Mars Lander Paradox

Gabe Ehrlich

Let's say you're in charge of route planning for a Mars lander mission. The lander will travel out to a scientific site and then return to base with a sample. Every mission has risk, so your funders have tasked you with coming up with a route that keeps the chance that the mission will fail below 5%. (Treat all probabilities in this scenario as small enough that $1 - (1-p)(1-q)$ can be approximated by $p + q$.)

Your geographical (marsgraphical?) survey indicates two routes: one longer and safer and one shorter and more treacherous. Your team calculates that during any one-way trip along the longer route, there's a 2% chance that the lander will fall into a crevasse and the mission will totally fail (otherwise the lander will arrive unscathed), and for the shorter route that number is 4%. If you can shorten the route you will, because wear and tear is expensive and reduces the lifetime of the lander. Unfortunately, based on the risks for each route, you conclude that the only way to keep your risk within acceptable bounds is to take the longer route both ways.

Flash forward a year and it's now a few days into the mission. The lander has taken the longer route and has arrived safely at the sample site and collected the sample. Your plan was to return along the longer route with 2% one-way risk, thereby keeping the risk for the entire mission below the 5% threshold. Unexpectedly, your team comes up with another idea. They argue that since the lander has successfully completed the first portion of the trip without failure, the only relevant risk comes from the return trip, and hence the shorter route with 4% one-way risk is acceptable. The initial 2% risk doesn't matter because the lander didn't fail. You see their point and you announce your decision to take the shorter route back. You're about ready to pull the switch when the project's funders call.

The funders counter that if this decision had been made from the beginning—taking the longer route there and the shorter route back, assuming safe arrival at the sample site—then the total risk would be 6%, which exceeds the acceptable threshold. They have many investments to manage, so they explain it this way: if you had 100 Mars lander route planning teams who decided it was okay to plan to take the longer route both ways, and then change their minds if they arrive safely and take the shorter route back, then you would expect 6 of them to fail (2 on the outbound trip and an additional 4 on the return trip), which exceeds the 5% risk threshold. Therefore you're obligated to take the longer route back.

Who's right?