Evaluating Cost Reduction Ideas

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Why is this a problem?

- If a proposed change decreases the construction cost and has no other effect, it is simple. Accept the change.
- What if it introduces a risk?
- What if it just defers an expense to a later operating or improvement budget?
- What if it increases operating costs?
- What if it decreases the luminosity?
- What if it decreases the availability?
- What if it decreases the energy?
- These all have different units. How do we compare apples and oranges?

Process

- Give idealized linear formula
- Examine each term trying to determine the correct value for the conversion constant
- Learn that this is difficult and they have large errors
- Learn that some effects are non-linear
- Still useful because we might converge on conversion constants later and it tells us what needs to be evaluated for each proposed change.
- Also gives a way to understand why people disagree with each other.
- Evaluation is simpler if we keep the requirements fixed. This forces us to look at derivatives and optimize by making one thing cheaper and worse while making another thing more expensive and better giving a net cheaper with no change in spec.

The Idealized Linear Formula

- $<\Delta C> = - P_w C_c + (1 - P_w) C_x + K_{RD} C_{RD} + K_{ops} C_{ops1} + K_{ops} N_{year} C_{opsN} - K_{lum} \Delta L \, P_L + K_{Engy} \Delta E$
  Where
- $<\Delta C>$ = The expected (average) value of the cost change. Negative is a saving.
- All K's are conversion constants, the same for all proposed changes
- Other symbols are different for each change

$- P_w C_c + (1 - P_w) C_x$

- P_w is the probability the change works
- C_C is the reduction in construction cost if the idea works.
- C_X is the increase in construction cost if the idea does not work.
  - **$C_X = 0$ if one can just go back to the original plan.**
  - **Expediting to make up for a schedule delay or cost of partially implementing the change and then backing out can make $C_X > 0$**
- Can be multiple terms like these corresponding to different times the decision is made to back out.

$K_{RD}C_{RD}$

- C_{RD} is the cost of doing the R&D and engineering for the change. For many changes, this is negligible compared to C_C and can be ignored
- K_{RD} converts R&D dollars to construction dollars.
  - **It my be easier to get R&D money than construction money.**
  - **Probably region dependent**
  - **My guess is K_{RD} = 0.5 within a factor of 2**

K_{ops} C_{ops1}

- This term handles the deferred purchase of some nonessential item like the last few klystrons or some diagnostics.
- C_{ops1} is the onetime increase in operating or upgrade cost to compensate for what was left undone during construction.
- K_{ops} converts operating or upgrade dollars to construction dollars.
  - **Similar to K_{RD}**
  - **It my be easier to get Ops money than construction money.**
  - **Probably region dependent**
  - **My guess is K_{ops} = 0.5 within a factor of 2**
- After the project is funded and has a fixed budget, K_{ops} gets much bigger

K_{ops} N_{year} C_{opsN}

- This term handles the extra operating costs caused by a construction cost reduction, for example using thinner wire in magnet or AC power distribution will decrease construction costs but increase the operations power bill.
- C_{opsN} is the annual increase in operating cost due to the change.
- N_{year} is the number of years of operating to count
- The cost engineers specified 10 years for RDR optimizations, but omitted the K_{ops} factor.
- My guess is N_{year} =10 within a factor of 2

Now the going gets tough

- It is time to ask how much money would have to be saved to make it worthwhile to halve the average luminosity or reduce the CM energy by 100 GeV.
- Main (selfish) reason to accept such scope reductions is to increase the probability the ILC gets funded.
- I think everyone would agree that if we could cut the construction cost by 5 B ILCU by reducing the design luminosity a factor of 2 that we should do it and that if it would only reduce the construction cost by 50 M ILCU we should not.
  - **Can we reduce that factor of 100 estimating uncertainty?**

K_{lum} ΔL P_L

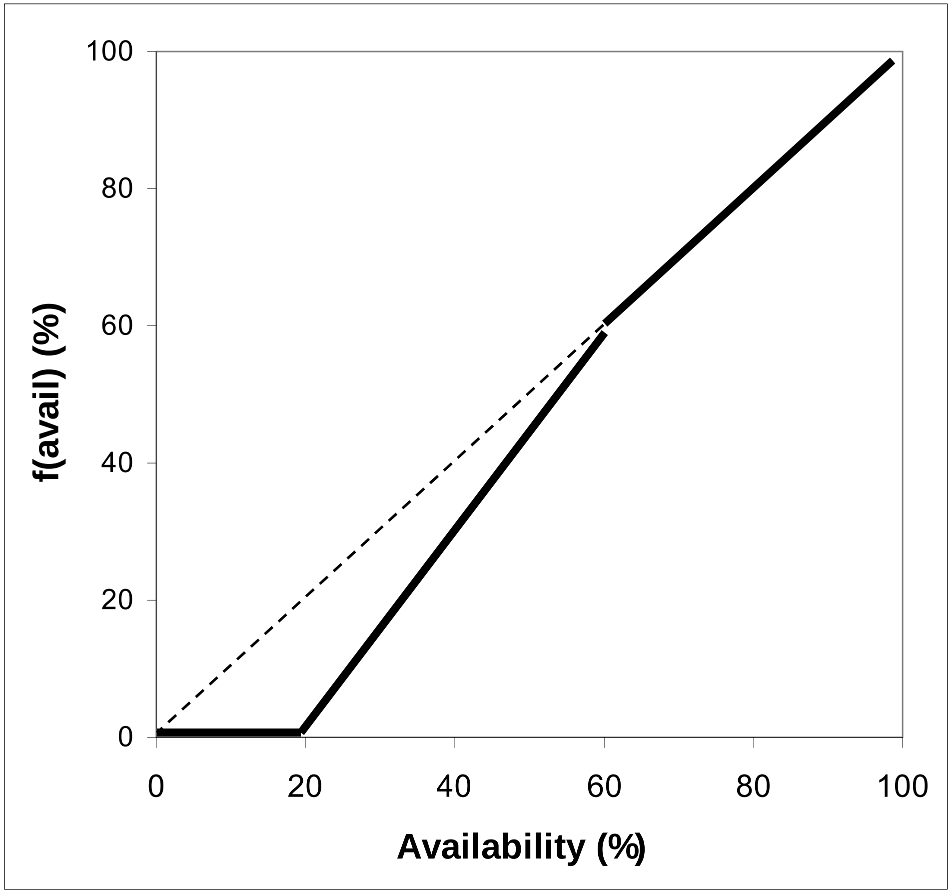
- ΔL = log2(factor change in luminosity). E.g. if the luminosity would go down a factor of 2 then $\Delta L = -1$
- K_{lum} converts ΔL to construction cost.
- P_L is the probability the luminosity will decrease by ΔL

K_{lum} :How much is a factor of 2 in Luminosity Worth?

- Clearly K_{lum} < 6.7 BILCU or it would be worth building 2 ILC's
- One could say that if we halve L we would run ILC for 20 years instead of 10 and
  - **Count the total cost of running the lab for 10 years or K_{lum} = 10*300M = 3 BILCU**
  - **Count the marginal cost of running the lab (mainly electricity) for 10 years or K_{lum} = 10 years * (number of hours in a 9 month run) * (Power consumption in MW) * (electricity price per MWhr) = 10*6579*180*110 or K_{lum} ~ $1.3 BILCU.**
  - **These do not account for the lost time to get results and the impatience of physicists.**
- PEP-II spent about $12M to double L for an accel that cost about $200M to build: 6% of the construction cost. 6% of the ILC cost gives K_{lum} = 0.42 BILCU
- I'd say K_{lum} = 1.3 BILCU within a factor of 2

What about Availability?

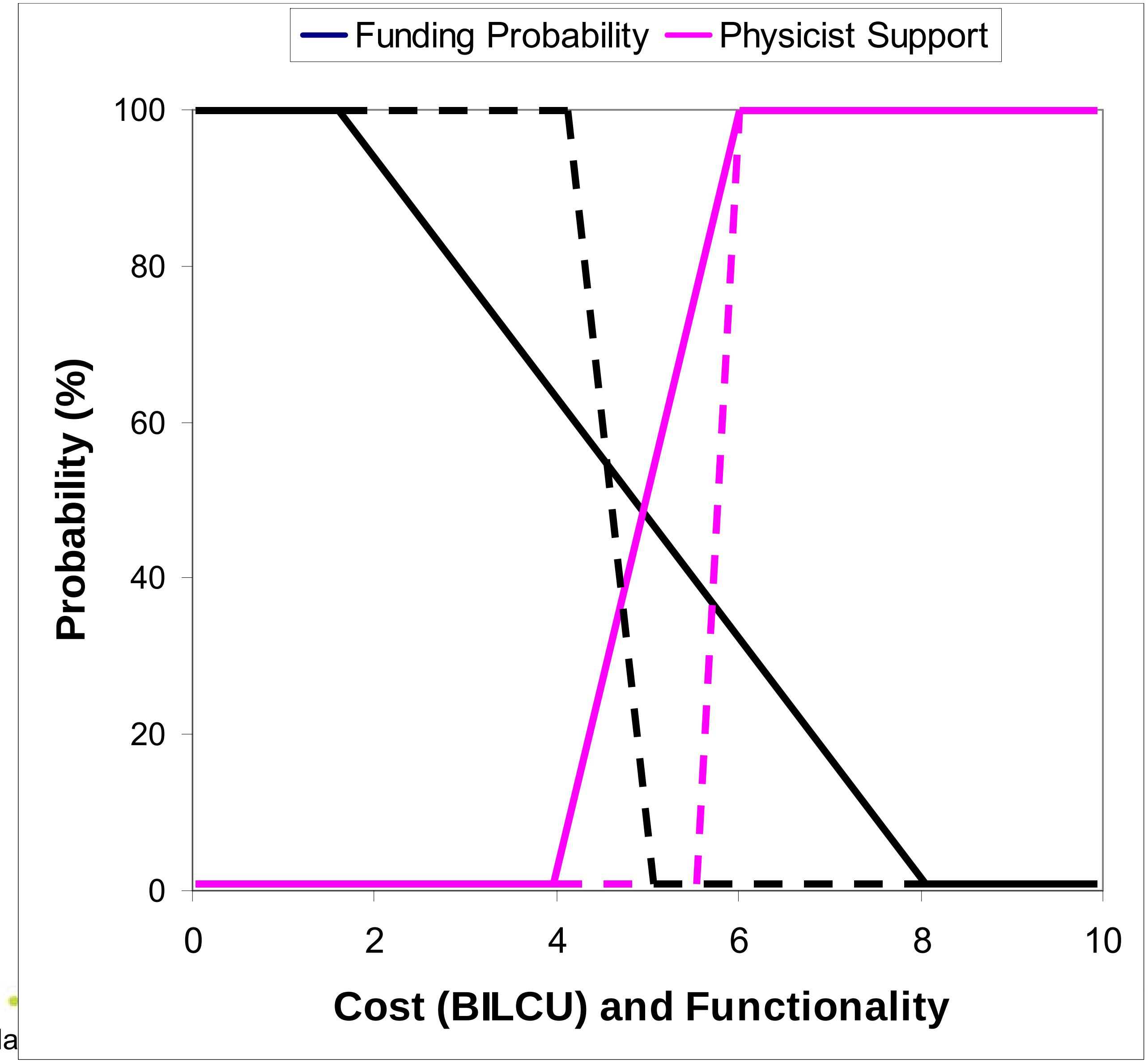
- WWS did not give us an explicit spec. for availability.
- We can either make up a reasonable one or use the WWS integrated availability spec and intL(avail) = f(avail)*intL(100)
- f(avail) is nonlinear because operations becomes very inefficient at low avail



K_{Engy} ΔE

- ΔE is the CM energy reduction in GeV
- K_{Engy} converts ΔE to construction dollars
- This one is even more fuzzy than the previous and probably is quite nonlinear. There is a threshold energy below which people consider the accel to be nearly worthless.

Nonlinear effects



Summary

- Evaluation is simpler if we keep the requirements fixed. This forces us to look at derivatives and optimize by making one thing cheaper and worse while making another thing more expensive and better giving a net cheaper with no change in spec.
- Derivatives can later be used to decide on reduction of specs. Optimization depends on virtually unknowable nonlinear group psychological functions.