Beginning the Agile Journey - A Guidebook

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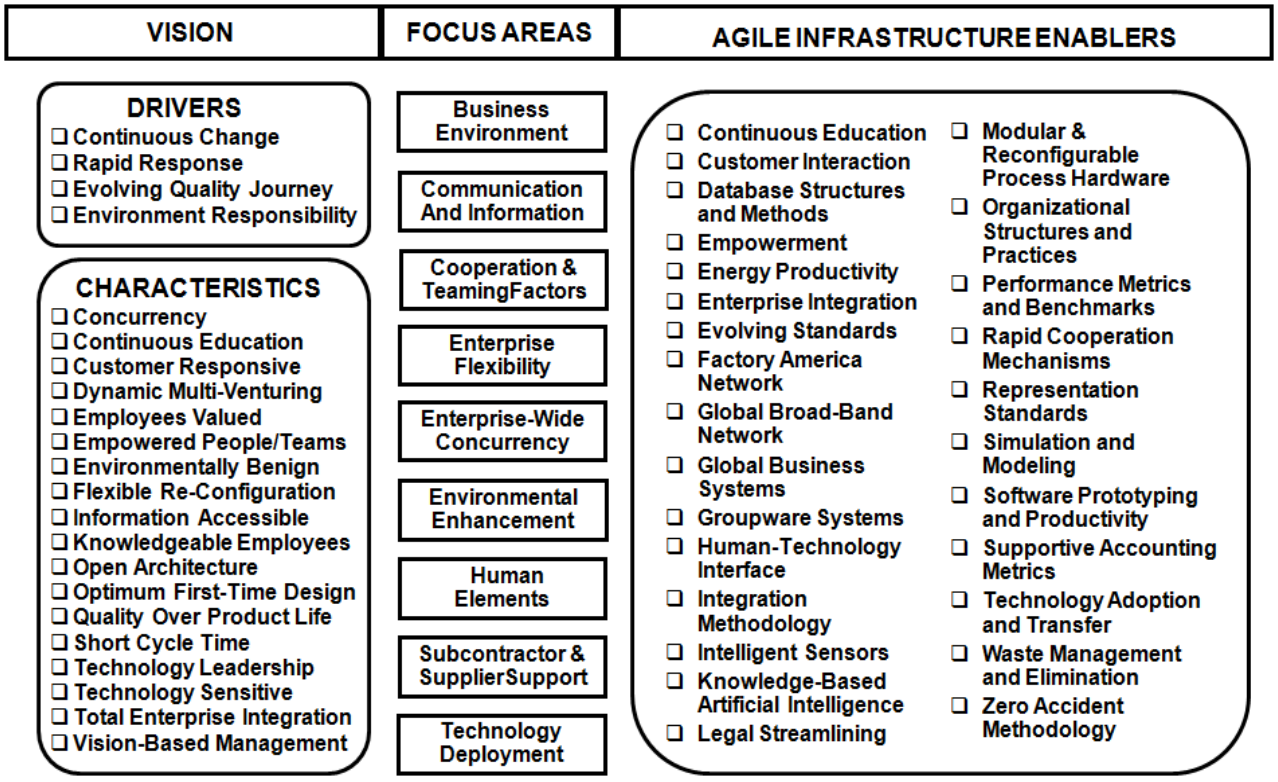

AGILITY DEFINED

The Ability to Thrive

in a

Continuously Changing,

Unpredictable

Environment.

RECONFIGURABLE EVERYTHING

About the Author

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He has organized, chaired, and facilitated a wide variety of consortia projects, commercial and DoD initiatives, and workshops involved with agile enterprise research, infrastructure development, and technology transfer.

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A GUIDEBOOK GUIDE

Origins and Intentions

This guidebook is written for people who want personal involvement in the emerging competitive environment and the enterprise transformation process. It will help you understand what's going on and why it's happening in general; but most importantly, it gives you tools for examining your own operating environment, for creating new insights, and for helping everyone become part of the solution.

You can read this guidebook and understand the forces that are shaping your enterprise - or you can employ this guidebook and be one of the forces that shapes your industry. All the answers aren't here; but the objective is illuminated, the values established, and tools to guide the first important steps of the journey are provided.

The models, suggestions, tools, and opinions in this guidebook are the result of the author's investigations over the last seven years into competitiveness issues. It relies heavily on materials that have begun the process of refinement in the Agile Production Focus Group activities of the Agile Manufacturing Enterprise Forum; and consequently owes a lot of credit to the many people who participate in that ongoing forum.

These tools are still being developed. What is presented here for your use is a snapshot of progress so that you might participate in the unfolding drama as well. These tools are undergoing test usage in a number of production operations during 1993 and will undoubtedly grow in the process. They have already demonstrated usefulness in helping to guide a developing awareness of the dynamics of change and the options for accommodation.

These are early-stage tools, fashioned to hack away the jungle of confusion that begins our journey. As we progress these "machetes" will surely be replaced with more complex tools better suited to a progressive and more complex understanding.

The tools in this guidebook are meant as participative group exercises, under the belief that engaged minds develop ownership and insight for understandings that are rarely transferred in one-way presentations. Also, unlike the Lean Paradigm, which has a 40 year history of developing operating experience, the Agile Paradigm is a new concept with a clear goal but no role model as yet.

The author's belief is that Agile is a simple concept - his experience is that it is initially difficult for many people to wrestle with. Some try to make it too pervasive and encompass all that we currently believe about "business best practices". Others confuse it with Lean concepts such as flexibility and cycle-time-reduction.

How to Use this Guidebook

Read it and circulate it. Then use it to structure an internal awareness and investigation program. Make it the focal point for self-directed task-force examinations of selected procedures, processes, production equipment, software systems, and integration architectures.

Use the exercises to kick-off your next annual planning session.

Use it as a guide to evaluate your next investment decisions in computer and software technology, in production process equipment, in facilities, in human resource programs, and in any other action that brings structure to your operating environment. And when you do use it, please provide feedback to the author that will help improve it and its methods.

FOUNDATION ISSUES AND CONCEPTS

Introduction

In 1991 a vision-based strategy for the emerging global competitive environment was compiled by a broad-based group of organizations in the USA. This activity was led by a core group of thirteen companies and facilitated at Lehigh University under Department of Defense funding. Attempting to articulate rather than invent the national consensus, this core group listened to more than forty advisors from various national priority studies and activities, and another 150 corporate representative in a series of traveling workshops. The results have been published as The 21st Century Manufacturing Enterprise Strategy and are available from Lehigh University's Iacocca Institute.

Thus was born the concept of the agile manufacturing enterprise, with "agility" pegged as the single most important new characteristic an enterprise will have when entering the 21st century. Simply stated, agility is that characteristic which allows an organization to thrive in an environment of constant and unpredictable change.

The compelling nature of the vision spawned many follow-on initiatives in government and industry: Congress is galvanized into bipartisan funding support for the national development of agile technologies and infrastructure; a consortia led by some of the Department of Energy's National Laboratories is focused on agile technology; ARPA formed an Agile Production working group within the research community, and in 1993 is the channel for Congressional agile funding; independent conferences, seminars, and workshops all across the country are focused on agile strategies; and most importantly, an industrial-led initiative called the Agile Manufacturing Enterprise Forum is sponsoring focus group investigations to define the metrics, benchmarks, technologies, structures, human roles, justifications, and migration paths that will make the agile enterprise a commonplace reality.

The tools in this guidebook have taken shape from the author's participation and guiding role in these and other focus group, workshop, and consortia activities. As such, they have been molded by many people's efforts and contributions across the broad range of process, discrete parts, and government manufacturing interests.

As you will see later in the discussion contrasting "lean" and agile paradigms, agile is a brand-new concept without the benefit of lean's forty years of discovery and development. Agile is the recognition of a new objective, rather than a compilation of previous successful business experiments that someone else conducted. Consequently, you are in at the beginning of this one. That means you get to hack the paths through the jungle.

"You can tell the pioneers by the arrows in their backs" was a thought that was appropriate in a bygone era when things changed slowly and there was still plenty left if you followed someone else. We'll see why this is no longer operative when we borrow conceptually from "chaos theory" to look at enterprise complexity today. This will not be done with any mathematical rigor, but will offer a perspective on the sources of chaos in many of our major enterprises today.

A Quick Look at the Issues

Things keep happening faster and faster. The technology alternatives we have for our products and our manufacturing processes continue to grow at an increasing rate. In some markets this already means a product bought six months ago costs more then a better featured product available today. Soon this will mean that a factory built last quarter cannot compete in cost and quality with a factory built next quarter.

The emerging global competitive enterprise arena is a rapid and continuously changing environment . The nature of imminent change in technology, markets, customer expectations, and competitors is quickly becoming impossible to predict. Many companies have already found themselves in a constant reaction state - buffeted by events they had not foreseen. They will be no match for the new competitor.

The new competitor will be the enterprise that thrives on continuous and rapid change. The principal characteristic of these successful enterprises will be agility - the ability to move fast in all ways. An agile company maintains leadership by constantly introducing improvements to its own markets, by instantly seizing unexpected opportunities, and by rapid and decisive response to unforeseen threats.

The principal impediments to change are structural in nature, and generally form the architecture of such "systems" as the organizational hierarchy, functional business unit interaction, corporate decision making process, customer/company relationship, MIS software, plant control software, process hardware flexibility, even business relationships and the process that develops them.

These systems must be restructured to allow decisions at the point of knowledge, to encourage the flow of information, and to foster concurrent cooperative activity.

An important element of agility is this concept of the knowledgeable and empowered workforce. This is a major contributor to agility because it allows decisions to be made rapidly at the point of maximum knowledge. It also encompasses, at least in principal, the concept of a fluid organizational structure free to reconfigure quickly as needed. Additionally, however, it must be noted that agility cannot exist without these very same fundamentals applied to the corporate computer support infrastructure - which already exists, is ubiquitous, and defines the corporate entity every bit as much as the human elements. The real importance of this computer infrastructure stems from the fact that it is the enabling support system for human judgment.

Together, these two areas are principal cornerstones of agility: human interaction structures and computerized support structures. If either cannot be changed continuously or reconfigured quickly, agility cannot exist. These two areas are also today's biggest impediments to agility - both have an established and traditional structural approach that is extremely difficult to change.

For instance: a company with little or no concurrent engineering may look upon a computerized information link between engineering and manufacturing as a major improvement. However, it is a mistake to think that this information link alone contributes to agility. If implemented with traditional approaches, this will more likely lock in (for all of time thereafter) a well defined but limited information exchange that will be the antithesis of agility. In other words, if the link is done wrong, the company is more agile without it. Traditional integration approaches have erected a great deal of inertia to change.

Technology's Role

Software has become an integral part of the enterprise operating characteristics. It is playing a vital role in running our factories, controlling our processes, supporting our decision makers, measuring our performance, connecting us to our customers and suppliers, and augmenting our product designers. Software systems and integration technology is at the very core of the corporate architecture.

In many circles today it is unpopular to offer technology as a solution to our competitiveness problems. Popular thought is focused on people and organization and method. Without doubt, we have much to do here. However, when it's done it will still be glued together with software and integration technology. Unfortunately, too many of today's top managers are computer illiterate - even phobic. They do not realize how pervasive the computing infrastructure is in their own companies. Nor do they realize how inadequate it is.

We have too many managers focused solely on learning the lessons the Japanese wrestled with in the last three decades. We do have to learn these lessons - but we don't need to stop advancement while we do so. Some companies have allowed themselves to be side-tracked while they "go back to school".

In the meantime, with their Intelligent Manufacturing Systems initiative, the Japanese are now focused on factory integration technology as the next area for major advancement. They think that a completely different approach to

integrated control systems architecture is required - one they refer to as "holonic". Holonic systems are basically composed of autonomous modules that are self scheduling, yet cooperate to achieve the common goal. In the USA we often refer to these structures as "object oriented", and are now seeing these concepts emerge under "client-server" architectures.

Systems structured this way allow software and hardware modules to be improved, modified, or even replaced with little risk of hurting the overall system. They exhibit a great deal of robustness when certain parts of the systems environment do not perform as desired or expected. They can be restructured quickly. They can accommodate increased capacity requirements easily. In short, they exhibit all the characteristics of agility.

Many key managers in some of our major corporations have turned their back on hard technology. Technology alone is clearly not the path to competitiveness, but neither are human factors, reorganization, collaboration, and new methods. What is clear is that things continue to change. If we fail to keep up with technology changes while we catch-up in the other areas, we will find ourselves playing catch-up on all fronts.

Agile companies will be asking questions that illuminate the impediments to change. How fast can you restructure a plant for new product? Can you safely improve your process control software on a daily basis? How many signatures are required to approve tool acquisition or a product idea? How long does it take from concept to product delivery? How many tools are (should be) scrapped before they return their investment? How long does it take to hammer-out a collaborative partnership arrangement. How much is invested in employee growth?

In an age of continuous and unrelenting change it becomes impossible to anticipate even a small fraction of the potential challenges, opportunities, and threats that a company will face. Enterprises that succeed will be those that master broken-field running, that are capable of changing course quickly and economically, and that systematically adopt strategies and build infrastructure for thriving in an unpredictable environment.

A Closer look at Driving Forces

Continuous change was identified in the 21st Century Manufacturing Enterprise Strategy as a major driving force of the agile enterprise. Anyone who has purchased a personal computer recently understands the impact that rapid technological advancement is having on the marketplace. If the purchasing decision can be postponed by two weeks, a lower cost and better featured product will be available. As consumers, we have all seen our music collection change from records, to 8-track tape, to cassette tape, to CD, and now to DAT and a new CD format. Though electronic products seem to have the fastest cycle of obsolescence, rapid innovation and shrinking cycle times are affecting virtually all fields.

It is a mistake to think that this accelerating pace of innovation only affects products. New technology, materials, and methods also affect the processes used to build products. Already, we see the plant that was built six months ago is unable to compete in cost and quality with the competitive plant just built with newer processing technologies and methods.

Markets and competition are also undergoing continuous and dramatic change. Where many of us eagerly await the new market opportunities that China and the Eastern Bloc promise, we will also have to contend with the new and significant competition that these markets will bring. Their abilities to purchase goods and services will be directly related to their abilities to generate currency. And right behind them will come South America, Africa, and others.

Newly industrialized countries do not have to go through all of the stages that established countries have taken. Because they have no entrenched industrial base, they can take immediate advantage of the latest production methods. Competing on the basis of low labor rate alone is no longer the only threat these new entries pose. With a growing global focus on quality of life and living standard, industrial balance will shift continually for many decades.

Rapid response was also identified as a major driving force for agility. By itself this can be a formidable competitive advantage - the ability to respond quickly to competitive threat and to market opportunity. Looked at against a backdrop of continuous change, however, it becomes part of a cycle that provides a new set of market dynamics.

A great deal of current activity in industry is focused on reducing cycle times: moving customer desires and product ideas into product deliveries faster. When a competitor becomes better at this it is necessary to improve quickly or find yourself with late market entries, shrinking market share, and lost leadership. In an age of continuous and rapid change, rapid response by your competition will drive you out of business in only a few cycles if you too cannot respond rapidly.

An important question arises: Are we moving into an age where we will be constantly responding to threats? Will the growing global competitive arena throw new ideas, new competitors, new technologies, and new customer demands at us from new places faster than we can anticipate? In an age of continuous and unrelenting change, rapid response must be a core competency and not just a stroke of good-luck or a special Herculean effort.

Must we be buffeted by unexpected change, or is it possible to thrive in this emerging competitive arena? More to the point, is it possible to exist at all if one is responding with effort rather than with ease? Competition based on rapid response is a predictable outcome of continuous and unrelenting change, and becomes a driving force itself when wielded by others.

An "**evolving definition of quality**" is the third major driving force of interest. Eliminating customer unhappiness with products that require excessive maintenance, become useless too soon, or cost too much to own seems an obvious move today. While many USA companies are still mastering this capability, however, Japan has moved on to a new frontier: *miryokuteki hinshitsu* - making products right so they delight the user and cause a positive emotional reaction. This second phase of quality employs subtle but impression-forming engineering decisions that create a personality and an aura for a product that emotionally bonds it to the user.

All very well for today, but what about tomorrow when an equivalent product can be bought for half the price with twice the functionality and emotional enjoyment? In an age of continuous and unrelenting change, the things we buy become obsolete too quickly. Even today, the newly purchased laptop computer is a disappointment before it's taken on its first trip, an investment made in CD's will have to be repeated in a few months for a smaller format, and the car recently bought really should have a passenger-side air bag now that they are available.

Basically, the things we buy are making us unhappy with them sooner and sooner. It is already becoming difficult in many product areas to feel value in proportion to cost. This is because the utility and value of a product in many cases is not inherent and static, but relative to alternative possibilities in a highly dynamic marketplace. The definition of quality continues to change, as everything else does. Life-cycle value becomes an important quality dimension when continuous change and rapid response alter our perceptions of the things we have just purchased.

Product design will probably deal with this third quality phase through a platform approach. New designs will provide remanufacturable or field alterable products that can be changed or improved during the course of ownership. These may include concepts such as automobiles designed for constant upgrade of dashboard accessories, music recordings sold independent of transient delivery media, and extensible robots that will accept additional axes of motion.

In any event, we can be sure that the process equipment we purchase for our production needs are products also, subject to the same risks of obsolescence and potential for long life-cycle value.

The Case for Starting Now

We talk a lot these days about reduced cycle times, about more production variety faster and in smaller quantities, and about customer responsiveness. Easy words to believe in - and easy goals to achieve. We can get variety from new flexible manufacturing equipment. We can get faster from new lean production methods. We can get customer responsiveness from a new attitude. We can do all of these things and still fail miserably in the new continuous-change/rapid-response world.

The Japanese are already doing these things; so are many of the world's best companies. But what happens when the business premise changes? What happens when the world goes into recession? What happens when the market wants trucks and you're making cars, or personal computers and you're making minicomputers, or better quality now and you have too much corporate inertia, or innovative machine tools, or anything different immediately because it is available somewhere else? If you're not agile, nothing much happens for quite a while - and then maybe nothing much happens ever again.

The 21st Century Manufacturing Enterprise Strategy established a time period 10-15 years in the future as the setting for the agile vision. This was done for very practical reasons that are important to understand. Firstly, the vision had to be far enough ahead that the investigators could ignore how it would happen, else they would get stuck by the existing paradigm rules. Secondly, the vision had to be close enough so they wouldn't postulate cold fusion and other wishful thinking. Thus, the vision was based on seed ideas that could already be pointed to, and was unconstrained by today's "the-way-things-are" rules.

The important part to understand is that this was just a mind trick. It was used to break out of existing thought constraints. The vision has nothing really to do with 10 years or even 15 years in the future. It could just as easily be describing next year or even today in some sectors. It is for the most part an amalgam of the best bits and scattered pieces already being practiced in industry right here in the USA. The future part has to do with the time it will take to extend, mature and coalesce all of these bits and pieces into a critical mass of widely-accepted corporate operating strategy.

So much for the future part. What about the present? What should be done now in order to start the migration toward an agile enterprise? What is an agile enterprise composed of anyway? And how will we develop an awareness and clarity of the issues associated with this new concept of agileness? These and other questions are the focus of this guidebook.

Chaos Theory and Enterprise Operations

We have seen the future, and it is upon us already. Continuous unrelenting change, and rapid effective response. It's already happening and will only get faster. What will successful enterprises look like?

Simply put, a successful enterprise will *thrive* on continuous change. Its most potent competitive asset will be its ability to respond rapidly and correctly. This is as hard to refute as the converse, that an enterprise that is always taken by surprise, constantly buffeted by unanticipated change, is bound to be fatally slow in a crucial response eventually. Murphy has the odds.

Why are slow responses more fatal now than before? In a rapid change, short cycle market, being first on a growing market curve means dominating market share. With obsolescence right around the corner, a late entry may find nothing but declining profits and marginal returns at best. No, not all the time. But yes, enough of the time that all those body blows will lose the fight in the end.

Perhaps we can learn something by looking at "Chaos Theory", a recently popularized branch of mathematics that is exploring new insights into complex systems like the stock market, weather, fluid dynamics, whole economies, and even genetic evolution.

- Chaos Theory is a collection of techniques for analyzing complex systems; and provides valuable and useful insights into those systems whether or not they turn out to be "chaotic" in the mathematical sense.

- A chaotic system operates within deterministic bounds on the trajectory of its "attractor"; but may unpredictably move from a stable operating area to an unstable operating area on its attractor when "initial conditions" change minutely.

- Mathematically, the attractor for a system is just the solution locus for its defining differential equations; and the "initial conditions" are the constants in each equation.

An "enterprise" is a system that is definitely complex; and appears to satisfy the mathematical requirements for definition as a chaotic system as well.

The operating characteristics of the "generic" enterprise are determined by a very large set of differential equations, most of which are unknown to us, and most of which are unimportant for specific enterprises and specific times. Included in this set of equations are some whose initial conditions have recently drifted far enough to cause a growing number of important enterprises to enter "chaotic regime", i.e., they have all of a sudden started operating on an unstable portion of their attractor.

Historically, we have come to understand our enterprises and how to operate them through trial and error, albeit some trial with intelligent forethought. We succeed in finding periods of stable enterprise operation when we have succeeded in identifying approximations to the important terms in the enterprise equation. Fiddling with the initial conditions of each of these terms then provides us the knobs to adjust and fine tune enterprise operation.

This works until a combination of initial conditions on previously insignificant terms drift or get shocked into different values, and all of a sudden the old knobs no longer control the enterprise.

For instance, if the rate of product innovation in a certain industry gradually changes from a four year cycle to a twelve month cycle, and at the same time globalism gradually increases the number of real competitors, and a leading company in that industry gradually adds management layers as success fuels large growth, there will come a time when the company's decision making process is unable to hit market windows before the major share is established by someone else.

In fact, when that time comes, it probably comes from only a very small change in any or all of these three values, but the results will be disproportionately dramatic. Entering a market late, even by a month, when the window is short and brand dominance is established quickly, can cut a product's potential revenue stream by half or much more. Assuming the company has other products in the same industry, it will only be a very short while before all of them fall from grace. This company has entered a chaotic regime.

AGILE TERMS IN THE ENTERPRISE EQUATION

E (the Enterprise) as a function of t (Time)

- **Technology I nnovation Cycle Time: Continues to Get Shorter.**
- **Likelihood of Being S urprised: Grows as Globalism Brings More Players.**
- **Structural R igidity of the Enterprise : Increases, Traditionally, with Age and Size.**

$$E(t) = \ldots\ldots + c_1 I + c_2 S + \ldots\ldots + c_3 R + \ldots\ldots$$

Restoring operational stability to this company can't occur by reversing the drift in the conditions that caused it. The pace of technological innovation in the company's product area is outside of its scope of control. It may be able to slow its decline or even recover for a moment by cutting management layers, but the cycle of innovation continues to shrink and will eventually be too short for whatever number of layers the company structure can permit as a minimum.

We have here an example where a stable system's initial conditions have slowly drifted until all of a sudden it seems to jump to a very different shaped operational trajectory. The knobs that were successfully twiddled before no longer bring the system back into stability. In fact, many of them are counter productive. As growth occurred, adding management layers and decision approval steps was important to insure stable growth and minimize the risk of bad product decisions. Now, this is precisely the wrong thing do.

The "real" generic enterprise equation has not changed one bit. What has happened is that the initial conditions on some of the equation's terms we have been previously unaware of have finally reached a point where, in combination, they affect the operational trajectory. Since some of these initial conditions, like the technological innovation cycle, are outside the control of the company, it must find new knobs to turn that can counter balance the undesirable effects. For instance, in our simple example, it might change the architecture of the product development and decision making process, so that multi-tiered approvals are not required and people with the requisite development and marketing skills can be mobilized quickly.

THE KNOBS HAVE CHANGED

- **To Damp Out New Conditions:**

  $$E(t) = \ldots + c_1 I + c_2 S + \ldots + c_3 R + \ldots\ldots$$

- **Turn Some Lean Knobs NOW:**

  $$E(t) = \ldots + c_1 I + c_2 S + \ldots + c_3 R + \ldots + \text{[knob]} + \ldots.$$

- **And Find Some Agile Knobs FAST:**

  $$E(t) = \ldots + c_1 I + c_2 S + \ldots + c_3 R + \ldots + \text{[knob]} + \text{[knob]} + \ldots.$$

PUTTING AGILITY IN PERSPECTIVE: A PROFILING TOOL

A Working Definition for Agility

What precisely is agility? How do we measure it? How do we know when we have it? Is there a simple metric or index? How can we develop both analytical and intuitive understandings of agileness in our operating environments? The investigation of these questions continues in various forums, with some answers and tools beginning to take useful shape.

Early discussions about agility have exhibited a great deal of confusion, along with a constant difficulty in separating agile from fast and agile from flexible. Many companies are preoccupied and committed with lean and TQM programs that seem in competition with yet another perspective. Adding to the confusion are proponents from both the agile and the lean camps that would collect all the best practices under their favorite banner; willing us to believe that each is a comprehensive answer to all the competitiveness issues.

Amidst all this promise and all this confusion lie some real pearls.

In mid-1992 the Agile Production Focus Group of the Agile Manufacturing Enterprise Forum set out to understand and communicate to others what agility looks like in the production environment; believing that an exercise focused on the tangible production operating environment would identify basic principles that could later be generalized for the enterprise. Twice it explored paths that enumerated an ever increasing list of characteristics and relationships, falling into the "best practices" trap. Eventually it came to believe that too much detail was inappropriate at this early stage of understanding, and hardly useful in helping the uninitiated understand basic concepts. Much of the exercises and tools in this and subsequent sections owe their maturation to this Focus Group.

Communicating basic concepts is the first order of business.

To this end we can adopt a working definition of agility as: the ability to thrive in an environment of continuous and unanticipated change. The focal point here is "change" - the ability to initiate it, and the ability to respond to it. "Thrive" is a key word because it implies both long term success, as opposed to a lucky response, and because it implies wielding agility both as an offensive as well as a defensive capability. "Continuous and unanticipated" underscores the new long-term picture but, most importantly, distinguishes agility from mere flexibility, enabling successful change even when there is little advance notice and no prior expectation.

The Agility Profile Matrix

Though we are still in an early stage of understanding, one thing has become clear already: an agile enterprise has broad change capability that is in balance across multiple dimensions. We come to understand how important the "balance" part is when we test candidate examples against extreme conditions.

Would you call it agile if a short-notice change was completed in the time required but at a cost that eventually bankrupted the company? Or if the changed environment thereafter required the special wizardry and constant attention of a specific employee to keep it operational? Is it agile if the change is virtually free and painless but out-of-synch with market opportunity timing? Is it agile if it can readily accommodate a broad category of change that is no longer needed, or too narrow for the latest requirements?

These questions help us tease apart this thing called agility into four principal dimensions: cost, time, quality, and scope. To be agile, there is a requirement to "score" well in all four dimensions. Scoring is not an area we are yet able to address against a universal yardstick. Instead, you will find here a subjective approach to quantitative scoring that is used to focus a qualitative analysis.

An operation may successfully accommodate many changes without all dimensions being above the agile threshold. These kinds of changes don't represent the full range required for thriving on the unanticipated, and can provide a very false sense of security. A few successes at narrow-band change can lull an operation into thinking it is agile even when all dimensions have not been stressed.

You can change virtually anything if **cost** is no object. However, if your response to change costs too much relative to your competitor's costs, there will be a steady erosion of working capital, or at least a higher tax on shareholder profits. Change at any cost is not viable, else we need not restructure anything - we can simply throw out the old and buy a new capability; assuming, of course, that we can bring something new to the operational level quick enough.

But the cost of change alone does not provide a metric for agility. Completing a change in a timely manner is the only effective way to respond at all. Thus, **time** of change becomes an equally important factor, especially in an environment characterized by continuous and unanticipated change.

Quick, economical change, however, is still not a sufficient profile for agility. The **quality** dimension is necessary in order to reflect the robustness of the change. If we cut corners in the process of changing in order to do it quickly and economically, we end up with a fragile, spit-and-bailing-wire result.

Finally, something is considered to be agile precisely because it is prepared to thrive on change. But how much change? The dimension of **scope** addresses this question. Scope is the principal difference between flexibility and agility. Flexibility is that characteristic you fix at specification time. It is the planned response to anticipated contingencies. Agility, on the other hand, repostures the fundamental approach in order to minimize the inhibitions to change in any direction. Being agile is to recognize that the frequency of required change has accelerated to the point where contingency lists are outdated as soon as the ink drys. At the heart of scope is the architectural issue: rather than build something that anticipates a defined range of requirements, or ten or twelve contingencies, build it so it can be deconstructed and reconstructed as needed.

Thus, for some element of an enterprise to be agile it must have a balanced response-to-change capability across the four dimensions of cost, time, quality, and scope.

Agility Profile Matrix: Four Balanced Dimensions - Three Arbitrary Categories

	Cost	Time	Quality	Scope
People	(Evaluation)	(Evaluation)	(Evaluation)	(Evaluation)
Product	(Evaluation)	(Evaluation)	(Evaluation)	(Evaluation)
Process	(Evaluation)	(Evaluation)	(Evaluation)	(Evaluation)

The four agility dimensions of cost, time, quality, and scope form the basis for a powerful profiling tool. We will explore the use of this tool applied to examples in three enterprise areas: people, product, and process. This is not an attempt to be comprehensive - for we might also inquire into the agility of an enterprise strategy, or the agility of enterprise business relationships, just to name two other categories. It is worth noting that evaluating a product's agility is an exercise that can be applied to a piece of production equipment as well. After all, a piece of production equipment is just a product bought for, and employed in, the manufacturing process.

The entries in this matrix can be both quantitative and qualitative. The purpose of the matrix is to structure an analytical discussion that focuses on the **dynamics of change** for a specific area under scrutiny. Before seeing this tool applied to some examples, however, a final note on *balance* is in order.

When is an enterprise sufficiently agile to be called an agile enterprise? Perhaps when adequate agility exists in each and every one of the necessary enterprise system structures. Note that we are suggesting that "all" necessary structures must be agile in order for the enterprise to be agile. Again, we see the concept of balanced capability associated with agileness.

We can have agile departments without having an agile company. In fact, we will undoubtedly begin the journey to agile on a department-by-department basis. In many cases, an agile department responding to a threat focused in that area will successfully defend the company, giving the illusion that the enterprise is agile. OK - as long as we don't take solace in the illusion and think the task is done.

Using the Agility Profile Matrix

In group workshop settings the Agility Profile Matrix has been used to analyze a variety of machines, processes, procedures, strategies and other such enterprise elements. To the participants, the exercises were extremely illuminating; though the examples below can only hint at the insights gained by those who were actively engaged in the analysis.

Invariably, if someone did not act as critic, measuring the example constantly against the working definition of agility, and against the single-minded focus on the dynamics of change, the analysis wandered. Quality of change was often confused with the quality of the device or process under examination; and more often, with the quality of the product produced from the device or process. Evaluating new processes sometimes got confused between a focus on the process change itself and a focus on the resulting accommodation to product change. This wandering and seeming confusion actually added to the value of the tools application. Different participants at different times brought the group back on track by pointing out where the analysis had strayed and the revelation was always instructive.

You may disagree with the ratings and comments on the chosen examples below. That's fine: they are assessments made on subjective scales known only to the people involved in the actual rating. The exercise of actually rating these elements for their agility, and developing a set of supporting comments, is the point. Those that engaged in the exercise came away with a much deeper understanding of what agility is and, especially, what is agile and what is not. More specifically, those with ownership in the item being analyzed came away with a new appreciation and insight into its value.

Until we develop some universal scale for agileness the subjective scale is quite useful. The examples below were obtained by asking people to discuss the elements under scrutiny for how they accommodated unexpected change in each of the dimensions of cost, time, quality, and scope; and to rate that accommodation from zero to one on their own subjective agile scale. Zero means they felt that the element in question was totally non-agile. One meant it could not be usefully more agile under any circumstances. Thus, these ratings are measured against a particular rater's desires, goals, needs, expectations, knowledge, and other equally personal factors. Surprisingly, most of the examples shown were done by groups of people numbering anywhere from five to fifteen, yet represent a firm group consensus.

People Organization - Employee Core Augmented by Temporaries:

	Cost	Time	Quality	Scope
Category: People Organization **Type:** Employee Core Augmented by Temporaries.	**0.9** - Temps incur no training investment & no severance costs, & optimize employee training cost.	**0.9** - Agencies maintain rosters of qualified people, hiring risks minimized, immediate reductions.	**0.9** - Highly robust changes in staff size and team configuration, good morale, right skills.	**0.9** - Broad internal skills, temporary specialty skills, large temporary pools available.

- **Cost** - Providing a core group of employees with permanent employment and continual training can result in a highly knowledgeable, broad-skilled, and mobile workforce. Augmenting this core with outside temporaries to absorb fluctuating staff requirements and provide specialty skills protects the core group's employment and training investment. Though an apparent hourly premium is paid for temporaries, all hours are applied to production activity and none to training and skill broadening. Additionally, total training investments are reduced by reducing the loss of trained people who are eventually replaced by people in need of training when increases are required. Finally, when staff reductions are required they can be reflected immediately in payroll costs and do not incur additional severance costs.

- **Time** - Staff increases and reductions can be made much quicker in the temporary ranks than in the permanent ranks. Specialty skills can be found almost immediately among organized labor pools, professional agencies, and independent consultants. The interview and hiring process goes much quicker because agencies keep a roster of qualified people and the penalties for mistakes are more easily remedied.

- **Quality** - Change in the organization here is focused on staff increases, staff reductions, team configuration, and team reconfiguration. After a reduction in staff size there is relatively no debilitating dip in moral since the permanent employee ranks are protected and the remaining temporaries have chosen this way of life. Increases in staff size with temporaries requires an initial shake-out period since the incoming people are never as trained and dedicated as permanent employees, but overall this activity is comparatively robust as "hiring" mistakes can be more quickly corrected and specialty skills can be more readily found. If the increase is going to be made in the permanent employee ranks because the business base-line has grown, hiring will be done from the pool of known temporaries on-site - a highly robust approach.

  Configuring teams with skill-sets matched to tasks is facilitated by both the ongoing training investment in permanent employees and the option to augment the teams with highly specialized temporaries. Reconfiguring teams benefits from the same availability of broad skills, and also from a familiarity of dynamic interpersonal relationships that comes from mixing a permanent-temporary workforce.

- **Scope** - The magnitude and variety of potential change in both size and skill-base of the total workforce is quite large. Keeping a core group of permanent employees allows a sizable investment in continuous training - keeping these people current as well as making them broader. Augmenting the permanent workers with temporaries as needed, and bringing in specialty-skills whenever required, insures that large workforce capacity changes can be accommodated as well as a changing skill-mix requirement.

Product (Process Production Equipment) - Batch Reactor:

	Cost	Time	Quality	Scope
Category: Product Production Equip. **Type:** Batch Reactor Vessel.	**0.7** - Low cost changeover relative to per-day production revenue.	**0.2** - Registration and certification procedures for EPA and others is very slow.	**0.9** - Rock-solid after reactor vessel is re-plumbed, re-gauged, re-controlled, and re-certified.	**0.6** - Limitations due to tank linings, shapes and sizes matched to the chemical reaction.

- **Cost** - Though batch reactors are considered to be general purpose equipment, switching the product to which it is assigned, say from polyglycol for the polyurethane seat cushion market to paper coatings for the stationary market, is not to be taken lightly. Reactor vessels are generally installed into a matrix of input and output delivery system components, such as pipes and transport mechanisms, that need to be rebuilt for a different product. The EPA and local regulatory agencies also impose requirements on registration and certification for the new use the reactor will be put to. Though costly, by comparison to the value of the production it is negligible. Gauges, controls, and control software will also need to be constructed for the new production activity. All in all, when compared to the revenue generated by the new production unit these costs are negligible, often less than one day's output.

- **Time** - This is the biggest stumbling block to agility. Changing controls, control software, gauges, piping and transport mechanisms really only requires a few weeks from start to full compliance product output. The major time consumption is in the regulatory approval process. If gases are to be vented and then incinerated, for example, the EPA gets involved. Generally, the local fire department will also require registration and inspection. Experience shows that it is difficult to accomplish these regulatory procedures in less than six months even under extremely urgent priority conditions.

- **Quality** - Once a reactor is switched over to a different product it is a solid operation. Re-plumbed, re-controlled, re-gauged, and recertified, it is once again a dedicated and reliable production resource.

- **Scope** - General purpose always has its limitations. With reactor vessels it is seen in the linings and the hardware configuration. Chemical reactions must be matched to tank linings in order for a reactor vessel to be a production candidate. These linings are generally permanent and not something that can be changed once the vessel is built. Hardware configurations also play a role when shape and size are important to the reaction under consideration.

Process - Use of General Purpose Board Tester:

	Cost	Time	Quality	Scope
Category: Process Equipment **Type:** General Purpose Board Tester	**0.3** - Test software costs too much to develop for each new board to be tested.	**0.4** - It takes too long for software and fixture development for each new board to be tested.	**0.8** - Solid operation on all boards set-up for test. Problems with one set-up don't affect others	**0.7** - Accommodates a reasonable range of board sizes and types, but is not universal.

- **Cost** - Though a general purpose electronic board tester is a highly flexible piece of production equipment, the cost to introduce another board to the suite of boards that can be tested on the device is quite high. These costs are incurred in programming the test software and designing and building the board test fixtures. Some of these

costs are due directly to the general purpose nature of the tester, making programming and fixturing more complex.

- **Time** - Cost and time go hand-in-hand here since the costs are caused by both software and hardware engineering time. Both time and cost would be greatly improved if test programs and fixture designs were generated automatically from the engineering design documentation.

- **Quality** - Once a new board test suite and fixturing is completed, the general purpose tester is quite robust in processing the new board.

- **Scope** - The general purpose nature of these testers allows a fairly wide range of board sizes and types, though there are always some restrictions, particularly in mixed analog/digital production environments.

Getting It Right

- Be precise on what is being evaluated.
- Focus on the response to the "unexpected".
- Focus on a single architectural level.
- Use uninvolved critic to review for the above.

Avoiding Pitfalls

Experience shows us that it is very easy to get side-tracked and confused in these Agility Profile Matrix evaluations. Partly, because there is a tendency to confuse speed and flexibility with agility. Partly, because it is sometimes difficult to separate a production element from its environment. Partly, because we know the production element very intimately, and have a strong model of its strengths and weaknesses in our minds.

We have found that we must be precise about what we are measuring and rating. For instance, a general purpose board tester is highly flexible, perhaps even agile, within the bounds of the boards it is already set-up to test. However, when a new board is introduced we find this highly flexible piece of equipment to be very non-agile, as it is non-trivial to introduce a new board into the system. The key point here is that we have focused on the "introduction of a new board" into the production environment, rather than just the ability to handle a lot of different boards.

Note that the board tester was evaluated for its ability to handle the "unexpected" - a board that was not current in its test suite. Evaluating it on its ability to handle what it is already fully prepared for is not a test of agility, but rather of flexibility.

If we are in an agile enterprise, with an agile factory, that has an agile process, that utilizes an agile piece of production equipment to produces an agile product, we must be very careful about which "architectural level" we are examining. Even if some or none of these are agile, it is easy to shift the point-of-view in the examination, especially when we move from one dimension to another.

For instance, we might evaluate a process for producing custom-colored, custom-formulated caulking compounds. When looking at the cost dimension we might rate it highly agile because changing from one formulation to another is instant with no waste. When we get to the quality dimension we might rate it high here as well, because the color match for each customer requirement is precise. However, what we have done is mix an evaluation of the process change cost with an evaluation of the resultant product quality. If the quality issue had focused perhaps on the lack of cross-contaminates when the change was made, we would be evaluating the change dynamic itself as intended.

One useful technique is to employ a procedures critic - someone who hasn't participated in the evaluation or has no emotional involvement with the item being evaluated. With experience the need for the critic diminishes, but people new to the evaluation process almost always bring some passion to the act that clouds the results.

Agility is rooted in architectural issues: the integration structure of production control and information systems, the organizational structure for employees, the equipment hardware modularity, business practices and procedures, individual practices and procedures, and other structural realities that determine how things work together over time. A subsequent section in this guidebook will look more closely at fundamental architectural issues that determine agility in all four dimensions, and provide a more analytical framework for profiling scoring exercises.

LEAN and AGILE: SYNERGY and CONTRAST

Lean and Agile Contrasted

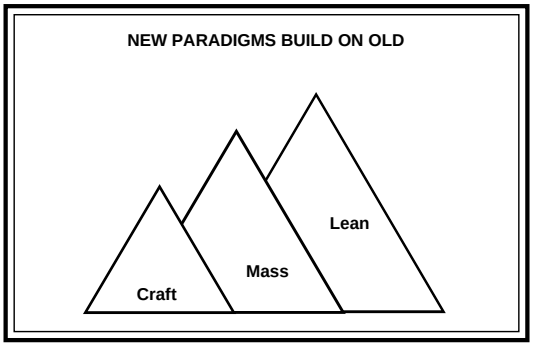
A year before the 21st Century Manufacturing Enterprise Strategy was published a book called The Machine That Changed The World became available. Written by James Womack, Daniel Jones, and Daniel Roos, and based on a five year MIT study on the future of the automobile, this book is the definitive work on lean manufacturing.

As the authors explain it, lean is a term applied to a collection of practices that began in Japan at Toyota in the 50s and deserve full credit for Japan's ascendancy in the automotive world. The lean movement in the USA is an attempt to understand what some Japanese already know, and The Machine That Changed The World packages these understandings quite readably for consumption in the USA as well as elsewhere. On the one hand it is an excellent history book, and on the other it is a call to action. The views expressed about lean below are based on the materials presented in the book.

The lessons of lean are extremely important for our understanding of agile. Many USA companies today are in the midst of major programs to emulate the Japanese methods and want to understand how agile relates. Others, listening to the rhetoric from both views hear much in common and want to know what the differences are. That lean and agile are both competing for mind share at the same time is just one more sign of how fast things are moving. No sooner do we understand what the Japanese have been building for the last 40 years then we have a new view that claims equal importance and urgency. This section will attempt to put these two into perspective and show where synergy and contrast exists.

Lean is a set of practices intended to remove all waste from the system. It is predicated on maximal usage of resources. It gave birth to, and encompasses, JIT, Kaizen, Kanban, empowered teams, quality circles, cycle-time-reduction, small-lot manufacturing, flexibility - practically all of the current wave of change methodologies. And virtually the same things that the "agile movement" claims in its domain.

The lean paradigm has been incrementally developed by Toyota since the 50s as a sequence of profound objectives and tactics, the completion of one guiding the way to the next. Forced to design a flexible stamping press because their volume couldn't afford a large number of single-part dedicated presses, Toyota discovered that small-lots in fact cost less then mass-production runs: inventory carrying costs and defective parts were both greatly reduced. This showed the way to JIT concepts, which led the way to the Kanban system. To utilize flexible stamping presses effectively, highly skilled teams were necessary. Serendipity played a hand when a major strike was resolved with employees gaining empowerment through decision responsibility. And this led the way to quality circles and Kiazan incremental improvement concepts, and eventually to "empowering" the distribution channel and the customer by involving them in the business decision making processes. All the while, a core of genius broadened these basic understandings across a larger and larger portion of the enterprise activity.



No grand vision drove this development. This was a continuing sequence of innovative steps taken by very perceptive people.

Lean is fundamentally different from mass production, and worthy of distinction as a new manufacturing paradigm of equal import and impact. To be agile, one must be lean as a prerequisite. Agile might be viewed as the wave after lean.

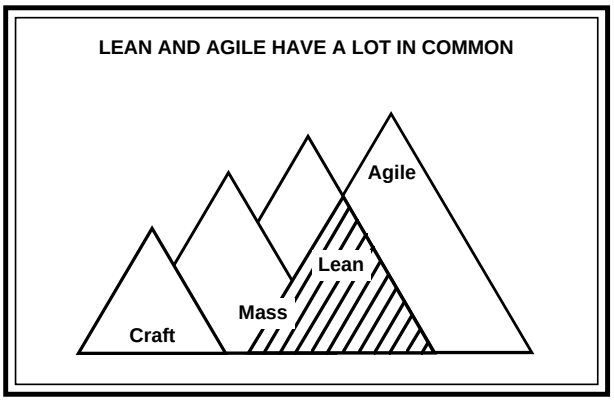
Lean is a response to competitive pressures with limited resources, agile is a response to complexity brought about by constant change.

Lean is bottom-up driven, incrementally transforming the mass-production model. Agile is top-down driven responding to large forces.

Lean is a collection of operational tactics focused on productive use of resources, agile is an overall strategy focused on thriving in an unpredictable environment. As such, lean, with its bottom-up, incremental development, and 40 years of development, has a demonstrable number of proven methodologies. Agile, with its top-down vision and 12 months of recognition, has identified a compelling objective and is now beginning the search for enabling methodologies.

The important activities within the agile movement today are top-down attempts to define the requirements for an agile operation. The wasteful activity in the agile movement is stumbling about in the lean areas trying to rediscover and redefine the excellent work already done in that arena.

Another very sharp demarcating difference: key performance metrics for mass production and lean production have a lot in common, those for agile are completely new. For instance, Lean will compare itself to mass production by noting the improvement in productivity, quality, space efficiency, and inventory size. The Machine That Changed The World claims the lean production paradigm deserves the title revolution just as Henry Ford's mass production paradigm did when it reduced direct assembly time over craft production by a factor of nine.



The agile production paradigm is not tied to the same performance scale as craft, mass, and lean, which are focused on (relatively speaking) short-term, fixed, production cycles. Agile, as applied narrowly to production, deals instead with the abilities of an organization to perform across product production cycles rather then within them, to reconfigure a factory for an unplanned production requirement for instance. Of course, as product cycles continue to shrink, what used to be thought of as long-term issues may in fact play out many times over in traditional short-term time spans.

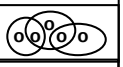
Lean is a concept emphasizing production, albeit the complete chain from customer to disposal as well as design for manufacturability. Agile is broader in its application, encompassing such areas as product design concepts beyond producabilty alone, business relationships, and corporate strategies, as well as all of the elements of the production chain.

Lean and agile can also be contrasted by looking at one as a collection of operating tactics, focused within the production cycle, and the other as an operational strategy, focused across production cycles. All such statements are oversimplifications. Nevertheless, they offer comparative perspectives as we all attempt to corral the lean beast the Japanese gave birth to in the 50s, and the agile beast the Americans are starting to create in the 90s.

Are these two ends of the same beast? When lean finishes its experimental development will it reach the agile goal? Probably not - as unpredictable change accommodation is not the root focus, optimal utilization of resources is - and the two conflict when lean is completely successful.

The most discernible difference between lean and agile surfaces when we look at architectural roots of manufacturing paradigms. Craft production is based upon the comprehensive single unit: one man builds an entire rifle, one team builds an entire car. Mass production introduced specialized work modules and sequential work flow past these modules. Lean brought us flexibility with its alternate paths and multiuse work modules. And now agile brings us reconfigurable work modules and work environments.

OPERATING METHODS
Rooted In
ARCHITECTURES

	Craft	Mass	Lean	Agile
Reconfigurable				
Flexible				
Fixed		-o--o--o--o-		
Comprehensive	◯			

It is too early to expect the same depth of understanding in the newly birthed agile as we have come to know in the more mature lean. One promises the future, the other studies the past.

The Machine that Changed the World raised the question as to whether lean production techniques could withstand the stress of business downturns; noting that they were developed and applied during the Japanese period of constant industrial growth and increasing prosperity.

Perhaps the answer lies in the December 21, 1992 Business Week article describing how good Japanese lean practitioners in the automotive industry are reacting in non-lean ways to Japan's current downturn:

- Honda is adding management layers because "engineers had too much freedom"; and sharing common parts across many more models than previously.
- Japan Electronic and Control Systems, a major sub-system supplier, has had to start monitoring quality with on-site inspectors at a growing number of its suppliers.
- Toyota and Nissan are both cutting product variations and options.

The most telling quote in that Business Week article is from the president of Honda: "We're facing matured, low-growth markets for the first time ever....We have to make ourselves very flexible to quickly respond to an uncertain future." The age of agility is here. It is the natural successor to lean, and it deals precisely with the weakness of the lean paradigm: making things so efficient that they become fragile to change.

What appears to be true is that all new paradigms retain a large dose of their predecessors. Though we focus on the differences in order to advance to the next stage, a closer look reveals a much larger common core. Those companies currently making the transition from mass production to lean production are not likely to find any conflict or wasted effort in a subsequent transition to agile: most of the requirements for lean are also requirements for agile, and leanness to the point of fragility is unlikely to be attained in these early stages. Knowing that the ultimate goal is agile, however, should help set priorities and transition sequences.

Never before have we seen two major paradigms come so close together. Before we have a chance to internalize our understandings of lean through operational experience, here comes agile. But then again, the USA is starting on lean forty years late. Perhaps the lessons of lean can be learned in night school at the same time the potential of agile is developed and exploited.

A Note on Lean in the Defense Community

The defense community in the USA in the early '90s is undergoing a more intense change process than any other industry. With one principal customer, the companies in this community are all affected simultaneously - both in market downsizing and in new customer requirements for the market that emerges. Strong demands for more affordable defense systems is putting a focus on manufacturing and its basic methodology. It is compelling to take the lessons and approaches catalogued under the lean heading and seek application for them in an industry previously shaped by regulatory procurement practices.

Lean production techniques are at home in the automotive community and its mass-production tradition - focusing on smaller-lots and higher variety while bringing lower costs and higher quality.

But smaller-lot-size is relative, and is unlikely to extend into the quantities of defense production, unless weapons systems take on a design and construction similarity as consistent as automobiles, and also support the large aggregate volumes inherent in the auto markets. For instance, even though all missiles of every type bear some generic similarity, the scope of their dissimilarities is far greater than that found in automobiles; and even if you could pool different missile "models" through one factory, the total quantity per year would still be far less then an auto factory.

The techniques of lean, at least as we know them currently, are intimately related to these characteristics of large aggregate volume and highly similar product:

- The lean version of JIT inventory arrival is impractical in small sporadic quantities.
- Work-team empowerment and skill-breadth under lean approaches rely upon the similarity of the product regardless of model or vehicle type.
- Lean process concepts rely upon similarity in form factor, materials, and process steps and techniques offered by the automobile product; and also rely upon the automotive volumes to justify the equipment design approach and cost.

In order to bring lean benefits to the defense community one must go all the way to agile, and even redefine some of these lean concepts along the way for a very different environment.

The hand-craft automotive companies, like Astin-Martin and Ferrari, are not at all like the hand-craft weapons-systems manufacturers. Those auto companies don't build all their parts special - they buy most of their subsystems from a thriving high-volume auto-parts supply industry.

Reading The Machine That Changed The World might leave the impression that job-shop and craft-production will be displaced by lean production across the board. The book accurately refers to the fact that lean production in autos is allowing major auto companies to compete with the few hand-craft shops that are left for quality and customized options (variety). These hand-craft shops, however, are still making an automobile similar to those made in the higher volume but lean production shops. And, those craft shops purchase a large percentage of their subassemblies from high volume parts manufacturers. Nevertheless, there are undoubtedly many values the aerospace and defense community can gain from a judicious employment of lean practices; keeping in mind that the expectations raised in the book are appropriate for a very different set of production characteristics.

Automatic rifles - now there's an opportunity maybe.

The new defense procurement environment may well create an agile defense industry even faster than that which develops in the commercial sector. In today's environment the Department of Defense has more to do and less to do it with: they must stay on top of the accelerating technological innovation cycle or risk an enemy with superior capability, yet the end of the cold war is reducing budgets. The strategy under these conditions is to invest in advanced technology demonstrators, making only enough operational prototypes of new systems to know they are

viable. Production capability for these systems is not brought on stream unless and until deployable quantities are needed. Thus, when the call comes, the defense industries will need to rapidly ramp up production with inexperienced workers, unprepared factories, and no production history. In some cases they will even have to reconstitute discontinued production capabilities. All of this needs to be done without compromise on cost and quality. That's agile.

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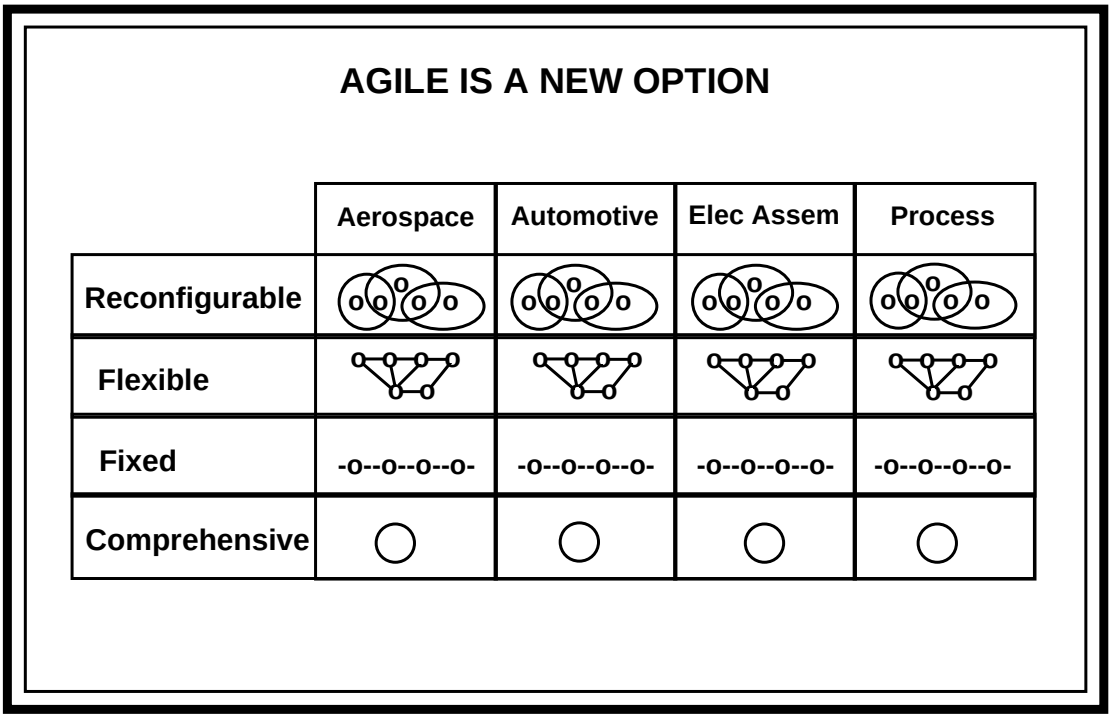


MIGRATION STRATEGY

When unrelenting and uncontrollable change dominates, the human assets of an enterprise are its most important element. The knowledgeable and empowered workforce becomes the major contributor to agility because it allows decisions to be made rapidly at the point of maximum knowledge. It also encompasses, at least in principal, the concept of a fluid organizational structure free to reconfigure quickly as needed. Additionally, agility cannot exist without these very same fundamentals of reconfiguration and distributed decision making applied to the corporate computer support infrastructure - which defines the corporate entity every bit as much as the human element. The real importance of this computer infrastructure, however, stems from the fact that it is the enabling support system for human judgment and rapid decision implementation.

Together, these two areas are the principal cornerstones of agility: human interaction structures and computerized support structures. If either cannot be changed continuously or reconfigured quickly, agility cannot exist. These two areas are also today's biggest impediments to agility - both have an established and traditional structural approach that is extremely difficult to change.

In building a migration strategy that will transform the enterprise from its current status to one which is highly agile, it is valuable to understand that the bulldozer approach is not required. The very nature of agility is centered on accommodating constant change. As a result, good agile structures are always in a state of evolution and flux - and are capable of co-existing in a highly heterogeneous environment - even one which is only partially agile. Thus, migration to the agile objective is easily done incrementally.

The agile enterprise is inevitable, as it is the only successful response to the quickening pace of change. Since the pace of change is uncontrollable, it is only a matter of time when only agile enterprises will exist. So how long can you wait to begin the migration? Look around, review the business news, there is ample evidence that waiting until the need is obvious is too late, even for our most revered institutions. The agile vision is here precisely because things are changing too fast for the traditional response mechanisms.

Shared Vision Workshops

Beginning the process starts by involving the people in the organization. The agile enterprise requires a cultural change in the way that people interact and the way that people react to change. Dealing with constant change is not a natural activity. We all go to great lengths to stabilize everything around and about us. As the pace of change quickens, successful response will only happen when the work force at all levels shares a common vision.

Shared-vision workshops have proven to be a powerful mechanism for creating definition, buy-in, and evangelical support for the common vision. Shared-vision workshops are not an exercise in uncovering the consensus. They are instead consensus developers. Developing a shared-vision is a process that uncovers certain irrefutable fundamental driving forces that support a working vision of the future. It has the same unifying effect that comes from identifying a common enemy. This was the very concept and process employed in developing the 21st Century Manufacturing Enterprise Strategy, and is responsible for the early and wide-spread appeal of the conclusions.

Shared-vision workshops that are expected to initiate a change process in an organization begin with a clear understanding of the goals and a careful choice of the workshop participants. Effective goals call for wide-spread buy-in and mobilization to action, not simply the articulation of a vision among an elite few. Above all else, people must be chosen for their ability to influence others - they become the change agents.

When an organization decides to make a major and permanent change, and is serious about creating and arming a cadre of internal change agents with effective tools and a well articulated vision, workshop time and intensity become important - and might span a 90-day period at a few days per week.

This vision-based planning approach creates a clear picture of the corporate future, identifies simple fundamentals that justify that future, and prioritizes short and long-term supporting moves to advance on that future. Most of all, vision-based planning answers the why of what you decide to do. This promotes initiative and encourages responsibility everywhere in the corporation. It is a foundation for empowerment.

Vision-based planning offers a way to measure and evaluate alternative strategies and tactics, and provides a framework for subsequent real-time operational decisions. It puts existing programs such as TQM, Cycle Time Reduction, Lean and others in perspective, providing a link for integrating these with new understandings and needs.

Self discovery, ownership, clear foundations, and simple models. These are the principals that guide effective shared-vision workshop activity.

Three important parts of any agile-enterprise migration strategy include:

- Developing a shared vision.
- Conducting agility assessments.
- Seeking agility migration enablers and tools.

Agility Assessments

This guidebook has introduced some tools for conducting agility assessments - exercises that people at any level in an organization can employ to examine existing practices or processes, and use to evaluate new strategies or acquisition alternatives. Importantly, these assessment exercises are conducted in groups rather than as solo activities; helping to build new patterns of thinking.

When assessment exercises are coupled with good data and metric gathering, powerful understandings emerge. The real costs of inflexibility become evident. Most importantly, the business-case justifications become analytical rather than intuitive, making buy-in by the more intractable functional areas of the company much easier to attain.

The value of doing agility assessment exercises include:

- Strengthening a shared-vision.
- Reducing the costs of inflexibility.
- Getting More Value From Investments.
- Developing the business case for agility.
- Setting priorities.
- Unleashing a motivated team.

Migration Enablers

Enablers are supporting mechanisms and infrastructure elements that support the human-centered activities of constant evaluation and constant decision making.

The 21st Century Manufacturing Enterprise Strategy identified 27 important enablers for the successful competitor in the emerging business environment. With the exception of the two that are aimed solely at environmental drivers - Zero-Accident Methodology and Waste Management and Elimination - the remaining 25 play a key role in the realization of the agile enterprise. Rather then base a strategy on wishful thinking, like anti-gravity effects or cold-fusion energy sources, the enablers for agility were required to have at least early promising visibility. Thus, we are able to identify some investments, acquisitions, and methodologies that can come into play immediately for those ready to begin the migration process.

Beginning the Agile Journey - A Guidebook

Whether or not an enterprise has already decided that it must begin the journey to agileness in earnest, it makes organizational, strategic, and purchasing decisions everyday that can bring it closer with virtually no pain. The brief outlines below are intended to help guide the interested in recognizing currently available technologies that can help the migration process. They are listed in alphabetical order.

- **Continuous Education**

In a continuously changing environment driven by technological innovation and globalism, important decisions and judgment calls must be made rapidly and frequently. The quality of these decisions and judgments will be in direct proportion to the currency and quality of the knowledge possessed by the decision makers. An organization's ability to make and implement good decisions under these conditions will be the principle determining factor in its viability. This not only means that the entire work force from bottom to top needs constant training, it also means that the company's shareholders will attach a significant value to this investment in training as well.

New modes of training and learning are required in order to integrate this process into the everyday work activity. New training systems that deliver individualized training and remote group training with computer-aided mechanisms will be an important part of the equation. For instance, in a rapidly changing product mix remote group training is important for introducing new products and options to a field sales force and service organization. Remote training mechanisms also offer promise in the area of supplier/subcontractor improvement programs and relationship familiarization when integrated working relationships must be developed quickly and improved frequently. New desk-top multi-media software is providing an important new ingredient to computer-aided-education; making individualized on-the-job training a powerful option.

- **Customer Interaction**

Making the customer a part of the product design and improvement activity is becoming a key business strategy for an increasing number of companies; especially those who are moving to a higher degree of customization and customer specificity in delivered product. With an shortened product cycle and the accompanying increase in change frequency, the involvement of the customer can no longer be served by occasional meetings and discussion. Companies on the leading edge are already placing workstations at customer sites with product configuration and design tools to facilitate the order configuration and entry process. As multi-media and desk-top video conferencing mature customer interaction will become even more integrated with the supplier, facilitating remote face-to-face meetings.

- **Database Structures and Methods**

The agile enterprise is one that has empowered individuals making good and timely decisions. Access to information, whether its part of the internal corporate database, under the control of suppliers and customers, or available by dial-up subscription, is a critical component of good decision making. New object-oriented distributed database approaches provide great promise to rationalize both management and access in a complex information environment. Simple human interfaces into complex information networks should follow shortly; making information access independent of the repository and available to anyone with desktop computer support.

■ **Empowerment**

When decisions have to be made quickly, frequently, and knowledgeably, they have to be made at the point closest to the need where the greatest information and knowledge exists. This is true whether its people or control software. For instance, agile factory control software is "empowered" to adjust a machine schedule for real-time surprises and opportunities on the fly. By the same token, empowering people to make decisions about the work they do and how they do it is the only way to get fast informed decisions. Unlike software, people often respond to this "responsibility" with an increased devotion and interest in the work they do, adding another important dimension to the values of empowerment.

Empowered and self-direct workteams are a growing commitment in many advanced organizations. Teaming provides the necessary skill-mix in an integrated unit, empowerment provides the ability to be responsible, and self-direction encourages pride and ownership for the results. Support for these powerful productivity advances starts with a strong program for developing teams over time. The transition period is difficult for management, professional, and hourly workers alike, as old ways are deeply ingrained.

Teaming tools require a different type of desktop and workstation computer support then those now considered traditional. Groupware concepts are starting to come to market that make it possible for multiple people to interact simultaneously on designs, writing tasks, strategy development, concurrent engineering, data interpretation, and other activities that have been individualized and sequential in the past. Electronic group-mail and desktop conferencing capabilities are in their early stages of market entry but have already shown their ability to weld integrated teams from people separated by great distances and previously-incompatible time-zones.

■ **Energy Productivity**

Energy is what makes the world go round; and it stops when the energy does. An agile company in an agile era recognizes the single-point failure that energy can represent to operations. Unexpected shutdowns, brown-outs that destroy equipment, and other energy related surprises are even less tolerable in a world that waits for nothing. Though an agile organization is one that thrives on unexpected change, it is also one that eliminates and reduces those sources of change that are controllable. Alternative sources of energy and energy efficient equipment and processes are becoming major considerations in a company's operating strategy. Whether it's more efficient motors or more efficient computers, in manufacturing enterprises or service related enterprises, the consumption of electrical energy by business equipment has become a focus of vendor and purchaser alike.

■ **Enterprise Integration**

Concurrent engineering became a popular objective in recent years as organizations understood the great inefficiencies in sequential, arms length, over-the-transom transfer of product designs into manufacturing. Though it may have been the first place where corporate functional concurrency gained legitimate strategic focus, it is only the beginning. Though some might say that we have long been plagued by concurrent marketing, where so-called vapor-ware and late-to-market products are talked-up and even sold before design is finished, today's quickening pace no longer confers an advantage to such mistakes whether they are intentional or not. Preannounced product is too often being eclipsed before it becomes deliverable. Many of the mistakes in this area can be blamed on the lack of enterprise integration - where different functional units in an organization are out of synch with each other, where sequential activities take to long to discover problems that cause major backtracking or unacceptable costs, and where inefficient functional interactions add up to a missed opportunity. Finding a way to integrate the entire enterprise into a single concurrent entity has become a strong focus for many companies today. Enterprise integration is in fact one of the principle focus group activities at the Agile Manufacturing Enterprise Forum (see reference below for contact information).

In all but the smallest companies, enterprise integration relies on an information systems infrastructure provided by computers. Until recently, the concept of integration required that a corporation standardize its information

infrastructure on a single vendor approach for hardware as well as software applications. The complexity of managing such an environment coupled with the inability to keep pace with new advances made true enterprise integration an impossibility. Major changes in the computer support world are now opening the door for large scale integration. Important enabling concepts include open-systems, distributed heterogeneous networking, platform independent software, object-oriented technology, and client/server architecture.

- **Evolving Standards**

Standards are important in order to build an infrastructure that facilitates change. Plug-compatibility is the key requirement here whether we want to upgrade or reconfigure a capability. However, in the past our standardization procedures have taken so long to accomplish that few have stabilized before the issue is obsolete. Evolving standards recognize two important concepts: an initial standard must be established before the market develops, and standards must be living things that evolve along with technology and requirements. We are starting to see this happen with organizations such as the Object Management Group (OMG) which was set up in advance by a large number of suppliers and users who expect an active market in object-oriented technologies.

- **Factory America Network**

The United States has two unique strengths in its large, diversified supplier base and its leadership in the information sciences. The Factory America Net (FAN) concept marries these two strengths and basically envisions an on-line business environment - where suppliers and business partners interact seemlessly over an electronic commerce network. Well beyond the early attempts at EDI (Electronic Data Interchange), FAN embodies an inter-enterprise integration that eventually spans the globe. Early enablers are network tools and applications that start the electronic interaction in the supply chain, and range from simple electronic mail and financial transactions to more involved concurrent engineering tools and database sharing.

- **Global Broad-Band Network**

This major infrastructure element is the fundamental fiber-optic communications transport mechanism needed by the country to support integrated electronic commerce. When the 21st Century Manufacturing Enterprise Strategy was published this was a distant expectation. Since then accelerating activities and priorities promise real capability in the USA by the end of the century, keeping pace with Japan and the advanced parts of Europe.

- **Global Business Systems**

Globalism carries with it an enterprise structure that is distributed around the world. No longer reserved only for the worlds largest companies, internationally distributed business operations are becoming more practical as communication and interaction support technologies mature. Some large advanced companies are already running integrated product design teams around the clock around the world. A few are already downloading product manufacturing data from engineering and design centers into factories anywhere in the world, shifting product production from one factory to another as local requirements and capacity favor.

- **Groupware Systems**

In some sense the agile era is resurrecting the historical concept of the renaissance-man and craft worker. Making good decisions quickly in today's complex environment requires concentrating broad understandings and skills in the human elements of the enterprise. The times we live in, however, have so much more knowledge and complexity that a group/team concept has replaced the individual of times past. Whether we recognize the nature of the group effort or not, whether we augment the ability of groups to work together or not, the fact remains that important decisions and projects are the combined effort of many people and have been for some time.

Early enabling technologies for group activity are already coming to market in the form of networked desk-tops, concurrent engineering tools, electronic mail, work-flow managers, multi-media document processors, and other productivity enhancers that are specifically focused on groups rather than individuals. For many, early use of groupware tools will help ease the inevitable cultural change in working relations.

- **Human-Technology Interface**

With the relentless turnover of personal-productivity technologies as well as new production equipment and information system software, today's workforce is already finding it difficult to master necessary tools before they are replaced by something else. Anything that stabilizes the human-technology interface, especially while underlying technology changes, makes it easier, quicker, and less costly to take advantage of improvements.

Open systems offer the potential for hardware upgrades from a broad vendor base while user software remains unchanged. Graphical user interfaces bring the potential for common look and feel, and subsequent accelerated learning, to a wide variety of personal-productivity enhancers. Standardized APIs (application program interfaces) offer the potential for system software upgrades while the user software remains unchanged. Leading-edge work in the area of "personal-agents" offers the opportunity to relegate the drudgery of technology interface to a new type of software.

- **Integration Methodology**

Frameworks and tools for integrating systems composed of heterogeneous hardware and software are just starting to appear on the market. A large step forward occurred recently when the Object Management Group (OMG), an international organization, released the Common Object Request Broker Architecture (CORBA). CORBA is structured specifically to accommodate the integration of a wide variety of object oriented systems, and is being supported by a large number of computer and systems vendors. By itself, CORBA is not an integration methodology, but it begins to develop a framework for a methodology.

- **Intelligent Sensors**

As computational elements get smaller and less expensive, it becomes highly desirable to do data reduction and even some decision making right at the point of sensor application. For instance, packaging an acoustic sensor with on-board data analysis for use in a machine tool can reduce greatly the amount of data transfer between the sensor and the machine controller. Importantly, it removes the need for data reduction from the machine controller, allowing it to concentrate on more sophisticated control activity. These intelligent sensors have the ability to respond quicker to dangerous situations since they are dedicated to single function activities. Like the human peripheral nervous system, some things are best done immediately without waiting for the central processor to evaluate the situation. The concept of intelligent sensors is a reflection of the object-oriented autonomous module architecture concepts so important to agility.

■ **Knowledge-Based Artificial Intelligence**

Perhaps one of the most promising emerging knowledge-base technologies for human support is the so called "personal agent". A personal agent is a programmed intelligent assistant that gradually takes on the responsibility for interfacing a specific human to the world of electronic information - providing a highly friendly and intelligent interface that evolves effective and individualized personal communication modes for the human it supports. The personal agent is one way to insulate people from learning detail about a rapidly changing and growing technological environment; providing them with a stable interface that learns how to translate requests and filter incoming information.

As a desk-top assistant, a personal agent might be instructed to handle a large percentage of electronic-mail response - re-routing and forwarding messages with certain key words and subject material to people more appropriate. As a data-finder, a personal agent might take instruction to go get information about something and automatically search a large and diverse number of internal and external databases. As a production operator's assistant, a personal agent might be instructed to respond in standard ways to many common conditions which would otherwise require human intervention - like notifying the maintenance department when preventative maintenance is needed, or finding someone appropriate to respond to an urgent alarm condition.

■ **Legal Streamlining**

The legal area is one of the biggest impediments to the agile enterprise, inserting long delays in the development of partnering relationships, supplier negotiation, and contractual activities of all kinds. With shrinking market windows and more complex products, delays in starting a productive partnership or other business relationship can easily doom the opportunity before it even starts. Equally important is the recognition that the continuously changing environment no longer supports the concept of rigid hell-or-high-water contractual relationships - partnerships and supply relationships will recognize that long term benefit comes from short-term flexibility in response to unpredictable events. The old-line "gottcha" business contract may squeeze some extra advantage out of one product cycle, but another and another come right behind it; and crucial partners will find alternative relationships with others easier as globalism and growing complexity bring a greater need for interdependence.

Some companies are already experimenting with close interdependent product development activities that skirt the traditional legal involvement entirely. Much of this activity is motivated by grass-roots expediency rather than by corporate design - where groups in two or more companies work together on a joint product design effort with nothing more then an informal common interest or perhaps a more formal purchase order. Skirting a protective system cannot be a good idea in the long run, but appears to be the only mechanism open currently for meeting the needs of some rapid response opportunities.

■ **Modular & Reconfigurable Process Hardware**

Flexible production equipment has broadened the range of usefulness for many investments and lengthened the period when they can be productive. Unfortunately, flexible equipment requires accurate foresight about the future to insure payback. New concepts in equipment architectures are starting to emerge that offer "extendibility" rather then mere flexibility. For instance, rather then replace that three-degrees-of-freedom robot with a new one offering four degrees of freedom, new approaches in early testing stages offer the option of buying an add-on degree of freedom in a plug-on joint/arm/control package. These approaches are the hardware equivalent of the software object-oriented architecture concept.

■ **Organizational Structures and Practices**

Empowerment and self-directed work team organizational structures are well past the experimental phases in many major corporations already. Much is yet to learn in reward systems, reconfiguration methods, and consensus/leadership issues, but it is clear that true empowerment unleashes a grass-roots motivation that has a major impact on productivity and innovation. Critical for an agile enterprise is the need to place decision making responsibility as close to the actual work activity and knowledgebase as possible in all enterprise functions. True empowerment accomplishes this. Companies beginning or just considering the transformation to empowered work teams should investigate the approaches and lessons learned by others. Consultant expertise should be sought for sure, but nothing is as good as a close deep look at another company's experience in this area.

■ **Performance Metrics and Benchmarks**

Benchmarking tools for measuring agileness are still in the formative stages. This guidebook has suggested some mechanisms for developing metrics and benchmarks. Ongoing activity in the community of people investigating the agile enterprise continues to produce more such tools. The Agile Manufacturing Enterprise Forum (AMEF) has a series of focus groups that are creating deeper understandings and more tools in this area. The Agile Production Focus Group of the AMEF, chaired by the author, has contributed to the design and testing of the tools in this guidebook; and welcomes others who would like to participate in the ongoing tool development activities. Another AMEF focus group is dedicated to performance measures and benchmarks; and has produced a 400+ item self-assessment test for probing the characteristics of agility across the enterprise. See references at the end of this section for more information on joining these activities.

■ **Rapid Cooperation Mechanisms**

In the age of fast-paced, unrelenting change the speed with which new partnerships and business relationship become productive is paramount to success. Many companies are experimenting with consortia activities and collaborative-project modes by actively participating in organizations like the National Center for Manufacturing Sciences (NCMS). Though other consortia such as SEMATECH and MCC offer pooled research and development activities, the NCMS is distinguished by its requirement that the project activity be conducted by the participating members in active collaboration. With approximately 150 member organizations in 1993 and some five years of operating experience it is clear that collaborative modes take practice and learning. One big benefit that umbrella consortia organizations can bring to their memberships are mechanisms that enable quick collaborative-team formation.

■ **Representation Standards**

Inter-enterprise integration and electronic interaction, as well as internal enterprise integration, needs common representational standards for parts descriptive data. PDES (Production Data Exchange Specification) and STEP (Standard for the Exchange of Product Data) are two related standardization activities that offer some utilization already.

■ **Simulation and Modeling**

In an age requiring fast change and rapid market entry it will be too easy to make big mistakes. The analysis and design-augmentation role that simulation and modeling has played in the past will be superseded by its values in reducing risk. Whether its building an automated production process or designing a new product with concurrent engineering approaches, simulation is becoming an integrated part of an iterative design prototyping process. On the production front, new "virtual factory" software products are starting to appear that provide a much deeper modeling of the factory environment then simple simulators.

■ **Software Prototyping and Productivity**

Software is a rapidly growing component of almost all products today, as well as a major constituent of production automation control and enterprise decision support. Finding ways to reduce costs and increase productivity of software creation and modification is already the top priority for many companies. CASE (Computer Aided Software Engineering) tools have proved their abilities to help here, and are now being augmented with visual and object-oriented prototyping environments, reusable software modules, and "persistent object" concepts.

- **Supportive Accounting Metrics**

Activity based accounting is an example of the object oriented encapsulation concept applied in the area of cost accounting. It packages the costs associated with a given production unit with that unit. In essence, it then transfers the costs associated with the utilization of a production unit to the item receiving the action. Changing the production environment resources, changing product mix, or reconfiguring the environment in any way maintains accounting accuracy.

- **Technology Adoption and Transfer**

The mainstay of most technology transfer attempts today involve telling people who don't want to listen about things they don't want to hear. Adopting new ideas and changing stabilized patterns is something few people do for the sheer pleasure of it. Successful adoption programs occur when people are offered a path toward achieving something they already believe is necessary and beneficial. Consequently, rather than placing focus on the technology that should be transferred or adopted, it is much better to spend time and effort on illuminating and prioritizing the problem that can be solved by adopting a new approach or technology. Equally important is the need for "buy-in" and ownership of the problem understanding. These ends are well served by facilitated workshops and exercises that involve people in self discovery activities which identify and measure the problem.

Tools that help develop awareness of agile-enterprise impediments and costs, and recognition of solutions, is what this guidebook has been all about. The profiling tools discussed in this guidebook can be used effectively to evaluate problems as well as solutions - and are inherently self-discover mechanisms that require the active involvement and the creation of understanding.

References and Contacts

- Agile Manufacturing Enterprise Forum (AMEF), Lehigh University, Terry Schmoyer, 215-758-6351.
- AMEF Agile Production Focus Group, Chair: Rick Dove, Paradigm Shift International, 510-652-7528.
- AMEF Performance Measures & Benchmarks Focus Group, Chair: Len Allgaier, General Motors, 313-947-0686.
- AMEF Enterprise Integration Focus Group, Chair: Dick Engwall, Westinghouse Electric, 410-765-0709.
- National Center for Manufacturing Sciences, Frank Curtin, VP Member Development, 313-995-0300.

SURVEY DATA TAKEN AT WORKSHOPS

In the Hewlett-Packard sponsored workshops series, survey data was been gathered by Paradigm Shift as part of its ongoing research into national baselines and agile enterprise migration strategies. This section is included to provide feedback to those who have participated in this survey activity, and to others who are interested in national perceptions and actions relative to the importance of change on enterprise operations.

The intention is to show each workshop group how its responses compare to the cumulative responses; and when enough response exist to break them into industrial sectors, to show that as well.

The series includes nine workshops and the data is being returned to the participants before all workshops are finished. Thus, some of the earlier workshop guidebooks will contain cumulative rollups that do not encompass the complete series. When the program is finished, however, a complete set of cumulative rollups will be made available to anyone who so requests. On the following pages are the two questionnaires that were utilized in gathering the data, followed by graphical rollups of the results.

Perceived Change Trends

The first questionnaire attempts to assess how attuned people in industry are to the quickening pace of change and its impact. To this extent it represents fact rather than opinion, as it reflects the perceptions of the participants. The intent of this exercise is not to predict the future course of change, but rather to understand how its dynamics are perceived by those who live with it.

To this end the participants were asked to consider 1985 as a base-line "normal" year; and were asked to show their beliefs about how 1990 compared to 1985, and how 1995 would compare to 1985. Three aspects of change were considered: time, cost, and frequency; in eleven different corporate-structure areas.. If more time was spent in 1990 coping with change then in 1985, the number will be larger then the 1985 base-line of 100. Likewise, if the costs were greater or the frequency of occurrence were greater, the corresponding number will be larger.

USA Corporate Priorities

The second questionnaire seeks to understand where corporate priorities across the USA lie relative to programs that will help stabilize the effects of change. People were asked to guess what their corporate priorities were rather then be restricted to what they may or may not feel is the corporate party line. In this case we are dealing in pure opinion. However, this opinion is probably grounded in observation rather than rhetoric and perhaps carries more value as a gauge of true action.

Seminar coding of the graphic data on the following pages is as follows:

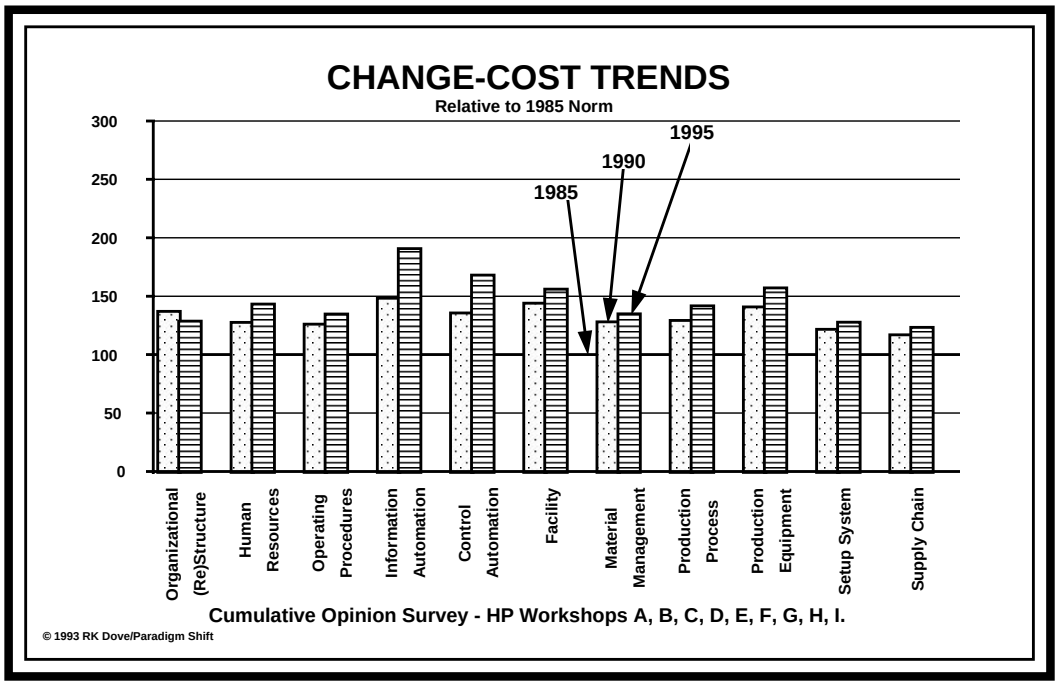
A	Irving, TX	April 21, 1993
B	Livonia, MI	May 5
C	Burlington, MA	May 6
D	Itasca, IL	May 13
E	Orange, CA	May 25
F	Manhatten Beach, CA	May 26
G	Cleveland, OH	June 1
H	Paramas, NJ	June 2
I	Santa Clara, CA	June 9

CHANGE TRENDS:

	Time			Cost			Frequency		
	'85	'90	'95	'85	'90	'95	'85	'90	'95
o Organizational (Re)Structure:	100			100			100		
o Human Resources:	100			100			100		
o Operating Procedures:	100			100			100		
o Information Automation:	100			100			100		
o Control Automation:	100			100			100		
o Facility:	100			100			100		
o Material Management:	100			100			100		
o Production Process:	100			100			100		
o Production Equipment:	100			100			100		
o Changeover/Setup System	100			100			100		
o Supply Chain:	100			100			100		

FOCUS AREAS and ENABLERS

- Technology Deployment Focus
  - Continuous Education
  - Technology Adoption and Transfer
  - Human-Technology Interface
  - Knowledge-Based Artificial Intelligence
- Enterprise Flexibility Focus
  - Intelligent Sensors
  - Software Prototyping and Productivity
  - Integration Methodology
  - Modular & Reconfigurable Process Hardware
- Enterprise-Wide Concurrency Focus
  - Enterprise Integration
  - Factory America Network
  - Representation Standards
  - Simulation and Modeling
- Communication and Information Focus
  - Global Broad-Band Network
  - Factory America Network
  - Database Structures and Methods
  - Evolving Standards
  - Enterprise Integration
- Subcontractor/Supplier Support Focus
  - Cooperation and Teaming Focus
  - Evolving Standards
  - Technology Deployment Focus
- Cooperation and Teaming Focus
  - Factory America Network
  - Empowered Individuals and Teams
  - Enterprise Integration
  - Groupware Systems
  - Rapid Cooperation Mechanisms
- Environmental Enhancement Focus
  - Energy Productivity
  - Waste Management and Elimination
  - Zero Accident Methodology
- Business Environment Focus
  - Legal Streamlining
  - Organizational Structures and Practices
  - Performance Metrics and Benchmarks
  - Supportive Accounting Metrics
  - Global Business Systems
- Human Elements Focus
  - Empowered Individuals and Teams
  - Continuous Education
  - Customer Interaction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Operating Procedures
Information Automation
Control Automation
Facility
Material Management
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Production Equipment
Setup System
Supply Chain
Cumulative Opinion Survey - HP Workshops A, B, C, D, E, F, G, H, I.
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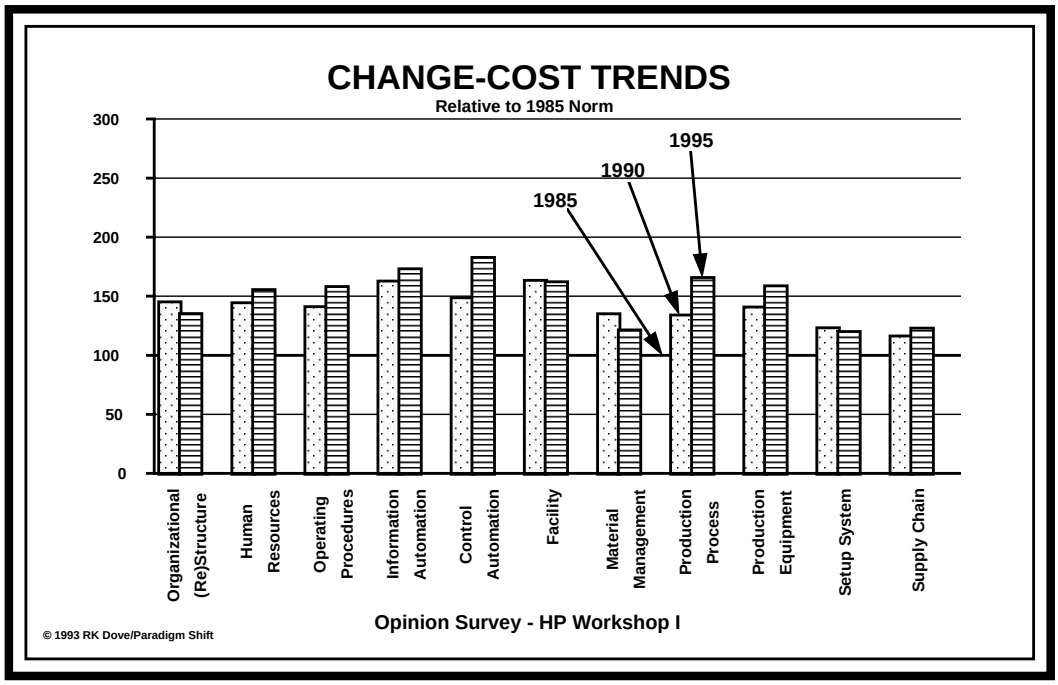
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Opinion Survey - HP Workshop I
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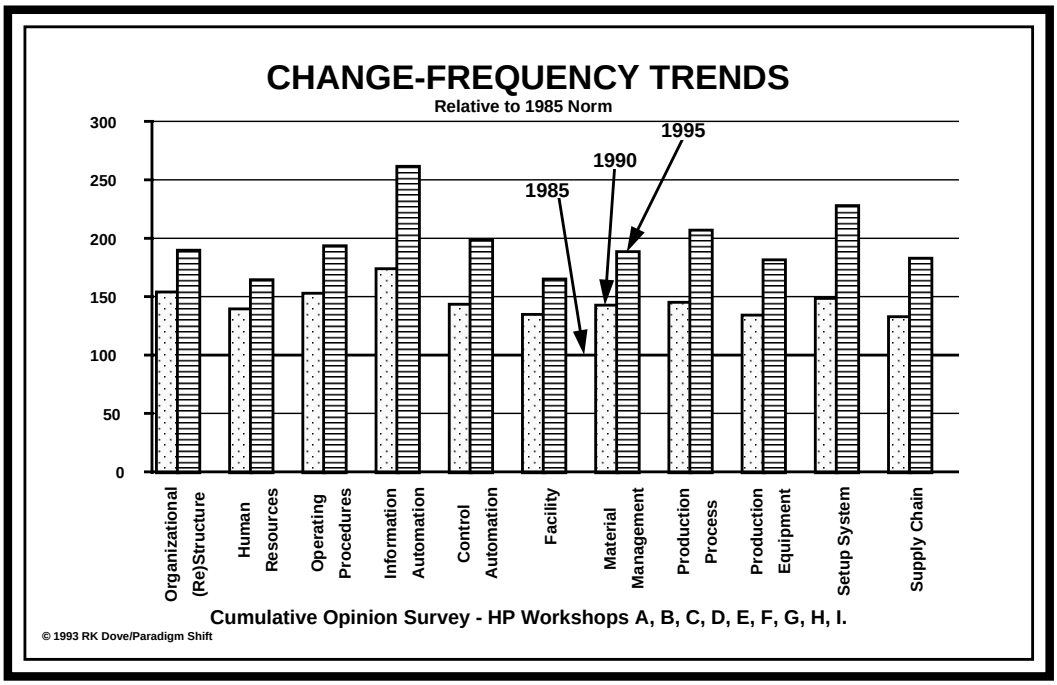
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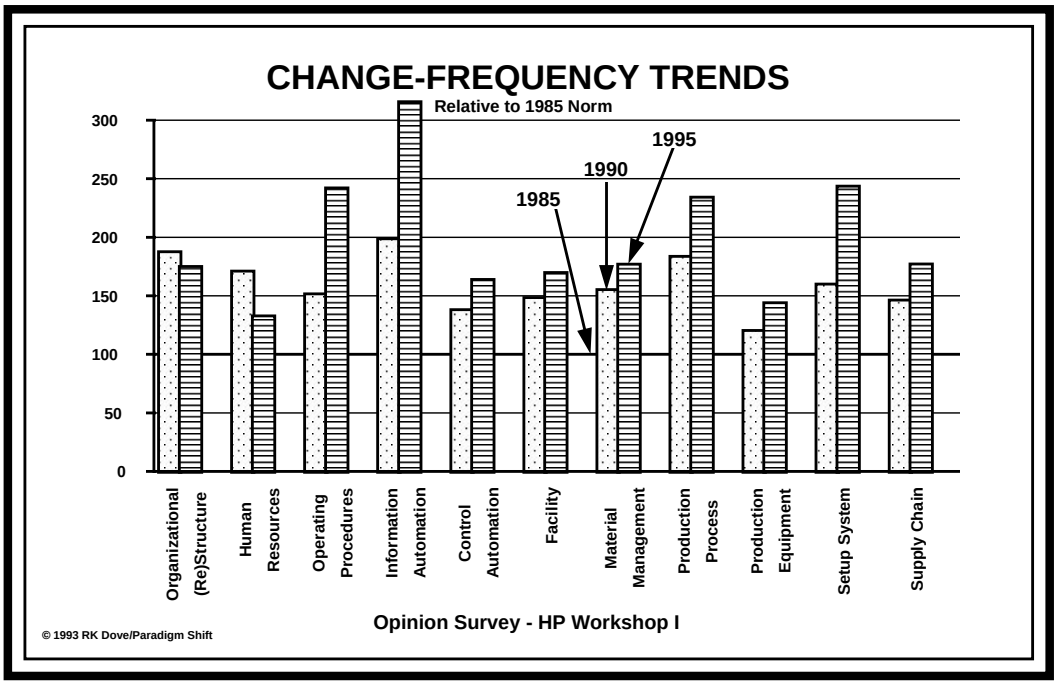
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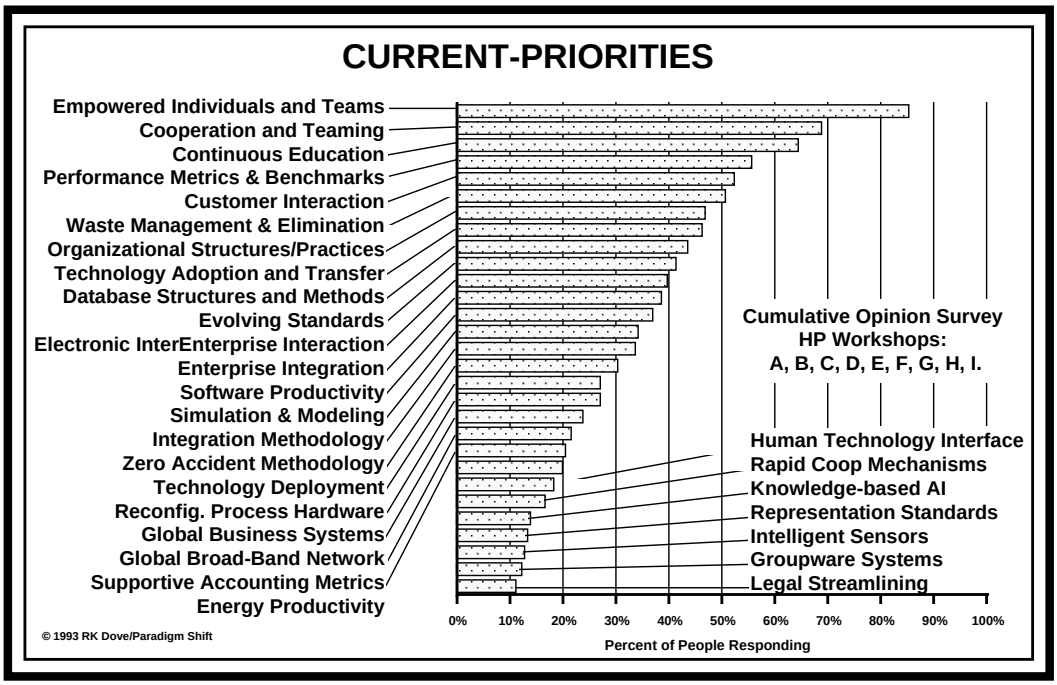
CURRENT-PRIORITIES
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Performance Metrics & Benchmarks
Customer Interaction
Waste Management & Elimination
Organizational Structures/Practices
Technology Adoption and Transfer
Database Structures and Methods
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Knowledge-based AI
Representation Standards
Intelligent Sensors
Groupware Systems
Legal Streamlining
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100%
Percent of People Responding
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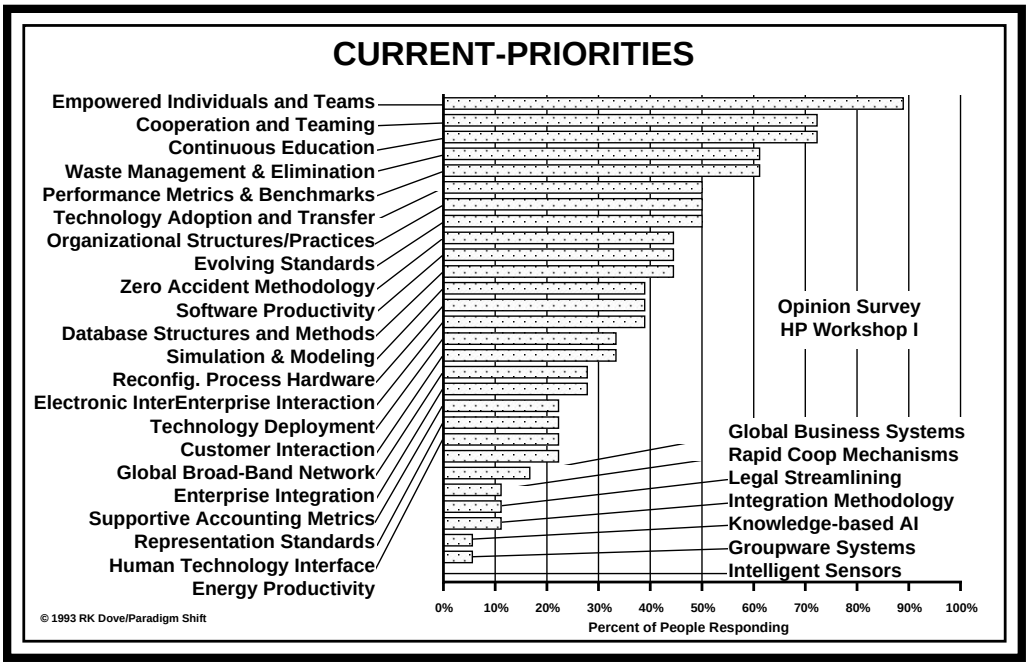
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