



Counting Jelly Beans (or buying a Multibeam System)

by Pat Sanders

COUNTING JELLY BEANS

Let's pretend you work for a company that makes jelly beans. Your boss decides you need a new 'jelly bean counting and packaging machine' that continuously counts out a bunch of jelly beans and seals them in a plastic bag.

You do some investigation and find four potential vendors. Each vendor allows you a chance to test their machines. You put a big jar of jelly beans through each machine and make a note of the results. **YOU DON'T KNOW HOW MANY JELLY BEANS YOU ARE PUTTING THROUGH THE COUNTERS, ONLY THAT IT IS THE SAME AMOUNT EVERY TEST.**



After hand-counting the results, you come up with the following table:

TABLE 1.

Company	Acme Bean Counters (ABC)	International Bean-Count Machines (IBM)	National Bean Counters (NBC)	Expert Swiss Precision Numerators (ESPN)
Attempt 1	9,658	9,858	10,013	10,002
Attempt 2	10,003	9,862	10,042	10,003
Attempt 3	10,680	9,870	9,956	9,999
Attempt 4	9,716	9,866	9,988	9,997
Attempt 5	9,992	9,860	10,016	9,999
Average:	10,010	9,863	10,003	10,000
Standard Deviation	406	5	32	2
95% Confidence Level	796	9	64	5
Cost:	\$40,000	\$80,000	\$120,000	\$200,000

The results from the machine of Acme Bean Counters (ABC) show it to be very noisy, but it is relatively cheap. Judging from the large 95% Confidence Level, the results from this machine are not repeatable. The only thing it has going for it is the low price.

The results from the IBM machine look very good. The 95% confidence level at 9 beans shows the results from this machine to be very repeatable. In addition, it has the 2nd lowest

price! I'm a little worried that the average is much less than the average of the other counters, but who is to say which one is right?

The results from the NBC machine show it to be a little more noisy than the IBM machine, as the 95% confidence level is up to 64 beans. It is also more expensive than the IBM machine.

Finally, we have the ESPN machine. It has the best repeatability (5 beans!), but damn, it's really expensive.

MY DECISION: ACCURACY VS REPEATABILITY

I want to get the most value for my money. I want a machine that is repeatable and accurate, but I can't measure accuracy. Based on the information above, I would select the IBM counting machine. It gets repeatable results and saves me \$40,000 over the NBC counter and \$120,000 over the ESPN counter.

Next, I hire a summer intern and put them to work hand-counting the beans in the jar. After several weeks of tedious bean-counting, the intern comes back and tells me that there are 10,000 beans in the jar. My decision to buy the IBM bean counter is not looking good and I immediately start to look for a scapegoat.....

Since I now know the accuracy and the repeatability of the counts, I could make a more informed decision. It comes down to this:

TABLE 2.

Company	Acme Bean Counters (ABC)	Interna- tional Bean-Count Machines (IBM)	National Bean Coun- ters (NBC)	Expert Swiss Preci- sion Numera- tors (ESPN)
Average:	10,010	9,863	10,003	10,000
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95% Confidence Level	796	9	64	5
Cost:	\$40,000	\$80,000	\$120,000	\$200,000

- **ABC:** Cheap, poor-repeatability, pretty close on the average.
- **IBM:** 2nd lowest price, excellent-repeatability, not very accurate. This one is 'Out'.
- **NBC:** 2nd highest price, pretty good repeatability, very accurate.
- **ESPN:** Damn expensive, very good repeatability, super accurate.

It all boils down to what uncertainty I willing to accept in order to save money on the purchase.

The ESPN system is fantastic! But if I am willing to accept a 95% confidence level of 59 more beans, I can save \$80,000 by going with the NBC machine. (I could estimate the marginal cost savings of the increased uncertainty is $\$80,000/64 \text{ beans} = \$1,355/\text{bean}$.) Maybe the extra cost of the ESPN machine is not worth the increased repeatability!

HOW DOES THIS HAVE ANYTHING TO DO WITH MULTIBEAM SYSTEMS?

- When purchasing a multibeam system, you really can't judge accuracy. If you can do a Performance Test, you can get an idea of the repeatability of the system.
- Just like the TV commercial tells you to ask for the Carfax, you should always ask to see the Performance Test results before buying a multibeam system.
- Have you ever stopped to think about the cost of uncertainty?

THE PRICE OF UNCERTAINTY

I can minimize my uncertainty by using a high-end multibeam system and limiting my beam angles to 45 degrees. It's going to take a lot longer to survey (and time on the water is VERY expensive), so my investment and survey costs are going to be higher, but the resulting uncertainty of my soundings will be low.

Conversely, I can go to the opposite extreme and buy a 'low-end' multibeam system that is pretty noisy and open it up to 75 degrees. My time on the water will be drastically reduced, so my investment and survey costs are much lower. However the resulting uncertainty of my soundings will be higher.

Let's say you have a choice of a survey that costs \$70,000 with an average uncertainty of 6cm, versus a survey that costs \$30,000 with an average uncertainty of 15cm. Which one will you choose?

Time to go feed the squirrels while you ponder the question....