HOW DO ENGINEERS SOLVE PROBLEMS

Make sure you understand the problem

One of the biggest cause of project failures is not being clear about what problem you are trying to solve. If you don't have a clear view of the target you will be unlikely to hit it. Your first priority is therefore always making sure that you really understand the problem. I have personally encountered many situations where the people who consult me about engineering problems do not themselves really understand what is going wrong: what they *need* may not be what they *want*. Ask questions, probe and do not accept easy answers.

- Some aspects of the problem are usually more important than others. The ones that your solution *must* address are the **critical** issues. For example, the control systems of an aircraft should never fail for any reason. (Though aircraft makers have sometimes got this wrong, with deadly consequences.)
- The others are **non-critical** and you may be able to trade off doing better on some of these criteria against doing worse on others. So, you may decide, in consultation to your client, to reduce the scope of what you hoped to achieve in order to reduce costs or deliver more quickly. (You offer the `standard' rather than the `premium' service.) This happens all the time in the real world.

Try to avoid prejudging the solution when stating the problem

So, I say: "*Recover debris from a nuclear reactor*." I don't say "*Design a steel grab to recover debris from a nuclear reactor.*" There may be a better way. (Perhaps a "soft" robot - a bit like an octopus for example - would be better able to handle a wider range of irregularly shaped objects. Don't laugh - people are really working on "octobots"!)

Learn to Recognise Potential Solutions

When a problem has critical attribute you have to find a solution that addresses *all* the critical attributes. For example, I might suggest that your design needs to 1) get into awkward places *and* 2) pick up debris *and* 3) bring it out. Doing two out of three may be an interesting step on the way to a solution but it is not a solution. (In fact, putting a robot into a nuclear reactor and getting it stuck makes the original situation a lot worse.)

If you cannot fix the gaps, then you dismiss the ideas that do not address *all* the critical aspects, and you are left with the possibles.

After that, you may have to worry about: What it will cost? How easy will it be to build? How long will it last? What human skills are required to do the work and do we have them? These are important ways to find the *best* solution. It is rare to find that one of the options ticks all the boxes. We often have to compromise and there is usually no simple way to rank the options: this is where we exercise *engineering judgement*. Those who show good judgement become chief engineers and earn large salaries.

Then and only then you decide which option (or sometimes options) you will take forward to a detailed design study.

Steal Ideas that Work!

One of the best definitions of engineering is "learning from other peoples' mistakes". To a large extent, engineering is about improving and adapting solutions that have already worked to the current problem.

- Stealing ideas is OK and even applauded in engineering provided it is not covered by a patent.

Learn from Nature

Natural organisms have spend millions of years evolving good engineering solutions to common problems. Watch and learn! This is now the very respectable engineering discipline of `biomimetics'.

Combine Solutions

A good way of being inventive is by combining bits of solutions that do not in themselves do everything we need, but they may do when put together. Not so very long ago executives used to carry mobile phones and "personal digital assistants". They might also have had personal music players and cameras. Then Steve Jobs complained about carrying round all these little boxes and told his engineers to build the first iPhone.

Try it "The Other Way Round"

I once had the very difficult computing problem of trying to predict the way the a shape changed over time inside a nuclear reactor - that is, I wanted to be able to say "*In six month it will look like this*." I found I could calculate the sequences of shapes we had to go through but some small shape changes took much longer than others to happen, and I could not do the calculation in a step-by-step way, say minute by minute, as you might see it in a movie, without the whole thing taking more computer time than I had available. Fortunately, I found that one attribute of the solution - the total amount of material that had burned away - had to be closely related to the time, and I turned the whole thing round and reduced the total computing time by a factor of 100. It took me hours of discussion to get my boss to approve the project report because I had to get him to see the problem in a different light. Eventually: "*Oh! I see! It is really obvious!*" They are the triumphs you remember.

During the second World War German bombers were using a new radio navigation system to guide them to targets over London. R.V. Jones, later a physics professor at Aberdeen, famously devised a method of interfering with the system in order to fool them into dropping bombs where Britain wanted them to fall (in open fields). This is now know as the "*Battle of the Beams*". I was once lucky enough to hear him talk about "*The Other Way Round*" where he explained how a slightly different point of view can turn a failed solution into a solution to a different problem. (The "Post It" note is the result of a failed attempt to develop a very sticky adhesive. The un-sticky adhesive they discovered turned out to be a wonderful solution to a different problem.)

I have used this advice profitably many times.

Learn from Experience

When we started a new job at EdF Energy the very first question we ask is "*Have we done this before?*" (By this we really mean "*Has anyone we know about done it before?*") We then ask "*What did we do right*?" and also "*What did we do wrong?*"

Speak to any athletics coach or music teacher in the world and they will all say that the way to improve is to do less of the things that do not work, and to do more of the things that do work. The first step on this road is learning to be highly self critical of your own performance. (This is why CREST assessments have a `self reflection' requirements.