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Introduction to Successful Predicting of Product Performance (Reliability, Durability, Safety, Quality, Recalls, Profit, Life Cycle Cost, and Others)

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Abstract

This paper will discuss the problem with successful predicting of product performance (reliability, quality, durability, safety, recalls, profit, life cycle cost, and other interconnected technical and economic components of performance). The best component for analysing the performance situation during service life, including predicting, is recalls, because, first, recall accumulates the safety, reliability, durability, quality, profit, and total economic situation. And second, there is open official and objective information about the number of recalls from Government (National Highway Trafic Safety Administration and others), as well as companies-producers.

Therefore, for analyzing the situation with the product performance, including predicting, this paper considers the situation with recalls. First, it will demonstrate how dangerous the current situation is with recalls, safety, reliability, and durability, especially in automotive, including in the USA for last thirty years. Then it will be demonstrated that recalls directly connect with profit.

It will analyse the basic causes that leads to unsuccessful predicting. This paper proposes the basic way to eliminating the above situation. This way consists of appropriate methodology and obtaining initial information for predicting the successful specific product performance. This way also shows how one can solve the above problem through increasing the interconnected reliability, durability, safety, and life cycle cost.

Current Situation with Recalls

Now predicting of product performance components (quality, reliability, durability, maintainability, safety, life cycle cost, profit, recalls) is not successful. Therefore, there are many problems with product performance in automotive and other industries. One from them is not stopping the recall process situation.

Recalls relate to many types of product. For example,: “Laptop batteries that catch fire. Pet foods that make animals sick. Children's toys covered in lead paint. It's hard to pick up a newspaper, watch TV or browse the headlines online without stumbling onto a report of a recall. In the past few years, there have been recalls for beef, chicken, candy bars, spinach, peanut butter, medicines, power tools and baby cribs” [4].

“An automotive recall is a way for a manufacturer to tell you that there could be something about your car or truck that presents a risk of injury or property damage. And if you want to drill down to the very core of the issue, automotive recalls are intended to fix known problems with vehicles in an effort to keep roadways safer. Traffic crashes are the number-one killer of Americans under the age of 34, and a staggering 42,000 deaths are recorded each year on U.S. highways [source: ODI]. Some of those lives could be saved by repairing unsafe vehicles or removing them from the oads. But who has the authority to do something like that?”[5].

If we will consider the causes of automotive recalls for many years and many automakers, we will see the following causes:

- defects in components from air bag to seat raild;
- spiral cable;
- wiper motor;
- seat frames;
- starter relay;
- instrument panel bracket;
- unintended acceleration;
- cruise-control switch spontaneus combustion;
- steering and water pump problems;
- faulty power window switch;
- problem with a battery cable cover in the trunk;
- ignition switch defects;
- safety belts;
- transmission;
- electrical and electronic issues;
- and others.

Table 1. Top manufacturers that issued recalls in 2011 - 1013 [6], [7], [8], [9], [10] (US market)

COMPANY	YEAR	# OF VEHICLES RECALLED, MILLION
TOYOTA	2011	3.5
FORD	2011	2.7
HONDA	2011	1.5
TOYOTA	2012	5.3
HONDA	201`2	3.6
GENERAL MOTORS	2012	1.5
FORD	2012	1.4
CHRYSLER	2012	1.3
TOYOTA	2013	5.3
CHRYSLER	2013	4.7
HONDA	2013	2.8
HUYNDAI	2013	2.2
FORD	2013	1.2

If one will analyse the situation with recalls, the first conclusion from the above is: this problem is connected directly with safety-quality-reliability-durability.

The second conclusion is: one recognize these problems a several years after beginning manufacturing that **means: no designers, no researchers, no testers, no manufacturers, no other group of professionals could not predict and prevent successfully these problems during research, design and manufacturing - before the product came to the consumers.**

The third conclusion is: **the companies in automotive and other industries do not have reliable strategy and methods to predict and prevent successfully recalls during life time of the product and often during warranty period.**

One more problem, as US governmental says, is food-dragging on the recall [2].

Recall problem also connect problems with maintainability, availability, life cycle cost, and many others that influence on economic situation, which during the development of technology often leads to their decreasing instead of increasing, as was planned during research, design, and manufacturing.

If we will consider the situation with recalls during long time, we will see:

• **Last three years large automakers recalled in US market millions of vehicles** (Table 1).

Moreover, the trends demonstrate that the safety-quality-reliability-durability are going down.

• **Total number automobile recalls in the USA during last more than thirty years is going constantly up** (Figure 1).

This situation is continue to go down. For example, it was written in April 2014: "All told BMW AG, Fiat Chrysler Automobiles, Ford Motor Co., General Motors Co., Toyota and Volkwagen AG have recalled nearly 15 million vehicles since the start of the year". [7]

"Recalls by auto makers have been steadily increasing over time and the pace is accelerating in the past three years. A study by financial advisers Stout Risius Ross Inc. showed recalls ramping up between 2010 and 2013, attributing at least some of the increase to stronger enforcement by National Highway Traffic Safety Administration and the highly public nature of Toyota recalls in 2009 and 2010" [11].

One can see from the Table 1 top manufacturers that issued recalls in 2011 - 1013.(US market)

The problems with increasing recalls in continued in 2014. For example, "General Motors has recalled more than 18 million vehicles (first two quarter 2014 - L.K.) in the U.S. since January (2014)" [11].

"The continuation of the above problems one can see on example General Motors situation in 1st and 2nd Quarters 2014. "This quarter, it has forecast taking a $1.3 billion loss for costs related to recalling 7 million vehicles, including those with faulty ignition switches. It has also said it will take a $400 million pretax charge for changes in Venezuela's currency. That will come on top of any losses in Europe, which have totaled more than $18 billion since 1999."[14],

The New York Times wrote June 30, 2014 [15]:" But even as G.M. addresses its safety shortcomings with a beefed-up roster of product investigators, the spiraling number of new recalls - G.M. has surpassed 29 million worldwide this year - is threatening to undermine the company's reputation for quality".

The problem is not only in economic situation, but with people's life. In [16] was written: "At least 29 people have died and 27 people have been seriously injured in crashes involving General Motors cars with defective ignition switches. Attorney Kennet Feinberg, who was hired by GM to compensate victims, updated the totals Monday". "Feinberg says he has received 184 death claims since August. Of those, 29 have been deemed eligible for compensation, up two from last week. Twenty-seven of the 1,333 injury claimants have also received compensation offers. GM knew about faulty ignition switches in Chevrolet Cobalts and other small cars for more than a decade but didn't recall them until February.

Table 1 displays top auto manufacturers that issued recalls from 2011 to 1013.(US market).

Similar situation is in British market, including with expensive cars that produced with specific technology. For example: "Aston Martin has been forcet to recall more than 1,600 of its most expensive sports cars after the discovery of an electronic fault that can lead to a dangerous loss of power. It is the second safety alert affecting the iconic British-car-market this year. In February, nearly 18,000 cars were recalled. [19]"

And : "Now Aston Martin has issued a new safety notice - this time affecting the £ 133,000 DB9 Coupe, as well as the Volante and the four-door £ 148,000 Rapide S, which has been described by monitoring enthusiasts as the world's most beautiful four-door sports car." [19].

In Australia was written [20] that the driver of expensive cars (vintage wedding car0 had to be taken to hospital and his prized Jaguar was badly damaged.

As was written earlier, the problem with recalls relates not only to automotive area, but in electronics, electrical, and other areas. In [5] was written: "As electronics have become more prevalent in everything from biomedicine to transportation, the need for advanced assessment of electronics reliability has become a necessity. For example, Cochlear Inc. was forced to recall its cochlear implants due to moisture-induced failure in the electronics, resulting in major surgeries, explants, and losses of more than $150 million. Similarly, Medtronic Inc. recalled its pacemakers due to electrical 'opens' of interconnection electronics.

Since 2011, GM has recalled over 19 million vehicles and Toyota has recalled over 25 million vehicles due to electrical problems. The Boeing 787 Dreamliner fleet, certified to achieve a battery failure of no more than 1 per every 10,000,000 flight hours, was taken out of operation for more than 14 weeks due to two Li-ion battery fires in a two-week span (2 failures in less than 52,000 flight hours), and then allowed to resume flying without identification of the root cause of failure. Unfortunately, many of these electronics systems failures are in some sense inevitable, because the current methods to assess such systems have a fundamental flaws due to unique application environments, complex degradation mechanisms, and interactions between performance parameters".

Figure 1 demonstrates total number of automotive recalls in the USA for period 1980 - 2013.

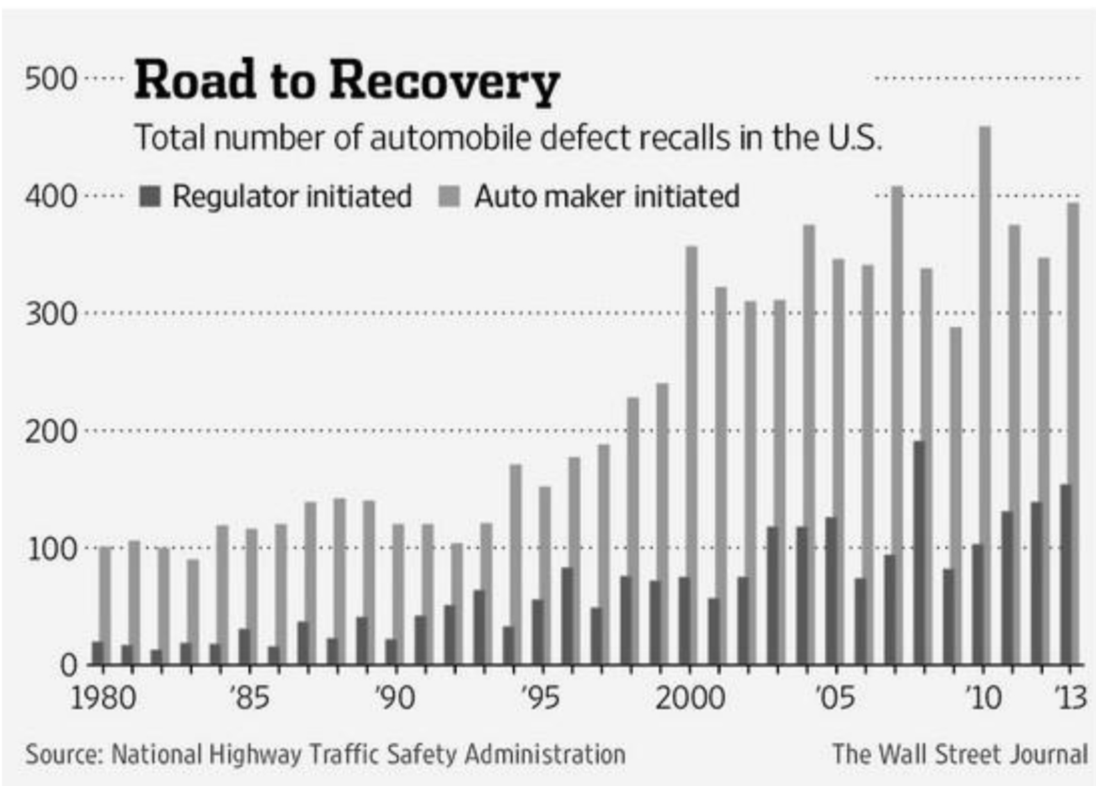

Figure 1. Total number of automotive recalls in the USA in 1980 - 2013. [13]

Current Situation in Performance Predicting

Described above situation with recalls directly relates with level of product's peformance predicting.

The ability to predict in the scientific-technical performance area is especially underdeveloped. Especially its relates to the successful predicting of the performance components and hew technology.

It is known that predicting is useful when it is successful. This is one of the basic problems in engineering and impact the producer and user economic situation.

The important components of performance are quality, reliability, safety, durability, maintainability, life cycle cost, profit, recalls, and others. All of these are interconnected.

There are many approaches to methodology of performance and its components predicting that have been published. For example, life cycle costing (LCC) allows the identification of main cost drivers while considering all economically relevant monetary flows over the entire life cycle. Hense, with the holistic perspective, LCC enables derivation of promising measures to influence these costs (e.g. decision support for product design phase) while avoiding unfavorable problem shifting through life cycle phases [28].

Reliable predicting of total product and life cycle costs are crucial for the life cycle management of products. These costs are predominantly dictated by the actual operational behavior of the product's lifetime, and cannot be sufficiently determined through deterministic calculations due to the stochastic and the dynamic nature of the problem. This is specifically true when considering running systems with unknown lifetime and operaton parameters.

The paper [29] presents a dynamic methodology for predicting life cycle costs based on product failure mechanisms, their associated critical lifetime predicting parameters and optional maintenance strategies to enable decision support for product design and use phase strategies.

In [30] stochastic model (SLCC) has been developed to perform life cycle cost (analysis for several water main rehabilitation alternatives). A maintenance plan was developed for water main rehabilitation alternatives based on the SLCC model. Web-based SLCC software was developed to perform the SLCC of water mains.

The authors think that the system will help municipal engineers to predict the suitable new installation and/or rehabilitation programs as well as their corresponding costs, thereby to avoid any unpleasant surprises. A combination of repair, renovation, and replacement techniques are integrated in the model to develop different scenarios for rehabilitation of water mains.

In paper [30], the authors "…proposed a Bayesian Belief Network (BBN) based approach to quality prediction and assessment for a software product line. A BBN represents domain experts' knowledge and experience accumulated from the development of similar projects".

There are many articles and papers in reliability predicting, especially electronic product. For example, RAMS 2012 Proceedings published 6 papers in this area. Most of them relate to theoretical methods in software design and development. For example, both physics-based modeling and simulation and empirical reliability has received interest in computer graphics.

For better understanding this, let us consider the history of reliability predicting. The term reliability predicting has historically been used to denote the process of applying mathematical models and data for purpose of estimating field-reliability of a system before empirical data are available for the system [31].

In [31] was analysed the history of reliability predicting for more than 25 last years.. The result of this analysis was: In engineering (automotive, commercial, and aerospace) efficiency prediction is not very successful. The causes is problems with published methodological approaches of predicting, as well as obtaining accurate initial information for successful predicting.

Empirical and current physics-based predicting of reliability do not reflect the measured reliability in the field Now the above situation in reliability-durability-safety-recalls-predicting is continuing to worsen, leading to worsering economic situation.

On September 19-20, 2012, RMS (Reliability, Maintainability, and Supportability) Partnership organized in Springfield, VA a Department of Defence, Department of Transportation, and Industry workshop and symposium "A Road Map to Readiness at Best Cost for Improving the Reliability and Safety of Ground Vehicles" [32]. During this workshop, many presenters and attendees voiced a concern that reliability, durability, and safety are exibiting decreasing trends.

One possible explanation for such observations is that there are not enough strong requirements to industry in these areas.

Currently, during the design, research, manufacturing, and usage of the product/process, one consider separately solutions for problems of reliability (durability), maintainability, serviceability, etc.) from other factors, such as quality, human factors, safety problems.

However, in the real world these processes act simultaneously and as one complex: they are interacted, interconnected, inerdependent, and influence each other. Therefore, when one uses separate consideration of the above problems, one artificially does not take into account the real world situation. The result is different reliability, durability, safety, and maintainability during research, design, and manufacturing than in real world. The final result is unpredicted recalls and other economic losses [21], [22], [23], [31].

About the Way for Successful Predicting of Product Performance

How can one solve the problem with insufficient predicting of product performance?

This problem was analysed in previous author's publications (see References) where was consider the basic causes that leads to mistakes in performance components (reliability, durability, safety, quality, maintainability, life cycle cost, profit, recalls, and others) predicting.

The basic way to eliminating the above situation that consists of appropriate methodology and accurate initial information for successful predicting product performance. This way also shows how one can solve the above problem through increasing the interconnected reliability, durability, safety, profit, and decreasing life cycle cost.

Also shown will be the basic mistakes in research, design, and manufacturing of new product.

This is, as Phillip Coyle, the former director of the Operational Test and Evaluation Office (Pentagon) said in US Senate that: **if during the design and manufacturing one tries to save a few pennies in testing, the end results may be a huge loss of thousands of dollars due to faulty products which have to be replaced, because of this mistake.**

Conclusions

Current situation with performance predicting can be demonstrated by recalls, because recalls accumulate the situation with safety, reliability, durability, life cycle cost, profit, and other interacted performance components.

The situation with recalls, especially in automotive industry, demonstrates that during last more than thirty years recalls are going up.

The basic way for improvement the above situation is development predicting methodology and obtaining accurate initial information for predicting specific product.

As demonstrated previous author's publications, accelerated reliability and durability testing technology (ART/ADT) is a source for obtaining this information.

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The Engineering Meetings Board has approved this paper for publication. It has successfully completed SAE’s peer review process under the supervision of the session organizer. The process requires a minimum of three (3) reviews by industry experts.

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