NEVER A DULL DAY: THE LIFE OF AN INDUSTRIAL STATISTICIAN!

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Looking for a career with an exciting new challenge each day? Then consider becoming an industrial statistician. Today's industrial statisticians are in the thick of their companies' initiatives to build products or deliver services that delight customers—and to increase market share and profitability. Their involvement is holistic and runs from product conception to field deployment.

It has not always been that way! I have had the good fortune of working for the same company (GE) for over 45 years, first as an applied statistician—and, for almost three decades, as the leader of a corporate statistics group serving the entire company that has grown from 4 to 18 people. For much of my career, the major emphasis was on crisis mitigation. We quantified the magnitude of unanticipated field failures and evaluated alternative ways of minimizing the damage. In contrast, our goal today is to build products or provide services that eliminate such surprises by proactive avoidance—although, admittedly, once in a while a few problems still slip through.

So what is the statisticians' role in product development? (Our role in providing improved services will be discussed elsewhere.) It is to help ensure that we obtain the most meaningful data for driving improvement, that we squeeze the maximum useful information out of such data, and that we make the best possible business decisions, in the face of uncertainty, from this information. In short, it's our job to help *avoid* unpleasant surprises—no matter whether the product is an appliance, a power generation system, an engineering plastic, a jet engine, a lighting system, a locomotive or a medical scanning device (some of the products with which my group is engaged).

In particular, we become involved in

- Helping design the best possible product
- Guiding the transition from design to manufacturing
- Ensuring we build a consistently excellent product
- Evolving an optimum servicing and problem avoidance strategy
- Leveraging the information on past failures to avoid future ones

We will elaborate briefly on how statisticians add value in each of these areas, and how modern technology continues to add excitement to our roles.

<u>Designing the Best Possible Product</u>

The goal of all commercial enterprises is to make money. Key to this is providing customers the right product at the right time. However, a product is only as good as its design. Thus, we need to understand, up front, what our customers seek (and are willing to pay for). Statisticians become involved in this in developing statistically valid studies of customer needs.

Given this information, we help ensure that the product that is eventually designed meets or exceeds what the customer wants. One important criterion for most products is reliability, or performance over time in the customer's hands. Thus, statisticians are involved in making sure the product will provide close to flawless performance over its designated lifetime. This may involve us participating in a critical assessment of product performance (such as in a so-called "failure mode and effects analysis"), conducting

probabilistic analyses of the system and simulation studies, and the design and analysis of accelerated life tests that provide early identification and removal of failure modes. Particular attention is given to making the design robust to variability in the environment in which the product is to be used. For example, we want our refrigerators to operate successfully in parts of the country with vastly different climates, and for our wash machines to perform flawlessly for customers with widely different laundry loads.

Eventually, statisticians help demonstrate that the product meets or exceeds customer requirements. For a washing machine, this might mean proposing an accelerated testing plan that demonstrates over an elapsed time period of, say, 3 months—and with a high level of statistical confidence, say, at least, 90%—that fewer than 5% of the resulting product will experience serious malfunctions during the first ten years of life!

Transitioning the Product to Manufacturing

Designing a good product and building prototype units that work is one thing. Successfully transferring this design to mass production is quite another. Today's statisticians work with their engineering counterparts, for example, in establishing supplier specifications and test requirements, setting parts specification limits that will help ensure system requirements are met with a high probability, and establishing in-line and end-of-line quality checks. In summary, we need to make sure that the proven performance of the designed product is preserved in the ramp-up to high volume production The initial metric of success is keeping scrap and rework at a minimum. However, the ultimate goal is for the product to perform flawlessly during its intended lifetime in the hands of the consumer.

Ensuring a Consistently Excellent Product

OK—so we have designed a superior product and learned how to build it successfully in large quantities. Our next challenge is to make sure we continue to do so. This is often harder than it may sound, especially when we, and our suppliers, are faced with ever-increasing pressure to make changes that will reduce costs. Fortunately, statisticians have worked in this area for decades, giving birth to the field of statistical quality assurance. More recently, this has been extended to helping ensure not only consistently high end-of-the-line quality, but also equally high field reliability.

Evolving an Optimum Servicing and Problem Avoidance Strategy

We are all aware of the need for routine maintenance for our automobiles. Periodic oil changes and lubrications help extend the life of our cars and keep them in good running order. Sometimes, routine maintenance also identifies impending problems which, when properly addressed, avoid later costlier, and often inconvenient, interruptions of service. Individually, we take periodic medical check-ups and routine diagnostic tests—and increase their frequency with advancing age—in order to address, or mitigate, the impact of previously undetected health problems.

Similar periodic maintenance checks are required for many products, and especially those that require consistently safe operation, such as aircraft engines, locomotives, and power generation equipment. But how frequently should such checks occur and what in-shop maintenance strategy will lead to maximum life? For example, when should we be replacing a $100 part to avoid a $100,000 field problem due to, say, unplanned future shutdowns and expensive product tear-downs? Again, industrial statisticians play a key role in providing the answers.

And what is even more exciting is this - advanced technology now allows us to *remotely* monitor the field performance of systems such as locomotives and medical scanning devices, and to provide early warning of potentially impending field failures so that we can fix the failures before they ever occur, without any interruption of service! One may only wonder how long it will be until we are all wired with devices that automatically dial 911 and bring care our way—before we even realize we have a problem! But how do we develop a system that uses past data to maximize the probability of detecting a forthcoming breakdown,

say, a minute, an hour or, even a day before it happens—while keeping the number of false alarms at a minimum? Well, just ask your friendly industrial statistician.

Leveraging Information on Past Failures

When we fully succeed in each of the preceding endeavors, we will rarely experience failures during the expected lifetime of a product, and that, of course, is our goal. However, in the meantime, appropriately leveraging field failure data provides our last line of defense. We use information on past failures to avoid future failures both for the current design and for future designs.

In fact, as I have suggested earlier, the identification of field problems and especially their quantification and future prediction has, in the past, been the major occupation of many industrial statisticians. A frequently encountered question has been "is the worst behind us, or does what we have seen to date represent only the proverbial 'tip of the iceberg', suggesting, perhaps, that an expensive product recall need be considered"! This so-called "coroner's role" (terminology suggested by Herb Ginsburg) has, in recent years, happily been replaced by the much more proactive tasks described above.

And Much More!

We have described only a few of the many areas in with which today's industrial statisticians are involved, focusing on those that relate mainly to the successful introduction of a new product. There is much, much more! For example, our gang of corporate statisticians is

- Assessing the impact of a proposed programming change on TV viewing.
- Helping determine how to price long term service warranties on locomotives.
- Understanding the root causes of variability in delivery times.
- Determining the optimum line of credit to be granted to consumer credit card holders, based upon past performance and ability to pay.
- (And my favorite example of a few years back) Planning a designed experiment to determine whether birds can tell the difference between jet engine noise and mating calls.

The Best is Yet to Come!

There have been tremendous changes in the industrial statistician's role during the course of my career! I have emphasized the critical the switch from a reactive to a more proactive role. The impact of computer technology has been mind-boggling! I started my career studying orthogonal polynomials-- converting data into "orthogonal" to make least squares model fitting by hand less intractable. Today statistical algorithms are at our customers' fingertips—per a recent Business Week article (see References) on how Pillsbury's technical staff avails itself of statistical analysis via the Web! Moreover, the Six Sigma initiative in my company and elsewhere (see Hahn, Hill, Hoerl and Zinkgraf (1999), and Hahn, Doganaksoy and Hoerl (2000)) has provided management and technicians a basic appreciation of statistical tools and made such tools readily accessible. "Data mining" has become universal and the statistical design of experiments no longer requires a professional statistician. As a result, our role as data analysts is steadily decreasing and is focusing, more and more, on the taming of large data sets.

All of this provides great new opportunities for industrial statisticians to serve as statistical leaders—a term popularized by the late and great Ed Deming (see Hahn and Hoerl (1998)). Statistical leaders engage principally in leveraging statistical concepts and thinking (see Hoerl, Hooper, Jacobs and Lucas (1993), and focus their activities on mentoring and supporting the most business-vital and technically challenging problems dealing with getting the right data, and converting such data into actionable information.

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