

Building a Science of Agile Enterprise

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The Agile manufacturing concept is gaining considerable interest, even though it is hidden in a mass of confusing explanations and interpretations.

Agile is a very seductive word. One that finds immediate and personal definition for almost everyone. It can capture cycle time reduction -- with everything faster. It can encompass mass customization -- with customer responsiveness. It can embrace virtual enterprise -- with streamlined supplier networks and joint ventures. It can echo reengineering -- with continual process transformation. It can demand a learning organization -- with systemic training and education. It can build on Lean production -- with high resource productivity.

Confusion is evidenced in many ways. Some people ask for the difference between Agile and Lean, Agile and TQM, Agile and Mass Customization. Others say that Agility is their next priority after completing their transformation to Lean production, or whatever else they are currently embarked upon.

It is time to crystallize the understanding of this very useful and important concept.

Agility was born in 1991 when an industry group observed that the increasing rate of change in the business environment was outpacing the adaptability of traditional manufacturing organizations. Dominant organizations were suddenly failing when continuously changing markets and customer interests found new sources of satisfaction.

Agility is the word that describes the missing characteristic in these organizations. They could not adapt at the same pace as their changing environment -- neither to counter a threat nor take advantage of a major opportunity.

This adaptability idea for organizations is not anything new, however. Organizations have always existed in a changing environment and have always had to adapt -- ever since the first humans banded together for purpose.

Organizational adaptability is a core viability requirement -- just like profitability. In order to continue as a viable entity an organization must meet two conditions for existence: it must satisfy some purpose (profitability) and it must continuously adapt as necessary to changing environmental conditions. When either of these conditions is not met the organization is threatened with extinction. In this sense an organization is just like an organism - both lead a transitory life in a hostile environment that requires the consumption of energy and constant vigilance.

In the life metaphor we talk about evolution and mutation as ways to accommodate a changing environment. We look for the mechanics of this characteristic in the genome of life. Equivalently in the organization we must look to see how

the organization is organized -- both statically and dynamically.

To mix metaphors, Agility is a plumbing issue first and foremost. Operating strategies like lean production, and transformation strategies like process reengineering are all facilitated by an underlying proficiency at change. If the organization is "proficient" at change it can and will adapt to take advantage of unpredictable opportunity as well as counter the unpredictable threat.

Being Agile means being proficient at change -- and allows an organization to do anything it wants to do whenever it wants to. Thus, an Agile organization can employ business process reengineering as a core competency when transformation is called for. It can hasten its conversion to Lean production while that is still useful. And importantly, it can continue to succeed when constant innovation becomes the dominate competitive strategy.

Trying to differentiate mass customization or Lean from Agile miscasts all as operating strategies. And asking for the differences between TQM and Agile misclasses both as transformation strategies.

Holding off Agile programs until a transformation to Lean production is completed incorrectly assumes that these are sequentially dependent concepts. Rather than close the barn door after the horse has left, a transformation to Lean production will happen faster and with less expense as the organization becomes more Agile.

Agility is a core fundamental requirement of all organizations. It was not interesting as a focused concept when environmental change was relatively slow and predictable. Now it gains considerable attention and a growing number of proponents.

Confusion in this early stage of understanding is introduced principally from two sources: indiscriminate use of the word to promote narrowly related technologies, and a seductive focus on the business strategic advantages and manifestations. The nature and reality of an Agile organization is determined by how it is organized -- it is a systems and structural issue.

Science is born from gathering data, analyzing for patterns, making hypothesis on principles, and iterating toward validation.

The accompanying overheads present the nature of structural Agility, and proposes a set of underlying principles based on "Best Agile Practice" reference base information being assembled at the Agility Forum.

BUILDING A SCIENCE OF AGILE ENTERPRISE

Defense Manufacturing Conference
Phoenix, Arizona, 28Nov-1Dec, 1994

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DRIVING FORCES

- Decreasing Innovation Cycle
- Increasing Globalism

Have Destabilized the Business Environment

Unpredictable
Uncontrollable
Unrelenting

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CORE REQUIREMENTS

Companies Have Always Had to Respond to a Changing Environment.

Like any Living Organism - Adapt or Die.

Adaptability, Like Profitability, Is a Core Survival Requirement.

Recently the Pace of Change has Outpaced our Organizational Adaptability.

So Now We Look for a Way to Alter the DNA of the Organism.

Agility is What We Call this New Degree of Adaptability

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WHAT KIND OF THING IS AGILE?

Is Agile a Business Strategy -- Like Customer Responsiveness?

Is Agile an Operating Paradigm -- Like Mass Manufacturing?

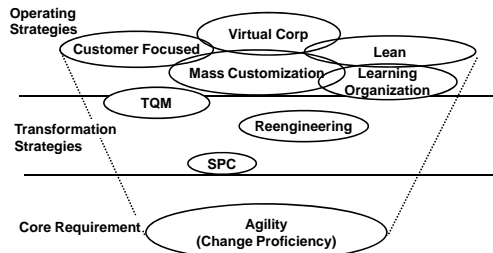
Is Agile a Core Competency -- Like Innovation?

Is Agile a Fundamental Requirement -- Like Profitability?

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SUCCESSFUL ENTERPRISE MUST BE PROFICIENT AT CHANGE



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THE AGILE ENTERPRISE

Possesses the Characteristic of Agility So That It Can

Do Anything It Wants To Do:

- Be More Customer Responsive?
- Be More Competitive?
- Maintain a Position of Leadership?
- Survive in a Changing Environment?
- Develop Core Competencies as Needed?
- Reengineer its Business Processes?
- Whatever!

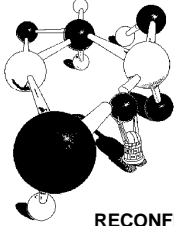
The Agile Characteristic is Enabling, It Is Not an End in Itself.

Agility Enables Next Generation Competitiveness.

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AGILITY DEFINED

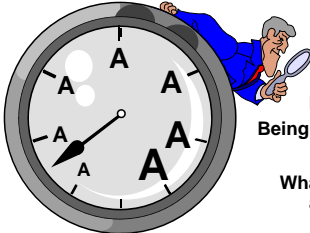


The Ability of an Organization
to Adapt Proficiently (Thrive)
in a
Continuously Changing, Unpredictable
Business Environment.

RECONFIGURABLE EVERYTHING

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BUILDING THE AGILE METER



If Being Agile is
Being Proficient at Change,
What Kinds of Change
are of Interest?

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AGILE MEANS PROFICIENCY IN 8 CHANGE DOMAINS

<u>Change Domains:</u>	<u>Modes:</u>
<input type="checkbox"/> Creation	Build New Capability.
<input type="checkbox"/> Capacity	Increase/Decrease Existing Capability.
<input type="checkbox"/> Capability	Add/Delete Unique Capability.
<input type="checkbox"/> Reconfiguration	Change Relationships Among Modules.
<input type="checkbox"/> Migration	Transformation of Basic Concepts.
<input type="checkbox"/> Performance	Real-Time Operating Surprise.
<input type="checkbox"/> Improvement	Continuous, Daily Incremental Upgrade.
<input type="checkbox"/> Recovery	Failure Corrections and Alternatives.

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PROFICIENCY?

If We Can Change Instantly,
are We Agile . . .

If It Costs \$1 Billion to Accomplish the Change?

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FOUR PROFICIENCY METRICS REFLECT TOTAL ABILITY TO RESPOND

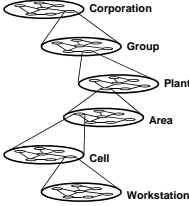
Analysis: General Purpose Electronic-Board Tester.

Cost (of Change)	Time (of Change)	Robustness (of Change)	Scope (of Change)
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.

(Scored on an arbitrary scale of 0.0 - 1.0)

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APPLYING CHANGE-PROFICIENCY METRICS At All Levels - In All Change Domains



- Cost of Change:**
 - Cost to "Market".
- Time to Change:**
 - Time to "Market".
- Robustness of Change:**
 - Running Quality Record.
 - Running Scrap/Repair Rate.
- Scope of Change:**
 - Predictability of Time & Cost.
 - Lost Opportunity Rate.
 - Market Innovation Rate.

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**NEW PRODUCTS TODAY:
Shorter Cycles -- Higher Frequency**

Means More Production Turmoil:
New Parts, New Process, New Skills, New Methods, New Training.

Which Means More:
Shakeout, Problems, Redesigns, Scrap, Overtime, and Slippage.

With Growing Bottom-Line Impact on:
Cost, Quality, and Time To Market.

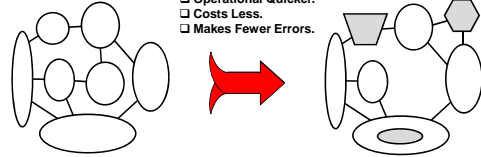
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**OBJECTIVE:
MORE NEW PRODUCT WITH LESS NEW PROCESS**

A New System Made Mainly From Proven Parts:

- Built Faster.
- Operational Quicker.
- Costs Less.
- Makes Fewer Errors.



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Strategy: Reusable, Reconfigurable, Scalable Systems

INTERVENTION

Business is an experimental science.
We learn what works by examining the survivors.

- We can wait a decade and study those that are left standing.
- Or we can examine the pieces that already exist, extract principles, and work on the missing parts.

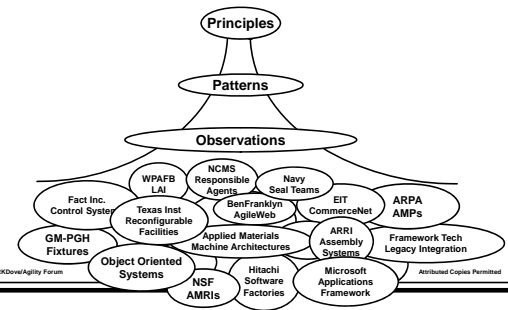
A choice between natural selection and genetic intervention.

Before we can manipulate the genome of business we must map it first.

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LOOKING FOR AGILE PRINCIPLES



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HYPOTHESIS: AGILE SYSTEM PRINCIPLES

Reusable

- Modular
- Plug Compatible
- Facilitated Reusability

Reconfigurable

- Non-Hierarchical
- Loose Relationships
- Distributed
- Self Organizing

Scalable

- Scalable Size & Structure
- Redundancy
- Extensible Framework

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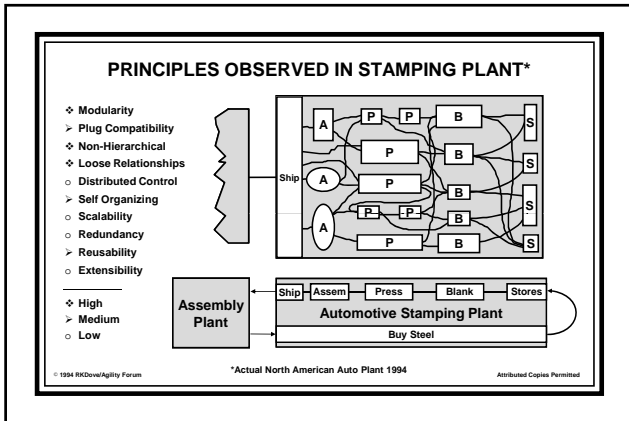
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AGILE SYSTEM PRINCIPLES

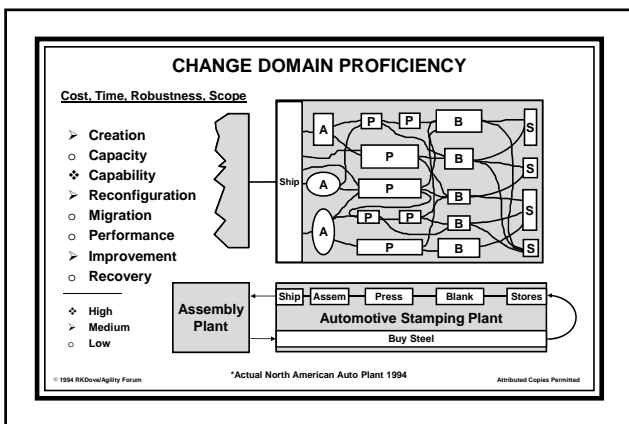
- Modular System
System composed of distinct separable units.
- Plug Compatible Unit Interfaces
Open system logical framework with standardized unit interactions.
- Non-Hierarchical Unit Communications
Non-hierarchical, direct negotiation, communication, and interaction among units at same level.
- Loose Relationships Among Units
Real-time, late-binding, reversible relationships.
- Distributed Control & Information
Unit self-scheduling and task planning with decisions made at point of knowledge, organization learning captured and retained locally but accessible globally.
- Self Organizing Unit Relationships
Dynamic scheduling, bidding, dynamic alliances and teaming, self adapting.
- Scalable Size & Structure
Unrestricted unit populations, and identical structural concepts across levels.
- Unit Redundancy
Duplicate unit types or capabilities to provide capacity fluctuation options and fault tolerance.
- Facilitated Unit Reusability
Standardized unit description templates and modification tools.
- Extensible Unit-Framework
Open system physical framework that accommodates any type of unit: legacy, common, or completely new.

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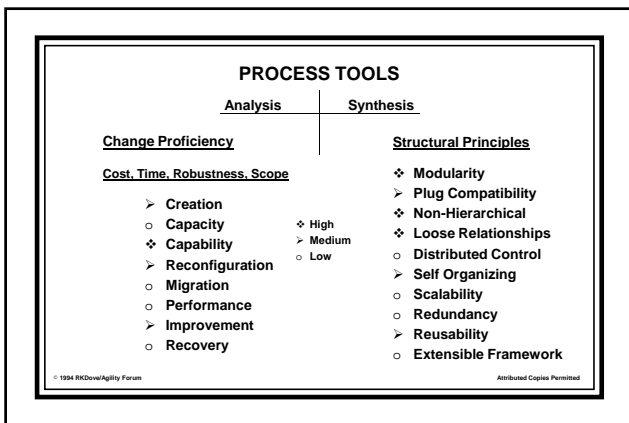


- ❖ High Agility
 - Medium Agility
 - Low Agility
 - ❖ Modularity - Individual machines are highly independent.
 - Plug Compatibility - No common standard interface for dies/machines/cells is present, yet most machines/cells can interact with people manually functioning as interaction agents.
 - ❖ Non-Hierarchical - Routing is freeform and unconstrained for the most part.
 - ❖ Loose Relationships - Routing is flexible in real time.
 - Distributed Control - Information is distributed but not readily accessible or accurate. Control is centralized to daily shop schedule meeting.
 - Self Organizing - Daily shop schedule meeting expedites problems and alternatives manually, but data is inaccurate and causes inefficient resource usage. WIP routing is unconstrained.
 - Scalability - Modularity not reflected in tooling and equipment construction, manual real-time re-scheduling causes thrashing at current sizing.
 - Redundancy - Poor machine utilization and poor surge capacity, even though there are multiple machines that a part could run on. Thus, we see physical redundancy that is not operationally available.
 - Reusability - Changeover times of dies not too bad, equipment is sometimes easy to reuse and sometimes difficult.
 - Extensible Framework - Systems and components have no definable standard nor mechanism for accommodating the influx of new technology.
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- ### KEY ISSUES AND GENERAL PROFICIENCY
- Creation
 - ❖ Start Up New Product Program (100+ Dies)
 - Create New Work Team
 - Gain Management/Labor Concurrence
 - Capacity
 - Short Run Service Parts
 - Downsizing
 - New Program Surge
 - Weld-Cell Bottlenecks
 - ❖ Capability
 - Absorb New Untrained People
 - Install New Presses and Assembly Equip
 - Lose Local Functions to Centralization
 - ❖ Die-Set Automation Assistance
 - Reconfiguration
 - Die Set
 - Press Relocation
 - Lean Transformation
 - Job Bumping

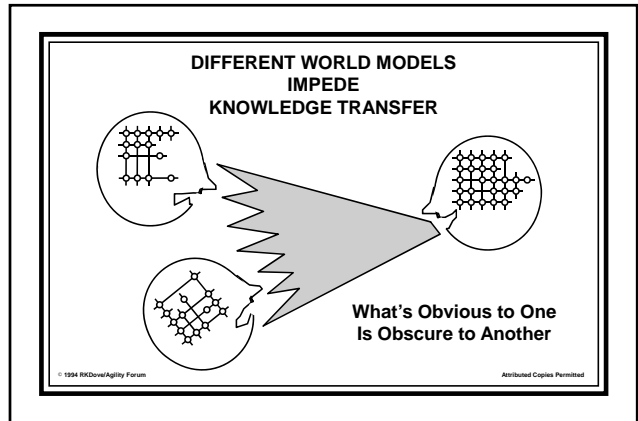
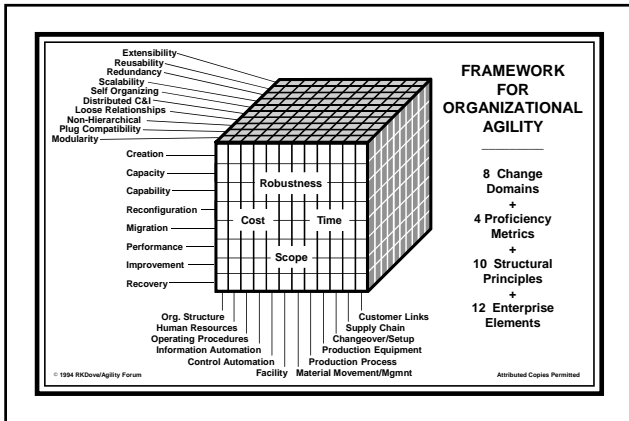
- Migration
 - To Work Teams
 - To Lean
 - To Common Plant Standards
 - To Centralized Support Functions
 - Performance
 - Daily Rescheduling
 - Tracking Product Status
 - Tracking Process Status
 - Bad Steel Stock
 - Improvement
 - ❖ Press/Blank Die-Set Time
 - Press Utilization
 - Overtime
 - Profit
 - Recovery
 - Die Engineering Change and Repair
 - Prices Fixed and Unrelated to Costs
 - Overtime to Avoid Late Delivery
 - Premium Freight to Avoid Late Delivery
- Proficiency: ❖ High ➢ Medium ○ Low
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RELATIONSHIPS: PRINCIPLES AND PROFICIENCY

	Modularity	Plug Compatibility	Non-Hierarchical	Loose Relationships	Distributed	Self Organizing	Scalable	Redundancy	Reusable	Extensibility
Creation	x	x	x	x	x	x	x	x	x	x
Capacity	x	x	x	x	x	x	x	x	x	x
Capability	x	x	x	x	x	x	x	x	x	x
Reconfiguration	x	x	x	x	x	x			x	
Migration	x	x	x	x	x	x	x		x	x
Performance	x	x	x	x	x	x		x	x	
Improvement	x	x	x	x	x	x	x	x	x	x
Recovery	x	x	x	x	x	x	x	x	x	x

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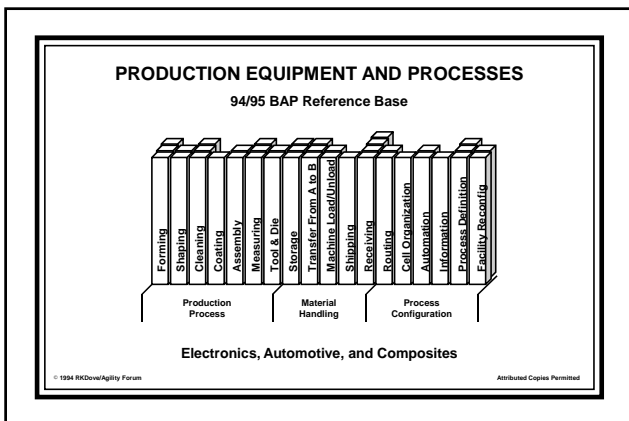
- ### FORUM BUILDING CASE REFERENCE BASE
- Agile Workforce
 - Agile Contracting
 - Agile Virtual Enterprise
 - Agile Production Systems
 - Agile Business Practices
 - Agile Information & Control Architecture
- ← This Discussion Will Focus On . . .
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BEST AGILE PRACTICE (BAP) REFERENCE BASE

BAP Means Proficiency in the 8 Change Domains

Category A	Category B	Category C	Category D	Category E	
					Creation
					Capacity
					Capability
					Reconfiguration
					Migration
					Performance
					Improvement
					Recovery

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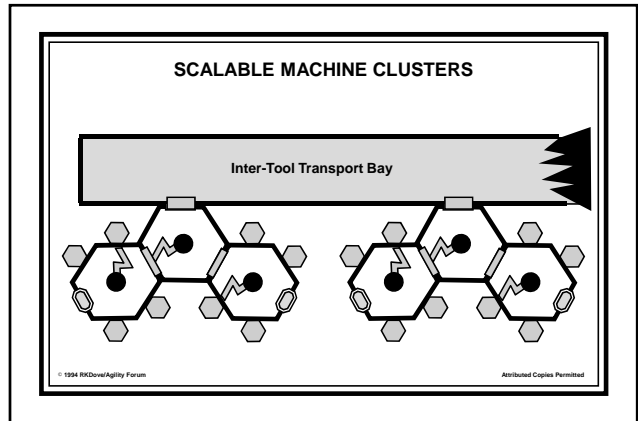
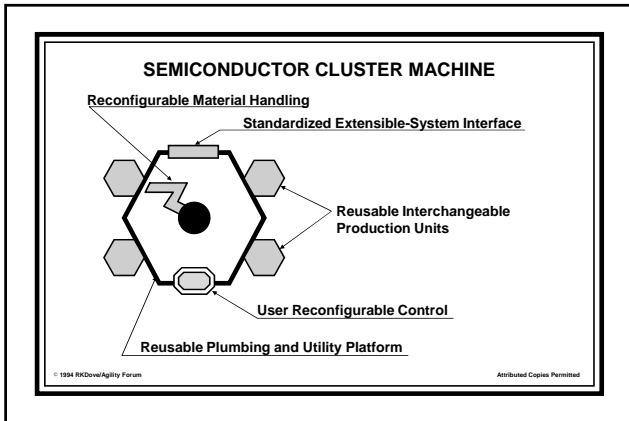


COMPARING APPROACHES

	BENEFIT	
Typical Approach	High Cost-to-Market	Agile Innovation
Use: Slow	Time-to-Market	Use: Fast
Acquire: Slow	Time-to-Market	Acquire: Fast
Use: Rework	Robustness	Use: Quality
Build: Scrap	Robustness	Build: First Time
Late	Scope	On Time
Catch-Up	Scope	Leadership
No-Bid	Scope	Can-Do

	FEATURES	
Not Reusable	Example	
Not Reconfigurable	Example	
Not Scalable	Example	

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CLUSTER-BASED WAFER PROCESSING

PRELIMINARY EXAMPLE

<p>Typical Approach</p> <p>Develop: \$High Upgrade: Slow Develop: No Upgrade: All Late Catch-Up No-Bid</p>	<p>BENEFIT</p> <p>Cost-to-Market \$Low Time-to-Market Develop: Fast Time-to-Market Upgrade: Fast Robustness Develop: New Advance Only Robustness Upgrade: Chambers On Time Scope Leadership Scope Can-Do</p>	<p>Applied Materials Inc</p>
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Monolithic Single-Process Machine

<p>FEATURES</p> <p>Not Reusable Not Reconfigurable Not Scalable</p>	<p>Base, Chambers Chambers Connected Machines</p>
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RECONFIGURABLE TEAMS

PRELIMINARY EXAMPLE

<p>High Perf Team</p> <p>4 Man-Months Use: 4 Months Build: 6 Months Use: 40% Rework Build: 30% Scrap 70% Predictable Low Innovation High Ops Lost</p>	<p>BENEFIT</p> <p>Cost-to-Market \$Low Time-to-Market Develop: 1/2 Day Time-to-Market Build: 6 Months Robustness Use: No Rework Robustness Build: 20% Scrap Scope 100% Predictable Scope High Innovation Scope Low Opportunities Lost</p>	<p>Navv Seal Team</p>
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FEATURES

OK Reusable	Excellent
Poor Reconfigurable	Excellent
OK Scalable	Excellent

(Sorry - No Seal Clip-Art)

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MODULAR CHECK FIXTURES

BEST AGILE PRACTICE

<p>Hard Fixtures</p> <p>\$70,000 Use: 4 Parts/Hr Build: 37 Weeks Use: 100% Accurate Build: 20% Rework 60% Predictable No Innovation High Ops Lost</p>	<p>GM Pqh Universal Holding Device</p> <p>\$3,000 Use: 40 Parts/Hr, 3.5 Min Set-Up Build: 1 Week Use: 100% R&R Accuracy Build: 1% Rework, Easy Mod 100% Predictable High Innovation Low Ops Lost</p>
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Massive Precision Machined Casting

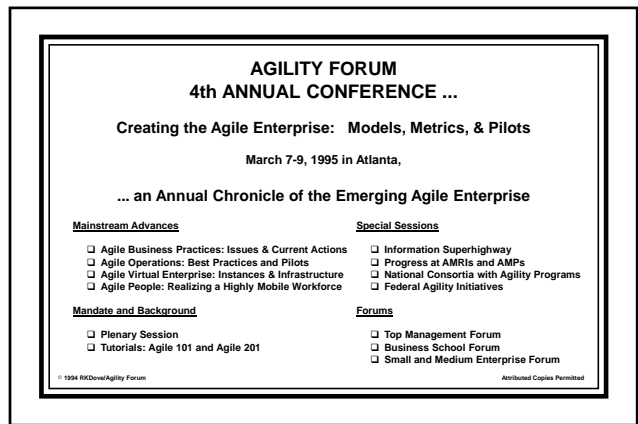
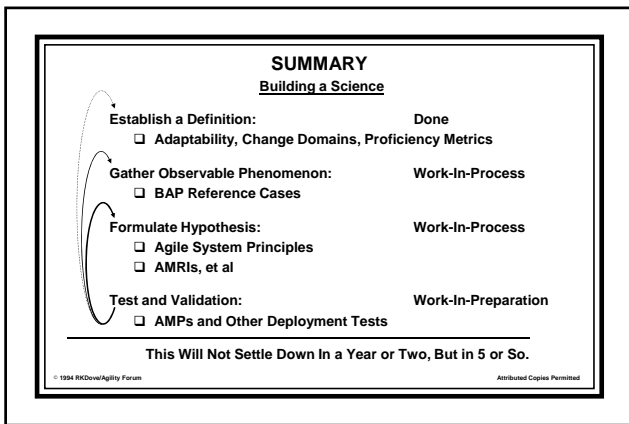
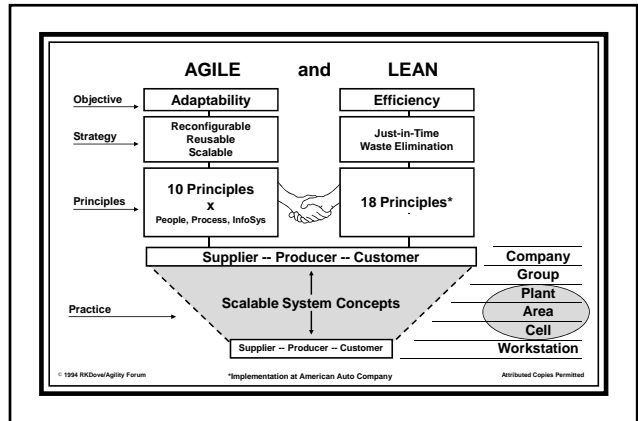
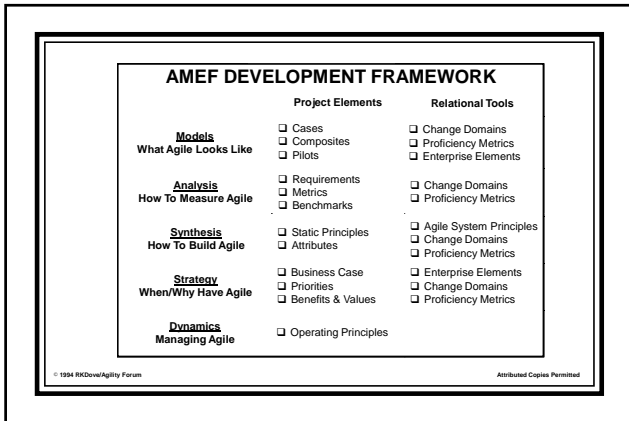
Common Base Matrix

FEATURES

No Reusable	Base, Retainers
No Reconfigurable	Retainers, Details
No Scalable	Details/Part, Parts/Base

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- ### NOTES: CHANGE PROFICIENCY SCOPE
- High Innovation (In) and Low Opportunities (Op) Lost
- Can ship "details" to another location by overnight delivery (Op).
 - Can have multiple fixtures cheaply and quickly (In, Op).
 - Can have duplicate fixtures at different locations (In, Op).
 - Fixture can be designed and built in as little as 16 hours if necessary (Op).
 - Can electronically transmit fixture details to duplicate remotely in 2 days (Op).
 - Temporary fixturing (In).
 - Set tooling (In).
 - Match checking (In).
 - Can be used for partial production checks (Op, In).
 - Fixture is portable and can go to production point (Op, In).
 - Fixture can cycle checks much faster so every 15th part could be verified (In).
- Stressed Plants Ideal Settings for Agile Developments**
Pittsburgh does small-run, high variety, spare body parts for GM. This development forced by space for storing 700 check fixtures, yet has universal applicability. Same can be said for their innovative solutions to universal shipping containers, universal door welding cell, and their shop-floor technician radio-network.



RICK DOVE

Rick is the Director of Strategic Analysis for the Agility Forum (previously known as the Agile Manufacturing Enterprise Forum); and chairs its Strategic Analysis Working Group and Agile Operations Focus Group. He is responsible for the Forum's development agenda and its industry focus group activities.

He co-chaired the original 21st Century Manufacturing Enterprise Strategy project at Lehigh University in 1991 - the industry led effort that started the Agility movement.

He has organized and chaired various consortia, commercial and DoD initiatives, and workshops in agile enterprise research, development, and technology transfer.

He has chaired NCMS's Technology Review Board and its Computer Integrated Operations Strategic Interest Group; and he has chaired ARPA's working group on Agile Production.

Most of his career has been entrepreneurial. He has raised venture funding, founded, and led companies in the systems integration, manufacturing software, computer manufacturing, office products, and food processing industries. Since 1985 he has focused on enterprise competitiveness issues.

He is also Chairman of Paradigm Shift International, Inc., a consultancy based in Oakland, California that specializes in competitiveness research, guidance, and deployment.

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