Engineering in a Season of Pandemic

What does engineering have to contribute to a pandemic response? Superficially the answer might seem to be, well probably not much; but further reflection may indicate engineers have more to contribute than first meets the eye. Many practices familiar to engineers in their normal work process are almost directly applicable to solutions to pandemic response,

- Design, maintenance, and operation of protective systems that overlay processes with potential harms during upsets,
- Data analysis leading to root cause and subsequent solutions addressing the root cause,
- Data analysis and revision to the efficacy of solutions developed to address root causes.

Although not normally engaged directly in disease progression, engineers are the ones who quite effectively design the protective systems used in hazardous processes; protective systems are designed to "squash out" exogenous and endogenous events. When a pandemic is triggered, the response to it requires protective systems much like the protective systems designed to squash out events in hazardous technological processes. Of course biological systems are not necessarily as familiar to engineers as technological systems but the lines are beginning to blur with the bioengineering fields making significant inroads in several areas.

Engineers also engage in "changing the future", predicting the effect of actions they impose on maintenance policies for equipment; this is an activity in the field of reliability engineering. They use past data to inform maintenance policy, revising those policies associated with problems that produce "the most pain." Engineers seem to deviate somewhat from virus investigators on this point as they are very wary of using past data to inform the future, they know error bounds on interpolation outside the data range quickly become intolerable; interpolating beyond the data range looks to engineers like someone driving a car looking in the rearview mirror.

Root cause analysis is shared with the virus researchers however, in a situation like the current pandemic, engineers may be more capable to effect large scale solutions. An example is nursing homes where sadly an airborne-transmitted disease spread is exacerbated by staying indoors and sharing air with others; clearly massive air exchange is required.[1] Engineers have already dealt with this problem for example in paint booths; they have even solved the problem of excessive cost in these situations using "heat wheels" to recover effectively all the cooling or heating effort. Large scale HEPA filters and other air particulate control are already used for example in computer chip manufacture and cleanrooms.

Given a problem to solve, engineers know how to quickly respond and adapt when things start to "fall apart" in critical applications. Most engineers may not be familiar with Bayes theorem, but they commonly use this "learning method" to adapt designs in almost real time; it is much like practical application of the scientific method where a hypothesis is tested (initial design) and data are reviewed that either support or refute the hypothesis and in each iteration, they learn, revise, and adapt.[2] They have honed the methods they use over many years in the pursuit of reliable and cost effective solutions to industrial problems; this differentiates scientists from engineers; the engineer will apply scientific principles up to the point of practical economics. As with Bayes theorem, many engineers may not be familiar with developing optimal solutions at the level of formality found in the discipline of Operations Research, but they certainly know how to apply the basic concepts of calculus and differential equations to help guide them to optimal solutions.[3]

[1] Although other mechanisms may also be significant, it appears that airborne spread through mist or droplets is a predominate mechanism. https://www.scientificamerican.com/article/how-coronavirus-spreads-through-the-air-what-we-know-so-far1/, accessed 17 June 2020.

[2] Bayes theorem closely follows intuition but has a formal mathematical definition used by probabilistic analysts. https://blogs.scientificamerican.com/cross-check/bayes-s-theorem-what-s-the-big-deal/, accessed 17 June 2020.

[3] Engineers know that the first derivative of a function will give a minima or maxima (from the second derivative) is an optimal point but generally are much less formal, for example asking about local or global solutions. https://www.informs.org/Explore/Operations-Research-Analytics, accessed 17 June 2020.