[preface to the undergraduate textbook:]
Regenerative Engineering
engineering symbiosis and resilience
Sam Iam / Salvatore Gerard Micheal

Preface:
So what is the essence of regenerative engineering? First we need to say what it is not:
robustness in computer science is the ability of a computer program to handle execution and input errors. It's a wonderful concept and is very important for the discipline. To make a system *robust* is *desirable* but it decidedly is *not* regenerative engineering.

There are two terms from biology we need in order to define regenerative engineering properly:
symbiosis and
resilience.
Symbiosis is nature's way of helping *two distinct organisms help each other* that – in the process – *satisfy some basic need for each alone*. Escherichia coli, in our intestines, is the most obvious and common example. But let's think about something less obvious: the honey bee and flowering plants. Honey bees extract pollen from flowers, use it to make honey which is food for bee larvae. In the process of going flower to flower, they fertilize the plants they visit, helping those plants sexually reproduce. Without bees, flowering plants would have difficulty reproducing. Flowering plants and honey bees are a recent evolutionary development. It's fairly well established that they *evolved together*, interdependent and symbiotic. Here's the catcher of the story: ***we eat honey***. For readers who believe in God, it's almost as if God ***engineered this symbiotic relationship*** for us. Which brings us to one *core component* of regenerative engineering: ***symbiotic relationships***.

A bad marriage could be labeled "codependent"; a good one: symbiotic. But symbiotic relationships do not have to be between people. *They can be between engineered systems* ***we***

design. This is one core component of regenerative engineering.

The other primary synthesis is *resilience*. It's a little more difficult to define and understand as it applies to RE. From systems ecology, one of my hobby areas, *biological resilience* is the organisms'/species' ability to "bounce back" from systemic disturbances whether natural or artificial. Because resilience is a bit more ambiguous than symbiosis, it's harder to "nail down". Let's look at an example from history. After WWII, America helped Japan rebuild and reestablish itself as a world economic power, one to be reckoned with. They agreed, and perhaps more importantly to follow through, with stipulations of the Treaty, namely a maximum of 5% of the national budget spent on military defense. The symbiotic relationship between Japan and the US emerged/evolved over time via *good will on both sides*. But deeper than that historical analysis is the analysis of *Japanese culture from an anthropological point of view*. I believe the spirit of the Japanese people did not die with the end of WWII; it was ***transformed***. Transformation can be personal, community, or global. The term implies ***enduring positive fundamental change***. This brings us back to resilience; as you can surmise, resilience is ***NOT*** robustness but something more like adaptability/plasticity. In evolutionary terms, it's a species genetic ability to adapt over eons. So in systems terms, it's *a system's ability to adapt over* ***decades/centuries of use***. This means we can't do "quick and dirty" engineering / patchwork engineering / non-holistic engineering if we ***earnestly*** want to practice regenerative principles. The ***CORE*** of regenerative engineering is ***designing resilience*** into our systems.

The next section is dedicated to the notion *frame-switching*. *How we frame a problem defines a solution set*. To fully comprehend framing is a bit like engineering resilience. It's not just thinking "outside the box"; it's more than realizing the "box" is a product of your mind. Frame-switching is essentially *reformulating a problem* that

is perhaps ill-defined. Easy to say but ***HARD*** to practice sometimes. So the "trick" of frame-switching is *implementation*. Frame-switching is a ***process***:
1. develop a model of the system, identification
2. attempt to validate it, verification
3. test the model, prototype it
4. test the prototype, implementation

For educated readers, this process seems awful familiar, right? Of course it's the *systems approach* but remember we're not "doing" systems engineering here; we're attempting to *define* frame-switching .. An example problem is good to review. I call it the "tall room problem": imagine you're stuck in a room with no visible supports, no way out except a doorway to your left, you look up and see two ropes hanging from the ceiling 100 feet up, you look back to the door and notice a knife and a sturdy post cemented into the floor just in front of the doorway, you peek out the doorway and notice the room is somehow suspended 200 feet off the ground, you realize you can't jump out without killing yourself, and finally you notice a signed note from me that says "there are at least two ways to use the ropes, knife, and post to get down safely xxx". You pinch yourself to make sure you're not dreaming and I wouldn't be surprised if you're cursing me .. I'm ***NOT*** going to give you the solution. If you care about yourself, don't look it up and don't ask a friend.

Think about that scenario if it was *for real*. You screw up one time, you're *dead*. Similarly, non-renewable resources on this lovely planet are decidedly *finite*. As engineers, we're *morally obligated* to *conserve* non-renewable resources for future generations, hell, for the *future of the planet*. Engineering "at any cost" is a luxury we can no longer afford, as if we ever could. We're *way beyond* the "three Rs" and conservation here; if we don't practice regenerative engineering in ***every*** endeavor from now on, it could easily mean the *extinction* of homo sapiens. Every single reader *knows* in their *gut* this is true .. Rephrase the problem above replacing you with Earth. The knife represents technology, the ropes non-renewable resources,

and the precariousness of the situation — our time in human history. What will we do with the knife? With the ropes?

As you can see, frame-switching is hard to define and very hard to implement. That's obviously an understatement. I'm reminded now of my daughter Hope, only 1.5 years old. There's a sanctimonious quote from the Bible about love, but I rephrase it thus: "There is hope, hope, and Hope. And the greatest of these is Hope." ***THAT*** is how much I believe in my daughter.

If you cannot believe in yourself as an instrument of positive change, stop reading and give this book to someone who can. I'm crying now as I write these words. If you're not, maybe you should check your species.

Love, Sam Iam / Salvatore Gerard Micheal