Knowledge Driven Product Development ™

AME Champions Meeting

June 2012

KNOWLEDGE/PD

Knowledge Driven Product Development ™

"Empower your employees with knowledge...

increase product development productivity

by a factor of four."

A Little About Me…

Working with Teledyne Technologies and other companies on KDPD transformations

KNOWLEDGE/PD LLC	2008
Retired	**2008**
President of Teledyne Benthos	2006
President & CEO Benthos, Inc.	2001
Retired	**2001**
President of Mannesmann VDO NA	1998
President of Philips Automotive	1995
SVP-GM Philips Television Business	1990
Philips Consumer Electronics Business	1975

MBA from Loyola University of Chicago

BSEE from the University of Illinois

Knowledge Driven Product Development ™

Root cause of product development problems

Origins of KDPD,

Empowering employees by learning to learn, and reusing knowledge

Knowledge Driven Product Development ™

Do you have any of these problems?

Missed schedules

Endless feature lists

Development cost overruns

Scope creep

Useless milestone meetings

Reinventing known knowledge

Resolving solved problems

Knowledge lost with attrition and retirements

Frustrated engineers

Poor quality at initial launch

Numerous late engineering changes

Manufacturing frustration

Poor customer acceptance

Wishful thinking though-out the process

Knowledge Driven Product Development

An opinion on the root cause
of today's
product development problems…

Typical Product Development Process

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Goal: *Define the Customer's Needs*	**Goal:** *Evaluate Alternatives, Select Best*	**Goal:** *Confirm Feasibility, Features & Functions*	**Goal:** *Verify Prototypes meet all functional specifications*	**Goal:** *Validate Pilot units meet Mfg. criteria for shipment*	**Goal:** *Ship to customers*
•Idea screening & Prioritizing • Create PRD for top 5 ideas • Voice of the Customer (VOC) checklist •PLT post - Idea Priority list & VOC checklist	•PLT & PDT ID Technical & Market challenges •Micro Innovation 3P workshop •Product and project definition (PLT & PDT) • Create FPS	•Create FRS •Prove technical & market feasibility •All functional groups develop plans	•Develop Bread Board Component Prototype • Build & Alpha Test Engineering Component prototypes •Review and release long lead documentation. •Continue Market feedback •Build & Beta Test Mfg. Prototypes	•Implement Beta test customer feedback. • Update and/or release all documentation • Build Mfg. pilot •Validate Mfg. processes, documentation, and pilot units	

Typical Product Development Process

So how well do they work?

Let's start with some simple PD metrics

From NCMS project - 1997

A Decade of Improvement Efforts

Continuous Improvement of Phase Gate Processes	Lean manufacturing tools applied to product development
more gates	VSM
more checklists	5S
more forms	3P

A Decade Later…

Incremental improvement

No real progress

2007 Assessment of 24 product development organizations

Phase Gate…Fundamental Deficiency

"Failure Assured"

Fuzzy Front-End
Land of Little Scrutiny

Start design early…
choose fast and be specific

Design Loopbacks

787

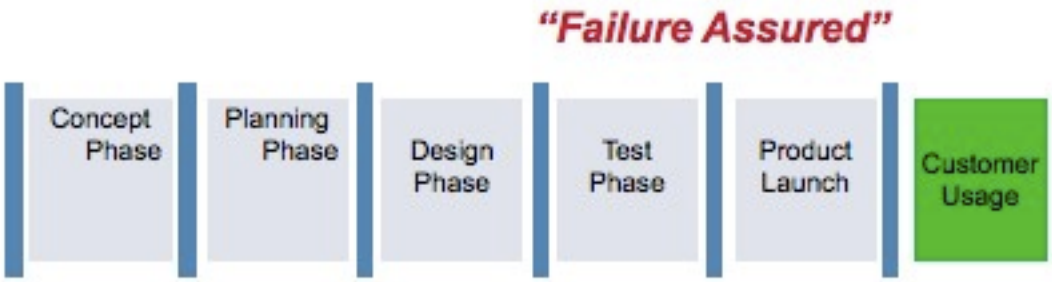
Concept Phase | Planning Phase | Design Phase | Test Phase | Product Launch | Customer Usage

You can't successfully value stream map…
a fatally flawed process

FEAR BASED DECISIONS
customer interests and technical feasible are unknown

Administrative approach
…are the CAD drawings complete?

Phase Gate…Fundamental Deficiency



The Origins of Knowledge Driven PD

Toyota is widely credited with KDPD leadership…

however…

Let's go back in time, over 100 years

Origins of KDPD

The Origins of Knowledge Driven PD

Imagine… ***The opportunity to develop a world changing product…***

Benefit to society...beyond imagination

Fame...Fortune

Immense personal satisfaction

The Origins of Knowledge Driven PD

But failure means…

Possible financial ruin
Injury or death to you or a family member
Many others have tried and
all have failed

How would you proceed?

Would you follow your phase gate development process?

The Origins of Knowledge Driven PD

Two Brothers…achieved one of mankind's oldest dreams…
manned, controlled, heavier-than-air powered flight

When:	1899-1903
Where:	Dayton, Ohio USA
Who:	Wilbur & Orville Wright
Education:	High school
Occupation:	Bicycle sales and repair

The Origins of Knowledge Driven PD

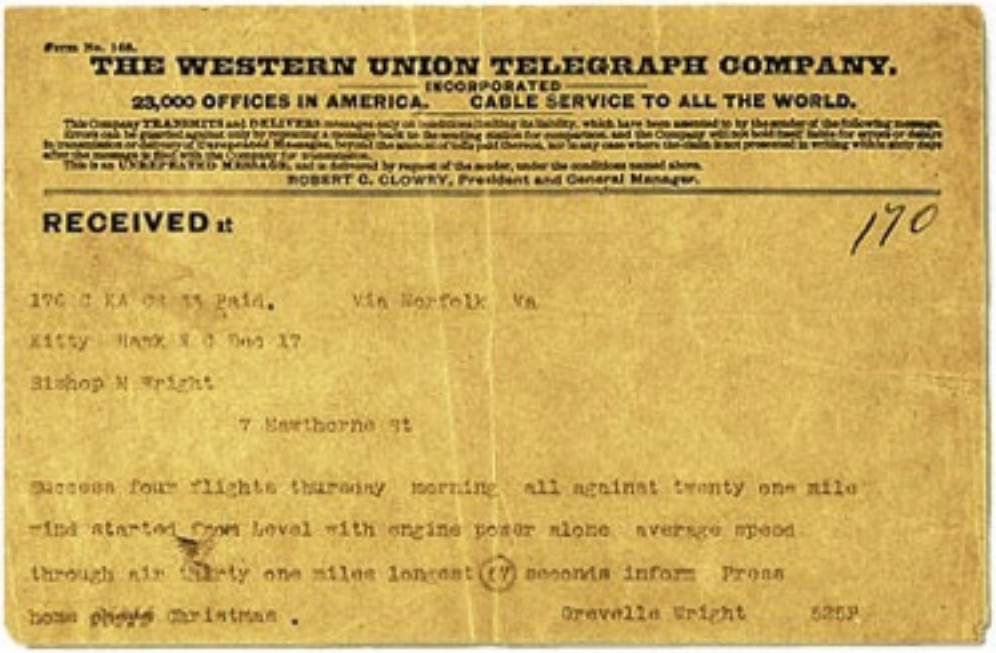
The Wright Brothers developed aerodynamic knowledge by

Testing before Design…

they did not want to die testing a poorly designed aircraft…

The Origins of Knowledge Driven PD

December 17, 1903



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INCORPORATED

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ROBERT C. CLOWRY, President and General Manager.

RECEIVED at 170

17C C KA CT 55 paid. Via Norfolk Va

Kitty Hawk N C Dec 17

Bishop M Wright

7 Hawthorne St

Success four flights thursday morning all against twenty one mile wind started from level with engine power alone average speed through air thirty one miles longest (57) seconds inform Press home people Christmas .

Orevelle Wright 525P

The Origins of Knowledge Driven PD

The Brothers determined that there were three knowledge gaps to close …
***Before**…designing their first airplane*

Control...Propulsion...Lift

Other investigators were spending 5000 hours designing and building their aircraft and about 5 seconds testing

The Origins of Knowledge Driven PD

Knowledge was captured in curves

The Origins of Knowledge Driven PD

Orville and I built a wind tunnel out of a wooden box...placed an aerodynamic measuring device ***made from an old hacksaw blade and bicycle-spoke wire...***

Results varied less than one-tenth of a degree. Over a two month period ***we tested more than two hundred models of wings...***results were hard to believe

From this knowledge, an reliable wing could be built...***it is doubtful if anyone would have ever developed a flyable wing without this knowledge***

Non-glamorous lab work is absolutely crucial to the success of a project.
...it would never have happened if we had not derived the correct aerodynamic data

"Isn't it astonishing that all these secrets have been preserved for so many years just so that we could discover them"

- Wilbur Wright 1939

The Origins of Knowledge Driven PD

The Wright Brothers
Closed knowledge gaps

***Lift**…wing design…wind tunnel testing*
***Propulsion**…propeller design…a rotating wing*
***Control system**…wing warping...weight shifting*

They sent a telegram home…

"Success Assured"

before their first flight on December 17, 1903

The Origins of Knowledge Driven PD

	Design & Test - ***Test & Design***
	Langley
Time Invested	**17 years**
Money Invested	**$70,000**
Approach	**Design** **Build** **Test** **Repeat**
Result	**Airplane never flew**

The Origins of Knowledge Driven PD

	Traditional	Toyota
Product Specifications	Specific as possible...early	Rough targets to start...details evolve
Design Decisions	Made as early as possible	Delayed as long as possible
Testing	Mostly after design, to fix	Mostly before design, to learn
Project management	Manage process compliance	Manage knowledge
Innovation Focus	New product concepts	Subsystem breakthroughs

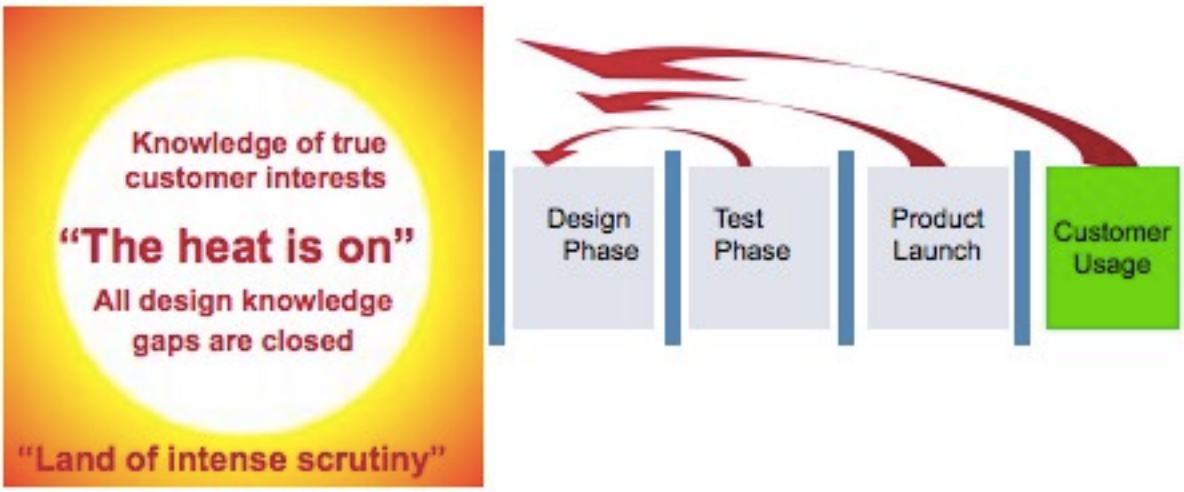
Design then Test

Test then Design

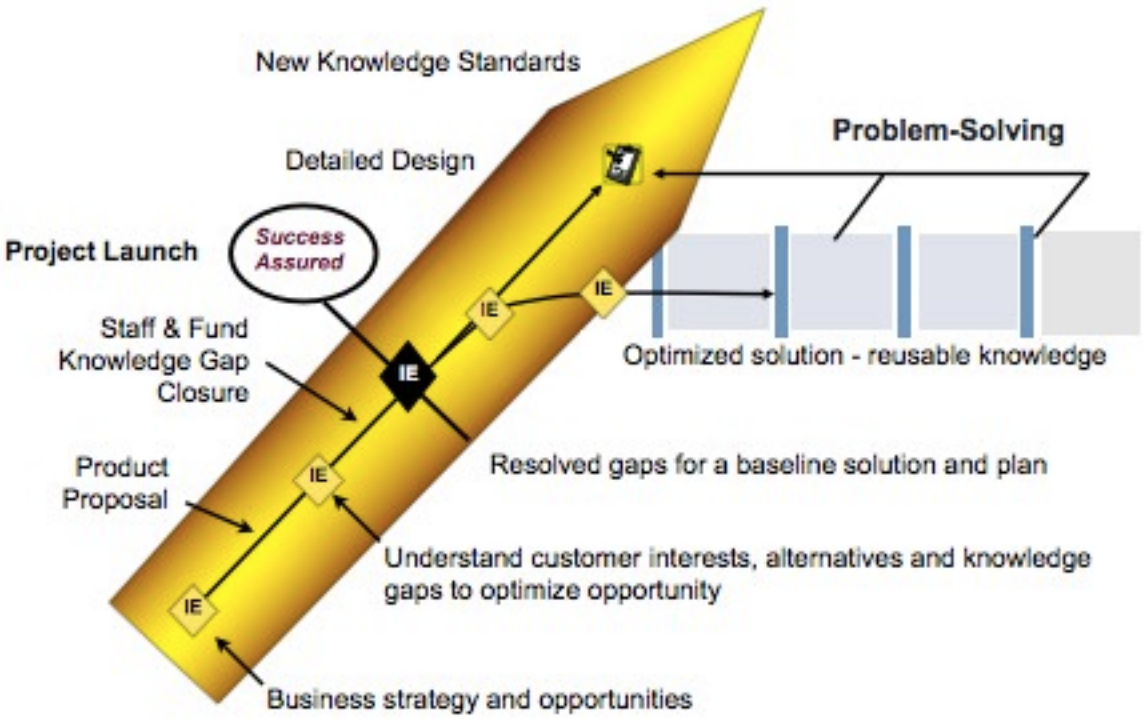
Results could be dramatically better

Phase Gate…Fundamental Deficiency

"Failure Assured"



Knowledge Driven Product Development



Knowledge Driven Product Development ™

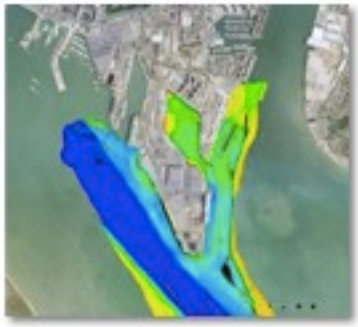
The Teledyne Benthos story

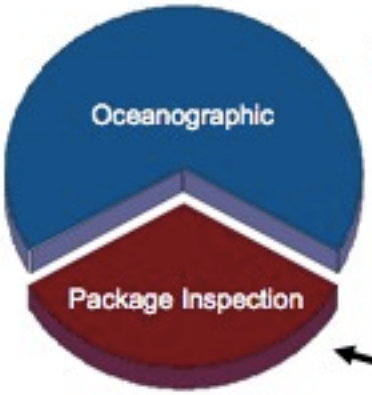
The Teledyne Benthos Experience

Side Scan Sonar & Bathymetry

Underwater Acoustics & Communications

Remotely Operated Vehicles





$50 million in sales

Leak Detection, Fill Height, Missing Caps

The Teledyne Benthos Experience

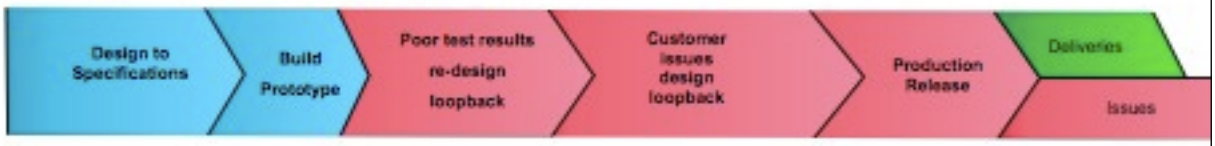
Phased Gate Product Development

Months

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Planned schedule **DESIGN & TEST**

Warning...Actual results may vary



FEAR BASED...SPECIFICATIONS AND DESIGN CHOICES

The Teledyne Benthos Experience

Lean factory initiatives had improved financials...

margins increased from 22% to 45% in a few years

New Goal…Grow Sales?

Deliver new products in one half of the time

Knowledge Driven Product Development

Benthos KDPD Training

Assessment of Progress
Assessment of Training, May
Coaching, February
Coaching, January

2007

Set Based Design, June
Knowledge Based Design, March
Knowledge Capture, November
Product Space Maps, October
Initial Class, August
Read Book, June

2006

2005

Phone Call...May 2005

Knowledge Driven Product Development

Knowledge of customer interests

Knowledge to design the product

"Before starting the design"

Knowledge Driven Product Development

Teledyne Benthos started building knowledge with…

Problem K-Briefs

They helped solve difficult problems,
freed up engineering resources
and began the creation of useful knowledge

All problem K-briefs were followed to closure

Problem Knowledge Briefs

Question?

How many of you have worked on problems
in your business…
that have never been fully resolved?

Problem Knowledge Briefs

Old Benthos Problem Resolution Form

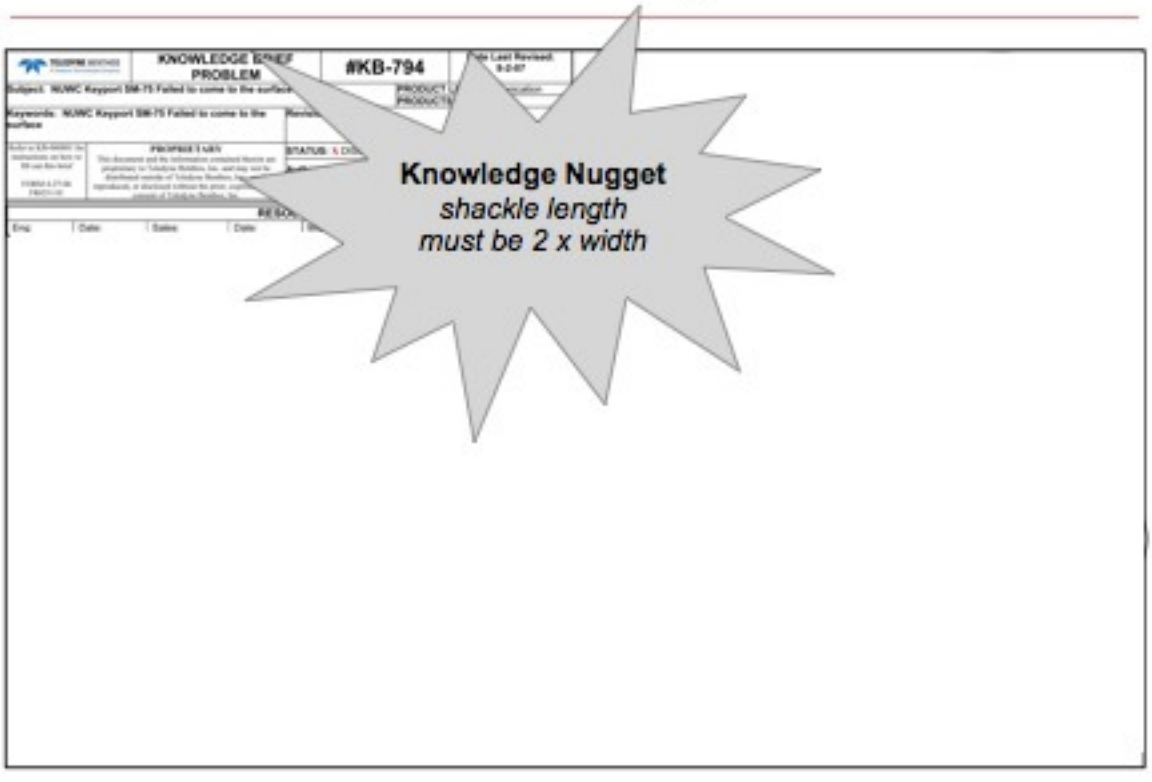
No virtual search ability available

No way to track progress on the problem presented

Static document: no evolution or change shown

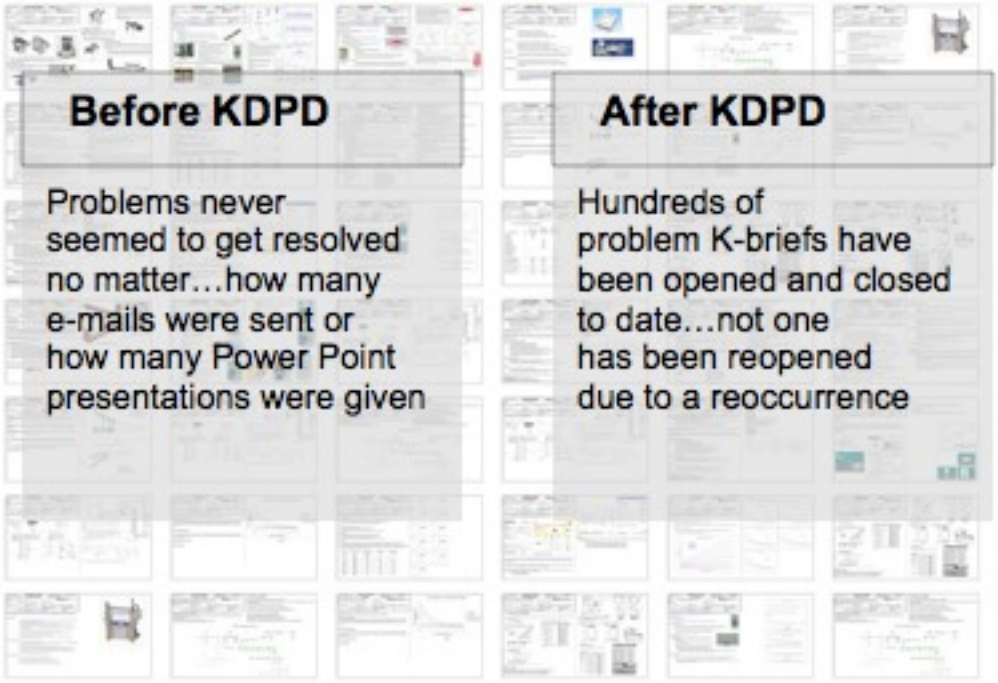
No images for further understanding

Problem Knowledge Briefs



Problem Knowledge Briefs

The Teledyne Benthos Experience



Problem Knowledge Briefs

Engage your employees...

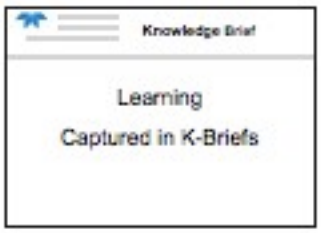
Become a learning organization with a dedication to mentoring and the LAMDA (Look-Ask-Model-Discuss- Act) process...

Your employees will gain a greater sense of significance, enthusiasm, persistence and pride in problem solving

Knowledge Driven Product Development

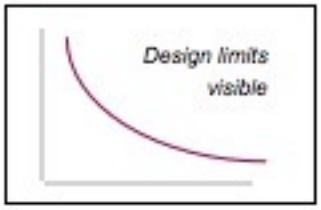
Tools of Knowledge Capture and Reuse

Learning Process



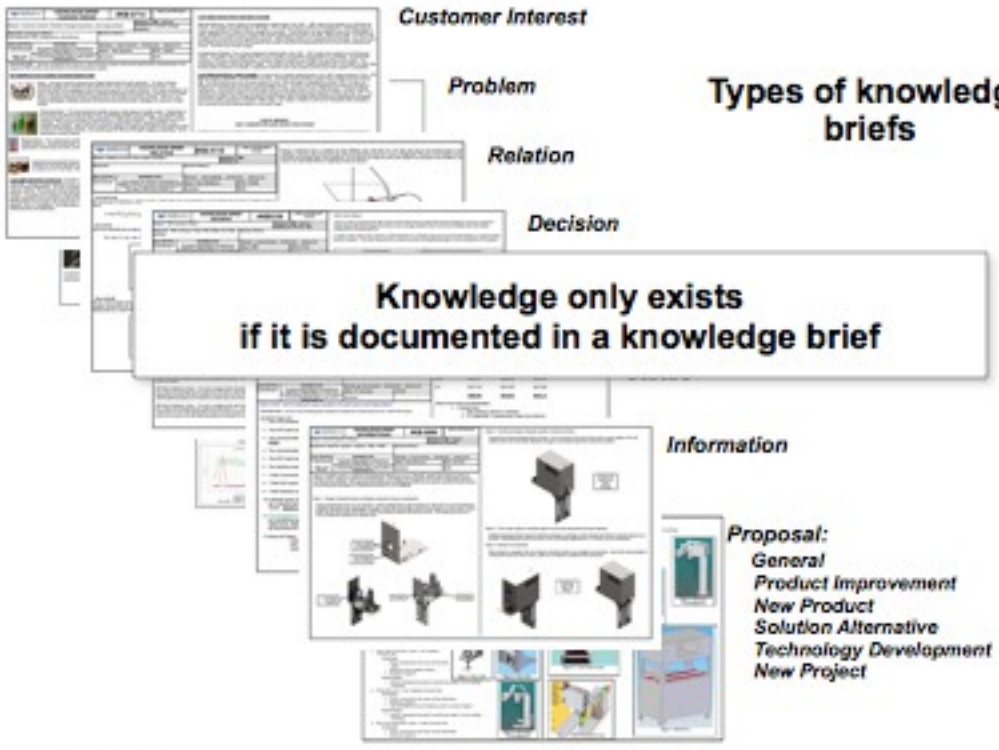
Concise Robust Knowledge

Knowledge Reuse



Knowledge Standards

Knowledge Driven Product Development



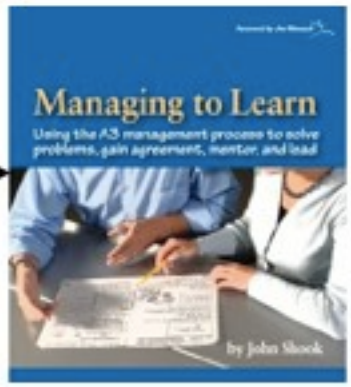
Types of knowledge briefs

Knowledge Driven Product Development

Problem knowledge briefs were the beginning

White board teachings…
All test results…
Proposals for product improvements…
Decisions for selecting design alternatives…
Relations (trade off curves)…
General information…

Customer Interests…



When existing knowledge is used and when new knowledge is created… capture in knowledge briefs

Knowledge Driven Product Development

Customer Interest Knowledge Briefs

Old

Detailed **Specifications*** given to Engineering from Sales

** FEAR based*

New

- Sales identifies key customer interests
- Engineering questions are answered
- Customer interests are quantified in engineering terms

Features, Features, and more Features…

* 2.5" 60% Serrated locking blade
* Nail file, nail cleaner
* Corkscrew
* Adjustable pliers with wire crimper and cutter
* Removable screwdriver bit adapter
* 2.5" Blade for Official World Scout Knife
* Spring-loaded, locking needle-nose pliers with wire cutter
* Removable screwdriver bit holder
* Phillips head screwdriver bit 0
* Phillips head screwdriver bit 1
* Phillips head screwdriver bit 2Flat head screwdriver bit 0.5mm x 3.5mm
* Flat head screwdriver bit 0.6mm x 4.0mm
* Flat head screwdriver bit 1.0mm x 6.5mm
* Magnetized recessed bit holder
* Double-cut wood saw with ruler (inch & cm)
* Bike chain rivet setter, removable 5mm allen wrench
* Removable tool for adjusting bike spokes, 10mm hex wrench
* Removable 4mm curved allen wrench with phillips head screwdriver
* Removable 10mm hexagonal key
* Patented locking philips head screwdriver Universal wrench
* 2.4" Spring less scissors with serrated, self-sharpening design
* 1.65" Clip point utility blade
* Philips head screwdriver
* 2.5" Clip point blade
* Golf club face cleaner
* 2.4" Round tip blade
* Patented locking screwdriver, cap lifter, can opener
* Golf shoe spike wrench
* Golf divot repair tool
* 4mm allen wrench2.5" blade
* Fine metal file with precision screwdriver
* Double-cut wood saw
* Cupped cigar cutter with double-honed edges
* 12/20-gauge choke tube tool

What is it?

Watch case back opening tool
* Snap shackle
* Mineral crystal magnifier with precision screwdriver
* Compass, straight edge, ruler (in./cm)
* Telescopic pointer Fish scaler, hook disgorger, line guide
* Shortix laboratory key
* Micro tool holder
* Micro tool adapter
* Micro scraper – straight
* Micro scraper – curved
* Laser pointer with 300 ft. range
* Metal saw, metal file
* Flashlight
* Micro tool holder Philips head screwdriver 1.5mm
* Screwdriver 1.2mm
* Screwdriver 8mm
* Fork for watch spring bars
* Reamer
* Pin punch 1.2mm
* Pin punch .8mm
* Round needle file
* Removable tool holder with expandable receptacle
* Removable tool holder
* Special self-centering screwdriver for gun sights
* Flat philips head screwdriver
* Chisel-point reamer Mineral crystal magnifier, fork
* Extension tool
* Spring-loaded, locking flat nose-nose pliers with wire cutter
* Removable screwdriver bit holder
* Phillips head screwdriver bit 0
* Phillips head screwdriver bit 1
* Phillips head screwdriver bit 2
* Flat head screwdriver bit 0.5mm x 3.5mm
* Flat head screwdriver bit 0.6mm x 4.0mm
* Flat head screwdriver bit 1.0mm x 6.5mm
* Magnetized recessed bit holder

Features, Features, and more Features…

The ultimate Swiss Army Knife

Fuzzy Front End
Superset of competitive features
High complexity products
Long development times
A vicious cycle…

Knowledge Driven PD
Products focused on
true customer interests
No loopbacks
A virtuous cycle…

Features versus Customer Interest

Features Missing from the Apple (first) iPad

are there reasons to consider waiting?…a look at what's missing

breaker for some.
ent - a deal breaker for a growing number of households
be able to plug in an external USB keyboard
ur pock
om the i
ou'll nee
eels like
t one m
Like, not
ions, fla
lly a sho

Conclusion - To be fair…there are positives... it's drop-dead gorgeous design aesthetic

Nevertheless, before you buy one...make sure you know it's limitations…let us know if we've missed any points here…

"…generated $9.5 billion in revenue in 2010"

Designing a New Driver?

Interchangeable heads and shafts
Forged carbon fibers
Full Length Hosel
Less face progression
Chemically Milled Hyperbolic Face Cup
Aerodynamic Body Design
Compression cured carbon fiber
Formed aluminum and cast steel
Sleeve weighing
Slightly open club-face alignment
Dual Crown technology
14 grams lighter
More aerodynamic head shape
9 grams of weight removed from the face
Red/Gold Shaft Fitting System
Lightest Driver on Tour: 25 grams lighter
Eight possible head positions
UST Wide Body Shaft Design
Polar Weighting
Cast titanium
Aerodynamic crown shape
Variable face thickness
Crown Plaque Alignment Aid
6-4 Titanium face

FAST TRACK technology
45 trajectory settings
Ti-9 face
Three face-angle settings (Open, Neutral and Closed)
Multi-Material Construction
Carbon fiber crown and sole
Swing weight screw
9 Point Face Technology
Offset Driver
Technologically advanced head
Dual-angle hosel
Loft adjustments
Lie adjustments
Sloped, ultra-thin crown
On-axis rear weight screw
Interchangeable shaft connection
Rear weight screw
Large symmetric profile head
Micro Welding
Frequency tuned sound
Neutral, low COG
Ultra thin crown technology
External sole weight pad

Shaft Adapter-Hosel System
Eight possible head positions
AXIV Core material in tip section
Increase shaft's "hoop" strength
Square Stability technology
Eight face angle options
Dual Point Technology
Center of gravity aligned
Optimal Face flex point
Three level face technology
Enhanced trampoline effect
Additional weight low and deep in the club-head
Ultra-durable construction
Pear shaped head
Slightly open face
Fast face insert
Folded round geometry
Larger overall body diameter
Titanium body and face
High performance weighting
Dynamic Moment of Inertia
Counter-balance effect
Maximum trampoline effect

Designing a New Driver?

Replace with - Key Customer Interests

Longer drives

Straighter drives

Designing a New Driver?

Key Customer Interests

Longer drives

Straighter drives

Properly fitted

Polar Weighting
Cast titanium
Aerodynamic crown shape
Variable face thickness
Crown Plaque Alignment Aid
6-4 Titanium face

Large symmetric profile head
Micro Welding
Frequency tuned sound
Neutral, low COG
Ultra thin crown technology
External sole weight pad

Larger overall body diameter
Titanium body and face
High performance weighting
Dynamic Moment of Inertia
Counter-balance effect
Maximum trampoline effect

Knowledge Driven Product Development

"It's not the customers job to figure out what they need"

Knowledge Driven Product Development

Engage your product development employees...

intellectually, emotionally and with a heightened level of ownership
for the success their new products
by connecting them to true customer interests

Knowledge Driven Product Development

Engage your engineers

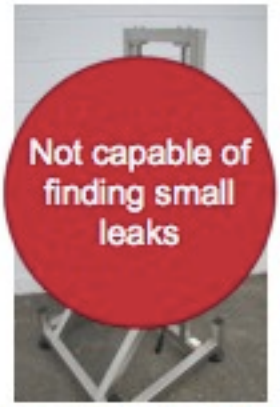
A co-equal role
with sales and marketing to determine
and meet customer interests

True customer interest **LAMDA** Defined as a design decision

Defining Customer Interest – Case Study

Customer interest was researched by design engineers

Defining Customer Interest – Case Study



Single Sensor Leak Detection

Size:	61" H x 32" D x 32" W
Weight:	200 lbs
Line Speed:	300' per minute
Leak Size:	.030"
Price:	$40,000

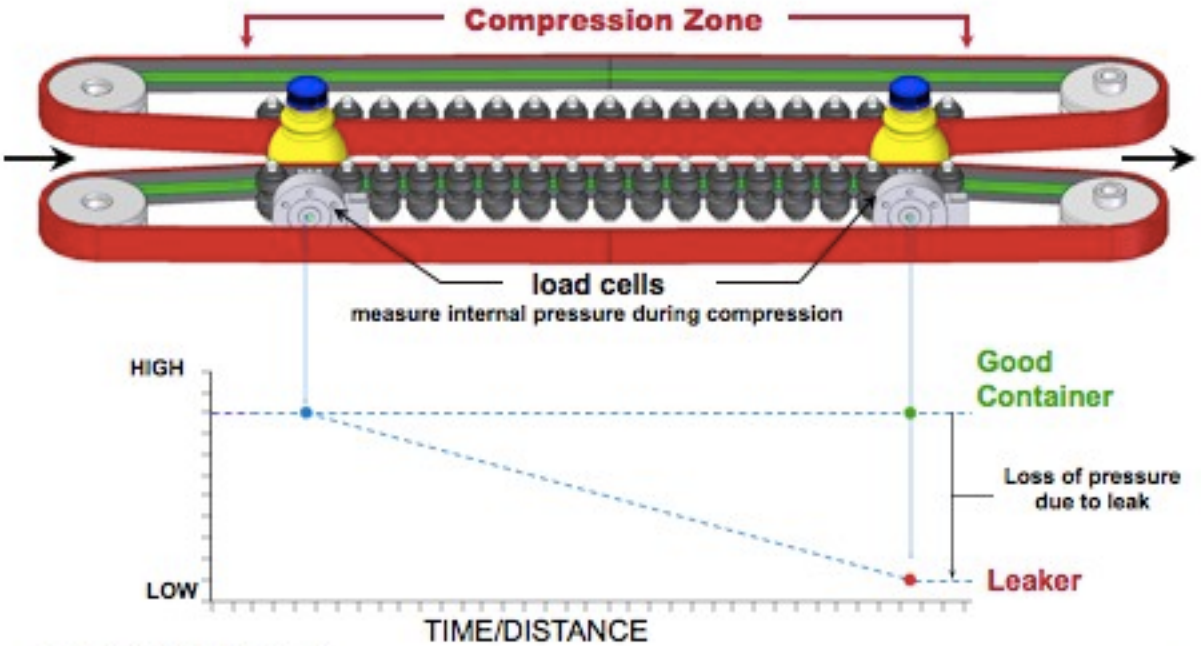
Dual Sensor Leak Detection

Size:	100" H x 53" D x 100" W
Weight:	2,000 lbs
Line Speed:	200' per minute
Leak Size:	.006"
Price	$90,000

No existing product could meet new customer interests

Knowledge Driven Design – Case Study

Using Load Sensors to Detect Leaks (patented)



Knowledge Driven Design – Case Study

Goals for New Leak Detection System

	Current System	New Customer Interest
Leak Size:	.006	Same
Maximum Speed:	200 ft/min	25% increase
Width:	100"	50% reduction
Price:	$90,000	33% reduction
Cost:		**50% reduction**

?

**The engineers did not know how to design the new system…
so knowledge gaps needed to be closed**

Knowledge Driven Design – Case Study

Closing known design knowledge gaps

Which form of **conveyance** was best for the application?

How **rigid** did the machine really need to be?

Load **cell spacing** needed to be decided?

**Start the design ASAP or…
test before design**

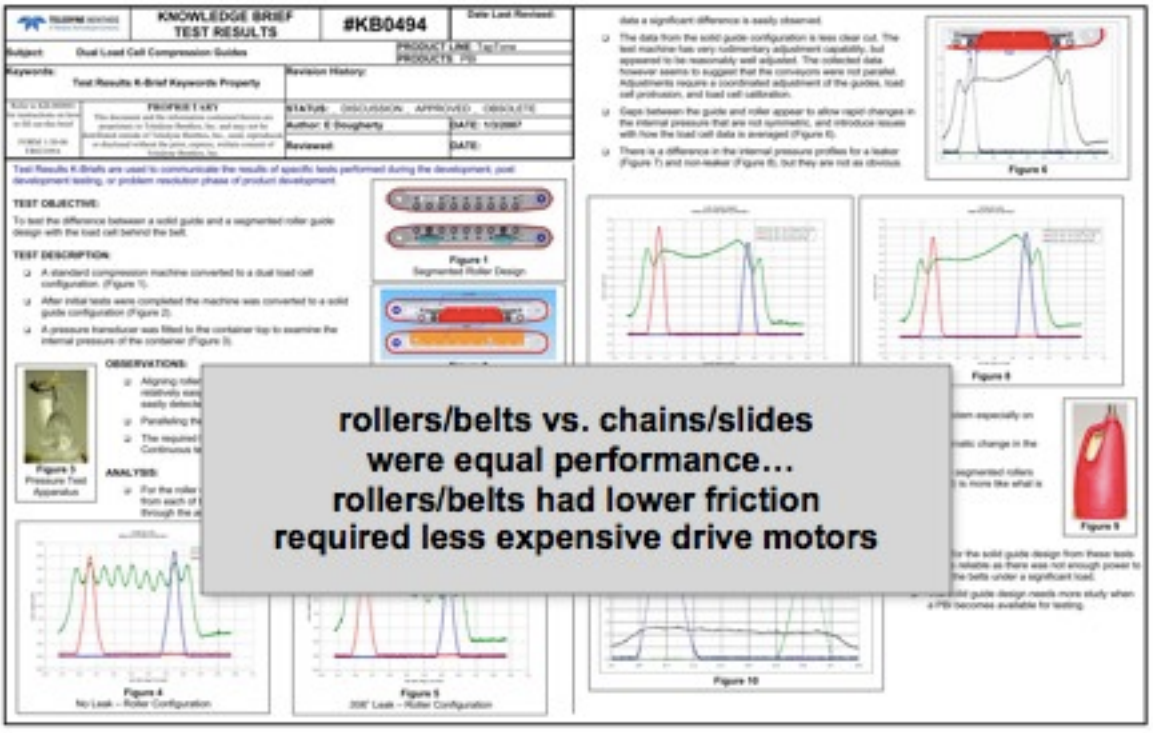
Knowledge Driven Design – Case Study

Question #1…Rollers & Belts vs. Chains & Slides

Rollers & belts

Steel backed chains & flights

Knowledge Driven Design – Case Study



KNOWLEDGE BRIEF TEST RESULTS #KB0494

Subject: Dual Load Cell Compression Guides

Keywords: Test Results K-Brief Keywords Property

Author: E Dougherty

Reviewed:

TEST OBJECTIVE:

To test the difference between a solid guide and a segmented roller guide design with the load cell behind the belt.

TEST DESCRIPTION:

- A standard compression machine converted to a dual load cell configuration. (Figure 1).
- After initial tests were completed the machine was converted to a solid guide configuration (Figure 2).
- A pressure transducer was fitted to the container top to examine the internal pressure of the container (Figure 3).

OBSERVATIONS:

ANALYSIS:

Figure 1 Segmented Roller Design

Figure 3 Pressure Test Apparatus

Figure 4 No Leak – Roller Configuration

Figure 5 .008" Leak – Roller Configuration

Figure 6

Figure 8

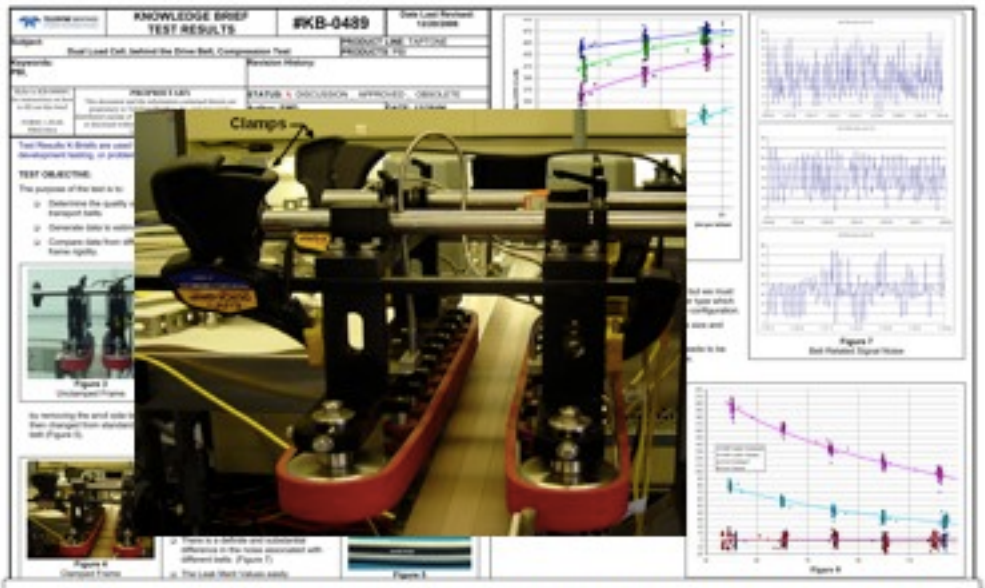
Figure 9

Figure 10

rollers/belts vs. chains/slides
were equal performance…
rollers/belts had lower friction
required less expensive drive motors

Knowledge Driven Design – Case Study

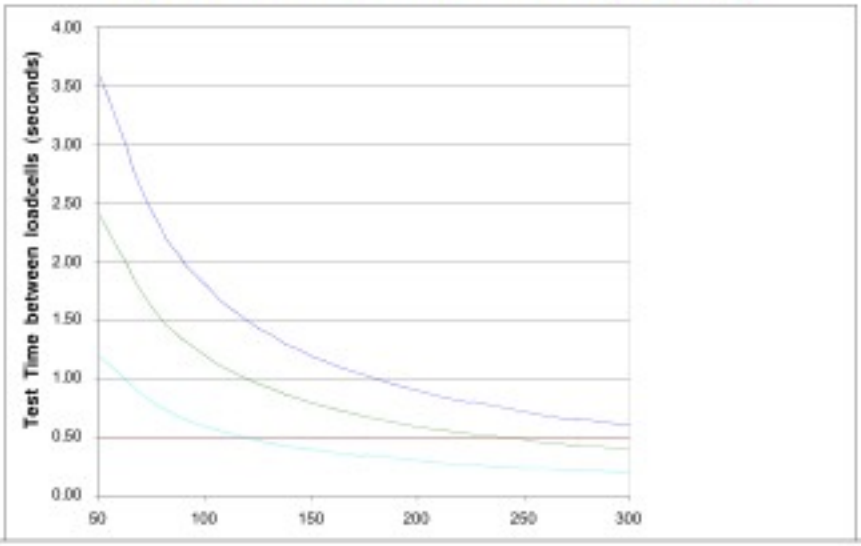
Question #2…How rigid did the machine need to be?



Inexpensive clamps increased performance threefold

Knowledge Driven Design – Case Study

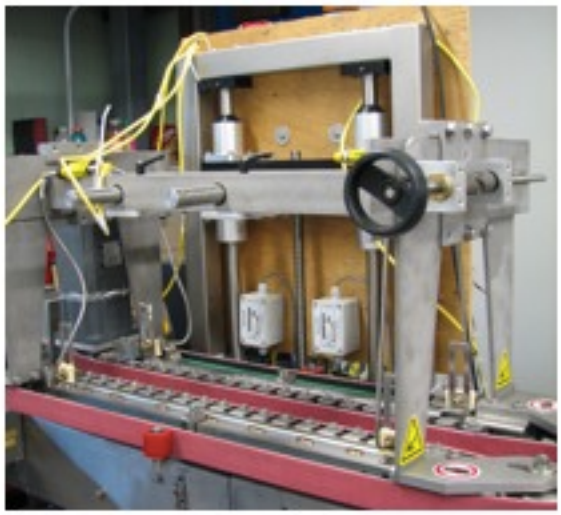
Question # 3…Load cell spacing



Tradeoff curves were generated to determine load cell spacing

Knowledge Driven Design – Case Study

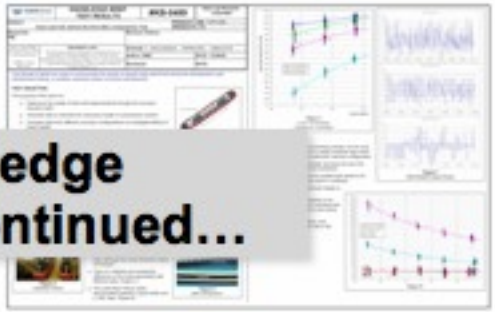
Test First, Then Design



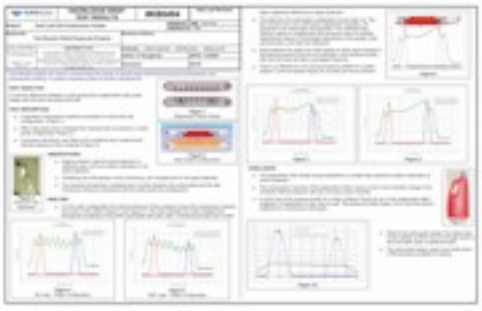
A test bed was designed and built in 4 weeks…

to generate additional knowledge

Knowledge Driven Design – Case Study



Knowledge creation continued…



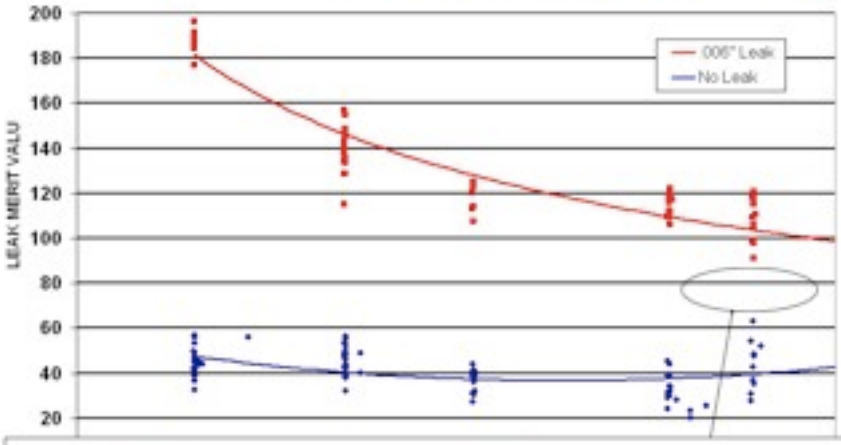
Knowledge Driven Design – Case Study

…until proof of concept was achieved

"Success Assured"

Knowledge Driven Design – Case Study

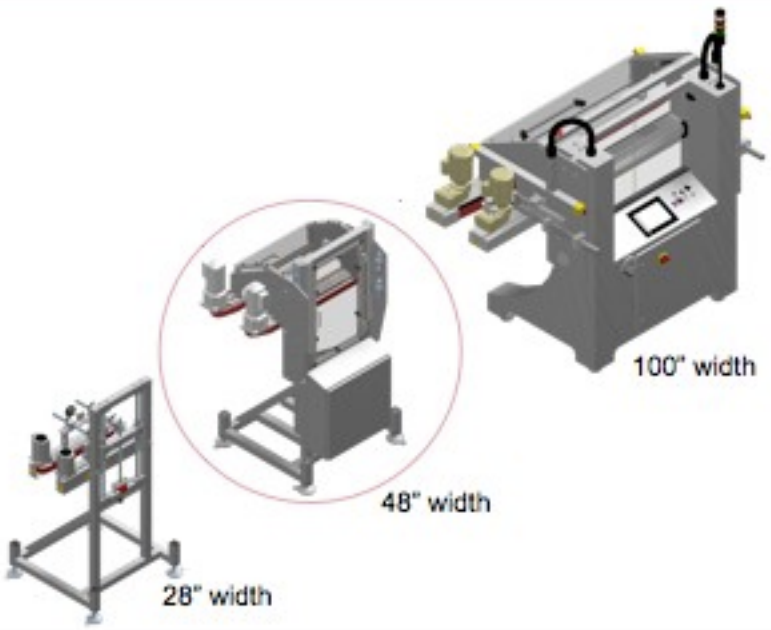
Results of Prototype Testing



With ***"Success assured"***…product design could now begin

Merit value separation between good/ bad containers at 220 ft/sec

Knowledge Driven Design – Case Study

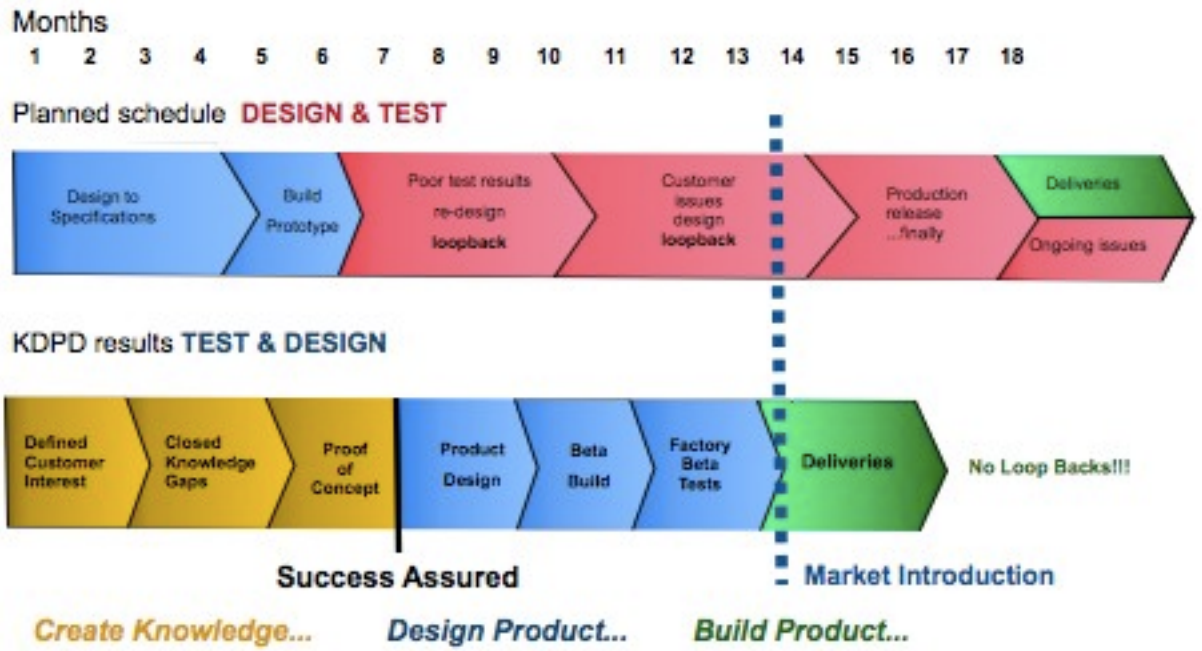


A design concept was chosen and a final LAMDA cycle occurred …to further refine customer interest

Knowledge Driven Design – Case Study

Concept drawings were reviewed with key customers before starting final machine design

The Teledyne Benthos Experience



Knowledge Driven Product Development

Engage your product development employees...

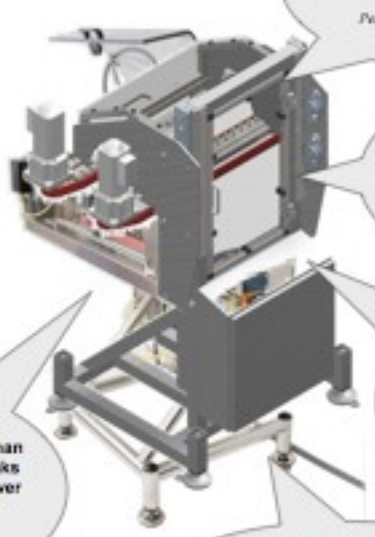
even in the face of difficult design knowledge gaps...
follow the principle of testing, to develop required knowledge,
before starting product design

Case Study… The Morning After

All key *customer interests* were met with the new design

Hole size:	.006"	✓
Max. line speed:	250'	✓
Machine width:	48"	✓
Pricing	-33%	✓
Cost	-50%	✓

Machine weight reduced by 80%



Taking the time up front to plan... resulted in a pilot build that was very close to production quality

Peter Novacon, Mechanical Engineer

The smoothest product released to manufacturing ever...the easiest first build

Trevor Best, Manufacturing

Early involvement of engineers collecting customer interests created a product our customers wanted

Rick Reardon, Sales Manager

Design works even better than expected...we're finding leaks we suspected but could never verify

Engineering Manager, Customer

The first flawless product launch... ever

Jim Kearbey, Vice President of Sales

Knowledge Driven Product Development

Future Designs Based on Knowledge

Define Customer Interest → Create Knowledge

Knowledge Base

High pressure aerosol can leak detection

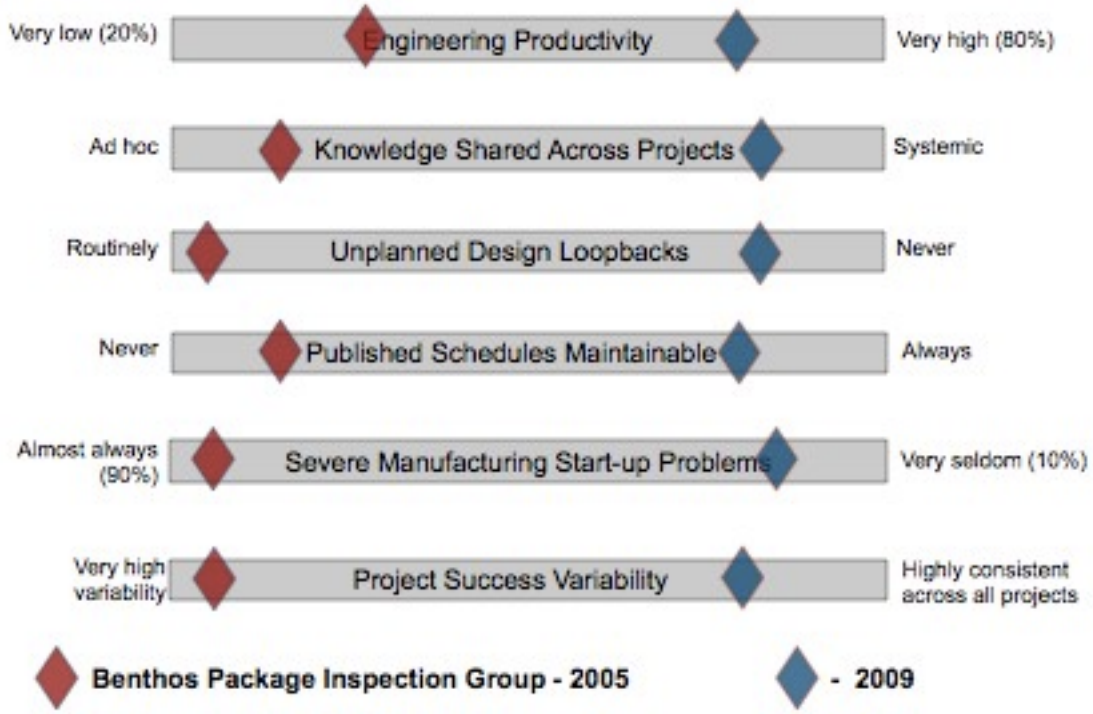
Next design

Define Customer Interest → Machine Design → Beta Build / Factory Test → Production Release

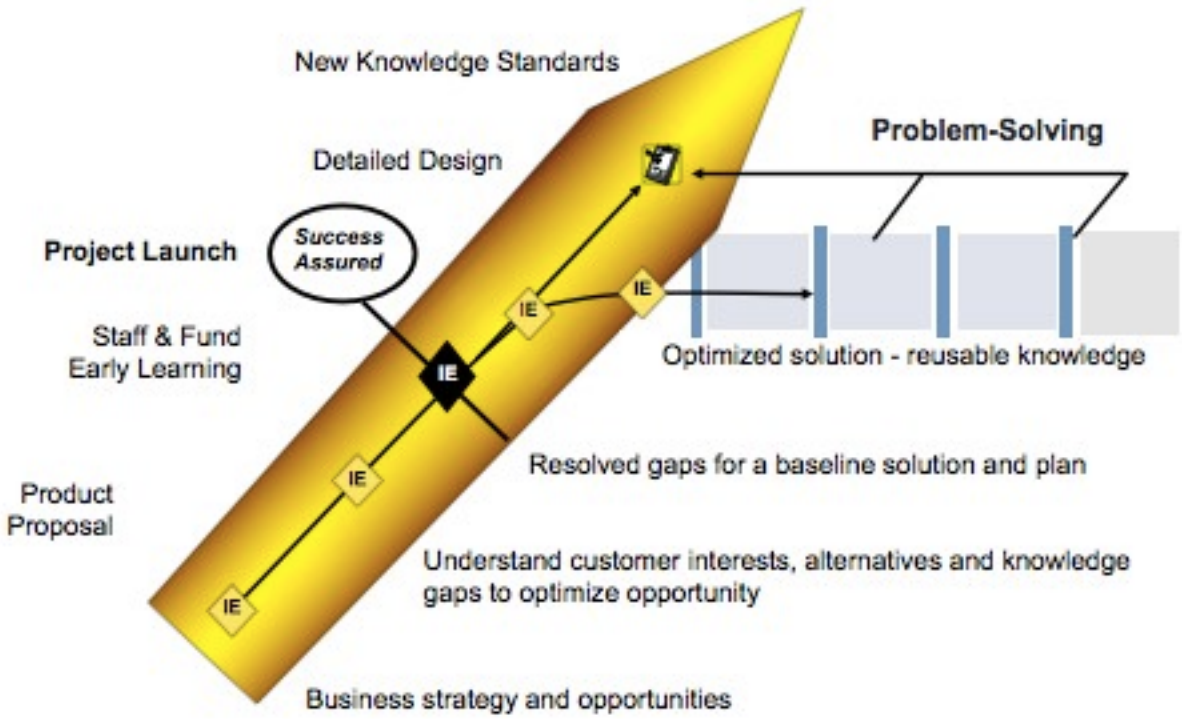
6 months - actual time

Reduce development cycle from 18 months to 9 months

Knowledge Driven Product Development



Knowledge Driven Product Development



What needs to change?

To achieve better PD results, leadership must follow KDPD principles with "Constancy of Purpose"

Decide on new behavior

Consistently exhibit behavior

"Management Behavior is Company Culture"

Warning: This change is hard!

A quote from Dr. Deming

"It is not necessary to change…

survival is not mandatory"

Success Assured

Knowledge of true customer interests

Knowledge to design the product

Failure Assured

"Empower your employees with knowledge...

increase product development productivity

by a factor of four"

Thank You, Ron Marsiglio

ron@knowledgepd.com