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WHATEVER HAPPENED TO COMMON SENSE?
[OR HOW UNFOUNDED ASSUMPTIONS]
[CAN CAUSE SERIOUS TROUBLES]
[IN RELIABILITY TESTING]

INTRODUCTION

The industrial and educational worlds are rife with fallacies which have misled and enslaved thosands of victims who thought they were doing the right thing, only to finally discover that they would have been much better off had they used common sense. Why is it that humans so often tend to make simplistic assumptions under the guise that they are being scientific and rigorous in their approach to a particular problem? Well, in this bulletin we shall give some typical examples in reliability which illustrate how terribly absurd it can be to follow unfounded assumptions instead of using common sense and applying some good judgment based on actual experience. Get ready for some surprises! This bulletin will introduce you to some of them in reliability testing.

THE DEPROGRAMMING OF SUCCESS RUN JOE

Joe was a serious student of statistics and probability. In college he had learned the SUCCESS RUN THEOREM, which so many reliability engineers employ. According to this theorem, a test for reliability to a time target (say, in hours) requires that we suucessfully run a total of 229 engines to the target with no failures permitted, in order to demonstrate 99% reliability of the engine design to the time target with 90% confidence.

Joe told this to his boss. whose name we shall call Mr. Director, since he was the director of engine testing. When Mr. Director heard that he must have a success run of 229 engines he grinned understandingly "Why Joe, how did you ever come up with such an answer? ,inquired Mr. Director. "Oh, that comes out of the SUCCESS RUN THEOREM", replied Joe.

The conversation proceeded between Joe and his boss as indicated below:

SPEAKER	REMARK
Mr. Director:	"I don't believe we need 229 engines."
Joe :	"But, that's what the theory demands."
Mr. director:	"I think we can get by with 6 or 7 engines."
Joe :	"How do you figure that?"
Mr. Director:	"Because I know from past experience that we'll never have less than 90% reliability."
Joe :	"Oh, I see -- I was assuming we could have 0% ."

SPEAKER	REMARK
Mr. Director:	"Furthermore, I have found it reasonable to assume the true rank in the interval 0% to 10% is parabolically distributed."
Joe :	"You mean it isn't a rectangular distribution."
Mr. Director:	"That's right."
Joe :	"What shall I do now, Mr. Director?"
Mr. Director:	"Why don't you figure out how many engines are needed when we assume no more than 10% will be bad (to target) and that there is a declining parabola as we go from 0% to 10% failed on the ranking scale?"
Joe :	"OK, I'll see what happens."

Joe went back to his desk and started deriving a new COMPRESSED SUCCESS RUN THEOREM based on a minimum reliability of 90% with the parabolic curve for ranks in the total range (0% to 10%) of possible fractions failed. After working a couple of hours on this new formulation, Joe was all done and went to knock on Mr. Director's door. "Come in, Joe", replied Mr. Director. "What did you find out?" "I found out that you were right -- all we need is 7 engines."

Then Mr. Director told Joe with a smile how just common sense had told him that the 229 engines originally proposed was a ridiculous number, based on the wrong assumptions. In this way, the boss had deprogrammed Joe away from the false belief which had been instilled into Joe's mind by his college instructor.

THE STORY OF CHARLIE AND HIS ARBITRARY CONFIDENCE

Charlie was the supervisor of the engine testing program at XYZ, Inc. The top management of the company had just informed Charlie that they had been granted a contract to build 200 engines annually for 10 years, for use in a special type of application. Each annual production has to be able to run trouble-free for 1000 hours. So, this means that there must be less than 1 chance in 200 for a failure annually. Then Charlie reasoned that the reliability of these engines to 1000 hours must be at least 1 - 1/200 = .995 . Charlie discussed the testing problem with top management, and pointed that a reliability of 99.5% for 1000 hours must be demonstrated. So, Charlie said "We'll work toward 90% confidence for this reliability of 99.5% to 1000 hours."
"From where did you get that 90% confidence figure?" asked one of the officials who was listening in. "Oh", replied Charlie, "Just off the top of my head. 90% confidence sounds pretty good, doesn't it?"

There followed a discussion between the same official and Charlie, as given below :

OFFICIAL : "I think we need a firm basis for our confidence."

Charlie : "What basis can you think of?"

OFFICIAL : "Well, I estimate that a catastrophic failure of an engine could cost us a loss of 3 million dollars, while at $1000 profit per sold engine would give us $200,000 from 200."

Charlie : "OK, if we have 90% confidence of living up to the required reliability (99.5%), then there is 10% confidence of failing to comply."

OFFICIAL : "That's right. In other words, 9 times out of 10 we would make $200,000 clear, while 1 time in ten we could have a net loss of $2,800,000."
"So, the 9 times of success yield 9 x $200,000 = $1,800,000
and the 1 time of catastrophic failure loses - $2,800,000.
For 10 sets of 200 this is a net loss of -$1,000,000."
"Thus, 90% confidence (9 to 1 odds) is inadequate."

Charlie : "This raises the following question: How many times larger do we want all gains to be than losses?"

OFFICIAL : "In the long run we want gains to be at least twice losses. Then we would never lose more than half of our possible gains."

Charlie : "So, this means that the ODDS in favor of reliability compliance must be twice the ratio

$$\frac{\text{Catastrophic Loss possible annually}}{\text{Successful Gains possible annually}}$$

i.e., (2 x 3,000,000)/200,000 = 30/1 ."

OFFICIAL : "So, what confidence is implied by 30 to 1 odds?"

Charlie : "30 to 1 odds implies a confidence equal to 30/31 = 96.8% ."

OFFICIAL : "So, you see, Charlie, a confidence level is not a number off the top of someone's head. It comes from GAINS & LOSSES."

Charlie : "I sure learned something important from this discussion."

Thereafter, Charlie never again assigned confidence levels for reliability tests in an arbitrary fashion. He had learned an important lesson in financial common sense.

CONCLUSION

From the stories of SUCCESS RUN JOE and CHARLIE'S ARBITRARY CONFIDENCE, we can see how common sense must be exercised and how unfounded assumptions can cause serious difficulties.

APPENDIX

We did not include the details of the mathematics involved in the problem which SUCCESS RUN JOE had to solve , since this would be of no interest to most people. Also, in regard to CHARLIE'S ENGINE TESTING PROBLEM , we have not elaborated on the required sample size which Charlie established. Anyone interested in these details should attend the special seminar put on by DETROIT RESEARCH INSTITUTE under the title "NEW AND EFFECTIVE METHODS IN STATISTICAL RELIABILITY" , which emphasizes similar practical problems. For those people especially concerned with engine testing we recommend our special seminar entitled "STATISTICAL DESIGNS FOR TESTING ENGINES AND POWER SYSTEM ASSEMBLIES".