Impossible engineering by Eric A. Bharucha

1)Mystery robot death

I was informed that multiple failures of an inspection robot were common it slowed down pipeline installation from offshore oil rig costing millions of dollars in downtime and delays in exploitation. Adding insult to injury, transporting the robot to shore by helicopter to a service center was cost on average 5K$ not including the repairs and even more when a loan unit was lent out.

Speaking with personnel from to operators, repair service technicians I also gathered that failures occurred more often in the morning and one part seemed to fail consistently regardless of the component damages. Service statistics also revealed noticed the highest concentration of service calls occurred in the south pacific from late October to April, or during monsoon season.

Using a 20$ table top humidifier from Walmart, I demonstrated the failure point of the system and zerod in on a 18 $ power supply that was purchased with no clean flux residues. Later demonstrated the failure using 5 cent plastic dropper and water exactly were the chicane in the ventilation system was creating a condensation point where one drop would cascade a catastrophic system failure. I issued a ECO such that he power supply de cleaned and coated in waterproofing varnish and the ventilation be deviated by a few mm. the problem never recurred. Prior to resolution he system had caused 11 years of repeated failures an estimated 1.4 million dollars in service charges 75+ million in lost revenue for clients. Sometime after the last incident sales picked p and the unit regained popularity selling 34$ million dollars more in revenue after its schedule removal from the market

2)In the blink of an eye

Clients around the world using a sensor interface product that was selling well began experiencing random failures and returning their units for replacement costing the company tens of thousands a month to the point where the replacement were offsetting sales into loss territory.

A sales representative provided a unit and host devices that consistently failed. Quickly I zeroed in on one particular chip in the device that seemed to initialized incorrectly. However other chips from the same manufacturer worked. AS it turned out there were 2 manufactures both claiming equivalence to one another. Combing through record and inventory I noticed that all failures came from one manufacturer only, but the other one was going into obsolescence. After investigation it was noticed that one device required 1 ms to startup while the other required ‘around 100ms’. Looking onto the latest version of the code and working with the software team I realized that 100ms was hardcoded into the latest release but some devices required into 130ms to startup. Simply changing the startup delay to 300ms and issuing a updated software solved the problem for all clients. And sales picked-up again.

3)Safety: red, black and blue

Production stopped on a lucrative production line of electronic equipment where I was an R&D engineering supervisor. I received a call requesting my help because all of a sudden, some connectors on sensitive equipment began failing QA test. When initially informed of this, I was told that the neither personnel or procedure had been changed in the assembly procedure. After a little digging, I discovered that a rubberized coating supplied

by a contractor had been replaced a few weeks prior. Upon inspection the black coating was an 'equivalent' replacement for waterproofing joints and seams. When looked at eh MSDS I quickly noticed it contained carbon black which could create parasitic impedance in the connector. After testing, this hypothesis was quickly confirmed. The impedance was due to the coating and it would worsen as this coating cured fully. The gravity of this effect was dependent on the time delay between production and QA. After finding this I quickly called the production manager and told him to get the blue one instead, as that should solve the problem. A production foreman called me a few hours later, shouting. 'Do you think you are god!' I replied calmly, what do you mean by that. As I explained that the black compound contained carbon and detailed why this was creating partial shorting in the connector, he cut me off angrily and replied: 'There's red and it's 7% cheaper why did you pick blue...'. I then said the red contained benzene and was carcinogenic. He then pardoned himself a wavering voice and thanked me before hanging up. I later found out his brother had died from chronic chemical exposure a few weeks prior.

4) Up and away

An aerospace PCB that had undergone extensive testing including: cryovac, shake rattle and roll testing, burn in etc. Was approved for space duty. During the first mission the system failed miserably and was partially recovered showing delamination of the PCB unit and component failures in excess of what seemed possible. Asked to lend a hand I started focusing on the mechanical assembly techniques rether than electronics when I realized that the new mechanical brackets were slightly different. They lacked thougholes, this caused a pressure build-up in one corner fastener inside the mounting fastener cavity. This resulted in fracturing of some mounting holes during depressurization and creating excessive vibration in that specific area. This had not been caught in simulation because prior brackets did not have this sealed cavity as previous mounting holes went through and through. Making a small hole in the bracket to extend it in the back solved the problem. Retesting the bracket and PCB under cryovac showed the failure with and without the new modification. The following mission was successful and this unit still in flight has never had a recurrence of this failure.

5) 2200%+ Implant improvement

Some years ago, I was given an academic implant prototype and told to make it regulatorily compliant. As we began testing, I quickly realized that the circuitry although functional, had little been designed without consideration towards safety or energy efficiency. After complete redesign and testing under my leadership the unit was approved and underwent clinical trials. The final longevity with the same usecase moved from 4 months to 7.4 years on a primary battery.

6) 168 hours

Midweek an intense design blitz, charge injection from digital controlled analog switches were causing a non-compliance during validation 3 weeks prior to client scheduled testing. The problem was solved by finding the actual chip designer and talking to him. The next morning, I had figured out a solution based on the previous evening's discussion and hand wired prototype without the charge injection glitch. During a 3-hour, nap I had a technician layout the modified circuit, and sent in for fab that afternoon. By Friday I had a new PCB and by Tuesday working prototype falling back into schedule...in 168 hours.

7) Surprise recovery

After several delays and compliance issues, a very complex and integrated die level PCB design was sent to an assembly facility for a first prototype. The tight schedule was making management staff and investors nervous

but having designed and tested the system thoroughly, I was confident integration was going to work. In the weeks leading up to the deadline the delivered prototype failed and no other runs were scheduled. I quickly noticed a wired bonding error in imaging of the device, and obtained a quick turn around from the contractor explaining the project would fail without their help. Despite not being in authority to guarantee payment of this second trial run, they went along with a trial run with the correction as the error came from a technical issue on their side. As the project deadlines approached we were able to continue working on the system. The day of the deadline, a meeting was scheduled to assess the delay on the program and whether to continue or abandon the design at great loss to the company. The conference room was filed with program managers the chief scientific officer and accounting managers. Filing in a minute before the start, I sat next to the door and I let the entire team vent. Many expressed dissent; frustration with slow progress; overly ambitious objectives and even some name calling... As my turn came, I took a deep breath and, with a stone face said: 'Well I was confident that we could deliver the prototype by today, and I understand your frustration with the delays and problems that we were experiencing, but they are all surmountable'. As some started laughing, I knocked on the door, a technician rolled in a lab cart with the implant in saline and telemetry and oscilloscope showing the completed device and proper signals. The meeting ended quickly, without a vote, and many detractors stormed in the CEO's office to tell him 'they' had succeeded...The project was one of the most successful was sold went into a large clinical trial.

8) Molecular problems

I was brought into a lab to solve a problem that had plagued to graduate students for 6 months one working on a PhD and a Master student. Both had tried to develop a process in molecular biology involving long PCR, for several months. Using physical chemistry and other techniques, I started from scratch optimizing all solutions and testing gradients to determine peak performance. After a week of work, I had good results even beating out the performance from a kit from Roche pharmaceutical in the second part of the assay. Both students graduated with scholarships and published work from the developed protocol.

9) Electro-optical design

Recently I was approached to design build and test optical equipment. The old design was finicky required manual alignments and was prone to requiring readjustment in the field. Not an optimal situation given the device was used in a wet lab for medical assays. Several well-known large corporations were approached to replace this critical module in the system. They all said no bid. This is when I stepped in and asked to have a go at it. After 3 months of part time work, I had a field ready system with thermodynamically stable design miniaturized optics, custom electronics, firmware all packaged in a metal enclosure, production ready with an automated alignment process.