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Improving Effectiveness with respect to Time-To-Market and the Impacts of Late-stage Design Changes in Rapid Development Life Cycles

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Abstract

Data suggest that lifecycle developments are reducing by 40% within consumer goods, defense, retail, automotive, aerospace and service industries where rapid innovation is required. The author proposes a rapid systems engineering framework to address late design changes and allow for flexibility (i.e. to react to unexpected or late changes and its impacts) during the product development cycle using a Systems Engineering approach. A System Engineering approach is crucial in today's product development to deliver complex products into the marketplace. Past literature, research, and methods such as concurrent development, simultaneous engineering, knowledge management, component sharing, rapid product integration, tailored systems engineering processes, and studies on reducing product development cycles all suggest a research gap exist in specifically addressing late design changes due to the shortening of life cycle environments in increasingly competitive markets. The author's research suggests that:
1) product development cycles **time scales are now measured in months** instead of years,
2) more and more products have interdependent systems and environments that **are fast-paced and resource critical**,
3) **product obsolescence is higher** and more organizations are releasing products and services frequently,
4) increasingly **competitive markets** are leading to customization based on consumer feedback.
The author will quantify effectiveness with respect to success factors such as Time -To-Market, Return-Of-Investment, Life Cycle Time and flexibility in late design changes by complexity of product or service, number of late changes and ability to react and reduce late design changes.

Where does my research help?

A lot of work is being done with respect to reducing product development time, concurrent engineering, reducing, rapid product integration, lean and agile methodologies and system engineering advances.

However not much research is currently being focused on the consequences of these life cycle reductions. Due to the shortening of the lifecycles, a lot of design changes are pushed towards the end of the life cycle and changes are made to products and services even after the life cycle.

My research focuses on how to effectively deal with these design changes using a Systems Engineering approach and provide flexibility in the system life cycle process.

Measure of Effectiveness Factors – Time, Cost, Quality

- **Time –** Cycle Time, Product Development Time, Concept to Customer Time, Time to Market
- **Cost –** Return on Investment (ROI), Cost of Ownership, Cost of Development
- **Quality –** Customer Satisfaction, Number of Design Changes post Mass Production,

Research Questions

- Are we experiencing faster design/development lifecycles?
- Is the System Engineering process different for rapid timelines?
- Are late design change impacts different for short vs. long lifecycles?
- Are more and more organizations experiencing late design changes in their products and services?
- Are we moving towards a more tailored approach – i.e. based user feedback and performance in the marketplace?

Hypothesis & Definitions

Null Hypothesis (Ho) - **Incorporating a Rapid Systems Engineering approach will increase effectiveness** in decision making and flexibility in design changes when used in fast paced and resource critical environments

Alternate Hypothesis (Ha) **– Using a traditional approach will decrease effectiveness** in decision making and flexibility in design changes when used in fast paced and resource critical environments

Definitions:

Rapid Systems Engineering: Is as a set of System Engineering tools, methodologies and management techniques that results in a SE life cycle which help reduce the time to market from concept to implementation, without sacrificing the quality of products. [1]

Effectiveness: The capability to yield the desired result or outcome.

Flexibility: The ability of reacting to uncertainty and unexpected changes which would help with reducing the impact of output redesign.

Literature Summary

- **Reviewed over 1600 abstracts / titles on the following terms:**
  - Tailored System Engineering Processes
  - Rapid Systems Engineering
  - Concurrent / Simultaneous Engineering
  - Long vs. Short Development Cycles
  - Industry Cycle Processes – Time Studies
  - Speed – Success Relationship in NPD

- **Preliminary Results**
  - **Reduction in NPD Cycle times** is a reality [1,2,3,4]
  - More organizations are **undergoing design changes** not only just along the Life Cycle but also after the Go Live Stage [5,6,7]
  - **Quicker product obsolescence**, more product variations and customizations and increasing competition are all elements organization are experiencing [8,9]
  - **Everchanging customer demands** and **constant technological advances** have increased the innovation in products and services [10,11,12]
  - **Agile** system engineering practices have **matured for software** projects **while hardware** system engineering continues to embrace **classical development** techniques. [13,14]

NPD Cycle Time Study [22]

Product	Organization	Cycle Time (months)			
		Previous	Now	# Reduced	%
Automobile					
Construction equipment	Deere & Co.	84	50	34	**40%**
Car - Viper	Chrysler	72	36	36	**50%**
Car - Accord	Honda	60	36	24	**40%**
Trucks	Navistar	60	30	30	**50%**
Electric clutch brake	Warner	39	9	30	**77%**
Communication Gear	Codex	34	16	18	**53%**
Medical					
Medical Imaging machines	Polaroid	72	36	36	**50%**
Commercial & Defense					
Fiber Optic Gyroscope/Multiple projects	DARPA	60	36	24	**40%**
E-2D Advanced Hawkeye	Northrop Grumman	95	136	-41	**-43%**
Boeing 777	Boeing	60	60	0	**0%**
Boeing 778	Boeing	65	83	-18	**-28%**
Airbus A-380	Airbus	44	49	-5	**-11%**
Consumer Products					
Copier	Xerox	60	36	24	**40%**
Desk Jet Printers	HP	54	22	32	**59%**
Copier - FX 3500	Fuji-Xerox	38	29	9	**24%**
Work Computers	IBM	48	14	34	**71%**
Air powered grinders	Ingersol Rand	40	15	25	**63%**
Cordless phones	AT&T	24	12	12	**50%**
Wedding rings	Feature Ent.	4	0.25	4	**94%**
Coffee Brewers	Keurig Green Mountain	26	14	12	**46%**

A study on reduction in Cycle Times

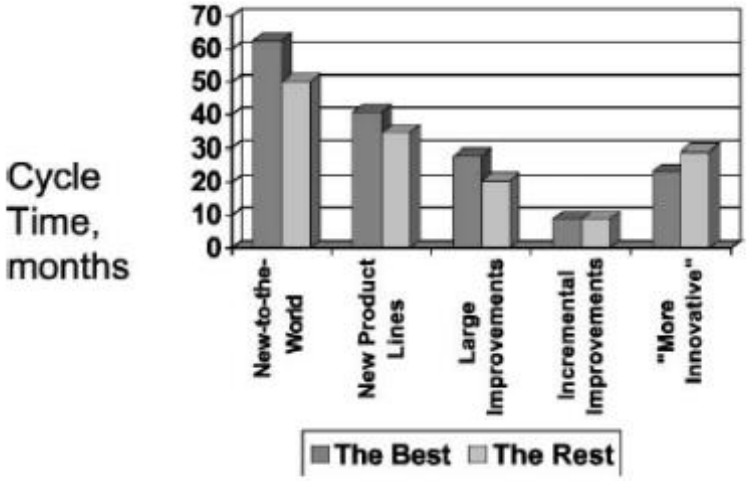


Fig. 4. Cycle time by project type.

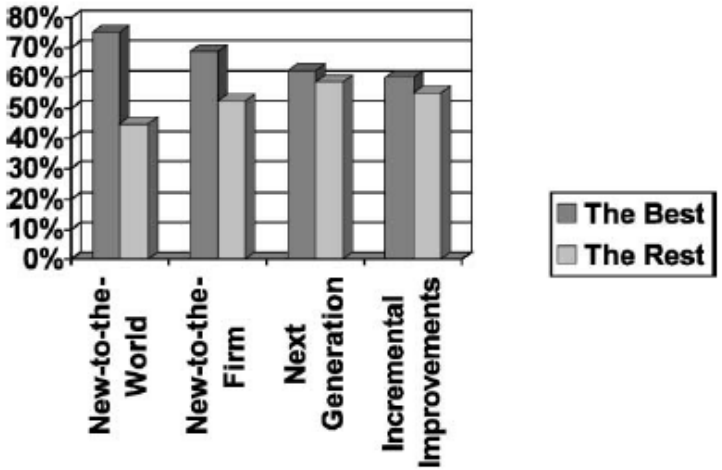


Fig. 5. Percentage of firms reducing cycle times in the last 5 years.

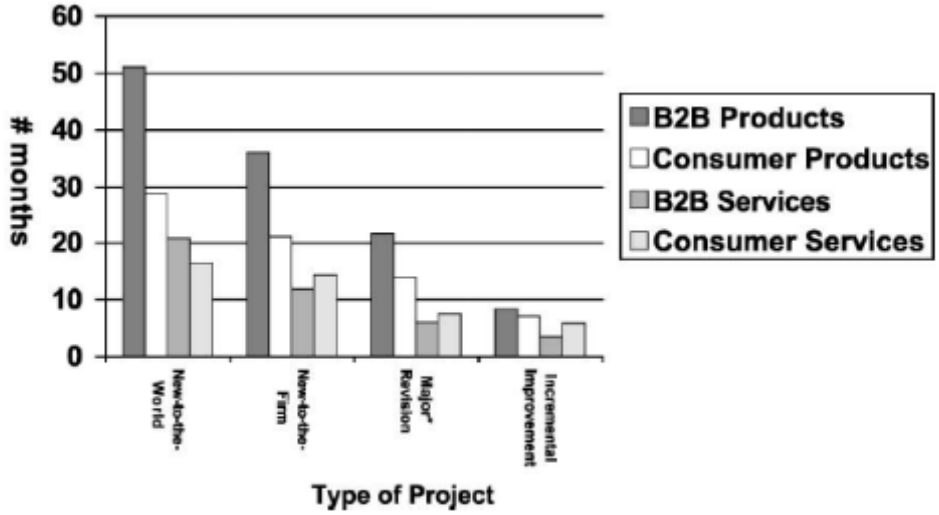


Fig. 7. NPD cycle time by market and product type.

Figure 1, 2 & 3: Source: Griffin, Abbie. (2002). Product Development Cycle Time for Business to Business Products. Industrial Marketing Management. 31. 291-304. 10.1016/S0019-8501(01)00162-6. [23,24]

Development Phase Comparison & Consumer Products Adoption Rates

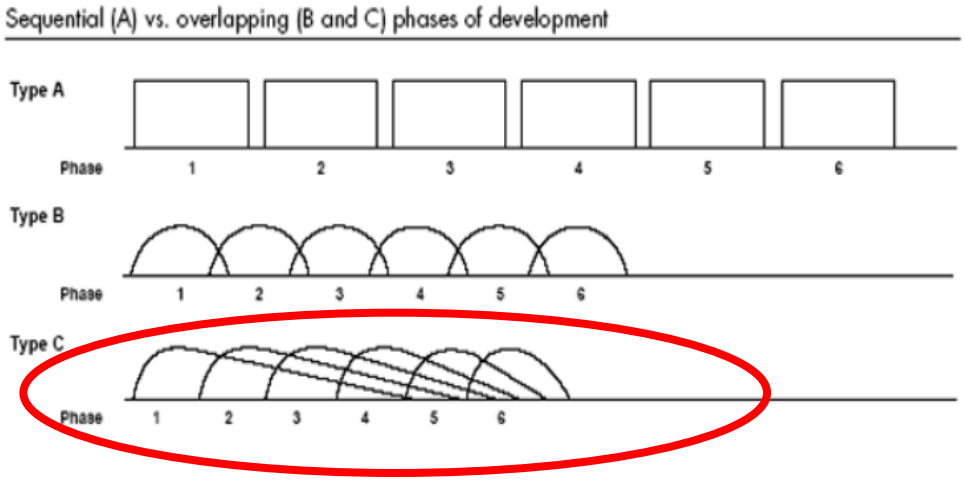


Figure 4: Source: Nonaka, Hirotaka TakeuchiIkujiro. "The New New Product Development Game." Harvard Business Review, 1 Aug. 2014, hbr.org/1986/01/the-new-new-product-development-game. [21]

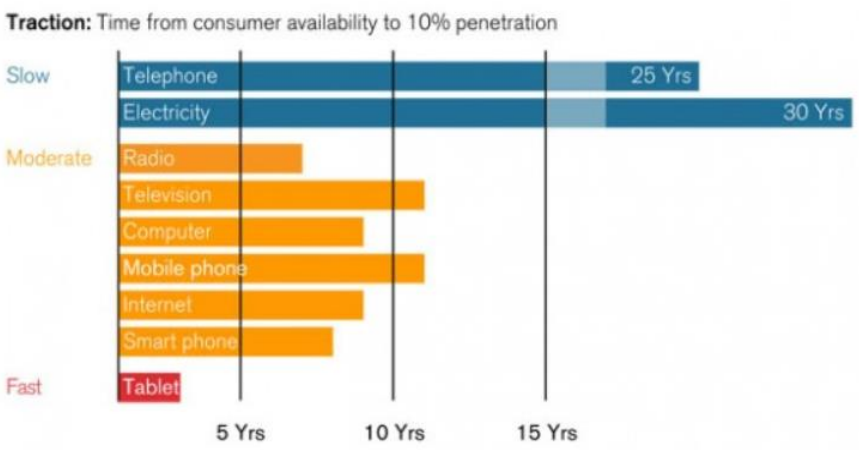


Figure 5: Source: DeGusta, Michael. "Are Smart Phones Spreading Faster than Any Technology in Human History?" MIT Technology Review, MIT Technology Review, 30 Dec. 2013, www.technologyreview.com/s/427787/are-smart-phones-spreading-faster-than-any-technology-in-human-history[22]

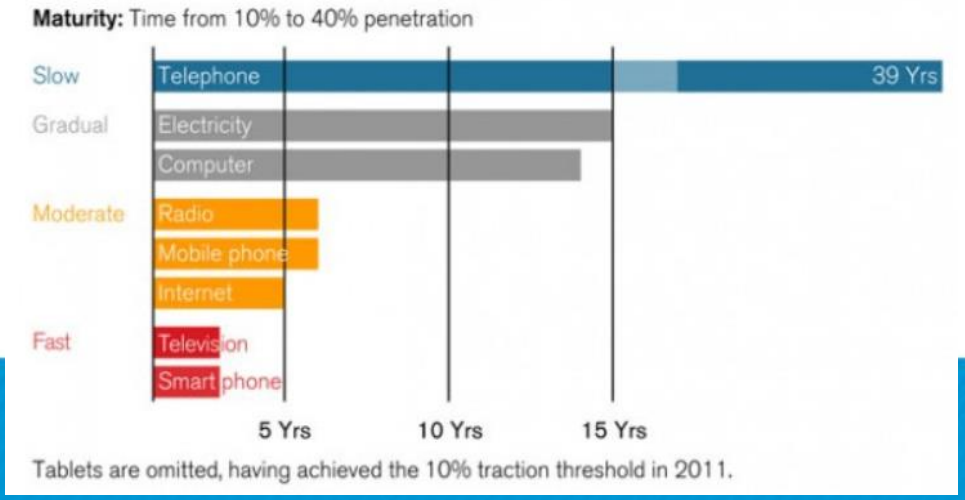


Figure 6: Source: DeGusta, Michael. "Are Smart Phones Spreading Faster than Any Technology in Human History?" MIT Technology Review, MIT Technology Review, 30 Dec. 2013, www.technologyreview.com/s/427787/are-smart-phones-spreading-faster-than-any-technology-in-human-history/. [22]

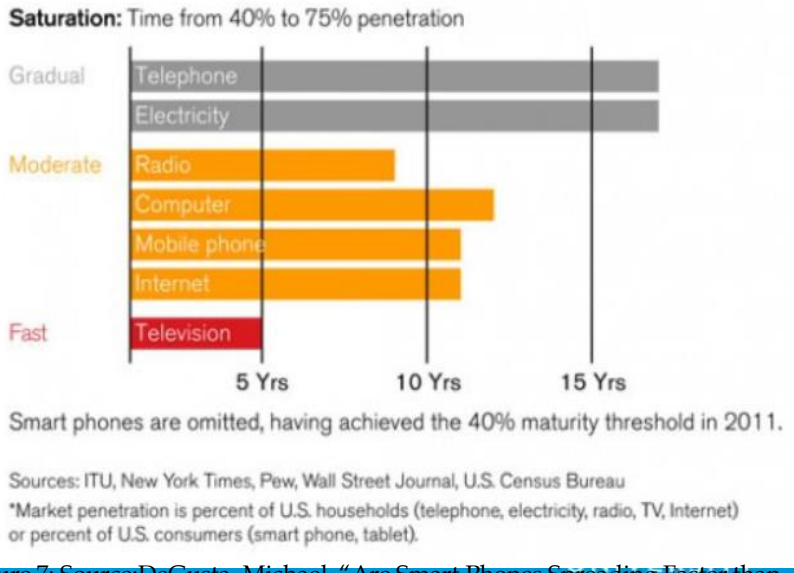


Figure 7: Source:DeGusta, Michael. "Are Smart Phones Spreading Faster than Any Technology in Human History?" MIT Technology Review, MIT Technology Review, 30 Dec. 2013, www.technologyreview.com/s/427787/are-smart-phones-spreading-faster-than-any-technology-in-human-history/. [22]

Examples for Discussion

The below examples share the good and bad side of focusing on time to market

Time & Flexibility – Next source of Competitive Advantage

Honda

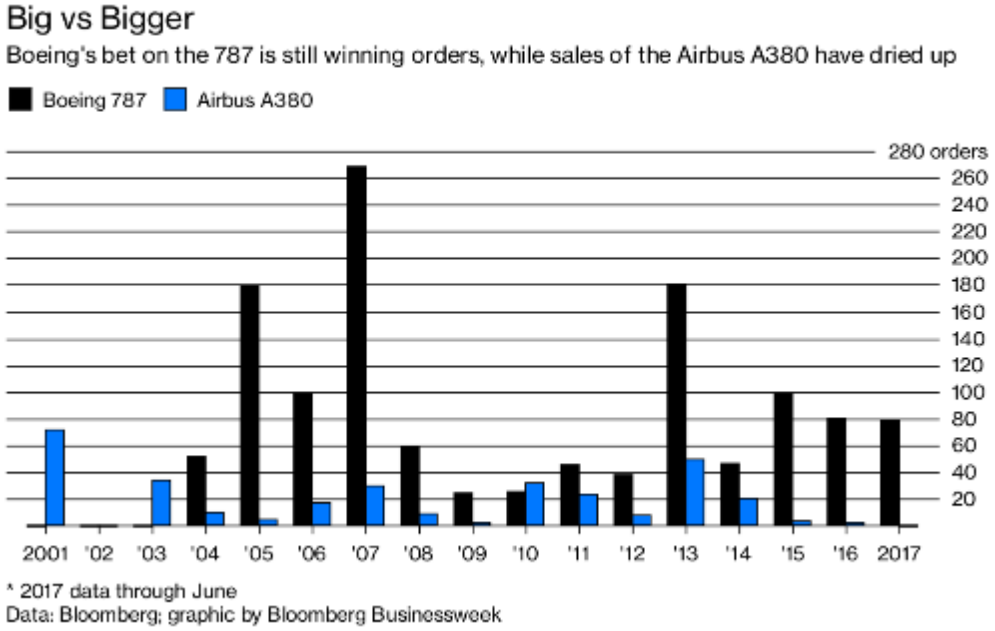
- Honda manufactures **three variation** – Honda Pilot, Honda CRV & Acura MDX in **one flexible manufacturing line**. [18]
- Single Assembly line and switch lines for newly designed vehicles in hours
- Allows the company to reduce manufacturing time, faster time to market, make customizations easily based on consumer feedback and increase efficiency.
- Company is able to accomplish **Time, and Cost** targets.

Figure 8, 9 & 10: Source: Eaton, Dan. "Honda starts production of Acura SUV in Ohio after $85M investment." Columbus Business First, Bizjournals.com, 1 June 2017, 16:14pm, www.bizjournals.com/columbus/news/2017/06/01/honda-starts-production-of-acura-suv-in-ohio-after.html.

Boeing's Gamble pays off after launch delays [16,17]

	Airbus A380	Boeing 787
Launch Date	August 2008	October 2011
Cost	$403.9 Million	$290.7 Million
Size	525	300 - 330
Deliveries	119	103
Order	259	1012

***Data as of Jan 2017



Boeing 787 vs. Airbus A380 – A Time to Market Study

Figure 11: Source:Topham, Gwyn. "Battle for the future of the skies: Boeing 787 Dreamliner v Airbus A380." The Guardian, Guardian News and Media, 29 Dec. 2013, www.theguardian.com/business/2013/dec/29/boeing-787-dreamliner-airbus-a380-battle-for-skies.

Figure 12: Katz, Benjamin D, and Julie Johnsson. "Boeing's Gamble on 787 Pays Off as Orders Outpace Airbus A380." Bloomberg.com, Bloomberg, 1 Aug. 2017, www.bloomberg.com/news/articles/2017-08-01/boeing-s-gamble-on-787-pays-off-as-orders-outpace-airbus-a380.

Volvo's Rapid Strategy

Volvo's 50% Attempt [15]

- Plans to reduce complete cycle time from **42 months to 20 months** on the XC90 Model by 2020
- Virtual testing & Simulation instead of prototype
- Common architectures and modules
  - **Volvo Engine Architecture (VEA)** – A Four cylinder engine which will be compatible in eight end-products, reducing complexity by **75% commonality.**
- Company is able to accomplish **Time, and Cost** targets.

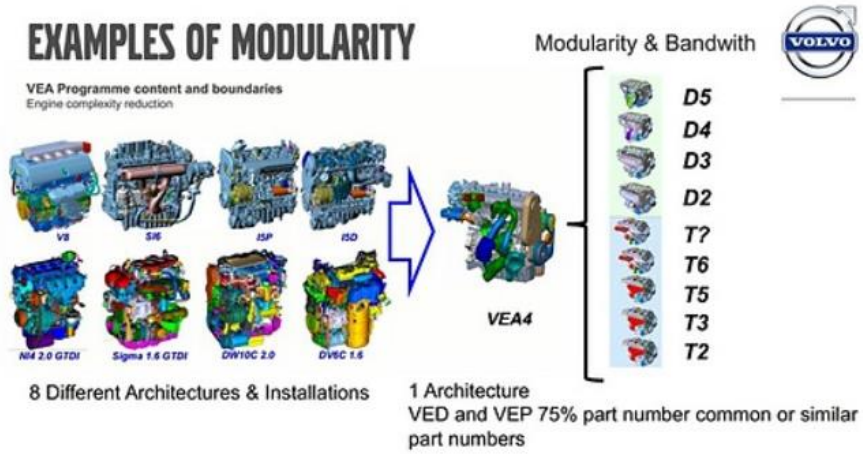


Figure 13 & Figure 14: Source: Morey, Bruce. "Volvo's Rapid Strategy aims at 20-month vehicle development;" SAE International. Oct 24, 2014. Web. March 4, 2017 <http://articles.sae.org/13621/>.

Samsung trips on Quality control measures in order to beat Apple

Samsung Galaxy Note 7 Recall

16.8% Share Price Drop & about $9.5 billion dent [19,20]

- Lab times and **testing periods were shrunk** to expedite approval and **focus on time-to-market**
- Increased complexity and faster timelines
- Battery Problem 1 – Battery size too small in one corner leading to short circuiting
- Battery Problem 2 – Incorrect welding by third party supplier

- Improved 8 point process for battery check and other quality related issues

Figure 16: Source: Wang, Jules. "Galaxy Note 7 explodes, and we're not talking demand." Pocketnow, 24 Aug. 2016, pocketnow.com/2016/08/24/galaxy-note-7-explodes-in-china.

Questions for the Audience

- Potential sources of data?
  - New Product Development Cycle Times from 2000 to 2017
  - Decrease or Increase in Manufacturing Cycle Times
  - Any time or cost comparison studies or data sources related to shortening of overall system life cycles

- Additional literature not included or missed during my review?

Biography

Education: Parth Devang Shah is currently a **Doctoral Candidate in Systems Engineering** at The George Washington University.

He also holds a **Bachelor's degree in Mechanical Engineering Technology** and a **Master's degree in manufacturing Leadership**, both earned at the Rochester Institute of Technology located in Rochester, NY.

Professionally: Parth is currently a **Director at Unique Instruments & Mfrs. Pvt. Ltd.** located in Bangalore, India. Unique Instruments is an Aerospace Company which specializes in manufacturing structural components for Commercial and Defense companies globally.
Prior to this, Parth Shah was a Senior Quality Engineer in the New Product Development Team at **Keurig Green Mountain** in Boston, MA.

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Questions, Concerns or Suggestions?

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