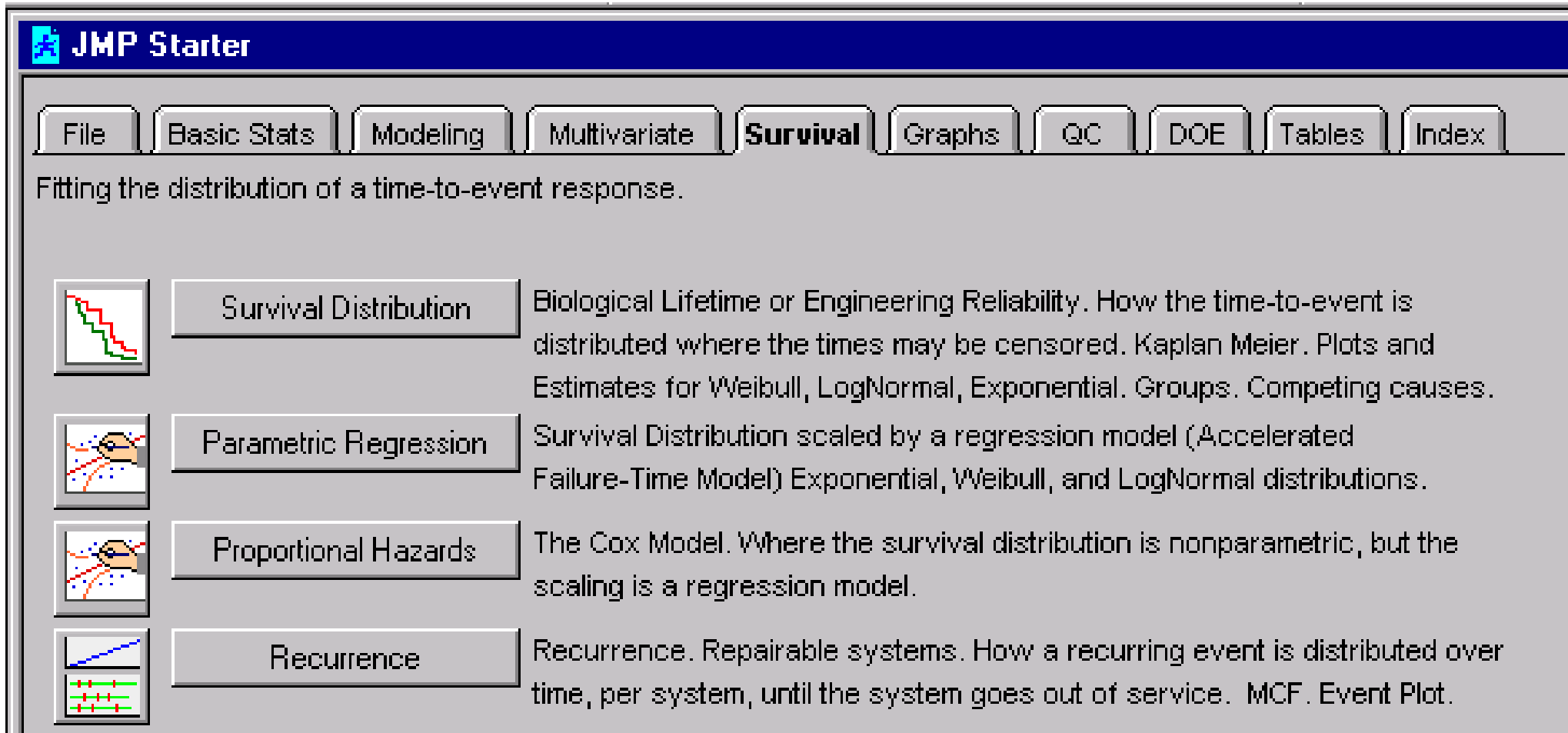


**A Case Study in Competing Risk
Reliability Analysis Using JMP Software**
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SAS Institute, Inc.

Outline

- Overview of Reliability (Survival) Analysis in JMP 4.0
- A JMP Script - Competing Causes GUI
- Analysis of some pseudo-data
- Analysis of Process data

Overview of Reliability Analysis in JMP 4.0



The screenshot shows the JMP Starter window with the 'Survival' menu selected. The menu items are: File, Basic Stats, Modeling, Multivariate, **Survival**, Graphs, QC, DOE, Tables, and Index. Below the menu, the text reads: 'Fitting the distribution of a time-to-event response.' The Survival menu is expanded to show four options, each with a small icon and a description:

- Survival Distribution**: Biological Lifetime or Engineering Reliability. How the time-to-event is distributed where the times may be censored. Kaplan Meier. Plots and Estimates for Weibull, LogNormal, Exponential. Groups. Competing causes.
- Parametric Regression**: Survival Distribution scaled by a regression model (Accelerated Failure-Time Model) Exponential, Weibull, and LogNormal distributions.
- Proportional Hazards**: The Cox Model. Where the survival distribution is nonparametric, but the scaling is a regression model.
- Recurrence**: Recurrence. Repairable systems. How a recurring event is distributed over time, per system, until the system goes out of service. MCF. Event Plot.

JMP Starter Window

Univariate Survival Launch Dialog

Survival / Reliability

The distribution of the time until an event

Select Columns

- Weibull 1
- Weibull 2
- Observed Time
- Censor 1
- No Censoring

Cast Selected Columns into Roles

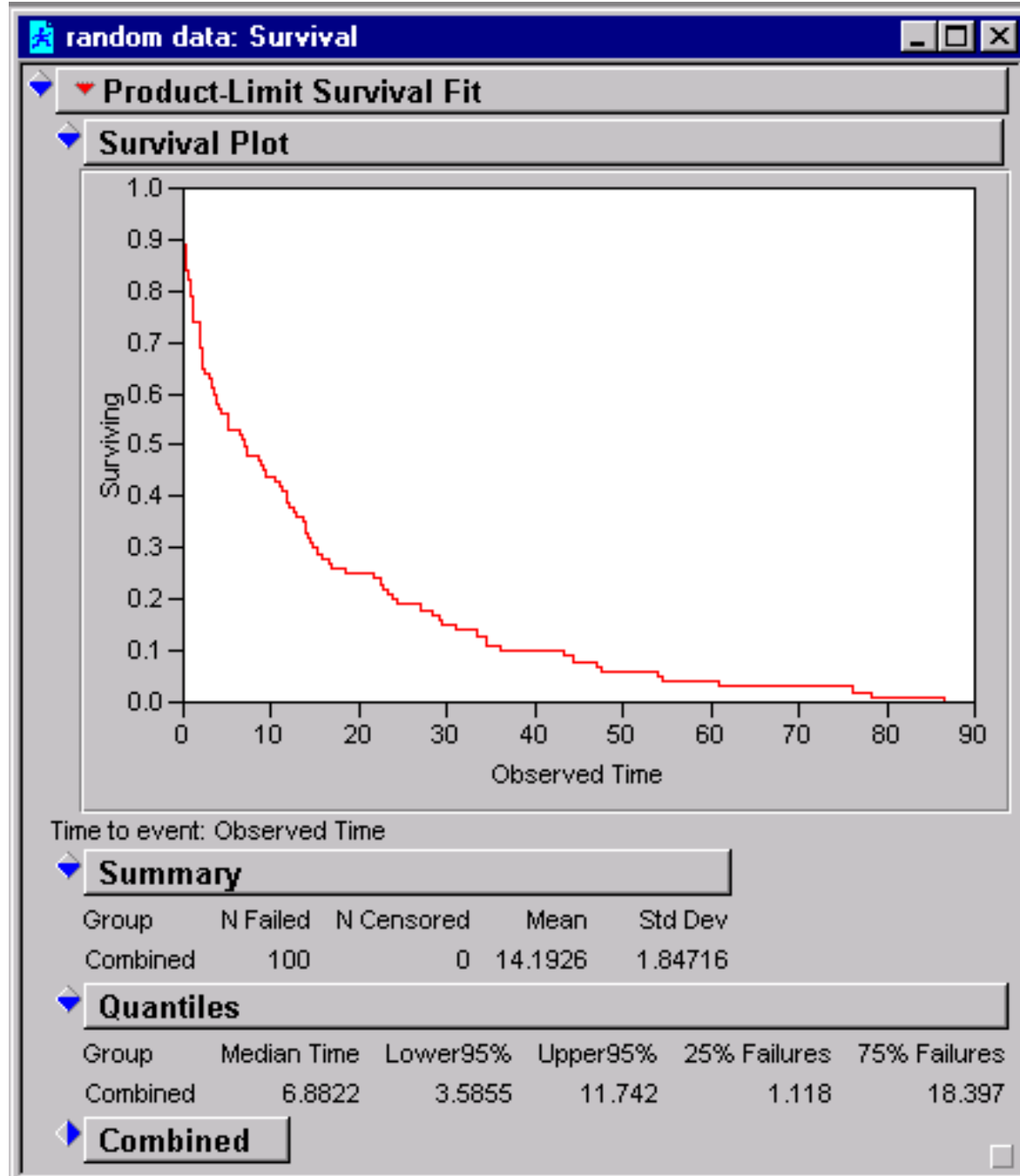
Y, Time to Event	<input checked="" type="radio"/> Observed Time
Grouping	<i>optional</i>
Censor	<i>optional numeric</i>
Freq	<i>optional numeric</i>
By	<i>optional</i>

Censor>0 indicates censored time

Action

- OK
- Cancel
- Remove
- Recall
- Help

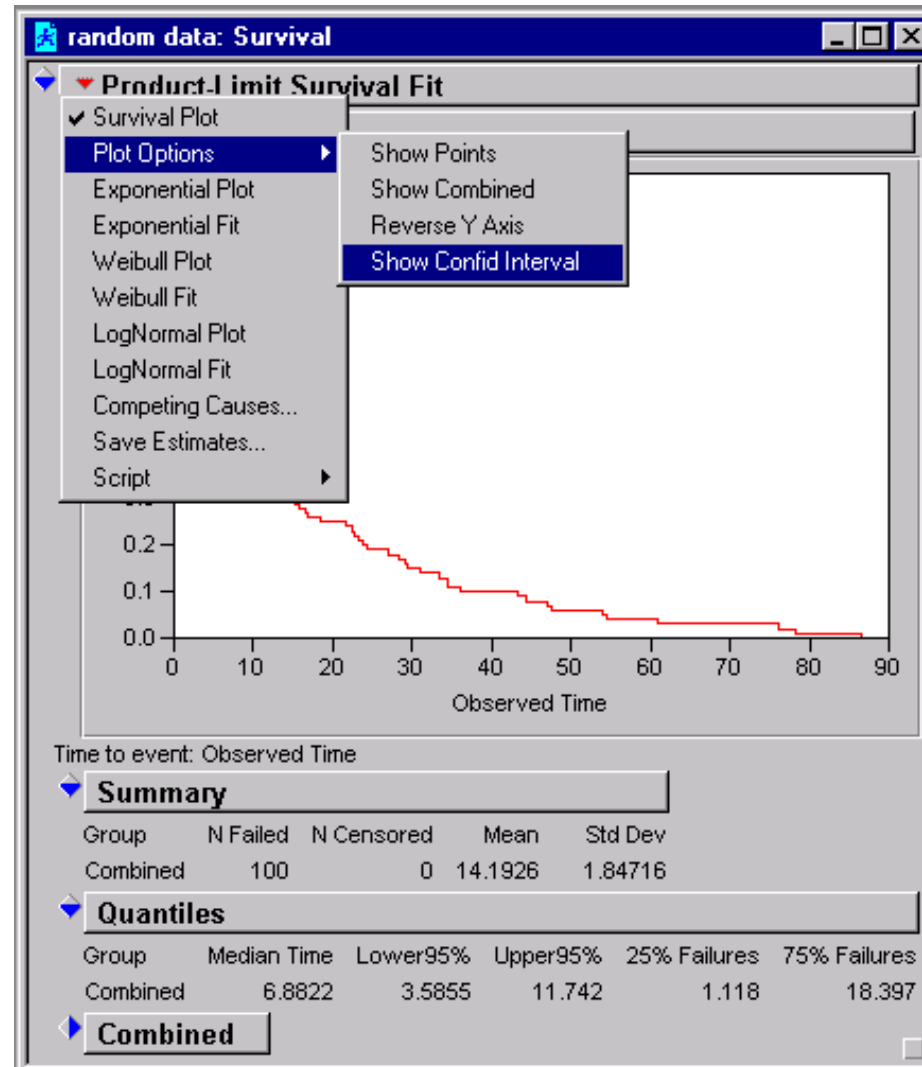
Default Analysis



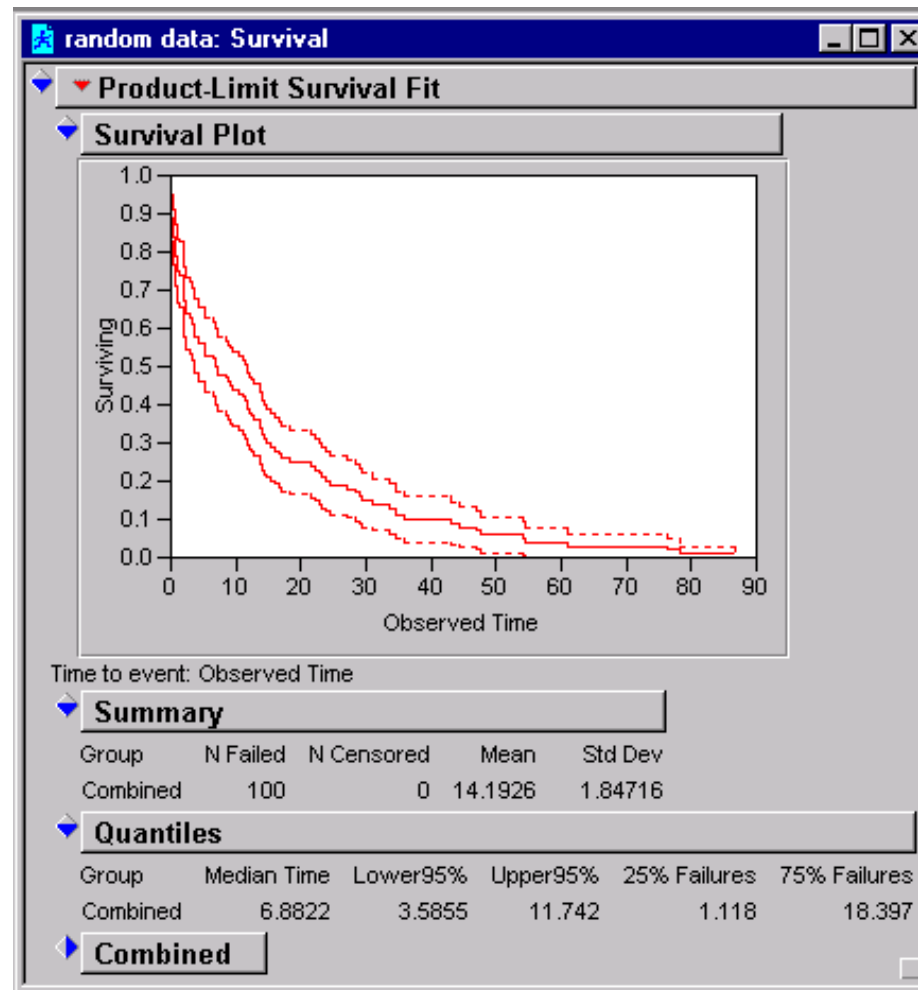
Default Analysis cont.

Combined							
Observed Time	Survival	Failure	SurvStdErr	N Failed	N Censored	At Risk	
0.0000	1.0000	0.0000	0.0000	0	0	100	
0.0000	0.9900	0.0100	0.0099	1	0	100	
0.0005	0.9800	0.0200	0.0140	1	0	99	
0.0013	0.9700	0.0300	0.0171	1	0	98	
0.0014	0.9600	0.0400	0.0196	1	0	97	
0.0279	0.9500	0.0500	0.0218	1	0	96	
0.0329	0.9400	0.0600	0.0237	1	0	95	
0.0355	0.9300	0.0700	0.0255	1	0	94	
0.0419	0.9200	0.0800	0.0271	1	0	93	
0.0424	0.9100	0.0900	0.0286	1	0	92	
0.0475	0.9000	0.1000	0.0300	1	0	91	
0.0718	0.8900	0.1100	0.0313	1	0	90	
0.2082	0.8800	0.1200	0.0325	1	0	89	
0.2210	0.8700	0.1300	0.0336	1	0	88	
0.2453	0.8600	0.1400	0.0347	1	0	87	
0.2891	0.8500	0.1500	0.0357	1	0	86	
0.3240	0.8400	0.1600	0.0367	1	0	85	
0.6482	0.8300	0.1700	0.0376	1	0	84	
0.6529	0.8200	0.1800	0.0384	1	0	83	
0.6870	0.8100	0.1900	0.0392	1	0	82	
0.7316	0.8000	0.2000	0.0400	1	0	81	
0.7633	0.7900	0.2100	0.0407	1	0	80	
1.0445	0.7800	0.2200	0.0414	1	0	79	

Options Menu Choice...



...and Results



Scripting Options Choice...

The screenshot shows the Minitab software interface for a survival analysis. The window title is "random data: Survival". The main menu is "Product-Limit Survival Fit". A sub-menu is open under "Script", showing options: "Redo Analysis", "Save Script to Datable", "Save Script to Report", "Save Script to Script Window" (highlighted), "Save Script for All Objects", and "Data Table Window".

Below the menu, a small plot is visible with a y-axis from 0.0 to 0.1 and an x-axis from 0 to 20. The plot shows a single data point at approximately (10, 0.05).

Below the plot, the text "Time to event: Observed Tim" is visible.

The "Summary" section contains the following table:

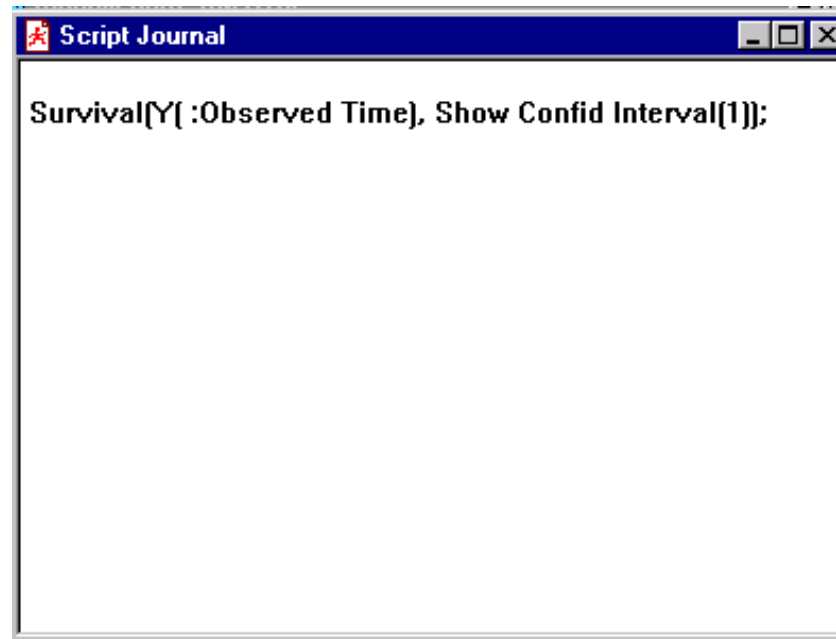
Group	N Failed	N Censored	Mean	Std Dev
Combined	100	0	14.1926	1.84716

The "Quantiles" section contains the following table:

Group	Median Time	Lower95%	Upper95%	25% Failures	75% Failures
Combined	6.8822	3.5855	11.742	1.118	18.397

The "Combined" section is currently empty.

...and Results

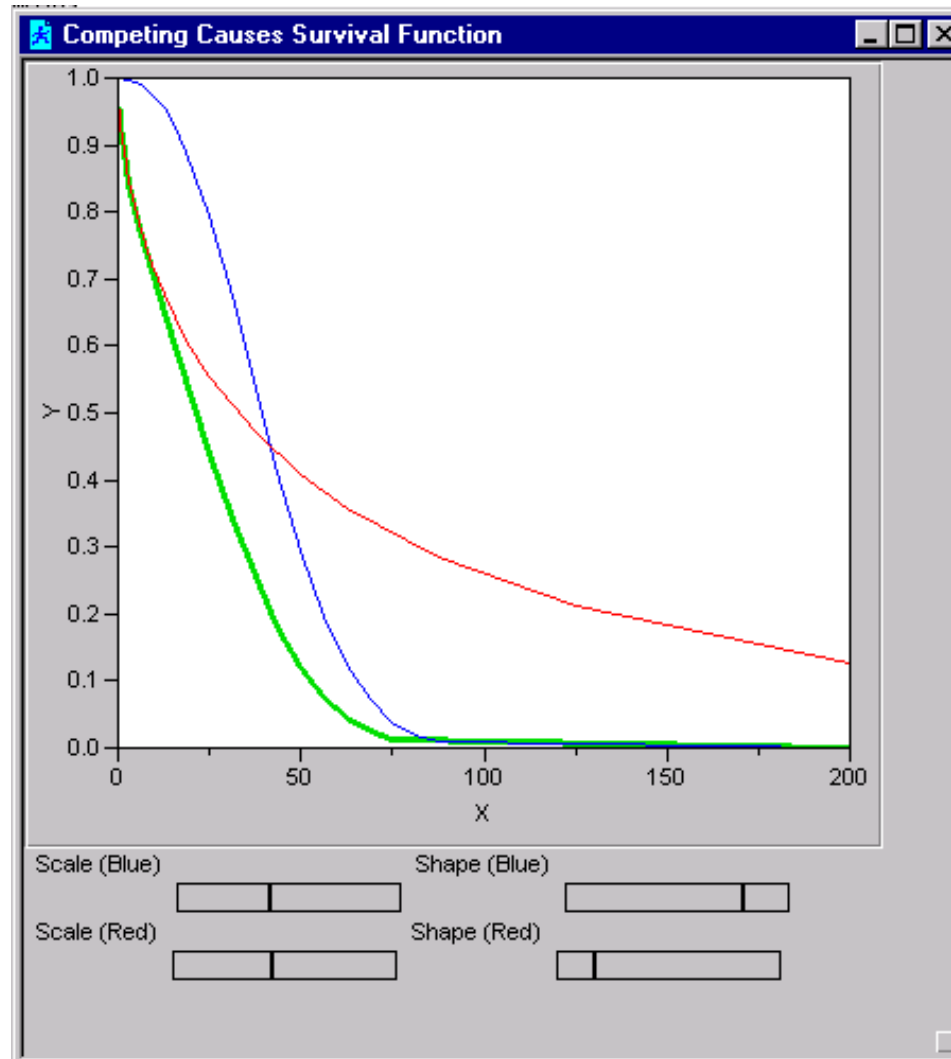


The image shows a screenshot of a software window titled "Script Journal". The window has a blue title bar with standard window controls (minimize, maximize, close). The main content area is white and contains the following text:

```
Survival[Y( :Observed Time), Show Confid Interval(1)];
```

Submitting the script above reproduces the analysis.

A JMP Script - Competing Causes GUI



Script

```
// Competing Causes Interactive Survival Plot
x=1; y=1;
shape1 = 2.4;          scale1 = log10(46);
shape2 = 0.6;          scale2 = log10(60);

survival = expr((1-Weibull Distribution(x, shape1, 10^scale1, 0))*(1-Weibull Distribution(x, shape2, 10^scale2, 0)));

gBox = Graph Box(FrameSize(500,300),Double Buffer,
  XScale(0,200),yScale(0,1),
  pen color("green");pen size(3);
  YFunction(survival,x),
  pen color("blue");pen size(1);
  YFunction(1-Weibull Distribution(x, shape1, 10^scale1, 0),x),
  pen color("red");pen size(1);
  YFunction(1-Weibull Distribution(x, shape2, 10^scale2, 0),x));

plot = gBox[FrameBox(1)];
NewWindow("Competing Causes Survival Function",
  v list box (gBox,
    h list box (textbox(" Scale (Blue) "),
      slider box (0,4, scale1,plot<<reshow()),
      textbox(" Shape (Blue) "),
      slider box (0.1,3, shape1,plot<<reshow())),
    h list box (textbox(" Scale (Red) "),
      slider box (0,4, scale2,plot<<reshow()),
      textbox(" Shape (Red) "),
      slider box (0.1,3, shape2,plot<<reshow()))
  )
);
```

Analysis of some pseudo-data

random data			Weibull 1	Weibull 2	Observed Time	Censor 1	No Censoring
shape1	2.2	1	22.3155051	74.4623742	22.3155051	0	0
scale1	60	2	74.7972305	6.68356133	6.68356133	1	0
shape2	0.5	3	46.7373946	12.4615701	12.4615701	1	0
scale2	20	4	106.637942	1.93713951	1.93713951	1	0
Survival Analysis		5	65.4554171	0.03548392	0.03548392	1	0
Competing Causes		6	35.7751211	11.9222539	11.9222539	1	0
Survival with Censoring		7	34.4962115	49.1092064	34.4962115	0	0
		8	47.5089675	139.357424	47.5089675	0	0
		9	54.3235326	14.0128334	14.0128334	1	0
		10	58.2916965	13.9316213	13.9316213	1	0
		11	47.1946481	1.11802666	1.11802666	1	0
		12	59.1734895	15.8112388	15.8112388	1	0
		13	54.0477133	109.05329	54.0477133	0	0
		14	35.9812974	53.969673	35.9812974	0	0
		15	33.4184061	35.6681479	33.4184061	0	0
		16	86.6135264	155.049008	86.6135264	0	0
		17	30.8565057	65.3996424	30.8565057	0	0
		18	20.3678807	0.73163429	0.73163429	1	0
		19	47.0602404	218.163575	47.0602404	0	0
		20	10.2799769	4.07989686	4.07989686	1	0

Column Formulae

Weibull 2

Table Columns: Weibull 1, Weibull 2, Observed Time, Censor 1, No Censoring

Functions (grouped): Row, Numeric, Transcendental, Trigonometric, Character, Comparison, Conditional, Probability, Statistical

OK, Cancel, Apply, Clear, Help

$scale2 * \left(-\log \left(1 - \text{Random Uniform}() \right) \right)^{\frac{1}{shape2}}$

Observed Time

Table Columns: Weibull 1, Weibull 2, Observed Time, Censor 1, No Censoring

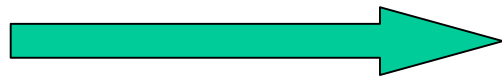
Functions (grouped): Row, Numeric, Transcendental, Trigonometric, Character, Comparison, Conditional, Probability, Statistical

OK, Cancel, Apply, Clear, Help

$\text{Min}(Weibull 1, Weibull 2)$

random data

- random data
 - shape1 2.2
 - scale1 60
 - shape2 0.5
 - scale2 20
 - Survival Analysis
 - Competing Causes
 - Survival with Censoring



random data: Survival

Product-Limit Survival Fit

Survival Plot

Time to event: Observed Time

Weibull Plot

Summary

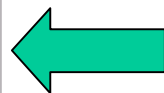
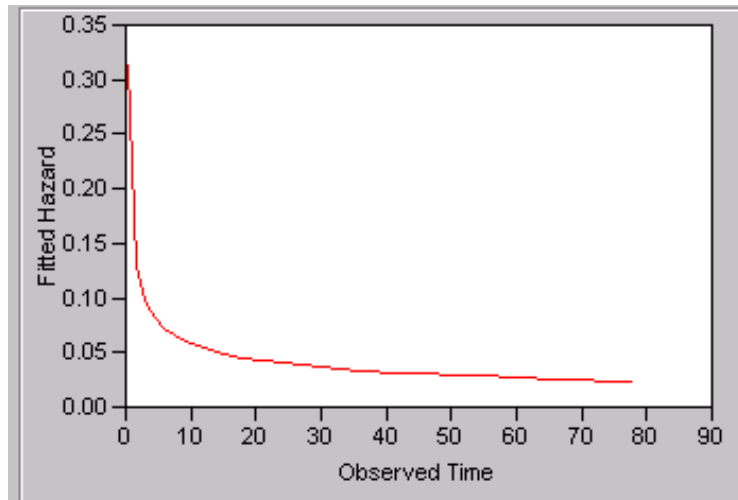
Quantiles

Combined

Competing Causes

Weibull Parameter Estimates

No Censoring	Alpha	Beta	N Failed	N Censored	logLikelihood
0	9.849671791	0.5761583490	100	0	-219.12917



random data

- random data
 - shape1 2.2
 - scale1 60
 - shape2 0.5
 - scale2 20
 - Survival Analysis
 - Competing Causes**
 - Survival with Censoring



random data: Survival

Product-Limit Survival Fit

Survival Plot

Time to event: Observed Time

Weibull Plot

Summary

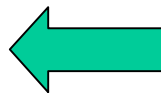
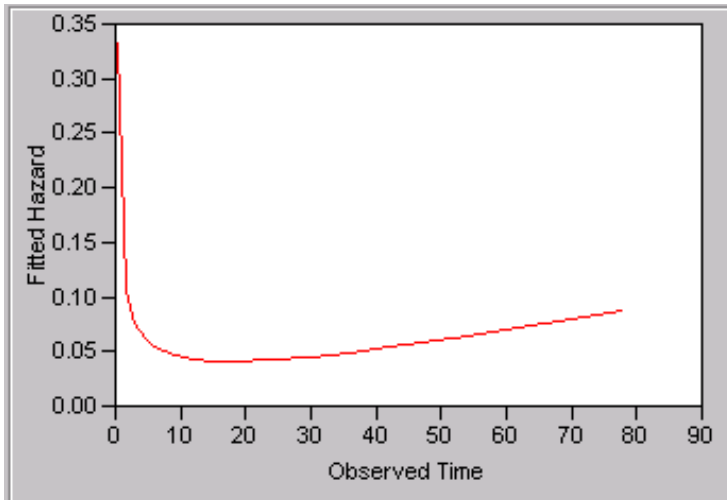
Quantiles

Combined

Competing Causes

Weibull Parameter Estimates

Censor 1	Alpha	Beta	N Failed	N Censored	logLikelihood
0	49.43716520	2.17633191	22	78	-26.376237
1	14.74048389	0.45548560	78	22	-215.92035



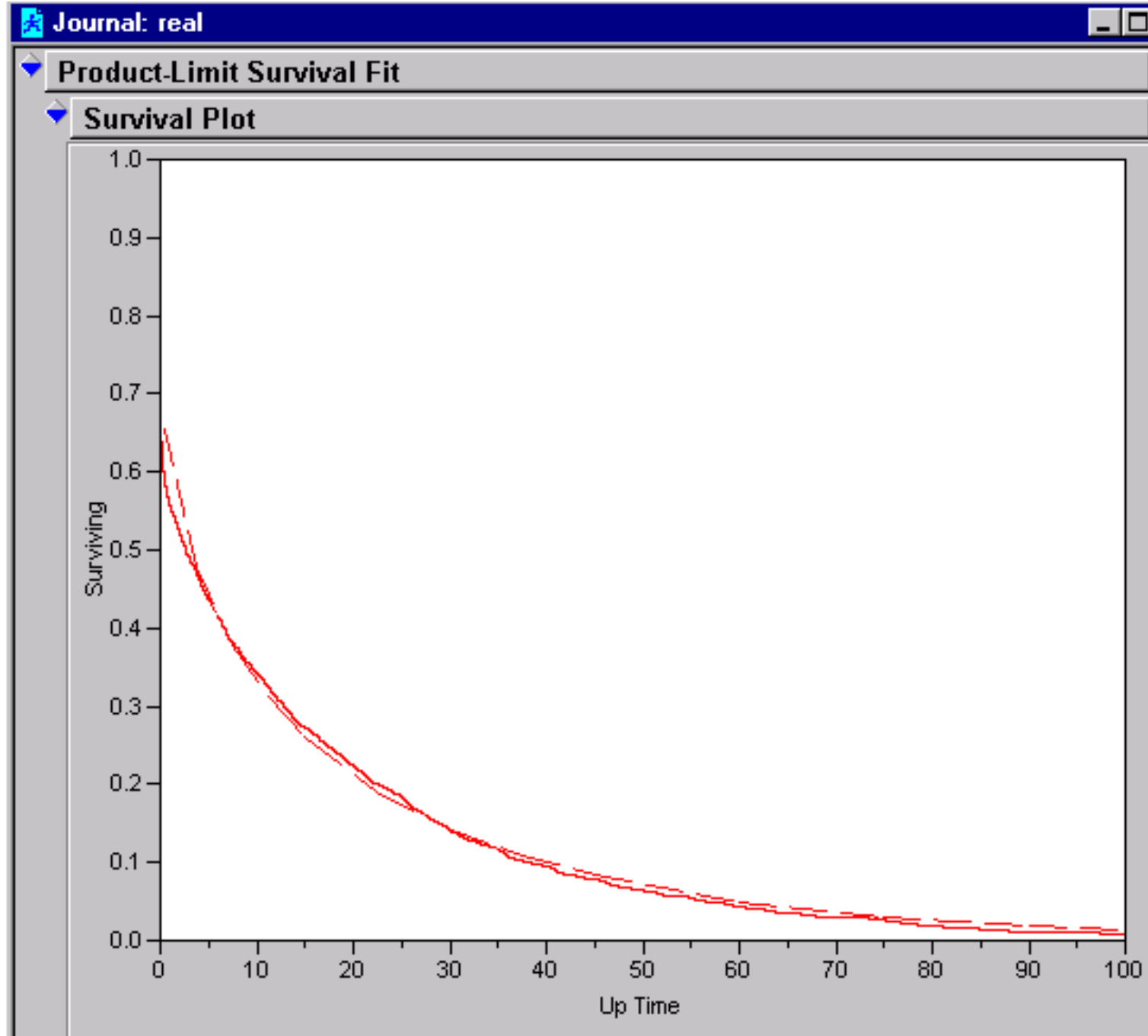
Analysis of Process data

failure mode		30 Cols	Up Time	Failure Mode	Censor
failure mode					209
Survival Analysis					
Survival for FM 209					
Competing Causes					
Columns (4/0)					
<input checked="" type="checkbox"/> Up Time					
<input checked="" type="checkbox"/> Failure Mode					
<input checked="" type="checkbox"/> Censor 209 +					
<input checked="" type="checkbox"/> Zero +					
Rows					
All Rows	2264				
Selected	1				
Excluded	0				
Hidden	0				
Labelled	0				
		1	134.18167	808	1
		2	2.1366667	808	1
		3	0	808	1
		4	31.951665	711	1
		5	33.471668	104	1
		6	0	104	1
		7	0.0517	104	1
		8	0	104	1
		9	0.07	104	1
		10	0.0733	104	1
		11	0.0583	104	1
		12	0.0783	104	1
		13	0	104	1
		14	0	104	1
		15	0.0733	806	1
		16	0.182	104	1

Top Failure Modes

cause model		Failure Mode	Alpha	Beta	N Failed
▼ cause model	1	305	2095.58539	0.41802564	184
	2	804	1672.63641	0.58103421	159
▼ Columns (4/0)	3	209	840.662431	0.61528138	150
<input checked="" type="checkbox"/> Failure Mode	4	605	257.659589	1.05085605	107
<input type="checkbox"/> Alpha	5	406	6050.50221	0.69328967	93
<input type="checkbox"/> Beta	6	304	777.941571	0.81241961	68
<input type="checkbox"/> N Failed	7	302	3385390.49	0.3135513	67
▼ Rows	8	412	536139.398	0.31297188	64
All Rows	9	706	695.017697	0.89973746	61
Selected	10	210	14264.7619	0.48370601	57
Excluded	11	808	6479.30876	0.55011778	54
Hidden	12	408	16575014.6	0.28865867	48
Labelled					

Competing Causes Fitted Survival



Omitting Causes

