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Quantifying Annual Affordability Risk of Major Defense Programs

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Quantifying Annual Affordability Risk of Major Defense Programs

or,

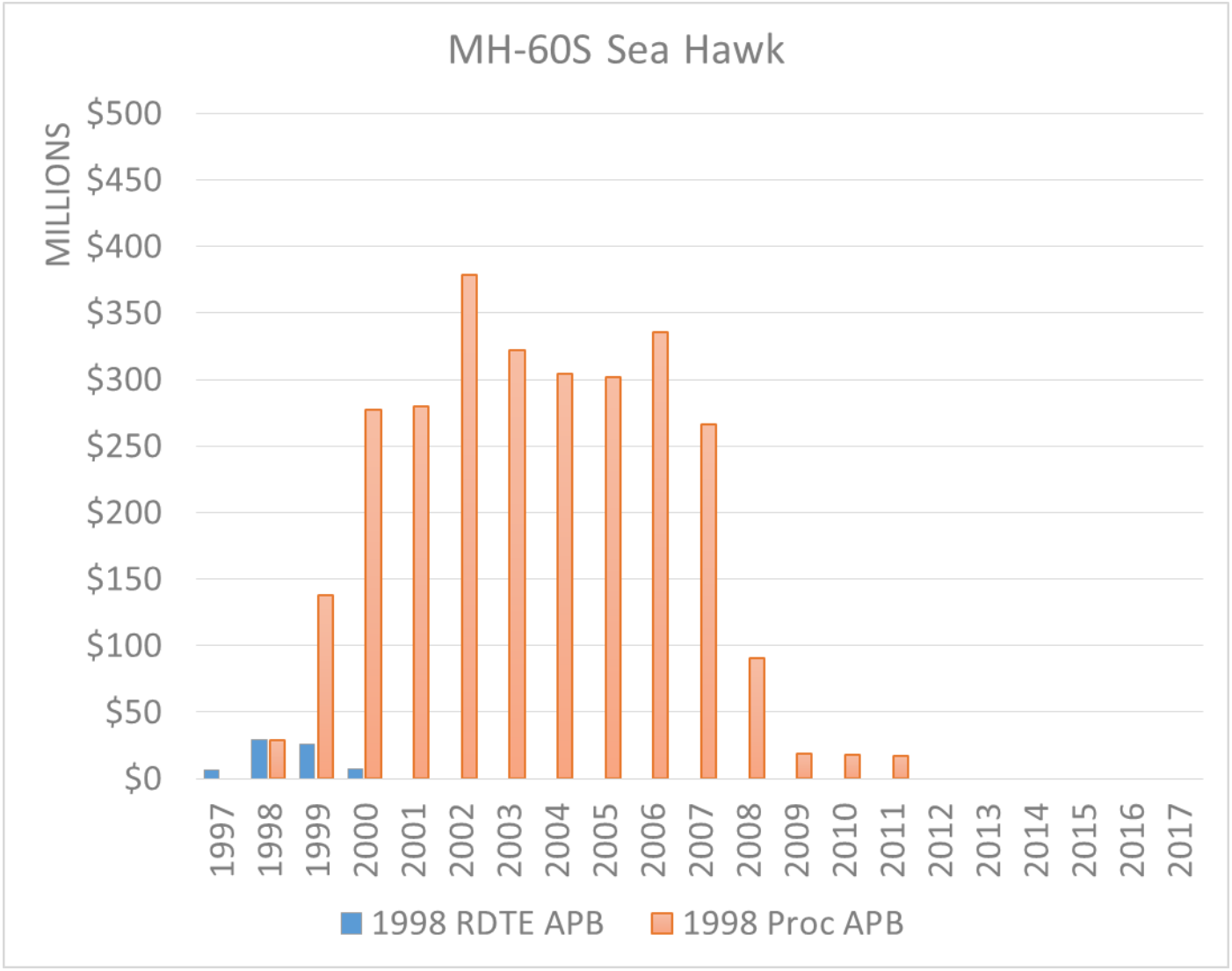
How Much is this Really Going to Cost Me Next Year?

Naval Postgraduate School

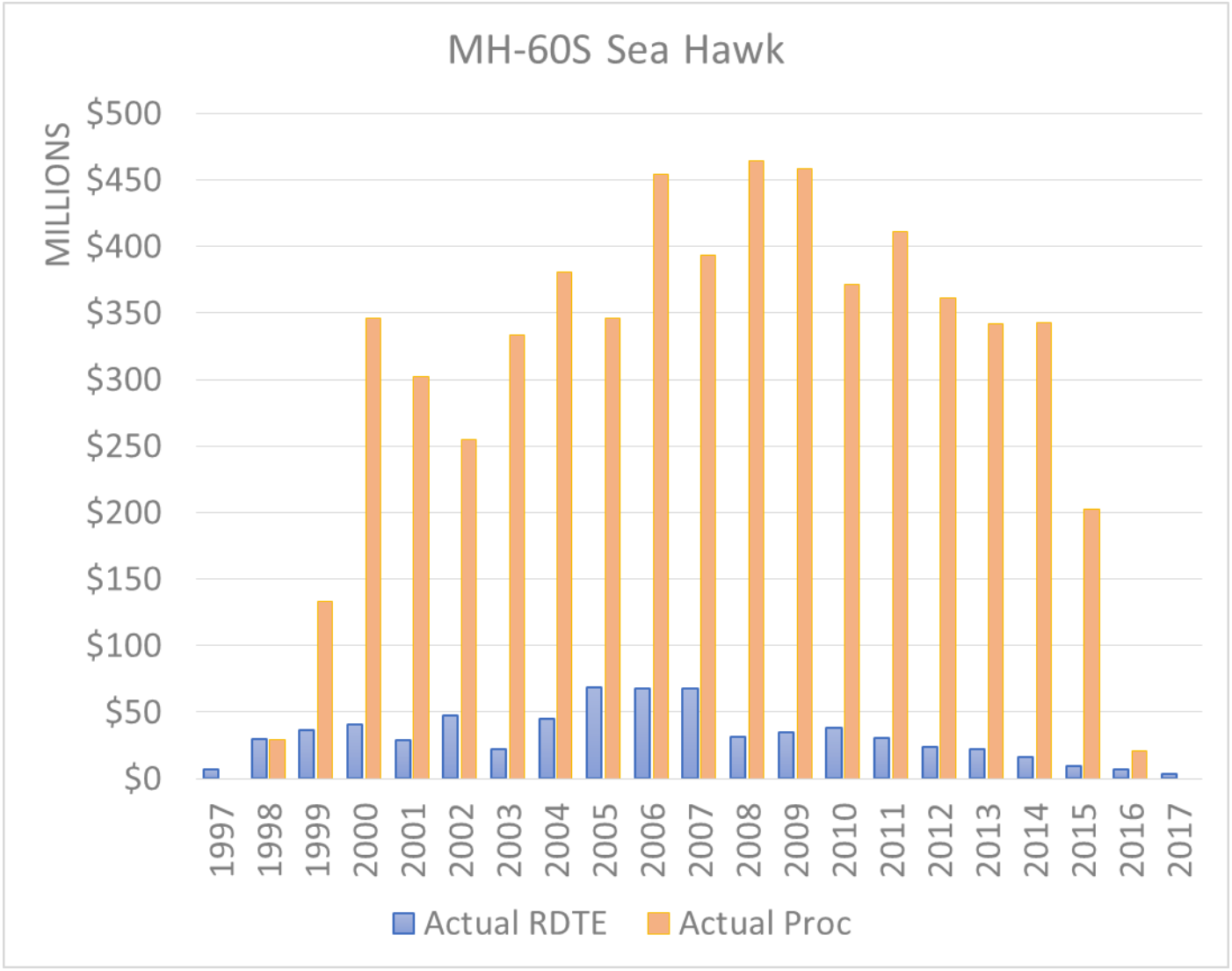
Acquisition Research Symposium

9 May 2018

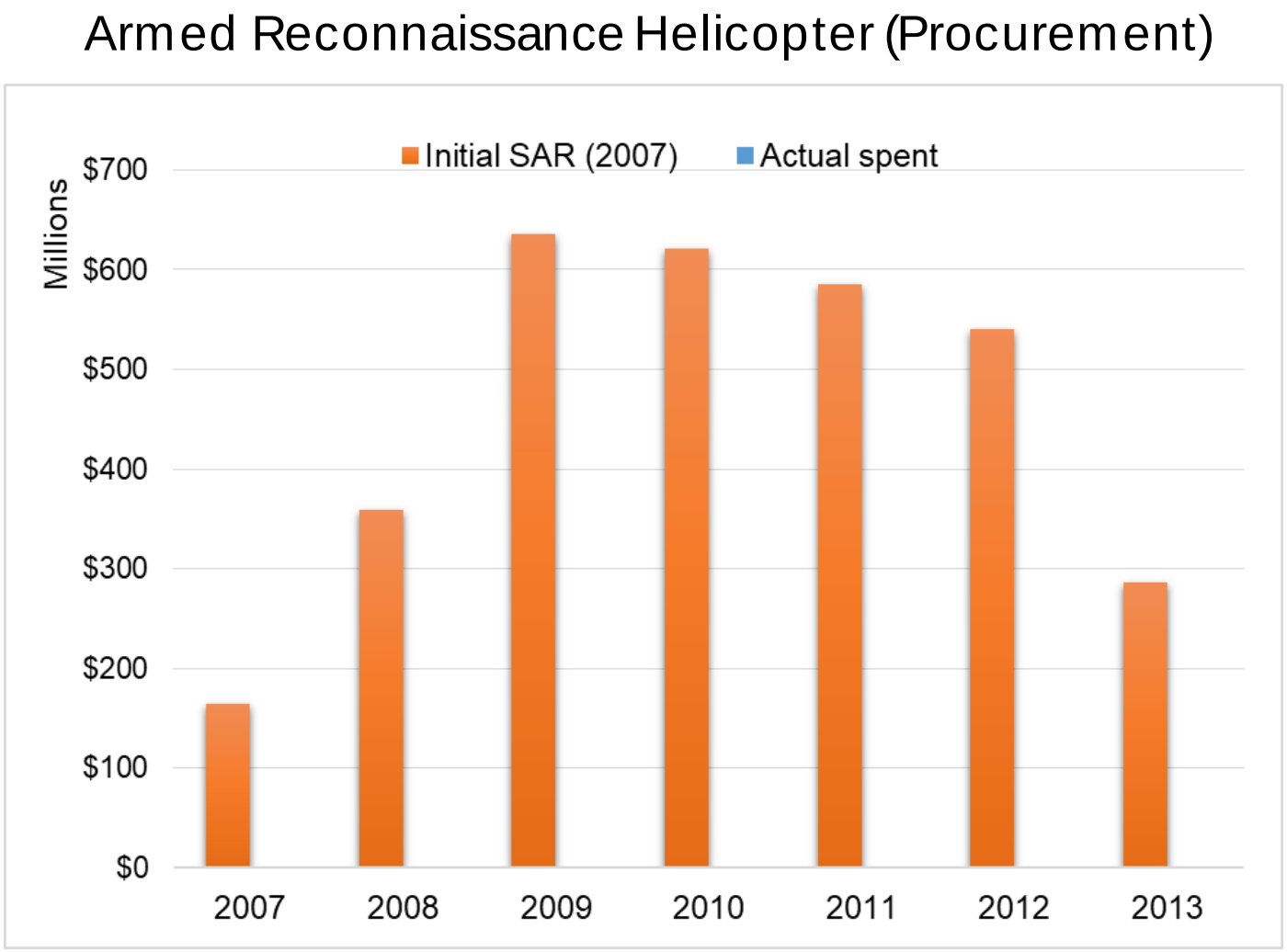
New programs have official acquisition baselines



That's not what actually happens



The change can go in either direction



You can't judge affordability from the cost estimate

Point estimate – no error bars…

Confidence level is unstated (and probably wrong)…

Profile has the wrong shape anyway…

The quantities are wrong as well…

Why is that?

The program we authorize is not the program we execute

The cost estimate is based on the assumptions that the system described in the CARD is the system that will be built, in the quantities specified, on the schedule specified.

None of those things are ever true. Even if the cost estimate were perfect, it's estimating the wrong thing.

Sensible planning should be based on

what we're actually likely to do

how many dollars we're likely to have to do it with

Resource Managers don't care about expected or unit cost

They care about questions like:

What's the probability that the actual funding profile will exceed the budget sometime during the FYDP?

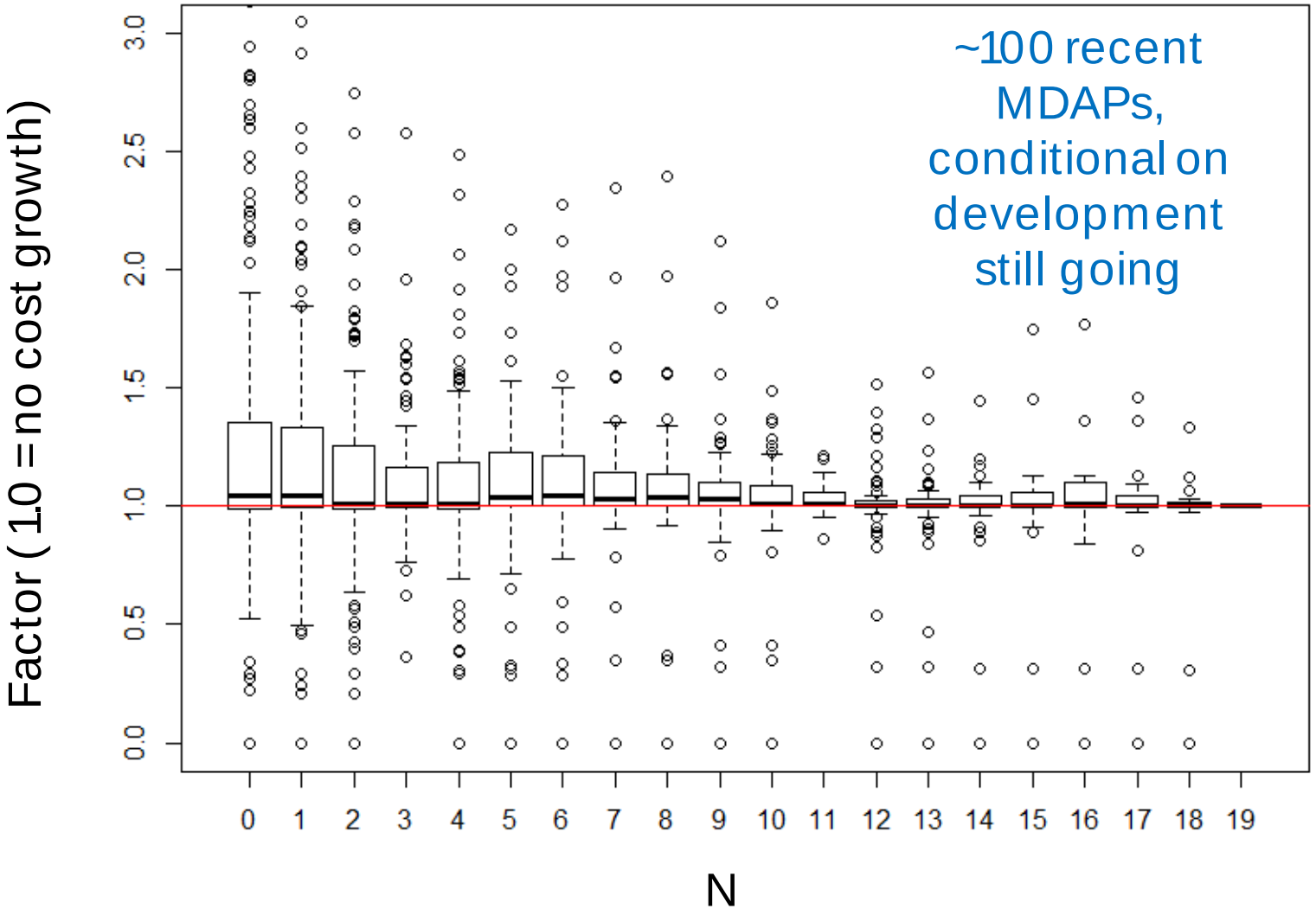
How much contingency funding would give this portfolio of programs a 90% chance of making it through the FYDP?

Answers to those questions depend on the *shape* of the annual cost distribution and the year-to-year correlations, not just the expected value or most likely cost

Currently, **no tools exist to answer these questions**.

Looking at tails is very different from looking at averages

Remaining RDT&E cost growth factor after N years of development:



Profiles are a problem

Annual costs of a program are highly coupled

Profiles change systematically, in both shape and size

We ought to be able to use historical program outcomes to predict how profiles might change, and how likely those changes are

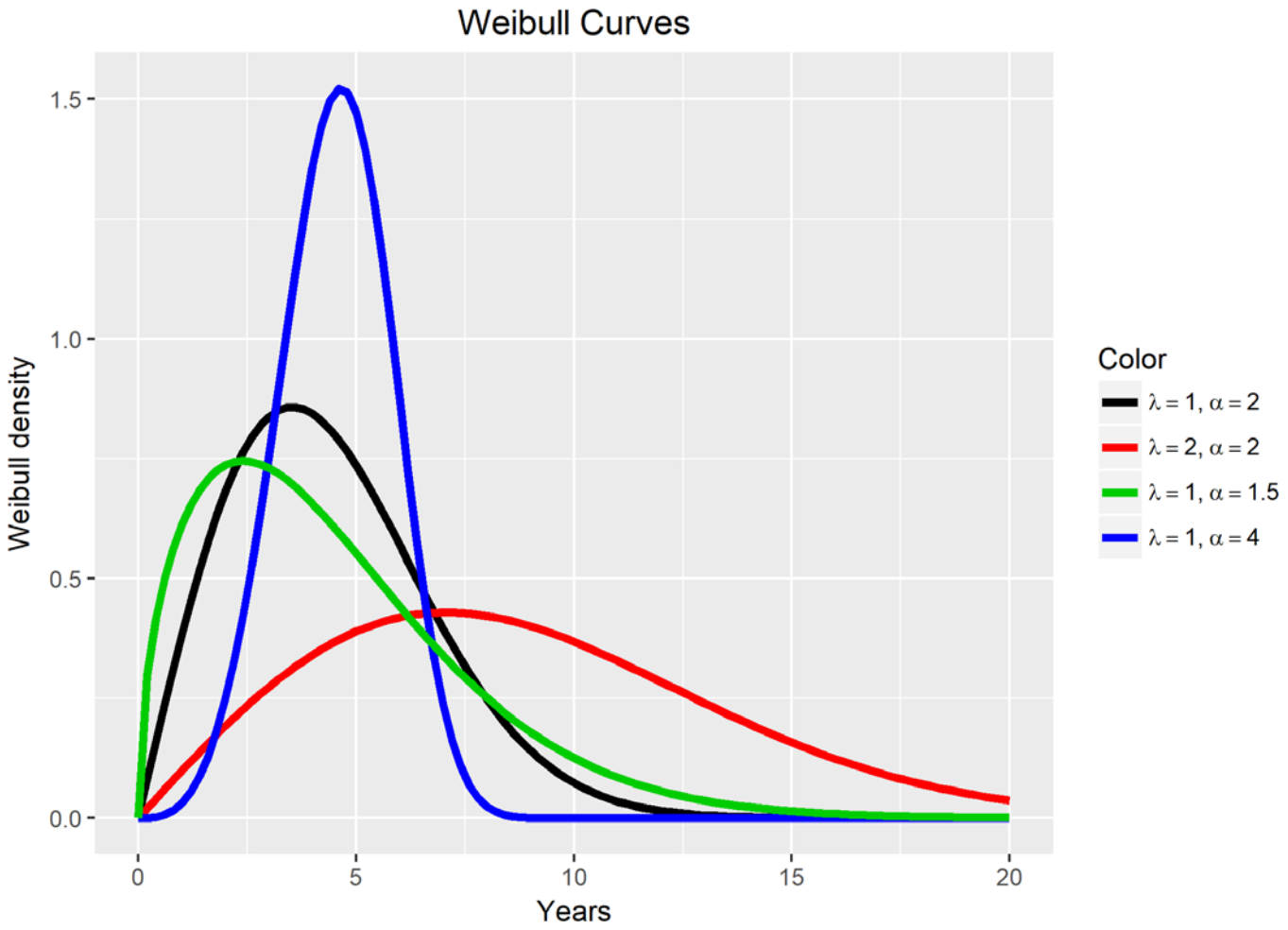
Functional regression provides a way to do this

Assume that funding profiles are reasonably well described by some particular parametric functional form, $f(\underline{\theta})$

Fit that functional form to the original and final profiles for all of the programs in the historical database

Use regression to predict the parameters that generate the final profile from the parameters of the original profile and other information about the program

Development profiles have (roughly) a Weibull shape



$$W(t|\alpha,\lambda) = \frac{\alpha}{\lambda}\left(\frac{t}{\lambda}\right)^{\alpha-1} \exp\left(-\left(\frac{t}{\lambda}\right)^{\alpha}\right) 1(t \geq 0)$$

Discretize and truncate to get annual funding amounts

$$C(t) = K \cdot W(t|\alpha, \lambda) + \epsilon(t), t = 1, \ldots, T$$

where $\epsilon(t)$ is the independent random error in year t and the constant K is chosen such that $\sum_{t=1}^{T} C(t) = C$

Use other program attributes that might be predictive

Service (Army, Navy, Air Force, USMC, Joint)

Commodity (Aircraft, Helicopter, Satellite, Missile, ..).

Program size

Budget climate

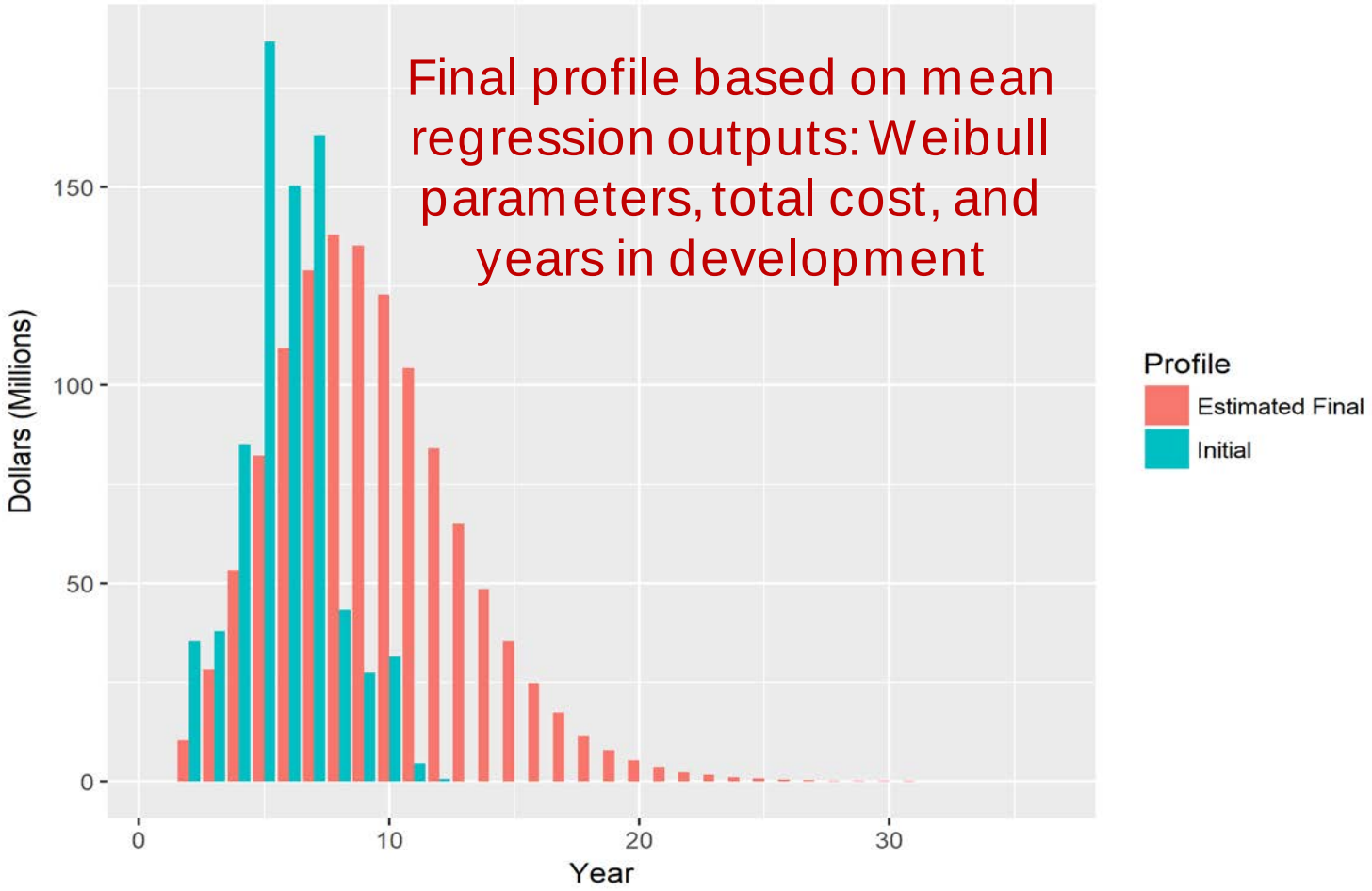
Pre-MS B funding

Schedule optimism (relative to commodity average)

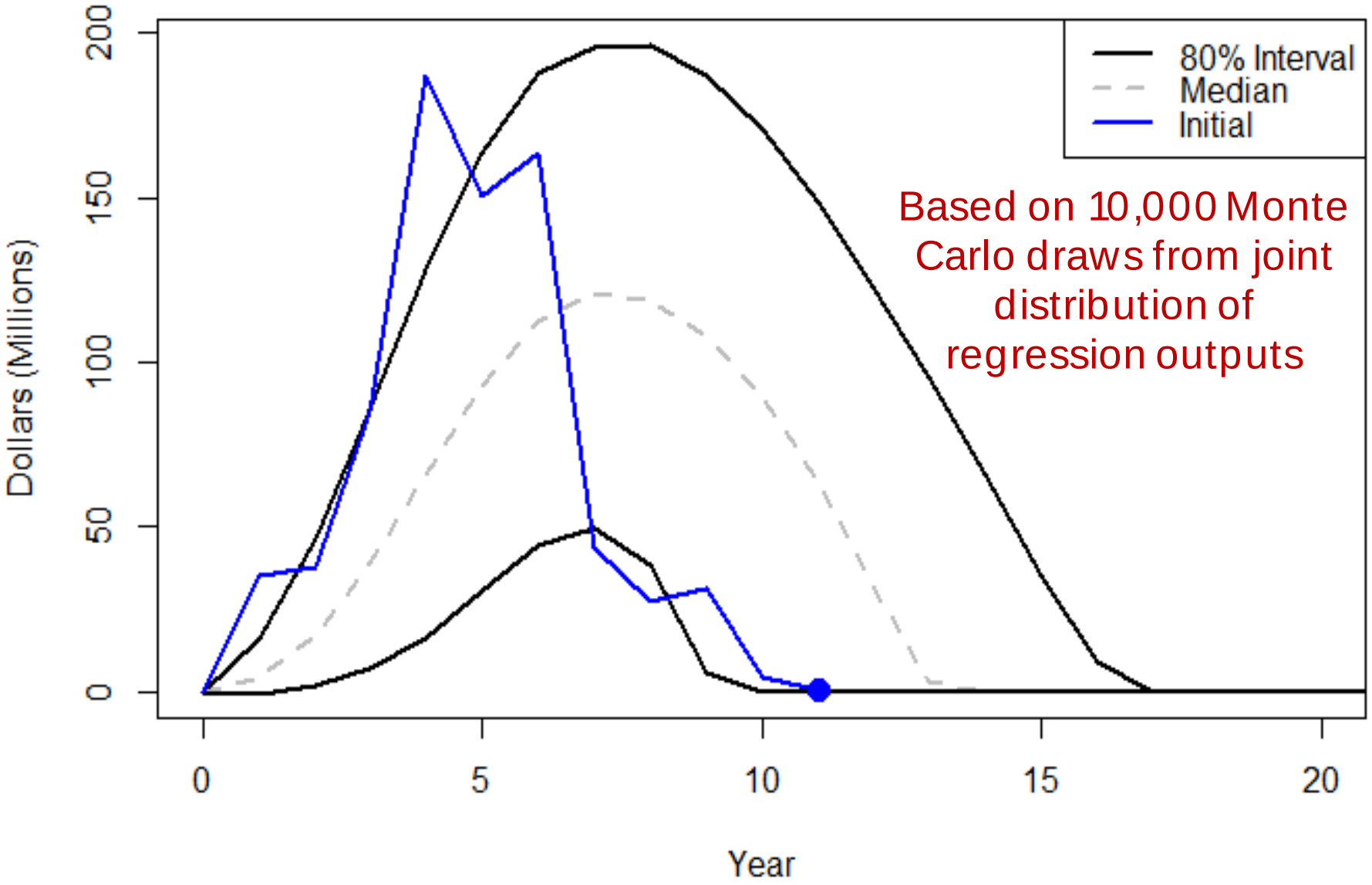
Cost optimism (ditto)

…

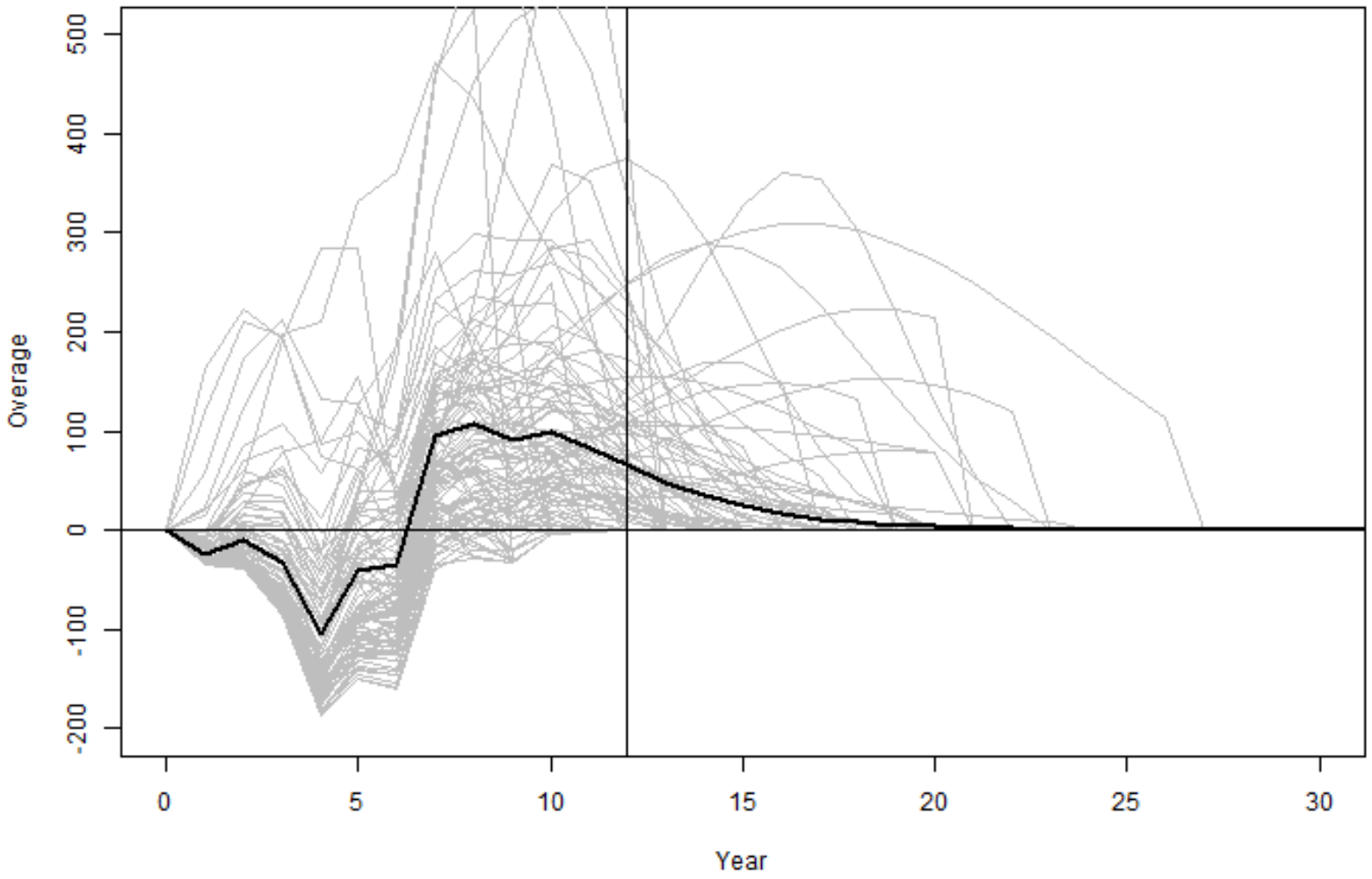
Example: a notional Army helicopter program



The mean prediction is not what we care about, though



The variation in possible outcomes is large



How much contingency would we need to make this work?

Table 1. Expected Budget Overages in Five-Year Bins

Overage (Millions)	2.6	336.6	333.4	67.0	9.2	1.4
Years	1–5	6–10	11–15	16–20	21–25	26–30

Over the first five years, only need an additional $2.6M (on average) to fully fund the program

Years 6-10 look a lot worse

In practice, we care more about how much it would take to achieve a given level of cost certainty – e.g., at least a 90% chance of staying within budget + contingency over an N year horizon

It works even better at the portfolio level

Consider N programs being managed as a portfolio, with common contingency pool K that carries over year to year

Use Monte Carlo to estimate how much contingency is needed over the next few years to achieve high affordability confidence for the portfolio as a whole

Top up the fund if necessary

Get the benefits of averaging over mostly uncorrelated outcomes at different points in the program life cycle

There are some details I didn't talk about

Bayesian Seemingly Unrelated Regressions to generate the distribution (including covariance) of final profile parameters

Adding back in the noise that Weibull fits remove

Functional forms for Procurement profiles

Regression models for mid-life programs

Portfolio management policies

Will the method still work if people really start using it?

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Acknowledgments

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