Knowledge Flow in Product Development

Charlie Baker

Lean Powered Innovation

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Charlie Baker Bio

- GM Executive Director and Global Functional Leader for Interiors Engineering – 2011 -2016
- Johnson Controls Group Vice President for Automotive Experience – 2005 – 2009
- Honda R&D North America – Vice President, Chief Engineer of Acura CL, Acura MDX, Honda Pilot, Honda Accord – 1990 – 2005
- GM Saturn and Pontiac Motor Division – Engine design and test engineer – 1982 - 1990

Key message points

- Knowledge flow in Product Development is the equivalent of product flow in manufacturing.
- PDCA is the foundation of knowledge flow and needs to be universally applied.
- Knowledge flow consists of creation, collection, curation and application.
- The "who" of knowledge management (SMTEs) is as important as the "how".
- Diagnose the knowledge flow opportunities to prioritize efforts relevant to the business. $ based metrics are particularly useful.

The challenge of JCI Product Development

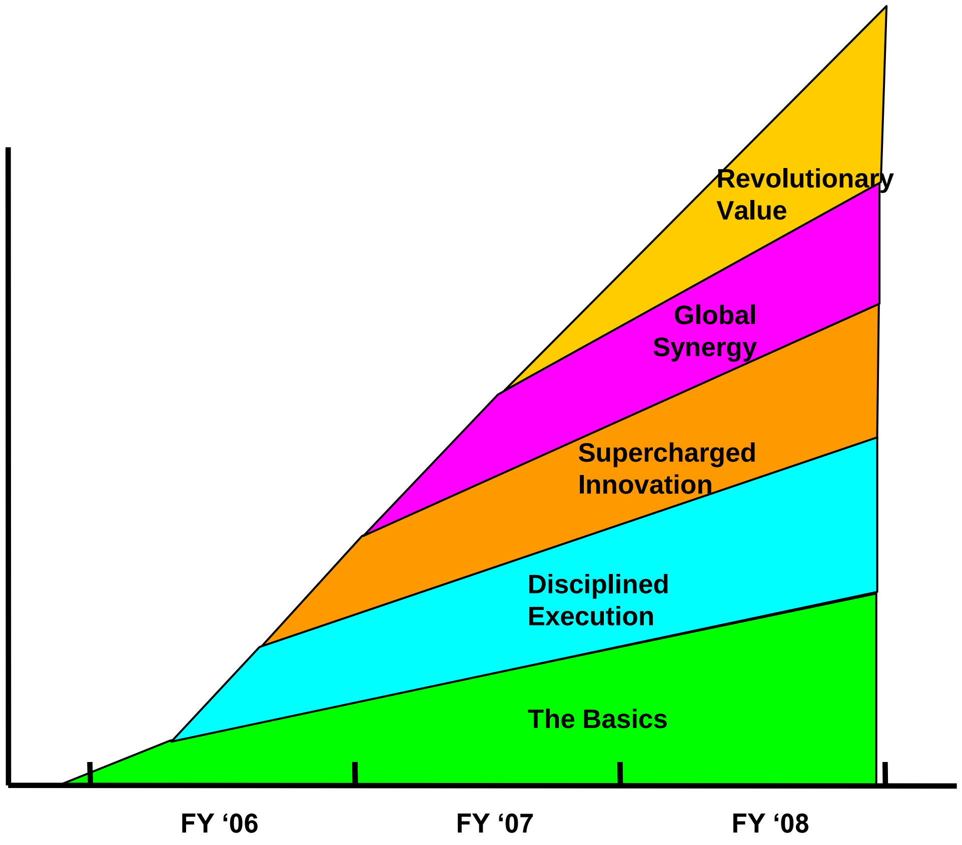
- Joined JCI with responsibility for North American Engineering in 2005 – roughly $8B per year sales in seats, interiors and electronics to the auto industry.
- 7 major seat programs underway – all in distress and customers were very upset. Many engineering mistakes, program delays and failure to meet specifications, which were quite complex. Roughly 500 engineers.
- Analysis of the waste for engineering mistakes for the previous year: $83M in excess engineering time not chargeable to the customer and tooling that had to be scrapped because of design changes.

Knowledge flow in traditional Product Development

- Repeated mistakes.
- Limited and sporadic use of PDCA.
- Unclear responsibility for knowledge creation, collection, curation, and application.
- “Systems” that are avoided or not used.

Overall approach and strategy

- Diagnose the problem – create waste metrics denominated in $
- “The Basics”: Basic Engineering Process
- “Disciplined Execution”:
  - Requirements engineering
  - SMTEs
  - Design reviews



Basic Engineering Process

Plan "Work as a team, use the whiteboard"

1) **Define** Problem or Objective
   - Grasp the situation, go and see
   - Use ACTUAL parts, drawings, data, location, situation, history
   - Understand customer and program requirements
2) Establish **Targets**
   - What is the best measurement scale?
   - Clarify system targets. Flowdown targets to subsystems, and components
   - Quantify and consider variation
   - List important assumptions
3) Understand the **Physics**
   - What is actually happening? What should be happening?
   - What is the root cause?
   - Diagram or graph the physics with the target and variation.
   - Develop hand calculations, simulations, transfer functions to describe the physics and variation
4) **Brainstorm** Alternatives
   - Get others involved with non-basic problems
   - Capture the manufacturing process requirements
   - Work as a team, build consensus
5) **Analyze** and Rank Alternatives
   - Use Pugh Analysis, tradeoff curves, or other appropriate method and actual data
   - Use understanding of physics and manufacturing process to meet targets
6) Evaluate **Impact** in all Areas
   - Consider unintended consequences for selected concept
   - Consider constraints, trade-offs, interactions, variation, etc. to mfg, cost, mass, timing etc.
   - Revise the Pugh Analysis
7) Create Visual, Detailed, Double-ended **Schedule**
   - Work back from critical objectives and forward from current state to create the schedule
   - Clarify risks (technical, commercial, & timing) and plan to mitigate risks
   - Input who, what, when, where, how, measures (process & results)
   - Identify and obtain support or resources from others

Do

8) **Execute** Solution
   - Conduct trials as needed.
   - Implement according to plan
   - Minimize product performance variation. Set tolerances for ease of manufacturing and low cost

Check

9) **Confirm** Results
   - Go and see results; confirm with data
   - Check against targets
   - Assure manufacturing processes are capable
   - If not what expected then…
     - Check assumptions
     - Revise plan, develop and execute again

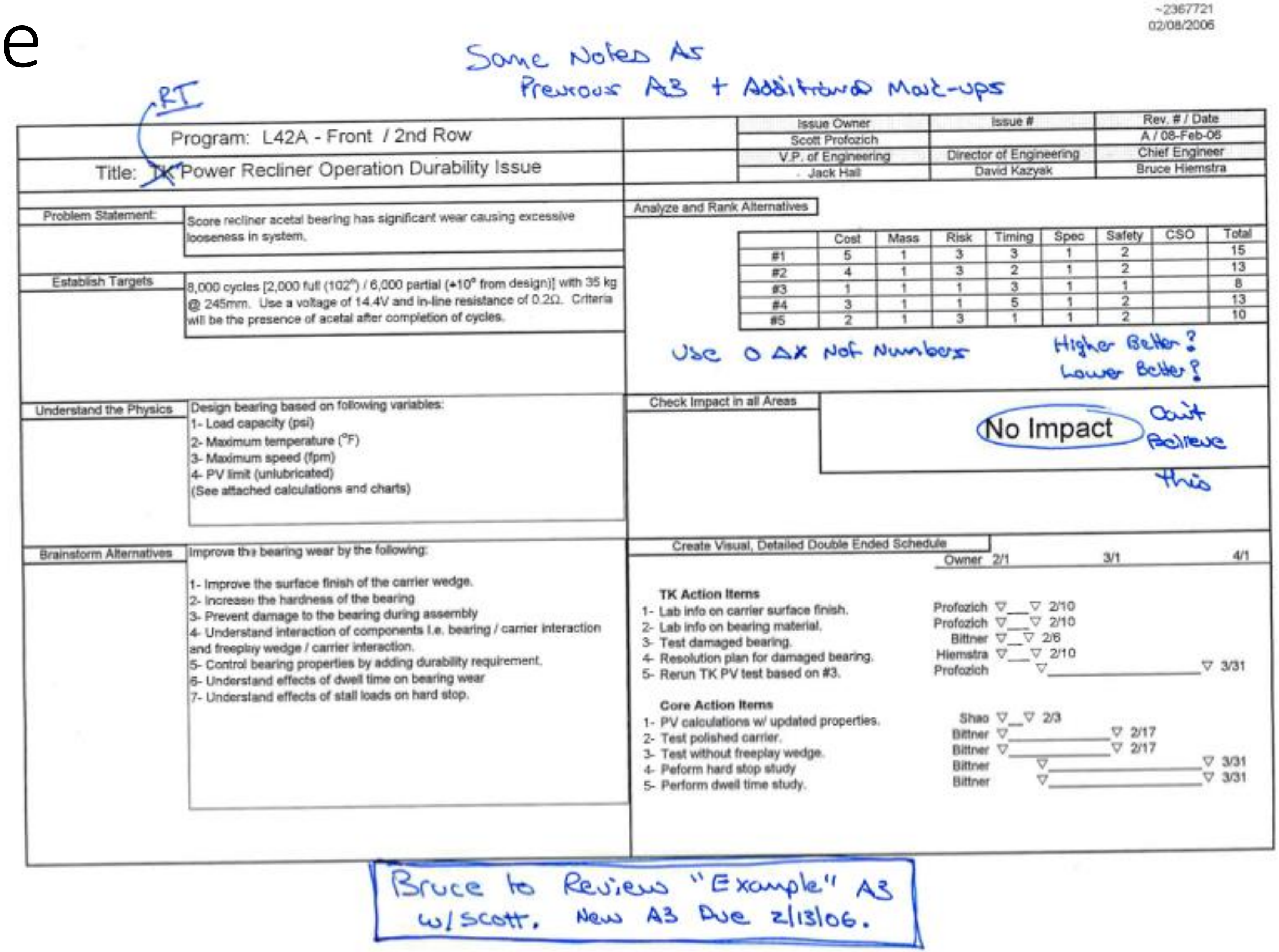
Act

10) **Reflect** & Transfer to Knowledge Base
    - Document and standardize
    - Prevent recurrence
    - Educate others

BEP example

The start of methodical **creation** of knowledge (documentation of a standard problem-solving process).

Example is not of a good A3, but shows the coaching expected.



~2367721
02/08/2006

Some Notes As Previous A3 + Additional Mark-ups

RT

Program: L42A - Front / 2nd Row

Title: ~~TK~~ Power Recliner Operation Durability Issue

Issue Owner	Issue #	Rev. # / Date
Scott Profozich		A / 08-Feb-06
V.P. of Engineering	Director of Engineering	Chief Engineer
Jack Hall	David Kazyak	Bruce Hiemstra

Problem Statement: Score recliner acetal bearing has significant wear causing excessive looseness in system.

Establish Targets: 8,000 cycles [2,000 full (102°) / 6,000 partial (±10° from design)] with 35 kg @ 245mm. Use a voltage of 14.4V and in-line resistance of 0.2Ω. Criteria will be the presence of acetal after completion of cycles.

Understand the Physics: Design bearing based on following variables:
1- Load capacity (psi)
2- Maximum temperature (°F)
3- Maximum speed (fpm)
4- PV limit (unlubricated)
(See attached calculations and charts)

Brainstorm Alternatives: Improve the bearing wear by the following:

1- Improve the surface finish of the carrier wedge.
2- Increase the hardness of the bearing
3- Prevent damage to the bearing during assembly
4- Understand interaction of components i.e. bearing / carrier interaction and freeplay wedge / carrier interaction.
5- Control bearing properties by adding durability requirement.
6- Understand effects of dwell time on bearing wear
7- Understand effects of stall loads on hard stop.

Analyze and Rank Alternatives

	Cost	Mass	Risk	Timing	Spec	Safety	CSO	Total
#1	5	1	3	3	1	2		15
#2	4	1	3	2	1	2		13
#3	1	1	1	3	1	1		8
#4	3	1	1	5	1	2		13
#5	2	1	3	1	1	2		10

Use O Δ X Not Numbers

Higher Better?
Lower Better?

Check Impact in all Areas

No Impact

Don't Believe this

Create Visual, Detailed Double Ended Schedule

Owner 2/1 3/1 4/1

TK Action Items
1- Lab info on carrier surface finish. — Profozich ▽—▽ 2/10
2- Lab info on bearing material. — Profozich ▽—▽ 2/10
3- Test damaged bearing. — Bittner ▽—▽ 2/6
4- Resolution plan for damaged bearing. — Hiemstra ▽—▽ 2/10
5- Rerun TK PV test based on #3. — Profozich ▽—▽ 3/31

Core Action Items
1- PV calculations w/ updated properties. — Shao ▽—▽ 2/3
2- Test polished carrier. — Bittner ▽—▽ 2/17
3- Test without freeplay wedge. — Bittner ▽—▽ 2/17
4- Peform hard stop study — Bittner ▽—▽ 3/31
5- Perform dwell time study. — Bittner ▽—▽ 3/31

Bruce to Review "Example" A3 w/ Scott. New A3 Due 2/13/06.

Requirements engineering

- “5 why” analysis of the $83M waste generated by Engineering: most was caused by agreeing to requirements in the quote process that could not be achieved by the proposed designs.
- Business units were aligned to customers, and cross business unit communication and collaboration in the quote process were weak.
- Created “Requirements Engineering” function to sign off on quote packages before presentation to the customer.
- Implemented with a staff of 2 to start (Director and Senior Engineer).

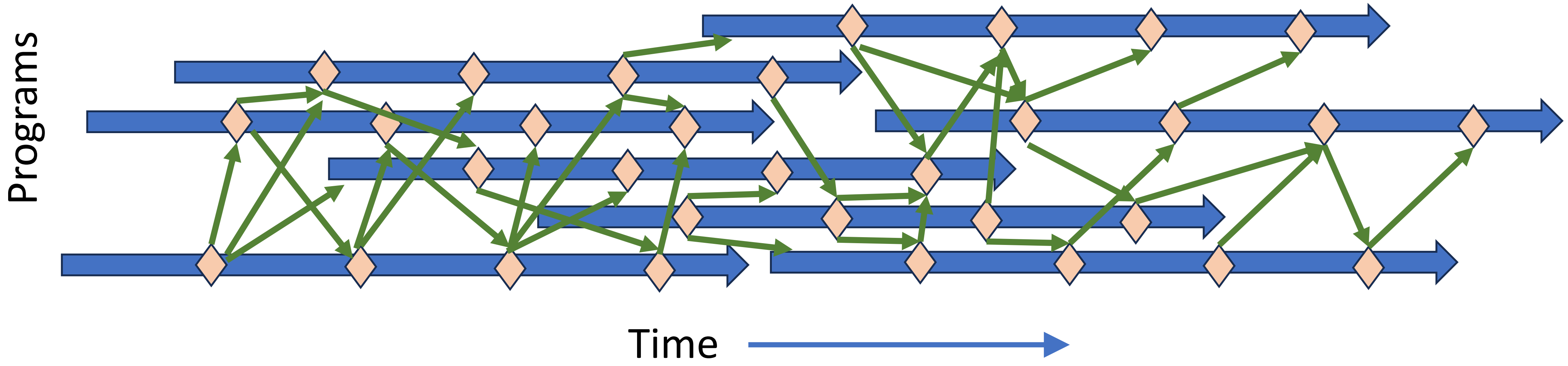
Subject Matter Technical Experts (SMTEs)

- Requirements Engineering a critical first step, but not adequate to manage all important knowledge.
- SMTEs position created to **collect, curate and apply knowledge.**
- ”Defense” – solving problems, avoiding risk (DFMEA, FTA, PFMEA), competitive benchmarking.
- “Offence” – technology prospecting, innovation, creation of solution sets, supporting commercial strategy, driving VA/VE, creation of cost tables.
- 12 SMTE + Director of SMTEs positions were created.
- Goals set for program efficiency, product cost and product quality.

Design reviews

- Design reviews are the touch points for knowledge flow.
- Content varies by phase of the program
  - Innovation
  - Creation/ application of preferred solution sets
  - Requirements (in quoting process)
  - Risk mitigation and optimization
  - DFMEA/ PFMEA/ FTA application
  - Problem solving
  - VA/VE and cost reduction
- SMTEs have sign off responsibility, but collaboration is critical.

Knowledge flow



Traditional Engineering knowledge flow problem statement:

Knowledge from individual programs is siloed with the only sharing being "lessons learned" databases. These are frequently not up to date, lack background and context ("why"), and are treated by teams as a "check the box" exercise.

Lean knowledge flow:

Knowledge is created, collected, curated and applied thru A3 creation by the entire organization, collection, curation and application by SMTEs in design reviews with program teams at critical points in the program.

Results

- Waste metrics were mostly improved by A3 culture and the implementation of Requirements Engineering.
- Reflection conducted 24 months after implementation yielded waste numbers too low to measure (from $83M to less than $1.0M)
- SMTE impact was largely to improve program execution efficiency/ cost, product cost and product quality (roughly 30% improvement after 3 years).
- The larger story is documented in Chapter 11 of “The Toyota Way to Continuous Improvement” by Liker and Franz

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