuss the process of value creation was totally unexpected.

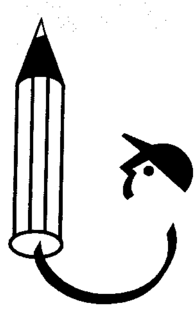
Nevertheless several customers and suppliers accepted the challenge. By jointly evaluating several sample streams they soon learned that the OEMs, the supplier, and the supplier's suppliers were working at cross purposes on information management and conducting many activities in the wrong place at the wrong scale with a large cost penalty. Thus an effort by one firm mid-way along the value stream to raise consciousness caused all of the parties to think in new and more productive ways.

To be successful, the mapping leader needs to be someone who can gain the respect of upstream partners by conducting a rigorous and fair process. Logical candidates are from purchasing, production control, logistics, operations, or a process improvement function like quality or process engineering. Any of these can work. However, assigning a buyer from purchasing to be a mapping leader can lead to problems if upstream participants believe that the real purpose of mapping will be to uncover waste at suppliers, followed by demands for immediate price reductions. Thus a purchasing function will probably need to assign mapping leadership to someone from its supplier development group if all participants are to be convinced that the process is fair, balanced, and aimed at win-win-win outcomes.

The value stream team needs to include representatives of all the firms and facilities that share ownership and management of the stream. Ideally, it would also include the relevant departments within each firm — sales, operations, production control and logistics, purchasing, manufacturing engineering, information management, and product engineering. However, this can make the team too large to walk the value stream together, which is often a critical learning experience. Thus we generally recommend a small team with a minimum of one representative per company. The team can query the functions supporting the value stream as necessary to fill in missing information.

The Wrong Role for Consultants and Staffs

An understandable inclination in any firm with busy line managers — and this surely includes practically all firms — is to delegate the task of creating value stream maps to outside consultants or to internal staff groups, typically in operations planning or process improvement departments. However, in our experience this is misguided. The findings of the consultant or staff expert are rarely credible to the managers who need to take action and the consciousness raising experience of walking the value stream together — discovering the waste and jointly agreeing to a cross-firm action plan — simply never happens. A beautiful report is produced by the consultant or staff team — and in our experience the beauty and precision of the maps is generally inversely proportional to their usefulness — but the findings are then filed away and soon forgotten.



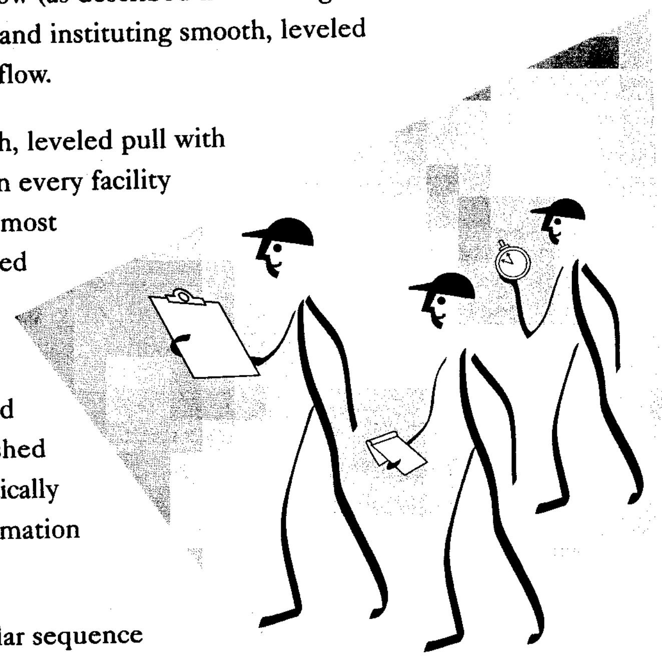
Remember: Only managers taking clear responsibility can fix the mess. So the same managers ought to draw the maps.

Taking a Walk

Once designated, the leader and the team need to take a walk together along the value stream, draw the current state map, and then ask, "Which steps create value?, Which steps are waste?, Why is order flow so erratic?, Why is quality so erratic?, Why are deliveries so erratic?, How can value be enhanced for the end-customer?"

Once the map is drawn so that the current state of an existing value stream is known precisely, it's time to create the first of two "future state" maps that remove wasted steps while stabilizing processes and simplifying information flows. Future State 1 achieves the future state shown in *Learning to See* within each facility touching the product. This means introducing continuous flow (as described in *Creating Continuous Flow*) wherever possible and instituting smooth, leveled pull between the areas of continuous flow.

Future State 2 then introduces smooth, leveled pull with frequent replenishment loops between every facility touching the product. In the process, most warehouses are eliminated, or converted to cross dock operations.



An Ideal State may then co-locate at one site all of the activities required to proceed from raw materials to finished goods, in the process eliminating practically all transport links and needs for information management.

You may or may not find this particular sequence appropriate for your own value streams. In particular, if you are mapping a new value stream for an entirely new product you will probably want to skip directly from the current (business-as-usual) state to an ideal state. We follow the three-step sequence, beginning with Future State 1, in this breakthrough guide because we believe that this is likely to be the most typical approach.

Two Final Benefits

A Diagnostic for Functions

As teams draw their current state value stream maps, they are likely to make a surprising discovery. Most problems identified along the value stream will trace directly to the performance of various functions — information technology, production control, logistics, product engineering, operations, purchasing. What's more, weaknesses in functional performance discovered in the sample value stream will almost certainly be present in every other value stream the firms touch. In our experience, the functions want to support the value stream for each product. But they have a hard time seeing the connection between their activities and the needs of the product.

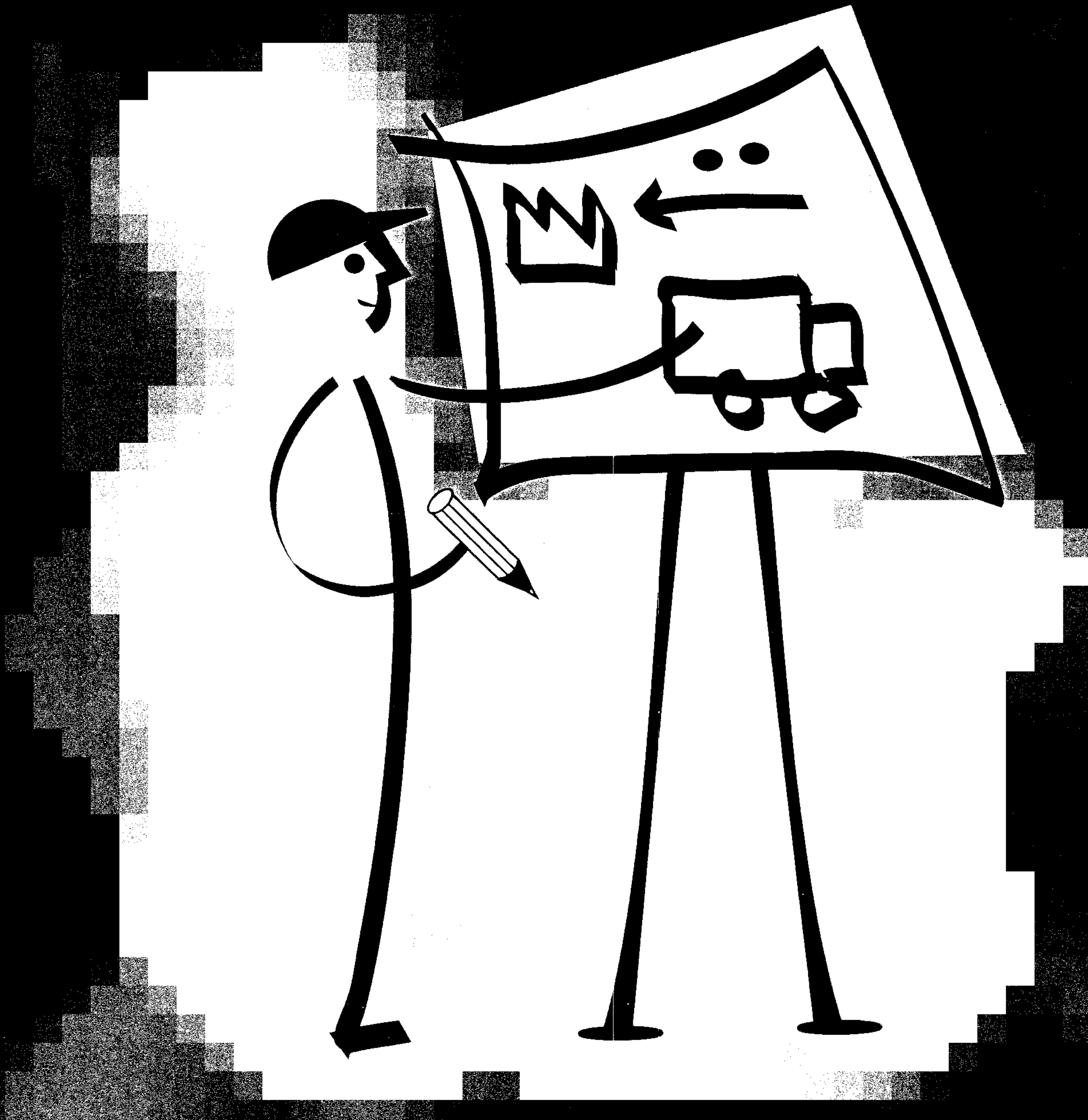
Thus an important benefit of the mapping process — in addition to a breakthrough in consciousness about the magnitude of waste and the enormous opportunities for improvement — can be to give much clearer guidance to each function about its role in supporting value streams. *A real bonus can be achieved if the improved functional performance can then be applied to all value streams within the participating firms.*

A Diagnostic for Relations Between Firms

As teams start mapping, they are likely to make yet another discovery. Today we all use language stressing partnership and cooperation between firms sharing value streams. However, mapping teams in most cases will discover an enormous gap between these high-level principles of collaboration and the day-to-day reality down at the level of each value stream. If the value stream map shows widespread confusion and counter-productive actions between firms at the value stream level, it will be obvious that "partnership" at the top isn't translating into competitiveness at the bottom.

Fortunately, value stream mapping provides a clear and consistent language for firms to start an intelligent conversation with each other about the root causes of their shared cost, quality, reliability, responsiveness, and communications problems. (Indeed, we believe a relentless, fine-grained focus on improving each value stream, rather than high-level agreement on principles, is what has given Toyota its edge in creating the world's leanest supply base.) *A real bonus can be achieved if the practical lessons of shared value stream management can then be applied by each firm to its relations with its other customers and suppliers.*

PART II: THE CURRENT STATE MAP



CURRENT STATE MAP
THE EXTENDED VALUE STREAM
FUTURE STATE 1
FUTURE STATE 2
IDEAL STATE
FUTURE STATES

PART II: THE CURRENT STATE MAP

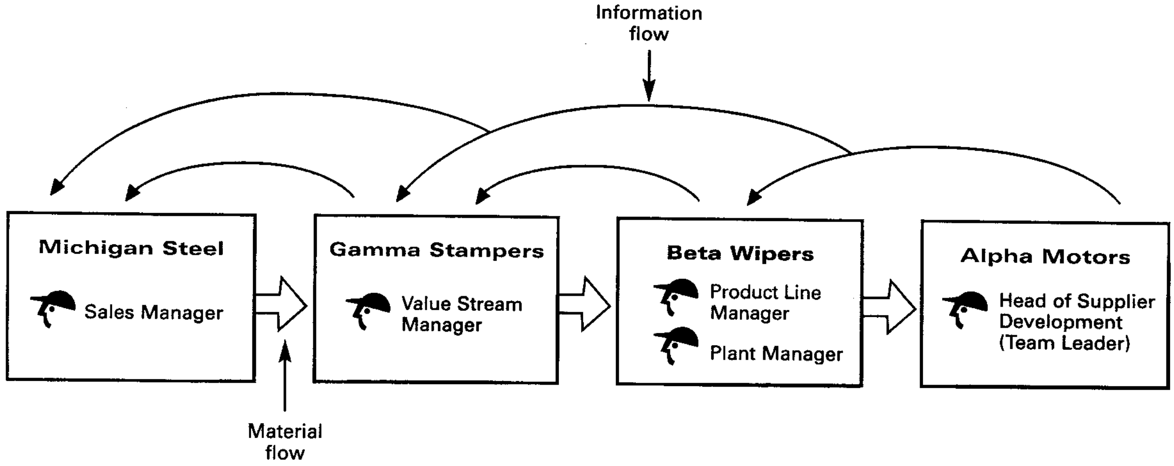
The Current State Map

With the basic principles of extended mapping in hand, it's time to accompany a value stream team creating a map of the current state for a specific product family. This map will characterize the value stream as it is today.

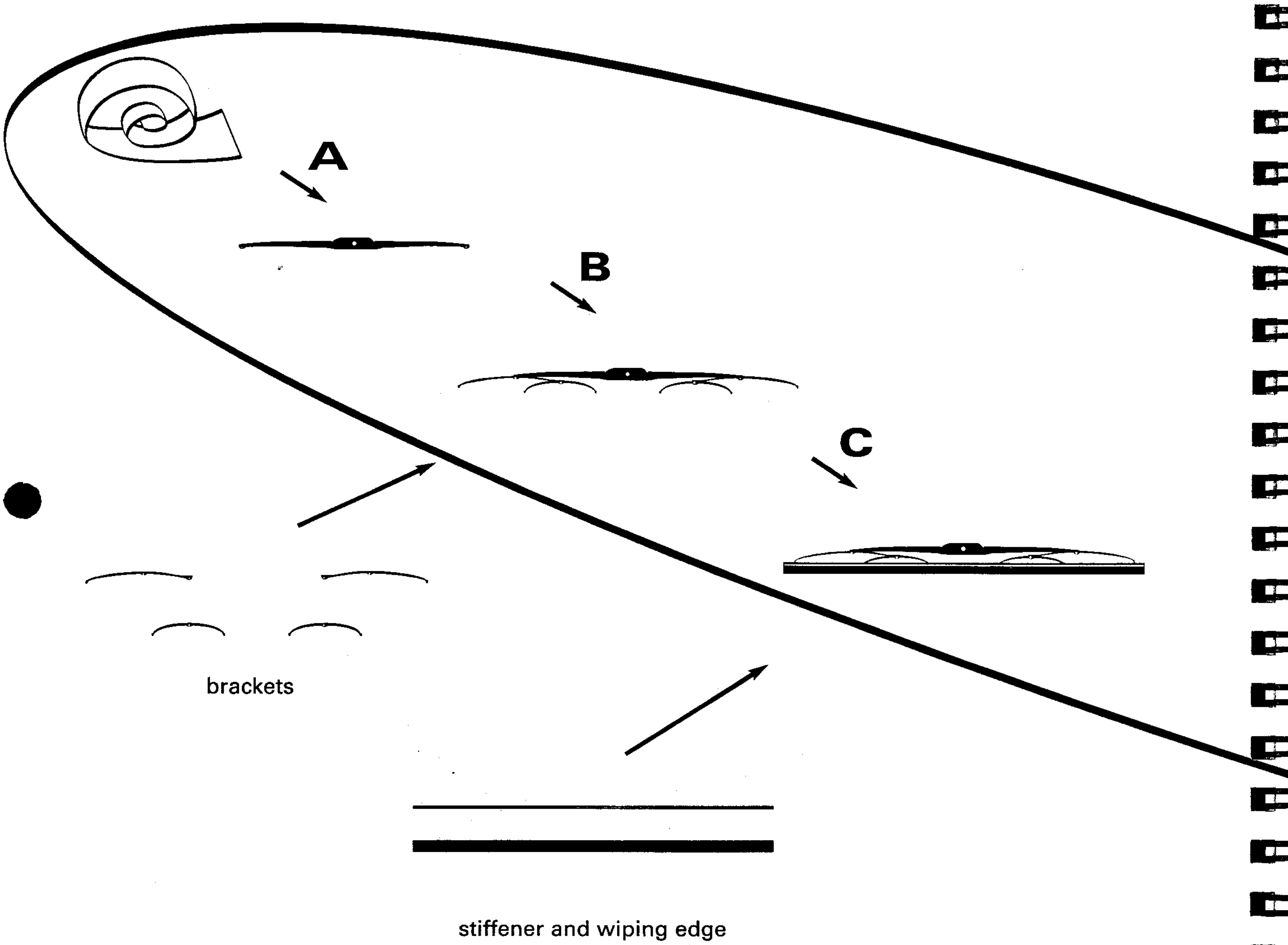
We've chosen to focus on a high-volume automotive component offered with a small number of options — a windshield wiper consisting of a blade holding the actual wiping edge and the arm attaching the blade to the vehicle. This product is similar in complexity and variety to the steering column bracket used to illustrate *Learning to See.*

We've decided to map only an intermediate portion of a total value stream, which runs its entirety from the end user (you in your car) at the downstream end to raw materials (iron ore in the earth) at the upstream end. The portion we will map starts at Alpha Motors, the final assembler of the finished vehicle, toward the customer end of the value stream. We then proceed back up the stream through the facilities of Beta Wipers and Gamma Stamping to the shipping dock at Michigan Steel, a raw materials service center. The five-member team, from the four firms sharing this portion of the value stream, will be led by the head of the supplier development in the purchasing department at Alpha Motors and includes the product line manager and the assembly plant manager at Beta Wipers, the value stream manager for this product family at Gamma Stamping, and the sales manager at Michigan Steel.

Windshield Wiper Value Stream Team



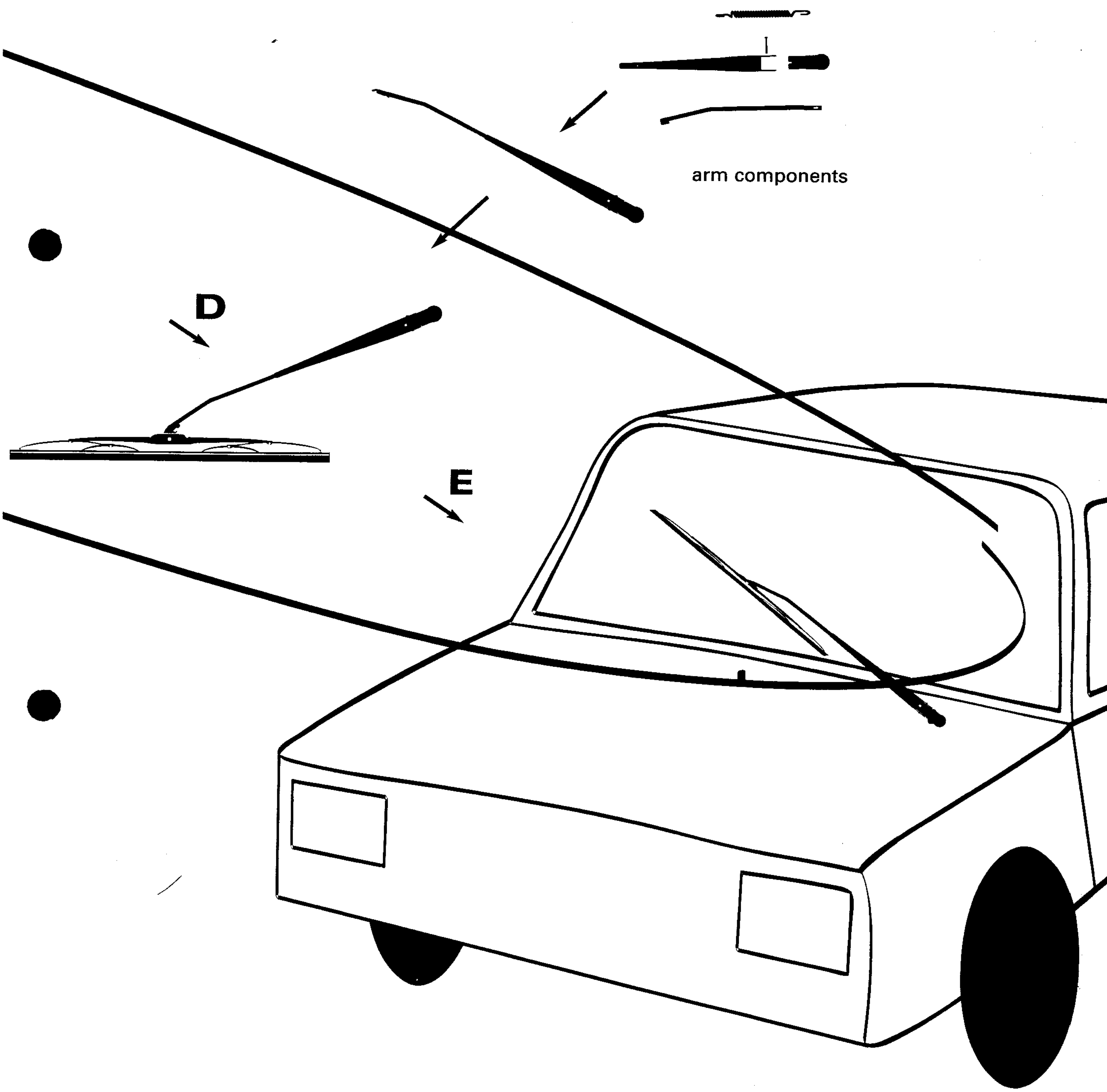
Windshield Wiper Assembly and Fabrication Path



Windshield Wiper Assembly and Fabrication Steps

A. Rolled steel stamped into blade spine
B. Four brackets attached to blade spine
C. Wiping edge attached to blade spine and brackets assembly
D. Blade assembly attached to arm
E. Assembled wiper attached to automobile

Before we start mapping, let's look at an exploded view of this product showing the parts going into the wiper and its fit-point on the end product. Note that we will only map the circled area in this initial map. This is to keep the map simple and to concentrate initially on raising everyone's consciousness of the extended value stream.



Our windshield wiper comes in two specifications — high trim and standard (HT and ST) — and in two sizes — small and large (S and L) — to fit two different vehicles (A and B). The right-hand and left-hand wipers are identical on the vehicles in this example. The trim levels differ only in the paint — a matte-black finish for the standard trim vehicles and a glossy-black finish for the high trim models. The designs for the two models differ only in the size of the parts, not in their number or basic design. This means that the wipers are interchangeable from a final assembly standpoint because they use the same fit points and require the same installation time. The wipers clearly form a product family because all of the actions occurring upstream — component assembly, painting, and stamping — are in the same process sequence in the same firms and use the same processing equipment with a few tool and fixture changes.

With the product family clearly identified, the first step for the team is to "take a walk" along the entire length of the value stream to be mapped, recording the facilities visited, the transport links, every action performed on the product, all information management actions, and the time required. We always suggest starting at the customer end because the customer is the point — indeed, the only point — of these material flows. No product should be advancing that the customer doesn't want and nothing should be happening that the customer doesn't consider of value!

For the wiper example, the list of actions on the product is shown in the following list. Note that we have numbered all of the steps (73) in the left-hand margin of the list and compared these with value creating steps (8) in the first column on the right. We have also recorded the total elapsed time (total product cycle time) which sums the time required to conduct all of the steps on a product (44.3 days) and compared this time with the actual value creating time (54.7 minutes), which is the sum of only the value creating steps.

Physical Actions Required to Create a Windshield Wiper

Total Steps	Value Creating Steps	Total Time	Value Create Time
Raw Materials Supplier:			
Michigan Steel, Dearborn Heights, MI			
1. Load coils for twice weekly direct ship		10m	
Transport Link 1			
2. Direct ship (truck), Tonawanda, NY (500 miles)		8h	
Second-Tier Supplier:			
Gamma Stamping, Tonawanda, New York			
3. Unload coils		10m	
4. Receive & create ticket		10m	
5. Store coils		14d	
6. Convey coil to Stamping Press 1		10m	
7. Mount on coil roller and feed press		5m	
8. Stamp initial (flat) shape	1	1s	1s
9. Accumulate stamped parts during run		4h	
10. Convey parts bin to storage		10m	
11. Store parts		48h	
12. Convey parts in bin to Stamping Press #2		10m	
13. Load parts in magazine, auto feed to press		10m	
14. Stamp final (curved) shape	2	10s	10s
15. Accumulate parts during run		4h	
16. Convey parts to storage area		10m	
17. Store parts		48h	
18. Convey parts to paint shop		10m	
19. Rack parts on moving conveyor, clean, dip, paint & bake	3	130m	52m
20. Remove parts, inspect, sort & accumulate in bin		2h	
21. Convey parts to storage		10m	
22. Store parts prior to shipment		48h	
23. Load parts for twice weekly direct ship		10m	
Transport Link 2			
24. Direct ship (truck) to Harlingen, TX (1500 miles)		96h	
First-Tier Supplier Warehouse:			
Beta Wipers, Harlingen, TX			
25. Unload		10m	
26. Formally receive		10m	
27. Store parts		48h	
28. Retrieve and load truck for daily direct ship		10m	

Total Steps	Value Creating Steps	Total Time	Value Create Time
Transport Link 3			
29. Direct ship (truck) to Reynosa, Mexico (100 miles with queue at border check point)		6h	
First Tier Supplier Assembly Plant: Beta Wipers, Reynosa, Mexico			
30. Formally receive and move to storage area		10m	
31. Store in receiving storage area		48h	
32. Convey from storage area to first assembly step		10m	
33. Store at first assembly step		8h	
34. Insert fastener clip and secure with pin	4	10s	10s
35. Accumulate parts in first assembly step		4h	
36. Convey parts to second assembly step		10m	
37. Store at second assembly step		8h	
38. Clasp wiper blade assembly to sub assemblies	5	10s	10s
39. Accumulate parts in second assembly step		4h	
40. Convey parts to third assembly step		10m	
41. Store at third assembly step		8h	
42. Insert wiping edge in blade assembly	6	10s	10s
43. Accumulate parts from third assembly step		4h	
44. Convey parts to inspection, test & pack step		10m	
45. Store parts at inspection & test		8h	
46.Conduct inspection, test & pack in protective sleeve			20s
47. Accumulate parts at pack		4h	
48. Convey parts to shipping dock		10m	
49. Store awaiting shipment		12h	
50. Load truck for daily direct ship		10m	
Transport Link 4			
51. Ship by truck to Harlingen, TX (100 miles with queue at border check point)		6h	
First-Tier Supplier Cross-Dock: Beta Wipers, Harlingen, TX			
52. Unload truck		10m	
53. Cross-Dock		10m	
54. Store awaiting full truck		12h	
55. Reload truck for daily ship		10m	
Transport Link 5			
56. Ship via multi-pick-up route (truck) El Paso, TX (600 miles)		96h	

Total Steps

	Value Creating Steps	Total Time	Value Create Time
Car Company Cross-Dock: Alpha Motors, El Paso, TX			
57. Unload truck		10m	
58. Cross-Dock		10m	
59. Store awaiting full truck		12h	
60. Reload truck for daily direct ship		10m	
Transport Link 6			
61. Direct ship to West Orange, NJ by truck (2000 miles)		96h	
Car Company's State Street Assembly Plant: Alpha Motors, West Orange, NJ			
62. Formally receive		10m	
63. Convey to storage area		10m	
64. Store awaiting need		48h	
65. Convey to kitting area		10m	
66. Transfer to assembly bins		10m	
67. Store in assembly bins awaiting need		2h	
68. Assemble wiper blade in holder to arm	7	1m	1m
69. Attach wiper arm with blade to vehicle	8	1m	1m
70. Line off vehicle and test		10m	
71. Store finished vehicles		12h	
72. Load train for daily direct ship		2h	
Transport Link 7			
73. Ship to Cleveland Distribution Center by train (500 miles)		12h	

Summary of Physical Actions

	Total	Value Creating
Steps	73	8
Time	44.3 Days	54.7 Min.

Distance 5300 Miles over 7 Transport Links

THE EXTENDED VALUE STREAM | FUTURE STATE 1 | FUTURE STATE 2 | IDEAL STATE | ACHIEVING FUTURE STATES

Learning to See Value

As we write down the actions, the ability to distinguish value-creating steps from currently necessary but wasteful steps and value-creating time from currently necessary but wasted time is critically important. The enormous gap between total time and value-creating time and between total actions and value-creating actions is the opportunity the value stream team must seize.

Given the importance of telling the difference between value and waste, it is not surprising that we often encounter readers and audiences who are anxious about their ability to categorize actions correctly. Actually, it is very simple. Put yourself in the position of the consumer and ask if you would pay less for the product or be less satisfied with it if a given step and its necessary time were left out.

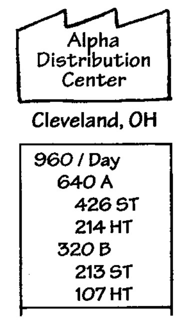
In the case of attaching the wipers to the vehicle in the Alpha assembly plant, the answer is clear. Consumers do not expect to receive their vehicles with the wipers in the front seat, accompanied by a polite note stating, "Some assembly required". The final attachment step clearly creates value for the customer. So do the seven actions of stamping the metal arms, painting them, and sub-assembling them prior to attachment on the vehicle.

By contrast, look at the many movements of the product within each plant between process steps, the long transport links between plants, the warehousing and cross-docking activities along the value stream, the numerous testing and inspection steps, and the repeated packing and unpacking of the product. Would you, as a consumer, be less satisfied with your vehicle if these currently necessary activities could somehow be left out? Of course not. And would you be happier if the car company could get you the model you want with the trim level you want quicker because these steps were left out? Of course you would. Indeed, the more these steps cause a delay in receiving exactly the product you want, the less you probably are willing to pay for it. Far from creating value, these shipping, packing, inspecting, and warehousing actions actually destroy it!

Drawing a Useful Map

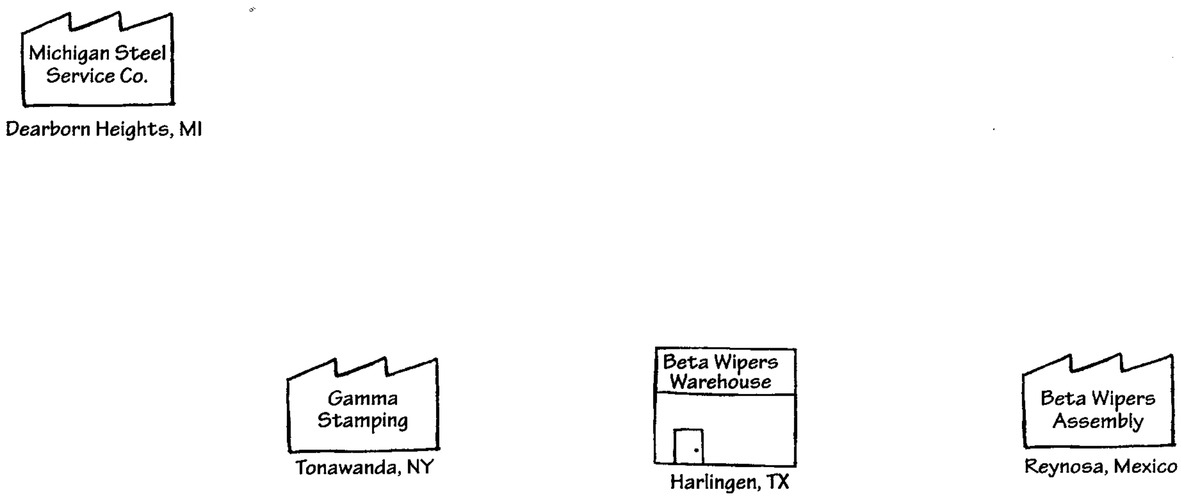
The long list of steps, categorized by waste and value, is highly provocative because it helps the team realize the enormous opportunity for savings. What's more, the ratios of value-creating time to total time (54.7 minutes out of 63,792 or 0.08%) and of value-creating steps to total steps (8 out of 73 or 11%) and the amount of transport distance (5300 miles) are quite typical for discrete manufactured products in the world today. Our example is the norm, not the exception, and similar ratios are likely to emerge from any maps you draw.

First View of the Current State Map Showing the Customer



However, for this information to be useful we need to simplify it and put it in a form managers can act on. The best way to do this is to group and summarize the data by each of the facilities and transport links the product encounters. Again, the place to start is with the customer, at the most downstream end of the map. In this case, the customer is the Alpha Motors Distribution Center, which interacts with car dealers to get end consumers the products they want. We'll represent this organization with a facility icon placed on the right side of the map. Underneath this icon we'll draw a data box recording the customer requirement for size and frequency of shipment.

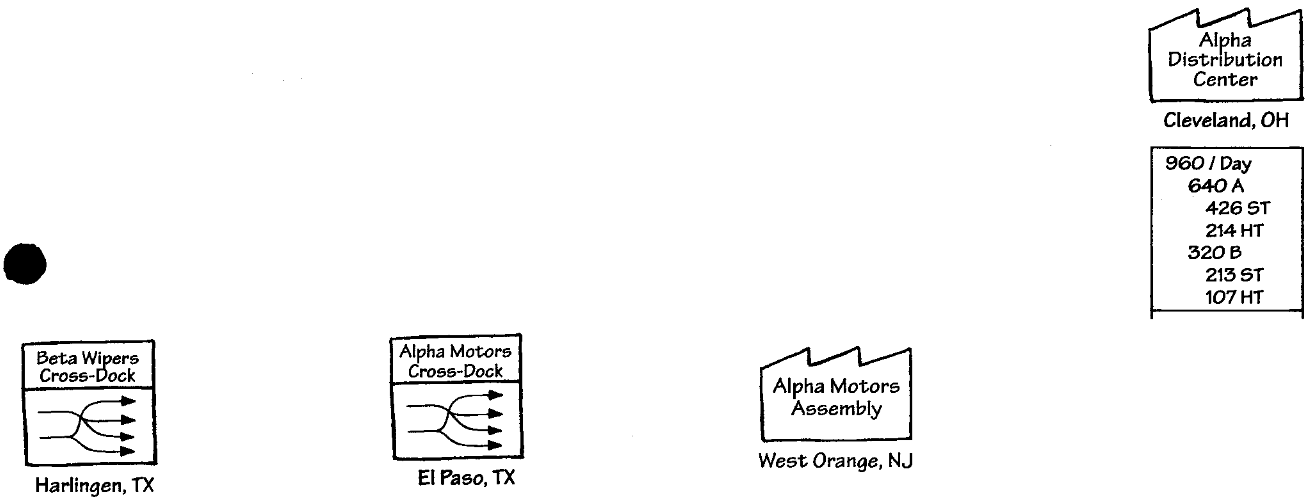
Note that this facility is a cross-docking operation where vehicles are sorted and sent onward as quickly as possible to several regional storage areas across North America. From there they go to auto retailers and then into the hands of the customer. Thus our intermediate-view map stops considerably short of the total value stream map that it may be useful to draw at some point in the future.



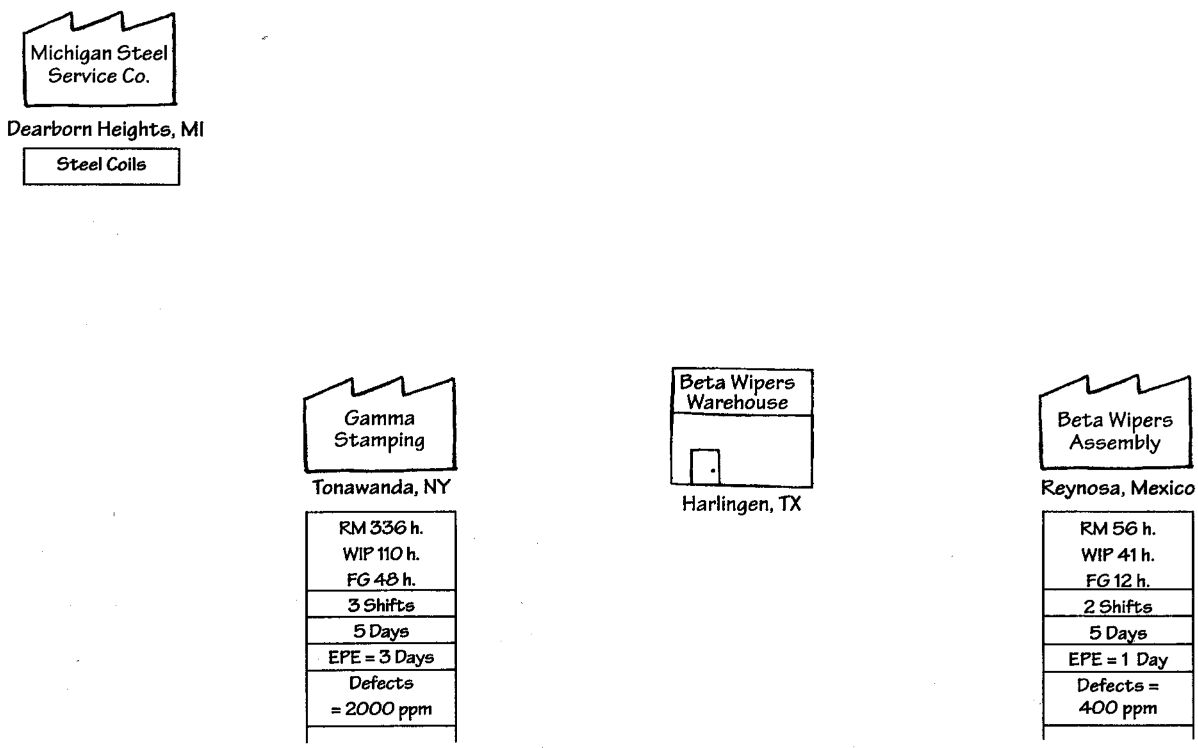
To get from raw materials to the Alpha Distribution Center, the product flows through seven assembly, fabrication, warehousing, and cross-dock facilities. These are:

- Alpha Motors' State Street Assembly Plant in West Orange, New Jersey
- Alpha Motors' Cross-Dock, for many components from many suppliers, in El Paso, Texas
- Beta Wipers' Cross-Dock, for parts sent from several plants to many customers, in Harlingen, Texas
- Beta Wipers' Component Assembly Plant in Reynosa, Mexico
- Beta Wipers' Parts Warehouse in Harlingen, Texas
- Gamma Stamping's Stamping and Painting Plant in Tonawanda, New York
- Michigan Steel's Service Center in Dearborn Heights, Michigan

Current State Map Showing All Facilities



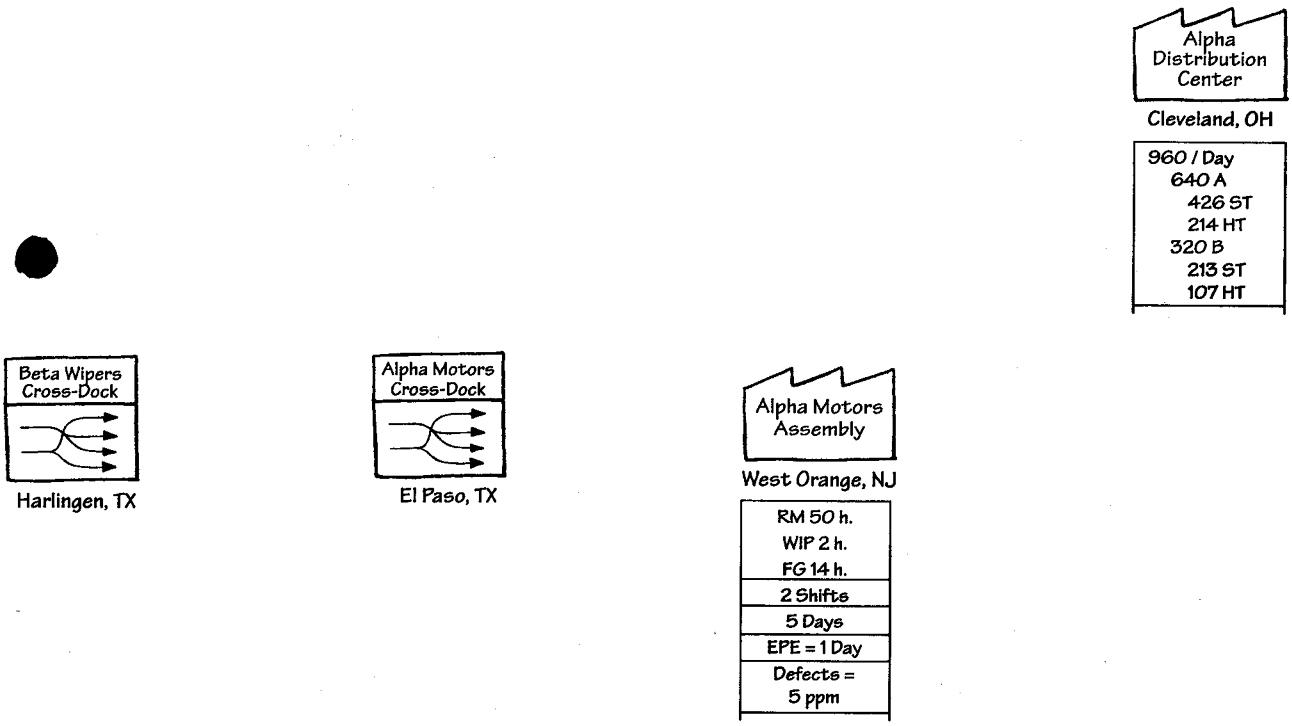
We have created two new facility icons not seen in *Learning to See*. One is a **cross-dock icon** for facilities where products are not stored but instead moved immediately from an incoming vehicle to an outbound shipping lane. The other is a **warehouse icon** for facilities where incoming goods are sorted and stored before shipment to their next point of use. (The icons used in this workbook are displayed on the inside back cover and explained in Appendix A.) You may want or need to create other icons, of course, in particular for activities not encountered in our example. Just make sure that everyone working on the extended map uses the same icons.



You will soon discover that you can't successfully gather and summarize the information needed for improving the value stream without drawing detailed current state in-facility value stream maps for products as they move through manufacturing facilities. This is why mastery of the material in *Learning to See* is a prerequisite for macro-mapping.

We've drawn current state facility-level maps for the three manufacturing facilities along this value stream — Gamma Stamping, Beta Wipers Assembly, and Alpha Motors Assembly — in Appendix B of this workbook, and you'll want to append your facility-level maps to your current state macro map as well. Note that the data box under each facility contains data on inventories (Raw Materials, Work-In-Progress, Finished Goods), the amount of productive time (the number of shifts per day and the number of working days per week), the frequency of the production cycle (showing how often every part is made, such as

Current State Map Showing All Facilities and Data Boxes



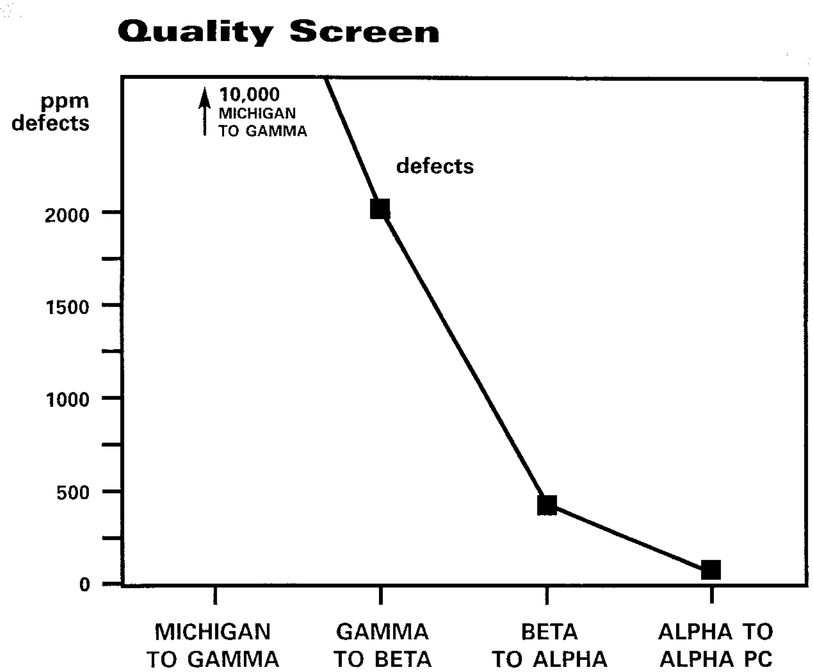
"EPE = 1 Day" meaning "every part every day"), and the defect level (in parts per million) as reported by the customer at the next downstream facility (or by the customer's inspector at the point of shipment in the case of the Alpha Motors Assembly Plant.)

We have not drawn facility-level maps for the Alpha and Beta cross-docks and for the Beta parts warehouse. This is partly to keep the size of this guide manageable and also because we will endeavor to eliminate these facilities altogether as we move through progressive future states. If your value streams will require large distribution warehouses in any imaginable future state — for example for service parts — or cross-docks, you should also draw maps of these facilities as a guide to improving their performance. Exactly which facilities merit in-facility maps and in what detail will always be a matter of judgment, so be prepared to adjust your approach as your experience accumulates and you encounter different situations.

The Quality Screen

As we look at the data in the facility boxes, we note a trend worthy of further examination. At Alpha Motors Assembly the defect rate for wipers installed on the vehicle — defects discovered by a representative from Alpha's Distribution Division in a final inspection just prior to shipment — is 5 per million. (Since Alpha is assembling 250,000 vehicles per year with two wipers per vehicle, this means that two to three wipers per year are rejected at final inspection, usually for scratches in the finish.) Yet when we look at defects emerging from Beta Wipers Assembly (as judged by Alpha), we note that there are 400 defects per million and when we look at defects emerging from Gamma Stamping (as judged by Beta) we note that there are 2000 defective parts per million. Finally, when we look at defects arriving at Gamma from Michigan Steel the figure soars to 10,000 per million.

In brief, quality is worse at every step up the value stream, a common phenomenon in practically every industry today. This means that to achieve 5 defects per million (approaching the Six Sigma level of 3.4 defects per million), the product is flowing through a series of quality screens in each facility, each of which results in scrap and inspection cost. The slope of this quality gradient can surely be reduced in future states and it is important to note carefully the current slope to aid our thinking on how to do this. We therefore recommend drawing a Quality Screen (as shown below) on the Current State map. In this case we have placed the diagram in a convenient spot in the lower right-hand corner.



Mapping the Transport Links

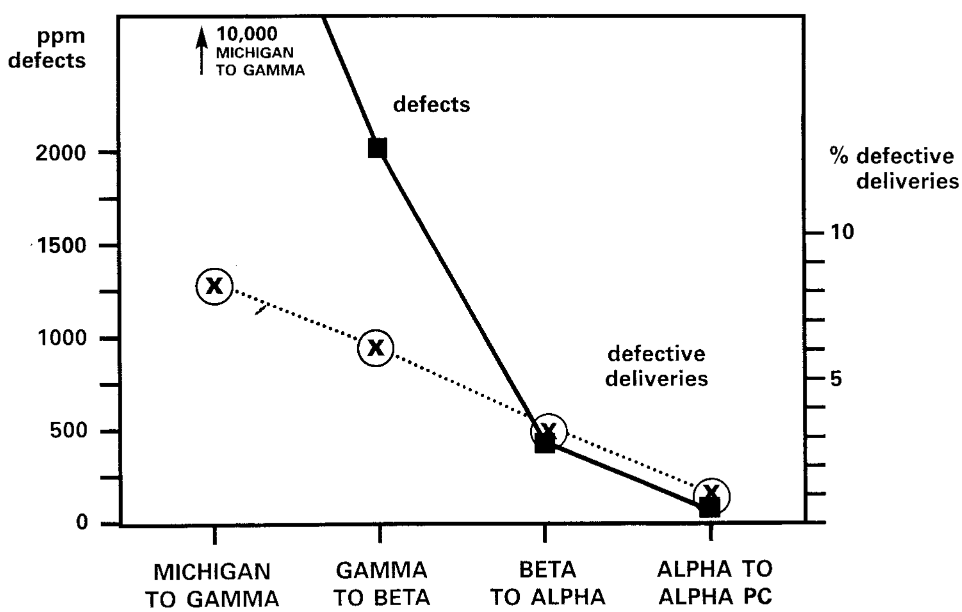
The next step, once the facility-level maps are drawn and the data have been summarized in facility boxes, is to add the transport links between the facilities. To do this, you may need boat, train, and airplane icons, in addition to the truck icon from *Learning to See.*

In this example, we will use the **airplane icon with a dotted line** for shipments expedited by air and a truck icon with the same style of dotted line for those expedited by truck. The numbers in the regular shipping icon (a truck or a train) show the frequency of shipments (e.g., "1 x day" = one shipment per day) while the number in the expediting icon shows the number of costly expedited shipments in the past year (e.g., "2 x year" = twice a year).

With these data in hand, we are ready to complete the physical flow portion of the map by drawing in the normal product flows between facilities, using broad arrows. Note that these are striped, "push" arrows because products are moving ahead at the command of a centralized information system and not necessarily in accord with the immediate needs of the next downstream facility. Under each of the transport links we record the distance in miles, the shipping batch size, and the percentage of defective deliveries as reported by the customer.

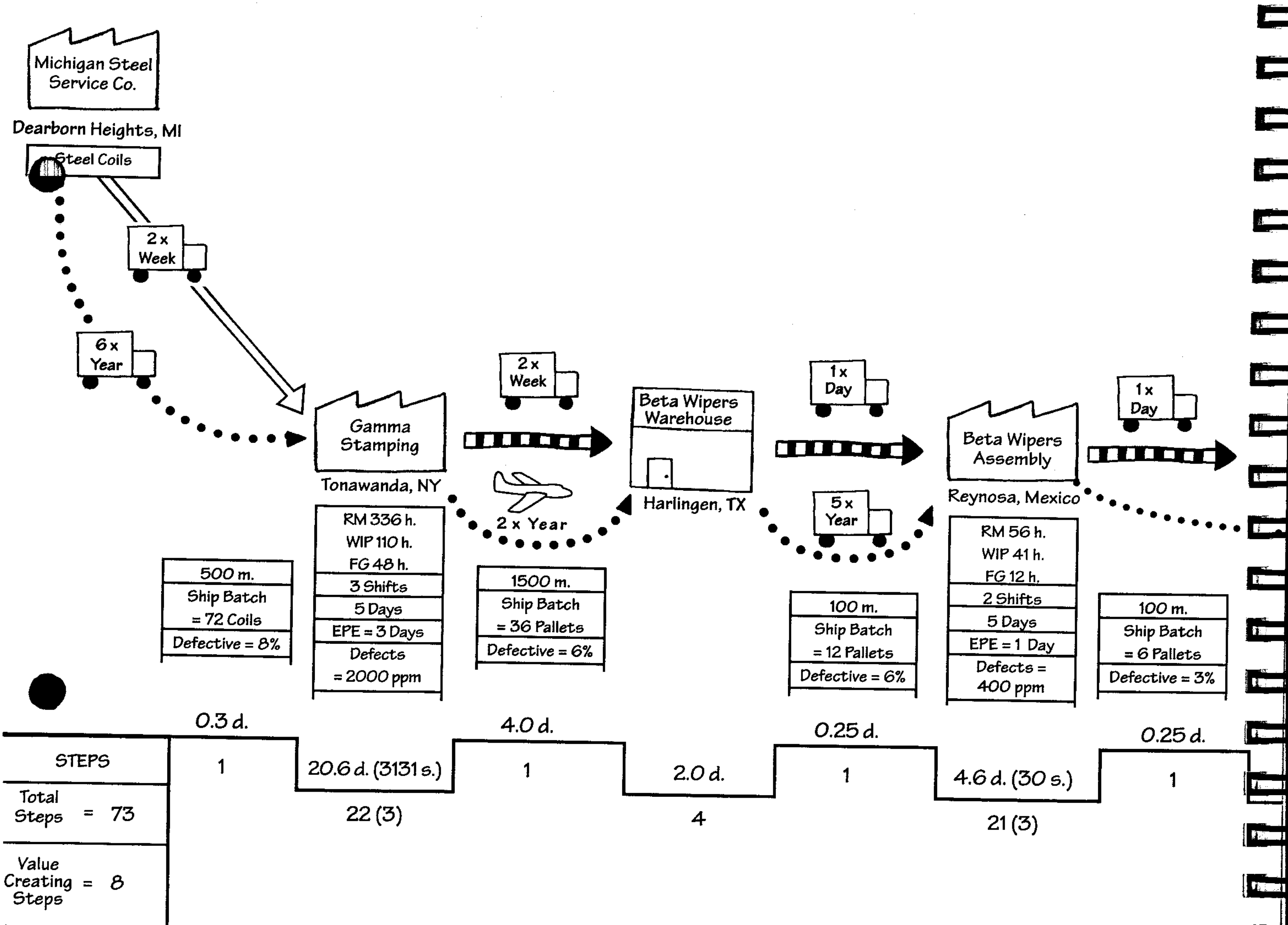
As these flows are drawn, the team should note one additional point — the trend in defective shipments: late, early, or incorrect (the wrong product or in the wrong amount). As is also typical in most industries today, we note that the further up the value stream a facility is, the more likely it is to make defective shipments. This situation is analogous to the quality gradient and equally worthy of improvement in future states because every defective shipment generates correction costs downstream and perturbs the schedule. For economy of space we have summarized this trend in the same box as the quality data on the Current State map, changing the label to the "Quality and Delivery Screen".

Quality and Delivery Screen

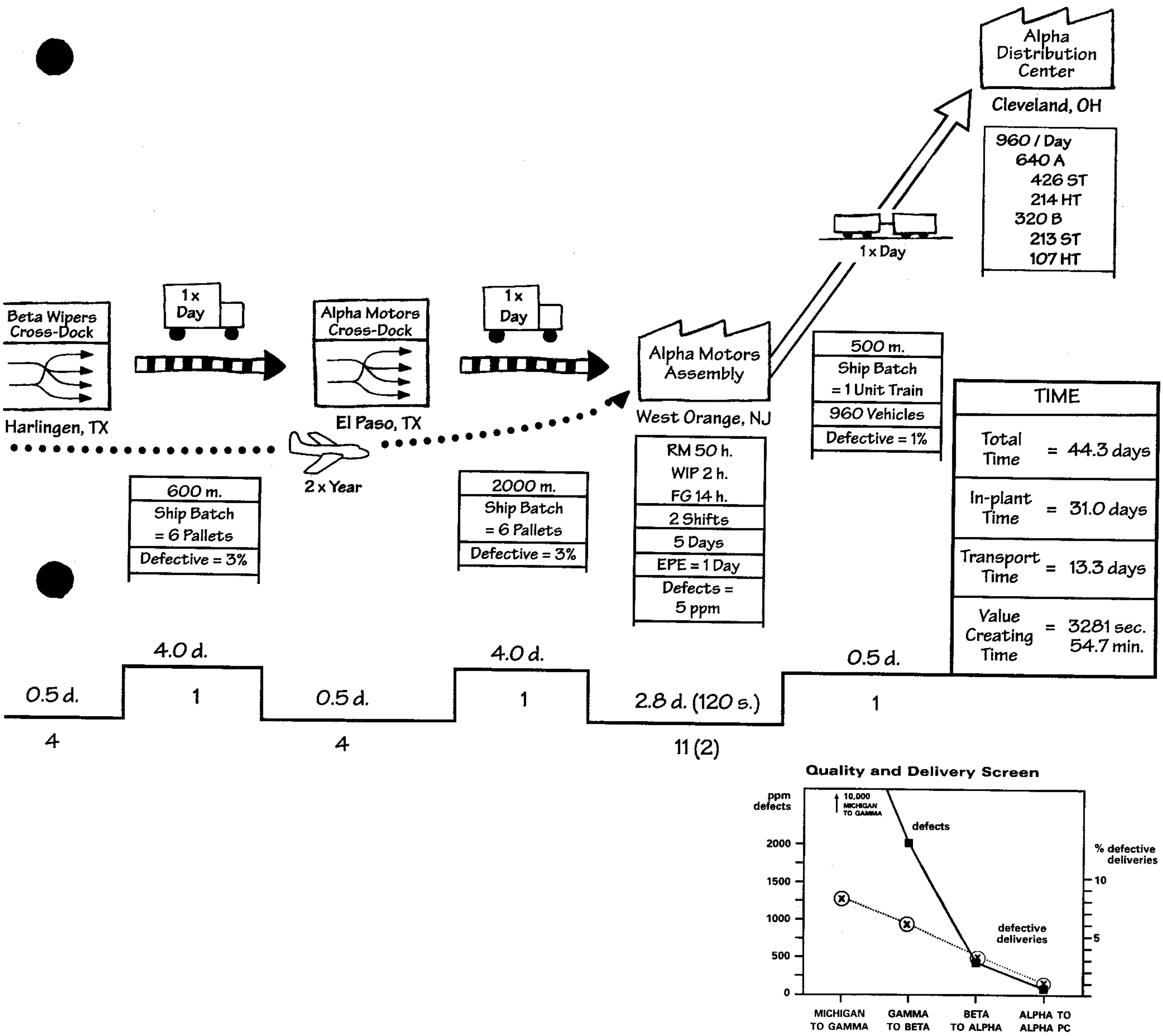


The "Bottom Line"

Finally, we can draw a time-and-steps line along the bottom of the map. Note that the first figure **above** each segment of this line is the total time within each facility and along each transport link, while the figure in parentheses to the right is the value creating time. The first number **below** each segment of the line shows the total actions (steps) taken on the product in each facility and transport link, with the value creating actions shown to the right in parentheses. Note that information needed for each facility is contained in the "Steps" and "Time" summary boxes at the ends of the time-and-steps lines on the individual facility maps.



Current State Showing all Facilities, Transport Links, Defects & Delivery, and Time-and-Steps Line



Mapping the Information Flow

The team has now completed mapping the physical flow of the product but the value stream map is only half done. This is for the simple reason that if no customer signals a demand for products from upstream, then nothing will flow. Or at least nothing should flow! We therefore need to go back to the upper right corner of our map and draw the flow of order and production information going back from the customer.

However, as we do this we need to warn you that mapping the information flow is the hardest part of the task. The sales, production control, and operations groups within most companies tend to communicate poorly and a manager who fully understands the information management methods of all three groups is a rarity. When you add the complexity of going across several companies and through sales, production control, and operations departments within each company, it's not surprising that very few line managers seem to have useful knowledge of how information is managed on a macro-scale.

Given this reality, you should start where orders enter the system and follow the order flow from department to department and from information management system to information management system, first through the most downstream firm and then upstream through the supplier firms. Be sure to use a pencil as you sketch information flows and keep an eraser handy! What's more, if you can, request these data ahead of your visit because many facilities and IT departments do not have them readily at hand.

To actually draw the information portion of the extended map we will need an additional icon for **production control**, which we have drawn in the shape of a computer terminal. The first of these is for Alpha Motors Sales Order Bank. At this point orders are aggregated and placed in inventory (shown by order queue icons along the information flows). They are held until the weekly sales planning meeting that decides the specification of the orders that should be released into the system, given orders in hand from dealers. These orders are then released upstream to the following firms and departments:

- Alpha Motors Headquarters Production Control
- Alpha Motors Assembly Plant Production Control
- Alpha Motors Assembly Plant Materials Control
- Beta Wipers Headquarters Production Control
- Beta Wipers Assembly Plant Production Control
- Gamma Stamping Headquarters Production Control
- Gamma Stamping Plant Production Control
- Michigan Steel Service Production Control

In almost all manufacturing companies, the sales and production control departments actually send a series of forecasts, schedules, and production releases back upstream. For example, in the car industry a three-month forecast, a one-month rolling schedule, a **weekly fixed schedule**, and a **daily shipping release** might be typical. For our purposes, the important information is the weekly fixed schedule and the daily shipping release because these actually trigger production in facilities and shipments between facilities. These are the information flows we will capture on this map.

If we follow the weekly schedule and write down the information management steps and the time involved, as we did earlier with physical actions performed on the product, we note the following along the longest path.

Information Actions Currently Required to Manage the Value Stream

Steps	Delays*
Production at Alpha Motors	
1. Dealer Orders queue in the Sales Order Bank	10 Days
2. Transmit weekly orders from Alpha Sales Order Bank	
3. Queue at Alpha Headquarters Production Control	14 days
4. Release weekly production requirements to Alpha Plant	
5. Queue at Alpha Plant Production Control	6 days
6. Release of daily production sequence	
Production at Beta Wipers	
7. Transmit weekly orders from Alpha HQ to Beta HQ	
8. Queue at Beta HQ Production Control	6 days
9. Transmit weekly production requirements to Beta Plant	
10. Queue at Beta Plant Production Control	6 days
11. Release of weekly production schedule	
12. Beta Plant issues daily orders from Beta Warehouse	
13. Alpha Materials Control transmits daily requirements to Beta Plant	
14. Beta Plant Production Control issues daily shipping release	
Production at Gamma Stamping	
15. Transmit weekly orders from Beta HQ to Gamma HQ	
16. Queue at Gamma HQ Production Control	14 days
17. Transmit weekly production requirements to Gamma Plant	
18. Queue at Gamma Plant Production Control	6 days
19. Release of weekly production schedule	
20. Beta Materials transmits twice-weekly requirements to Gamma Plant	
21. Gamma Plant Production Control issues twice-weekly shipping release	

* All transmissions are electronic and essentially instantaneous.

Delivery from Michigan Steel

22. Transmit weekly orders from Gamma HQ to Michigan Steel	
23. Queue at Michigan Steel	14 days*
24. Gamma Materials Control transmits twice-weekly requirements to Michigan Steel	
25. Michigan Steel issues twice-weekly shipping release	
Total number of steps	**25 steps**
Elapsed time for an order from the first to the last step (along the longest information path)	**58 days**
Actual processing time (assuming each MRP runs overnight)	**8 nights**

* All transmissions are electronic and essentially instantaneous.

The Value of Information

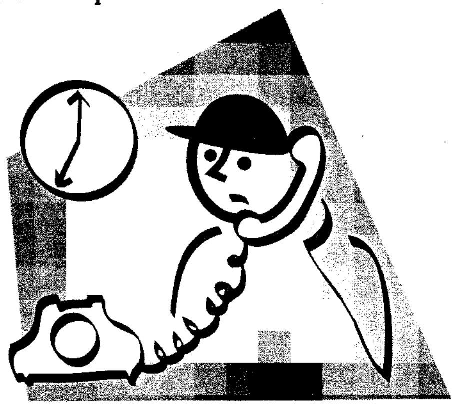
Note that we have made no effort to categorize information management steps as "value creating" versus "wasteful", as we did for the list of physical steps. This is because from the end customer's standpoint none of the information processing steps creates any value. To test this — perhaps shocking — assertion, just ask yourself whether you would be less satisfied with a product if it could be ordered and delivered to you with no management of production and logistics information. Obviously you would not be less satisfied. Indeed, you would be more satisfied if the cost savings from eliminating information acquisition and management could be passed along to you. Yet in the modern era of automated information management, most managers have implicitly accepted the notion that information is good, more information is better, and all possible information is best. In fact, information for control of operations is necessary waste (Type One Muda). Managers ought to be minimizing the need for it rather than maximizing it's availability. In the future states and ideal state we will show how.

As the weekly order information flows across the top of the map from headquarters to headquarters, it is also flowing from each headquarters down to plant production control departments where weekly schedules for each plant are set. For example, Alpha Motors' Assembly Plant Production Control takes the schedules from Alpha Headquarters Production Control, runs them through its computerized Materials Requirements Planning (MRP) system (after a delay averaging six days), and creates a rolling six-day ahead schedule for the assembly plant. This schedule is fully sequenced (e.g, a blue Model A with high trim, then a green Model B with standard trim) and takes into account line balancing constraints. For example, there are limits on how many Model As or Model Bs can be run down the line in a row without overloading some workstations where work content varies significantly between Model A and Model B. These schedules are then released to the plant floor.

At the same time information is being released to the floor in each plant it is also being sent upstream, from plant-level materials control departments, in the form of daily shipping releases. These are the precise amounts of each part number the upstream plant is authorized to ship to its downstream customer on the next pickup. These daily release amounts are based on known order lead times and the stocks thought to be on hand at the downstream plant.

From this it is apparent that there are two separate information flows coming into each plant — the weekly schedule from each firm's production control department and the daily release from the customer. Often, these flows are not precisely synchronized. So a third information management loop comes into play, which is direct communication between the materials handling department in the downstream plant and the shipping department in the upstream plant.

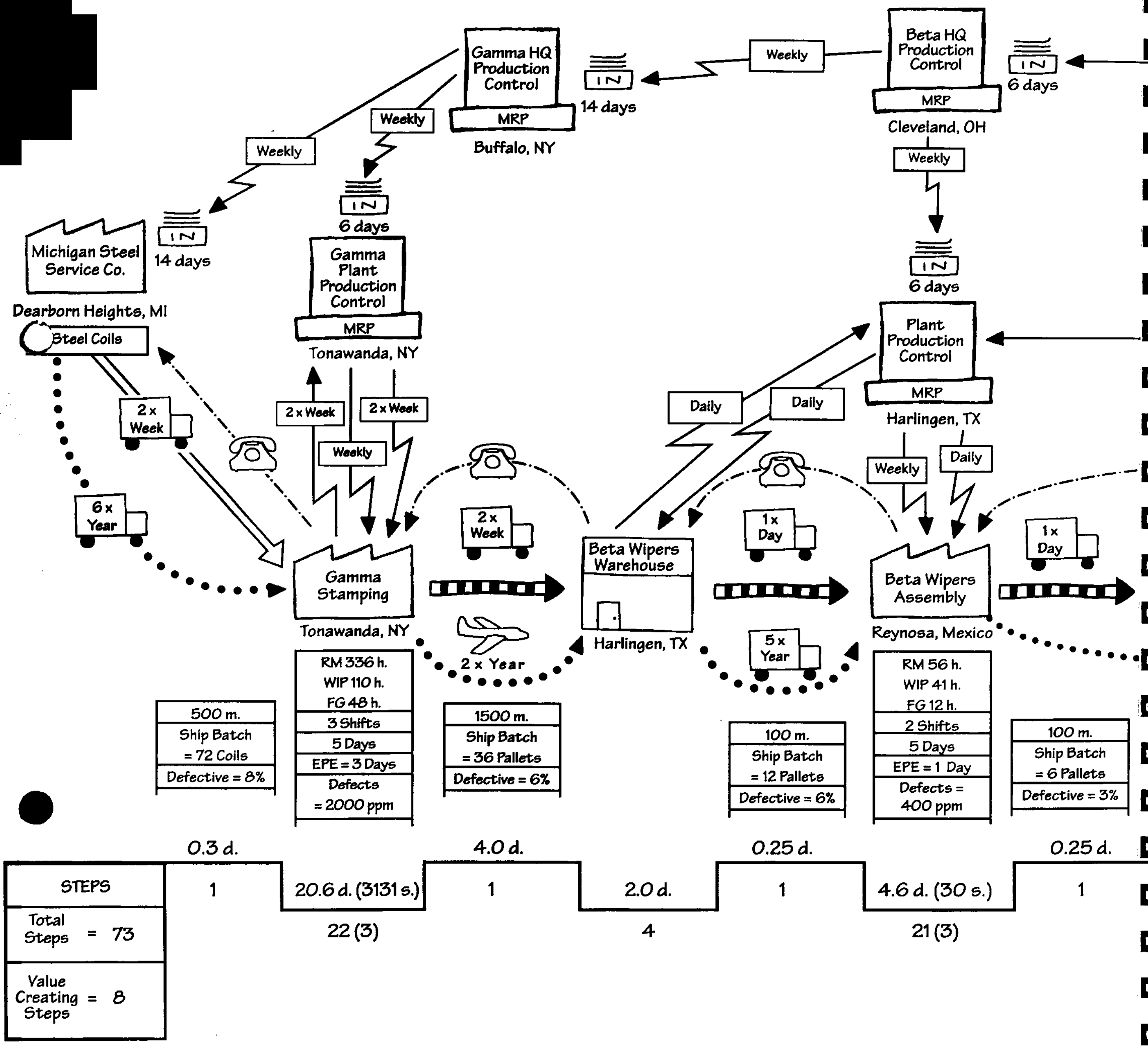
This direct link, usually a telephone voice line, becomes the real production control and shipping mechanism whenever managers at the ends of this link override the shipping releases and, in extreme situations, production schedules. They usually do this based on their direct observations of emerging shortages and their judgment about what to do in response. We have drawn these information flows between the plants with a dotted line and our **information expediting icon** — an old-fashioned telephone.

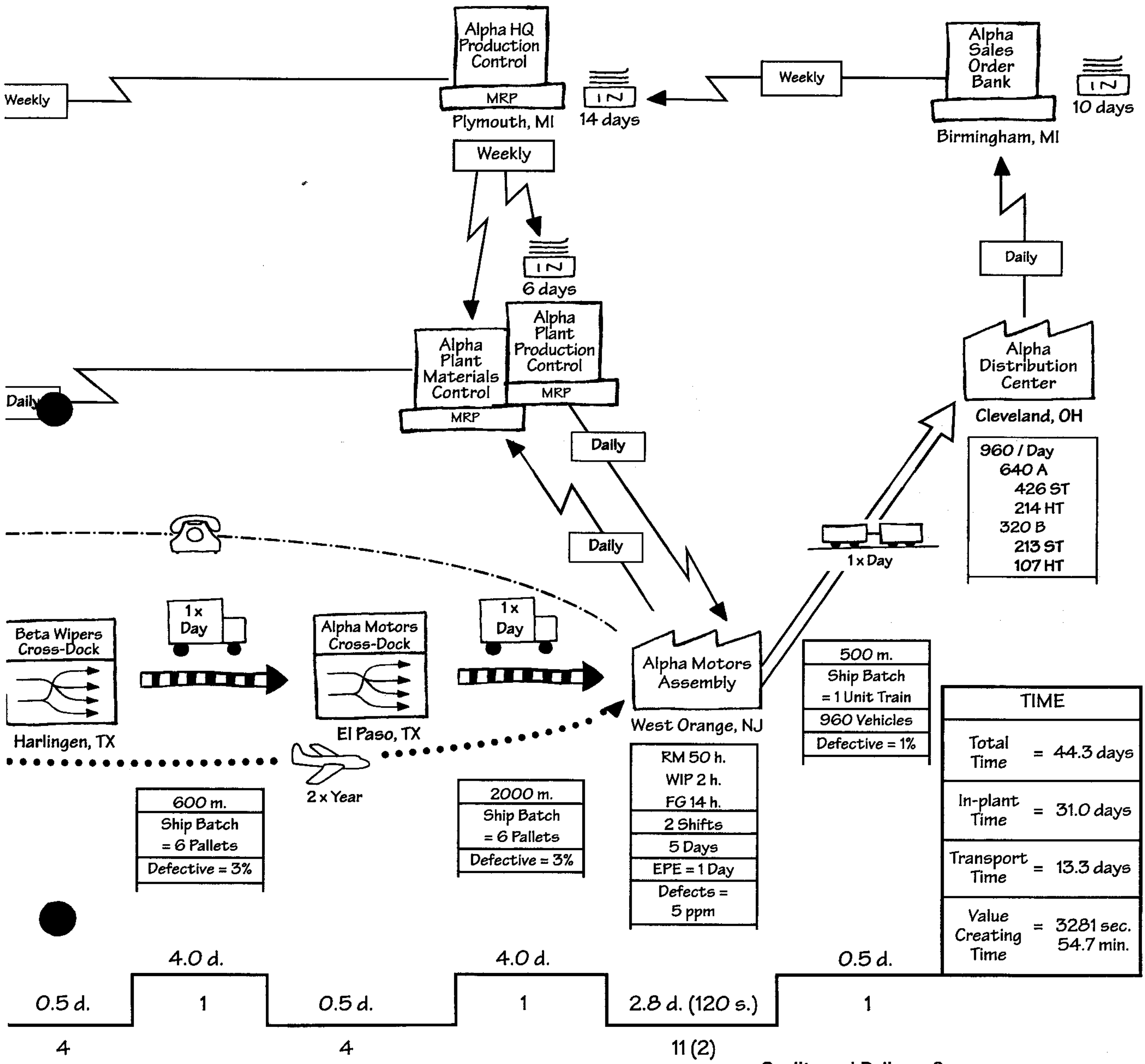


A Warning on Order Data

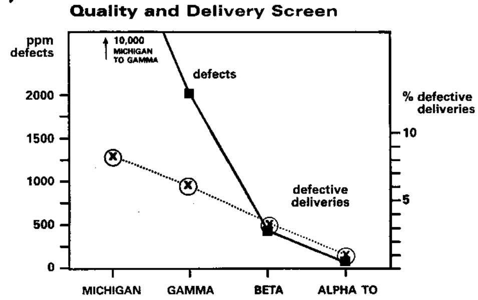
As you move upstream don't confuse the customer's official release with the amount each plant actually made. Instead gather from each facility data on what was actually produced daily over an extended period and compare this with customer daily requests in the form of shipping releases so you can see the relation of one to the other and the amount of variation in both. We're always amazed that companies awash in information about what ought to happen do a poor job of recording and preserving what actually happened. So you may need to dig a bit or even assign an observer to capture accurate information on plant-level production and shipping performance. What you find will be invaluable for achieving your future states.

Current State Map Showing Information Flow





Quality and Delivery Screen

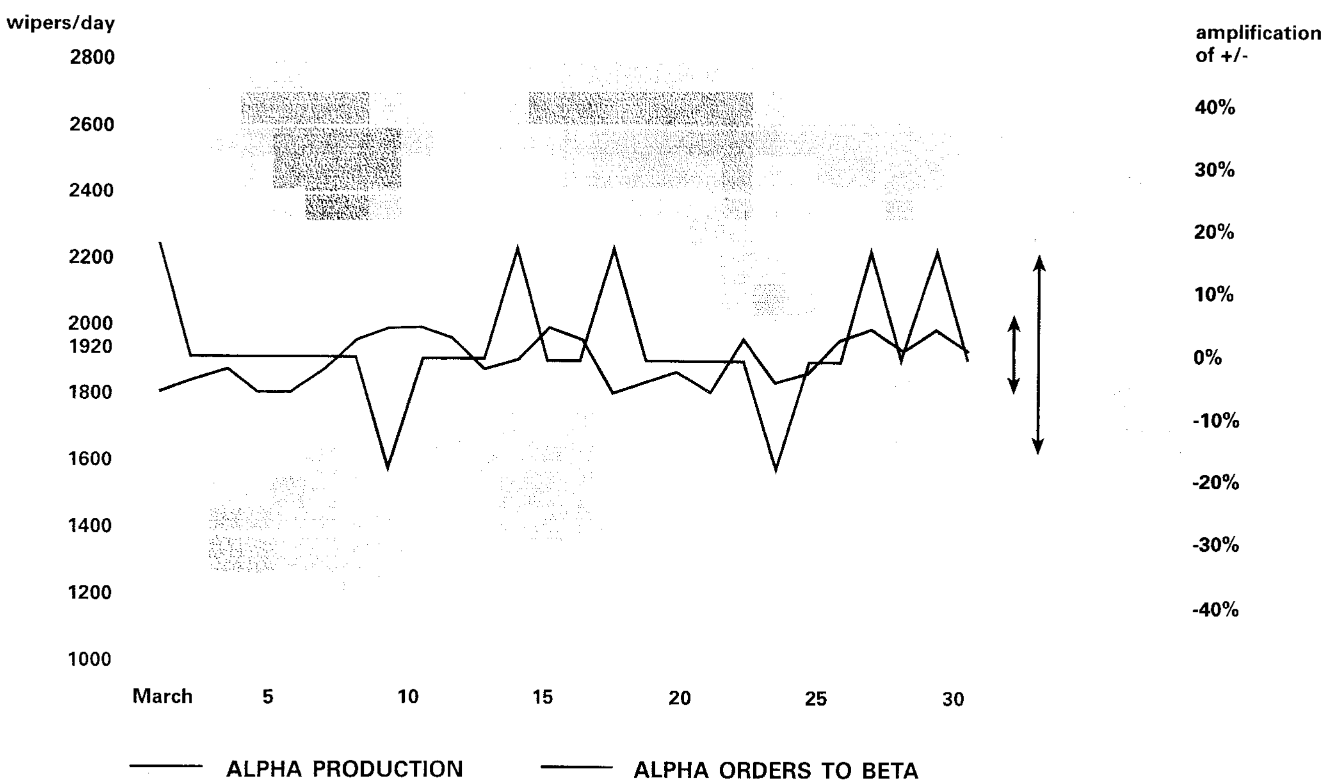


Demand Amplification

For the past year, Alpha Motors Sales Order Bank has sent very stable weekly orders calling for 960 vehicles per day, five working days per week to Alpha's Headquarters Production Control. And HQ Production Control has released level weekly buckets of orders to Alpha's Assembly Plant Production Control and to Beta Headquarters Production Control.

The actual build still varies from the schedule — due to pulling vehicles out of sequence to correct defects or because of problems in the paint booth or due to a lack of parts. However, by adjusting the schedule and working overtime at the end of each shift as necessary, the output of Alpha Motors Assembly varies by only about 5% from the 960 units planned for each day and all vehicles built are shipped on the daily train to the Alpha Distribution Center.

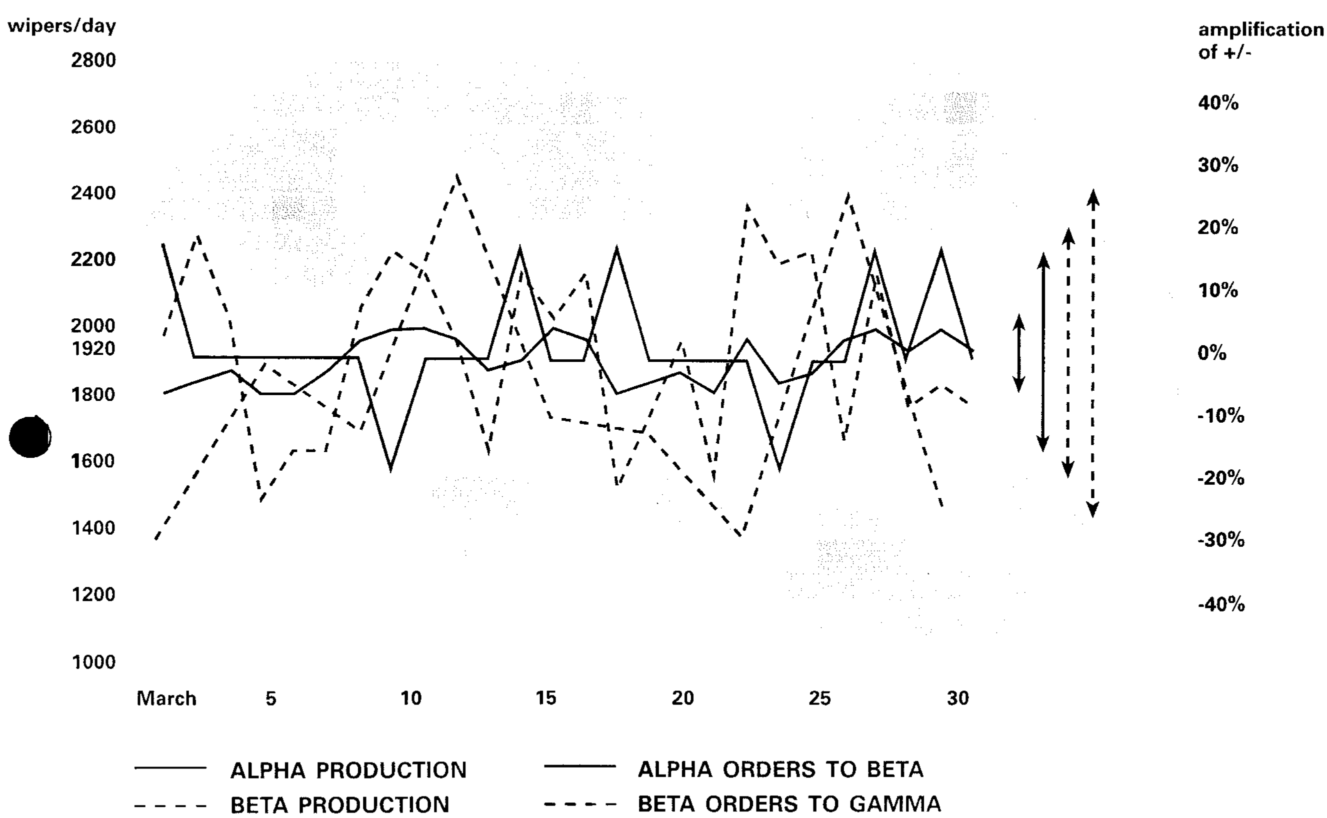
Demand Amplification for Alpha Motors



Similarly, the mix of models (A versus B) varies by only about 5% daily as does the mix of wipers (Standard Trim with flat paint versus High Trim with glossy paint.) On average, Model A accounts for two thirds of production and Model B one third while Standard Trim wipers account for two thirds of demand and High Trim the remainder. Thus production and shipments are fairly stable at the customer (right) end of our map.

Yet, as we plot the production and order/release data back upstream, we note that the amplitude of changes in both production and releases increases markedly from facility to facility. Minor variations in production at Alpha Motors Assembly become much larger by the time we reach Beta Wiper's assembly plant, as shown below.

Demand Amplification including Beta Wipers



THE EXTENDED VALUE STREAM

FUTURE STATE 1

FUTURE STATE 2

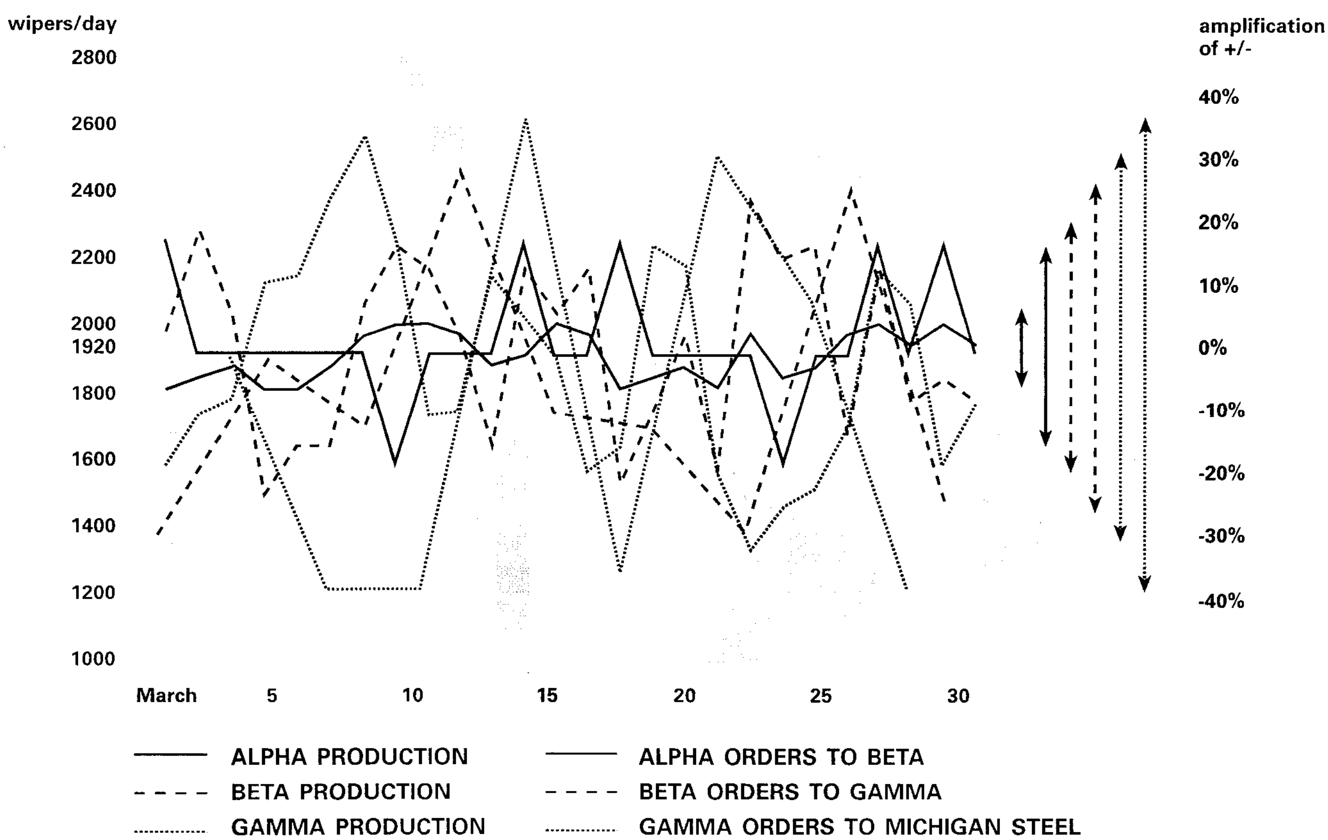
IDEAL STATE

ACHIEVING FUTURE STATES

By the time we reach Gamma Stamping, the variations are very large. Indeed, Gamma Stamping's releases to Michigan Steel varied by nearly 40% in the month prior to the arrival of the mapping team. This information for Gamma Stamping completes the Demand Amplification Screen for our current state, as shown below.

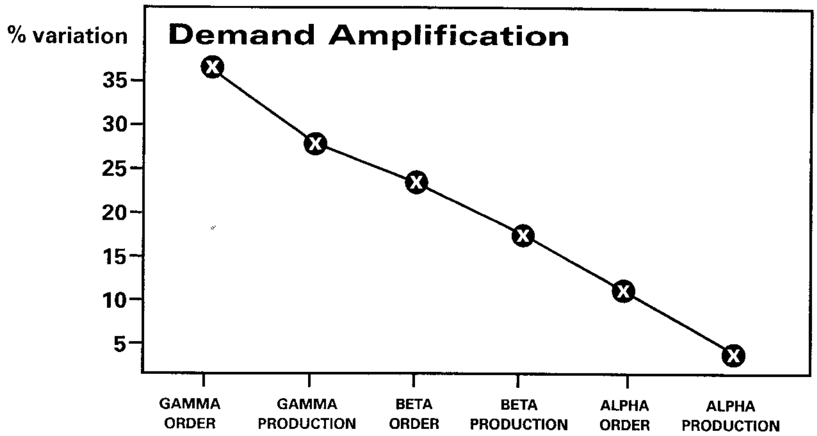
To make this very common phenomenon clearer, we've summarized the maximum percentage change in daily production and daily releases over the past month for each facility and aligned them in a simplified **Demand Amplification** chart as shown at right. We've placed this chart in a box in the upper left corner of our Current State map, as shown on the next page spread.

Demand Amplification Screen in Current State



To deal with the erratic order flow, Beta, Gamma, and Michigan Steel must either maintain extra production capacity or carry large stocks of finished goods in inventory or disappoint downstream customers a significant fraction of the time. Because failing to ship on time to meet customer needs is an unacceptable alternative for suppliers in the auto industry and because extra tooling can be very expensive, most firms in this industry, including Beta,

Simplified Demand Amplification Screen

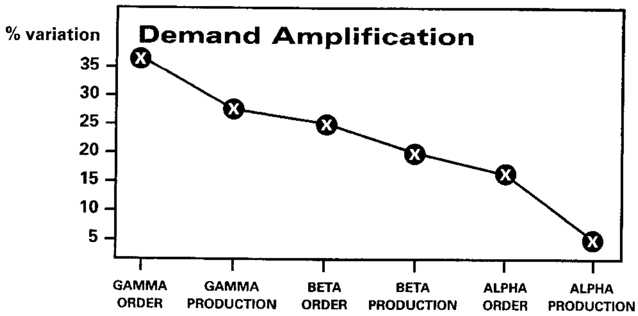


Gamma, and Michigan Steel, carry extra inventories to protect the customer. The cost implications of demand amplification are therefore apparent in the amount of extra inventories in the value stream.

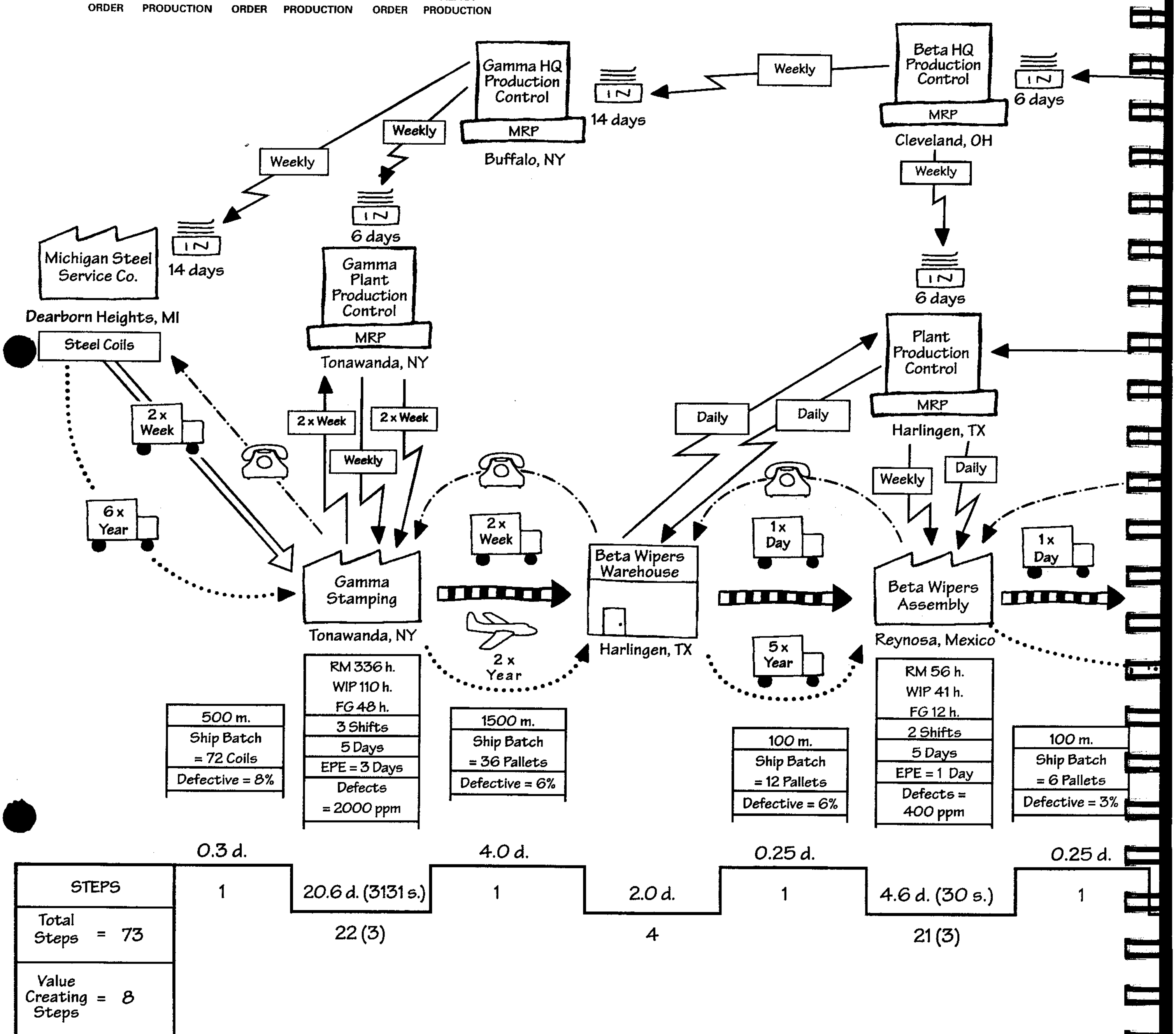
Why does this growing variation exist? For the simple reasons that production problems occur in every plant (even the leanest!), transport problems occur on every link, feedback on current conditions and amounts of product on hand is never completely accurate, and large minimum production and shipment quantities cause very small changes in the amounts needed downstream to produce much larger changes in the amounts requested and produced upstream.

To take the worst-case example, if one wiper is discovered to be defective at the assembly plant and the re-order amount is just on the edge of one new pallet (containing 320 wipers in our example) the re-order will jump to 2 pallets — or a total of 640 wipers — even though only one additional wiper is needed. And this phenomenon can be repeated several more times as the order flows back upstream, creating a wave. The reason this wave grows larger as we move upstream is because of the number of scheduling points (8) and the length of the delays (totaling 58 days) before information is acted upon. Each system recalculates its schedule based on its own (not very accurate) forecasts and on information from customers that is already up to a week old. This is the familiar and dreaded "Forrester Effect" documented by Jay Forrester at MIT in the 1960s.

The irregularities in the system are further exaggerated by the misalignment of what the official scheduling and releasing system (in the centralized computers) are saying and what the individuals in shipping and receiving jobs are seeing and doing. Then, as misalignments grow, confidence in the formal system declines and more and more of the actual scheduling and releasing may be done manually despite the large investments in information technology.

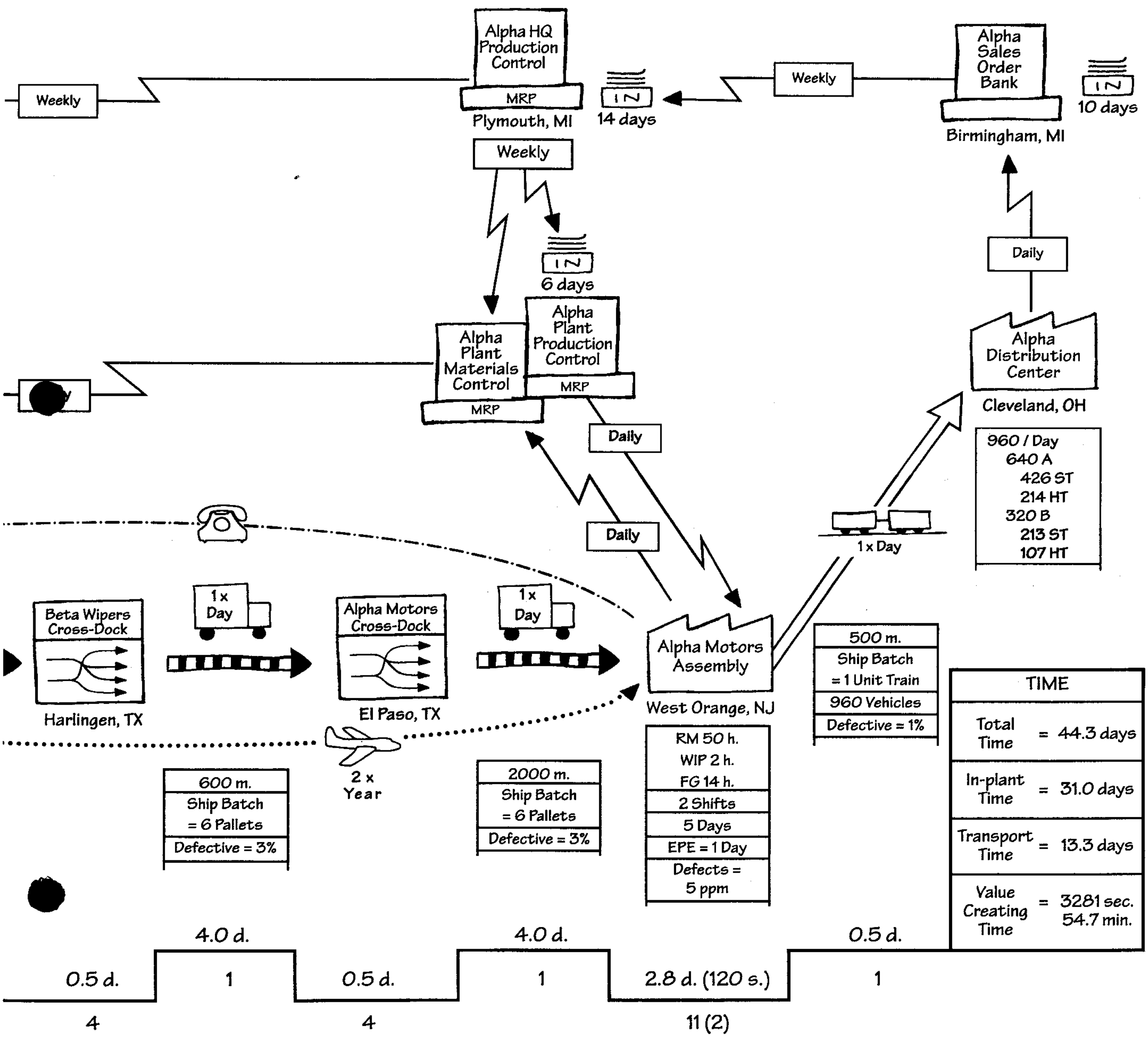


Demand Amplification
% variation
35
30
25
20
15
10
5
GAMMA ORDER
GAMMA PRODUCTION
BETA ORDER
BETA PRODUCTION
ALPHA ORDER
ALPHA PRODUCTION

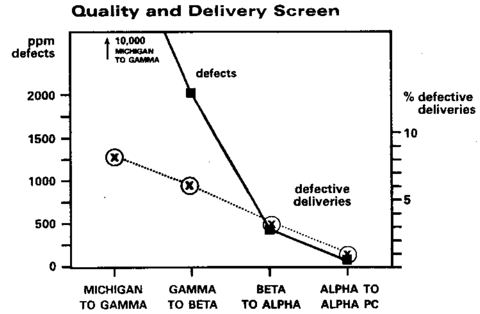


Gamma HQ Production Control
MRP
Buffalo, NY
Weekly
14 days
Beta HQ Production Control
MRP
Cleveland, OH
6 days
Weekly
Weekly
Weekly
Michigan Steel Service Co.
14 days
Dearborn Heights, MI
Steel Coils
6 days
Gamma Plant Production Control
MRP
Tonawanda, NY
6 days
Plant Production Control
MRP
Harlingen, TX
2 x Week
2 x Week
2 x Week
Weekly
Daily
Daily
Weekly
Daily
6 x Year
2 x Week
1 x Day
1 x Day
Gamma Stamping
Tonawanda, NY
Beta Wipers Warehouse
Harlingen, TX
Beta Wipers Assembly
Reynosa, Mexico
2 x Year
5 x Year
RM 336 h.
WIP 110 h.
FG 48 h.
3 Shifts
5 Days
EPE = 3 Days
Defects = 2000 ppm
500 m.
Ship Batch = 72 Coils
Defective = 8%
1500 m.
Ship Batch = 36 Pallets
Defective = 6%
100 m.
Ship Batch = 12 Pallets
Defective = 6%
RM 56 h.
WIP 41 h.
FG 12 h.
2 Shifts
5 Days
EPE = 1 Day
Defects = 400 ppm
100 m.
Ship Batch = 6 Pallets
Defective = 3%
0.3 d.
4.0 d.
0.25 d.
0.25 d.
1
20.6 d. (3131 s.)
1
2.0 d.
1
4.6 d. (30 s.)
1
22 (3)
4
21 (3)
STEPS
Total Steps = 73
Value Creating Steps = 8

Final Current State Map Showing Demand Amplification



Quality and Delivery Screen



The Limits of Our Map

As the team finishes recording these product and information flows, it seems sensible to conclude the Current State map at this scope of mapping. The map does not go all the way downstream to the customer taking delivery of a car at the dealership and it does not go all the way upstream to the steel mill, much less to ore in the ground. Mapping these additional steps would doubtless provide additional insights, but to do so would require large amounts of time and expense to examine organizations whose behavior the team has little prospect of changing right now. Yet even within this scope, the map covers a considerable portion of a lengthy and complex value stream and uncovers some very provocative performance features.

What We See When We See the Whole

With regard to physical flows we note that 44.3 days and 73 actions on the product are needed to achieve 3,281 seconds (54.7 minutes) of value creation involving only eight actions. This means that 99.9992% of the elapsed time and 89% of the total actions, while currently unavoidable, are of no value to the customer.

We can express these findings in terms of lead times and inventory turns:

LEAD TIME (in days)

	Gamma	+	Beta	+	Alpha	=	In-plant*	+ Transport	=	Total
Current State	20.6		4.6		2.8		31.0	13.3		44.3 days

INVENTORY TURNS (annually)**

	11	49	80	5

*Includes three days spent in warehouses and cross-docks.
*Note that facilities with simple, frequent activities (e.g., assembly operations) will have higher turns than facilities with many batch operations, and individual facilities will have higher turns than the entire value stream.

With regard to quality and delivery reliability, we note that end-of-the-value stream indicators of both measures are very good (5 ppm and 1% defective shipments to the customer) but this is achieved through a series of screens with significant costs and delays.

With regard to information about customer demand, we note that order information is acted upon up to 17 times and stored for up to 58 days in queues. What is more, six individuals in receiving and shipping directly intervene in mediating order flows within an expensive, technically sophisticated information management system that on its face is totally automated. Even with this intervention — and in some cases probably because of it — demand amplification, with compensating inventories to protect customers, increases steadily to a very high level as one looks back up the value stream.

Current State Summary

	Current State
Total Lead Time	44.3 days
Value Percentage of Time (value creating time to total time)	0.08%
Value Percentage of Steps (value creating steps to total steps)	11%
Inventory Turns	5
Quality Screen (defects at the downstream end over defects at the upstream end)	400
Delivery Screen (% defective shipments at the downstream over % defective shipments at upstream end)	8
Demand Amplification Index (% change in demand at downstream end over % change in demand at upstream end)	7
Product Travel Distance (miles)	5300

Finally, we must note a suddenly obvious point about the performance of the many departments and firms touching the physical product on its 44-day journey and order information on its 58-day journey: However effective the various functions — operations, production control, logistics, manufacturing engineering, quality, and purchasing — may be in achieving their own objectives, they are not at all effective in supporting this product on its path to the customer. What's more, because the processes involved are common to all products passing through these departments and firms, it is highly unlikely that they are doing a better job of supporting other product families. The functional diagnostic aspect of our extended mapping process — which we believe is its most important contribution to firms in the long run — therefore reveals severely mal-performing functions all the way up and down the value stream.

If this is an accurate portrayal of the current state — and, because the value stream team has directly observed it, there is good reason to think that it is — there are surely opportunities to speed the accurate delivery of products to the customer while eliminating large amounts of cost. To begin to do this we need to specify in the next section the features of a lean extended value stream that can deliver these benefits.

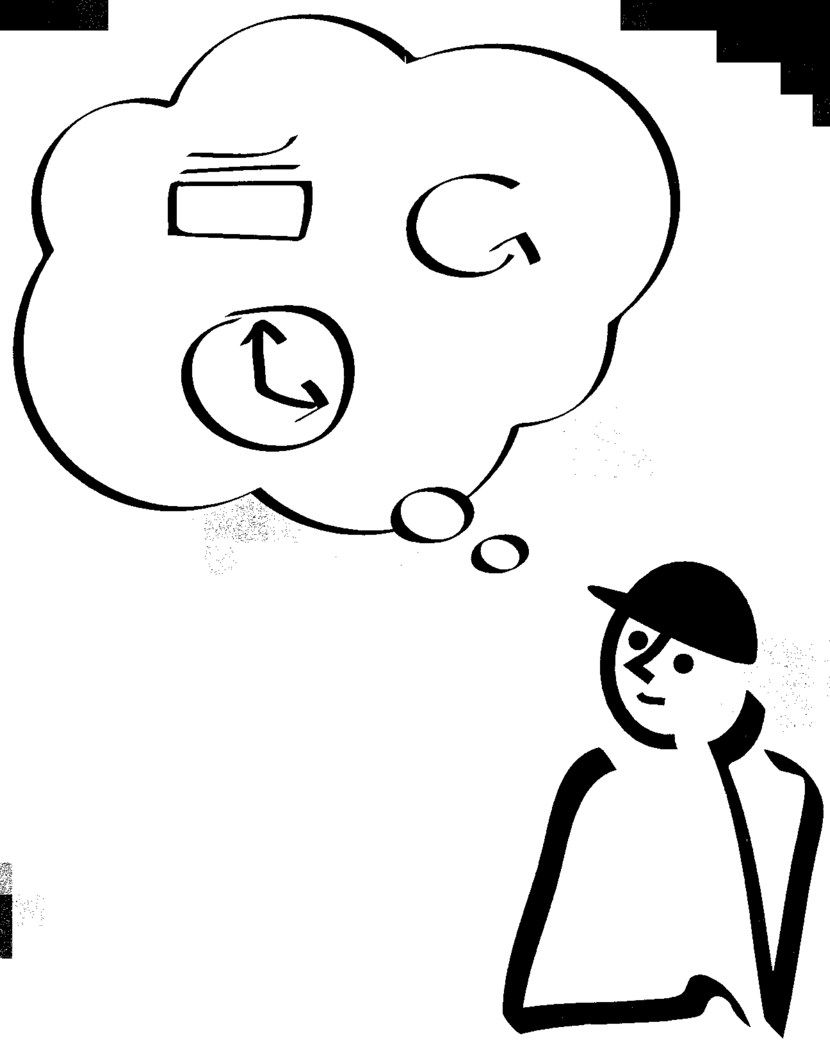
The Power of Simplicity

> "What do you consider the *largest* [scale] map that would be really useful?"
>
> "About 6 inches to the mile."
>
> "Only *six inches*!...We actually made a map on the scale of *a mile to the mile*!"
>
> "Have you used it much?, I enquired."
>
> "It has never been spread out... the farmers objected [that] it would cover the whole country, and shut out the sunlight! So now we use the country itself, as its own map, and I assure you that it does very well."
>
> — Lewis Carroll, *Sylvie and Bruno Concluded*, Chapter 11

As you experiment with drawing extended maps suitable for your product families, you may wonder just how much detail to include. We often find that novice teams — like Lewis Carroll's myopic mapmaker — want to record every conceivable detail about the current state, as well as mapping the flow of every part in the finished product. To make room for all this detail they even create wall-sized maps in corporate war rooms.

But too much detail in an extended map interferes with clear thinking about how to improve the value stream. We therefore urge teams to keep extended maps as simple as possible. The objective must be to truly "see the whole" by summarizing the value stream on a single sheet of paper (11" x 17" is a good size, A3 in Europe) and to use this big picture to raise consciousness among all the value stream participants. Only then can you identify ways to quickly improve performance all along the value stream and motivate the firms involved to optimize the whole.

PART III: WHAT MAKES AN EXTENDED VALUE STREAM LEAN?



PART III: WHAT MAKES AN EXTENDED VALUE STREAM LEAN?

Principles of a Lean Extended Value Stream

Fifty years ago Taiichi Ohno at Toyota enumerated seven types of waste in value streams. You may have them memorized by now but they bear repeating because the types of waste are the same at the process, the facility, and the extended value stream levels of analysis:

Overproduction — Making items upstream before anyone wants or needs them downstream.

Defects — Errors in products, paperwork supporting products, or delivery performance.

Unnecessary inventory — Products in excess of the amount needed to insure meeting customer needs.

Unnecessary processing — Activities not adding value that could be eliminated, such as a separate inspection step replaced by a self-monitoring machine with auto-stop, or flash-removal after molding eliminated with higher mold tolerances and better mold maintenance.

Unnecessary transportation between work sites — Moving products between facilities that could easily be consolidated.

Waiting — Usually production associates waiting for machines to cycle.

Unnecessary motion in the workplace — Associates moving out of their work space to find materials, tools, work instructions, and help.

When mapping at the facility level and at the process level within facilities, we are always concerned about **overproduction** due to poor information flows *within* facilities and the desire of managers to move products ahead to meet performance metrics for equipment utilization. (Ohno always stressed that overproduction is the worst waste.) We are also looking carefully for unnecessary processing, defects, waiting, and motion.

When we more our analysis of product and information flows to the extended, macro level, overproduction is still a critical concern but now due to erratic information flows between firms and facilities. And we are now specially interested in the two final forms of waste: **unnecessary inventories** (due to erratic information flows as well as incapable and batch-oriented upstream processes) and **unnecessary transportation** (caused by location decisions that seek to optimize performance at individual points along the value stream rather than the whole value stream). Reducing these three forms of waste — *largely by better managing information flows and logistics* — will be central concerns for our extended-mapping of future states.

What should a lean extended value stream look like?

First, everyone in the entire value stream should be aware of the rate of customer consumption of the product at the end of the stream.

You are probably familiar with takt time, which is the amount of product demanded per unit time adjusted for the amount of production time available. This is a wonderfully useful concept within every facility because it tells everyone the necessary rate of production from minute to minute to meet the needs of the next downstream customer. However, note that takt time will vary from facility to facility along a value stream if the amount of available production time differs from facility to facility and if downstream steps incorporate more than one unit of an upstream component. Thus takt time at the Alpha Motors Assembly Plant is 60 seconds (to build 960 vehicles during the sixteen hours of production time available each day) but is 30 seconds at Beta's wiper assembly plant running the same shift pattern (because each vehicle needs two wipers) and would fall to 15 seconds if the wiper assembly plant switched to only a single eight hour shift each day. Thus, in most cases, there is no single takt time for the entire value stream.

However, every facility along on the stream needs to be aware of the end rate of consumption to calculate facility-specific takt time. Production at every upstream stage should run on average at the same rate, as adjusted for the available amount of production time at each step and the need to make multiple copies of some products to incorporate in products downstream. Any time we see a chronic pattern of imbalanced production rates in different facilities we know we don't have a lean value stream.

However, please understand that every facility upstream should not conduct its activities in lock step with the current rate of the end facility in the stream. This seems to be the implication today of many naïve claims for e-commerce and the web: "If you know the rate of end consumption right now you can schedule yourself accordingly." In fact, what each facility should produce each morning is a leveled mix of what the next downstream facility requests for delivery this afternoon or tomorrow. Knowing changes in actual consumption at the end of the stream (particularly the amplitude of the changes) is extremely important for capacity planning but is not sufficient for controlling production today.

What we can learn from comparing production rates upstream with actual consumption downstream is how faithfully the production control system is sending true customer demand (which we call "signal") upstream versus distorted demand (which we call "noise"). If there is significant noise, producing "demand amplification" unrelated to true customer desires (as we see in our Current State map), steps need to be taken to eliminate these gyrations in future states.

A second feature of a truly lean extended value stream will be very little inventory. This inventory will consist of the minimum amount of (1) raw materials, (2) work-in-process, and (3) finished goods required to support the needs of the next downstream customer given (a) the variability of downstream demand, (b) the capability of upstream processes, and (c) the inventory required between processing steps due to batch sizes and shipping quantities. Toyota calls the minimum amounts of inventory needed to support the customers in a value stream at any given time the **standard inventory.** The standard is calculated for each category of inventory depending upon its function in the value stream. Toyota continually seeks to reduce this amount by decreasing batch sizes, increasing shipment frequencies, leveling demand, and improving capability.

Low Inventories with High Demand Variability and Low Process Capability = Chaos

We sometimes encounter lean implementers who seek to reduce inventories along a value stream without bothering to calculate the standard inventory needed for the current levels of variability and capability. An immediate "lowering of the water level" may indeed "expose the rocks" and put pressure on everyone to go faster to reduce variability and improve capability. However, a more likely consequence is chaos and outraged customers when the newly "lean" value stream fails to deliver the right amounts with the right quality at the right time.

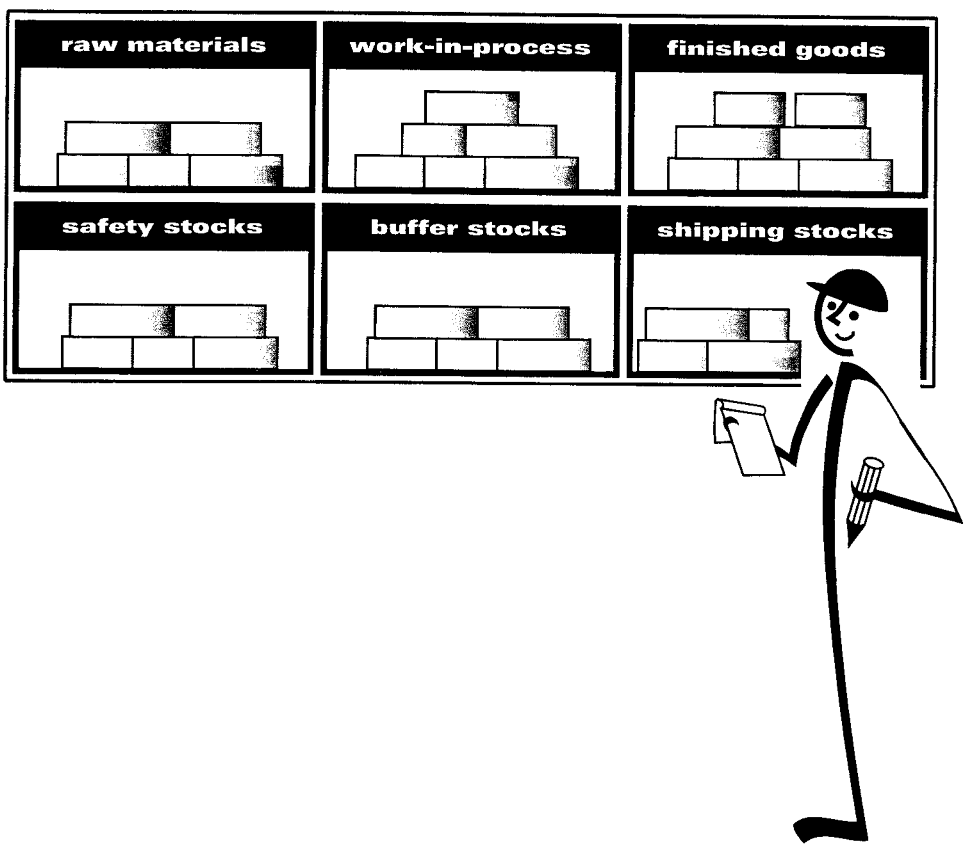
A better strategy is to calculate the standard inventory at every storage point along the value stream in the current state and immediately eliminate inventories greater than the standard. Then lower the standard and reduce inventories to the new standard in a future state after variability and capability issues are addressed.

The Many Forms and Uses of Inventory: Creating a Strategy

We've defined the three traditional categories of inventory and compared these with several additional categories in common use (as shown in the next page). Note that these categories overlap. "Finished goods" can be "safety stocks", "buffer stocks", or "shipping stocks". What's more, the same item – a pallet of windshield wipers in Beta's finished goods area, for example – can be included in several categories – a "safety stock" and a "buffer stock" in the case of our wiper – depending on the practice of the firm and the facility. The key point with regard to definitions is for the members of the value stream team to agree on a consistent use of this sometimes confusing terminology.

The key point with regard to the inventories themselves is for the team to make a strategic plan for every part in a future state, describing the reasons for keeping specific amounts of materials and goods in specific places as standard inventory. As they do this, many value stream teams decide to actually increase the amount of inventory in a downstream finished goods area near the scheduling point, both as a buffer stock and as a safety stock. This guards against demand amplification traveling upstream and facilitates the reduction of work-in-process and raw materials to a very low level in upstream facilities. By increasing inventory at one point – seemingly a step backward – it may be possible to reduce inventories at every other point along the value stream and for the value stream as a whole.

The Many Forms of Inventory



Types of Inventory

TRADITIONAL CATEGORIES

Defined by their position along the value stream

Raw Materials

Goods entering a facility that have not yet been processed.

Work-In-Process

Items between processing steps within a facility.

Finished Goods

Items a facility has completed that await shipment.

ADDITIONAL CATEGORIES

Defined by their function in the value stream

Safety Stocks

Goods held at any point (in Raw Materials, WIP, or Finished Goods) to prevent downstream customers from being starved by upstream process capability issues.

Buffer Stocks

Goods held, usually at the downstream end of a facility or process, to protect the downstream customer from starvation in the event of an abrupt increase in point demand by a customer — a demand spike that exceeds point production capacity.

Shipping Stocks

Goods in shipping lanes at the downstream end of a facility that are being built up for the next shipment. (These are generally proportional to shipping batch sizes and frequencies).

A third feature of an extended lean value stream is as few transport links as possible between steps in the production process.
As we have noted earlier, no customer attaches value to moving the product around. Indeed, customers will often be willing to pay more for a product if it can be supplied in the exact specification they want very quickly. Thus we need to ask about every transport link: Is this really necessary? Substituting modes, notably air for truck, is certainly an alternative way to reduce throughput time, but typically at an unacceptable cost premium. In general we want to eliminate transport rather than speed it up.

A fourth feature of a lean value stream is as little information processing as possible, with pure signal and no noise in the information flows that remain.
This means pulling information management down from higher levels of the organization, in remote information management departments, to the shop floor where each processing step and each facility can signal the previous step and facility directly about its immediate needs. We should schedule the entire value stream from only one point, in this case the assembly line of Alpha, and pull materials back up the value stream from this point.

A fifth feature of lean value stream will be the shortest possible lead time.
Indeed, this may be the most important of all. Taiichi Ohno often remarked the whole point of the Toyota Production System was simply to reduce lead times from raw materials to the customer. The shorter the lead time, the more likely it becomes that the entire value stream can respond to real orders rather than inaccurate forecasts. And the more likely it becomes that defects, process variations, and every other problem will be detected before significant waste is created.

A final principle of a lean value stream at the macro level is that changes introduced to smooth flow, eliminate inventories, and eliminate excess transport and lead time, should involve the least possible or even zero cost.
What's more, capital costs, when they are necessary, should be deferred until easier and quicker actions have already been taken.

The Plan for the Remainder of this Breakthrough Guide

The last principle suggests that we address in-plant product flows first using the methods described in *Learning to See* and *Creating Continuous Flow*. These entail practically no capital costs and will create what we will call our **Future State 1**, as described in Part IV of this Guide.

Once flow and pull have been introduced within each facility, eliminating many wasteful steps in the process, it will be time to examine the information and transport links between facilities. Often it will be possible to smooth the value stream and reduce the need for buffers by introducing direct feedback loops with leveling mechanisms for information flowing from each downstream "customer" to the preceding upstream "producer". We will do this in **Future State 2**, as described in Part V of this Guide, noting that a smooth pull of orders can often be tested on an experimental basis for one product family without effecting information flows for other products going through the same facilities.

With information flows smoothed and noise reduced, it will be time to reduce shipment sizes while increasing shipment frequencies between each facility and it's upstream customer. We will also do this in Future State 2.

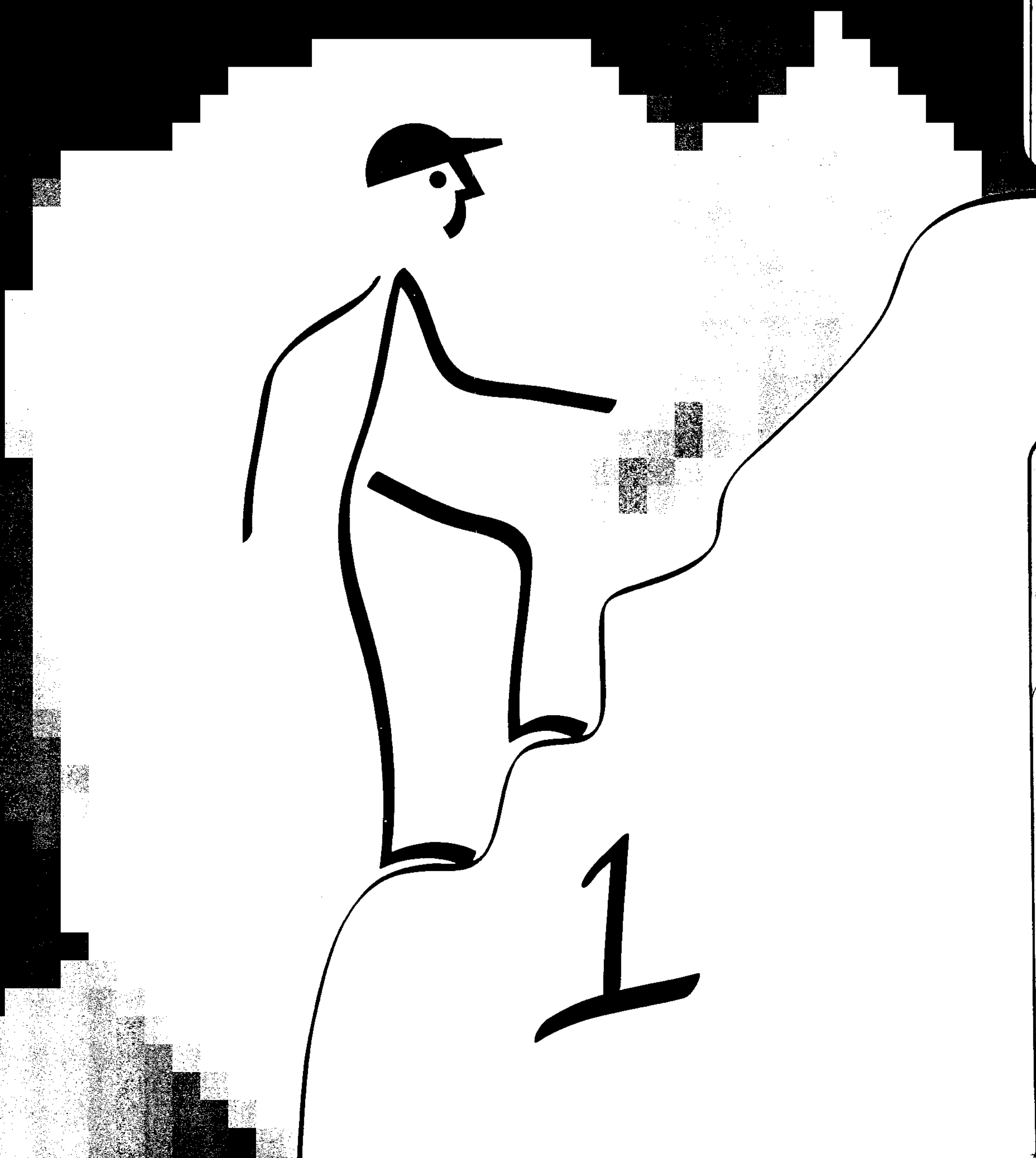
Frequent delivery in small lots will require the introduction of some type of "milk run" logistics between facilities and for the first time will raise the issue of relations between multiple product families. This is because organizing a milk run for the parts needed for only a single product family at the next downstream facility will often be impractical. Instead, major portions of a facility or an entire facility may need to make the leap from dedicated shipments arriving infrequently to shared shipments arriving often.

Finally, after Future State 1 and Future State 2 are achieved, it may make sense to begin re-sizing and relocating activities in order to "compress" the value stream. Doing this may make it possible to remove large remaining blocks of time and cost and move the value stream much closer to perfection in an **Ideal State**.

Because value stream compression will often require significant investments, sometimes by a firm at Point A that lower costs for a firm downstream at Point B, some method will be needed to justify these investments and determine how the firms can share the costs and benefits. We'll provide some simple guidelines in Part VI of this Guide, describing the Ideal State.

A truly ideal state will be the happy circumstance in which all actions create value with zero defects and consumer response is instantaneous. No one is likely to reach this perfect realm soon, but it is highly provocative to ask what types of product designs, production technologies, and locational logic can close as much of this gap as possible. What's more, the process of developing an Ideal State can provide an invaluable North Star for steering each value stream through succeeding product generations that come closer and closer to perfection.

PART IV: FUTURE STATE 1



PART IV: FUTURE STATE 1

Level Pull and Flow *Within* All Facilities

Future State 1 Summary

The Distance Still to Go

Future State 1

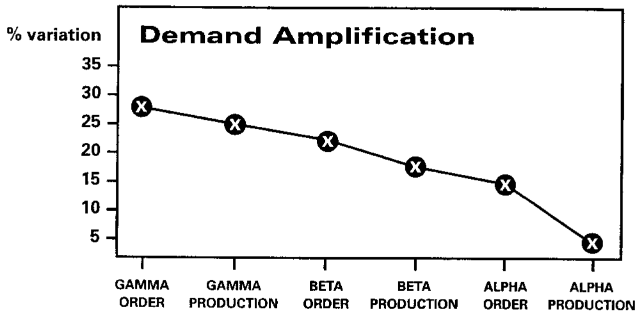
Once the team completes the Current State map and everyone agrees that it is accurate, the key question becomes, "What should be done in what sequence to create a better future state?" In our experience, the easiest place to start is to create future states within the walls of each of the facilities the product visits en route to the customer. By drawing and then achieving a future state of the type described in *Learning to See* within each major facility it will be possible to achieve a substantial improvement in the performance of the entire value stream and to do this within a short time. This creates confidence in the process and give teams a sense that much more is possible.

Beginning with this step also has the critical advantage of imposing a "price of admission" on all of the value stream participants. Drawing the current state map is fun but entails no real commitment. It's when you get to the, "What are we going to do today about the waste?" question that the hard issues arise. Insisting that each participating facility and firm quickly implement actual improvements as the price of continuing with the exercise also tends to gain buy-in for the process. Yet the hurdle is not too onerous because little capital investment is needed to achieve a future state within the individual facilities.

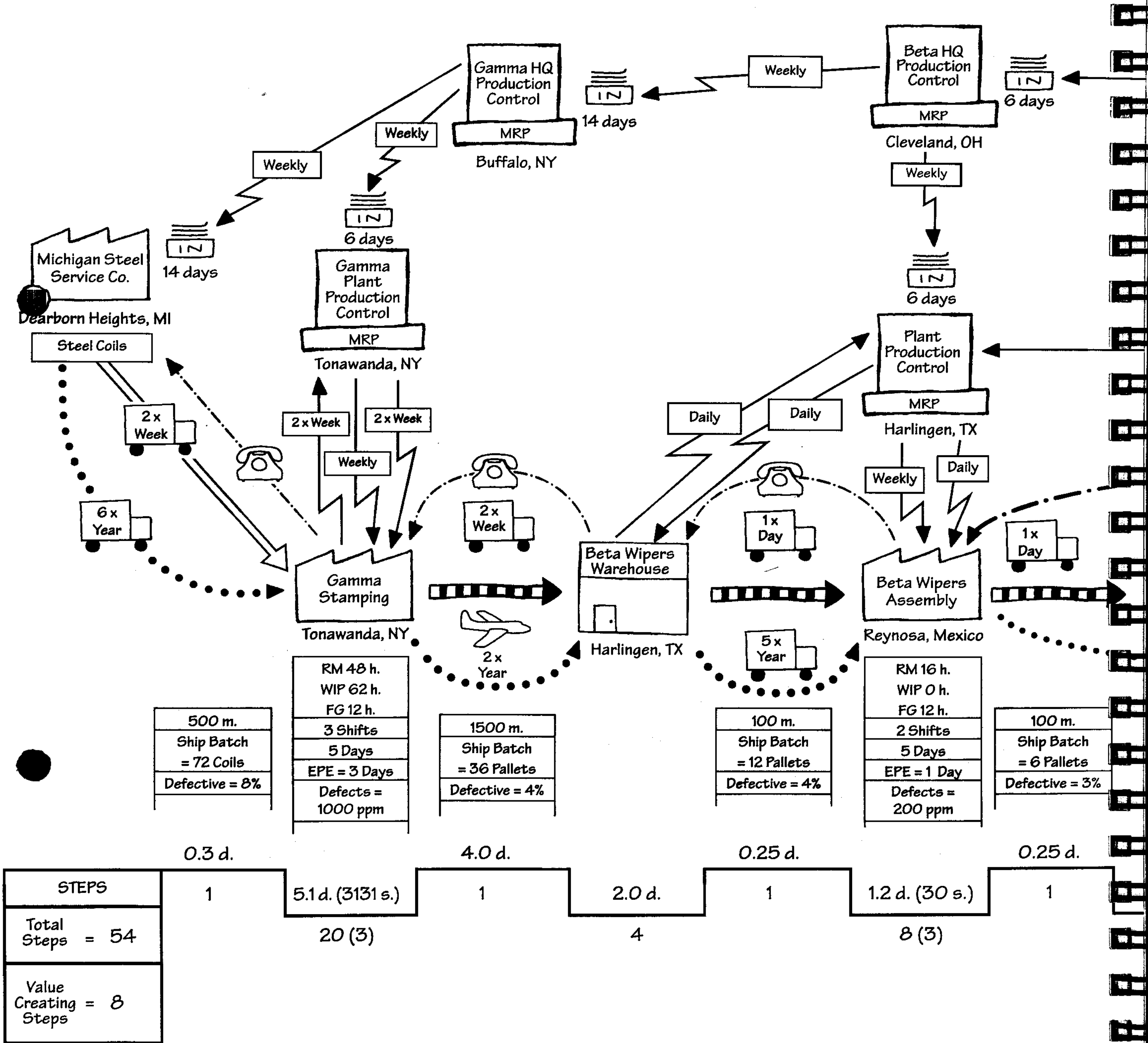
Level Pull and Flow *Within* All Facilities

In Appendix B, we show the Future State Maps for the Alpha Motors Final Assembly Plant, the Beta Wipers Component Assembly Plant, and the Gamma Stamping Part Fabrication Plant. At the urging of the extended value stream team, these were implemented and stabilized over a three-month period by newly appointed value stream managers in each plant. (As noted earlier, no changes have been attempted at the Alpha and Beta cross docks and in the Beta warehouse. This is both to keep the exercise manageable and because we will seek to eliminate these facilities in Future State 2.)

The cumulative result of these actions at the plant level is shown in the summary boxes on the Future State 1 map.

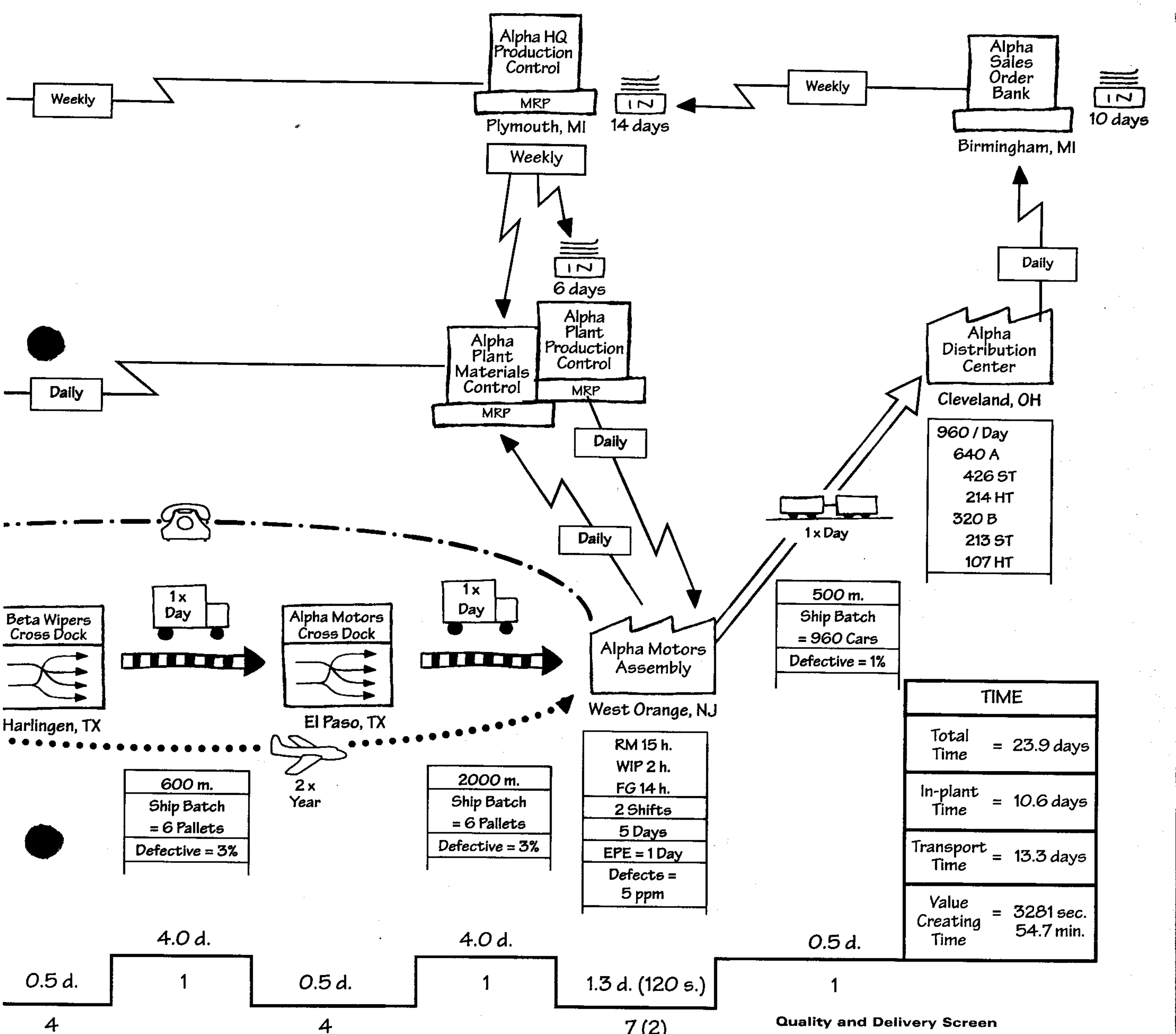


Demand Amplification
% variation
35
30
25
20
15
10
5
GAMMA ORDER
GAMMA PRODUCTION
BETA ORDER
BETA PRODUCTION
ALPHA ORDER
ALPHA PRODUCTION

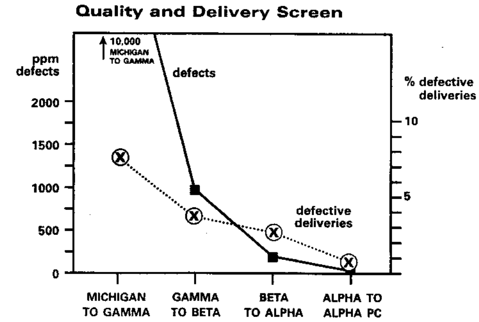


Gamma HQ Production Control
MRP
Buffalo, NY
Weekly
14 days
Beta HQ Production Control
MRP
Cleveland, OH
6 days
Weekly
Weekly
Weekly
14 days
6 days
Michigan Steel Service Co.
Dearborn Heights, MI
Steel Coils
Gamma Plant Production Control
MRP
Tonawanda, NY
6 days
Plant Production Control
MRP
Harlingen, TX
2 x Week
2 x Week
2 x Week
Weekly
Daily
Daily
Weekly
Daily
6 x Year
2 x Week
1 x Day
1 x Day
Gamma Stamping
Tonawanda, NY
Beta Wipers Warehouse
Harlingen, TX
Beta Wipers Assembly
Reynosa, Mexico
2 x Year
5 x Year
500 m.
Ship Batch = 72 Coils
Defective = 8%
RM 48 h.
WIP 62 h.
FG 12 h.
3 Shifts
5 Days
EPE = 3 Days
Defects = 1000 ppm
1500 m.
Ship Batch = 36 Pallets
Defective = 4%
100 m.
Ship Batch = 12 Pallets
Defective = 4%
RM 16 h.
WIP 0 h.
FG 12 h.
2 Shifts
5 Days
EPE = 1 Day
Defects = 200 ppm
100 m.
Ship Batch = 6 Pallets
Defective = 3%
0.3 d.
4.0 d.
0.25 d.
0.25 d.
STEPS
1
5.1 d. (3131 s.)
1
2.0 d.
1
1.2 d. (30 s.)
1
Total Steps = 54
20 (3)
4
8 (3)
Value Creating Steps = 8

Wiper Value Stream Future State 1



Quality and Delivery Screen



Only a First Future State

Please note that these Future States at the facility level are not the Ideal State within any facility. They are merely the first effort to introduce continuous flow with smooth pull while eliminating wasteful steps. The short time-frame for implementation means that existing technologies and product designs must be used.

Over time — as new generations of products and process technologies are introduced — it should be possible to go much further in successive current state/future state cycles within each facility. These in-facility efforts can and should continue even as the extended value stream team is pursuing Future State 2 and the Ideal State.

Future State 1 Changes

At Alpha Motors Assembly it was possible to eliminate a kitting operation and deliver parts directly from receiving to lineside. At the same time, a simple pull system was introduced between final assembly and wiper subassembly to cut the amount of inventory in half while smoothing the flow.

At Beta Wipers the team took advantage of the approach described in *Creating Continuous Flow* to relocate 4 formerly stand-alone tasks into one cell while reducing the number of production associates needed from five to three. At the same time, the team created leveled pull loops from the supermarket in the shipping area to the assembly cell and from the assembly cell to the supermarket in receiving, to reduce inventories and smooth flow.

Finally, at Gamma Stamping, the batch nature of the stamping and painting operations was accepted for the moment. Rather than trying to introduce continuous flow by cellularizing these operations, the team focused on introducing leveled pull loops between the three operations and reducing set-up times (from one hour to three minutes on the two stamping presses and from 30 minutes to five minutes in the paint booth). This permitted much smaller batches to be made, with frequent replenishment of the downstream supermarkets in small amounts.

Note that the extended map itself seems hardly to have changed. All of the facility boxes and flow arrows are as they were. Yet the summary figures in the facility data boxes are now considerably different and the data in the summary box at the lower right corner is different as well. Specifically, the total number of steps has been cut from 73 to 54 and total throughput time has been reduced from 44 to 24 days. All of the indicators of value stream performance in Future State 1, compared with the Current State, are shown on the next page.

Even more important, each firm participating in this shared value stream has quickly taken concrete steps to eliminate waste and improve performance in its own operations. This is not an example, as we see all too often, of downstream firms and facilities lecturing upstream firms and facilities on improving their performance while doing nothing about their own performance.

Future State 1 Summary

	Current State	Future State 1
Total Lead Time	44.3 days	23.9 days
Value Percentage of Time (value creating time to total time)	0.08%	0.16%
Value Percentage of Steps (value creating steps to total steps)	11%	15%
Inventory Turns	5	9
Quality Screen (defects at the downstream end over defects at the upstream end)	400	200
Delivery Screen (% defective shipments at the downstream over % defective shipments at upstream end)	8	8
Demand Amplification Index (% change in demand at downstream end over % change in demand at upstream end)	7	7
Product Travel Distance (miles)	5300	5300

At the level of the stamping plant, the component assembly plant, and the final assembly plant these changes are often truly impressive. In the most striking instance — the Beta Wipers component assembly plant in Reynosa — the number of steps at has been cut by 60% and the throughput time has been slashed by 75%. However, in terms of the entire value stream, as experienced by the customer at the end, the change in performance is more modest: a 25% reduction in the number of steps and 46% reduction in total throughput time, which is still much longer than the end customer is willing to wait. Thus the whole value stream is still producing to a forecast rather than to confirmed order. What's more, the performance improvements only assume these magnitudes when every facility touching the product achieves its future state.

This realization provides a useful insight to the value stream team about the limits of isolated, individual action: If you want to achieve a breakthrough — a "game changer" — that alters your position in your industry or produces profits far above industry averages, you'll need to optimize the entire value stream rather than stopping after improving the flow along small courses of the stream within your own facility — as many managers and firms do today.

Any firm unwilling or unable to implement the Future State 1 in its facilities is unlikely to be willing or able to take the next steps to achieve Future State 2. Therefore, if it becomes apparent at this point that some participants won't make this commitment, it will be critical to find alternative value stream members before other participants waste time in futile efforts. An obvious additional question for the firms downstream to ask is, "Do we want to keep the do-nothing upstream firms in our supply base?"

The Distance Still to Go

While the first five items in the summary box show a substantial improvement between the Current State and Future State 1, the last three items — the delivery screen, the demand amplification screen, and travel distance — show no change. This is because these indicators are driven by relations *between* facilities rather than activities solely *within* facilities. The next challenge for the team therefore is to tackle relations between the facilities. This necessarily requires tackling operational relations between firms.

PART V : FUTURE STATE 2

PART V: FUTURE STATE 2

Installing Leveled Pull *Between* Facilities

The Need for Controlled Experiments

Installing Frequent Transport Loops

Future State 2 Summary

Future State 2

As the value stream team achieves Future State 1 within each facility and begins to sense that collective management of the value stream is possible, it's time to take the next leap. This is to draw and quickly achieve a Future State 2, introducing a smooth and leveled pull along with frequent shipments between each of the facilities.

Installing Leveled Pull *Between* Facilities

In concept, this is very simple. What we want to do is to link each point of use of the product in a downstream facility with the previous point of production or shipment in the next upstream facility. In this way, consumption at the point-of-use is quickly and exactly replenished by the next upstream process.

In practice, shipping quantities will be considerably larger than minimum production quantities, even in a very lean value stream. For example, the minimum shipping quantity of wipers to the final assembly plant in this case is one pallet with 20 trays of wiper arms with each tray containing 16 wiper arms, for a total of 320 wipers. It is simply too expensive to ship individual trays, much less individual wipers.

The minimum production quantity, by contrast, would be one tray of 16 wipers. This is because set-up times and cost to alternate between Type A and Type B wipers in the two trim levels are now zero at the Beta Wiper Plant, after implementing Future State 1. But it would still be too expensive for materials handlers to wrap and move individual wipers.

Therefore, to level production to the maximum extent feasible as orders travel back upstream, we will want to send production signals to the work cell at Beta by trays rather than by pallets and to level these orders. For example, if 20 trays (one pallet) are ordered by Alpha Motors Assembly with the order consisting of:

5 trays of Type A, High Trim (which we will call Part #1)

5 trays of Type B, High Trim (Part #2)

5 trays of Type A, Low Trim (Part #3), and

5 Trays of Type B, Low Trim (Part #4)

We will want to send these orders to the Beta assembly cell in the sequence:

1/2/3/4/1/2/3/4/1/2/3/4/1/2/3/4/1/2/3/4

rather than in the sequence:

1/1/1/1/1/2/2/2/2/2/3/3/3/3/3/4/4/4/4/4

By repeating this production leveling process at every link upstream we will continually smooth production rather than creating waves due to batching.

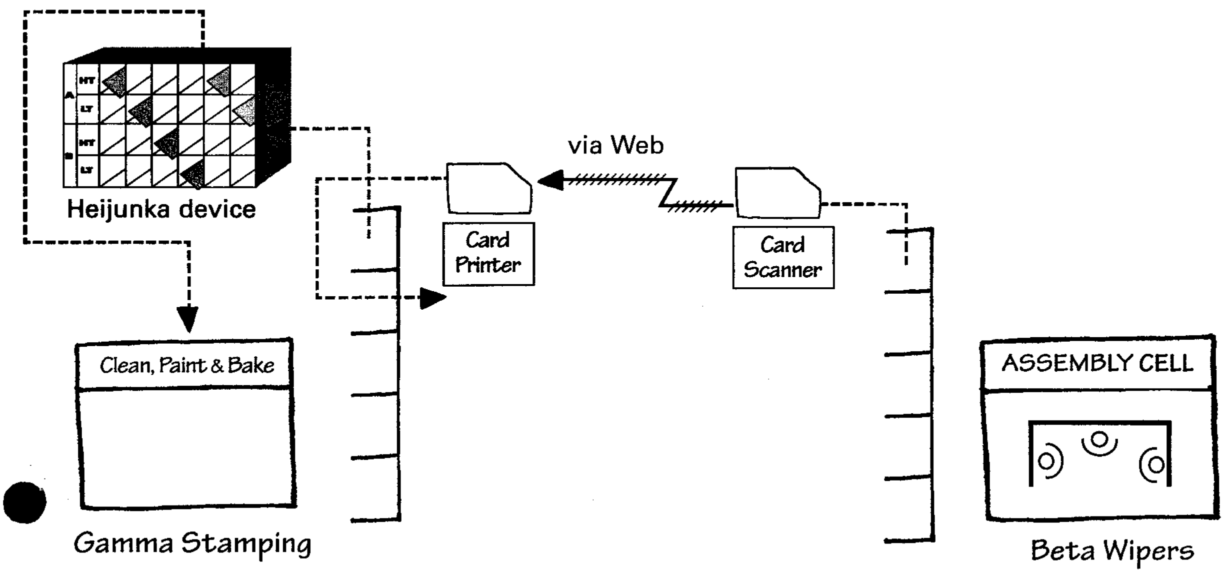
In practice, there are many ways to achieve this result. Some firms install pull systems on a strictly manual basis by collecting kanban cards from trays and phoning or faxing these orders back to the next upstream facility. There, kanban signal cards are written up and sent to the finished-goods supermarket to assemble the next shipment. (When plants are very close together and shipments from the next upstream facility occur many times a day — not the case in our example — the cards can be sent back with the truck bringing the new parts and returning the empty pallets. For many years, this was the primary method of information transfer in Toyota City.)

A small step up in automation would involve the use of an electronic reader to scan the kanban cards from emptied trays and send this information through an Electronic Data Interchange (EDI) network to the next upstream facility. There, new kanban cards could be printed and released to the finished goods supermarket to insert in trays and place in pallets for the next shipment. (When these trays are received in pallets at the downstream facility, the cards can be scanned again to confirm receipt and trigger supplier payment. They would be scanned one last time — and discarded to complete the cycle — when they are removed from the empty trays as the parts are consumed in the downstream process.) The cards removed from trays in the upstream supermarket as product is shipped would then be placed in some type of load-leveling (*heijunka*) device before transmission upstream to the previous processing step.

A further step in automation that has become attractive recently is to substitute a simple web-based information transfer system for the EDI link. The bar code scanning and the printing of new cards at the upstream facility remain the same but now the data are sent over the web. (This configuration of information management is shown in the diagram below.)

Still a further step is to eliminate the cards altogether and send electronic signals directly from the downstream process to the supermarket in the next upstream process where shipping instructions can be displayed on screens or hand-held devices. However, we always start to get anxious when information disappears into complex electronic systems

Electronic kanban using a bar code reader

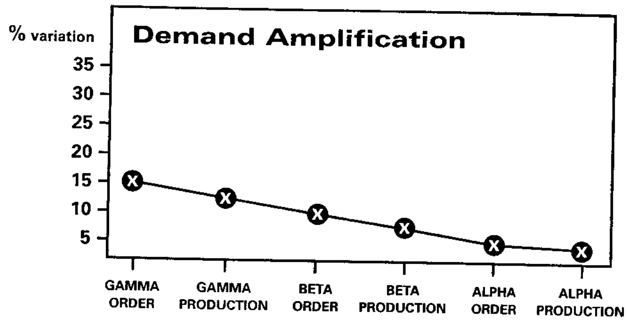


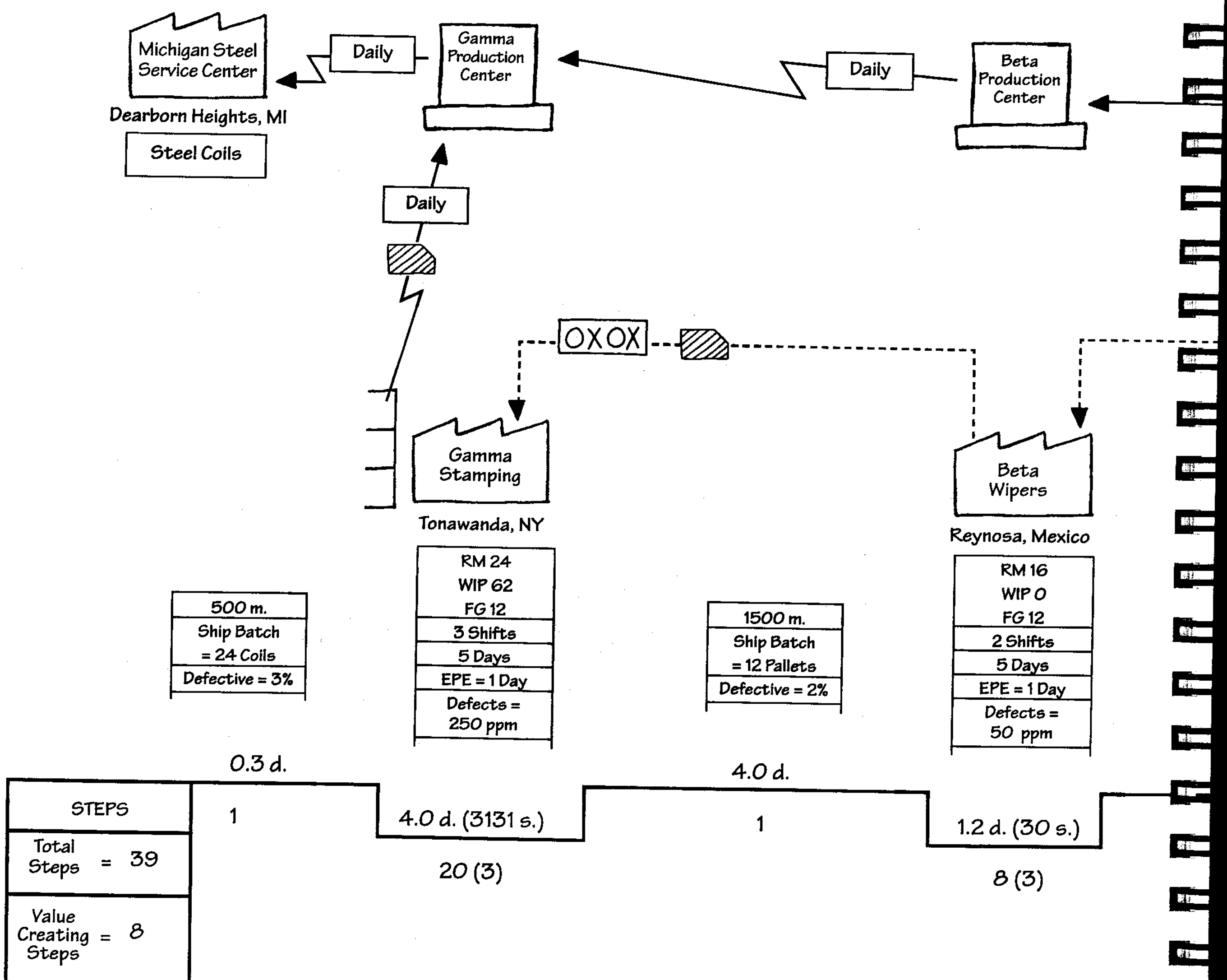
Note that the rows in the heijunka box are for the four types of parts in this product family while the columns (across the top) are for the pitch (rate) of withdrawal of the cards for conveyance to the upstream paint process.

whose inner workings are opaque to line managers and production associates. We advise using the simplest possible system that can get the job done, acknowledging that some businesses inherently require more complexity in information management than others.

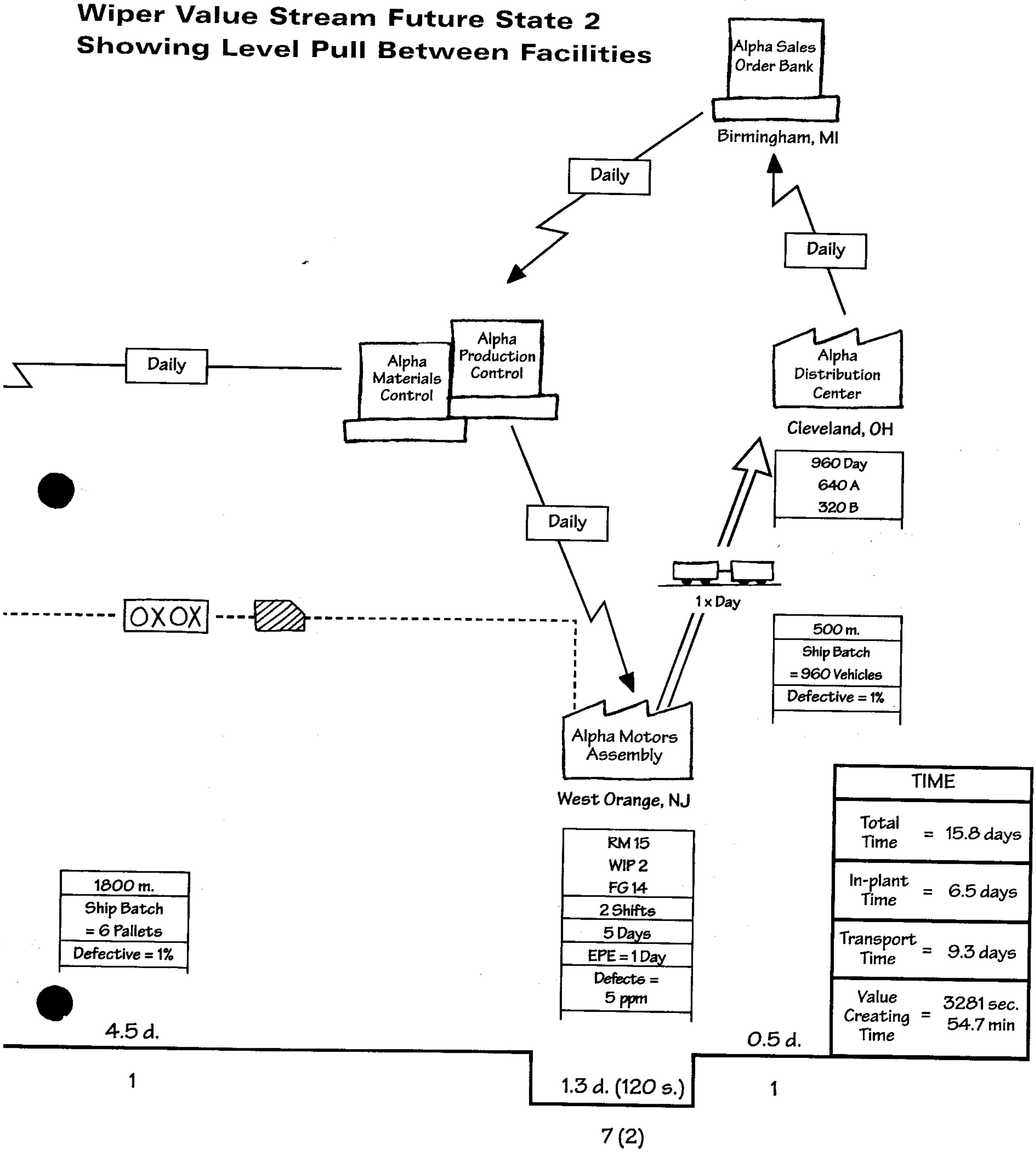
The key point to note about each of these arrangements is that there is no need to send day-to-day production instructions down from MRPs in the plant office or at company headquarters. Nor is there a need for customers to send daily releases generated by their scheduling computers. Rather than requiring elaborate calculations in a centralized processing system on what should be produced in each plant and at each machine — given expected operating conditions and pre-established lead times — the new system simply, reflexively re-orders from the next upstream point what has just been consumed by the next downstream point.

Note that the telephone-based expediting loop, which was often the real scheduling system in the Current State and in Future State 1, is now gone. If small amounts of parts are re-ordered and shipped automatically, accurately, and frequently in response to actual use, the need for expediting is eliminated. We've drawn this new information management system in our Future State 2 map.

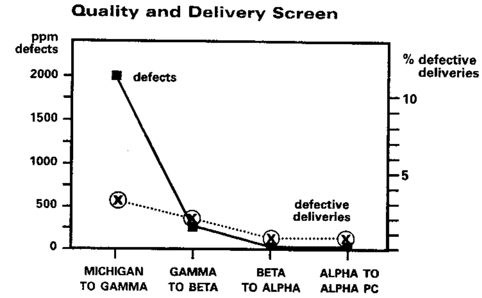

Demand Amplification
% variation
35
30
25
20
15
10
5
GAMMA ORDER
GAMMA PRODUCTION
BETA ORDER
BETA PRODUCTION
ALPHA ORDER
ALPHA PRODUCTION


Michigan Steel Service Center
Dearborn Heights, MI
Steel Coils
Daily
Gamma Production Center
Daily
Beta Production Center
Daily
OXOX
Gamma Stamping
Tonawanda, NY
Beta Wipers
Reynosa, Mexico
500 m.
Ship Batch = 24 Coils
Defective = 3%
RM 24
WIP 62
FG 12
3 Shifts
5 Days
EPE = 1 Day
Defects = 250 ppm
1500 m.
Ship Batch = 12 Pallets
Defective = 2%
RM 16
WIP 0
FG 12
2 Shifts
5 Days
EPE = 1 Day
Defects = 50 ppm
0.3 d.
1
4.0 d. (3131 s.)
20 (3)
4.0 d.
1
1.2 d. (30 s.)
8 (3)
STEPS
Total Steps = 39
Value Creating Steps = 8

Wiper Value Stream Future State 2
Showing Level Pull Between Facilities



Quality and Delivery Screen

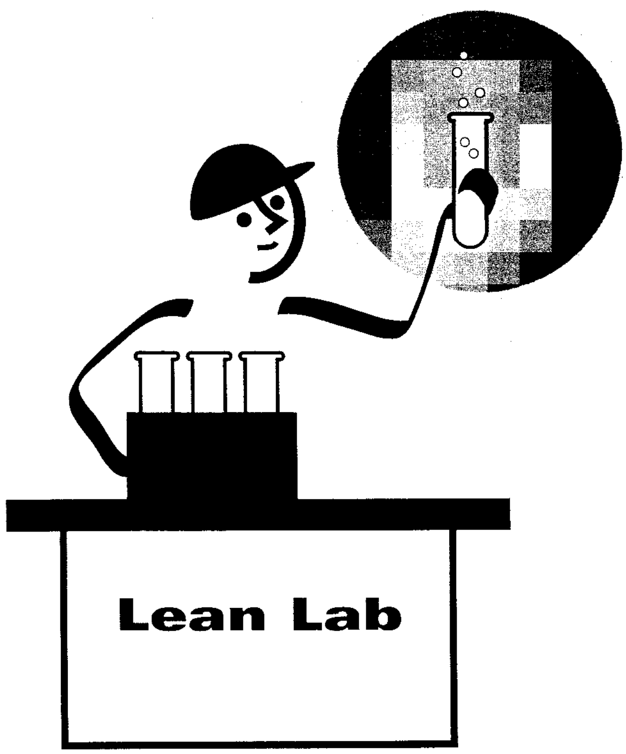


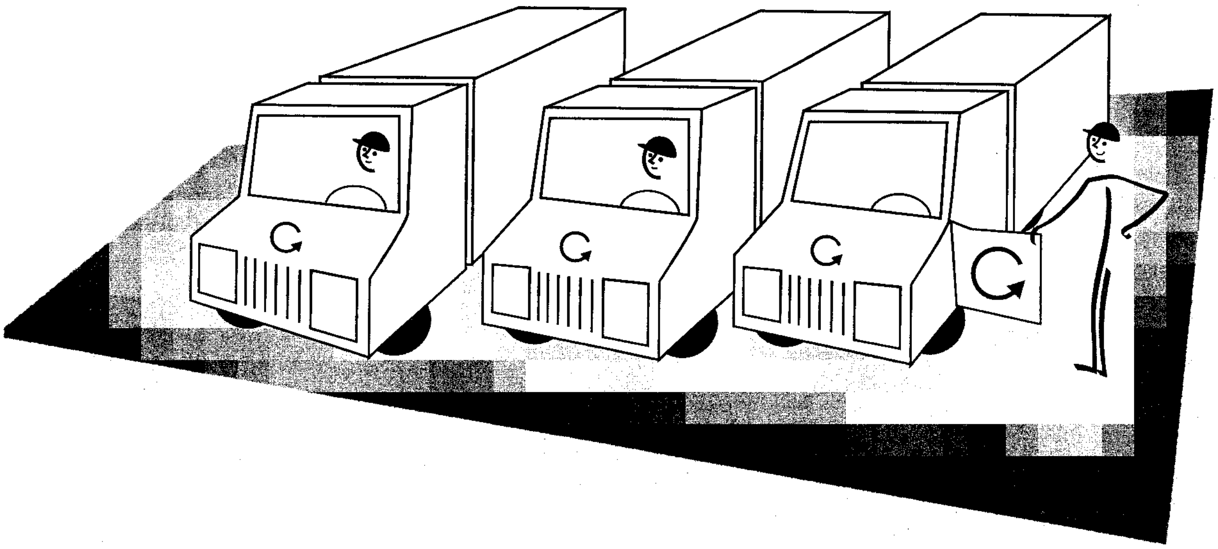
The Need for Controlled Experiments

"But," you will say, "how can you do this for information flow for only a single value stream co-mingled with many others? The same computer sending signals to control this stream is also scheduling other streams. Surely the whole system must be changed in order to change anything and this, realistically, is a massive and costly undertaking."

Actually massive change is not necessary. Just as we have disconnected our sample product family from the MRPs within several plants in Future State 1, and installed simple pull loops between activities within each plant, we can disconnect individual value streams currently running between facilities under central control and install simple pull loops.

The key point is for the value stream team to take this opportunity to try the experiment and judge the results. We confidently predict that the performance of the value stream as mapped in Future State 2 will argue for converting more and more product families to simple pull systems so that the overly complex production control systems commonly in place today are gradually converted to an activity where they are actually useful. This is capacity planning on a total system basis.





Installing Frequent Transport Loops

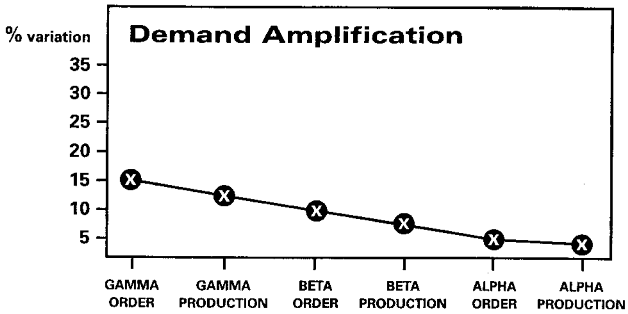
The logical and necessary complement to pull systems between facilities is increased shipping frequencies between facilities. This can be achieved by converting infrequent full-truck direct shipments between two facilities to frequent milk runs involving several facilities.

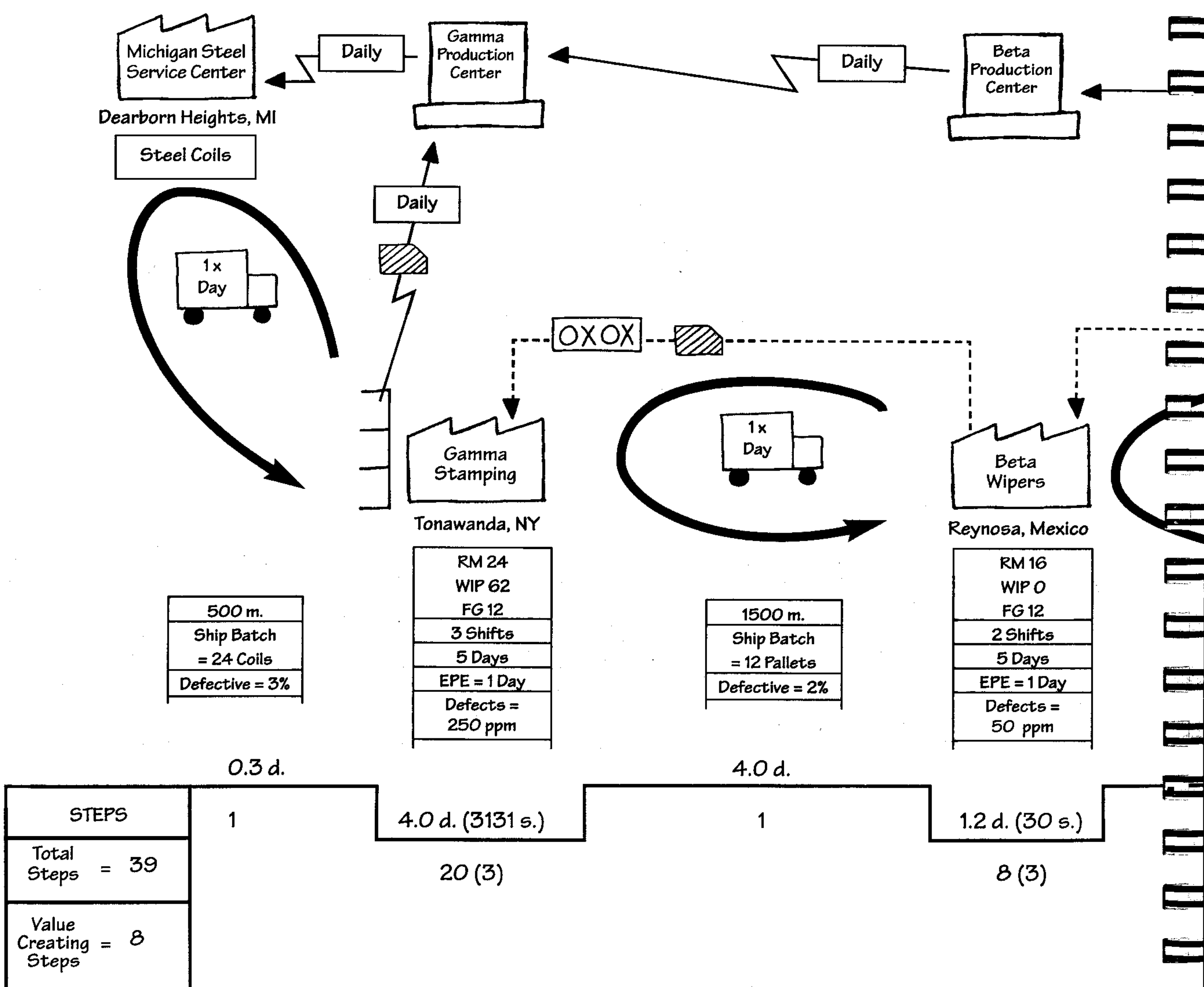
This has an additional and substantial benefit. The introduction of milk runs and more frequent deliveries makes it possible to eliminate the stop at the Beta Wipers warehouse in Harlingen and the long excursion to the Alpha Motors cross dock in El Paso. This saves eight steps and six days of throughput time and a thousand miles of transport. (Plus, if the parts for other value streams using these facilities are treated similarly, the facilities themselves can be eliminated with major cost savings.)

We've drawn these changes in the Future State 2 map by substituting our icon for **milk run replenishment** loops for the striped push arrows used in the Current State and Future State 1.

milk run
replenishment

Introducing pull loops and milk runs on an experimental basis will require a modest investment, but bounding the experiment can keep the amounts small until results are in and a decision is made on whether whole production systems should undergo conversion. And often these days, other suppliers and customers within an industry are already using milk runs. Perhaps your product can tag along.


Demand Amplification
% variation
35
30
25
20
15
10
5
GAMMA ORDER
GAMMA PRODUCTION
BETA ORDER
BETA PRODUCTION
ALPHA ORDER
ALPHA PRODUCTION


Michigan Steel Service Center
Dearborn Heights, MI
Steel Coils
Daily
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Beta Production Center
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OXOX
Gamma Stamping
Tonawanda, NY
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500 m.
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Defective = 3%
RM 24
WIP 62
FG 12
3 Shifts
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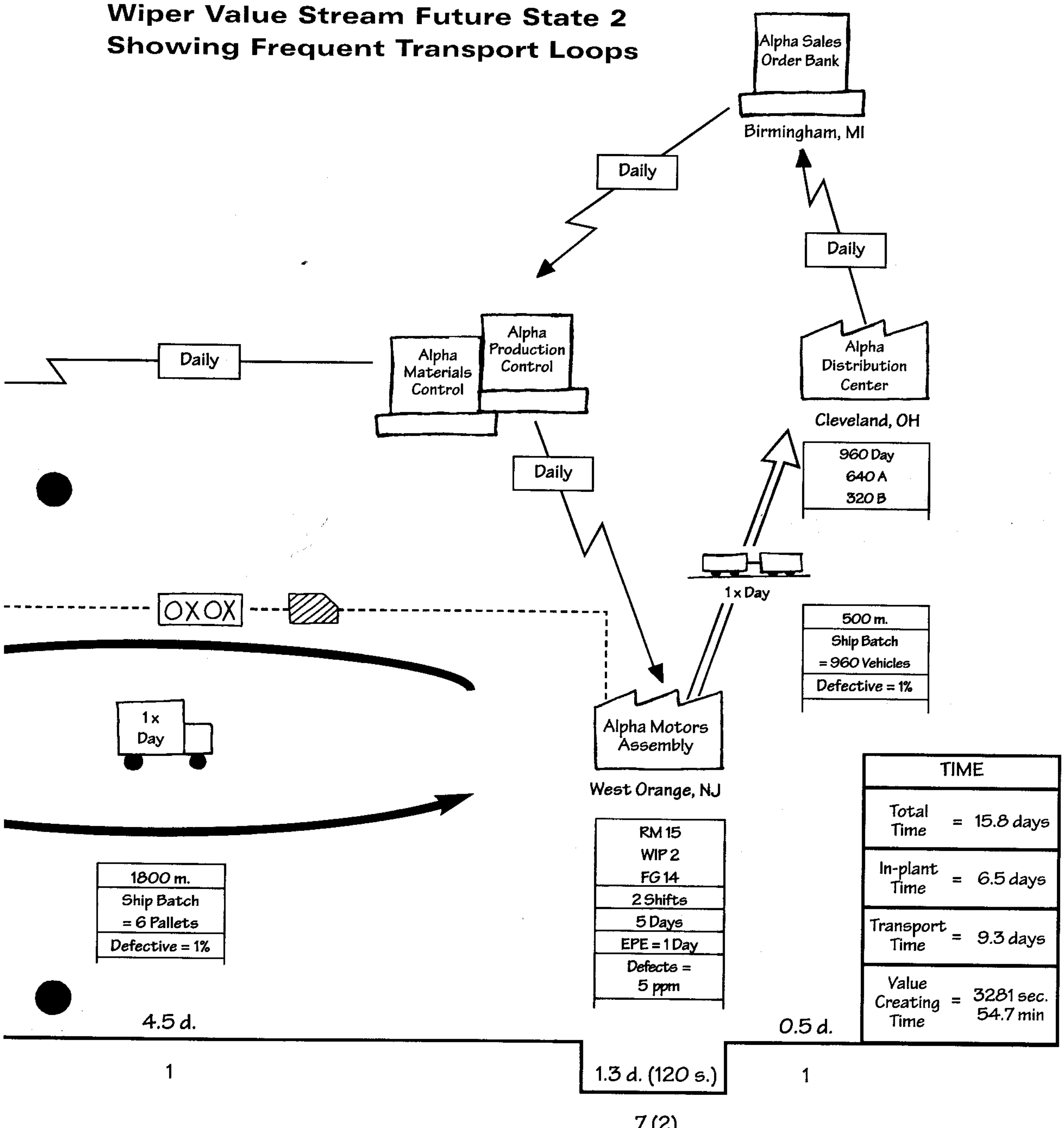
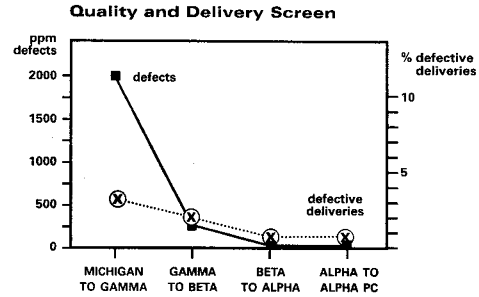
EPE = 1 Day
Defects = 250 ppm
1500 m.
Ship Batch = 12 Pallets
Defective = 2%
RM 16
WIP 0
FG 12
2 Shifts
5 Days
EPE = 1 Day
Defects = 50 ppm
0.3 d.
4.0 d.
STEPS
Total Steps = 39
Value Creating Steps = 8
1
4.0 d. (3131 s.)
1
1.2 d. (30 s.)
20 (3)
8 (3)

Wiper Value Stream Future State 2 Showing Frequent Transport Loops



Quality and Delivery Screen



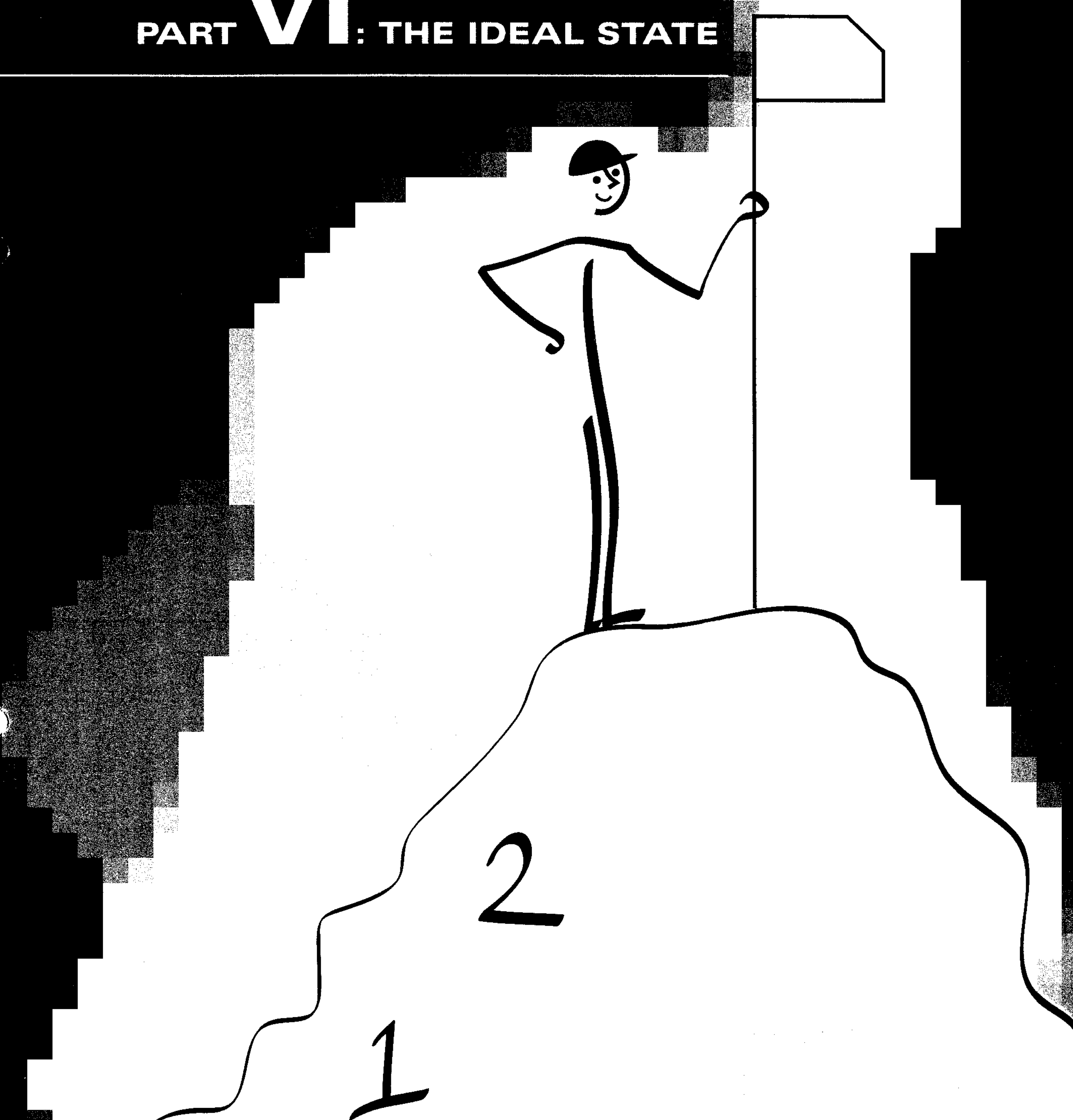
Future State 2 Summary

	Current State	Future State 1	Future State 2
Total Lead Time	44.3 days	23.9 days	15.8 days
Value Percentage of Time (value creating time to total time)	0.08%	0.16%	0.6%
Value Percentage of Steps (value creating steps to total steps)	11%	15%	21%
Inventory Turns	5	9	14
Quality Screen (defects at the downstream end over defects at the upstream end)	400	200	50
Delivery Screen (% defective shipments at the downstream over % defective shipments at upstream end)	8	8	3
Demand Amplification Index (% change in demand at downstream end over % change in demand at upstream end)	7	7	5
Product Travel Distance (miles)	5300	5300	4300

Totaling the Results

The consequence of smooth pull signals and frequent replenishment for our eight indicators of value stream performance is shown in the summary boxes on the Future State 2 map and in the chart above. The most striking change from Future State 1 to Future State 2 is the dramatic reduction in demand amplification, quality problems, and late shipments as the orders move back upstream. The amount of variation experienced at Michigan Steel is now much closer to the very low level of variation at Alpha Motors Assembly. In addition the dramatic reduction in shipping complexity and lag time between the creation of a defect and its discovery at the next downstream process has caused defects and shipping errors at the upper end of the value stream to converge on the low levels at the lower end of the value stream.

PART VI: THE IDEAL STATE



PART VI: THE IDEAL STATE

Compressing the Value Stream

The Logic of Relocation

Ideal State Summary

Winners Need to Compensate Losers

Timing the Leap to the Ideal State

Compressing the Value Stream

So far we have left every value creating activity in its original place, changing only information flows and shipment frequencies while eliminating unneeded warehouses and cross-docks. Although the value stream team has cut the number of steps from 73 to 39, reduced throughput time by 64%, and greatly damped demand amplification, much waste and long time lags remain.

Because it appears that most of the remaining waste and time are due to the need to move the product between many facilities and over long distances, a logical next step is "value stream compression" to relocate and co-locate value-creating activities so they can be performed faster with less effort.

What is the logic of relocation?

The first principle is simply that all manufacturing steps in the product should be moved as close together as possible. Ideally this would even be in the same room.

A second principle is that the closer this compressed sequence of activities is to the customer — Alpha Motors Assembly in our example — the better. The objective of lean thinking, after all, is to reduce costs and improve quality while getting customers exactly what they want when they want it. Remote manufacturing always works against this goal because it increases response time once the customers' desires are known. The unavoidable consequence for remotely located manufacturers who are determined to immediately serve their customers is to create inventories of finished units produced to (usually inaccurate) forecasts. In the current global security environment, where shipments across borders are subject to disruptions, this is even more the case.

"Do it all in one place" and "locate that place next to the customer" are useful principles to get started. However, a critical third rule is necessary: That if proximity should entail extra manufacturing costs (although the reverse will be more common), these costs must be weighed against the value of the time savings.

These principles in combination suggest a very simple location algorithm for most products:

1. If the customer is in a high labor-cost country (e.g., the U.S., Japan, Germany) and needs immediate response to orders, and if the product has relatively little labor content, conduct all of the manufacturing steps in close proximity and close to the customer in the high-wage country.

2. If the customer is in a high labor-cost country, is willing to wait for some shipping interval, and the product is price sensitive, manufacture the entire product, from raw materials to finished goods, in close proximity in a low-cost locale, shipping only the final goods. In our experience the correct location is almost always at a low-wage country *within* the region of sale. For example, Mexico for the U.S., China for Japan, Poland for Germany. Shipment of the finished product by truck, or a short ferry ride, and across only one border can still permit response to the customer within a few days, while shipment by sea from another continent requires weeks.

3. If the customer in a high labor-cost country needs immediate response but the product has high labor content, do a careful costing exercise to determine the correct location of manufacture. The best location might vary from a very low-wage site in another region of the world, with the product even delivered by air, to a new technology removing high-cost manufacturing labor in the high-cost country of sale and permitting the conduct of all manufacturing steps close to the customer.

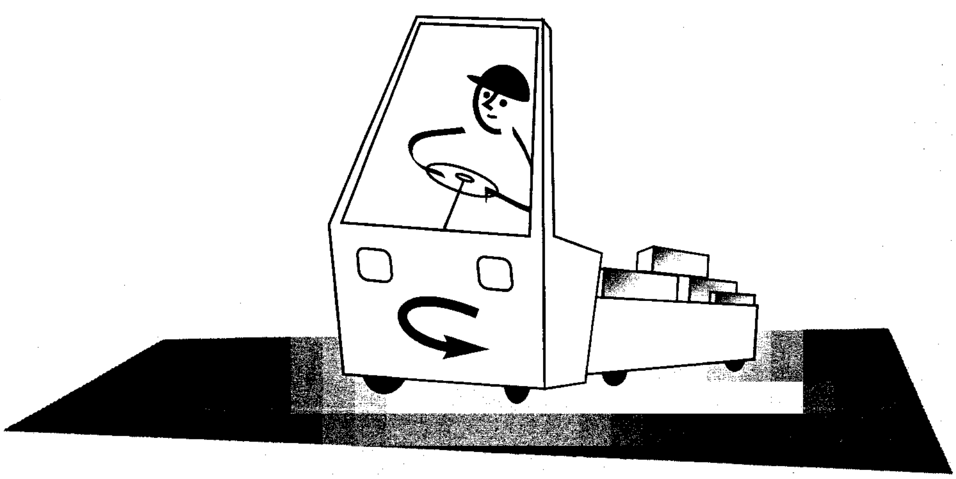
4. If the customer is in a low labor-cost country and scale requirements permit, manufacture the entire product — from raw material to finished goods — in geographic proximity in that country.

As the wiper value stream teams looked at the situation and pondered these rules it became apparent that the best location for an ideal state in this case would be immediately adjacent to the vehicle assembly plant in the high-cost country (the U.S.) This was because the amount of direct labor content in the product was actually very small, indeed only thirty seconds at the wiper assembly plant and a vanishingly slight amount at the stamping plant. (The number of wiper assembly operators required had already been reduced from five in the Current State to three in Future State 2.) The team found that a small increase in direct labor costs from relocation of this assembly step from Mexico to the U.S. — even when traditional corporate overheads were added to direct wage costs — would be more than offset by a big reduction in shipping, inventory, and general connectivity costs.

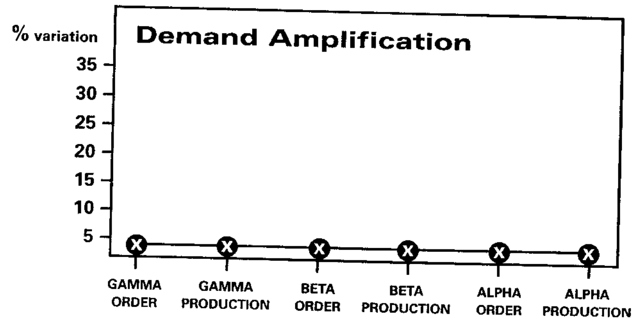
Ideal State Changes

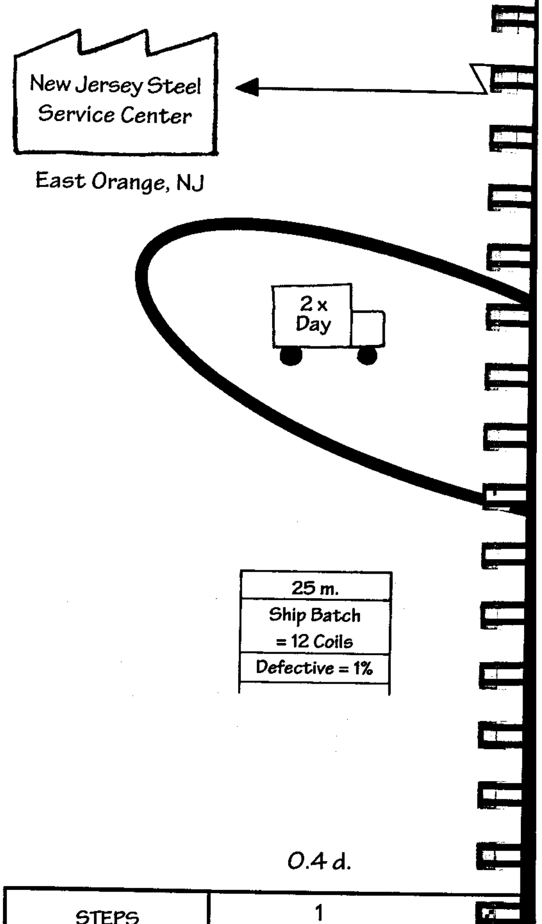
The value stream team therefore created the Ideal State map shown on the next page. Note that wiper assembly (including the blade-to-arm assembly step previously conducted in Alpha's assembly plant), painting, and stamping have now been compressed into one room in a "supplier park" on the site of the Alpha Motors assembly plant. A cheaper, low-speed stamping press has been introduced, which we call a "right-sized" tool because its capacity is proportional to the requirements of this value stream. This press is also able to make both the primary and secondary stampings for all of the other parts needed for the wiper assembly (see the schematic drawing on pages 12 and 13 showing these parts) and in very small batches to minimize inventories and lead times. A mini paint booth — a second right-sized tool — has also been designed and is located between the stamping step and wiper assembly.

Because the new wiper manufacturing module gets an electronic signal on what to build next as each vehicle leaves the paint booth in the vehicle assembly plant (a 3-hour lead time) and because the time needed from the start of wiper assembly until delivery to the final assembly line is less than the available lead time, wipers with high and low trim for vehicle models A and B can now be assembled to line sequence. They are then placed in line-sequenced trays of 40 wipers and conveyed to the fit point on the final assembly line every twenty minutes by a "water spider" (a small cart pulled by a converted fork-lift). The water spider loop connects several similar component plants adjacent to the Alpha final assembly plant, bringing back empty trays and needed parts to the wiper assembly area on each circuit.

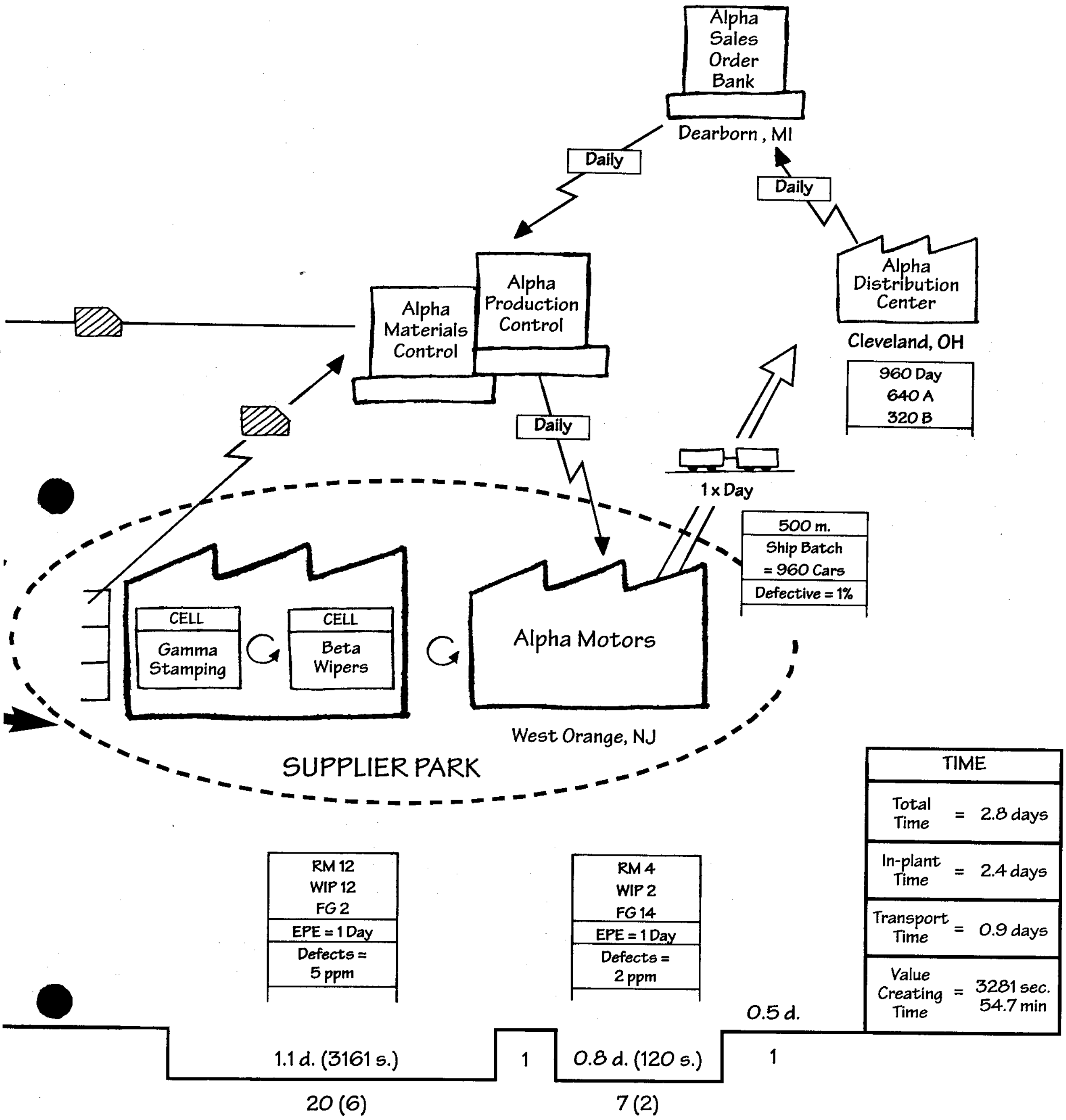


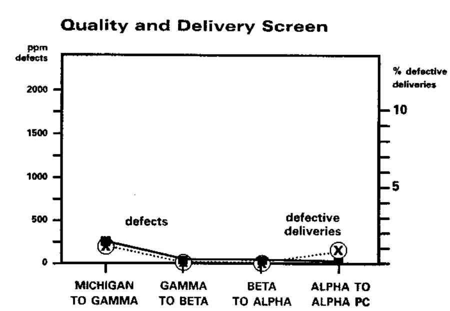
Wiper Value Stream Ideal State





STEPS	
Total Steps	= 30
Value Creating Steps	= 8


Alpha Sales Order Bank
Dearborn, MI
Daily
Daily
Alpha Materials Control
Alpha Production Control
Alpha Distribution Center
Cleveland, OH
960 Day
640 A
320 B
Daily
1 x Day
500 m.
Ship Batch = 960 Cars
Defective = 1%
CELL
Gamma Stamping
CELL
Beta Wipers
Alpha Motors
West Orange, NJ
SUPPLIER PARK
RM 12
WIP 12
FG 2
EPE = 1 Day
Defects = 5 ppm
RM 4
WIP 2
FG 14
EPE = 1 Day
Defects = 2 ppm
TIME
Total Time = 2.8 days
In-plant Time = 2.4 days
Transport Time = 0.9 days
Value Creating Time = 3281 sec. 54.7 min
0.5 d.
1.1 d. (3161 s.)
1
0.8 d. (120 s.)
1
20 (6)
7 (2)


Quality and Delivery Screen
ppm defects
2000
1500
1000
500
0
% defective deliveries
10
5
defects
defective deliveries
MICHIGAN TO GAMMA
GAMMA TO BETA
BETA TO ALPHA
ALPHA TO ALPHA PC

Ideal State Summary

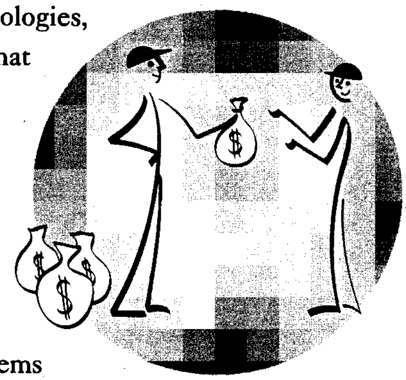
	Current State	Future State 1	Future State 2	Ideal State
Total Lead Time	44.3 days	23.9 days	15.8 days	2.8 days
Value Percentage of Time (value creating time to total time)	0.08%	0.16%	0.6%	1.5%
Value Percentage of Steps (value creating steps to total steps)	11%	15%	21%	27%
Inventory Turns	5	9	14	79
Quality Screen (defects at the downstream end over defects at the upstream end)	400	200	50	2.5
Delivery Screen (% defective shipments at the downstream over % defective shipments at upstream end)	8	8	3	1
Demand Amplification Index (% change in demand at downstream end over % change in demand at upstream end)	7	7	5	1
Product Travel Distance (miles)	5300	5300	4300	525

Dramatic Changes

Throughput time from raw materials to customer has now been reduced by 94% to 2.8 days, and practically all of the transport links, inventories, and handoffs — the key drivers of connectivity costs — have been eliminated, from the final assembler back through the wiper maker to the stamper and raw materials supplier. In addition, it is hard to tell where one company leaves off and the next picks up the value stream because activities formerly conducted by Alpha, Beta, and Gamma at locations thousands of miles apart are now being conducted in continuous flow in one room located across the road from the customer.

Winners Need to Compensate Losers

As future state and ideal state maps are drawn up, it will quickly become apparent that positive change is most likely if the team can find a way for winners to compensate losers. This is because it will commonly be the case that a downstream participant can get better value at lower cost if an upstream participant leaves out wasted steps, implements leveled pull systems with its suppliers, introduces more capable process technologies, and relocates activities. However, even when everyone can see that the incremental savings exceed the incremental costs of these initiatives, little is likely to happen unless upstream participants are compensated by downstream beneficiaries for taking costly actions that optimize the whole.



If it were easily possible to compare total product cost before and after the future state improvements, compensation might be an easier issue. However, traditional purchasing and accounting systems are often incompatible between value stream participants and in any case are poorly suited for calculating product costs for each product family. These systems typically require enormous amounts of data to allocate overheads by product and they usually fail to calculate costs in a way that all participants will accept as valid.

We propose keeping it simple by ignoring traditional systems and instead determining the incremental cost (in some common currency unit) and the incremental benefit (in the same currency unit) of each proposed change in the value stream in future and ideal states. This is surprisingly easy in many cases and can change the focus of the value stream team from redressing (or defending) the mistakes and inequities of the past to discovering win-win-win alternatives for the future.

The problem of cross-firm compensation will not be such an issue if the product being mapped is new and the course of the value stream is not constrained by existing facility locations or even existing suppliers. However, it will still be important to calculate connectivity costs for various configurations of the value stream to see which one will actually produce the best combination of low cost and rapid customer response.

Timing the Leap to the Ideal State

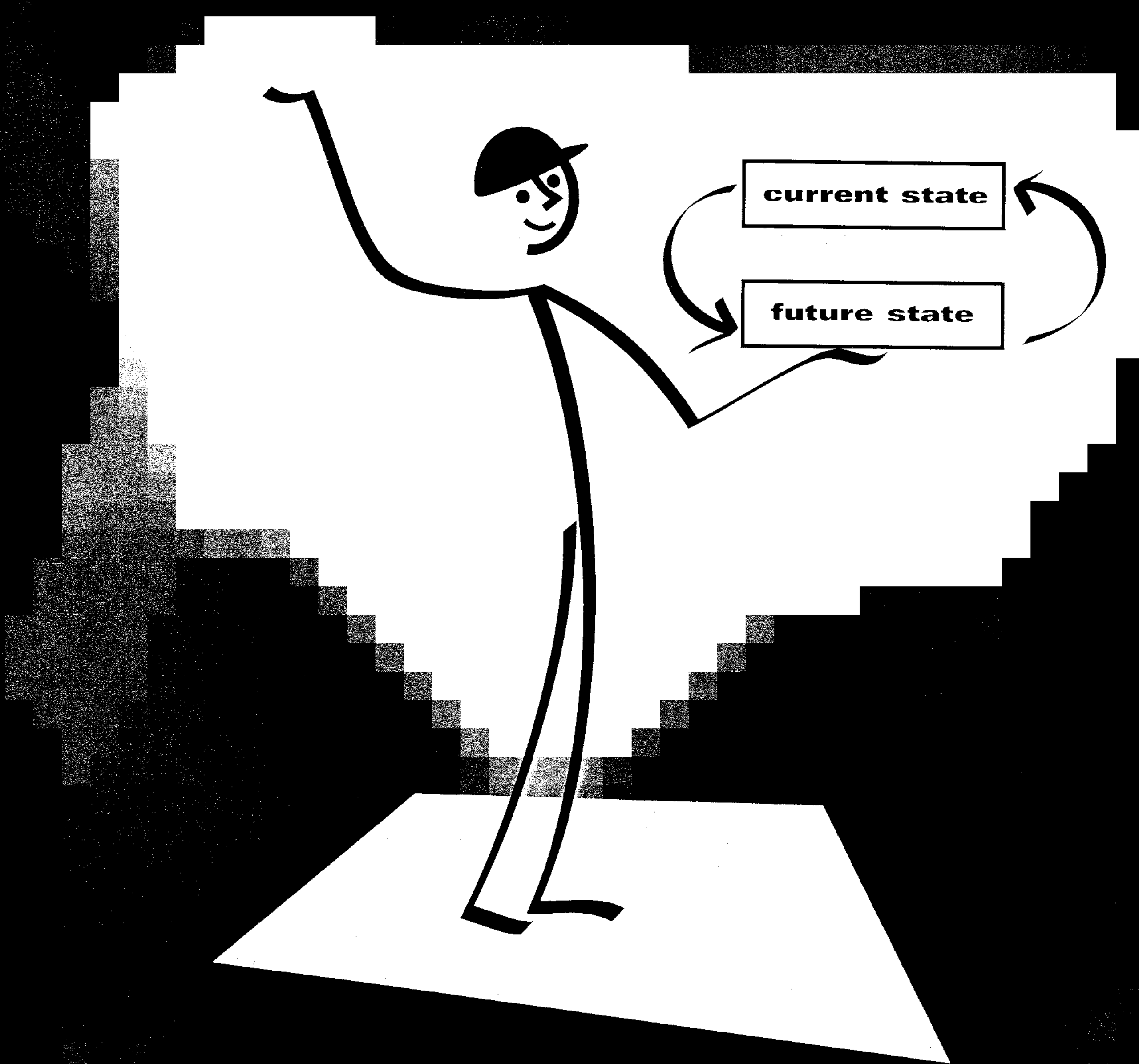
Because lower-speed presses will be cheaper and more capable if used on new part designs and a change in the raw material provider will be required as well (note that New Jersey Steel is to be substituted for Michigan Steel in the Ideal State, to reduce shipping distance for steel coils from 500 miles and eight hours to 25 miles and one hour), the best time to leap to the Ideal State will be with the next product generation, when new process equipment will be needed in any case.

The exercise of creating an ideal state to contrast with a business-as-usual state should therefore be conducted for every new product generation. This can lead to a very creative joint mapping of the ideal state from the very start of the next design, when the barriers to doing everything right are greatly reduced.

A Final Risk to Avoid

In developing the examples for *Seeing the Whole* we have learned of another risk for the value stream team to avoid. This is to turn the mapping exercise into a conventional cost study for a product family by trying to map the flow of every part going into the product. When teams do this we've found that they lose sight of the key point. This is that the types of waste exposed and the demand amplification discovered are also present in every product family passing through all of the participant firms. The first purpose of the exercise is to raise consciousness about systemic problems and to spur the development of systemic solutions requiring better performance by the functions, not to shave a bit of cost out of one specific product and then declare victory.

PART VII: ACHIEVING FUTURE STATES



PART VII: ACHIEVING FUTURE STATES

The Value Stream Plan

Achieving Future States

Value stream maps at the macro-level are very useful for raising consciousness about waste and the lack of customer responsiveness in today's typical current state, a situation often invisible to value stream partners looking only at their own operations. However, if consciousness is raised but no future state is achieved the whole mapping exercise just creates more corporate wallpaper — pure *muda.*

How can you actually achieve future states when many departments and firms must cooperate and no one person or firm is legally "in charge"? We have already suggested that progress is best made in a series of steps beginning with the easiest. If a Future State 1 can be achieved that reduces time and effort within each participating firm, this will give all of the value stream partners the courage and incentive to go further.

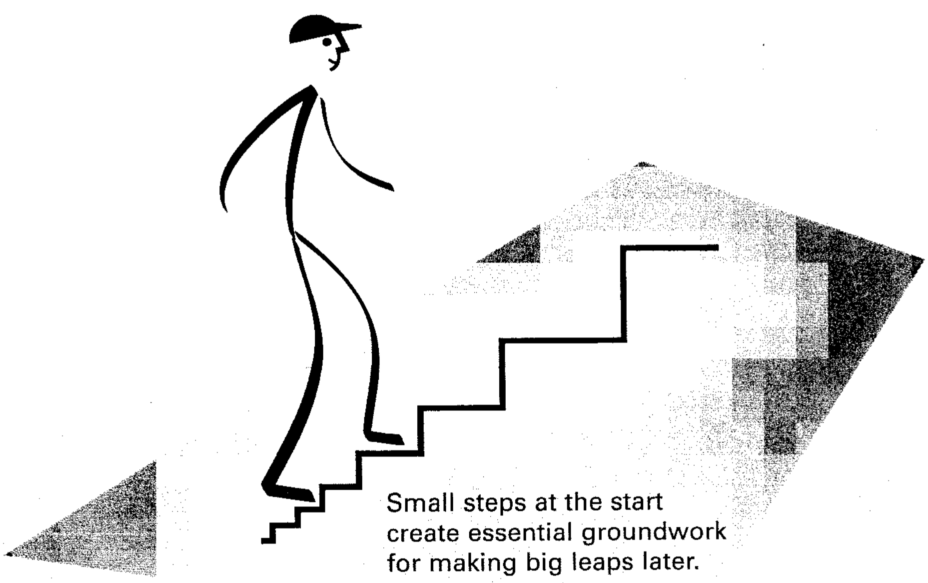
Then, if Future State 2 can be achieved as well — addressing production control problems to stabilize demand, remove noise, cut costs, and enhance responsiveness to the customer — the momentum for improvement will be much stronger. The prospects for successful introduction of the Ideal State, with its requirements for investment and relocation of activities, then become much brighter.

Running the process in the opposite direction, beginning with a big leap to an ideal state, may be possible in some cases — particularly for entirely new products — and we certainly don't want to discourage value stream teams in a position to make this leap. However, in the great bulk of instances, small steps will be essential at the start to lay the groundwork for big leaps later.

In our experience, Future State 1 can be achieved in about three months after completion of the Current State map. Future State 2 can be in place in six months after the achievement of Future State 1. However, conditions will vary and it may be more practical for the value stream team to begin implementing Future State 2 even if Future State 1 is not completely in place and stabilized. This is because many of the activities involved are quite separate and can proceed in parallel.

The timing for the Ideal State may range from "soon" (particularly for new products) to "much later". The team in our example concluded that the new supplier park configuration can be in place in four years, at the point that the next generation of vehicle Models A and B with redesigned wiper systems is introduced. Trying to move faster would mean that Beta and Gamma would need to continue their remote operations for their other customers and would incur substantial costs for duplicate tooling and underutilization of their existing facilities.

Even if the precise timing of the later states is hard to determine now, the simple act of writing down all of the necessary steps and agreeing on specific target dates for achieving specific steps has the highly useful effect of converting vague intentions and "no year" projects into concrete, trackable tasks.



Small steps at the start create essential groundwork for making big leaps later.

The Value Stream Plan

We suggest that the value stream team develop a value stream plan for their product family at the end of their initial walk, when the Current State map is drawn. This exercise should only take a few days. If it drags on, the odds are very high that nothing will ever be implemented. Just as in the case of lean production, velocity is critically important in lean improvement activities.

A value stream plan shows:

- exactly what your team plans to accomplish, step by step
- measurable goals for team members
- clear checkpoints with real deadlines and responsible individuals
- the formula for sharing costs and benefits among participating firms

It will be familiar to you if you have had experience with policy deployment or if you have already developed facility-level value stream plans of the type shown in Part V of *Learning to See* (and Part VI of *Creating Continuous Flow).* However, it will be a bit more complicated because this plan builds on the "Yearly Value Stream Plan" for each facility being developed at the same time, as illustrated in *Learning to See.*

The wiper value stream team developed a simple value stream plan, as shown on the next page.

START:	January 2002
TEAM LEADER:	Barb Smith, Alpha
TEAM MANAGERS:	Paul Doe, Beta; Joe Baker, Gamma; Sally Jones, Steel Supplier

YEARLY

Product-Family Business Objective	State	Value Stream Objective	GOAL (measurable)	QUARTERLY 2002: 1	2	3	4
Improve profitability on wipers for Alpha, Beta, Gamma, + steel supplier.	FS 1	*continuous flow where possible in all facilities *level pull within all facilities	Lead time = 23.9 days Inventory turns = 9 Quality screen = 200				
			Alpha	O	△		
			Beta	O		△	
			Gamma	O		△	
			Michigan Steel	O		△	
	FS2	*level pull between all facilities *frequent replenishment loops between all facilities	Lead time = 15.8 days Inventory turns = 14 Quality screen = 50 Delivery screen = 3 Demand amplification screen = 5				O
	IS	*value stream compression by co-locating all steps adjacent to customer	Lead time = 2.8 days Inventory turns = 79 Quality screen = 2.5 Delivery screen = 1 Demand amplification screen = 1				

O Start △ Completion

VALUE STREAM PLAN

SIGNATURES

ALPHA	BETA	GAMMA	STEEL SUPPLIER

SCHEDULE

2003				2004				PERSON IN CHARGE	RELATED INDIVIDUALS & DEPTS	REVIEW SCHEDULE	
1	2	3	4	1	2	3	4			REVIEWER	DATE
								Smith Doe Baker Jones	Operations Purchasing PC&L Manufacturing Engineering Quality (in every firm/facility)	○ ○ △ △	
								Smith	Ditto		
								Smith	Ditto		

○ On target △ Behind target

PRODUCT FAMILY:	Wipers for Alpha Models A+B

CONCLUSION

At the end of this brief breakthrough guide for achieving future and ideal states we must share a secret: You'll never actually achieve your ideal state! It turns out that there is always more waste to remove and that value for the customer can always be further enhanced.

For example, wipers might some day be molded as a single piece in matching body colors, eliminating the need for the stamping, painting, and final assembly of considerable numbers of parts. If cycle times for these activities were at or below takt times for wipers on the final assembly line and if changeovers from one wiper color and specification to the next were also essentially instantaneous (or at least within takt time), it would be possible to mold wipers to line sequence with total throughput time and value creating time both shrinking to seconds. At that point, the "Ideal State" portrayed in this workbook will appear to be full of *muda*!

However, there's a companion point that also seems to be a secret to many managers. This is that successive future states getting much closer to the ideal state can be achieved by real managers in real firms building current product designs in only a short period of time even when there is no "value stream dictator" giving orders. And even more can be accomplished with the next generation of products, before machines and facilities are locked in place.

The trick is to take a walk together so everyone can see the whole. Then estimate the "prize" available to the group if the whole value stream can be optimized. Then devise a mutually acceptable way to split the loot if the current state "Bank of Muda" can be robbed. It won't happen all at once and you'll probably never reach that happy land of completely frictionless cooperation but the challenge is to get started, gain some initial successes, and not look back.

As firms and departments learn to see together it should also be possible to make your maps ever more inclusive, eventually reaching all the way from the customer's use of the product through the life cycle back upstream to inchoate matter before any processing. And we believe it will be attractive to map wider and wider range of goods and services including office processes, as many readers have already started to do with the micro-maps in *Learning to See*. (For example, we at LEI have already heard from readers about mapping gold mining, fish stick manufacture, postal sorting operations, insurance claims processing, the writing of technical manuals for complex aerospace products, and visits to the doctor.) Because there is always a value stream whenever there is a product (whether it's a good, a service, or some combination), we are confident that consciousness will continue to spread about the potential of value stream mapping.

We wish you the best in your endeavors and hope to hear about your problems and your successes.

About the Authors

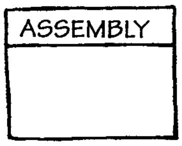
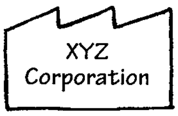
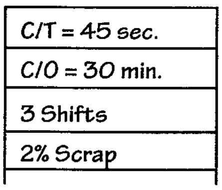
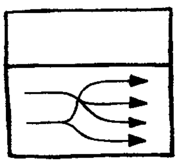
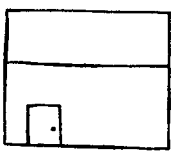
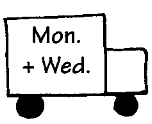
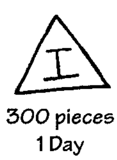
Dan Jones
Dan is co-author of *The Machine That Changed the World* and *Lean Thinking*, Professor at the Cardiff Business School in the UK, Senior Advisor to the Lean Enterprise Institute, and Chairman of the Lean Enterprise Institute's affiliate organization, Lean Enterprise UK. He has long had an interest in mapping entire value streams and took the lead in developing the examples presented in Chapter 2 of *Lean Thinking*. These began with the humble can of cola that requires 319 days to pass through six different companies and nine facilities across the world, firms and facilities that collectively conduct only three hours of value-creating activities before the cola finally reaches the customer.

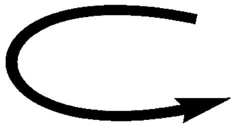
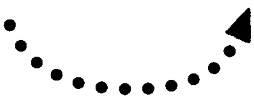
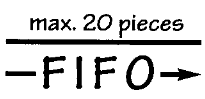
Jim Womack
Jim is co-author of *The Machine That Changed the World* and *Lean Thinking* and President and Founder of the Lean Enterprise Institute. He finds it hard not to think about extended value streams including those involving healthcare, mobility, food, communication, construction, defense, and logistics.

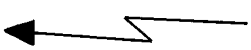
John Shook
John is co-author of *Learning to See*, and a Senior Advisor to the Lean Enterprise Institute. John learned value stream thinking during his eleven years with Toyota, where he concentrated on transferring Toyota's thought process from its origins in Japan to its affiliates and suppliers around the world.

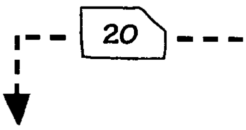
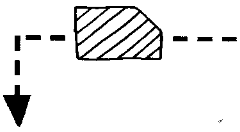
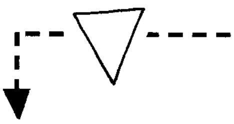
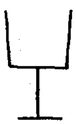
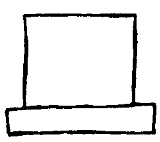
APPENDIX A - Extended Value Stream Mapping Icons

The icons and symbols for current and future state mapping fall into three categories: Material Flow, Information Flow, and General Icons.

Material Icons	Represents	Notes
	Manufacturing Process	One process box equals an area of flow. All processes should be labeled. Also used for departments, such as Production Control.
	Outside Sources	Used to show customers, suppliers, and outside manufacturing processes.
	Data Box	Used to record information concerning a manufacturing process, department, customer, etc.
	Cross-Dock	
	Warehouse	
	Plane Shipment	Note frequency of shipments.
	Train Shipment	Note frequency of shipments.
	Truck Shipment	Note frequency of shipments.
	Inventory	Count and time should be noted.

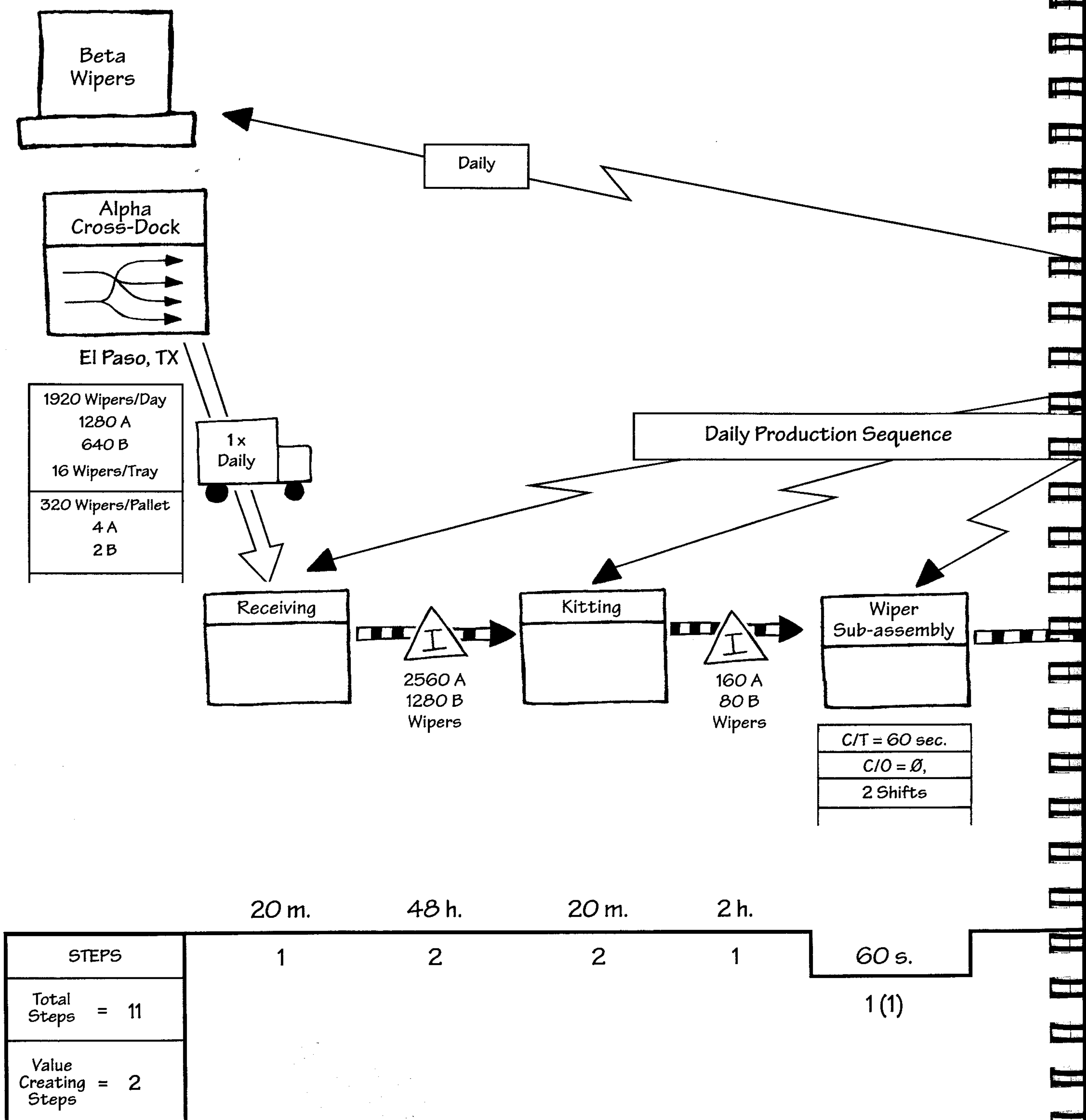
Material Icons	Represents	Notes
	Movement of production material by <u>PUSH</u>	Material that is produced and moved forward before the next process needs it; usually based on a schedule.
	Movement of finished goods to the customer	
	Milk Run	
	Expedited Transport	
	Supermarket	A controlled inventory of parts that is used to schedule production at an upstream process.
	Withdrawal	Pull of materials, usually from a supermarket.
	Transfer of controlled quantities of material between processes in a "First-In-First-Out" sequence.	Indicates a device to limit quantity and ensure FIFO flow of material between processes. Maximum quantity should be noted.

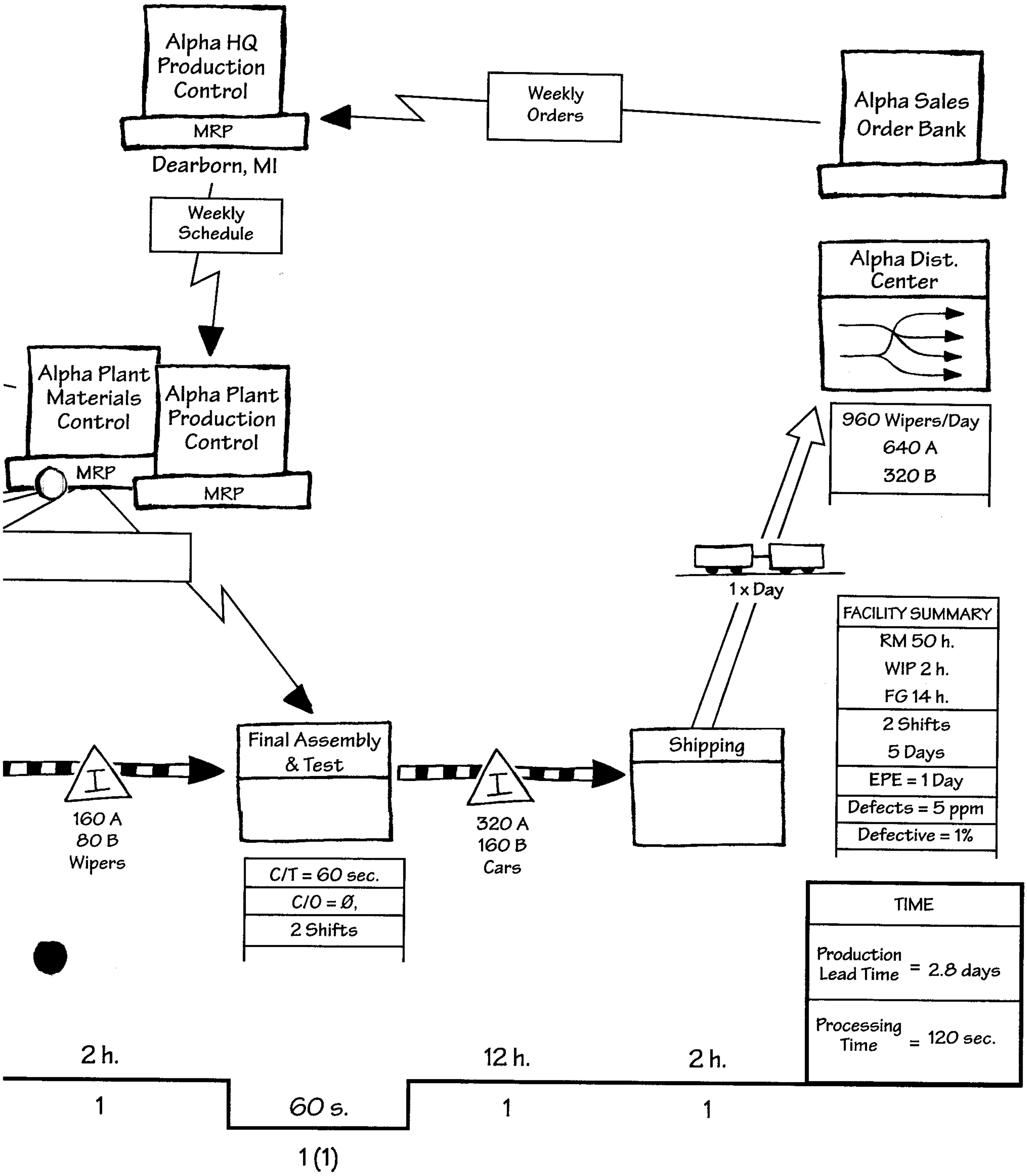
Information Icons	Represents	Notes
	Manual Information flow	For example: production schedule or shipping schedule.
	Electronic Information flow	For example via electronic data interchange.
	Information	Describes an information flow.

Information Icons	Represents	Notes
	Production Kanban (dotted line indicates kanban path)	The "one-per-container" kanban. Card or device that tells a process how many of what can be produced and gives permission to do so.
	Withdrawal Kanban	Card or device that instructs the material handler to get and transfer parts (i.e. from a supermarket to the consuming process).
	Signal Kanban	The "one-per-batch" kanban. Signals when a reorder point is reached and another batch needs to be produced. Used where supplying process must produce in batches because changeovers are required.
	Kanban Post	Place where kanban are collected and held for conveyance.
	Kanban Arriving in Batches	
	Load Leveling	Tool to intercept batches of kanban and level the volume and mix of them over a period of time.
	Control Center	
	Phone	
	Orders	

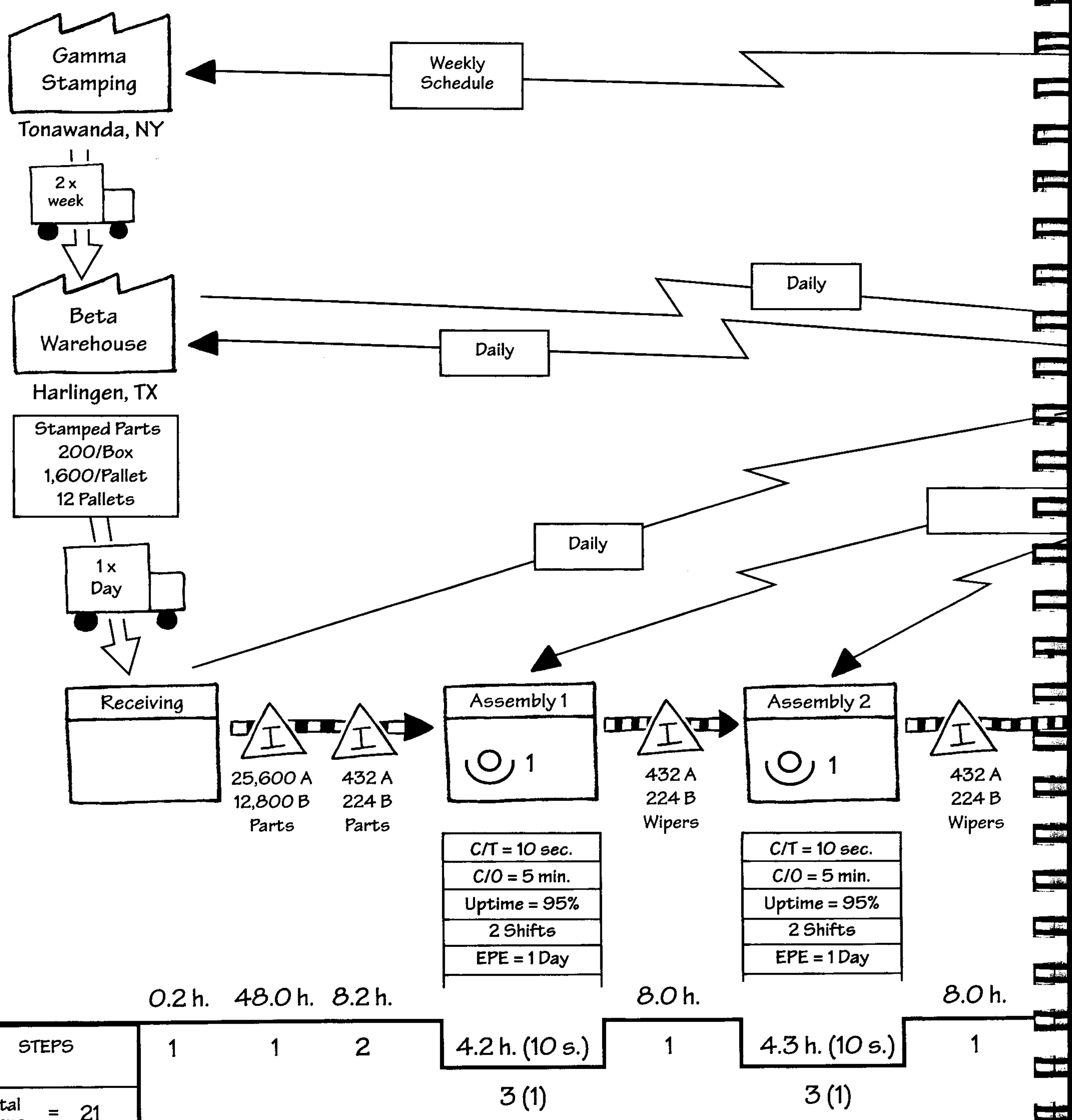
General Icons	Represents	Notes
	Operator	Represents a person viewed from above.

Appendix B: Alpha Motors Assembly Plant, West Orange, NJ
Current State — February 2002

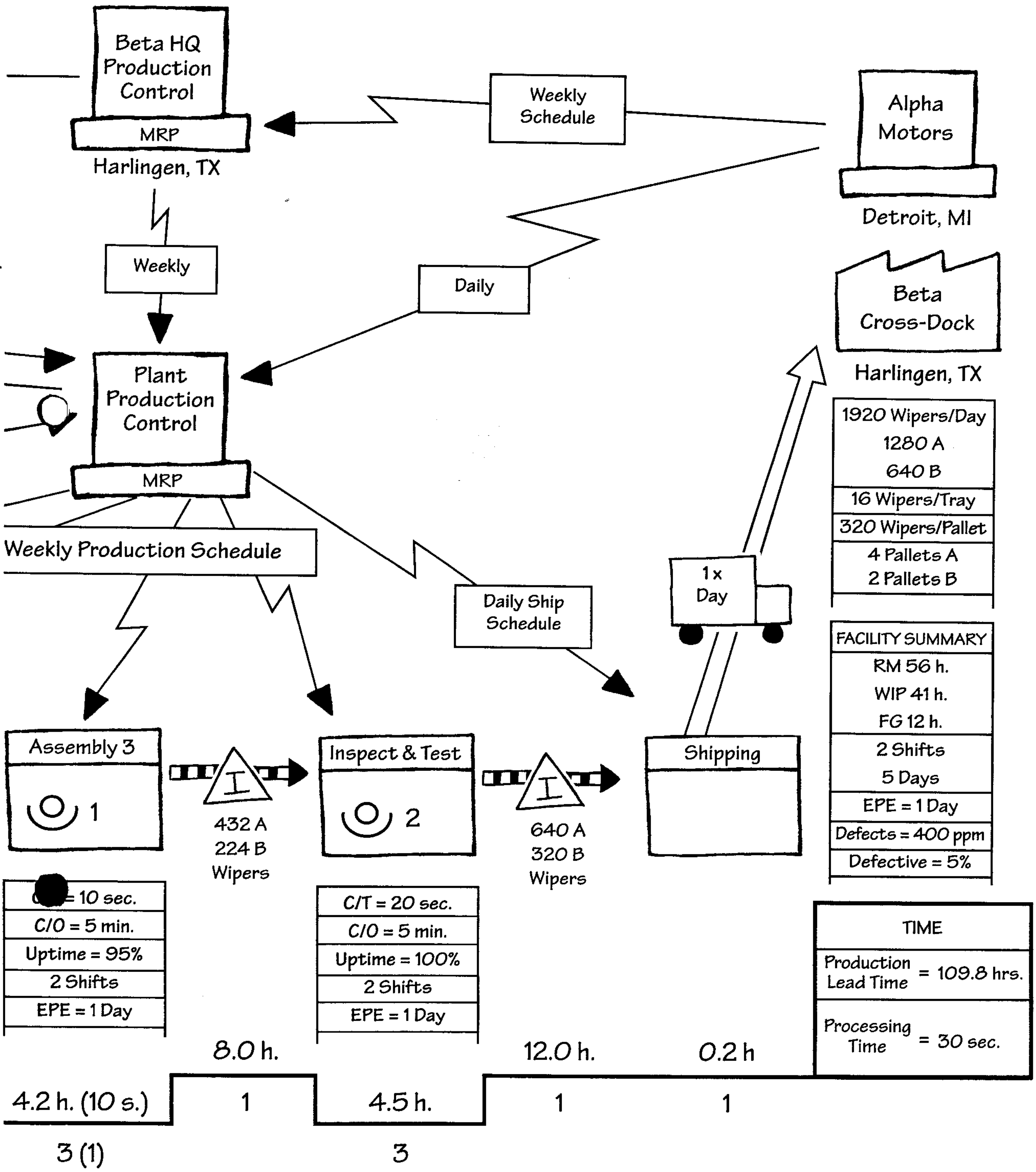



Alpha HQ Production Control
MRP
Dearborn, MI
Weekly Orders
Alpha Sales Order Bank
Weekly Schedule
Alpha Dist. Center
960 Wipers/Day
640 A
320 B
Alpha Plant Materials Control
MRP
Alpha Plant Production Control
MRP
1 x Day
FACILITY SUMMARY
RM 50 h.
WIP 2 h.
FG 14 h.
2 Shifts
5 Days
EPE = 1 Day
Defects = 5 ppm
Defective = 1%
160 A
80 B
Wipers
Final Assembly & Test
C/T = 60 sec.
C/O = Ø,
2 Shifts
320 A
160 B
Cars
Shipping
TIME
Production Lead Time = 2.8 days
Processing Time = 120 sec.
2 h.
1
60 s.
1 (1)
12 h.
1
2 h.
1

Appendix B: Beta Wipers Assembly Plant, Reynosa, Mexico
Current State — February 2002

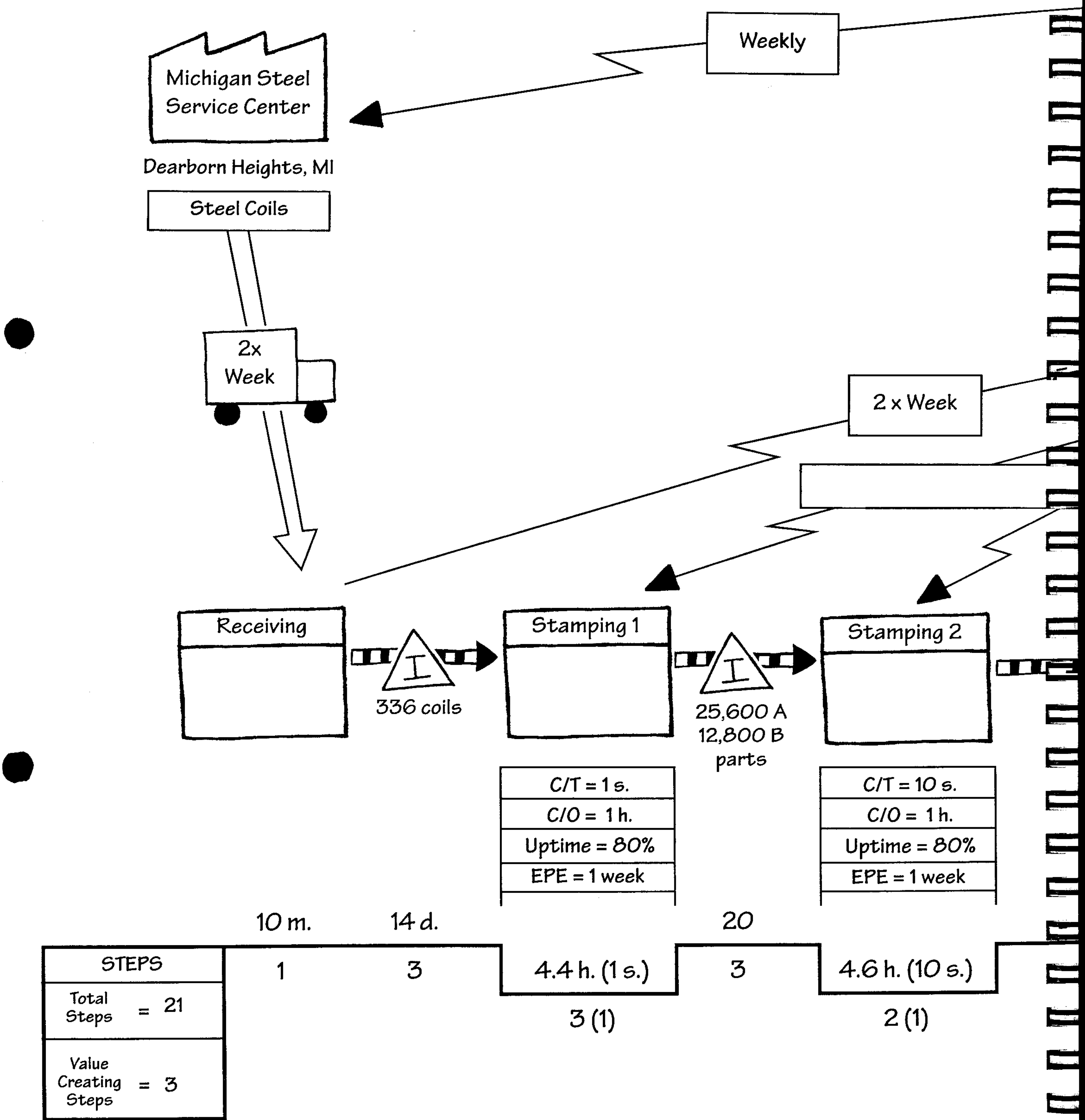


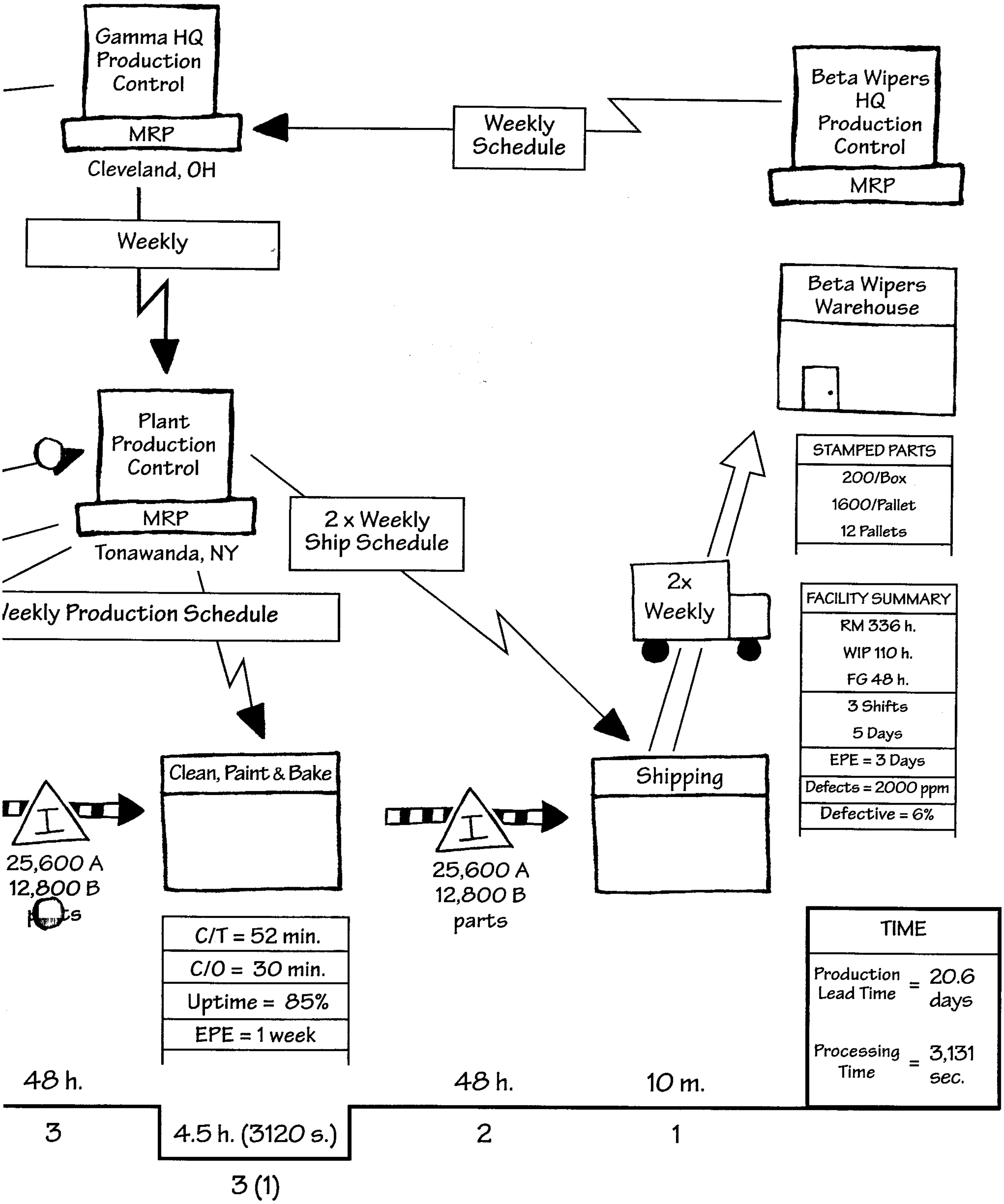
STEPS		
Total Steps	=	21
Value Creating Steps	=	3



Beta HQ Production Control
MRP
Harlingen, TX
Weekly Schedule
Alpha Motors
Detroit, MI
Weekly
Daily
Beta Cross-Dock
Harlingen, TX
Plant Production Control
MRP
1920 Wipers/Day
1280 A
640 B
16 Wipers/Tray
320 Wipers/Pallet
4 Pallets A
2 Pallets B
Weekly Production Schedule
1 x Day
Daily Ship Schedule
FACILITY SUMMARY
RM 56 h.
WIP 41 h.
FG 12 h.
2 Shifts
5 Days
EPE = 1 Day
Defects = 400 ppm
Defective = 5%
Assembly 3
1
432 A
224 B
Wipers
Inspect & Test
2
640 A
320 B
Wipers
Shipping
= 10 sec.
C/O = 5 min.
Uptime = 95%
2 Shifts
EPE = 1 Day
C/T = 20 sec.
C/O = 5 min.
Uptime = 100%
2 Shifts
EPE = 1 Day
TIME
Production Lead Time = 109.8 hrs.
Processing Time = 30 sec.
8.0 h.
12.0 h.
0.2 h
4.2 h. (10 s.)
1
4.5 h.
1
1
3 (1)
3

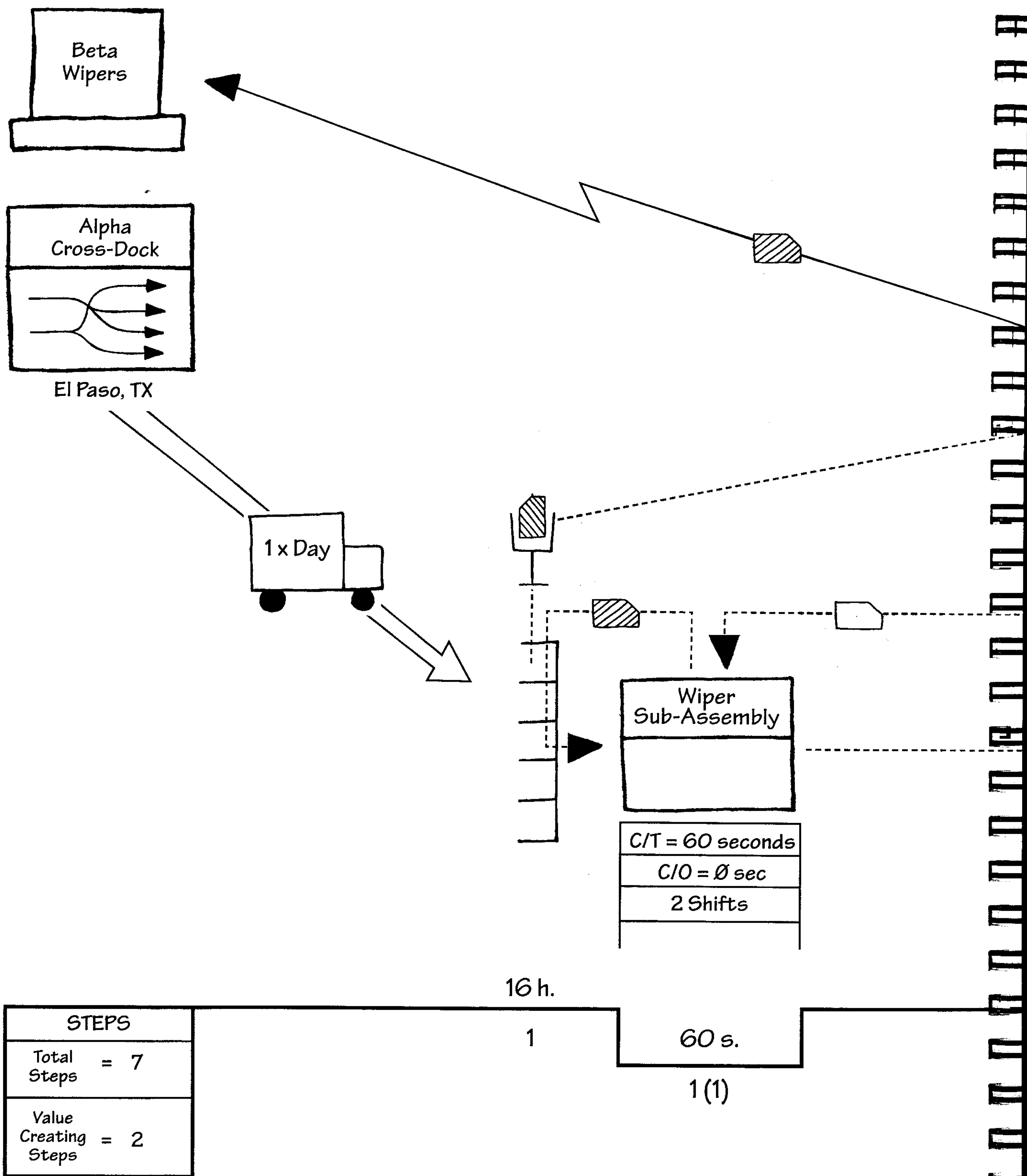
Appendix B: Gamma Stamping Assembly Plant, Tonawanda, NY
Current State — February 2002

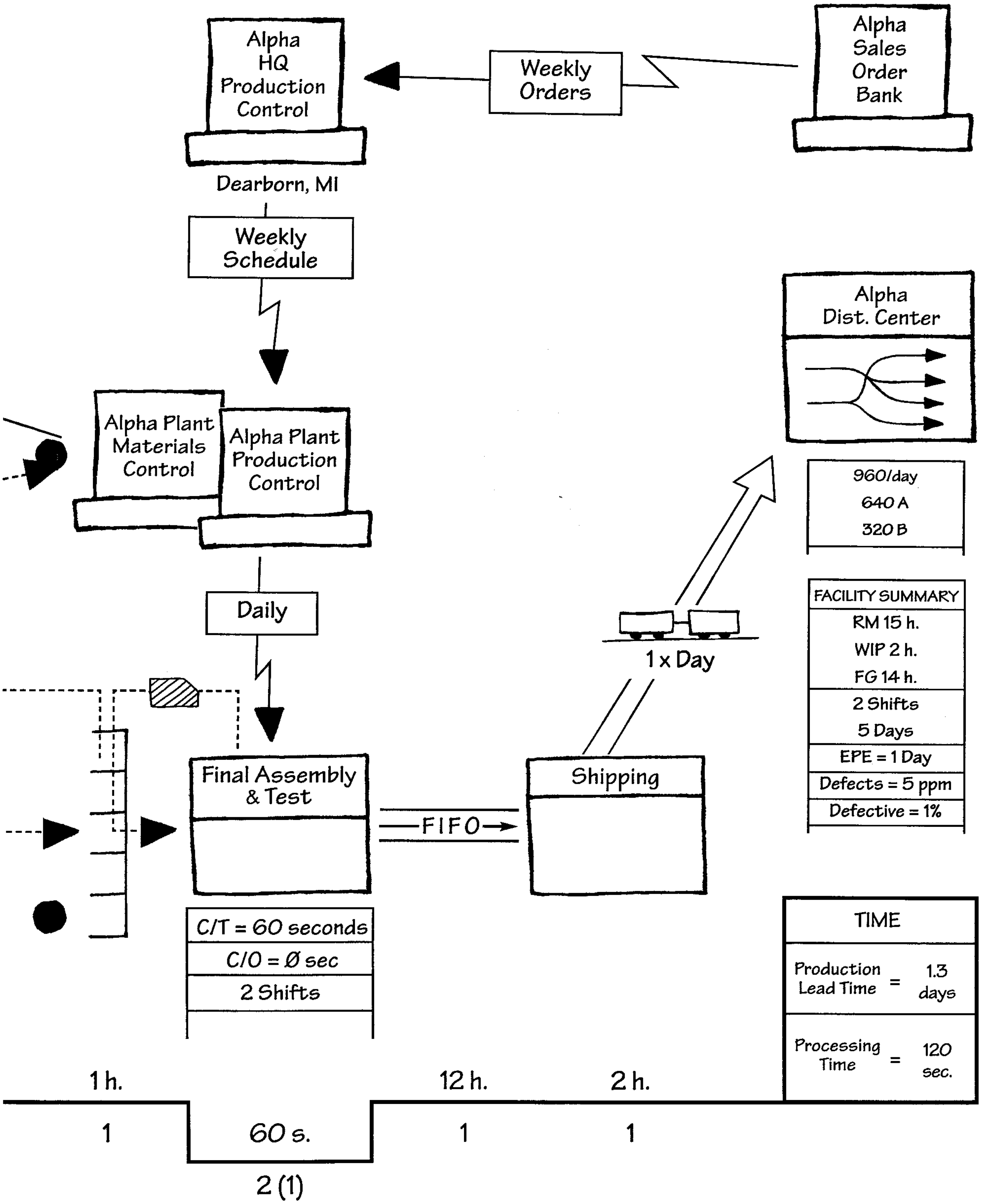




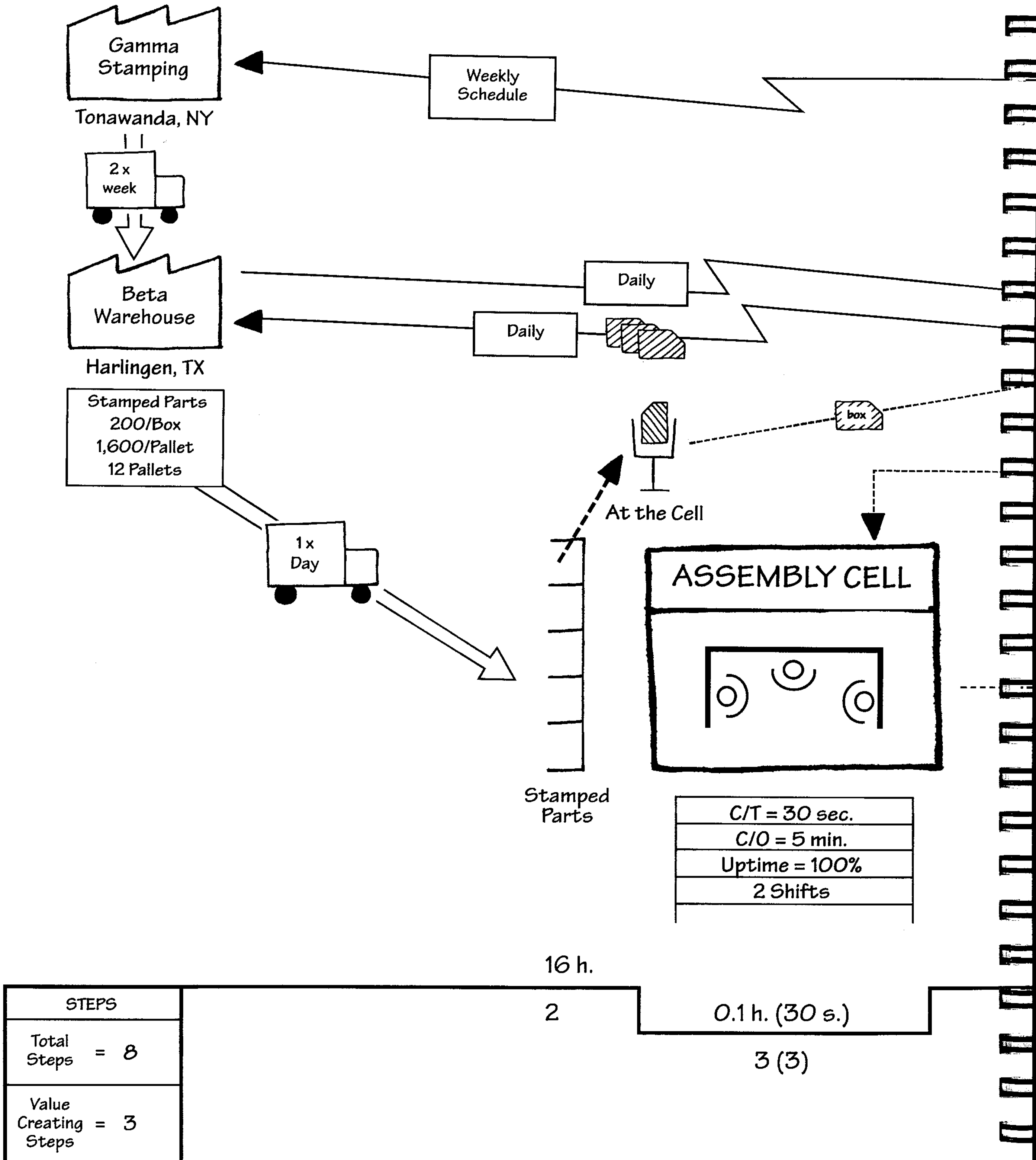
Gamma HQ Production Control
MRP
Cleveland, OH
Weekly Schedule
Beta Wipers HQ Production Control
MRP
Weekly
Beta Wipers Warehouse
Plant Production Control
MRP
Tonawanda, NY
2 x Weekly Ship Schedule
STAMPED PARTS
200/Box
1600/Pallet
12 Pallets
2x Weekly
FACILITY SUMMARY
RM 336 h.
WIP 110 h.
FG 48 h.
3 Shifts
5 Days
EPE = 3 Days
Defects = 2000 ppm
Defective = 6%
Production Schedule
Clean, Paint & Bake
Shipping
I
25,600 A
12,800 B
I
25,600 A
12,800 B
parts
C/T = 52 min.
C/O = 30 min.
Uptime = 85%
EPE = 1 week
TIME
Production Lead Time = 20.6 days
Processing Time = 3,131 sec.
48 h.
48 h.
10 m.
3
4.5 h. (3120 s.)
2
1
3 (1)

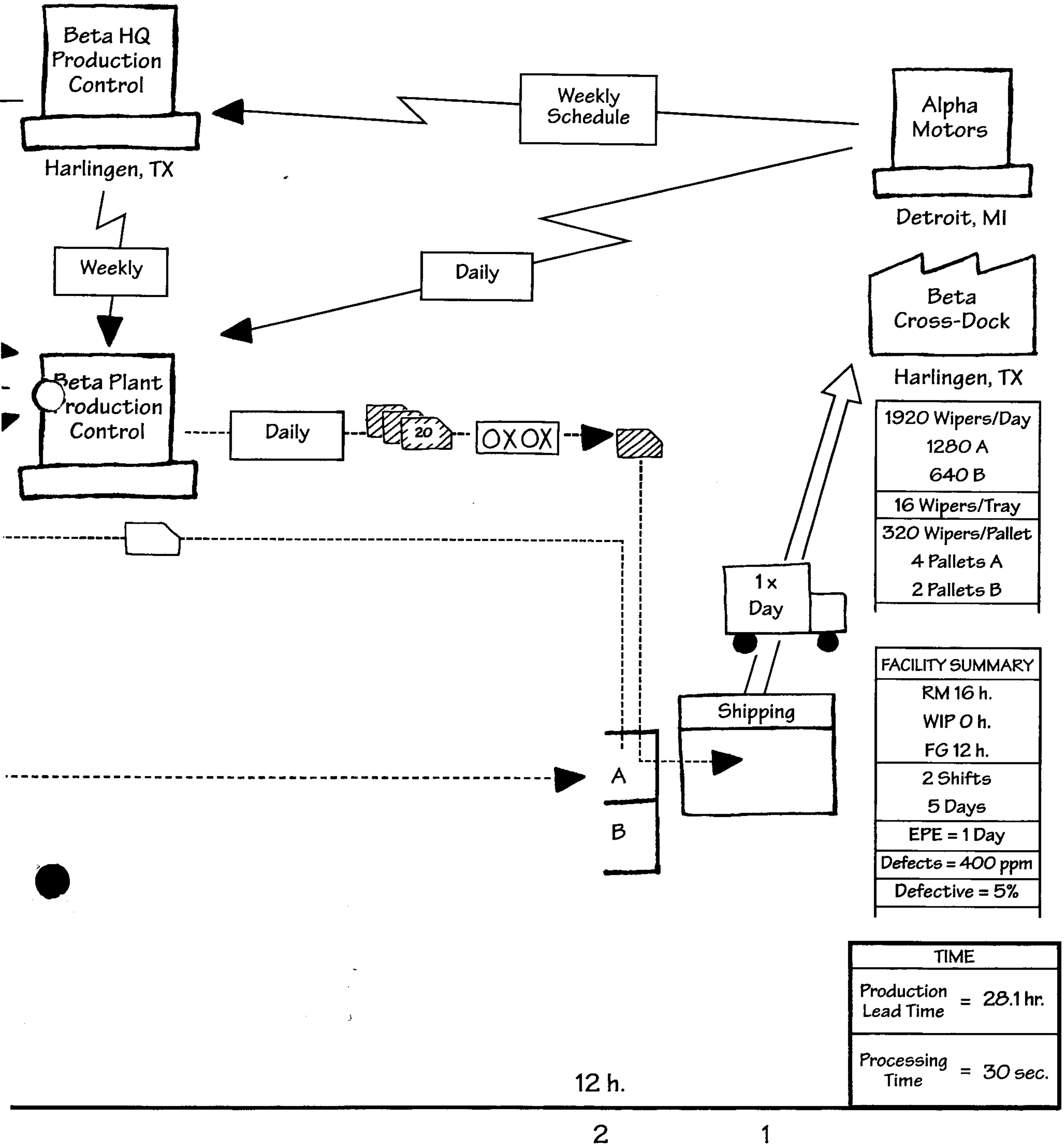
Appendix C: Alpha Motors Assembly Plant, West Orange, NJ
Future State — May 2002



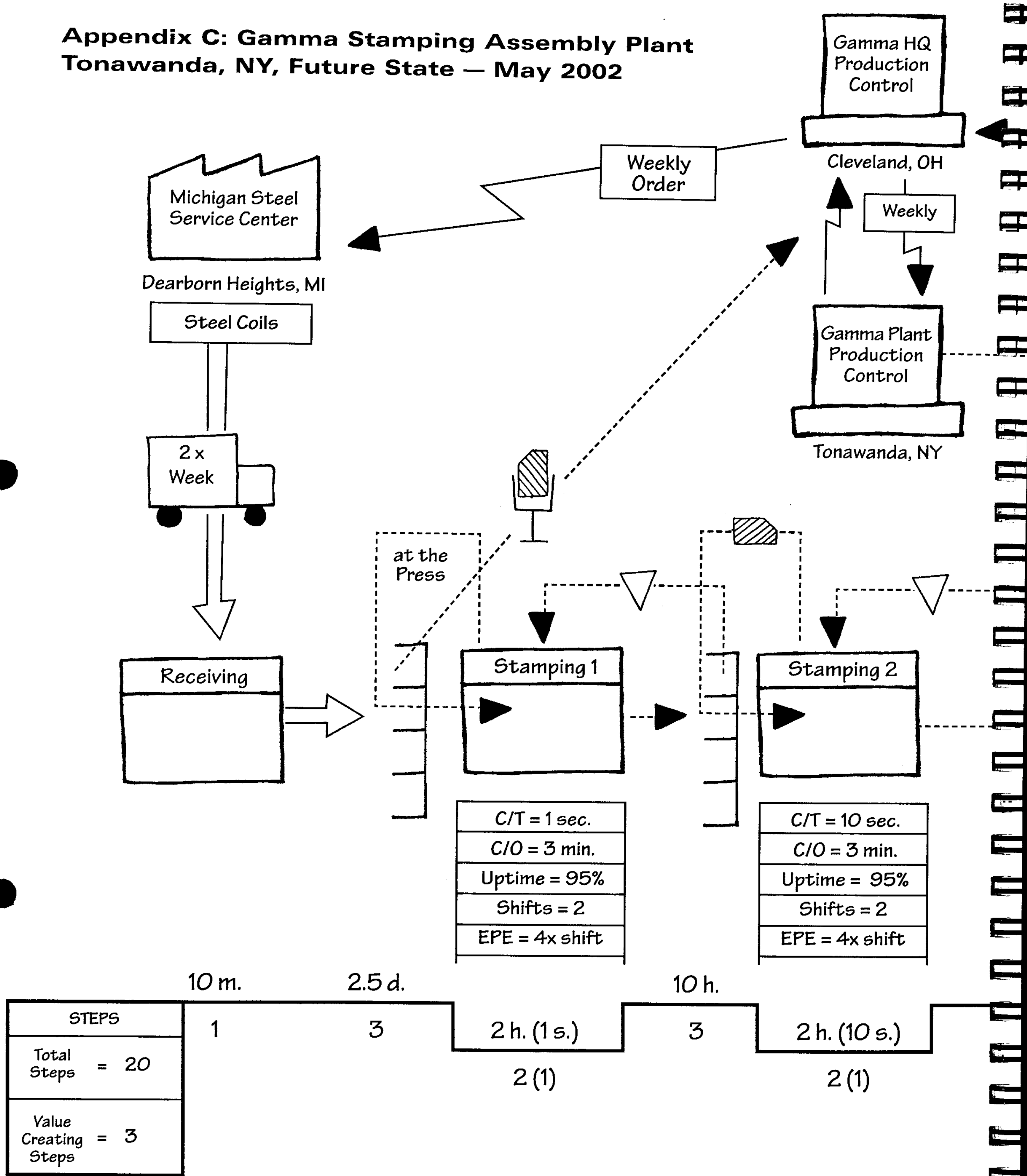

Alpha HQ Production Control
Dearborn, MI
Weekly Orders
Alpha Sales Order Bank
Weekly Schedule
Alpha Dist. Center
Alpha Plant Materials Control
Alpha Plant Production Control
960/day
640 A
320 B
FACILITY SUMMARY
RM 15 h.
WIP 2 h.
FG 14 h.
2 Shifts
5 Days
EPE = 1 Day
Defects = 5 ppm
Defective = 1%
Daily
1 x Day
Final Assembly & Test
FIFO
Shipping
C/T = 60 seconds
C/O = Ø sec
2 Shifts
TIME
Production Lead Time = 1.3 days
Processing Time = 120 sec.
1 h.
12 h.
2 h.
1
60 s.
1
1
2 (1)

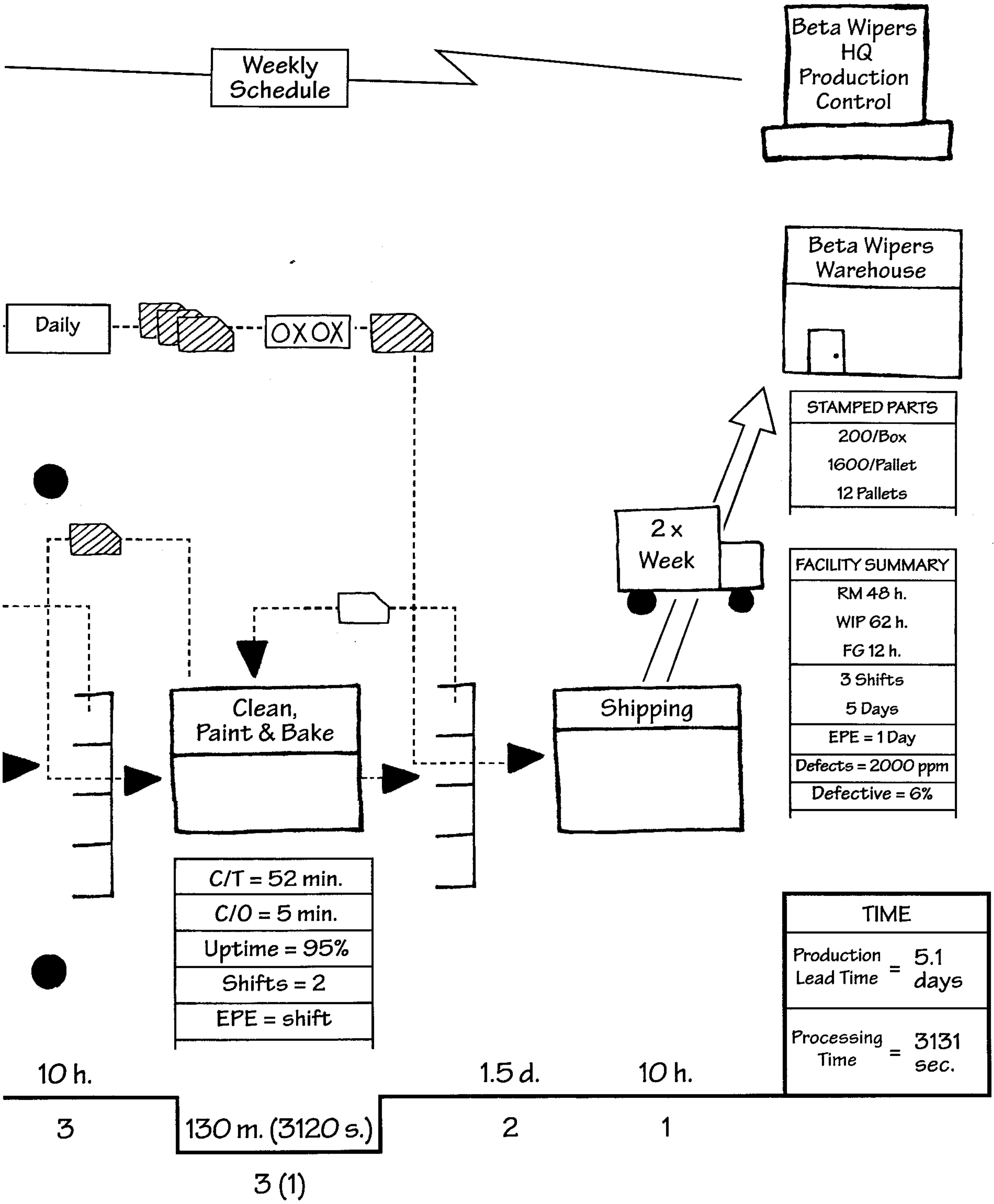
Appendix C: Beta Wipers Assembly Plant, Reynosa, Mexico
Future State — May 2002



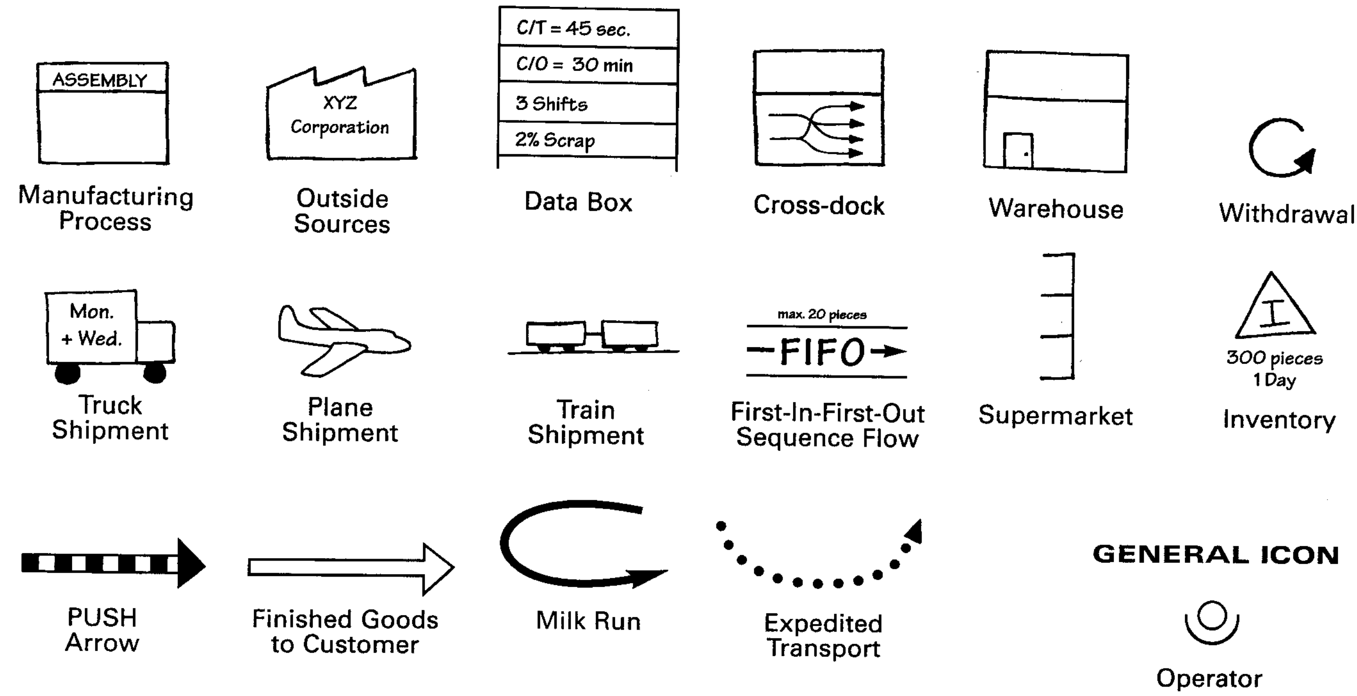

Beta HQ Production Control
Harlingen, TX
Weekly Schedule
Alpha Motors
Detroit, MI
Weekly
Daily
Beta Plant Production Control
Daily
20
OXOX
Beta Cross-Dock
Harlingen, TX
1920 Wipers/Day
1280 A
640 B
16 Wipers/Tray
320 Wipers/Pallet
4 Pallets A
2 Pallets B
1 x Day
Shipping
A
B
FACILITY SUMMARY
RM 16 h.
WIP 0 h.
FG 12 h.
2 Shifts
5 Days
EPE = 1 Day
Defects = 400 ppm
Defective = 5%
TIME
Production Lead Time = 28.1 hr.
Processing Time = 30 sec.
12 h.
2
1

Appendix C: Gamma Stamping Assembly Plant Tonawanda, NY, Future State — May 2002




Weekly Schedule
Beta Wipers HQ Production Control
Beta Wipers Warehouse
STAMPED PARTS
200/Box
1600/Pallet
12 Pallets
Daily
OXOX
2 x Week
FACILITY SUMMARY
RM 48 h.
WIP 62 h.
FG 12 h.
3 Shifts
5 Days
EPE = 1 Day
Defects = 2000 ppm
Defective = 6%
Clean, Paint & Bake
Shipping
C/T = 52 min.
C/O = 5 min.
Uptime = 95%
Shifts = 2
EPE = shift
TIME
Production Lead Time = 5.1 days
Processing Time = 3131 sec.
10 h.
1.5 d.
10 h.
3
130 m. (3120 s.)
2
1
3 (1)

MATERIAL FLOW ICONS



INFORMATION FLOW ICONS