Quantifying Year-by-Year Funding Uncertainty of Major Defense Programs

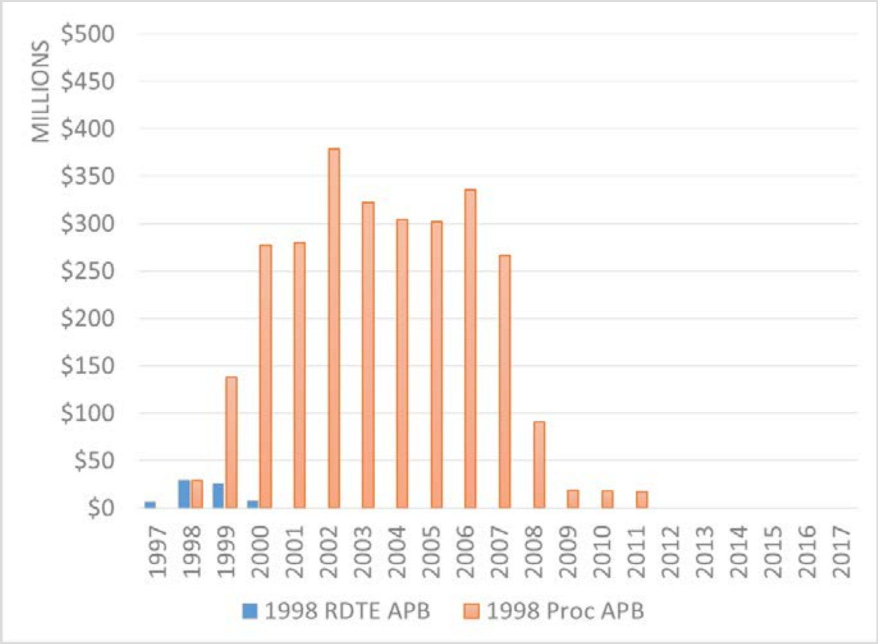
Part 2: Improved models for RDT&E and Procurement

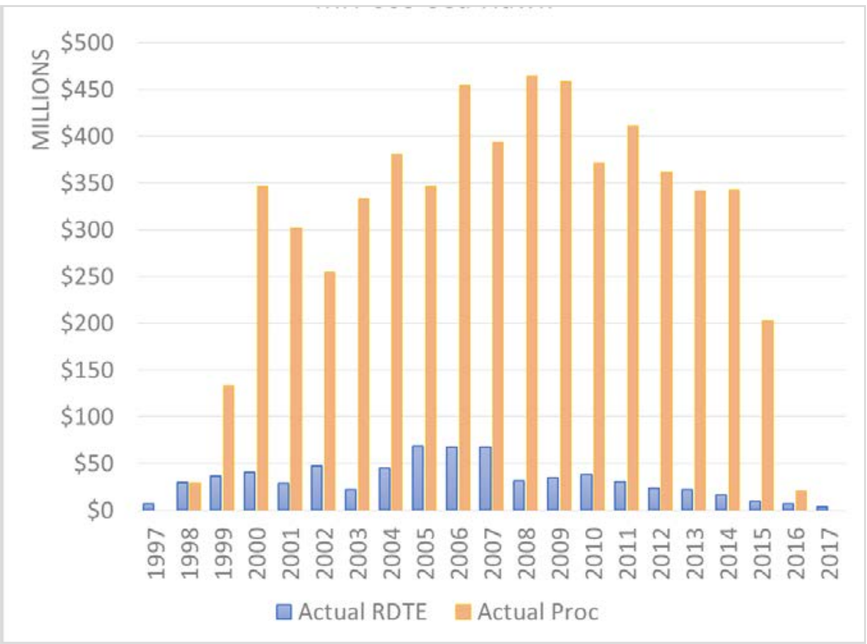
Naval Postgraduate School

Acquisition Research Symposium

May 2019

Actual spending isn't what was planned





Resource Managers don’t care about expected or unit cost

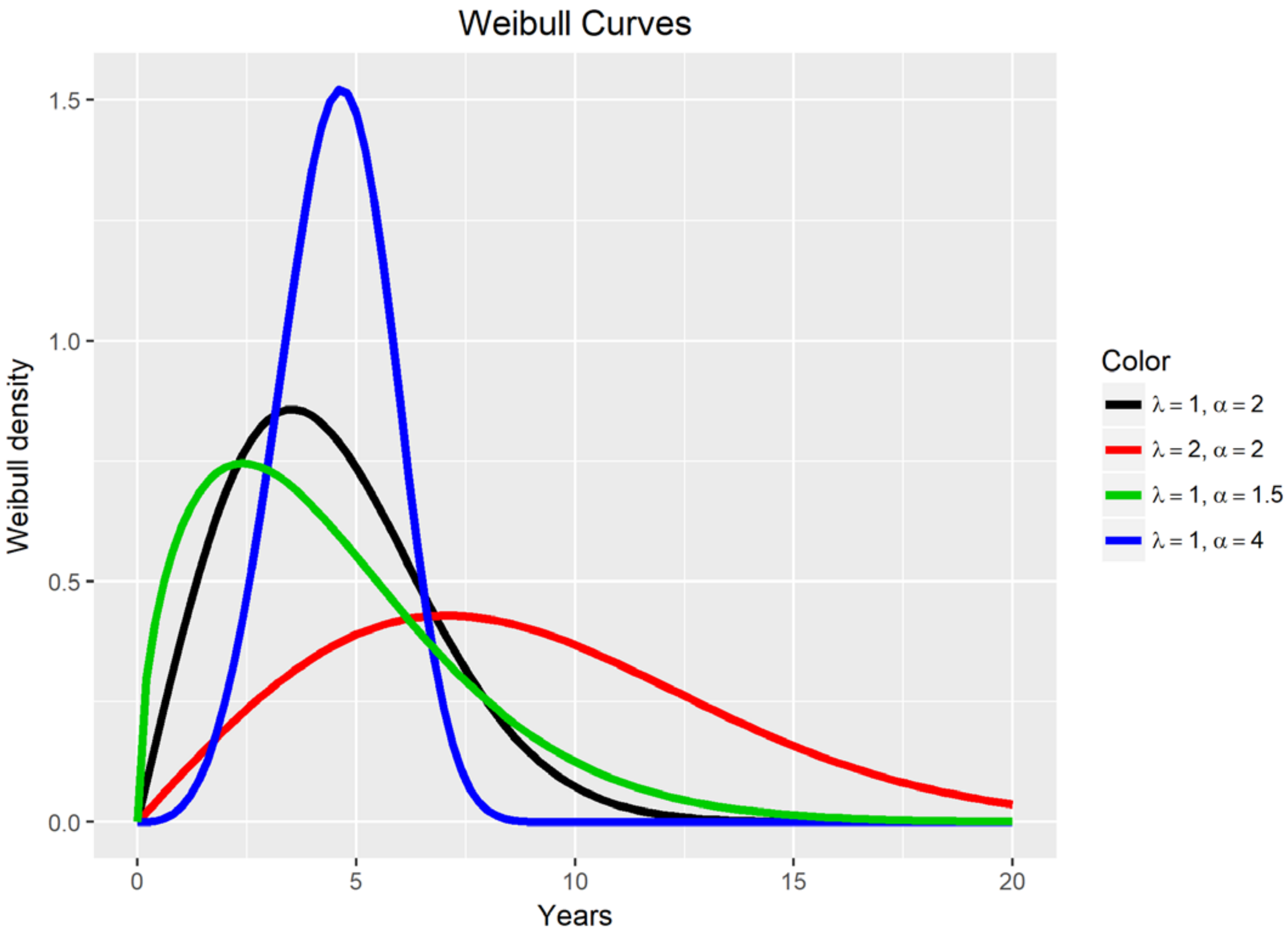
They care about questions like:

How much of my budget might this program consume over the next 10 years?

How likely is it that my projected budget will be enough to fund my portfolio of programs?

Last year, we presented early results from a model intended to be able to answer these kinds of questions

Last year's model used Weibull curves to approximate RDT&E funding profiles

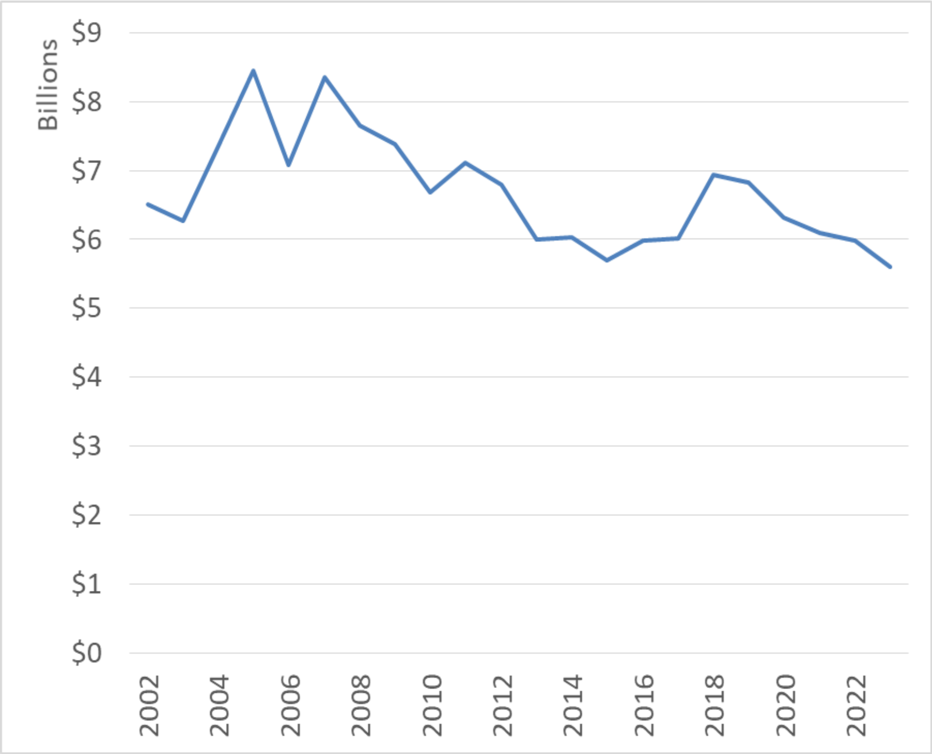


There are some problems with last year's approach

Many actual RDT&E funding profiles don't look much like a Weibull curve

- Level of effort programs
- Repeated block upgrades
- Technical issues
- …

Procurement profiles have similar issues – probably even more so



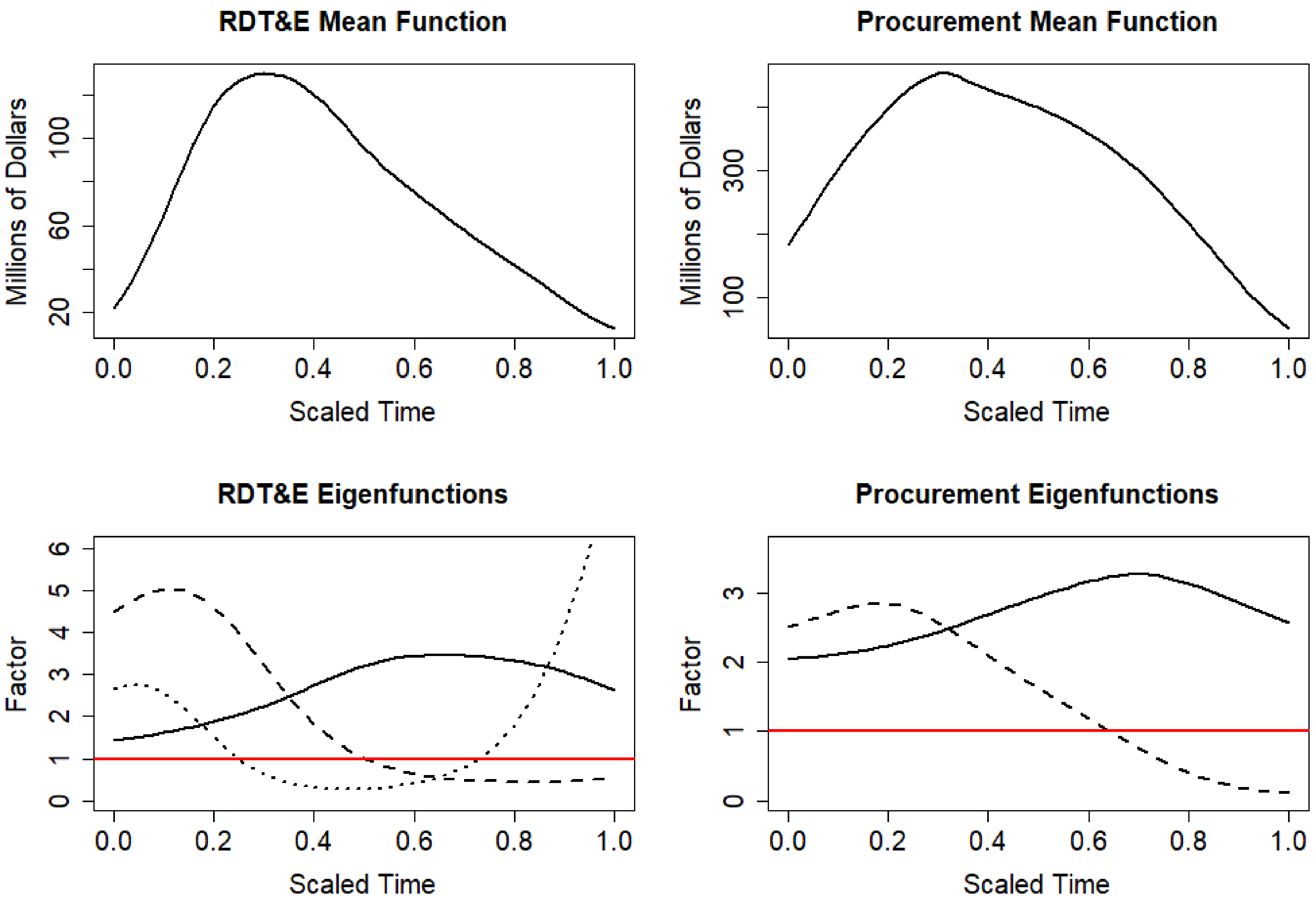
New approach: *Functional Principal Components Analysis*

FPCA represents historical spending patterns as an average profile plus a weighted sum of a few additional functions representing patterns of deviation from the average

$$f(t) = \mu(t) + \sum_{k=1}^{K} \omega_k \xi_k(t)$$

These additional functions (called "eigenfunctions" in the FPCA literature) are estimated from the historical outcomes, as the (statistically) best set of independent patterns of deviation

Average profiles and eigenfunctions for historical MDAPs



The model predicts the *distribution* of future profiles

We don't just want a point estimate of future spending; we want to know the year -by-year uncertainty as well

We take the planned and actual spending to date as input. We then predict the joint distribution of the weights on the various eigenfunctions (plus the overall cost and schedule growth factors) that will best fit the future actual spending.

We can then use that joint distribution to drive Monte Carlo simulation of the future funding profile

It also uses other program attributes that might be predictive

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

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

New start vs. Modification/upgrade

Planned duration

Planned total cost

Actual spending to date

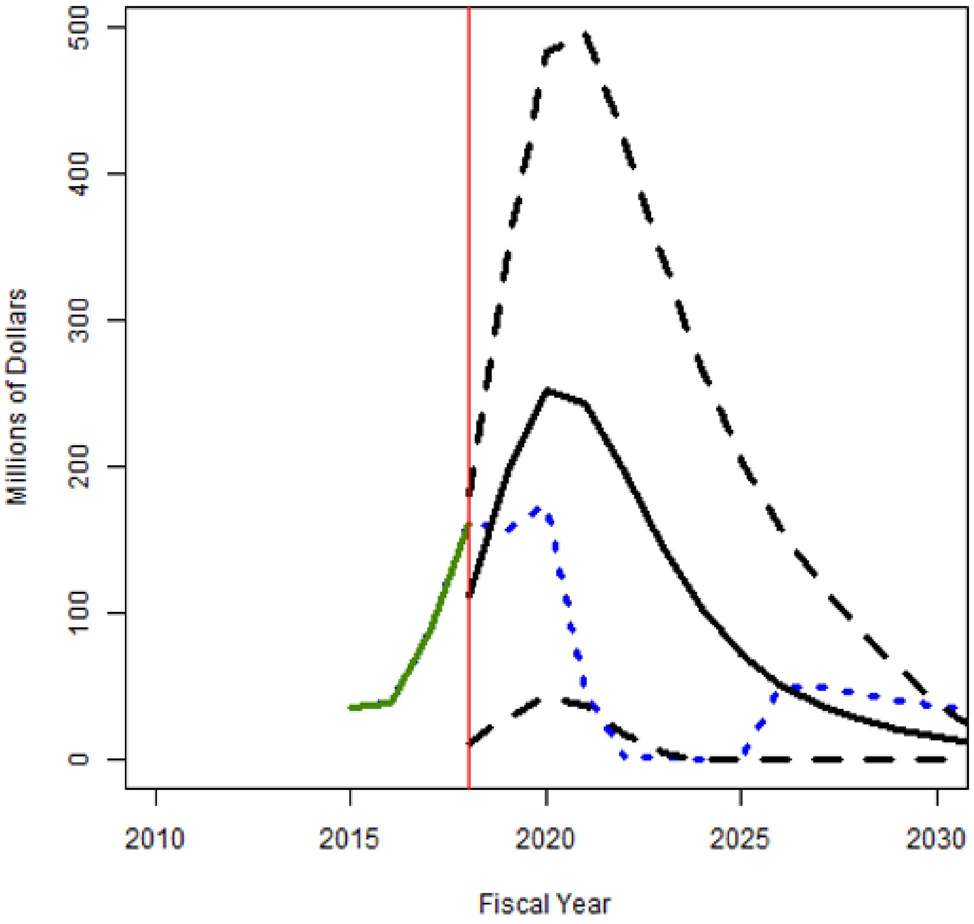
Budget climate

Schedule optimism (relative to commodity average)

Cost optimism (ditto)

…

Example: Projected RDT&E future funding



Based on 10,000 Monte Carlo draws from joint posterior distribution of best FPCA fit

Green = actual past funding

Red = date of latest actual data

Blue dash = program estimate

Black = mean FPCA forecast

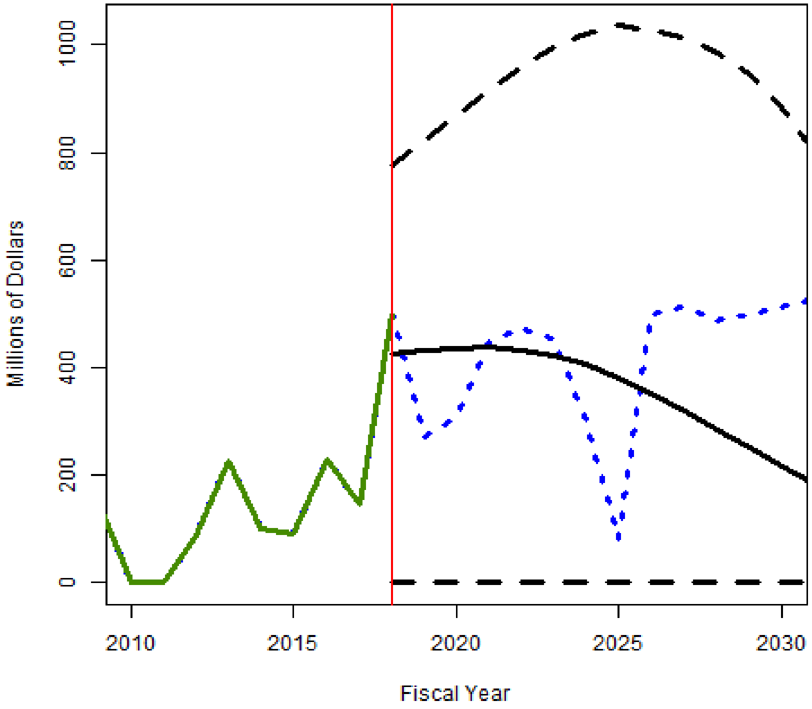
Black dash = 10% and 90% limits

Example: Procurement already partly complete

We weight the draws from the posterior distribution of best -fit FPCA parameters by how well the resulting profile matches the observed history to date

The result is a forecast that is conditioned on what has happened so far

Based on 10,000 weighted Monte Carlo draws from the joint distribution of regression outputs



This approach supports risk analysis at the portfolio level

Consider a set of programs being managed as a portfolio, possibly with some ability to shift funds among programs

Use the Monte Carlo model to estimate how much funding might be required in each of the next few years, given what we know about the programs

Compare those year -by-year distributions against likely portfolio budgets

There are some details I didn't talk about

Bayesian Seemingly Unrelated Regressions to generate the predictive distribution (including covariances) of final FPCA profile parameters

Scaling of historical programs to a standard size and duration for profile estimation, then separately estimating cost and schedule growth factors

Limitations of historical data sources

- Inconsistency in what counts as "a program"
- SARs* do not include all spending
- MDAPs are only half of the procurement budget

*Selected Acquisition Reports

Questions?

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