Engineering Ethics Cases with Numerical Problems

from an NSF & Bovay Fund sponsored workshop

August 14-18, 1995

Texas A&M University

Electrical Engineering Case 11

TV Reliability Problem

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I. Narrative

In the design of any system, one of the critical problems is to making sure that the system will operate when it is required to function. This is especially critical when the system has many subsystems and design constraints. The entire system cannot function as expected unless each and every subsystem in the system performs as expected. We define the system reliability in terms of the reliability of the elements of the system.

Assume that Engineer Doe decides to own and operate a small TV station called DOETV.

Doe has the option of buying new or used subsystems to put the TV station together. The TV station consists of five main subsystems with different reliabilities. The five subsystems must be connected in series as shown in Figure 1 for the system to operate as expected. The targeted audience is about 80% of a region of about 100,000 residences. The overall reliability of the five subsystems in Doe's TV station must be equal or greater than 0.40 in order to reach the targeted audience. Doe has promised his advertisers that their advertisements will reach the targeted audience of 80% or more in the region within his area of operation. The advertisers are therefore relying on this information to plan for the market share of their products.

II. Numerical Problems

Problem 1. Suppose the five new main subsystems have reliabilities of 0.85, 0.88, 0.90, 0.95, and 0.98 respectively.

(a) Determine the overall reliability of the entire system.

(b) Does that meet the acceptable reliability requirement for the targeted audience?

Problem 2. Assume that it costs about $10,000,000.00 to obtain an overall incremental increase in reliability of 0.1. What is the reliability cost of problem 1 where new subsystems were used?

Problem3. Doe realized that money could be saved by using used subsystems. The used subsytems have lower reliabilities.

(a) How much money was saved by using five used subsystems with reliabilities of 0.45, 0.50, 0.55, 0.65 and 0.70 respectively? Use the overall system reliability cost estimate of problem 2.

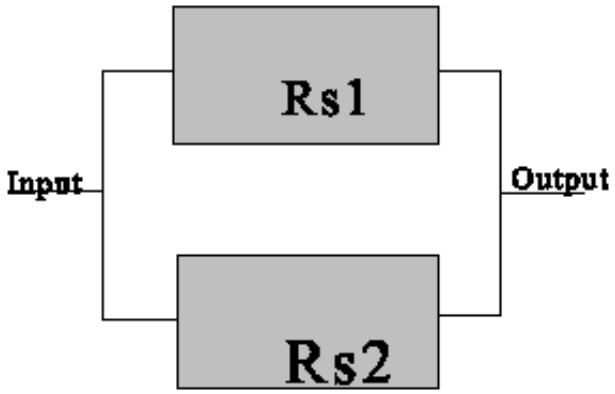
(b) Is the acceptable overall system incremental reliability requirement meet in this case?

4. Assume that Doe decides to increase the reliability of the overall TV station by using the system configuration shown in Figure 2. The reliabilities of both the first and second sets of the subsystems are the same as in problem 3.

(a) Determine the increase in system reliability.

(b) Using the cost estimates of problem 2, determine the costs of the reliability for this system.

(c) Does the reliability of the overall system meet the acceptable requirements for the targeted audience?



III. Ethical Issues

1. Doe promised his advertisers that he would meet a targeted audience of about 80% or more of the residences in the region within the area of operation. However, he did not meet this require-ment because of the used subsystems used in putting together the TV station. The reliability requirement needed to meet the 80% targeted audience is 0.40, but the TV station had a reliability of less than this, as demonstrated in numerical problem 3. Doe therefore, is not being honest to the advertisers. What should Doe have done considering the fact that he promised the advertisers that the TV station will meet the targeted audience of about 80% or more of the residences within the region of operation?

2. When Doe got his TV license from the FCC, the frequency of operation assigned to the TV station was such that it will cover the region inhabited by the 100,000 residences. No other TV station was to operate within this frequency. The public relied on DOETV for information etc. When Doe did not meet this obligation, the TV station did not only fail the public but deprived some members of the public the information they needed. Has Doe violated any aspects of the relevant professional codes?

IV. Solutions To The Numerical Problems

PROBLEM 1.

Let R1 be the reliability of subsystem 1, R2 the reliability of subsystem 2, R3 the reliability of subsystem 3, and Rk is the reliability of subsystem k. The arrangement shown in figures 1 and 3 imply that all of the subsystems must work to ensure success. Since the system fails even if one subsystem fails, the reliability of the entire system Rs is given by the product of the component reliabilities

$$R_s = \prod_{k=1}^{n} R_k = R_1 R_2 R_3 R_4 \ldots R_n$$

where Rk denotes the reliability of subsystem k.

Therefore,

(a) Rs = (0.85)(0.88) (0.90)(0.95)(0.98) = 0.627 = 0.63.

(b) YES, it meets the acceptable reliability requirement for the targeted audience. It only requires a reliability of 0.40 to meet the targeted audience.

PROBLEM 2.

It costs $10,000,000.00 for overall reliability of 0.1.

Therefore, for the calculated reliability of 0.63, it will cost

Rcn = [(0.63)/(0.1)] x ($10,000,000.00) = $63,000,000.00 or $63M.

PROBLEM 3.

(a)(i) Rs = (0.60)(0.65)(0.70)(0.75)(0.80) = 0.232 or 0.23.

(a)(ii) Rcu = [(0.23)/0.1)] x ($10M) = $23M.

(a)(iii) The savings will be

Rcn - Rcu = $63M - $23M = $40M.

(b) NO, the overall system requirement is 0.40. Since the calculated overall system requirement is 0.23, it is vey much less than the required reliability value.

PROBLEM 4.

(a) From the parallel configuration that Doe used, the overall system reliability will be

$$R_p = 1 - (1 - R_k)^k$$

Therefore, Rp = 1 - {(1 - 0.23)(1 - 0.23)} = 1 - {(0.77)(0.77)} = 0.41

The increase in reliability is

Ri = 0.41 - 0.23 = 0.18

(b) Cost for Rp = [(0.41)/(0.1)] x $10M = $41M

Cost for Ri = [(0.18)/(0.1)] x $10M = $18M

1. YES, it meets the overall system reliability requirement. The overall system reliability requirement should be equal or greater than

V. Solutions to Ethical Issues

Note: Some cases involve issues that are difficult to decide. Other ethical issues are rather straightforward: we know whether an action is right or wrong. Most of the ethical questions raised in this case are of this type. It is good to remind ourselves that many -probably most-ethical decisions are not difficult.

Even here, however, we may not know the best way to implement our ethical decision. That is, we may not know just how the person should carry out his ethical obligation. This case raises some of these kinds of question.

1. Doe wants to save money, but he also has an obligation to his advertisers and to the public whom his station is suppose to serve. He should probably get rid of the used equipment and buy new equipment. If he cannot afford new equipment, he should consider selling the station or attempting to raise more capital by selling stock in his company.

1. The Institute of Electrical and Electronics Engineers (IEEE) code requires members to "accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public …" If we regard his decision to use second-hand equipment as an engineering decision, he has not acted in a way that is consistent with the welfare of the public, because public welfare is not being served by the faulty equipment.

The IEEE code also requires members to "avoid real of perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist. Specifying equipment for his own station is an example of conflict of interest, and this conflict should have been made known to those affected.

The National Society of Professional Engineers (NSPE) is a professional organization to which all registered professional engineers can belong. The NSPE code requires engineers to "avoid all conduct or practice which is likely to discredit the profession or deceive the public.: If Doe is a member of this organization, his action appeared to both discredit the engineering profession and to deceive the public. Therefore, his action also violated the NSPE code of ethics.