[SQUEAKING]

[RUSTLING]

[CLICKING]

RICHARD DE NEUFVILLE: Richard de Neufville again. The previous segment that I prepared for you is to describe what the flow of averages is. But now, we're talking about why it is important.

And it's important because the standard practice that evaluates the performance of a system, under the most likely or the average conditions, gives you the wrong answer. If you do that, the result is the wrong estimates of the performance of any particular design, consequently the wrong ranking of the alternatives, and consequently the wrong choice of design. That is, unless you really look at how the system performance occurs over the range of possibilities, the ranges of demands, the ranges of performance, and ranges of prices-- unless you do that, you get the wrong answers.

Mathematically, they may be correct, but they're not what's going to happen. And you get the wrong choice of design. That's why you should care about it. That's why you should not be a victim of the flaw of averages.

So just let me put it in-- to show you how this works, to give you a concrete, a specific example, let's suppose we have a very simple measure of performance, which is that this f of x is equal to x squared plus 2, and that x can have-- with equal probability, it can be 1, 2, or 3. So on average, the average value of x is 2.

If we evaluate this function using that average value, we get x squared is equal to 4 plus 2, result 6. But that's not what the average value of that is. If we calculate it with x is equal to 1, we have 1 plus 2 is equal to 3. If x is equal to 2, it's 6, but if x is equal to 3, it's 9 plus 2, 11, all with equal probability.

And the average value of this is 3 plus 6 plus 11, divide by 3, which is 6 and 2/3. And it's not the 6 that is the value we calculate using the average. So the point is very simple-- that if you don't use the whole distribution, you'll get the wrong answer.

Now to be fair, there is an example, a counter-example. That is, if the situation is totally linear-- so I have an equation like the function is x plus 2, and you have 1, 2, or 3 with equal probability-- in that case, they are the same. But the world is not linear.

The world is, in fact, our systems, are almost always guaranteed to be non-linear. There are step functions. That is, we build one plan, and then we build another plan. So the capacity goes from this level in a step function to another level.

There are changes in prices. There are economies of scale. There's all kinds of things that happen. The world is not linear. So in general, the flaw of averages holds and you get the wrong answer if you use, if you base your calculations on, the average or most likely value.

So what are the practical consequences? Since the world is not linear, unless you work with a distribution, you get the wrong answer. It's as simple as that.

Any calculation done based upon a single expected trajectory of demand, or costs, or performance, rather than the distribution, gives you the wrong answer. The answer from a realistic distribution of what might happen differs from the result you get from the averages. So why is that? Because very often, the gains when things go well do not balance off the losses when things do not.

| have a visual example here that may be interesting to you. Here is a story of the drunk walking down the middle of the road. On average, he's in the middle of the road. The cars pass and don't hit him, but on average, he is hit by a car, in fact, and is dead. Do not be a victim of the flaw of averages.