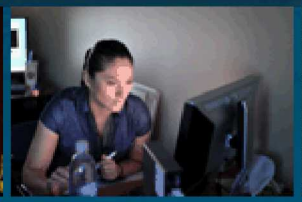
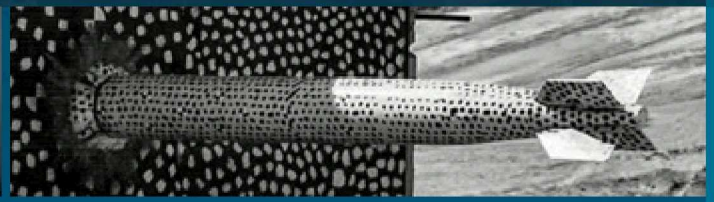
This paper describes objective technical results and analysis. Any subjective views or opinions that might be expressed in the paper do not necessarily represent the views of the U.S. Department of Energy or the United States Government.

SAND2018-10501C

JMP Into Retirement - The Reliability Platform in JMP





PRESENTED BY

Don Lifke, Systems and Component Reliability Engineering

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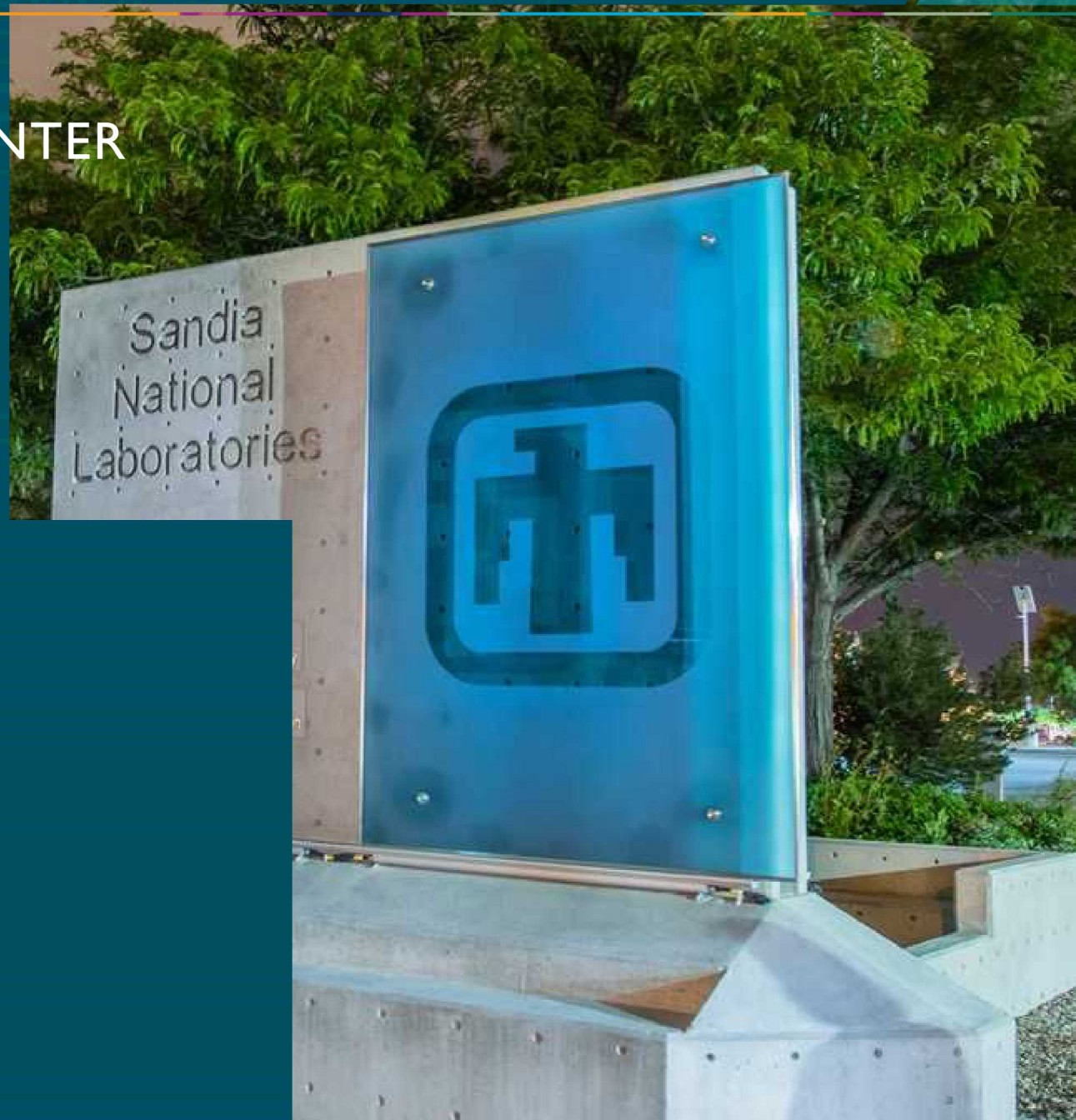


NUCLEAR DETERRENCE

Six major programs are carried out

W87/Mk21
Assembly

W76-1 Life

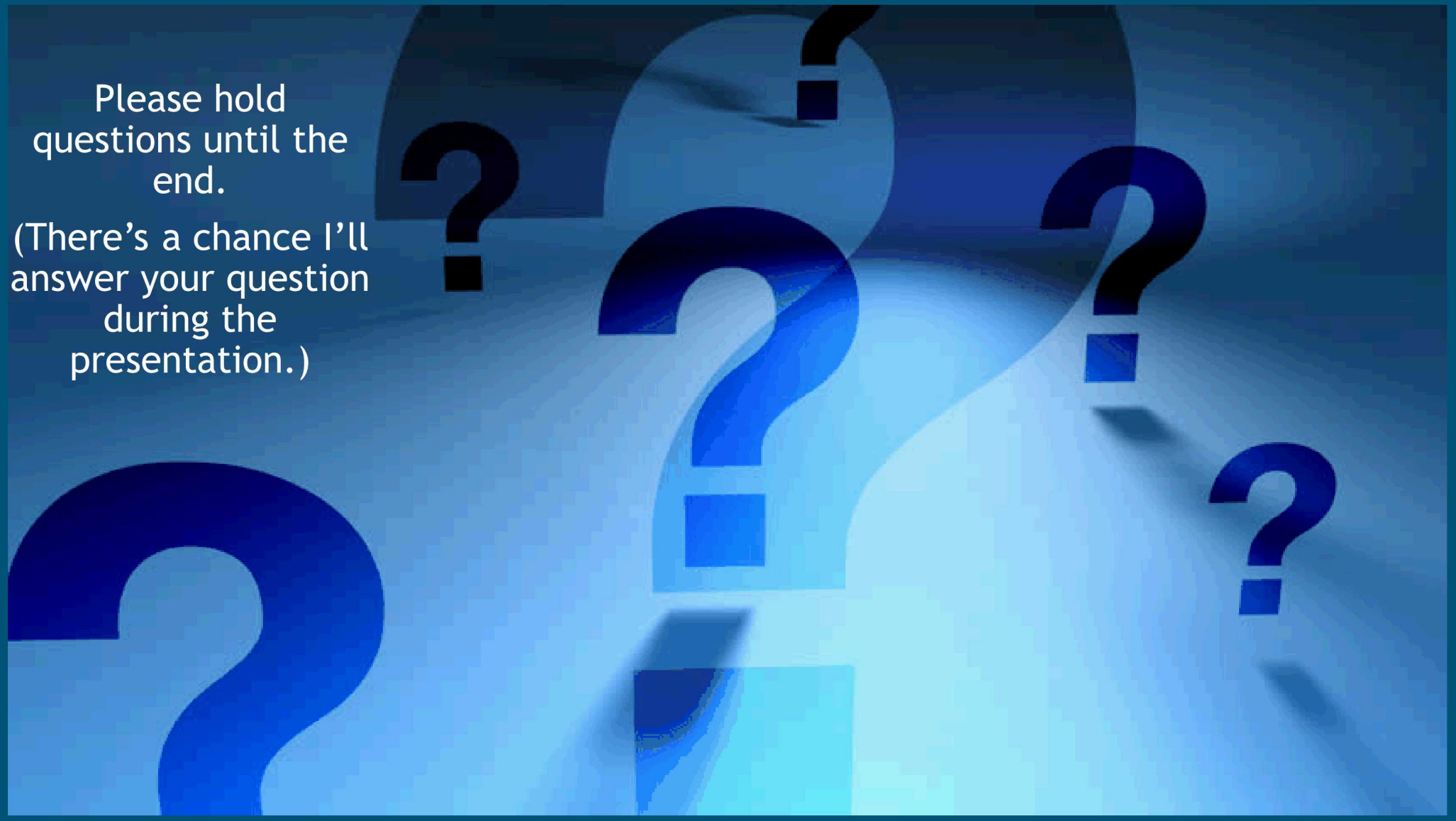
Mobile Gu

-4 Life Extension Program

Bright White Flash Video

Please hold questions until the end.

(There's a chance I'll answer your question during the presentation.)

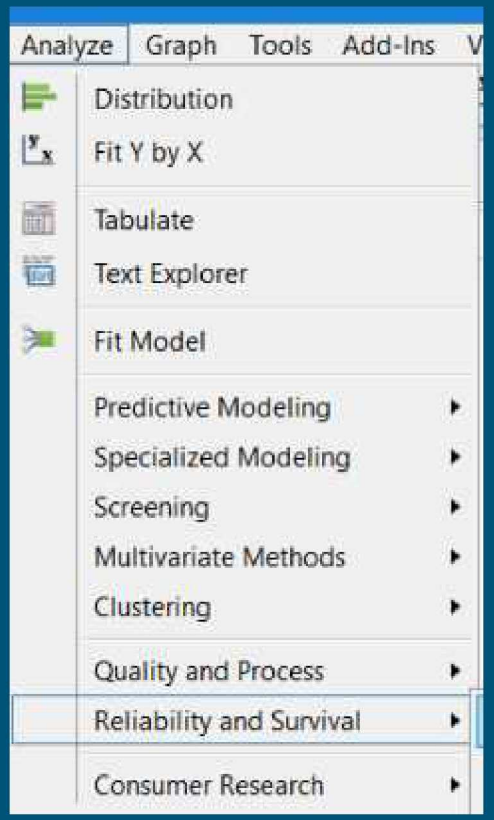


WHY DOES SOMETHING SO CERTAIN HAVE SO MUCH UNCERTAINTY?

AT LEAST IT'S NOT THIS COMPLICATED!

RETIREMENT PLANNING REQUIRES AN ESTIMATE OF LIFETIME

We can quantify the uncertainty of lifetime data using the Reliability and Survival tool



A NICE SET OF DATA EXISTS

Sandia Lab News published biweekly.

Some issues contain Retiree Deaths.

Retiree deaths

Robert	(age 94)	December 18
Richard	(93)	December 22
Billy	(68)	January 1

Sandia LabNews

Vol. 59, No. 20 September 28, 2007

Managed by Lockheed Martin for the National Nuclear Security Administration

Sandia National Laboratories

Benefits Choices 2008

HBE

(Almost) everything you need to know to make benefits changes during the upcoming open enrollment period, Oct. 20-Nov. 9. Stories and charts begin on page 6.

LDRD stars illuminate their work

Presentations show wide range of research activities

By Neal Singer

On a stage empty of décor in Bldg. 962 in Tech Area 4, six youthful-appearing LDRD (Laboratory Directed Research and Development) presenters captured the attention of a small audience of about 40 with the intensity of their descriptions of their projects.

The noise level rose afterward when a rotating flux of some 50 Sandians inspected 36 posters describing other LDRD efforts.

"It's about interacting, not just listening," said LDRD manager Hank Westrich (1011) approvingly of the freewheeling discussions. The location was chosen because of the large room available for poster presentations.

LDRD Awards for Excellence winners recognized. See page 5.

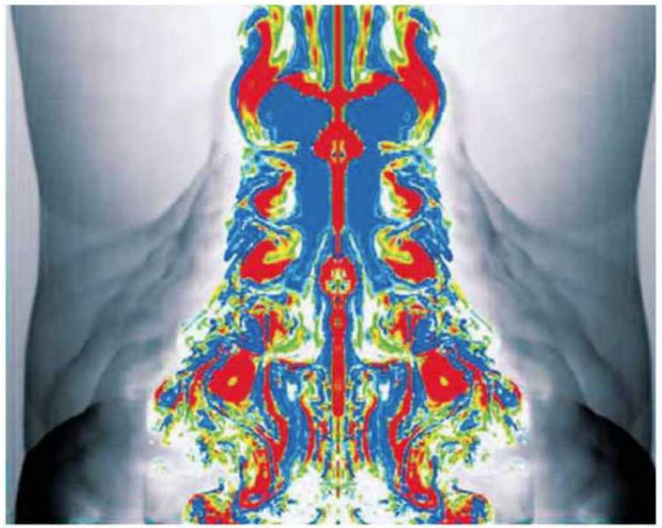
The oral and poster sessions were preceded by a fact-filled opening talk by Sandia Div. 1000 VP Rick Stulen, who explained the evolving basis for winning the coveted three-year funding, which the Labs has used to develop promising new technologies.

In official terminology, these start-up funds are the "seed corn" of the Labs, which "nurture its core, support its missions, and drive its future," said Rick.

The program's history and results are indeed unusual.

According to Rick's figures, early-stage LDRD grants have supported 60 percent of Sandia's R&D 100 award winners since 1992. (R&D 100 award winners are determined yearly by independent judges selected by *R&D Magazine* from projects submitted to the competition from around the world. The projects

(Continued on page 5)



DURING HIS LDRD DAY PRESENTATION, researcher Mark Boslough discussed the effects of an asteroid collision with Earth. As depicted in this computer model image developed by him, large ring vortices enhance downward energy flows, intensifying their coupling with Earth's surface.

ABOUT THE DATA

Four time periods chosen, to explore changes in the distributions through time.

Year	N
2001	75
2007	79
2013	77
2018	67

We live longer now than we did in the days of Vivaldi.

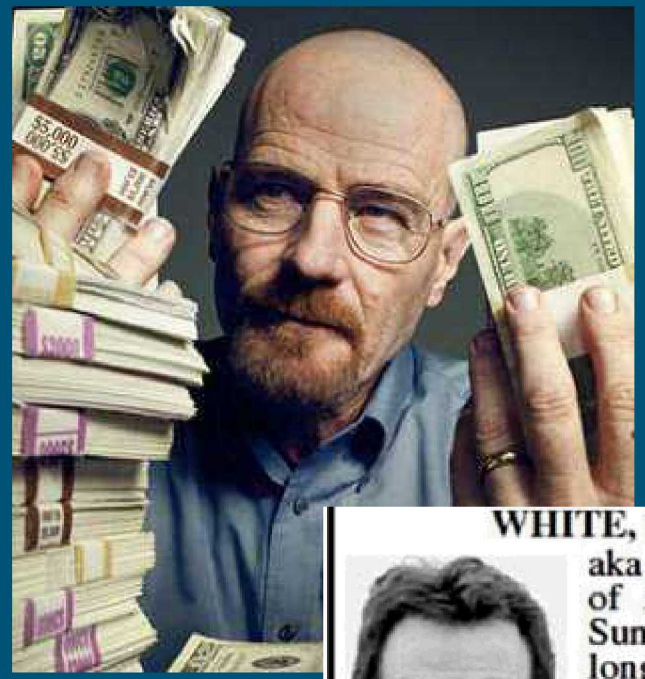
ADVANTAGES OF USING RETIREE DEATH DATA

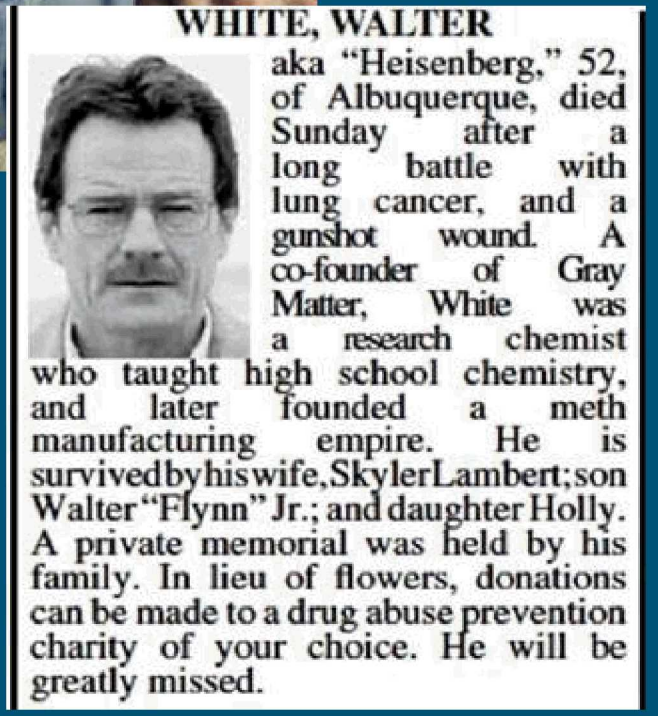
The Sandia Retiree population is a better representation of my particular lifestyle than the general population would be.

- Typically less risk taking
- More conservative lifestyle
- Similar income and education level

ADVANTAGES OF USING RETIREE DEATH DATA

- Only includes those who actually made it to retirement (unlike our friend Walter White)
- I don't care about retirement planning if I don't make it to retirement! (Sorry, kids.)



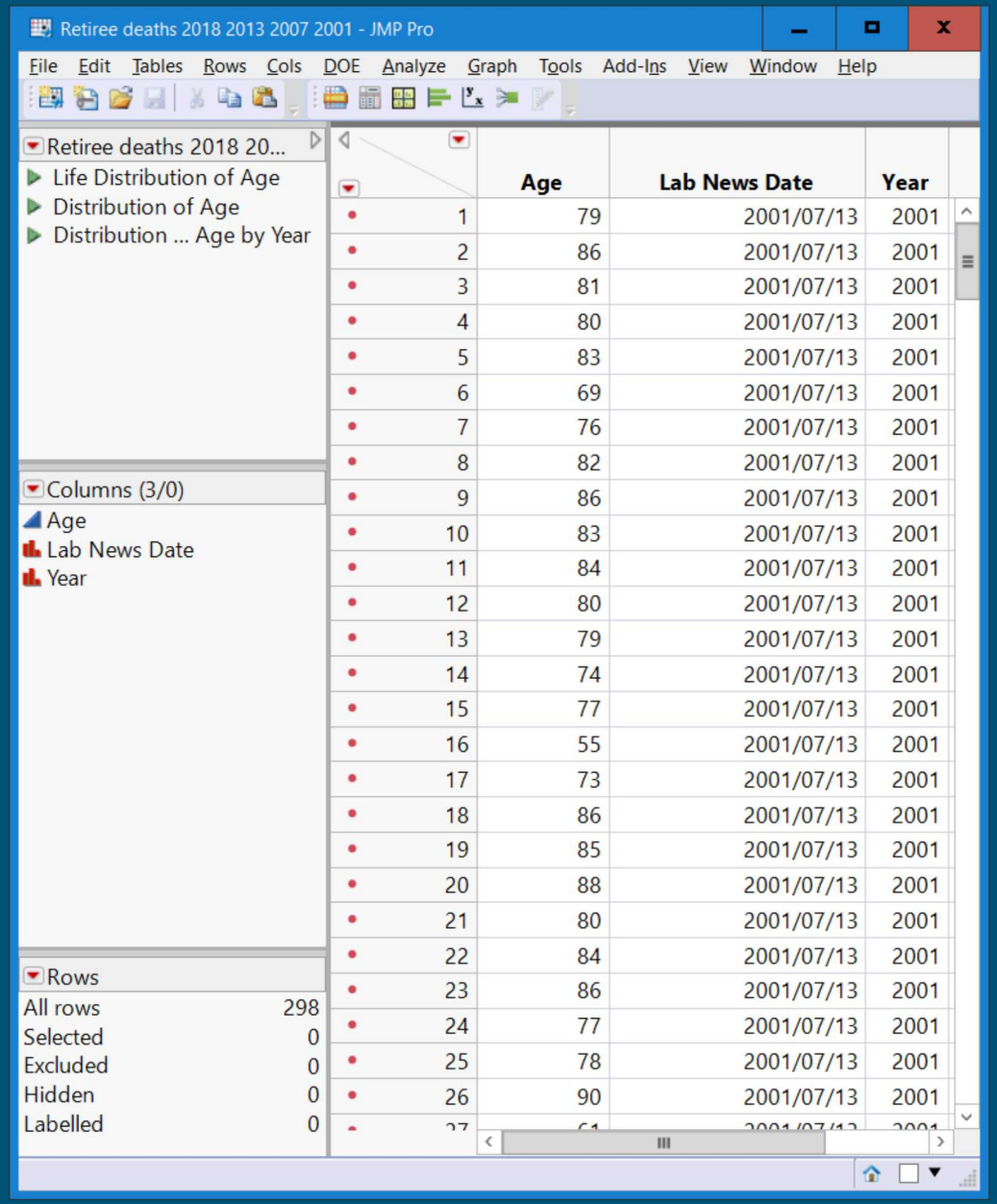


WHITE, WALTER

aka "Heisenberg," 52, of Albuquerque, died Sunday after a long battle with lung cancer, and a gunshot wound. A co-founder of Gray Matter, White was a research chemist who taught high school chemistry, and later founded a meth manufacturing empire. He is survived by his wife, Skyler Lambert; son Walter "Flynn" Jr.; and daughter Holly. A private memorial was held by his family. In lieu of flowers, donations can be made to a drug abuse prevention charity of your choice. He will be greatly missed.

LET'S GO TO JMP!

THE DATA FILE



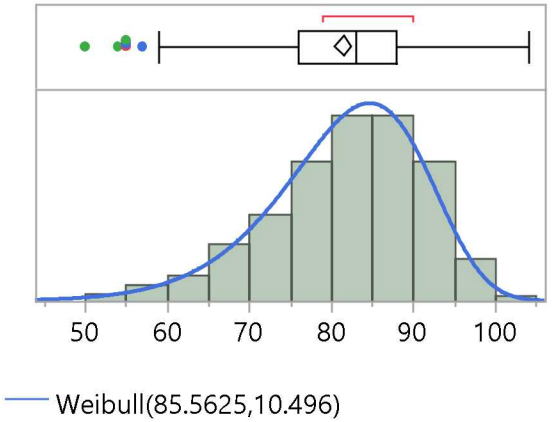
	Age	Lab News Date	Year
1	79	2001/07/13	2001
2	86	2001/07/13	2001
3	81	2001/07/13	2001
4	80	2001/07/13	2001
5	83	2001/07/13	2001
6	69	2001/07/13	2001
7	76	2001/07/13	2001
8	82	2001/07/13	2001
9	86	2001/07/13	2001
10	83	2001/07/13	2001
11	84	2001/07/13	2001
12	80	2001/07/13	2001
13	79	2001/07/13	2001
14	74	2001/07/13	2001
15	77	2001/07/13	2001
16	55	2001/07/13	2001
17	73	2001/07/13	2001
18	86	2001/07/13	2001
19	85	2001/07/13	2001
20	88	2001/07/13	2001
21	80	2001/07/13	2001
22	84	2001/07/13	2001
23	86	2001/07/13	2001
24	77	2001/07/13	2001
25	78	2001/07/13	2001
26	90	2001/07/13	2001

WHICH DISTRIBUTION FITS BEST?

Looking at all the data as one data set:

Distributions

Age



Compare Distributions

Show	Distribution	Number of Parameters	-2*LogLikelihood	AICc
☑	Weibull	2	2157.99009	2162.03077
☐	Extreme Value	2	2157.99009	2162.03077
☐	Johnson Sl	3	2158.58177	2164.66341
☐	SHASH	4	2157.80847	2165.94499
☐	Johnson Su	4	2158.58054	2166.71706
☐	Normal 2 Mixture	5	2159.38194	2169.58742
☐	Normal 3 Mixture	8	2156.50792	2173.00619
☐	Normal	2	2179.15633	2183.19701
☐	Gamma	2	2196.75684	2200.79752
☐	LogNormal	2	2207.83618	2211.87686
☐	GLog	3	2207.83618	2213.91781
☐	Exponential	1	3219.17643	3221.18995

Fitted 2 parameter Weibull

Parameter Estimates

Type	Parameter	Estimate	Lower 95%	Upper 95%
Scale	α	85.562534	84.581823	86.537444
Shape	β	10.496037	9.5863041	11.445829

Measure	
-2*LogLikelihood	2157.9901
AICc	2162.0308
BIC	2169.3843

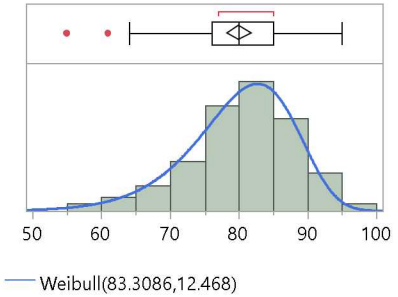
The Extreme Value distribution is equivalent to a two-parameter Weibull (α, β) distribution reparameterized as $\delta = 1 / \beta$ and $\lambda = \ln(\alpha)$.

WHICH DISTRIBUTION BEST FITS EACH YEAR?

Looking at the data by each year:

Distributions Year=2001

Age

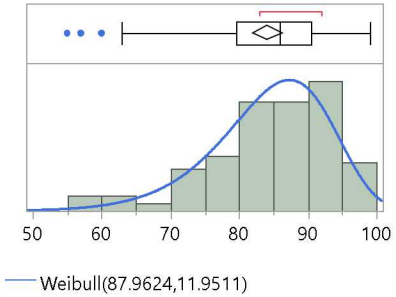


Compare Distributions

Show	Distribution	Number of Parameters	-2*LogLikelihood	AICc
☑	Weibull	2	512.45687	516.623537
☐	Extreme Value	2	512.45687	516.623537
☐	Johnson Sl	3	512.038425	518.376453
☐	SHASH	4	511.751319	520.322747
☐	Normal	2	516.251352	520.418019
☐	Johnson Su	4	511.96224	520.533668
☐	Gamma	2	519.918764	524.08543
☐	Normal 2 Mixture	5	514.485914	525.35548
☐	LogNormal	2	522.192174	526.358841
☐	GLog	3	522.192174	528.530202
☐	Normal 3 Mixture	8	513.887254	532.069072
☐	Exponential	1	807.328993	809.383788

Distributions Year=2013

Age

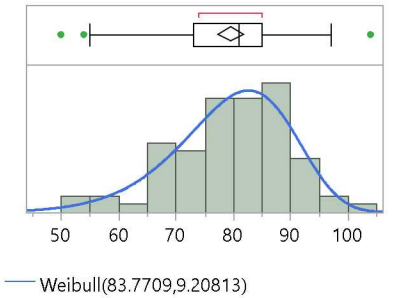


Compare Distributions

Show	Distribution	Number of Parameters	-2*LogLikelihood	AICc
☑	Weibull	2	547.141718	551.30388
☐	Extreme Value	2	547.141718	551.30388
☐	Johnson Sl	3	545.331457	551.660224
☐	Johnson Su	4	545.331457	553.887013
☐	SHASH	4	546.020995	554.57655
☐	Normal 2 Mixture	5	546.368113	557.213183
☐	Normal 3 Mixture	8	544.558723	562.67637
☐	Normal	2	560.148572	564.310734
☐	Gamma	2	567.122542	571.284704
☐	LogNormal	2	571.191003	575.353165
☐	GLog	3	571.191003	577.51977
☐	Exponential	1	836.631237	838.68457

Distributions Year=2007

Age

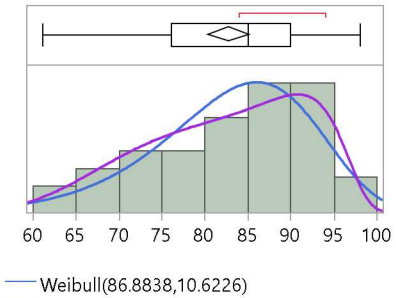


Compare Distributions

Show	Distribution	Number of Parameters	-2*LogLikelihood	AICc
☑	Weibull	2	585.71102	589.868915
☐	Extreme Value	2	585.71102	589.868915
☐	Johnson Sl	3	585.27244	591.59244
☐	Normal	2	588.323948	592.481843
☐	SHASH	4	584.111051	592.651592
☐	Johnson Su	4	584.647355	593.187895
☐	Normal 2 Mixture	5	582.386366	593.208284
☐	Gamma	2	593.00189	597.159785
☐	Normal 3 Mixture	8	579.182959	597.240102
☐	LogNormal	2	596.122956	600.280851

Distributions Year=2018

Age



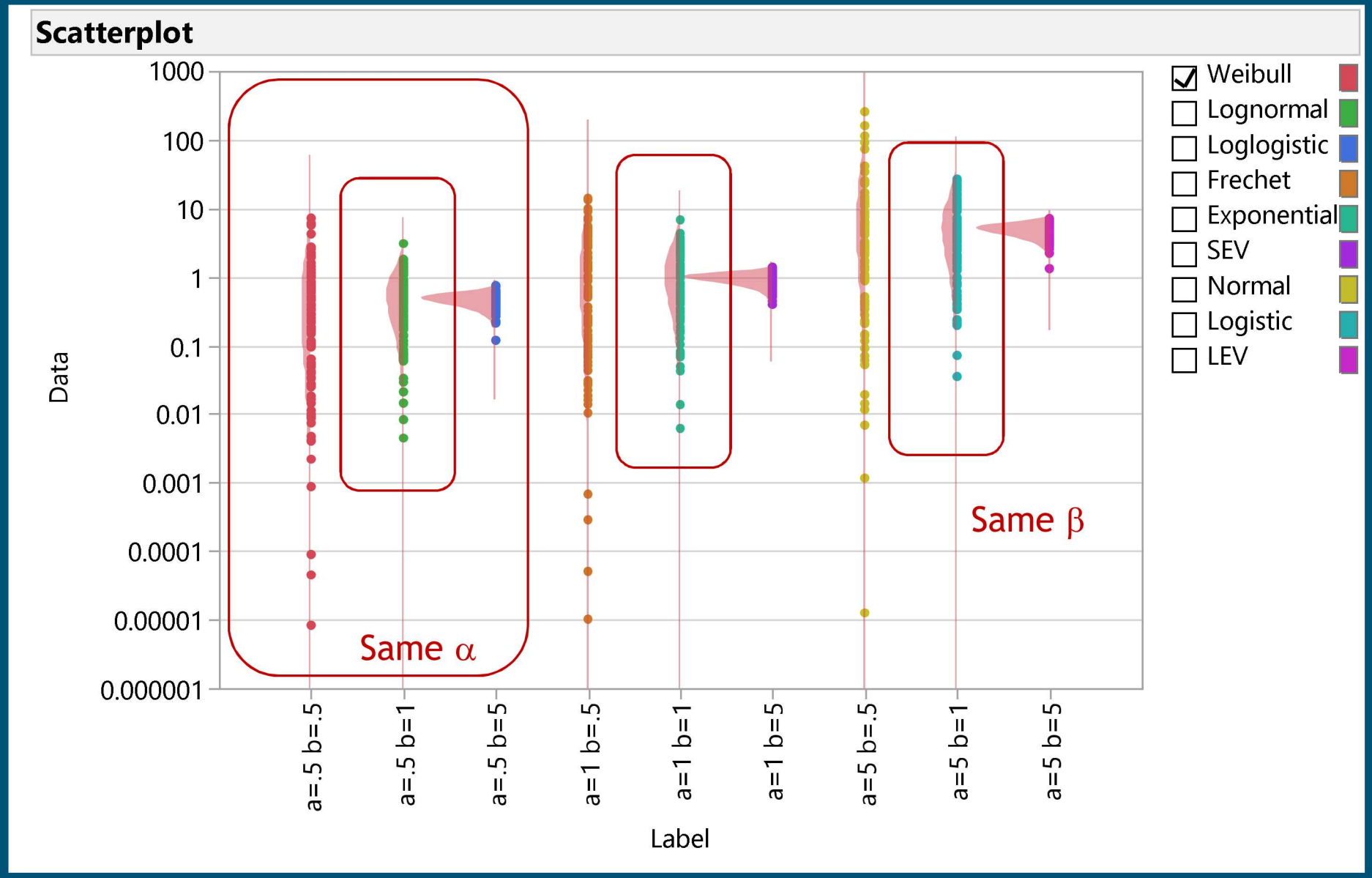
Compare Distributions

Show	Distribution	Number of Parameters	-2*LogLikelihood	AICc
☑	SHASH	4	482.573971	491.219132
☑	Weibull	2	488.394206	492.581706
☐	Extreme Value	2	488.394206	492.581706
☐	Normal 2 Mixture	5	482.579036	493.562643
☐	Johnson Sl	3	487.557808	493.938761
☐	Normal	2	494.690703	498.878203
☐	Normal 3 Mixture	8	481.766606	500.249365
☐	GLog	3	494.683167	501.06412
☐	Gamma	2	497.722611	501.910111
☐	Johnson Su	4	494.684096	503.329257
☐	LogNormal	2	499.580148	503.767648
☐	Exponential	1	725.666026	727.727565

All four years fit a Weibull Distribution fairly well

WEIBULL DISTRIBUTION PRIMER

$$y = \frac{\beta}{\alpha}\left(\frac{x}{\alpha}\right)^{\beta-1} e^{(-x/\alpha)^{\beta}}$$

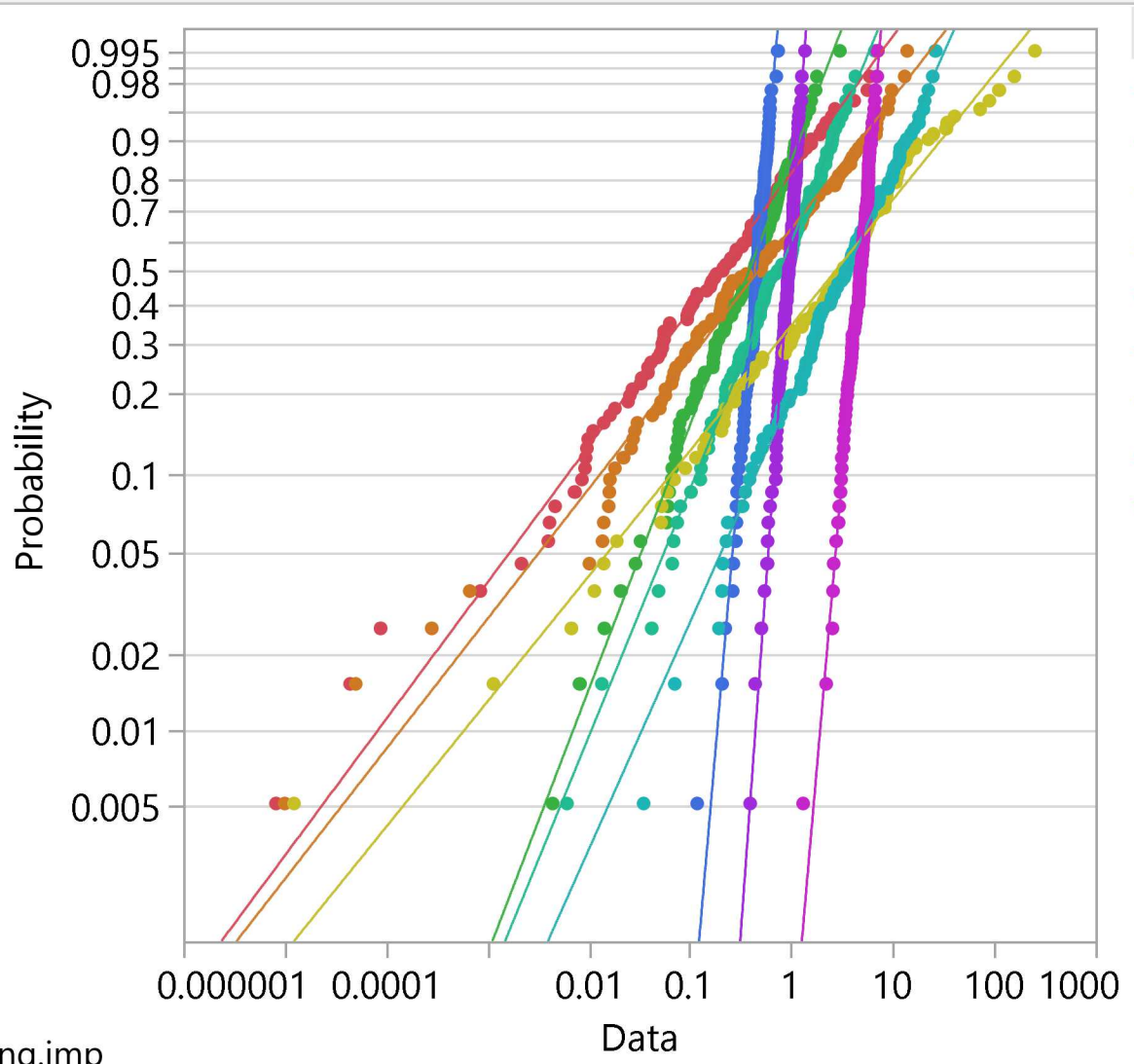


WEIBULL DISTRIBUTION PRIMER

Nonparametric Overlay

☐ Show Nonparametric CI

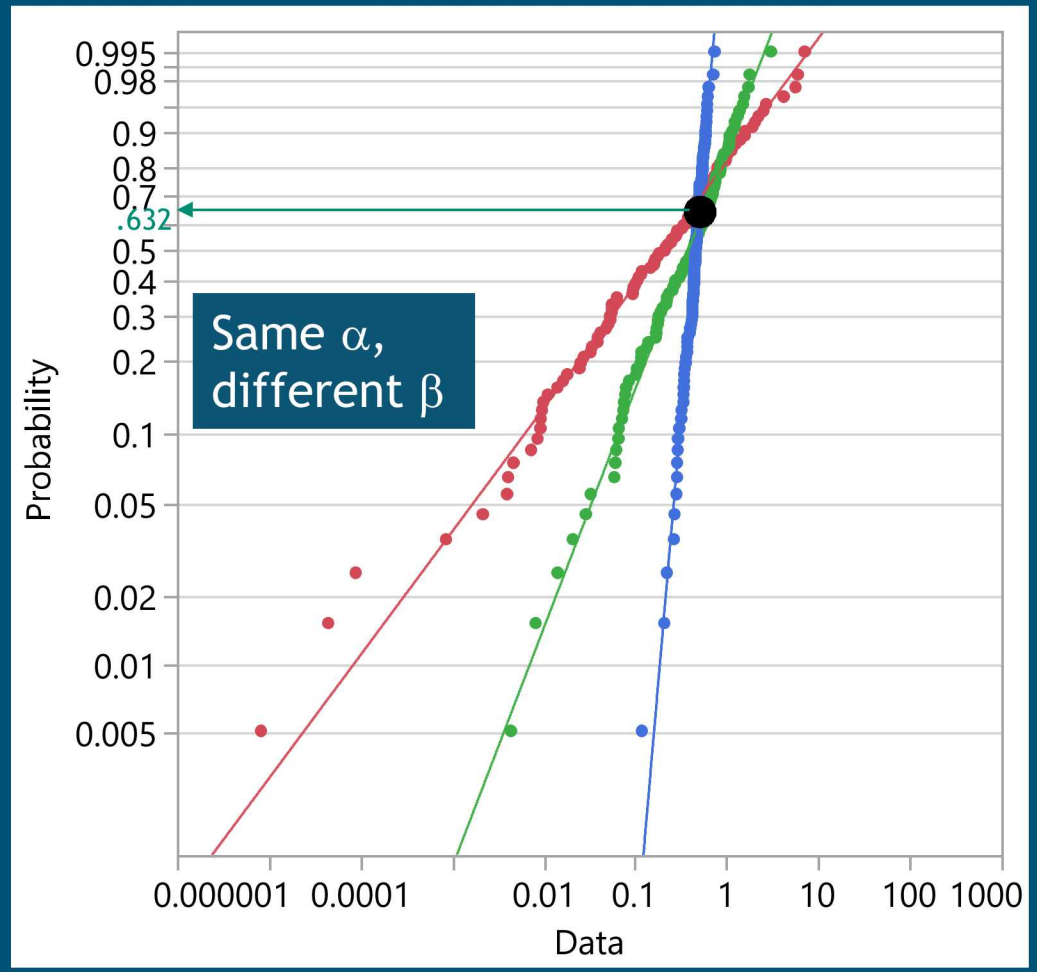
☐ Show Parametric CI

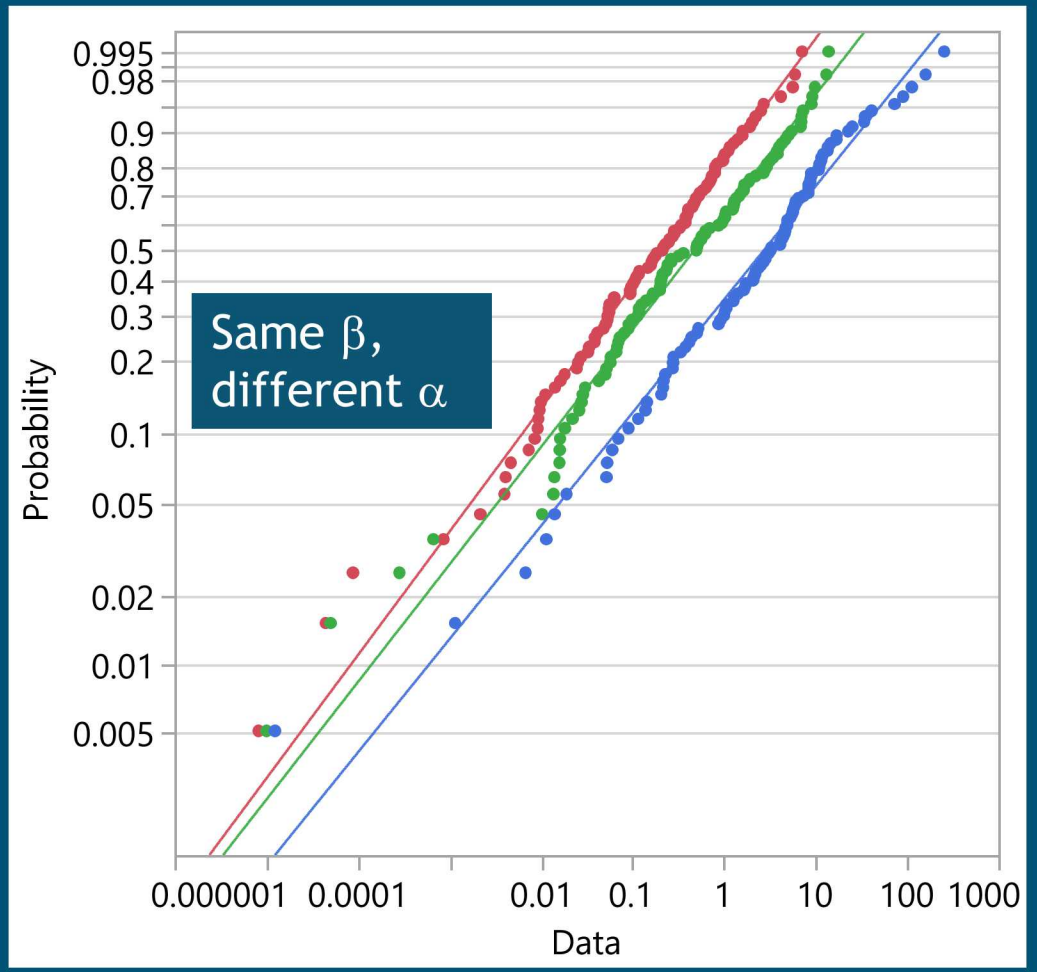


Weibull Curves alpha beta varying.jmp

WEIBULL DISTRIBUTION PLOTS – A LITTLE BACKGROUND

$$y = \frac{\beta}{\alpha}\left(\frac{x}{\alpha}\right)^{\beta-1} e^{(-x/\alpha)^{\beta}}$$

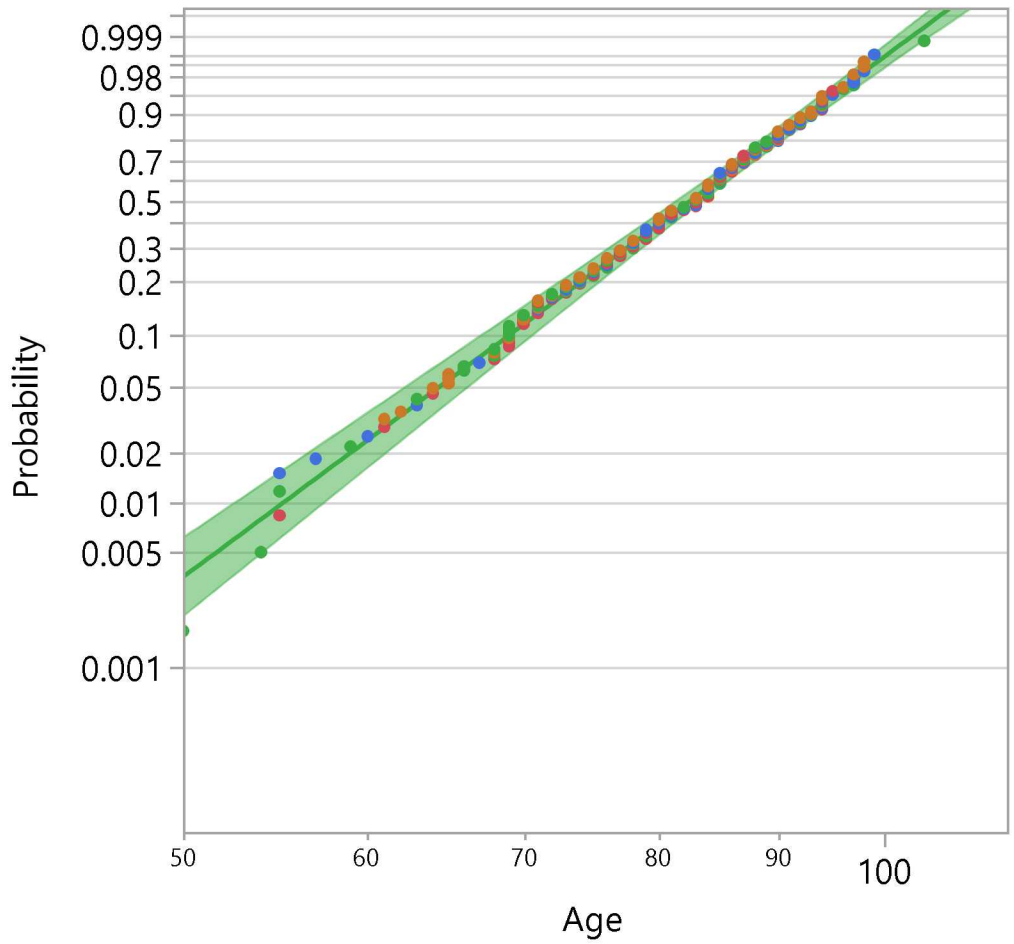




DATA PLOTTED WITH WEIBULL SCALE

Compare Distributions

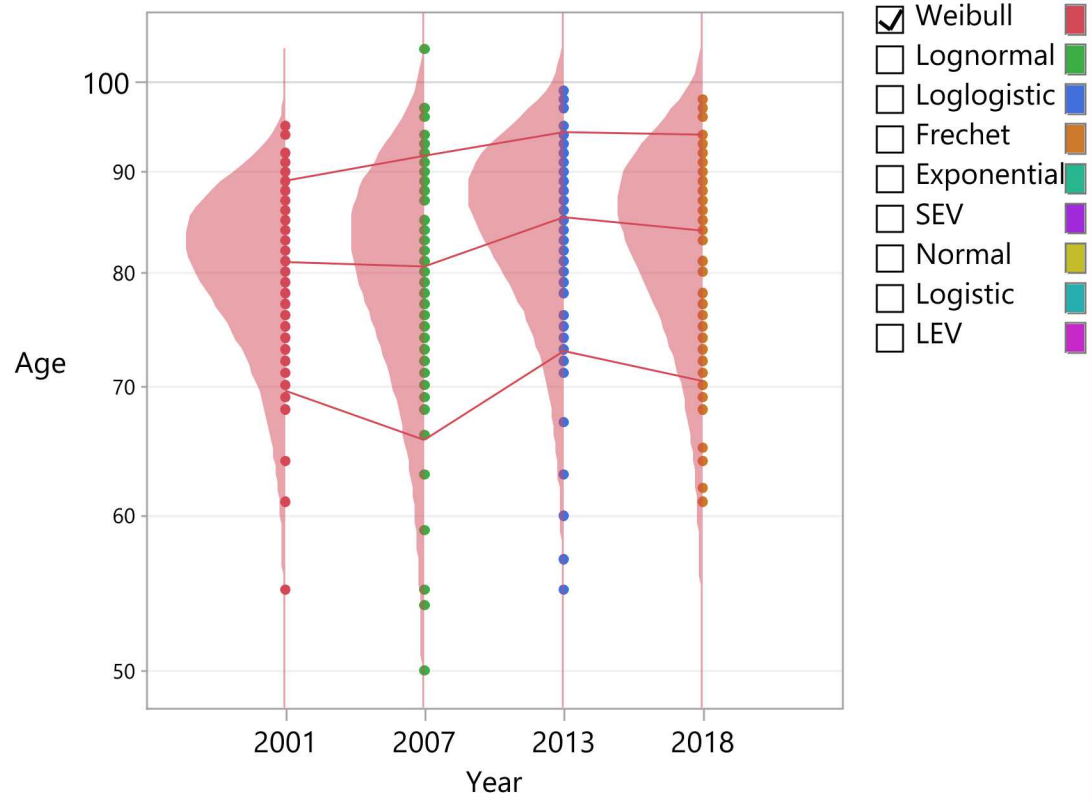
Distribution	Scale	
☐ Nonparametric	○	—
☐ Lognormal	○	—
☑ Weibull	◉	—
☐ Loglogistic	○	—
☐ Frechet	○	—
☐ Normal	○	—
☐ SEV	○	—
☐ Logistic	○	—
☐ LEV	○	—
☐ Exponential	○	—
☐ LogGenGamma		—
☐ GenGamma		—
☐ TH Lognormal		—
☐ TH Weibull		—
☐ TH Loglogistic		—
☐ TH Frechet		—
☐ DS Lognormal		—
☐ DS Weibull		—
☐ DS Loglogistic		—
☐ DS Frechet		—

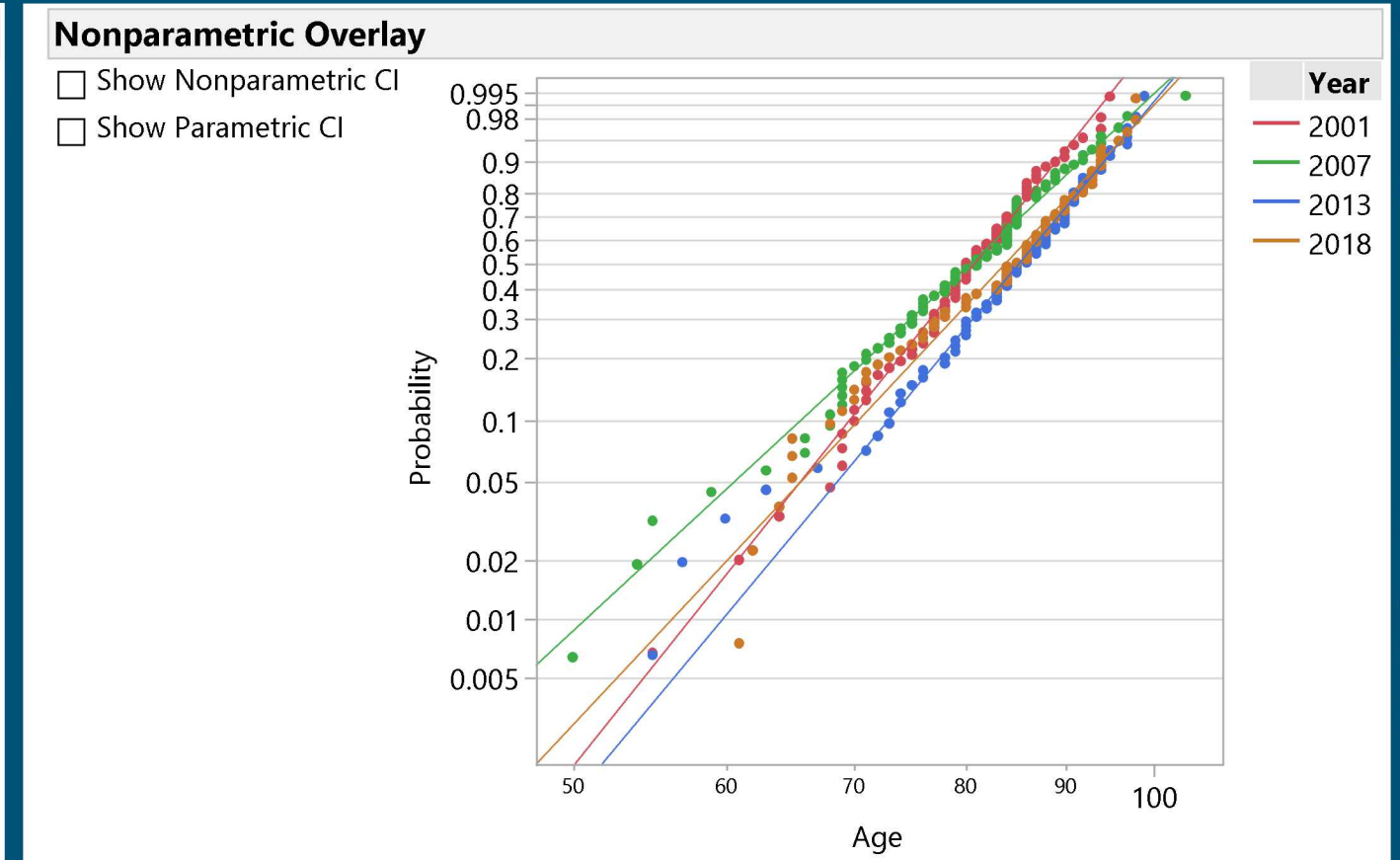


Probability values (y-axis) determined by Maximum Likelihood.

ARE WE GETTING HEALTHIER? FIT LIFE BY X

Fit Age by Year





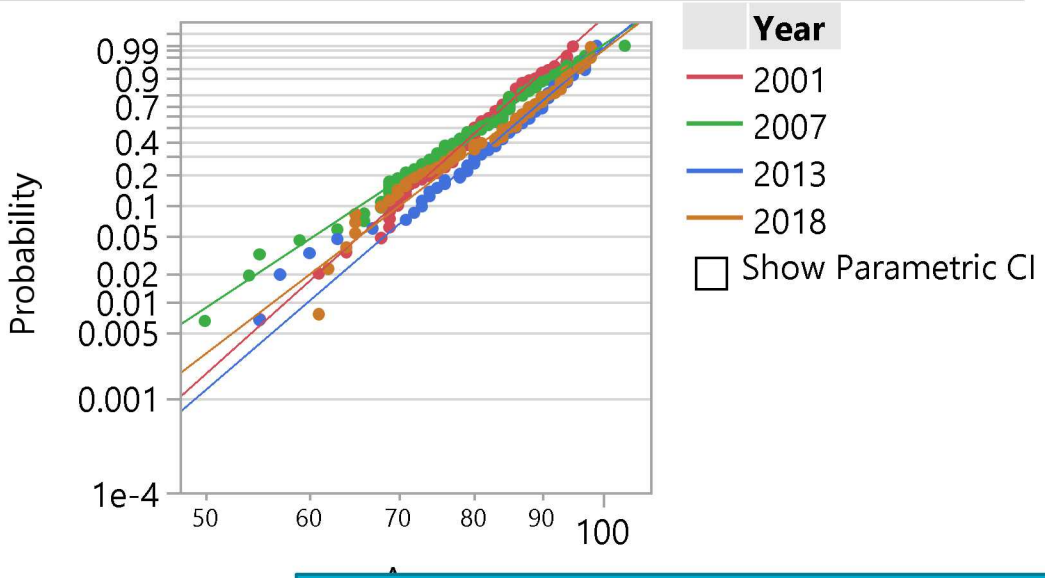
COMPARING LOCATIONS AND SCALES

Test Results

Description	L-R ChiSquare	DF	Prob>ChiSq
No Effect vs. Location	16.80089	3	0.0008*
Location vs. Location and Scale	7.485386	3	0.0579

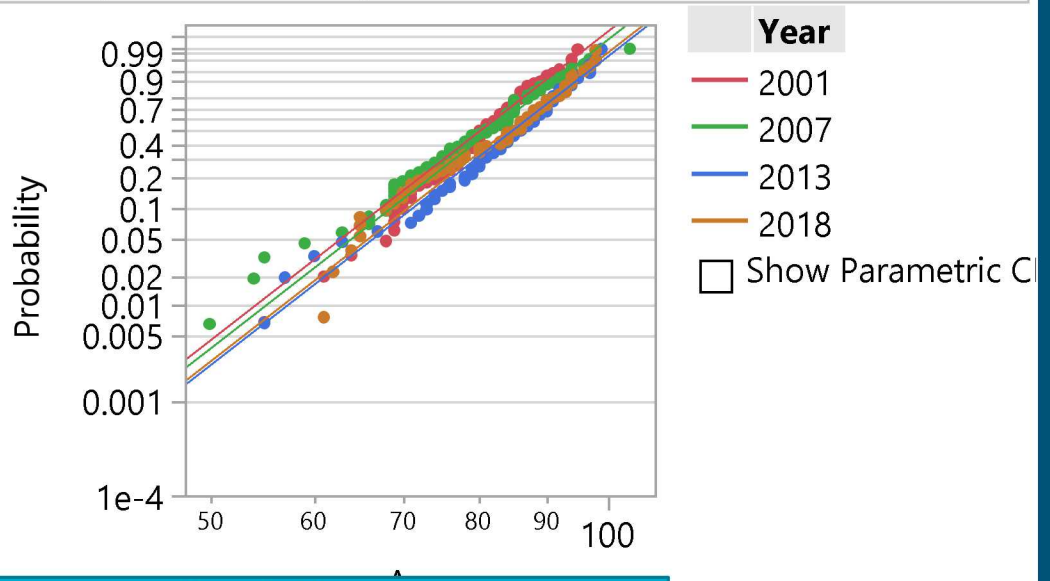
Diagnostics - Location and Scale

Multiple Probability Plot



Diagnostics - Location

Multiple Probability Plot



Locations (Intercepts) are statistically different.
Scales (slopes) are *not quite* statistically different.

WHAT AM I FORGETTING?

I am not considering retirees still living. That could be informative data!

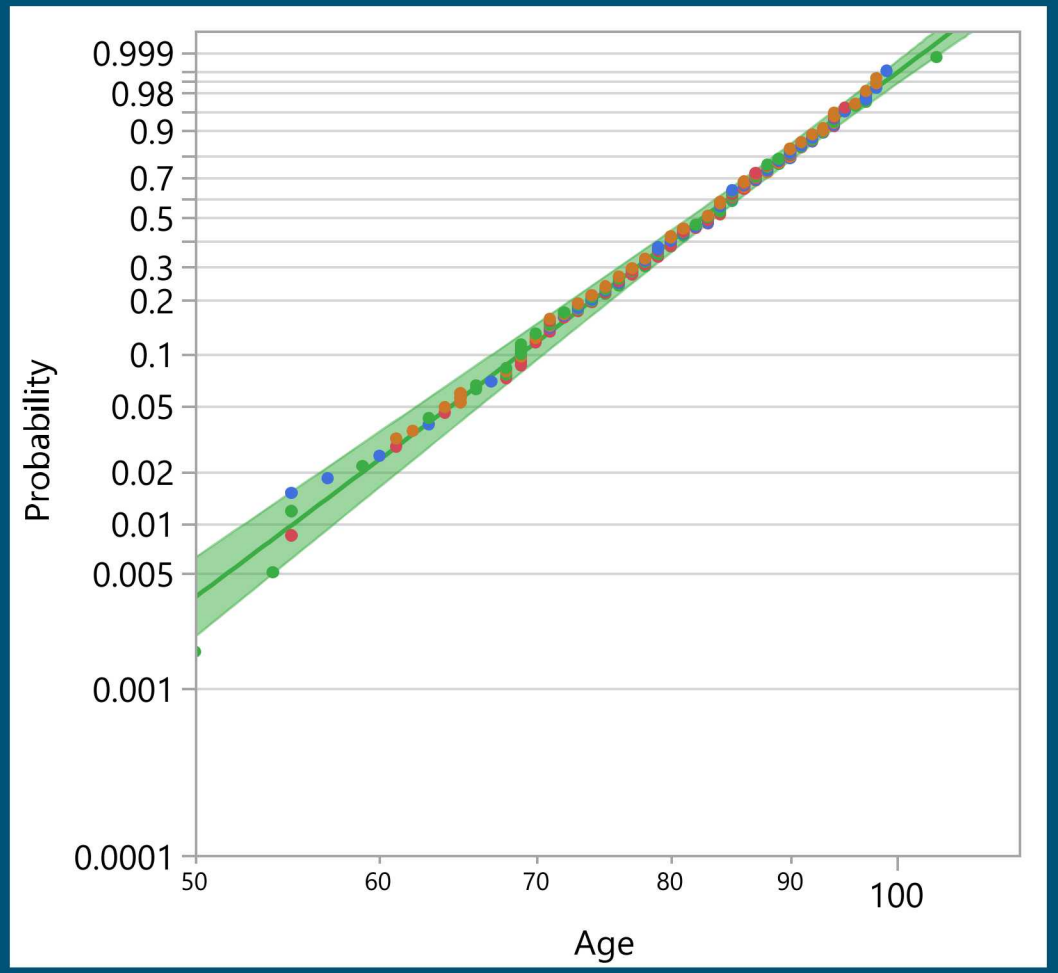
- This would be censored data that I could include, if I had it.
- JMP can handle censored data. However, I don't have access to the age of all retirees still living at the time, for each data set (2001, 2007, 2013, 2018).

WHAT AM I FORGETTING?

I tinkered with many different ways of estimating censored data for retirees still alive, but nothing practical became of it. As George Box says:

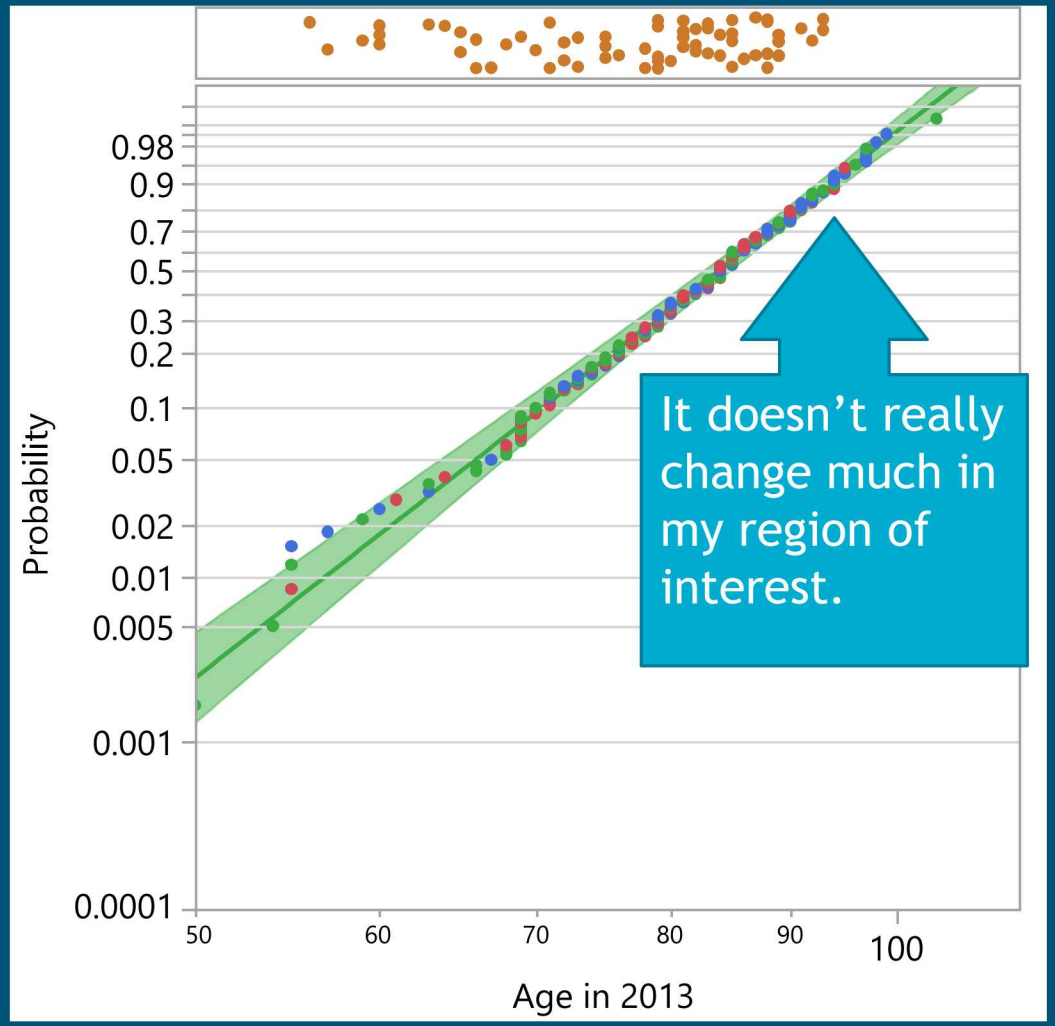
> "… all models are wrong; the practical question is how wrong do they have to be to not be useful …"

ORIGINAL DATA



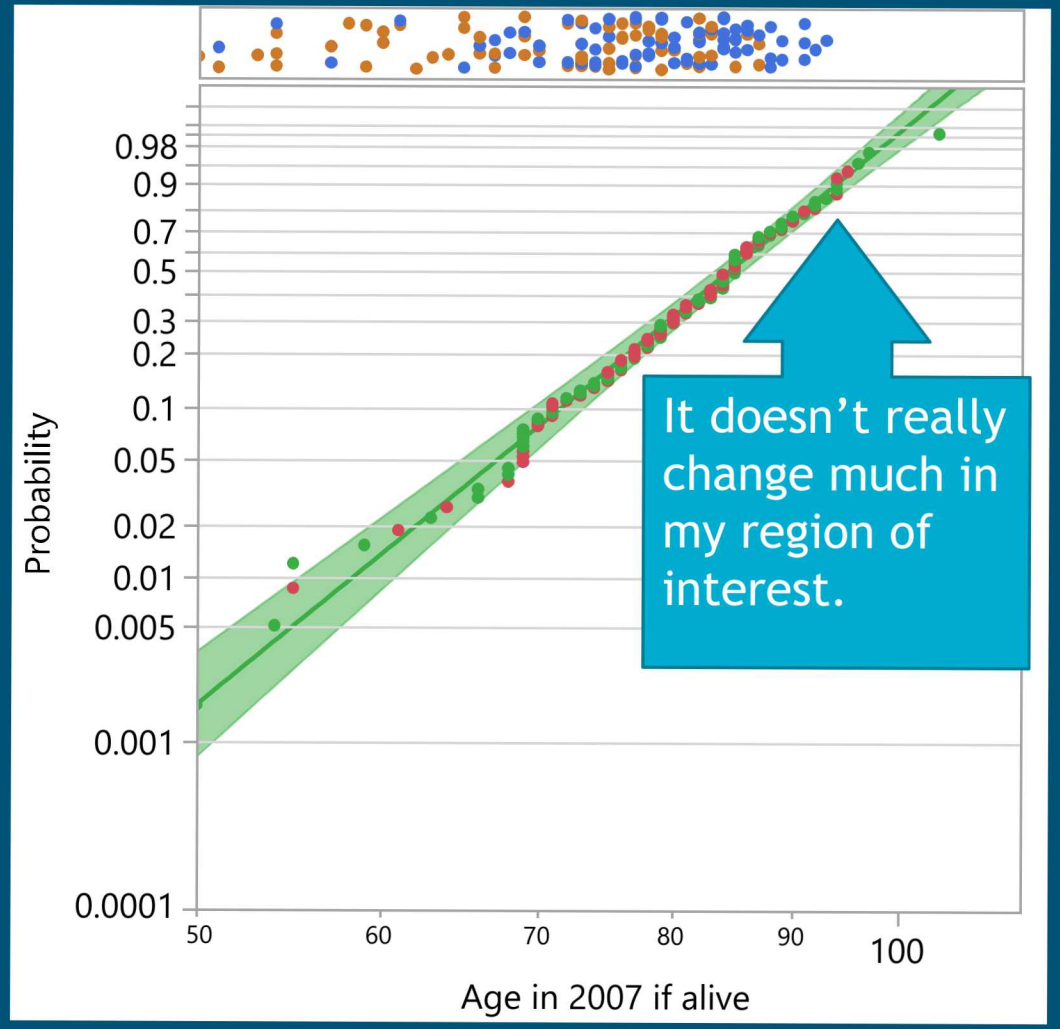
CENSORING 2018 DATA TO 2013

Let's go back in time to 2013 and treat 2018 data as censored, or suspended.



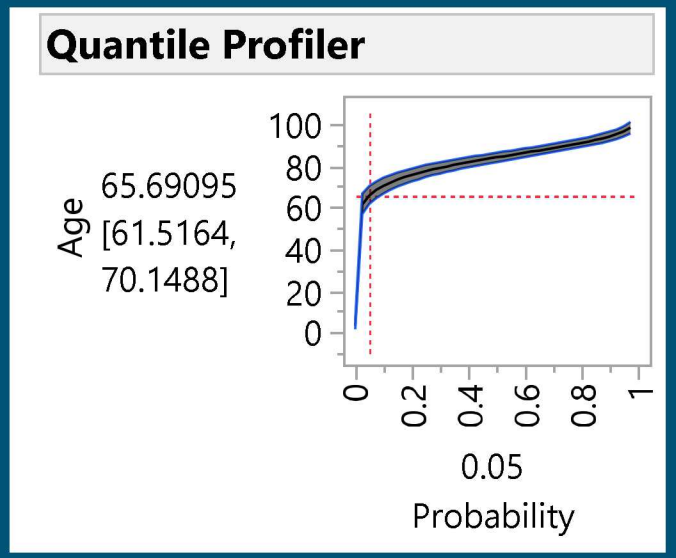
CENSORING 2018 AND 2013 DATA TO 2007

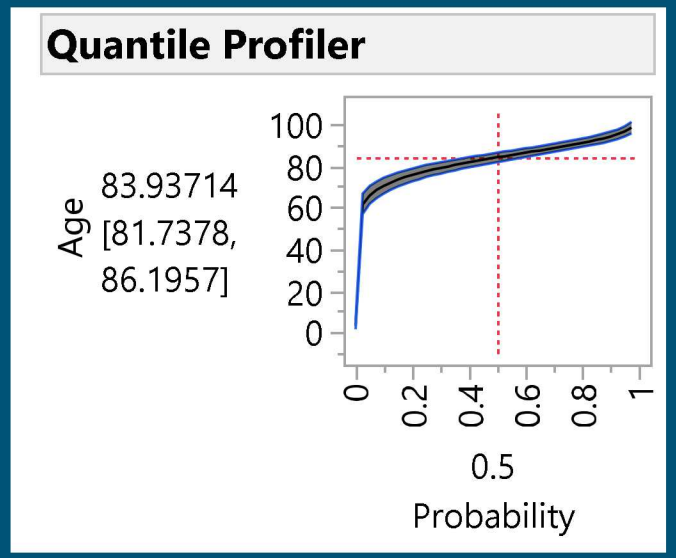
Let's go back in time to 2007 and treat 2018 and 2013 data as censored, or suspended.

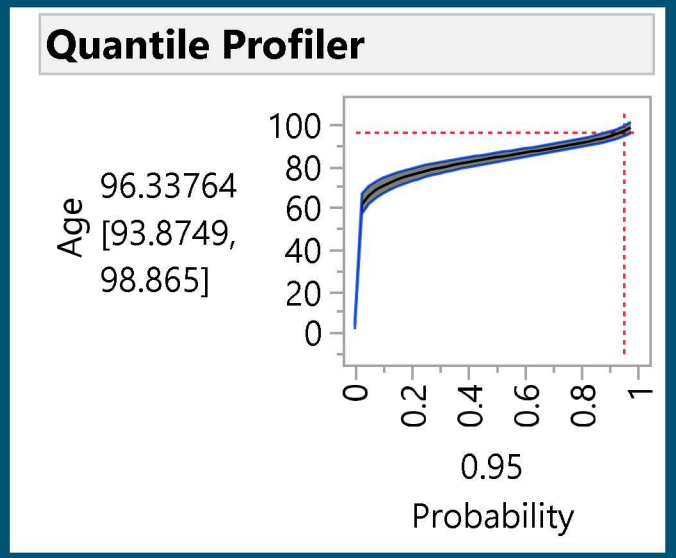


DETERMINING MY 90% CONFIDENCE INTERVAL

Using 2018 data:



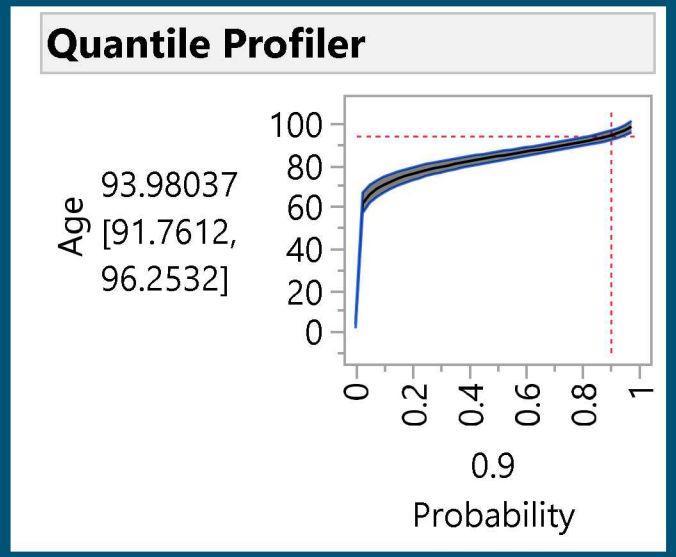




My best estimate is that I will live to be 84 years old.
The 90% Confidence Interval is 66 - 96 years old.

DETERMINING MY 90% UPPER CONFICENCE LEVEL

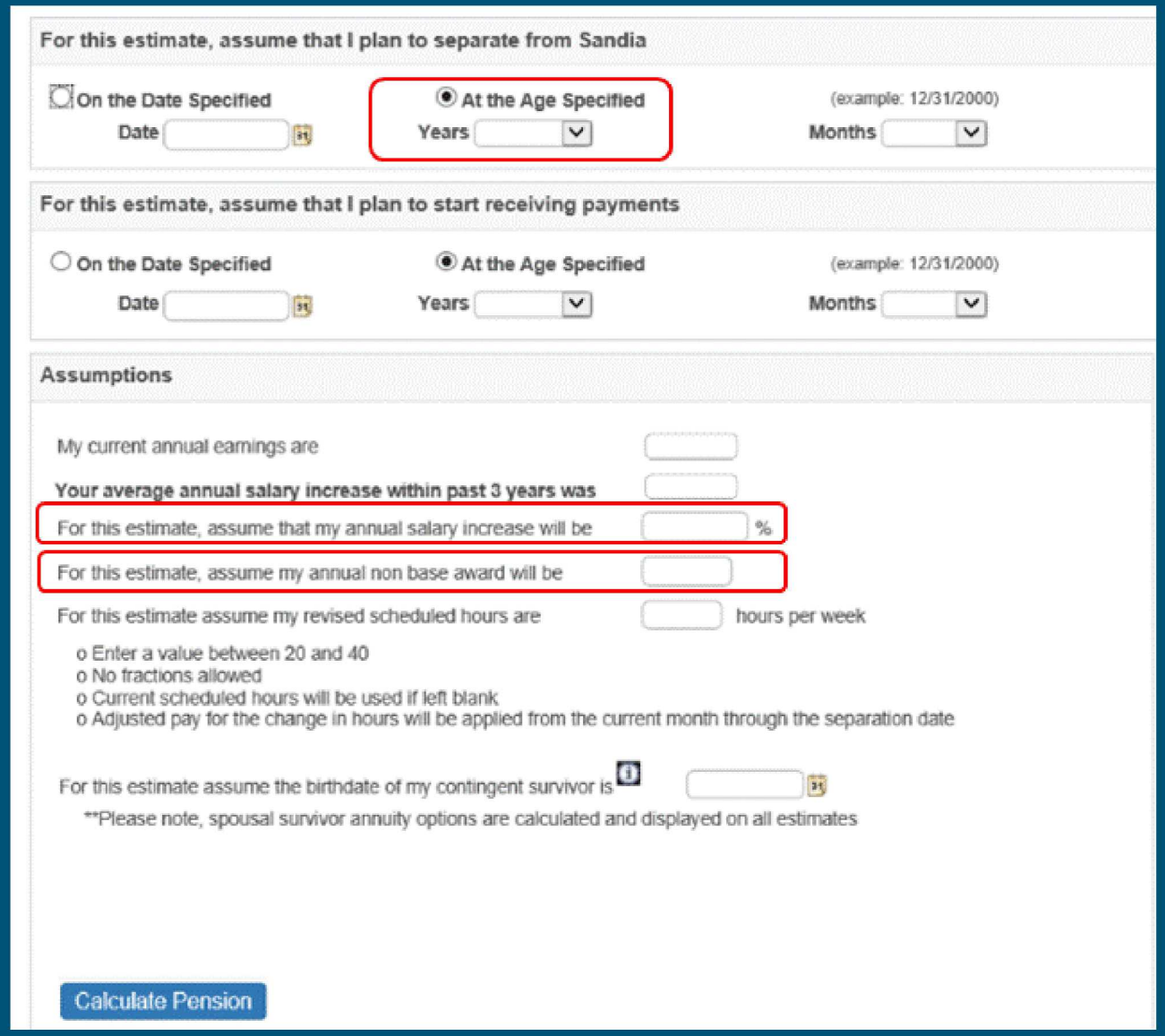
Using 2018 data:



90% Upper Confidence Level is 94 years. If I plan for retirement to age 94, there's a 90% chance I won't run out of money.

WHY DOES SOMETHING SO CERTAIN HAVE SO MUCH UNCERTAINTY?

OTHER JMP TOOLS TO HELP ME DECIDE – THE CUSTOM DESIGNER CAN BE USED TO CREATE A DOE FOR THE PENSION TOOL



Reverse-engineering the Pension Tool

LET'S GO BACK TO JMP!

RESPONSE SURFACE MODEL

Design

Run	Age at retirement	Annual salary increase	Annual non base award
1	62	0	2000
2	62	0	6000
3	62	3	4000
4	62	6	2000
5	62	6	6000
6	65	0	4000
7	65	3	2000
8	65	3	4000
9	65	3	4000
10	65	3	6000
11	65	6	4000
12	68	0	2000
13	68	0	6000
14	68	3	4000
15	68	6	2000
16	68	6	6000

Model

Intercept

Age at retirement

Annual salary increase

Annual non base award

Main Effects for the Pension Tool

Age at retirement*Age at retirement

Age at retirement*Annual salary increase

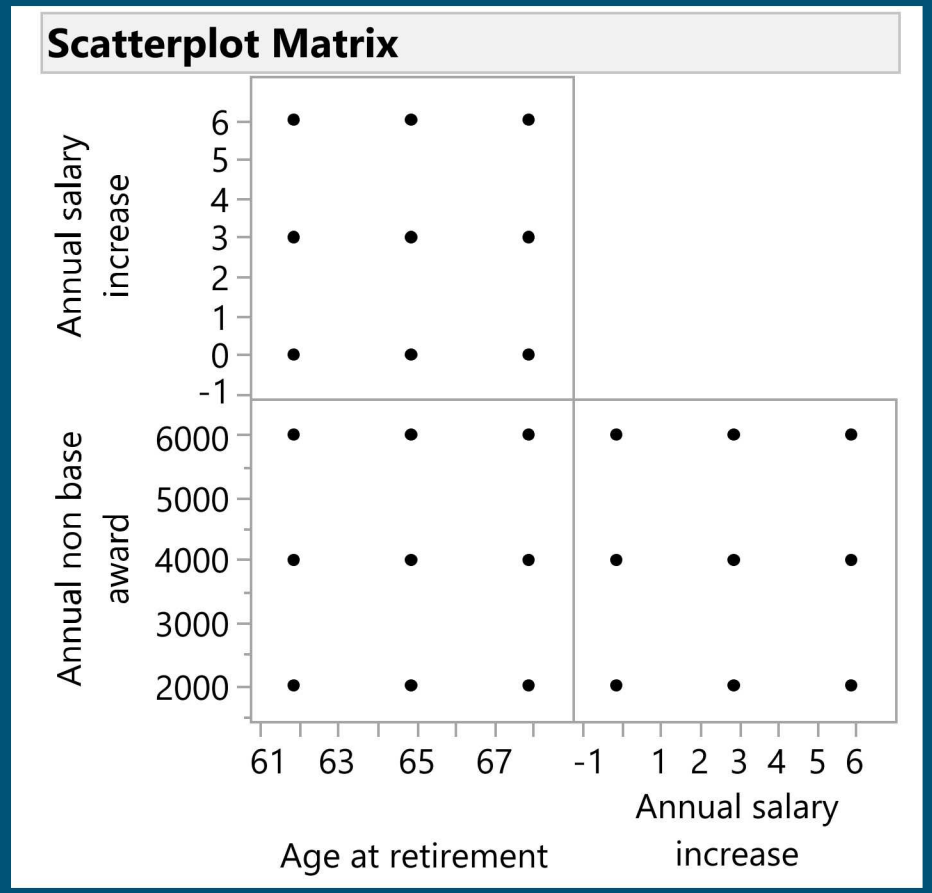
Annual salary increase*Annual salary increase

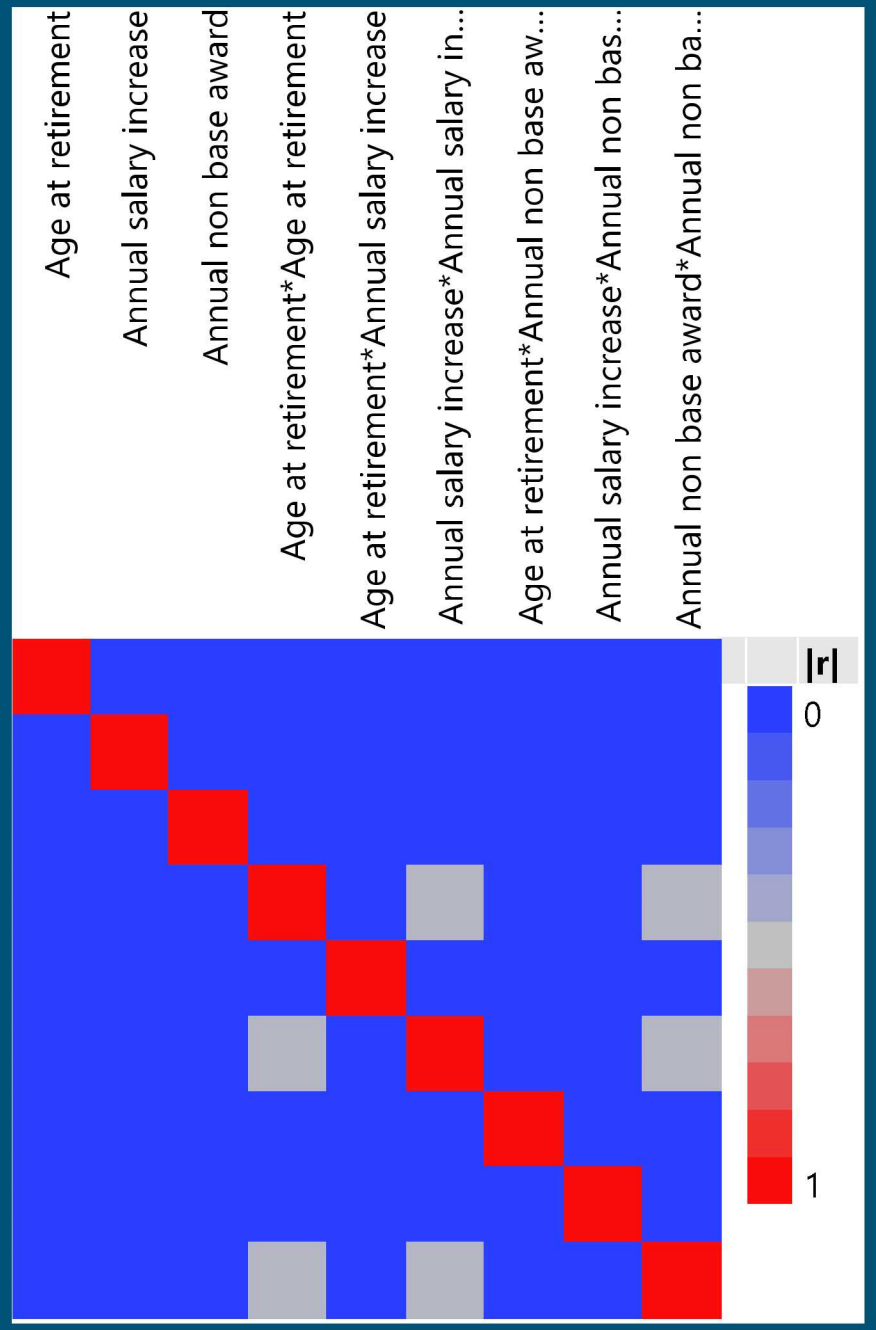
Age at retirement*Annual non base award

Annual salary increase*Annual non base award

Annual non base award*Annual non base award

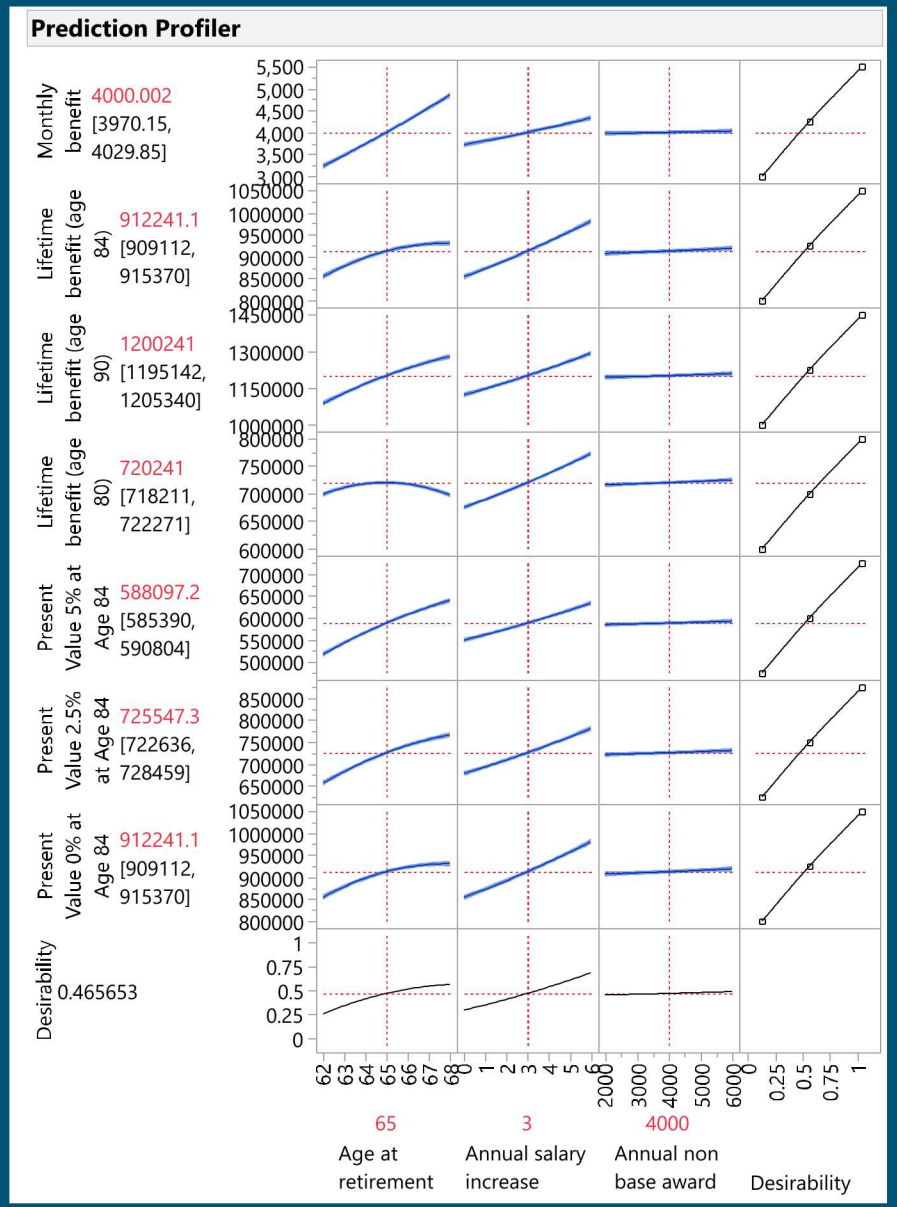
OTHER JMP TOOLS TO HELP ME DECIDE





MONTHLY, LIFETIME, AND LIFETIME ADJUSTED FOR INFLATION

A hypothetical example using the actual Pension Tool, but with all dollar amounts modified by an anonymous "fudge factor" to make the monthly benefit the average household benefit.



The average retired household spends $46,000 a year. That's about $4,000 a month.

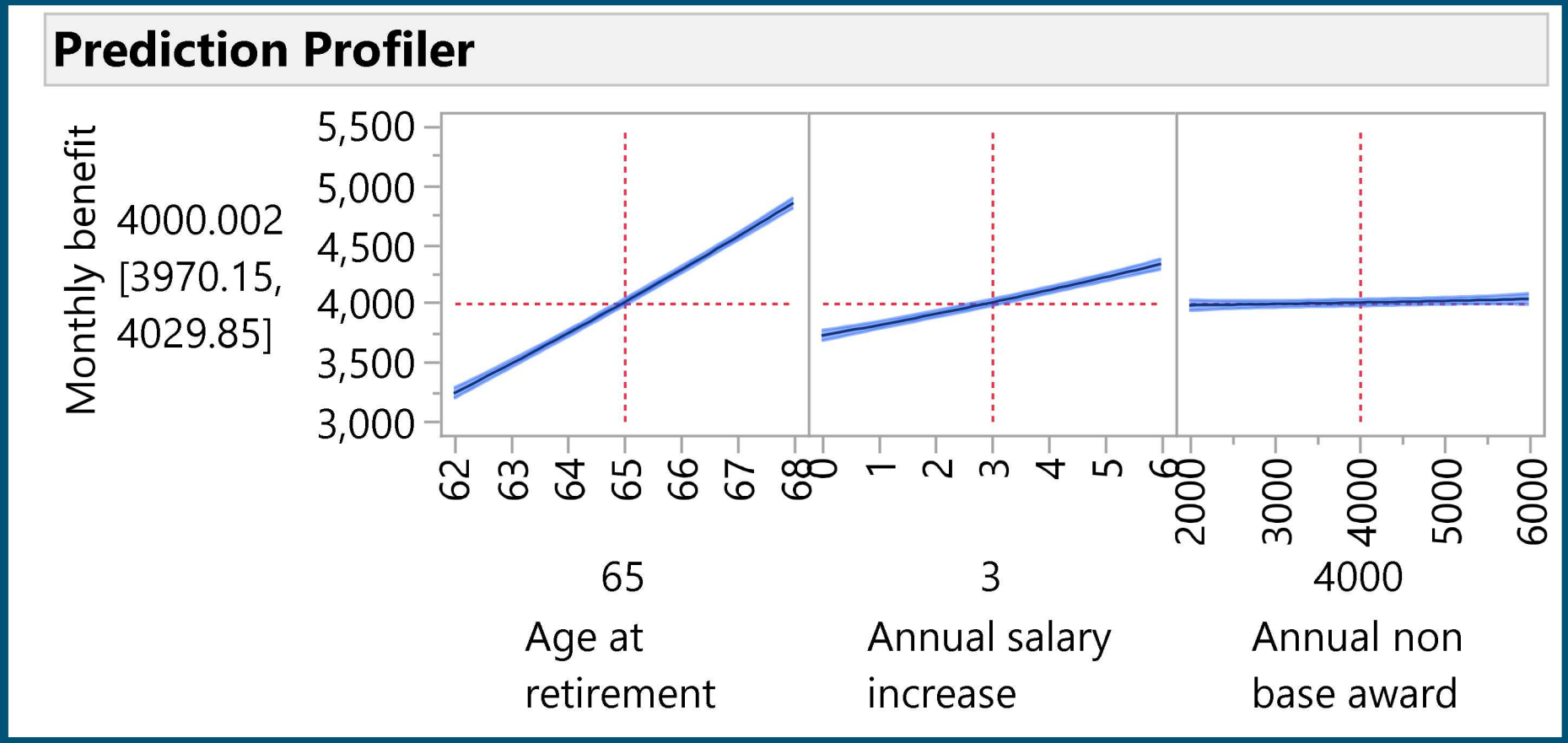
https://www.msn.com/en-us/money/retirement/heres-what-retirement-costs-the-average-american-each-year/ar-BBKYDks?ocid=spartandhp

A CLOSER LOOK

Columns with formulas were added for:

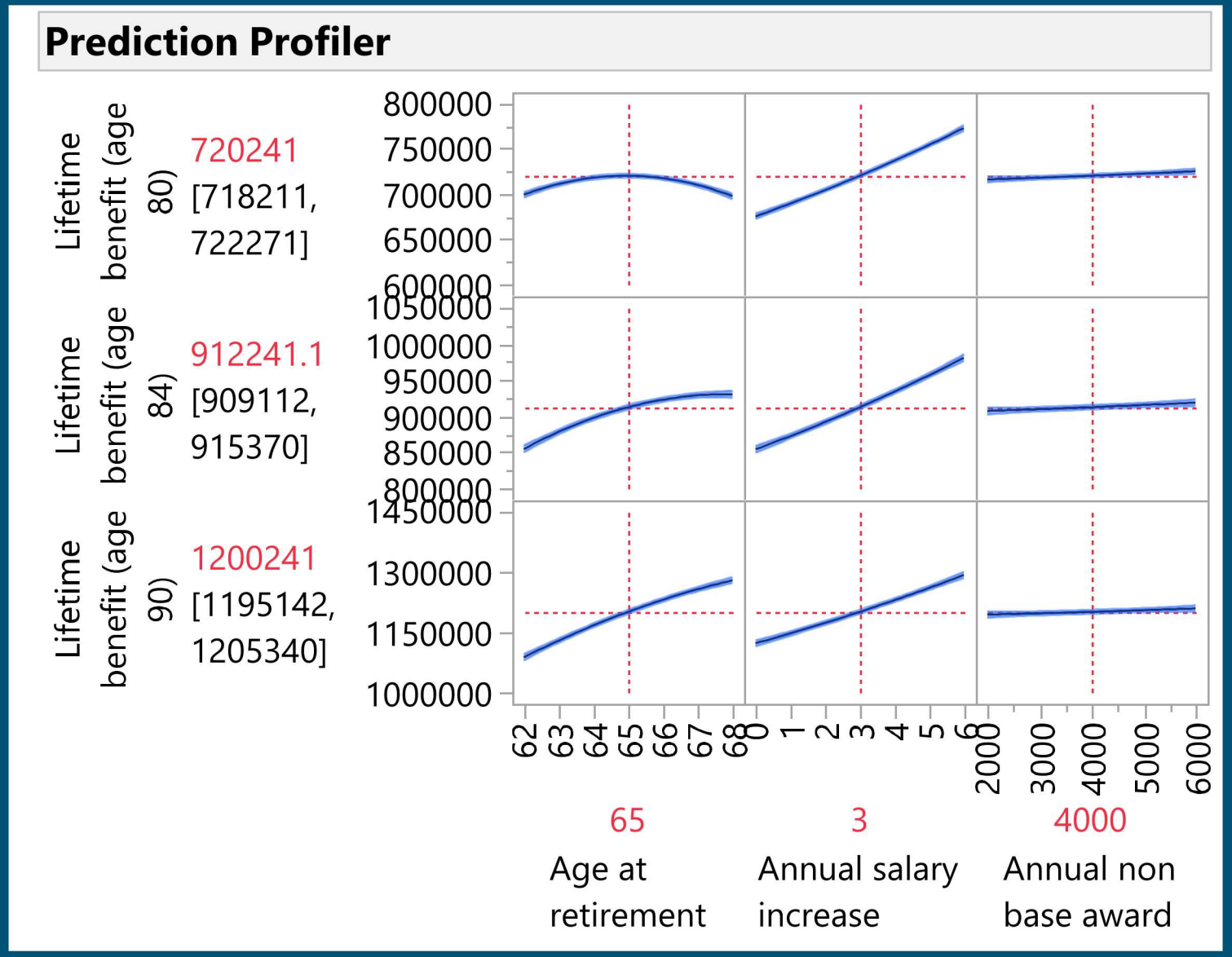
- Lifetime Benefit
  - Age 80
  - Age 84
  - Age 90
- Present Value of Lifetime Benefit at Age 84
  - 0% inflation
  - 2.5% inflation
  - 5% inflation

MONTHLY BENEFIT

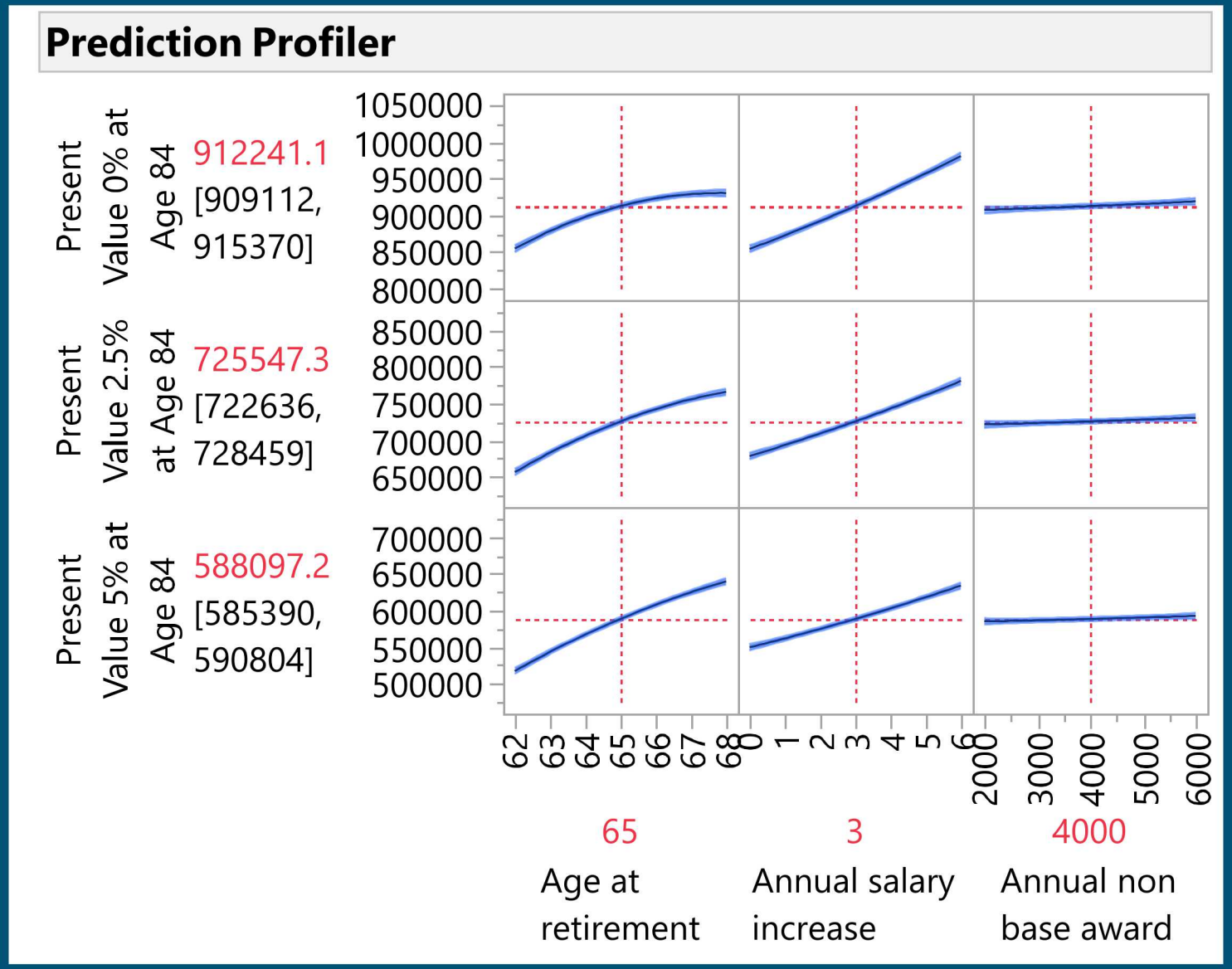


Age has the largest effect on Monthly Benefit

LIFETIME BENEFIT AT THREE DIFFERENT LIFESPANS (80, 84, 90)



ADJSUTING FOR THREE INFLATION SCENARIOS



SUMMARY

- Retiree Death Data was used to demonstrate Life Distribution and Fit Life by X
- Comparisons were made between four different time periods
- Uncertainties were quantified with Confidence Intervals
- Custom DOE was used to reverse-engineer a web-based applet
- Profiler replaced one data point at a time estimates

WHAT QUESTIONS DO YOU HAVE FOR ME?