All you ever needed to know about Product Development
and were too shy to ask

Professor Baback Yazdani

4th November, 2008
Contents

1. Why is Product Development Important?
2. What is Product Development?
3. Generic Processes and Theory
4. Role and State of Automotive Industry
5. Product Development in Automotive Industry
6. Generalisations
7. The Shape of Things to Come
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Thought for the day:

Product Development is the key to the success, prosperity and long-term sustainability of all companies, organisations, and material condition of our lives
A small mistake in Product Development can cost the reputation of a company
Mercedes Benz introduced the A-Class in 1997 after a $1.5 Bn Development.

The Swedish magazine, Teknikens Värld“ (World of Technique) tested one A-class at 60Km/h, simulating a moose-test, and the car flipped over!

2500 newly-sold cars were recalled
...and sales almost stopped!

Mercedes added stability control (ESP) and redesigned the car's suspension

Cost of Change = $ 250,000,000
A serious mistake in Product Development can cost the company
Story of Ford Edsel

- Biggest market research and marketing exercise in automotive history

- Development cost = $400 M (equivalent of $6.7 Bn in 2007)

- Planned to sell 200,000/year

- Sold
  - 58,000 in 1958
  - 16,000 in 1959

Ford Edsel nearly bankrupt
Ford in the late 50s
Repeated mistakes in Product Development will cost the company
Firestone disaster (2001)

More than 250 deaths and 700 injuries in the US were as a result of Ford Explorers rolling over after the tread separated on Firestone tyres.

22 May:
Ford to replace 13 M Firestone tyres and take a $3 Bn charge

18 July:
Ford reports $551M quarterly loss

1 Aug:
Ford's market share falls by 22%

17 Aug:
Ford cuts 10% of its white-collar workers

17 Oct:
First consecutive loss in a decade

30 Oct:
Ford CEO Jacques Nasser resigned
Logarithmic scale plot of cost of change to fix the Firestone problem
Product Development determines the outcome

Committed Costs

Incurred Costs

Cumulative Costs

Concept Stage
Full Scale Development
Testing/Prototyping
Productionisation
Production
Service
Superior capability in Product Development will renew the company and increase its profits over time
Toyota’s PD capability gives it long-term advantage

- Toyota’s Programme costs have been consistently 50-75% of European and US car makers
- Toyota’s PD lead times are nearly half those of European and US car makers
- Toyota’s Product Quality has consistently been at the top of JD Powers Quality Metrics
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## Sector classification

<table>
<thead>
<tr>
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<th>Complexity</th>
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<th>Low Complexity</th>
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<tr>
<td>- Glass</td>
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<td>- Glass</td>
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</tr>
</tbody>
</table>
Terminology

• Product

Something used by a customer or something sold by an enterprise – not necessarily physical and discrete
Aircraft, kettle, components, insurance, bank account, educational programme, training course, ....

• Product Development

Flow of activities from identification of market need to production and use of product

• Design

Execution of ideas, manifest in plans to deliver it
One of four fundamental processes in business

1. Product Development
2. Product Delivery
3. Planning, Execution, and Control: Management
4. Learning
5. Support and Supply
Triangle of compromise

Time

Cost

Quality
I/O of Product Development

Creativity → Product Development → Product
Technology →
Market Need →
Capital →
Further decomposition

Transformation

People
Capital
Technology
Market Need
Knowledge

Product
Development
Process Design
Development
Distribution Design
Development

Product
Delivery Process
Market Outcome
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1. Why is Product Development Important?
2. What is Product Development?
3. **Generic Processes and Theory**
4. Role and State of Automotive Industry
5. Product Development in Automotive Industry
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Fuzzy front-end and development funnels
Generic Product Development process

Research & Development
Technology Development
Technology Acquisition
Capability Acquisition
Project Management

Requirements Capture
Concept Development
Product Definition & Approval

Detailed Design
Prototyping
Product Test Finalisation

Process Design
Process Development
Process Test & Ramp-up

Supply chain Purchasing Preparation
Supply chain Development

Distribution Development
Market Preparation

Product Launch
Product Development cash flow

End of Life

Product Launch

Company Dependent

Market Dependent
Product life-cycle
Smith and Reinertsen’s work

The Four Economic Objectives

- Development Speed
- Product Cost
- Product Performance
- Development Expense

Relationships between the objectives: 
- Development Speed vs. Product Cost
- Product Performance vs. Development Expense

Smith and Reinertsen's work refers to the concept of these economic objectives and their interrelations.
Smith and Reinertsen’s work

**Expense Overrun**

- Baseline R&D
- R&D Expenses Overrun

**Cost Overrun**

- Baseline Unit Cost
- Unit Cost Overrun

**Performance Shortfall**

- Baseline Unit Sales
- Unit Sales with Performance Shortfall

**Schedule Delay**

- Baseline Unit Sales
- Unit Sales with Schedule Delay

---

Smith and Reinertsen’s work
Revenue depressed by Competitive Price erosion

Late to Market

J&LR: $65M / Month

Life Cycle shortened by
New Technology
Market Segmentation

Start-up Costs
Operational Costs

Budget Overrun

J&LR: 1% = $4.5M or 45 man years

Product life-cycle pressures

Revenue Costs
Budget Overrun
New product development Costs
Time

Revenue
Costs
Timing and impact of management attention and influence
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Major developments in industrial management

- **1770s**: Adam Smith: Productivity due to Division of Labour
- **1840s**: Charles Babbage: Mathematical treatment of organisation of production
- **1900s**: FW Taylor / Henry Ford: 'Scientific' production control by Layout Design, Labour Control, Motion Study
- **1920s**: GM vs Ford: Emergence of Horizontal Integration & competition through product differentiation
- **1930s**: First Application of Statistical Quality Control
- **1950s**: A. P. Slone’s application of Financial Statistics
- **1960s**: E. Deming’s teaching: Japan Adoption of TQM
- **1960s**: T. Ohno: JIT and Lean Production
Development of business strategies in AI

Cost Strategies
- Tighter Financial Controls
- Less investment
- Restructuring

Quality Movement
- SPC
- TQM

Technology Movement
- FMS / CIM / CAD-CAM
- Robotics
- Automation

Lean Production
- JIT / Supply Chain Mgt
- Japanese Transplants

Time Compression
- Process Re-engineering
- Focus on lead-times

Competing through Innovation
- PD Capability Design
- Differentiation Adoption of CE Innovation

Sustainability
- Hybrids
- Fuel Cells

Development of business strategies in AI

Development of business strategies in AI
Automotive industry

• An industry over 100 years old
• One of world’s largest industries
• Turn over of $1.4+ Trillion a year
• Employing more than 20 Million people

• One of the most organised and complex
• Innovator of industrial management practices

• Over capacity of 20 million units / year
• Intense international competition
• most systemised in Product Development
World’s major automotive markets (2002-06)
One of world’s largest industries (2007)

World Top 20 Vehicle Producing Countries

Millions

Japan
United States
PR China
Germany
South Korea
France
Brazil
Spain
Canada
India
Mexico
UK
Russia
Italy
Thailand
Turkey
Iran
Czech Rep.
Belgium
Poland

0 2 4 6 8 10 12

Millions
Top 20 vehicle producers (2007)
<table>
<thead>
<tr>
<th>Automaker</th>
<th>Market Capitalisation (€ Bns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toyota</td>
<td>158.2</td>
</tr>
<tr>
<td>Honda</td>
<td>54.8</td>
</tr>
<tr>
<td>Daimler-Chrysler</td>
<td>47.6</td>
</tr>
<tr>
<td>Nissan</td>
<td>41.2</td>
</tr>
<tr>
<td>VW</td>
<td>30</td>
</tr>
<tr>
<td>BMW</td>
<td>28.5</td>
</tr>
<tr>
<td>Renault</td>
<td>25.9</td>
</tr>
<tr>
<td>Volvo AB</td>
<td>22.4</td>
</tr>
<tr>
<td>Fiat</td>
<td>18.1</td>
</tr>
<tr>
<td>Porsche</td>
<td>16.8</td>
</tr>
</tbody>
</table>
Over capacity in global auto industry

![Bar chart showing production and capacity from 1992 to 2007.]

- **1992**: Production - 45 Million Units, Capacity - 55 Million Units
- **1997**: Production - 50 Million Units, Capacity - 65 Million Units
- **2002**: Production - 55 Million Units, Capacity - 75 Million Units
- **2007**: Production - 50 Million Units, Capacity - 70 Million Units

Legend:
- Blue: Production
- Maroon: Capacity

Source: Nottingham Business School, Nottingham Trent University
Drivers of new product development in AI

1. Environment, fuel prices, sustainability

2. Legislation

3. Intense international competition

4. Extremely sophisticated customers

5. Fragmentation of the markets

6. Inclusion of new technologies
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Vehicle attribute decomposition

Driving Experience
- A1. Ride
- A2. Handling
- A3. Steering
- A4. Braking
- A5. Performance
- A6. Performance Feel & Drivability
- A7. Traction
- A8. Off Road Suitability
- A9. Towing Ability
- A10. Fuel Economy
- A11. Passive Safety
- A12. Active Safety
- A13. Security
- A14. P/T NVH
- A15. Windnoise
- A16. Road NVH
- A17. Operational Noise Quality
- A18. Perceived Quality
- A19. Resistance To Degradation
- A20. Durability & Reliability
- A21. Running Costs
- A22. Creation Environmental Impact
- A23. Usage Environmental Impact
- A24. Disposal Environmental Impact
- A25. Occupant Accommodation
- A26. Seat Comfort
- A27. Clean Interior
- A29. Exterior Dimensions
- A30. Controls & Displays HMI
- A31. Day, Night & Poor Weather Vision
- A32. Infotainment
- A33. Climate Comfort

Safety

Quality

Environment

Convenience

Cost

EA1. Aerodynamics
EA2. Thermal Management
EA3. Weight
EA4. Electrical/Electronic Integration
EA5. Mechanical Integration

Vehicle Dynamics
- Perf. Econ. & Driv.
- Safety & Security

NVH
Perceived Quality
D&R
COO
Environment
Accommodation & Usability
Infotainment & HMI
All Weather Comfort & Vision

TASE
Weight
Elec. Integration
Package

Brand Specific Marketing Level1 Attributes. (Volvo Example)

Common Marketing/PD Level 2 Attributes

Engineering Execution
New model development
generic high-level process

Decision & Planning

- Business Proposition
- Product Proposition
- Concept Feasibility & Proposal
- Programme Approval

Delivery Phase

- Engineering Development
- Production-isation
- Product Launch
- Volume Production

Time
## Time to market for complete new vehicle

<table>
<thead>
<tr>
<th></th>
<th>Time to Market</th>
<th>Design Freeze &lt;ST&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toyota</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>Honda</td>
<td>32</td>
<td>18</td>
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<td>Mazda (655)</td>
<td>38</td>
<td>18</td>
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<tr>
<td>Nissan</td>
<td>28</td>
<td>19</td>
</tr>
<tr>
<td>Ford/J &amp; LR</td>
<td>51</td>
<td>25</td>
</tr>
<tr>
<td>Renault</td>
<td>49</td>
<td>26</td>
</tr>
<tr>
<td>DaimlerChrysler</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>General Motors</td>
<td>36 (SI)</td>
<td>30</td>
</tr>
</tbody>
</table>
Clarifying the fuzzy front-end of PD

- Co-Located Creative X-Functional Team
- Focused On New product Innovation

Annual Process Total Cycle Plan

Year 1
- Commercial
- Business
- Technical

Year 2
- Commercial
- Business
- Technical

Year 3
- Commercial
- Business
- Technical

Serial Development Of Particular Platform Or Vehicle Programme “Can Use”
Maximising knowledge and certainty

Commodity “Menus”
- Brakes
- Steering Column
- Multimedia
- Seats
- Steering System
- EDS
- Water Pump
- IP / Cockpit
- EGR
- Restraint Electronics
- Restraints
- Wheels
- Driveline
- Engine Mounts
- HVAC
- Exhaust
- Latches
- Clutch DMF
- Batteries
- Suspension
- Tires
- Shocks / Struts

Technologies “Menus”
- B
- C
- C/D
- Other
- Commercial

Powerpack “Menus”
- Powerpack 1
- Powerpack 2
- Powerpack 3
- Powerpack 4

Process, Methods, Tools & Information

Pre-Program / Packaging

Can use
Should use
Will use

GPDS

Program Team

Vehicle Architecture/Shared Technologies

Powertrain Architecture
Design engineering & development

Annual Activity
- Pre-PS Activity
- Product Planning Activity (Study Product Alt.)

DNA-D Direction
- Showcar Strategy
- Design Benchmarking
- PCP Support
- Technology Development Requirements

Concept Design
- Stance & Proportion
- Studies + Derivatives

Theme Investigations (Multiple => 3)

Theme Design (2 alternatives)

Sketch & 3DCG

3DCG & Model

Optical Quality Process

Production Design
- Refine CG & Clay
- CCRM Manufacture
- Prework

Develop Brand-Specific Aesthetic Design Language

Create ideas and concepts to anticipate future Consumer requirements

Design program exterior, interior, and under-the-hood and create CAD geometry
Can Have

Requirements

2-Phase development

Final Data Judgement

Development & Engineering Enhancements with GPDS

Digital Pre-Assembly

Faster CAE

Block Leaders

Synchronisation - Compatibility - Completeness

Digital Pre-Assembly

Development & Engineering Enhancements with GPDS

Final Data Judgement

2-Phase development

Synchronisation - Compatibility - Completeness

Digital Pre-Assembly

Faster CAE

Block Leaders
Engineering & Prototyping

Representative UN content

Donor Top Hat – aesthetics not important
VP production and tooling

The start point for each activity

Fixed data publication and release points for all parts

All Parts Tooling Window
Final Data to parts OK for VP from Prototype OR Production Tooling
The time for the window is dependent on the programme scale

Time for Production Tools to OK for PCF parts
Verification and crash test
Would you like to see the actual crash test clips?
By synchronisation of the complete vehicle in front of production releases we get:

**Single Point Of Release**

**Target**

**Delay**

**Time**

**Tools under development**

**New State**

**Previous State**

---

**Engineering**

**Synchronisation & mass production preparation**
Improved PD System

- Knowledge Acquisition
- Concept Investigation
- Detail Design
- Prototype & Test
- Pilot Production
- Production Ramp-up

- Index of attention and influence

- Ability to influence outcome

- Actual management activity profile

- Pushing attention to earlier stages
Decoupling and Alignment

Time

Cost

Quality
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Product Development: Value-add outputs

- Identification of Market Need (Including: white spaces, innovations)
- Concept Creation (Customer Proposition)
- Execute the Concept (Design & Engineering, Test and Build)
- Create Technologies
- Commodities
- Corporate IPR (Knowledge / Technology)
- Determine brand solution
- Product Creation Capability
- Marketing / Sales
- Manufacturing
- Corporation
- Other Customers or Companies
- Final Customer
Criteria for successful new products

- Offer a unique feature
- Higher relative quality
- Solution to customers’ problems
- Reduction of total customer costs
- Being the first of its kind
Product Development system

PD System

- People
- Process
- Management
- Organisation
- Tools & Technologies
Product Development capability

How fast = speed of development

How Many = throughput

How much investment = cost of development
Product Development capability

Lean PD is dependent on Time Compression

**PD Capability**

- **Speed of Development**
  - Lead-time Dependent

- **Cost of Development**
  - Overhead Costs x time
  - People Costs x time
  - Hardware Cost
  - Supplier Cost

Lean PD is dependent on Time Compression
Time Compression
i.e. How much can you reduce the lead-time of Product Development

At Program Level: Program Time Compression
Program Performance = $\Delta tc$

At Business Level: Rate of Time Compression
PD Performance = $\frac{dtc}{dt}$

PD Capability Metric

Graph showing improvement limit within given process & technology:
- Improvement
- Maintenance of SOP
Sources of Improvement

PD Performance

- Process changes
- Process enabling technology changes
- Environmental changes

Time
No new Products

= 

No future for that company
Effective Product Development

Strategic Advantages
- Extension of Profit Margins/Markets
- Pre-empting Competition
- Setting Standards
- Creation of PD Capability
- Invigorating People
- Enhanced Brand

Effective Product Development

Operational Advantages
- Lowering Costs
- Improving Quality
- Reducing Lead-Times
- Developing Skills
- Enhanced Image

Company Performance
- Growth
- Profitability
- Sustainability
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The shape of things to come
Do you want to see more?
Apologies for over-running on time!

??
Cumulative flow diagram
Monitoring queues

Little’s Theorem
Batch size

![Diagram of Batch Transfer and Continuous Flow]

- **Cumulative Quality**
  - Arrivals
  - Departures
  - Time
  - Batch Transfer
  - Queue

- **Cumulative Quality**
  - Arrivals
  - Departures
  - Continuous Flow
Technology Life Cycle

[Graph showing the Technology Life Cycle with stages: cutting edge, state of the art, advanced, mainstream, mature, decline. The graph illustrates the changes in industry profitability and number of firms across these stages.]
Non-convergent technologies

Firms participating in US integrated circuits industry
# Product-type positioning

<table>
<thead>
<tr>
<th>Complexity</th>
<th>High</th>
<th>Low</th>
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<tbody>
<tr>
<td>Risk</td>
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<td>Defence</td>
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<tr>
<td></td>
<td>Large Buildings</td>
<td>Food &amp; Drink</td>
</tr>
<tr>
<td></td>
<td>Ship Building</td>
<td>Packaging</td>
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<tr>
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<td>Automotive</td>
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<td>Volume Consumer Goods</td>
<td>Jobbing Builders</td>
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<td></td>
<td>Conventional M/C Tools</td>
<td>Simple Components</td>
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<tr>
<td></td>
<td>Pharmaceuticals</td>
<td>Paper</td>
</tr>
</tbody>
</table>

- **High Complexity**
  - Aerospace
  - Defence
  - Large Buildings
  - Ship Building

- **Low Complexity**
  - Cosmetics
  - Textiles
  - Food & Drink
  - Packaging
  - Jobbing Builders

- **High Risk**
  - Automotive

- **Low Risk**
  - Volume Consumer Goods
  - Conventional M/C Tools
  - Pharmaceuticals
  - Simple Components
  - Paper
  - Commodity Tools
  - Bulk Chemicals
  - Primary Metals
  - Building Material
Causes of PD Failure

- Moving Targets
  - Poor Project Execution
  - Poor Screening
  - Technology Strategy
  - Lack of Learning

- Policy Delays
  - Unstable Technology
  - Sequential Working
  - Market changes
  - Changes in requirement
  - Interference
  - Poor Resource Planning
  - Overestimating Technical Capabilities

- Unresolved policy Issues
  - Unresolved policy Issues
  - Inadequate resources
  - Too many projects
  - Poor Communication

- Functional Mismatch
  - Inadequate knowledge other functional capabilities
  - Organisation Structure
  - Role of Snr. Management

- Inadequate focus
  - No Common Vision
  - Poor Communication

- Technical Problems
  - Overestimating Technical Capabilities
  - Poor Technical Skills
  - Project Screening

- Poor Problem Solving
  - Poor Resource Planning
  - Poor Communication

- Wrong Product
  - Idea Generation
  - Marketing Strategy
  - Product Strategy

PD Failure

Causes of PD Failure
MPDS vs FPDS

![Graph comparing MPDS and FPDS with different models and Toyota's KO-J#1]