

**“CONFIDENTIAL”**

**ATTENTION: TEAM PRINCIPAL & RACE ENGINEER, FIVE STAR RACING INC.**

**LAP TIME SIMULATION REPORT**



By Director of Testing and Development, Five Star Racing  
Date: March 14, 2011

Sources:

<http://www.attwilliams.com/>

<http://mclaren.com/home>

[http://www.redbullracing.com/cs/Satellite/en\\_INT/Red-Bull-Racing/001242807156063](http://www.redbullracing.com/cs/Satellite/en_INT/Red-Bull-Racing/001242807156063)

<http://www.ferrari.com/English/Formula1/Pages/Home.aspx>

<http://www.mercedes-gp.com/en/#/category/race/>

CAUTION AND DISCLAIMER:

THIS REPORT IS INTENTIONALLY INCOMPLETE AND NOT ORGANIZED TO THAT OF AN ACTUAL SUBMITTAL. STUDENTS ARE TO USE IT TO GAIN INSIGHT ON THE APPLICATIONS OF SOME OF THE CONCEPTS WE HAVE LEARNED IN CLASS, SOME OF THE TOOLS AVAILABLE IN THE SOFTWARES, AND AS A GUIDE REGARDING SOME OF THE DUE DILLIGENCE NEEDED TO SUCCESSFULLY COMPLETE THEIR PROJECTS.

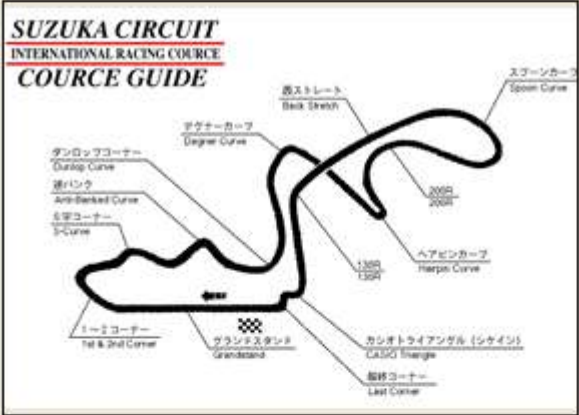
Kwabena Ofosu, PhD, PE  
Instructor  
EGS 2025 Probability and Statistics for Engineers  
VCC  
Orlando, FL

The purpose of this report is to simulate the time it takes to run this track by a race car. The track has been subdivided into 11 straightways and 10 turns. The time it took for the test driver to run each section over 10 laps was logged by our specialty GPS data logger.

Lap #	Timestamp (s)	Distance (m)	Distance (km)	Locked satellite	Latitude (deg)	Longitude (deg)	Speed (m/s)	Speed (kph)	Speed (mph)	Altitude (m)	Bearing (deg)	Longitudinal Acceleration (G)	Lateral Acceleration (G)
1	88391.167	4501.189	4.501189	10	-38.50214	145.2319238	66.13	238.05	147.82	51	161.07	0	0
2	88391.2	4503.32	4.50332	10	-38.5021783	145.2319317	66.17	238.2	148.01	51	161.06	0.13	0.13
3	88391.4	4516.478	4.516478	11	-38.50229	145.2319817	66.64	239.91	149.07	51.21	161	0.24	0.24
4	88391.6	4529.803	4.529803	9	-38.5024623	145.2320317	66.9	240.85	149.66	51.21	160.9	0.13	0.13
5	88391.8	4543.314	4.543314	10	-38.5025183	145.2320817	67.12	241.63	150.14	51.3	160.83	0.11	0.11
6	88392	4556.824	4.556824	10	-38.5026333	145.2321317	67.44	242.8	150.87	51.5	160.82	0.17	0.17
7	88392.2	4570.371	4.570371	11	-38.5027483	145.2321833	67.83	244.54	151.95	51.69	160.8	0.25	0.25
8	88392.4	4584.048	4.584048	11	-38.502865	145.2322333	67.96	244.65	152.02	51.71	160.66	0.02	0.02
9	88392.6	4597.614	4.597614	11	-38.50298	145.232285	67.5	243	150.99	51.71	160.64	-0.23	-0.23
10	88392.8	4611.217	4.611217	11	-38.503096	145.2323383	67.42	242.7	150.81	51.5	160.43	-0.04	-0.04
11	88393	4624.764	4.624764	11	-38.50321	145.23239	68.36	246.09	152.92	51.5	160.5	0.48	0.48
12	88393.2	4638.552	4.638552	11	-38.5033267	145.2324433	68.37	246.15	152.95	51.5	160.53	0.01	0.01
13	88393.4	4652.285	4.652285	11	-38.5034433	145.232495	68.65	247.15	153.57	51.5	160.48	0.14	0.14
14	88393.6	4666.221	4.666221	11	-38.5035617	145.2325483	68.76	247.52	153.8	51.5	160.48	0.05	0.05
15	88393.8	4680.009	4.680009	11	-38.5036783	145.2326017	68.96	248.24	154.25	51.41	160.37	0.1	0.1
16	88394	4694.186	4.694186	11	-38.5037983	145.2326567	69.15	248.93	154.68	51.21	160.37	0.1	0.1
17	88394.2	4708.179	4.708179	12	-38.5039167	145.2327117	69.28	249.41	154.98	50.91	160.36	0.07	0.07
18	88394.4	4722.189	4.722189	12	-38.504036	145.2327667	69.67	250.82	155.85	50.59	160.34	0.2	0.2
19	88394.6	4736.181	4.736181	12	-38.5041533	145.2328217	69.59	250.52	155.67	50.41	160.26	-0.04	-0.04
20	88394.8	4750.488	4.750488	12	-38.504275	145.232875	69.86	251.5	156.28	50.2	160.52	0.14	0.14
21	88395	4764.443	4.764443	12	-38.5043933	145.2329283	69.83	251.37	156.2	50.2	160.75	-0.02	-0.02
22	88395.2	4778.565	4.778565	12	-38.5045133	145.2329817	69.83	251.37	156.2	50	160.85	0	0
23	88395.4	4806.827	4.806827	12	-38.5047533	145.2330883	69.68	250.83	155.86	49.2	161.12	-0.04	-0.04
24	88395.6	4820.56	4.82056	12	-38.50487	145.23314	68.75	247.48	153.78	48.91	161.29	-0.47	-0.47
25	88395.8	4834.237	4.834237	12	-38.5049867	145.23319	67.62	243.43	151.26	48.59	161.46	-0.57	-0.57
26	88396	4847.876	4.847876	12	-38.5051033	145.2332383	66.53	239.5	148.82	48.3	161.58	-0.56	-0.56
27	88396.2	4861.331	4.861331	12	-38.5052183	145.2332867	65.19	234.67	145.82	48	161.6	-0.68	-0.68
28	88396.4	4874.23	4.87423	12	-38.5053283	145.2333333	63.58	228.87	142.21	47.8	161.74	-0.82	-0.82
29	88396.6	4886.721	4.886721	12	-38.505435	145.2333783	61.94	223	138.57	47.5	161.79	-0.83	-0.83
30	88396.8	4898.989	4.898989	12	-38.50554	145.2334217	60.36	217.3	135.02	47.09	161.86	-0.81	-0.81
31	88397	4910.905	4.910905	12	-38.5056417	145.233465	59.08	212.7	132.17	46.61	161.94	-0.65	-0.65
32	88397.2	4922.622	4.922622	12	-38.5057433	145.2335083	57.81	208.11	129.31	46.2	161.89	-0.65	-0.65
33	88397.4	4934.33	4.93433	12	-38.5058415	145.23355	56.71	204.15	126.85	45.9	161.98	-0.56	-0.56
34	88397.6	4946.117	4.946117	12	-38.5059417	145.2335917	55.36	199.29	123.84	45.5	162.19	-0.49	-0.49
35	88397.8	4957.918	4.957918	12	-38.5060333	145.2336283	54.23	195.22	121.3	45.29	162.52	-0.58	-0.58
36	88398	4969.578	4.969578	12	-38.5061267	145.233666	53.15	191.33	118.89	44.79	162.95	-0.55	-0.55
37	88398.2	4981.123	4.981123	12	-38.5062183	145.2336967	52.2	187.9	116.76	44.5	163.78	-0.49	-0.49
38	88398.4	4992.519	4.992519	12	-38.5063083	145.2337283	51.34	184.83	114.85	44.11	164.43	-0.44	-0.44
39	88398.6	4998.638	4.998638	12	-38.5063967	145.2337567	50.59	182.13	113.17	43.61	165.49	-0.38	-0.38
40	88398.8	5008.905	5.008905	12	-38.5064867	145.2337833	49.61	178.61	110.98	43.2	167.09	-0.5	-0.5
41	88399	5018.764	5.018764	12	-38.5065733	145.2338167	48.87	175.64	109.32	42.9	168.47	-0.38	-0.38

A computer program was developed to extract the data in the format it was logged, add designations of what straight or turn the vehicle was in at the time the data was logged.

RACING STRATEGIZER



Compile and Collate Curvature

Compile Curvature

Clear Curvature

Compute and Collate Average Speeds and Travel Times

Compute Run Times

Clear All



	J	K	L	M	N	O	P	Q	R	S	T	U	V
1	Speed (kph)	Speed (mph)	Altitude (m)	Bearing (deg)	Longitudinal Acceleration (G)	Lateral Acceleration (G)	X-position (m)	Y-position (m)	Turn name	curvature	5196	st1	
2	238.05	147.92	51	161.07	0	0	0	0	Start/finish	∞			
3	238.2	148.01	51	161.06	0.13	0.04	0.68	-2.04		∞			
4	239.91	149.07	51.21	161	0.24	0.04	5.03	-14.46		∞			
5	240.85	149.66	51.21	160.9	0.13	0.06	9.38	-27.05		∞			
6	241.63	150.14	51.3	160.83	0.11	0.04	13.73	-39.84		∞			
7	242.8	150.87	51.5	160.82	0.17	0.01	18.09	-52.63		∞			
8	244.54	151.95	51.59	160.8	0.25	0.01	22.58	-65.42		∞			
9	244.65	152.02	51.71	160.66	0.02	0.08	26.93	-78.39		∞			
10	243	150.99	51.71	160.64	-0.23	0.01	31.43	-91.18		∞			
11	242.7	150.81	51.5	160.43	-0.04	0.13	36.07	-103.97		∞			
12	246.09	152.92	51.5	160.6	0.40	-0.04	40.57	-116.75		∞			
13	246.15	152.95	51.5	160.53	0.01	-0.02	45.21	-129.73		∞			
14	247.15	153.57	51.5	160.48	0.14	0.03	49.7	-142.7		∞			
15	247.52	153.8	51.5	160.48	0.05	0	54.34	-155.86		∞			
16	248.24	154.25	51.41	160.37	0.1	0.07	58.99	-168.83		∞			
17	248.93	154.68	51.21	160.37	0.1	0	63.77	-182.17		∞			
18	249.41	154.98	50.91	160.36	0.07	0.01	68.56	-195.33		∞			
19	250.82	155.85	50.59	160.34	0.2	0.01	73.34	-208.49		∞			
20	250.52	155.67	50.41	160.26	-0.04	0.05	78.13	-221.65		∞			
21	251.5	156.29	50.2	160.52	0.14	-0.16	82.77	-235.18		∞			
22	251.37	156.2	50.2	160.75	-0.02	-0.14	87.41	-248.34		∞			
23	251.37	156.2	50	160.85	0	-0.06	92.05	-261.68		∞			
24	250.63	155.98	49.2	161.12	-0.04	-0.08	101.33	-280.37		∞			
25	247.48	153.78	48.91	161.29	-0.47	-0.1	105.83	-301.34		∞			
26	243.43	151.26	48.59	161.46	-0.57	-0.1	110.18	-314.31		∞			
27	239.5	148.82	48.3	161.58	-0.56	-0.07	114.38	-327.28		∞			
28	234.67	145.82	48	161.6	-0.68	-0.01	118.59	-340.07		∞			
29	228.87	142.21	47.8	161.74	-0.82	-0.08	122.65	-352.3		∞			
30	223	138.57	47.5	161.79	-0.83	-0.03	126.57	-364.16		∞			
31	217.3	135.02	47.09	161.86	-0.81	-0.04	130.34	-375.84		∞			
32	212.7	132.17	46.61	161.94	-0.65	-0.04	134.11	-387.14		∞			
33	208.11	129.31	46.2	161.89	-0.65	0.03	137.88	-398.45		∞			
34	204.15	126.85	45.9	161.98	-0.56	-0.05	141.5	-409.36	Turn 1 Entry	∞			
35	204.15	126.85	45.9	161.98	0	0	141.5	-409.38		∞			
36	199.29	123.84	45.5	162.19	-0.89	-0.1	145.13	-420.13		∞			
37	195.22	121.3	45.29	162.62	-0.58	-0.21	148.32	-430.7		∞			
38	191.33	118.89	44.79	162.96	-0.55	-0.16	151.51	-441.07		∞			
39	187.9	116.76	44.5	163.78	-0.49	-0.39	154.27	-451.27		∞			
40	184.83	114.85	44.11	164.43	-0.44	-0.3	157.02	-461.27		∞			
41	182.13	113.17	43.61	165.49	-0.38	-0.48	159.49	-471.1		∞			
42	178.61	110.98	43.2	167.09	-0.5	-0.71	161.81	-481.1		∞			
43	175.84	109.29	42.8	168.42	-0.38	-0.58	163.81	-491.71		∞			

The program then proceeds to compute parameters such as distance traveled, average speed, and travel time, for each straight and turn. For the 10 laps, the calculated values for each straightaway and turn are then compiled and collated. The mean and standard deviation were also computed for each dataset.

	CG	CH	CI	CJ	CK	CL	CM	CN	CO	CP	CQ	CR	CS	CT	CU
1	dist	speed	time	dist	speed	time	dist	speed	time	dist	speed	time	dist	speed	time
2	0.013443	63.12167	0.786707	0.119159	74.53091	5.755619	0.01027	99.9625	0.369862	0.231347	101.3159	0.220334			
3	0.014162	63.965	0.797071	0.126848	74.54171	6.12614	0.013866	101.585	0.491394	0.235842	101.8624	0.339569			
4	0.015796	64.04333	0.882876	0.128868	76.17088	6.090598	0.014713	102.9975	0.514238	0.234023	103.2367	0.950767			
5	0.016961	60.70571	0.946511	0.127863	71.82361	6.406354	0.013612	101.7625	0.481553	0.233945	99.25085	0.456075			
6	0.014236	62.95833	0.814025	0.126912	76.20363	5.995663	0.013662	104.916	0.46673	0.234711	101.9809	0.285456			
7	0.013475	61.55833	0.788014	0.12787	74.73686	6.120838	0.012734	102.696	0.44641	0.232373	101.4643	0.244713			
8	0.016256	64.85	0.913707	0.127462	75.82588	6.051517	0.013962	103.87	0.484821	0.235377	101.8484	0.320445			
9	0.014712	63.42833	0.835008	0.12963	60.70721	7.687176	0.006737	51.782	0.607386	0.202088	40.37649	18.96199			
10															
11			0.84295			5.279476			0.482799			9.510651			
12			0.064543			0.596368	w		0.056469			3.450063			
13															
14															

The next step is to determine the best distribution that represents the travel time over each straightway and turn. To do this the data is exported to Minitab to make use of Minitab's distribution fitting tools. For a distribution to qualify to represent that dataset, it must produce a p-value greater than the alpha value, and it must have the lowest AD-value among the competing distributions. If no distribution passes then we must make an educated guess based on the data. We can make an educated guess using the Triangular distribution. The process is described in detail the following sections of this memo.

Minitab - Untitled

File Edit Data Calc Stat Graph Editor Tools Window Help

3/10/2011 11:41:20 AM

Welcome to Minitab, press F1 for help.

Worksheet 1 \*\*\*

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
	dist	speed	time	s1		dist_1	speed_1	time_1	t1		dist_2	speed_2	time_2	s2		dist_3	speed_3	time_3	t2	
1	0.240634	149.730	5.79533			0.170044	104.691	5.84728			0.0654175	105.842	2.22504			0.218677	77.5765	10.1572		
2	0.243162	149.201	5.86397			0.174391	109.189	5.74972			0.0692734	103.401	2.37701			0.218623	76.8926	10.2356		
3	0.243045	150.150	5.82725			0.172128	104.911	5.90650			0.0694896	100.221	2.49610			0.219988	76.8770	10.3016		
4	0.247096	152.321	5.83994			0.173238	109.752	5.68308			0.0669244	103.171	2.33173			0.219955	76.4824	10.3348		
5	0.244543	149.987	5.87624			0.172392	110.011	5.64134			0.0681679	105.772	2.29839			0.215376	77.2573	10.0360		
6	0.244389	151.339	5.81343			0.173672	112.058	5.59586			0.0669033	102.864	2.33797			0.216159	77.9307	9.9854		
7	0.242770	152.170	5.74309			0.175195	110.409	5.70832			0.0698061	103.451	2.42223			0.218771	77.3093	10.1768		
8	0.246679	148.564	5.95327			0.171112	108.265	5.63760			0.0670250	104.449	2.31015			0.217820	77.0518	10.1769		
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Project

Show information for the column in the current worksheet

The screenshot shows the Minitab software interface. The 'Stat' menu is open, and the 'Quality Tools' sub-menu is expanded, highlighting 'Individual Distribution Identification...'. Below the menu, a worksheet titled 'Worksheet 1 \*\*\*' is visible, containing data for three trials. The data is organized into columns for distance, speed, and time for each trial, with standard deviation columns (s1, s2, s3) also present.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
	dist	speed	time	s1		dist_1	speed_1	time_1	s1		dist_2	speed_2	time_2	s2		dist_3	speed_3	time_3	s2	
1	0.240634	149.730	5.76533			0.170044	104.691	5.64726			0.0654175	105.842	2.22904			0.216677	77.5765	10.1572		
2	0.243162	149.261	5.86397			0.174391	109.189	5.74872			0.0682734	103.401	2.37701			0.219623	76.8926	10.2356		
3	0.243045	150.150	5.82725			0.172128	104.911	5.90650			0.0694896	103.221	2.49610			0.219988	76.8770	10.3016		
4	0.247096	152.321	5.83994			0.173238	109.752	5.68209			0.0666244	103.171	2.33173			0.219655	76.4824	10.3348		
5	0.244543	149.987	5.87674			0.172392	110.011	5.64134			0.0681676	105.772	2.29639			0.215376	77.2573	10.0360		
6	0.244389	151.339	5.81343			0.173672	112.058	5.69596			0.0669033	102.864	2.33797			0.216159	77.9307	9.9854		
7	0.242770	152.170	5.74309			0.175195	110.409	5.70832			0.0696061	103.451	2.42223			0.219771	77.3693	10.1768		
8	0.246679	148.564	5.95327			0.171112	109.265	5.63768			0.0670258	104.449	2.31015			0.217020	77.0510	10.1769		
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**Individual Distribution Identification** ✕

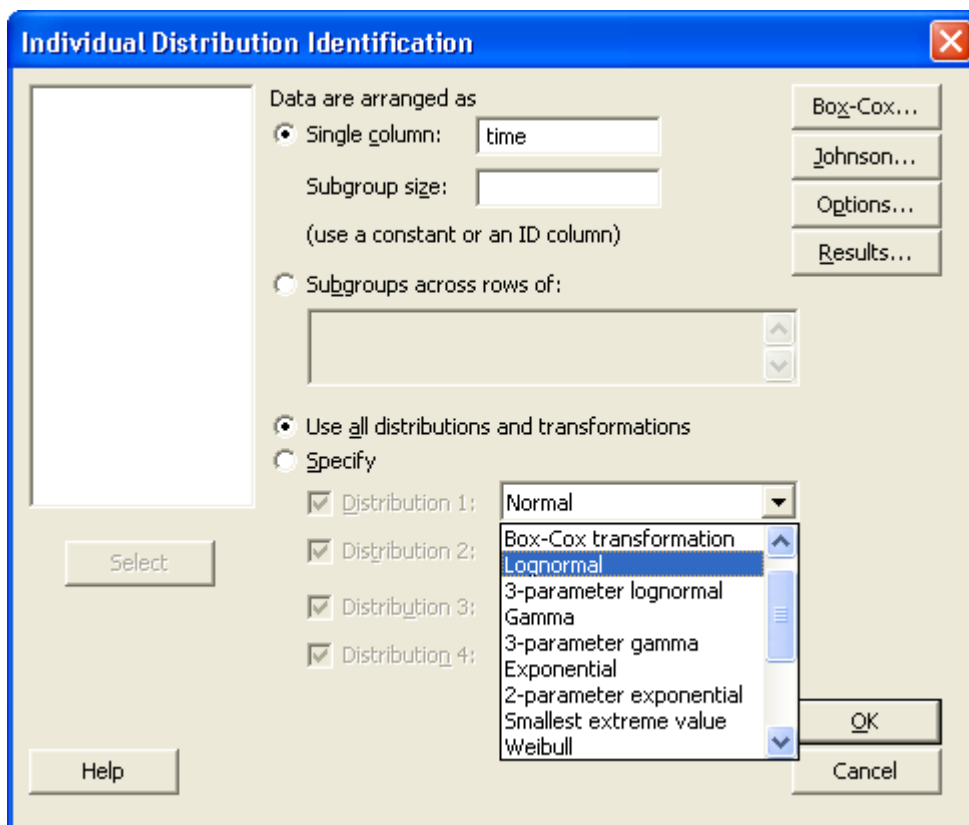
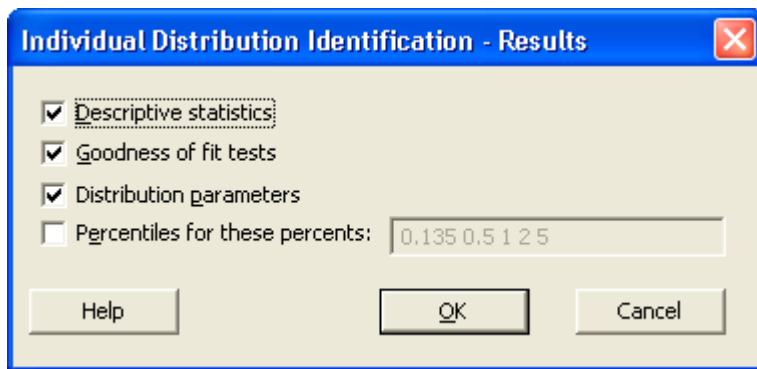
<ul style="list-style-type: none"> <li>C1 dist</li> <li>C2 speed</li> <li>C3 time</li> <li>C6 dist_1</li> <li>C7 speed_1</li> <li>C8 time_1</li> <li>C11 dist_2</li> <li>C12 speed_2</li> <li>C13 time_2</li> <li>C16 dist_3</li> <li>C17 speed_3</li> <li>C18 time_3</li> <li>C21 dist_4</li> <li>C22 speed_4</li> <li>C23 time_4</li> <li>C26 dist_5</li> </ul>	<p>Data are arranged as</p> <p><input checked="" type="radio"/> Single column: <input type="text" value="time"/></p> <p>Subgroup size: <input type="text"/></p> <p>(use a constant or an ID column)</p> <p><input type="radio"/> Subgroups across rows of:</p> <div style="border: 1px solid gray; height: 20px; width: 100%;"></div> <p><input checked="" type="radio"/> Use all distributions and transformations</p> <p><input type="radio"/> Specify</p> <p><input checked="" type="checkbox"/> Distribution 1: <input type="text" value="Normal"/></p> <p><input checked="" type="checkbox"/> Distribution 2: <input type="text" value="Exponential"/></p> <p><input checked="" type="checkbox"/> Distribution 3: <input type="text" value="Weibull"/></p> <p><input checked="" type="checkbox"/> Distribution 4: <input type="text" value="Gamma"/></p>	<p><input type="button" value="Box-Cox..."/></p> <p><input type="button" value="Johnson..."/></p> <p><input type="button" value="Options..."/></p> <p><input type="button" value="Results..."/></p>
---	---	---

**Individual Distribution Identification - Options** ✕

Display one probability plot per graph

Do not display confidence intervals on probability plots

Confidence level:



**Individual Distribution Identification** ✖

Empty list box

Select

Help

Data are arranged as

Single column:

Subgroup size:

(use a constant or an ID column)

Subgroups across rows of:

Use all distributions and transformations

Specify

Distribution 1:

Distribution 2:

Distribution 3:

Distribution 4:

Box-Cox...

Johnson...

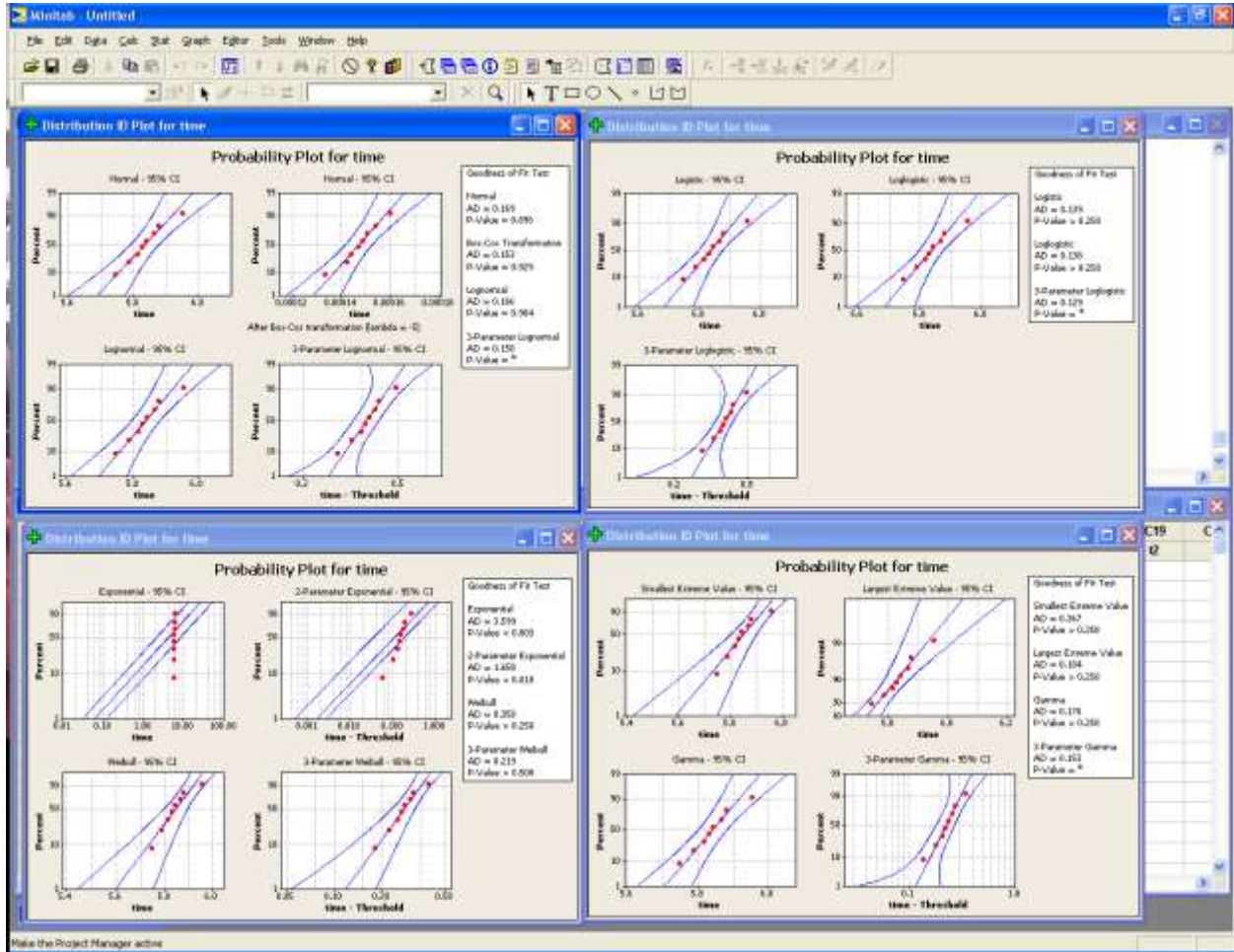
Options...

Results...

OK

Cancel

Section 1 (s1)



Minitab - Unfiled

File Edit Data Calc Stat Graph Editor Tools Window Help

Section

1 0 5.83768 0.0622096 5.80359 5.74300 5.95327 0.452761 0.072552

Box-Cox transformation: Lambda = -5.00000

Goodness of Fit Test

Distribution	AD	P	LRT P
Normal	0.169	0.896	
Box-Cox Transformation	0.153	0.929	
Lognormal	0.166	0.904	
3-Parameter lognormal	0.150	*	0.654
Exponential	3.599	<0.001	
2-Parameter Exponential	1.650	<0.010	0.000
Weibull	0.358	>0.250	
3-Parameter Weibull	0.219	>0.500	0.245
Smallest Extreme Value	0.387	>0.250	
Largest Extreme Value	0.184	>0.250	
Gamma	0.170	>0.250	
3-Parameter Gamma	0.153	*	0.632

Worksheet 1

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
	dist	speed	time	s1		dist_1	speed_1	time_1	s1		dist_2	speed_2	time_2	s2		dist_3	speed_3	time_3	s2	
1	0.240634	149.730	5.79533			0.170044	104.691	5.84728			0.0654175	105.842	2.22904			0.218877	77.5765	10.1572		
2	0.243162	149.201	5.86397			0.174391	109.189	5.74972			0.0692734	103.401	2.37701			0.218623	76.8926	10.2356		
3	0.243045	150.150	5.82725			0.172128	104.911	5.90650			0.0694896	100.221	2.49610			0.219938	76.8770	10.3016		
4	0.247096	152.321	5.83994			0.173228	109.752	5.68208			0.0668244	103.171	2.33173			0.219965	76.4824	10.3348		
5	0.244543	149.987	5.87674			0.172392	110.011	5.64134			0.0681679	105.772	2.29839			0.215376	77.2573	10.0360		
6	0.244399	151.339	5.81343			0.173672	112.068	5.59586			0.0668033	102.864	2.33797			0.216159	77.9307	9.9854		
7	0.242770	152.170	5.74309			0.175195	110.409	5.70832			0.0698061	103.451	2.42223			0.218771	77.3093	10.1768		
8	0.246679	148.564	5.95327			0.171112	108.265	5.63768			0.0670258	104.449	2.31015			0.217820	77.0518	10.1769		
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				

Project

Welcome to Minitab, press F1 for help. Exitable

**Individual Distribution Identification** ✕

Data are arranged as

Single column:

Subgroup size:

(use a constant or an ID column)

Subgroups across rows of:

Use all distributions and transformations

Specify

Distribution 1:

Distribution 2:

Distribution 3:

Distribution 4:

The screenshot shows the Minitab software interface. A menu is open, starting with 'Stat' and navigating through 'Probability Distributions' to 'Lognormal...'. The 'Lognormal' option is highlighted. Below the menu, a data table is visible with columns labeled C1 through C19. The data table contains numerical values for distance, speed, and time across 10 rows.

	C1	C2	C3	C4	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19
	dist	speed	time	s1	time_1	st		dist_2	speed_2	time_2	s2		dist_3	speed_3	time_3	z
1	0.240634	149.730	5.70533		5.64720			0.0654175	105.842	2.22904			0.210077	77.5765	10.1572	
2	0.243162	149.201	5.86397		5.74872			0.0602734	103.401	2.37701			0.218623	76.8926	10.2356	
3	0.243046	150.150	5.82725		5.90650			0.0694896	100.221	2.49610			0.219908	76.8770	10.3016	
4	0.247096	152.321	5.83994		5.68209			0.0666244	103.171	2.33173			0.219655	76.4824	10.3348	
5	0.244543	149.987	5.87674		5.64134			0.0681676	105.772	2.29639			0.215376	77.2573	10.0360	
6	0.244389	151.339	5.81343		5.59596			0.0669033	102.864	2.33797			0.216159	77.9307	9.9854	
7	0.242770	152.170	5.74309		5.70832			0.0696061	103.451	2.42223			0.219771	77.3693	10.1768	
8	0.246679	148.564	5.95327		5.63760			0.0670250	104.449	2.31015			0.217020	77.0510	10.1769	
9																
10																
11																
12																
13																
14																
15																
16																

Statistica - Untitled

File Edit Data Calc Data Graph Editor Tools Window Help

Statistica - Session

Descriptive Statistics

N	S*	Mean	StDev	Median	Minimum	Maximum	Skewness	Kurtosis
8	0	5.83788	0.0632086	5.83359	5.74309	5.95327	0.452791	0.072552

Goodness of Fit Test

Distribution	AD	P
Lognormal	0.166	0.904

ML Estimates of Distribution Parameters

Distribution	Location	Shape	Scale	Threshold
Lognormal*	1.76402		0.01081	

\* Scale: Adjusted ML estimate

Worksheet 1 \*\*\*

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
	dist	speed	time	s1		dist_1	speed_1	time_1	t1		dist_2	speed_2	time_2	s2		dist_3	speed_3	time_3	t2	
1	0.240634	149.730	5.79533			0.170044	104.691	5.84726			0.0664175	105.842	2.22504			0.218677	77.5765	10.1572		
2	0.243162	149.201	5.86397			0.174391	109.189	5.74972			0.0682734	103.401	2.37701			0.219623	76.8926	10.2356		
3	0.243045	150.150	5.82725			0.172128	104.911	5.90650			0.0694896	100.221	2.49610			0.219988	76.8770	10.3016		
4	0.247096	152.321	5.83994			0.173228	109.752	5.88208			0.0669244	103.171	2.33173			0.219955	76.4824	10.3348		
5	0.244543	149.987	5.87674			0.172392	110.011	5.64134			0.0681678	106.772	2.29639			0.215376	77.2573	10.0360		
6	0.244399	151.339	5.81345			0.173892	112.098	5.69596			0.0669033	102.864	2.33997			0.216159	77.9307	9.9854		
7	0.242170	152.170	5.74309			0.175195	110.489	5.70832			0.0686061	103.451	2.42223			0.218771	77.3893	10.1768		
8	0.245679	148.564	5.95327			0.171112	109.265	5.63768			0.0670258	104.449	2.31015			0.217820	77.0518	10.1769		
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				

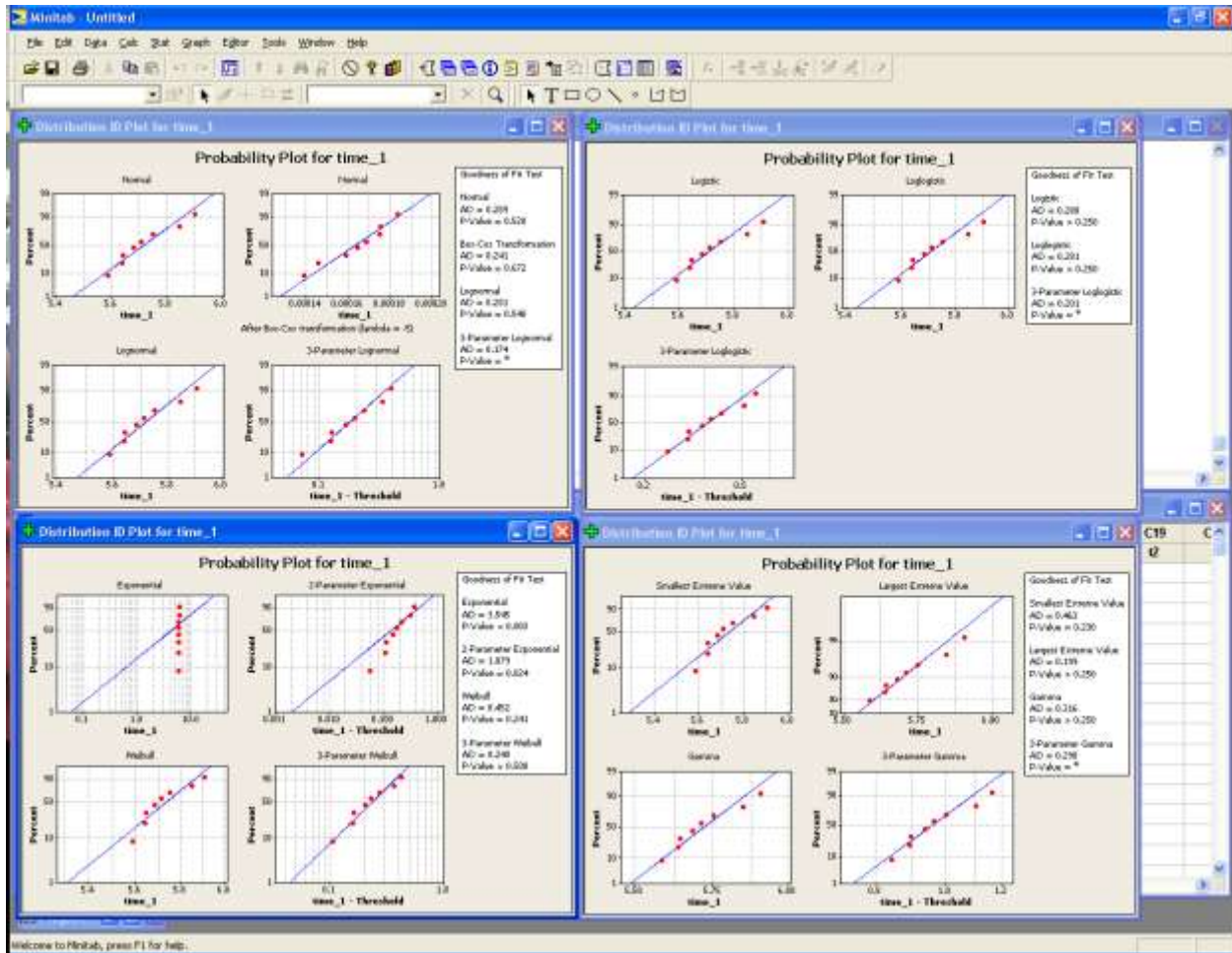
Project

Current Worksheet: worksheet 1

Editable

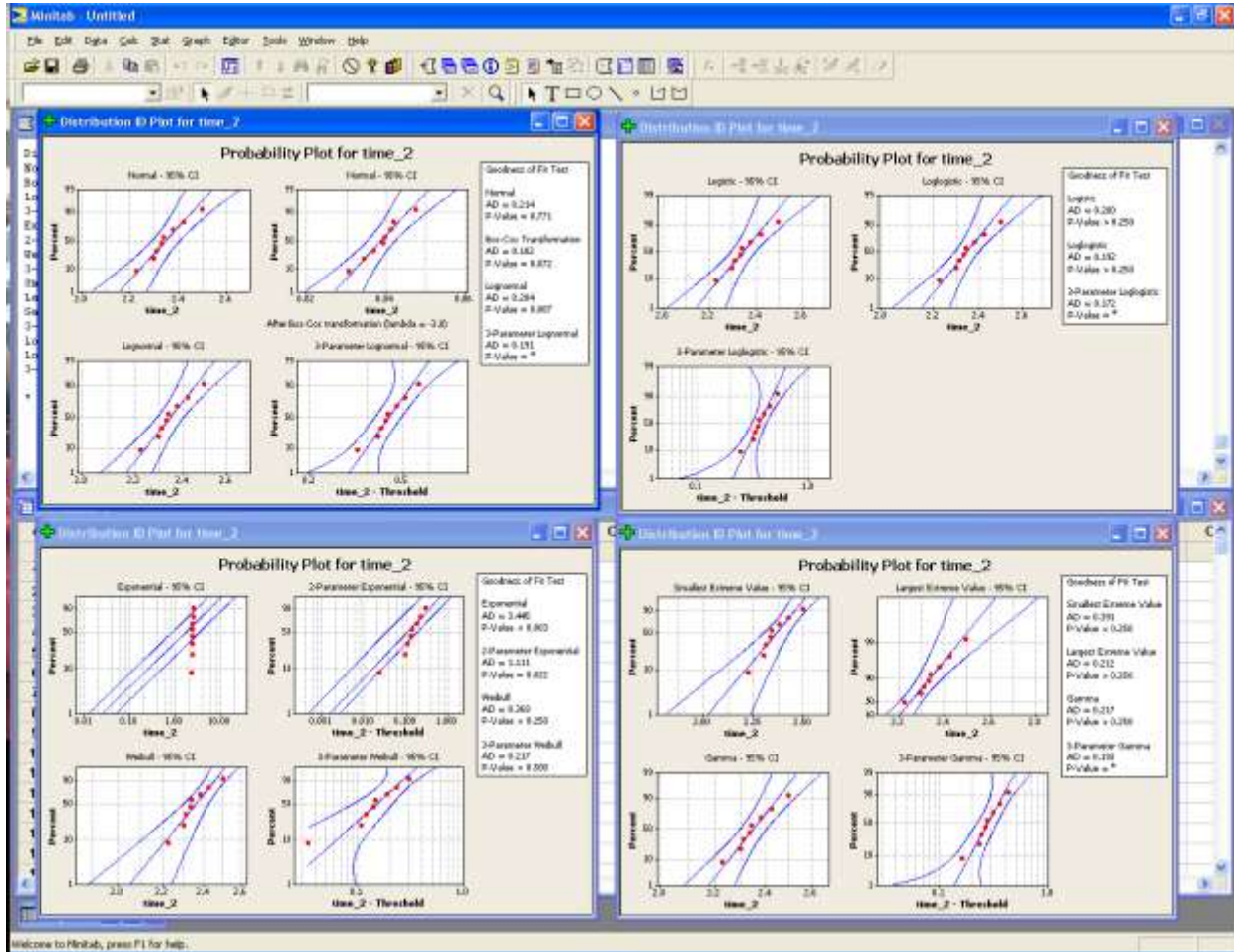


Section 2 (t1)



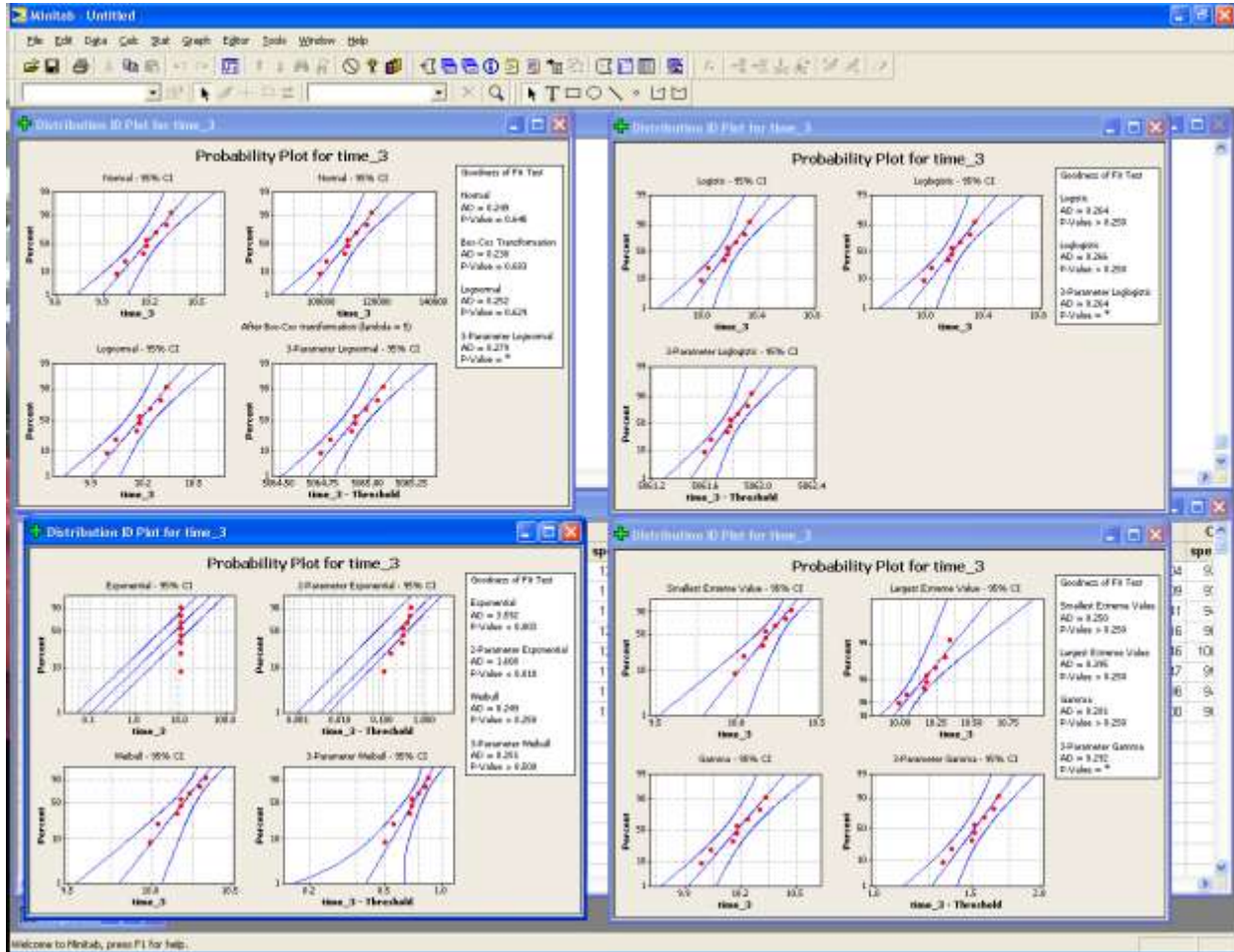
lognormal

Section 3 (s2)



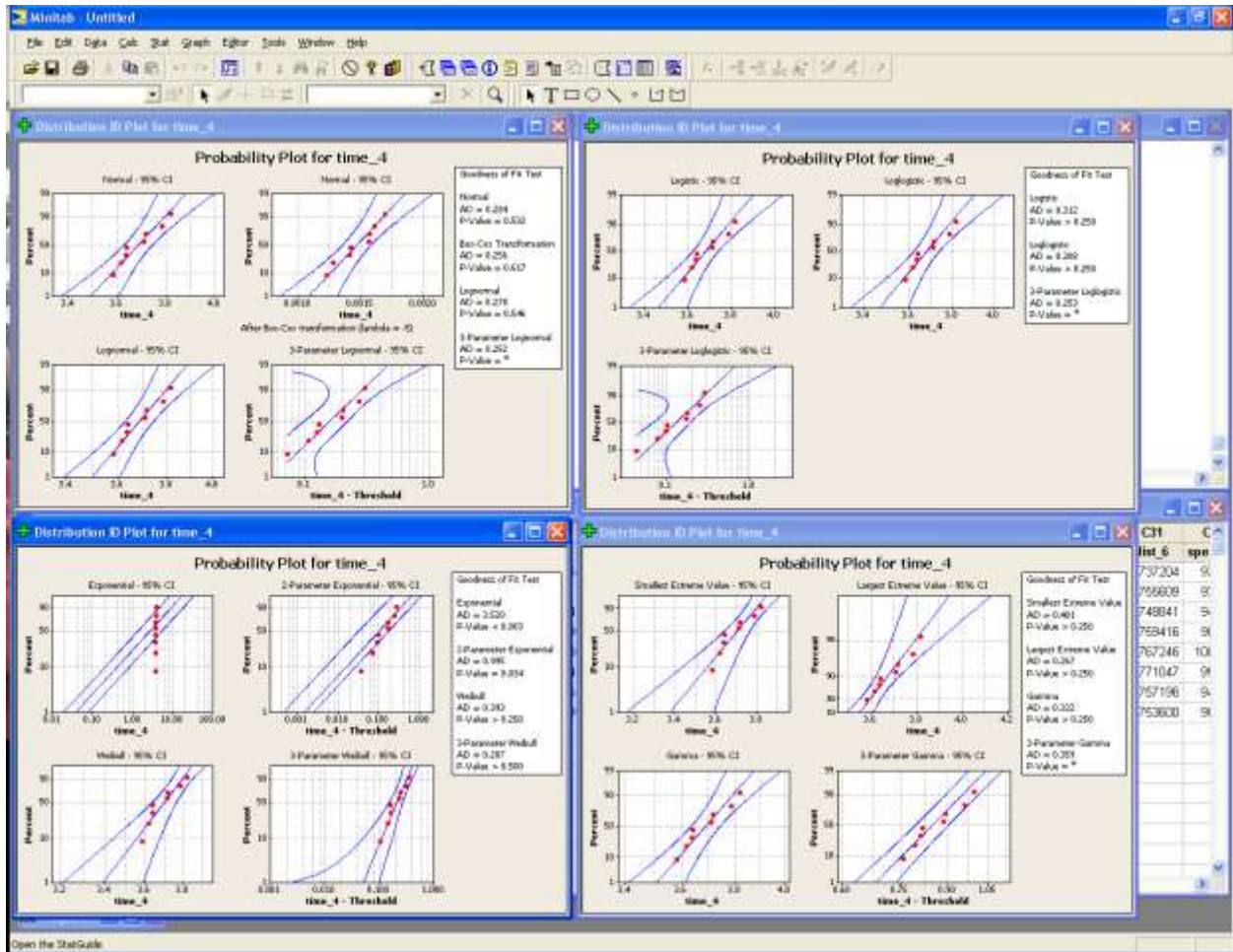
lognormal

Section 4 (t2)



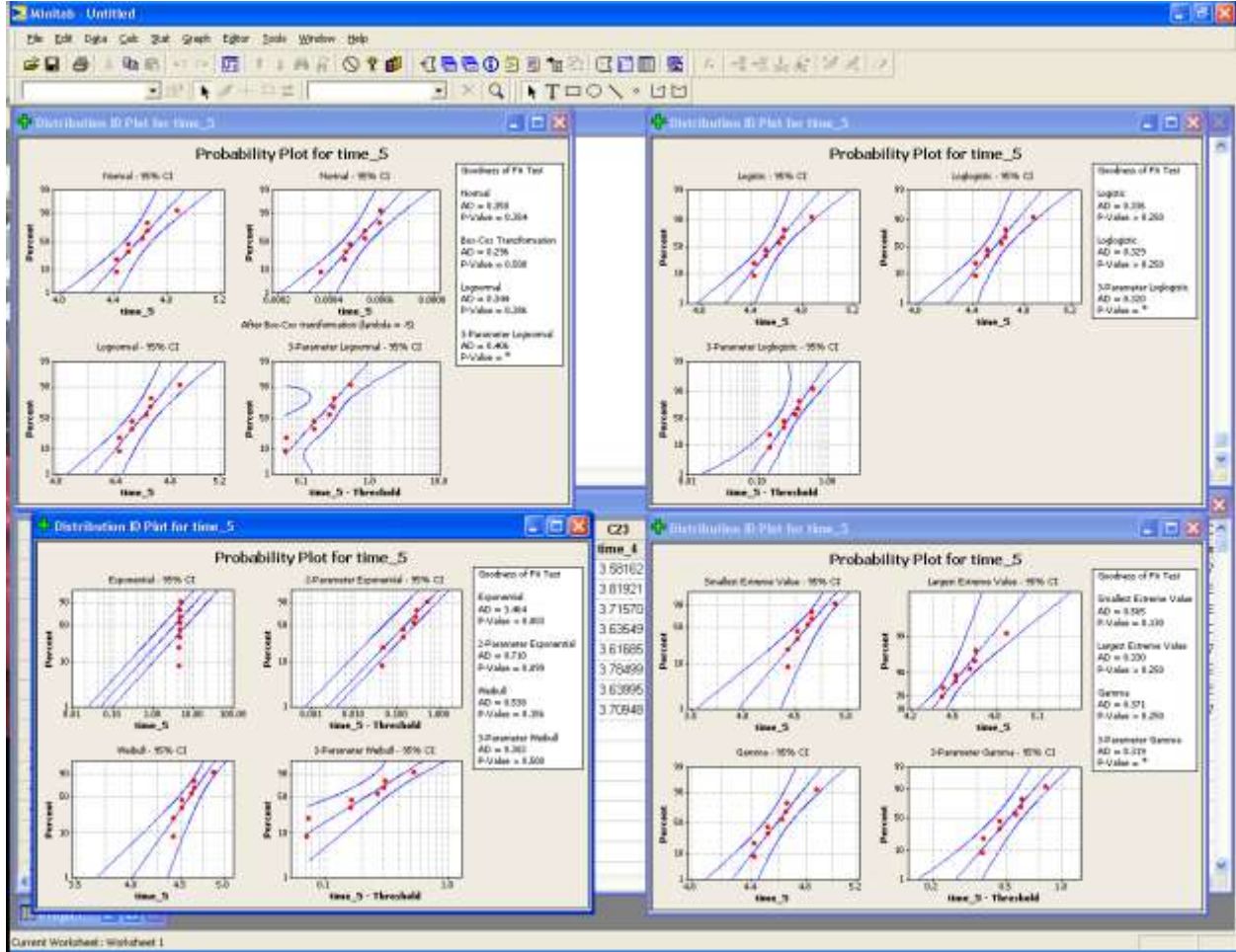
weibull

Section 5 (s3)



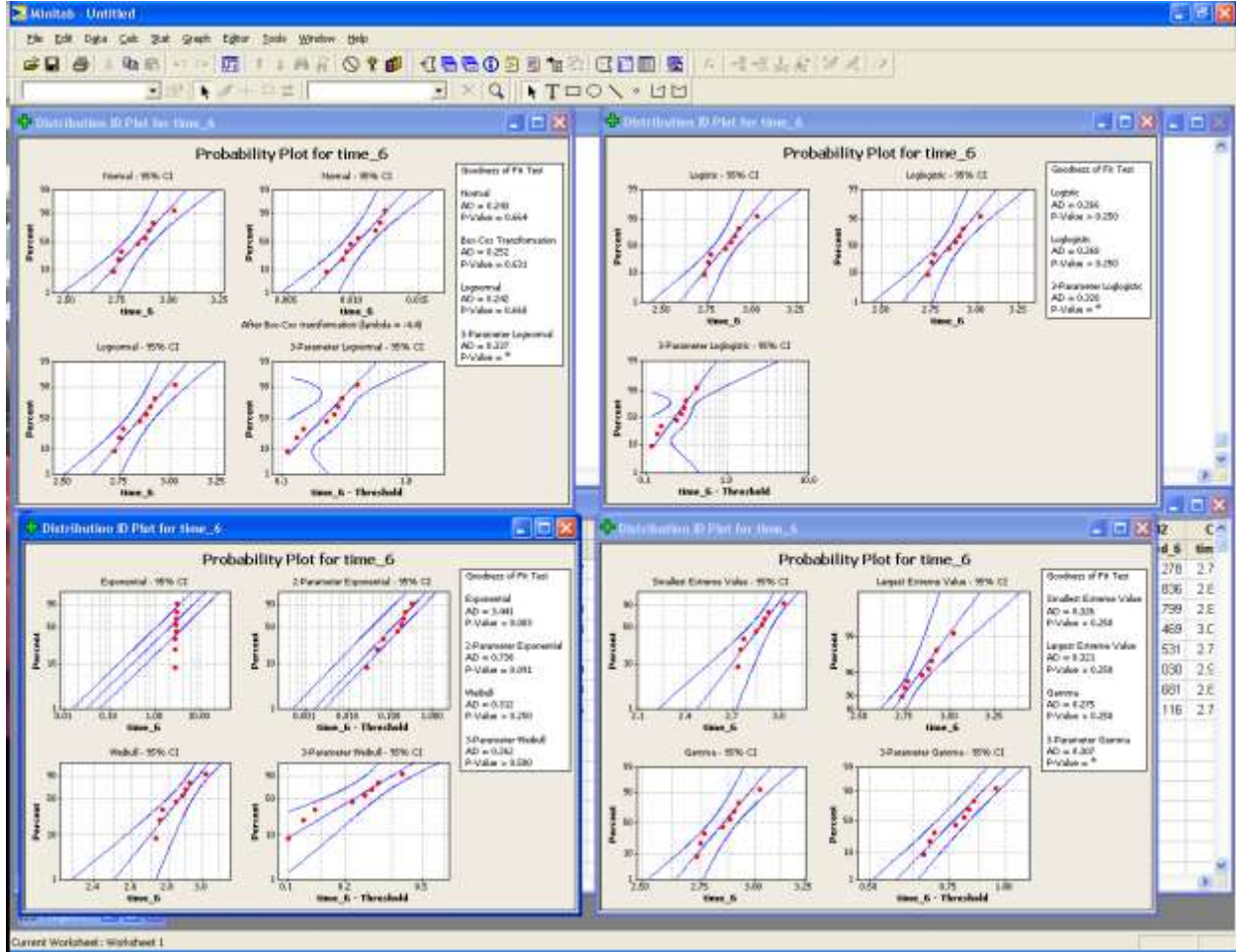
lognormal

Section 6 (t3)



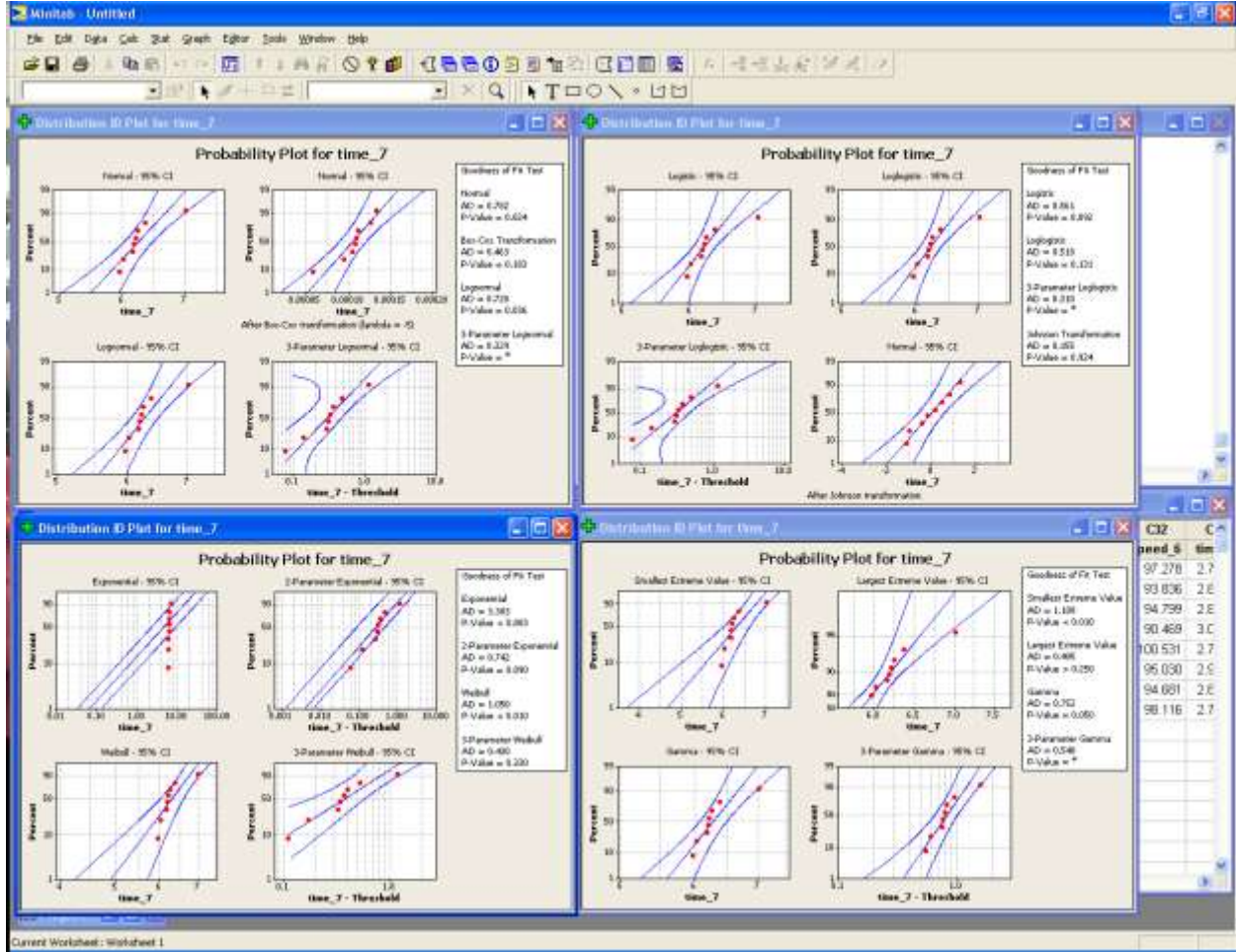
lognormal

Section 7 (s4)



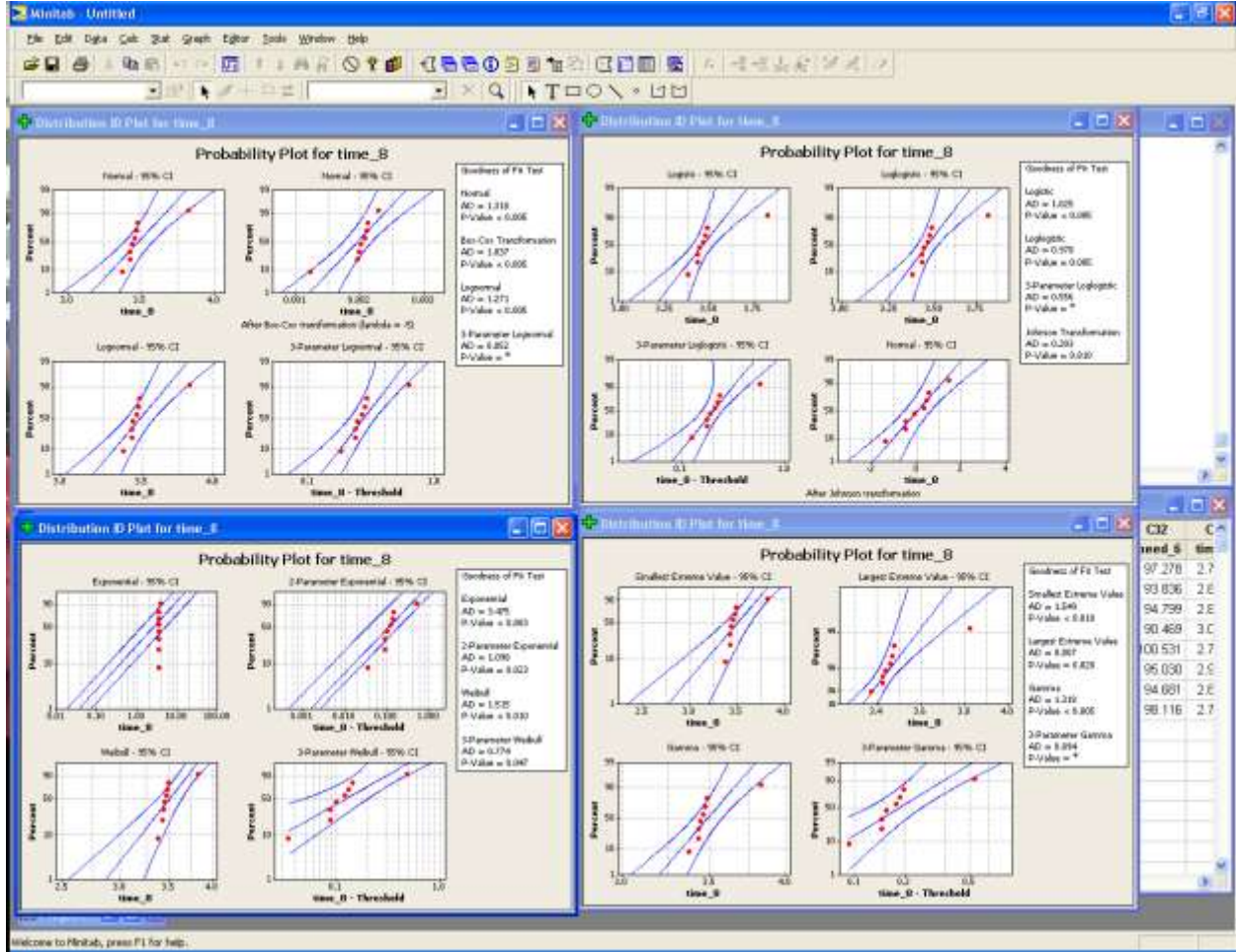
lognormal

Section 8 (t4)



Lognormal [but questionable]

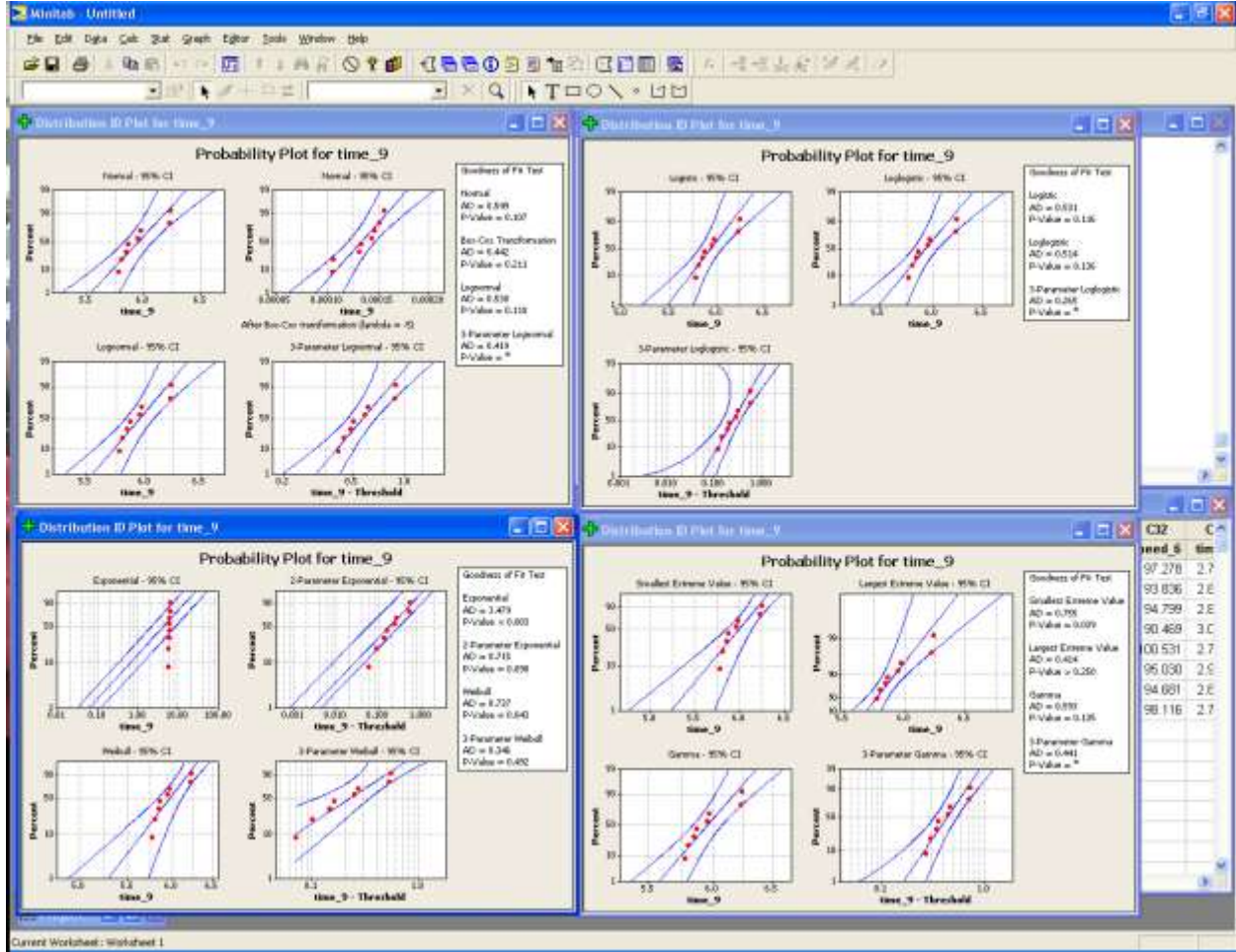
Section 9 (s5)



Lognormal [but questionable]

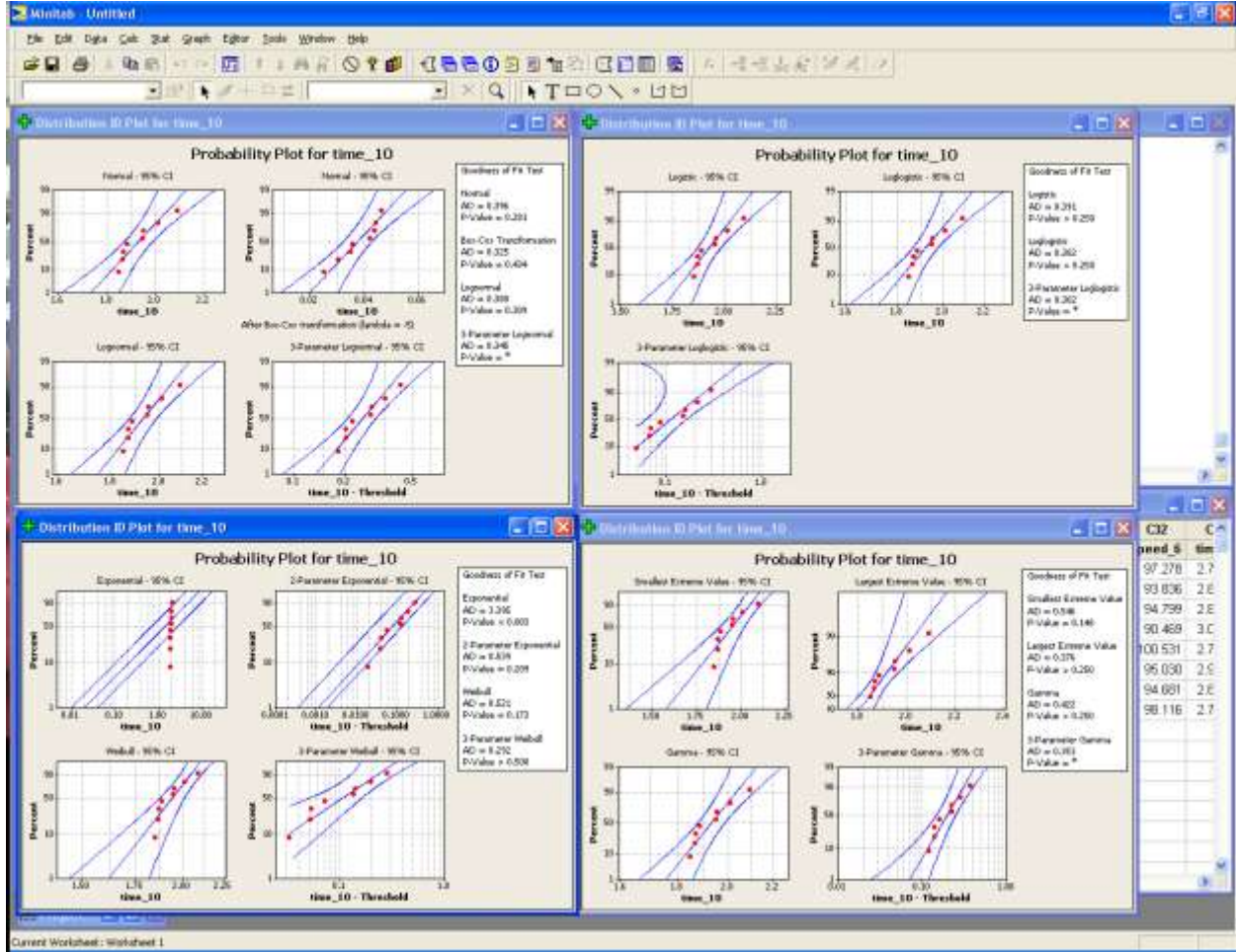


Section 10 (t5)



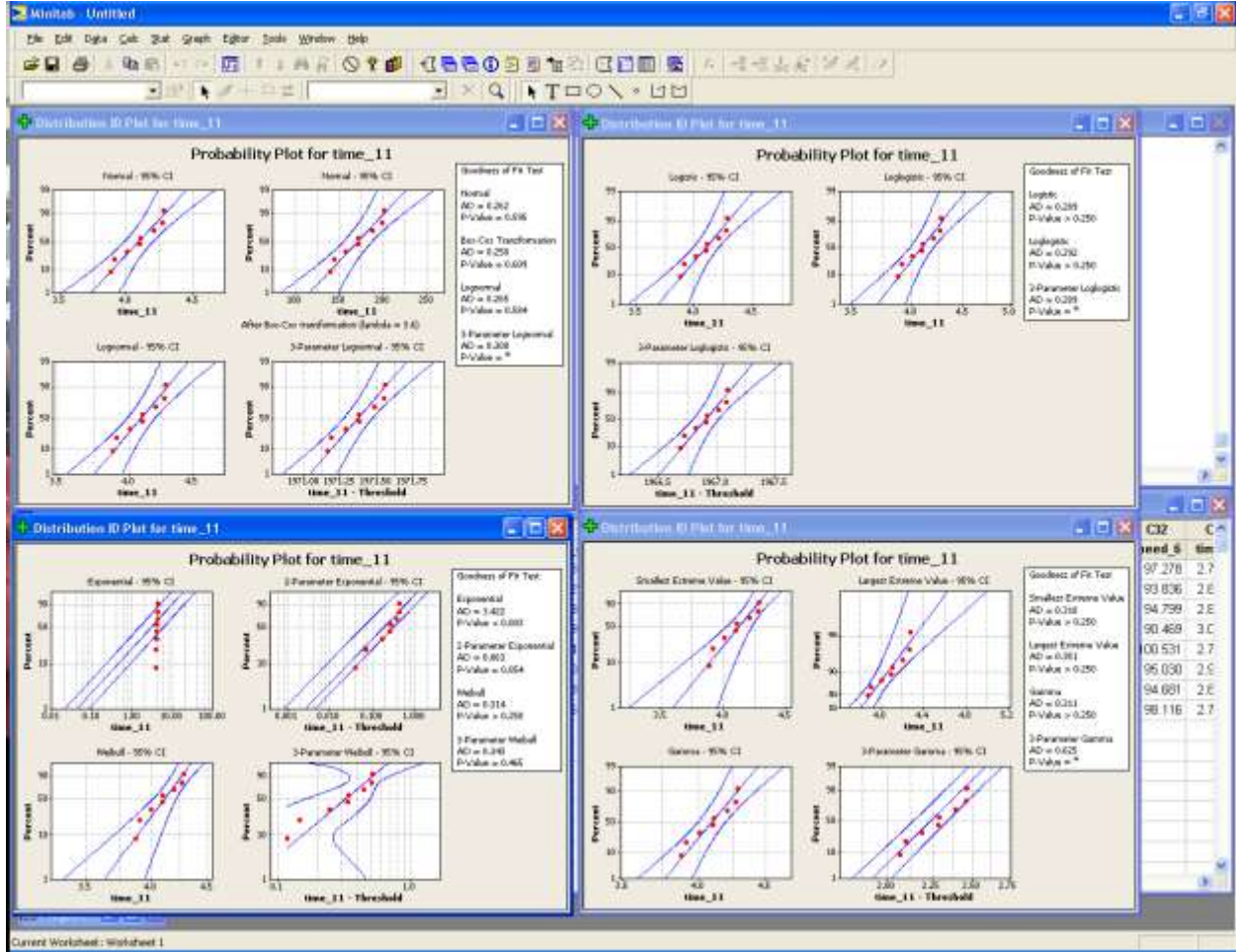
lognormal

Section 11 (s6)



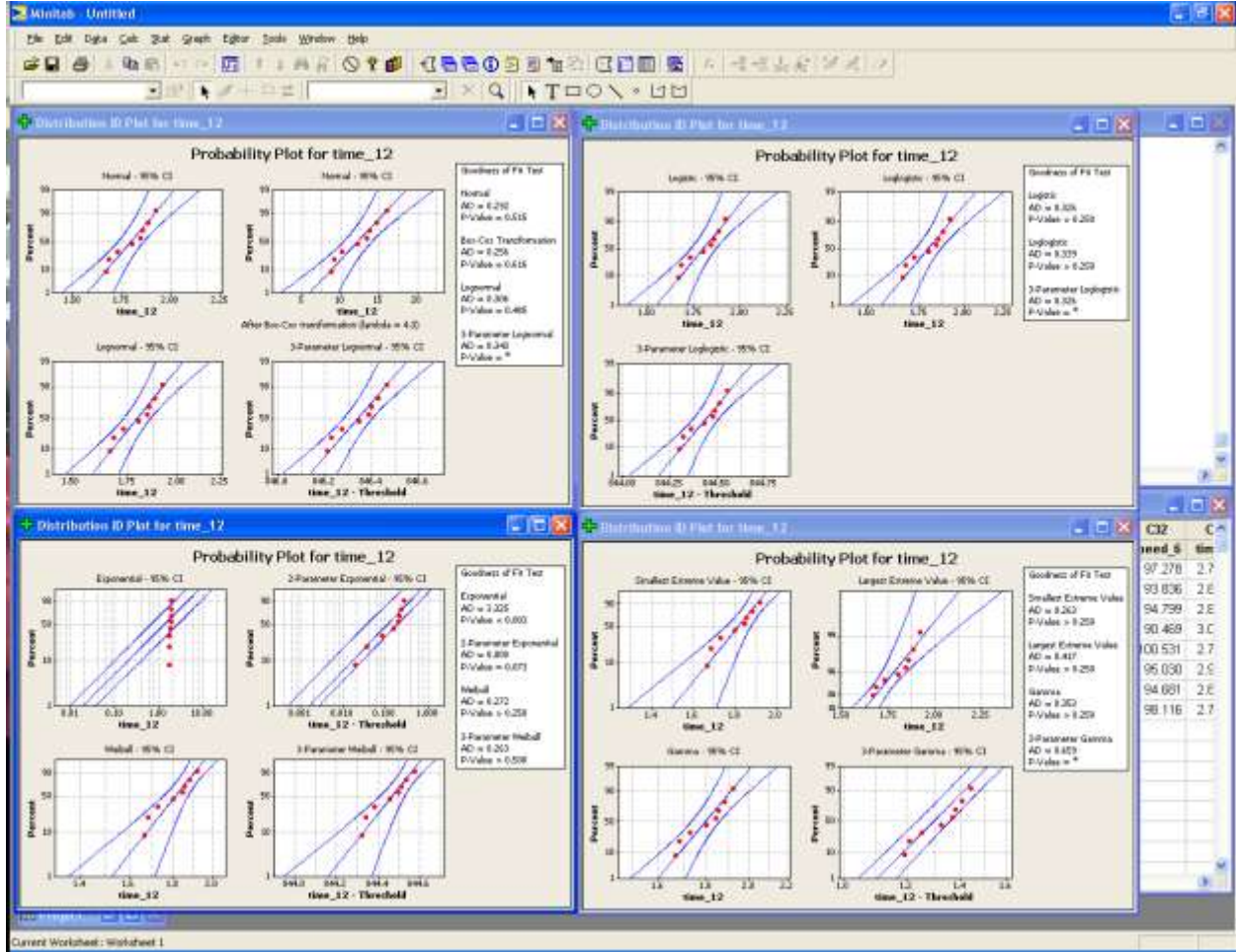
lognormal

Section 12 (t6)



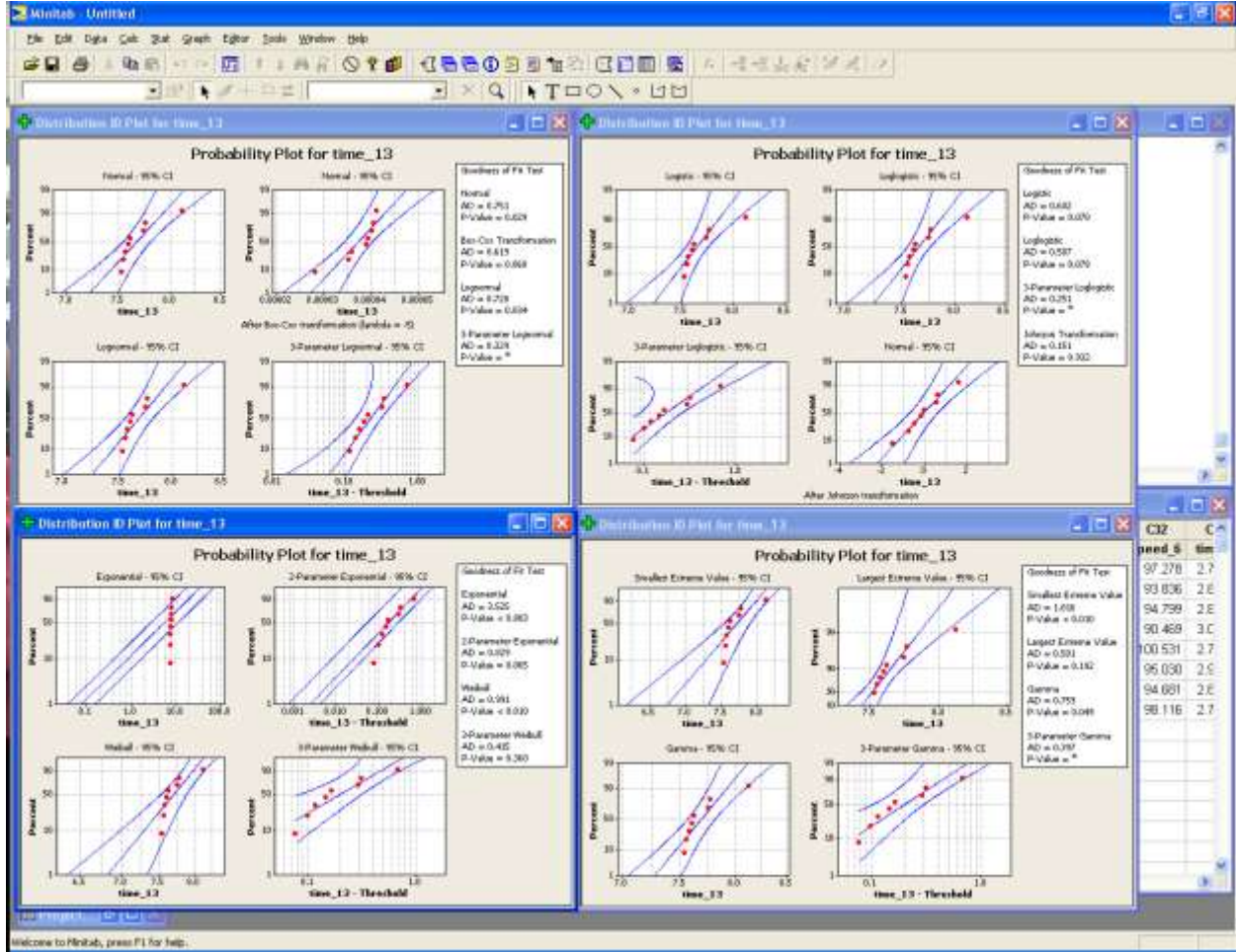
lognormal

Section 13 (s7)



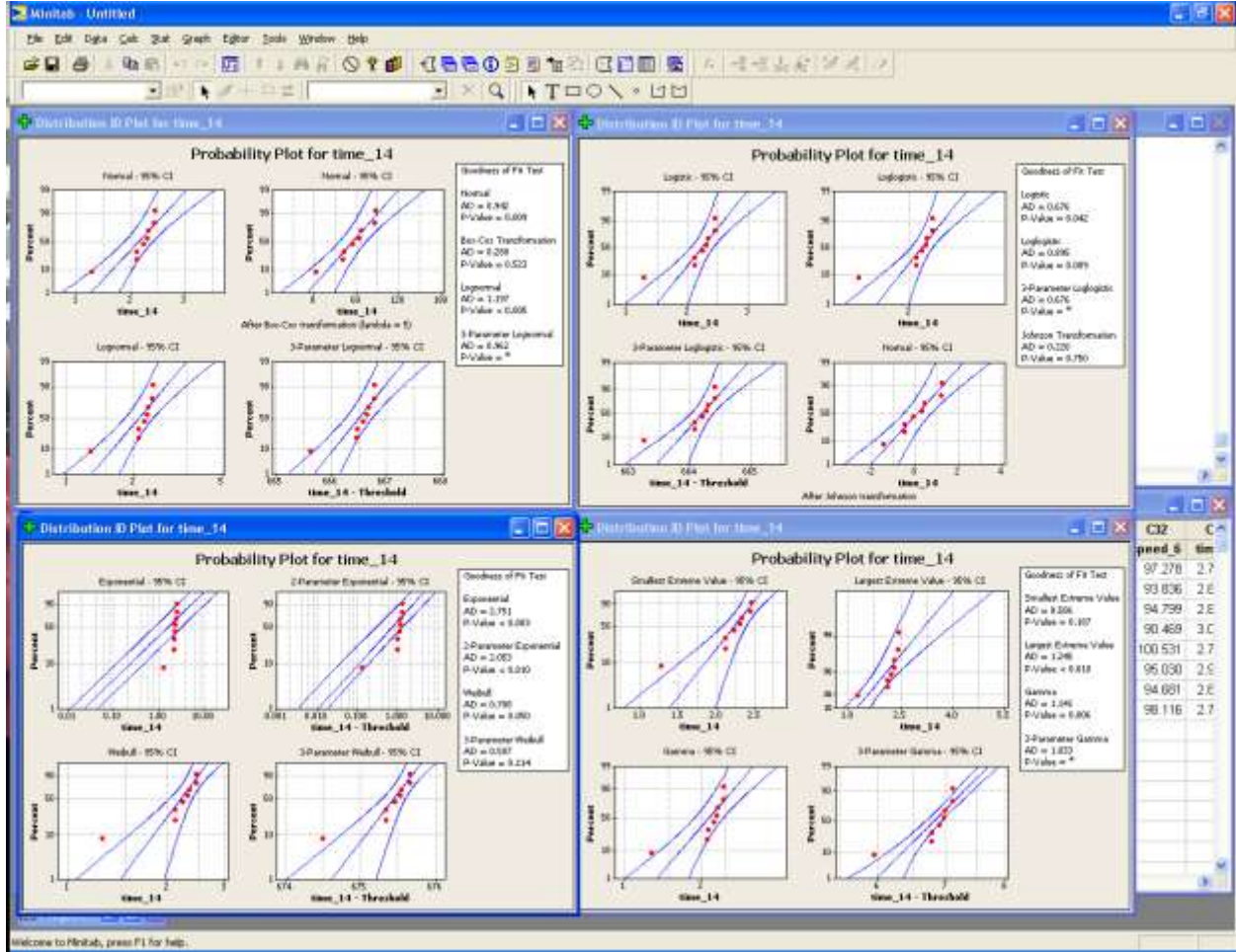
weibull

Section 14 (t7)



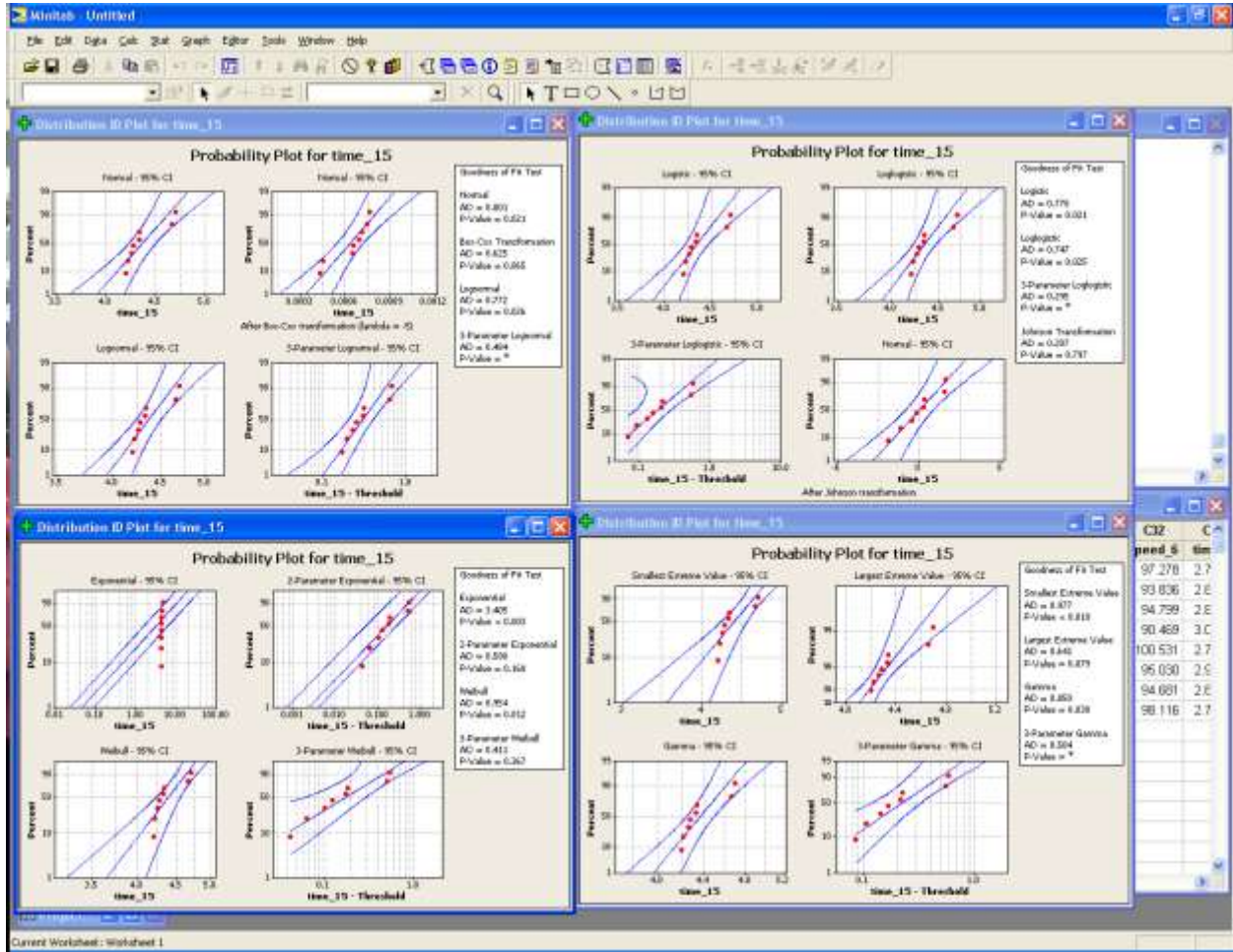
Lognormal [questionable]

Section 15 (s8)



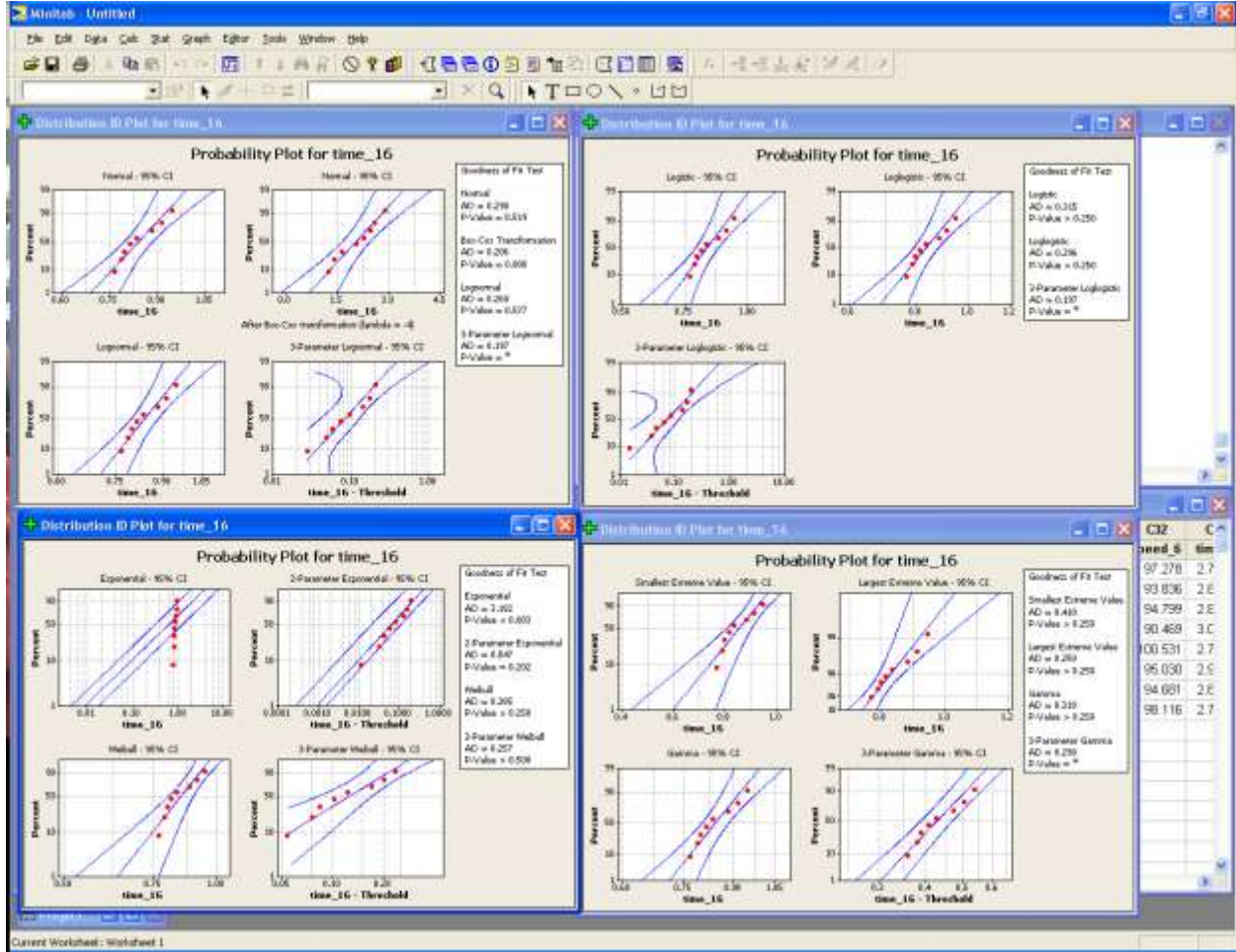
Weibull [borderline]

Section 16 (t8)



lognormal

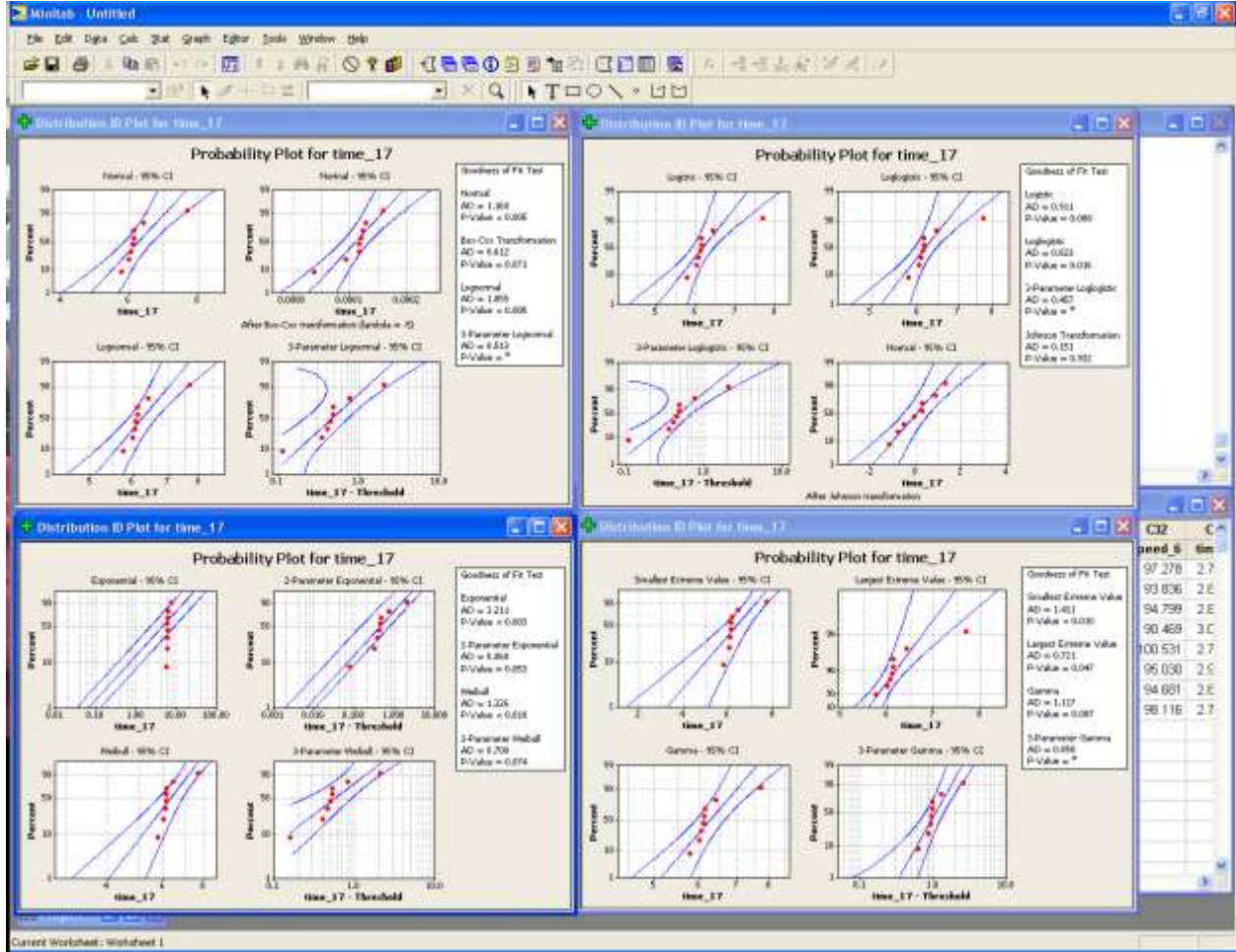
Section 17 (s9)



lognormal

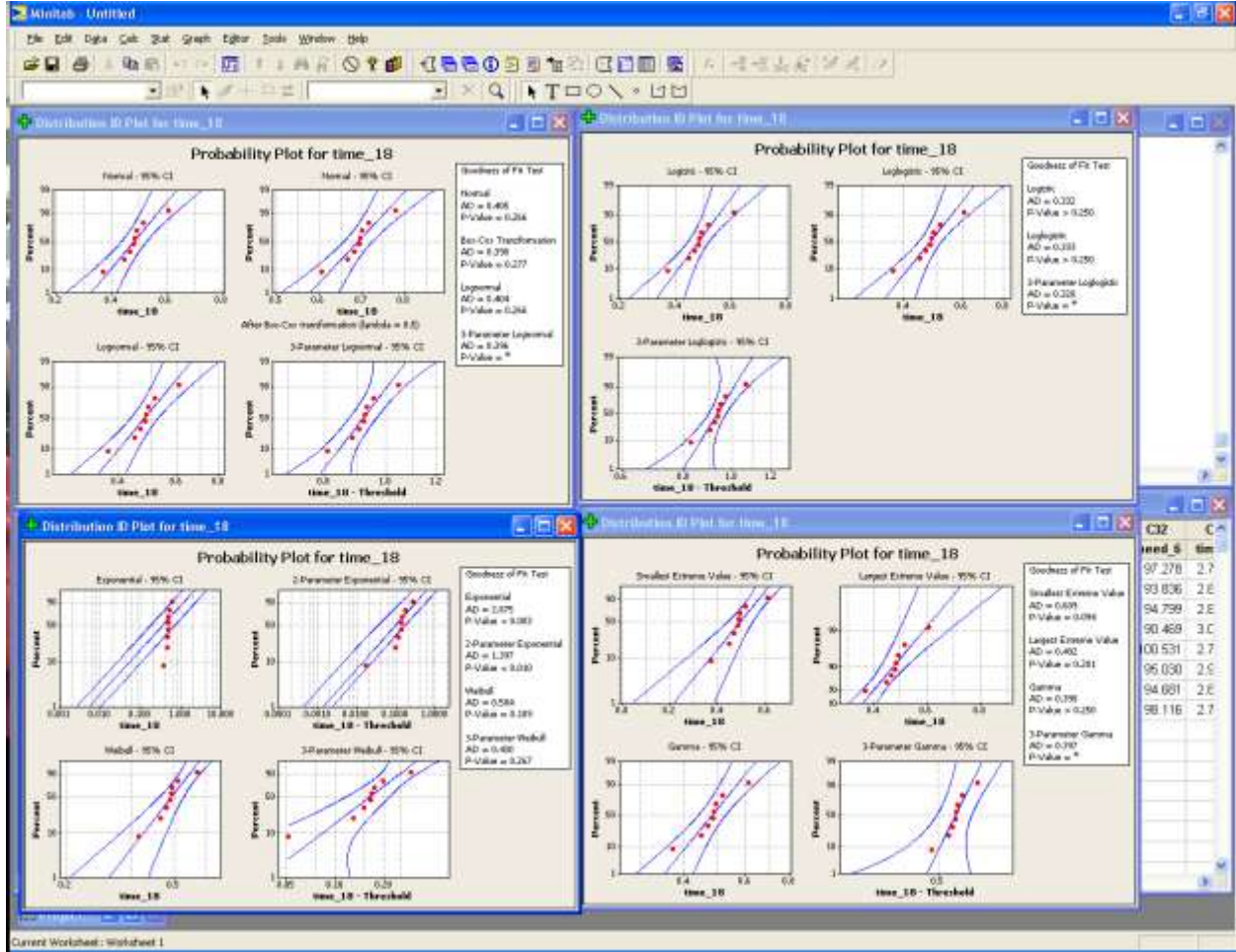


Section 18 (t9)



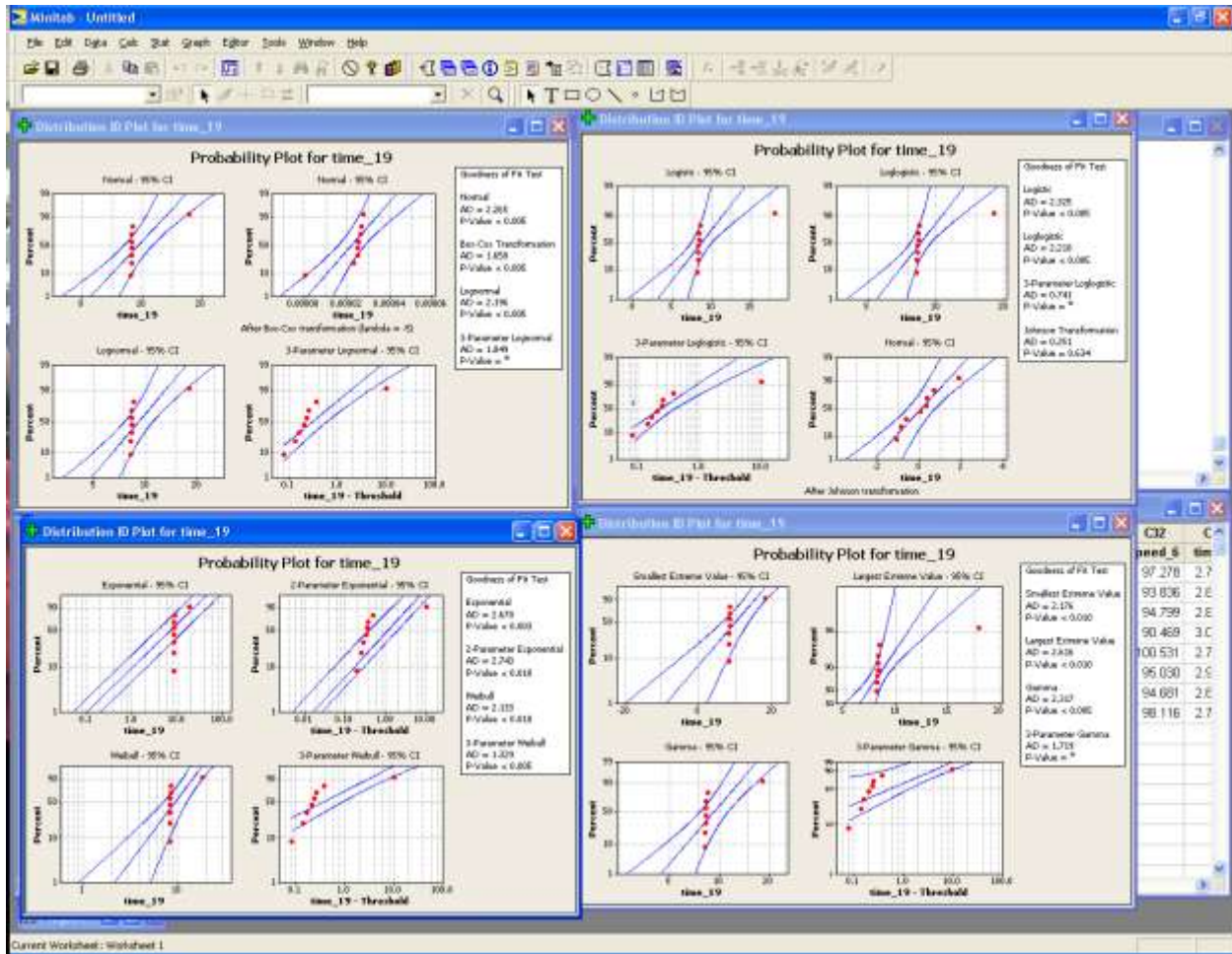
Weibull [questionable]

Section 19 (s10)



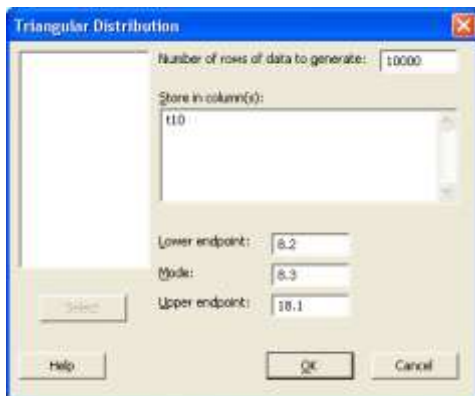
lognormal

Section 20 (t10)

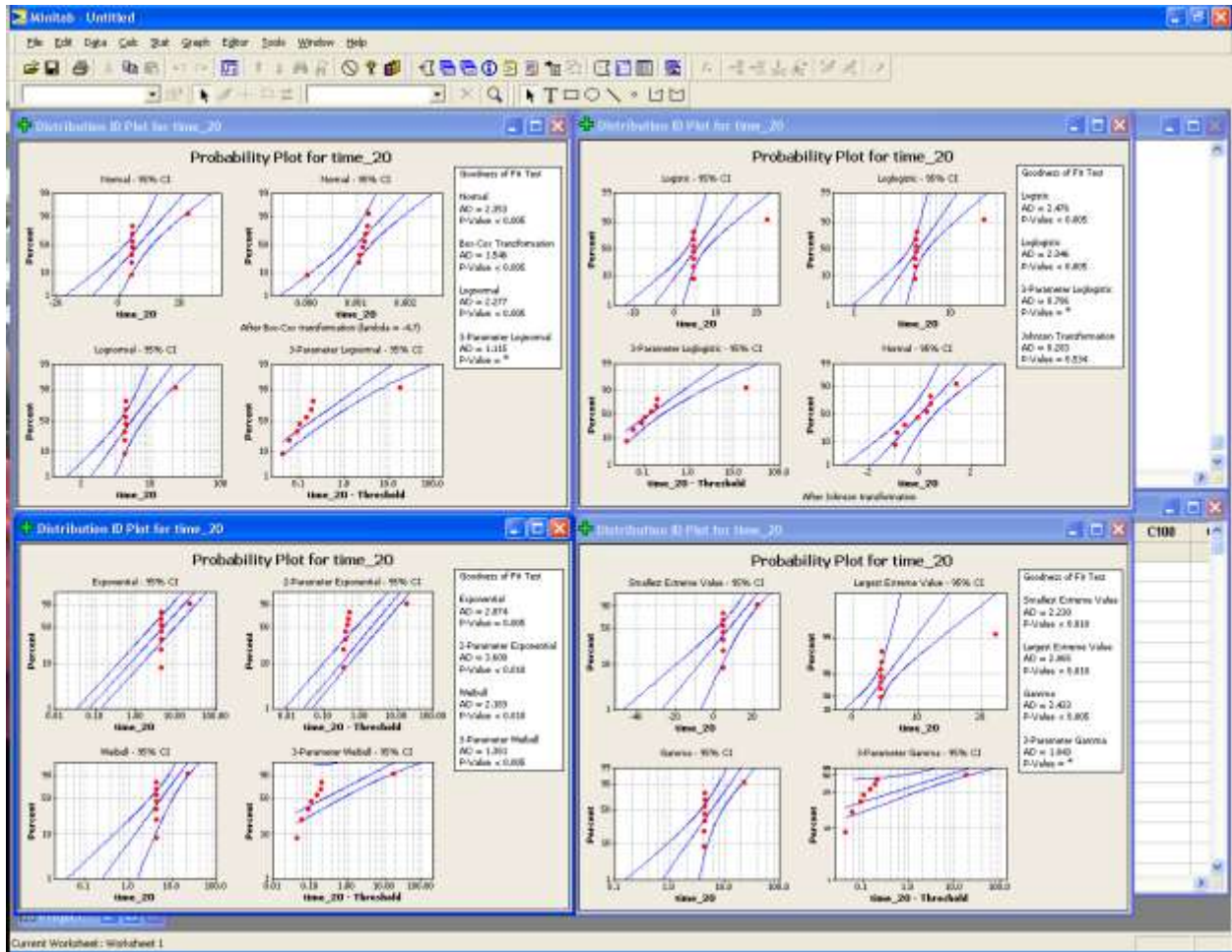


Lognormal [questionable]

I used a triangular distribution



Section 21 (s11)



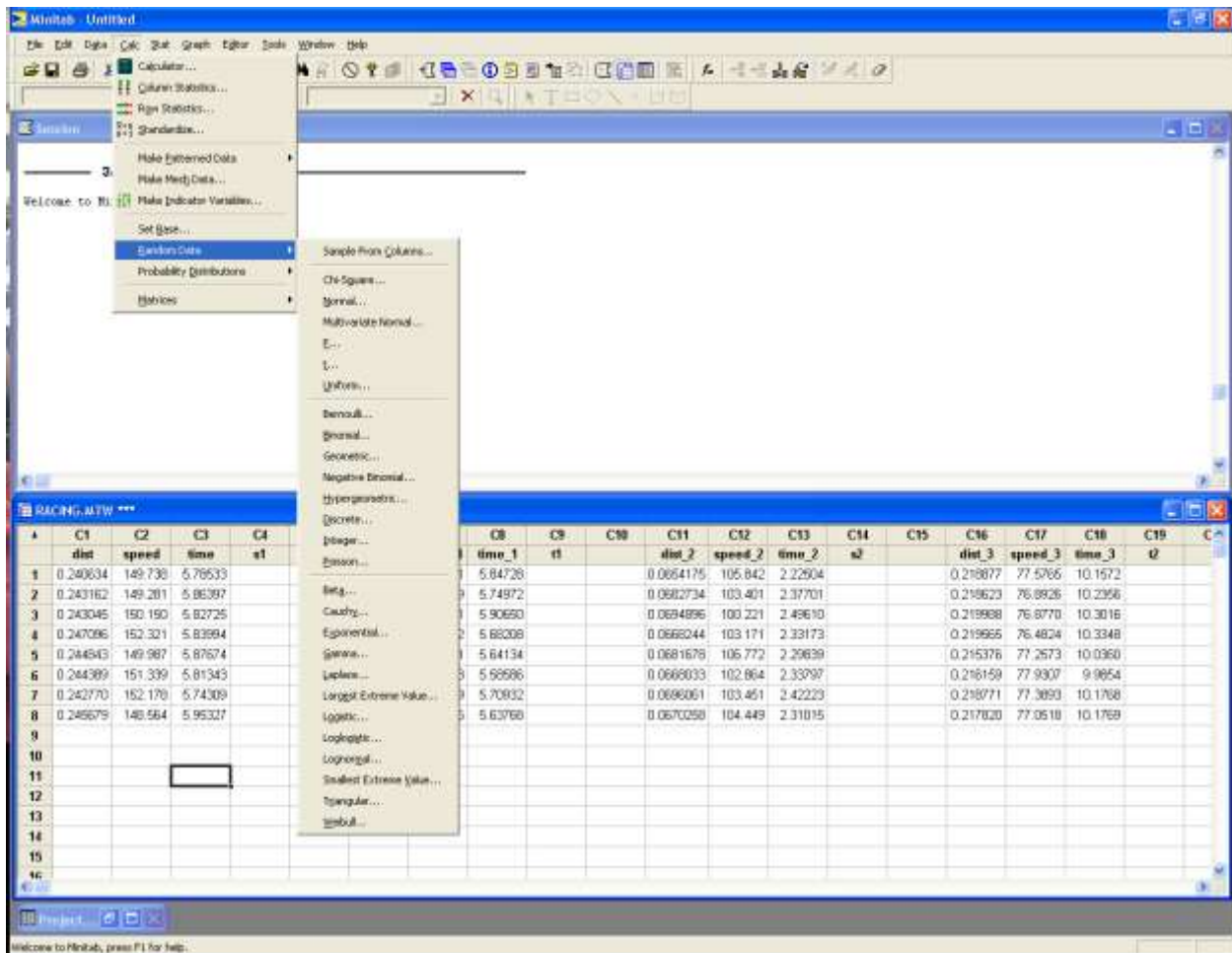
Weibull [questionable]

I actually used Triangular distribution

## Monte Carlo Simulation

Now that we have established the distributions for the time in each section of the track, we can now simulate these in order to simulate the time to complete one lap. We shall perform this simulation in Minitab (Excel also works fine) using 10,000 iterations.

In Minitab click on Calc-Random Data and the select the distribution relevant to the variable of interest, in this first case it is the lognormal for the time to traverse the first straight from the start line.



**Lognormal Distribution** ✖

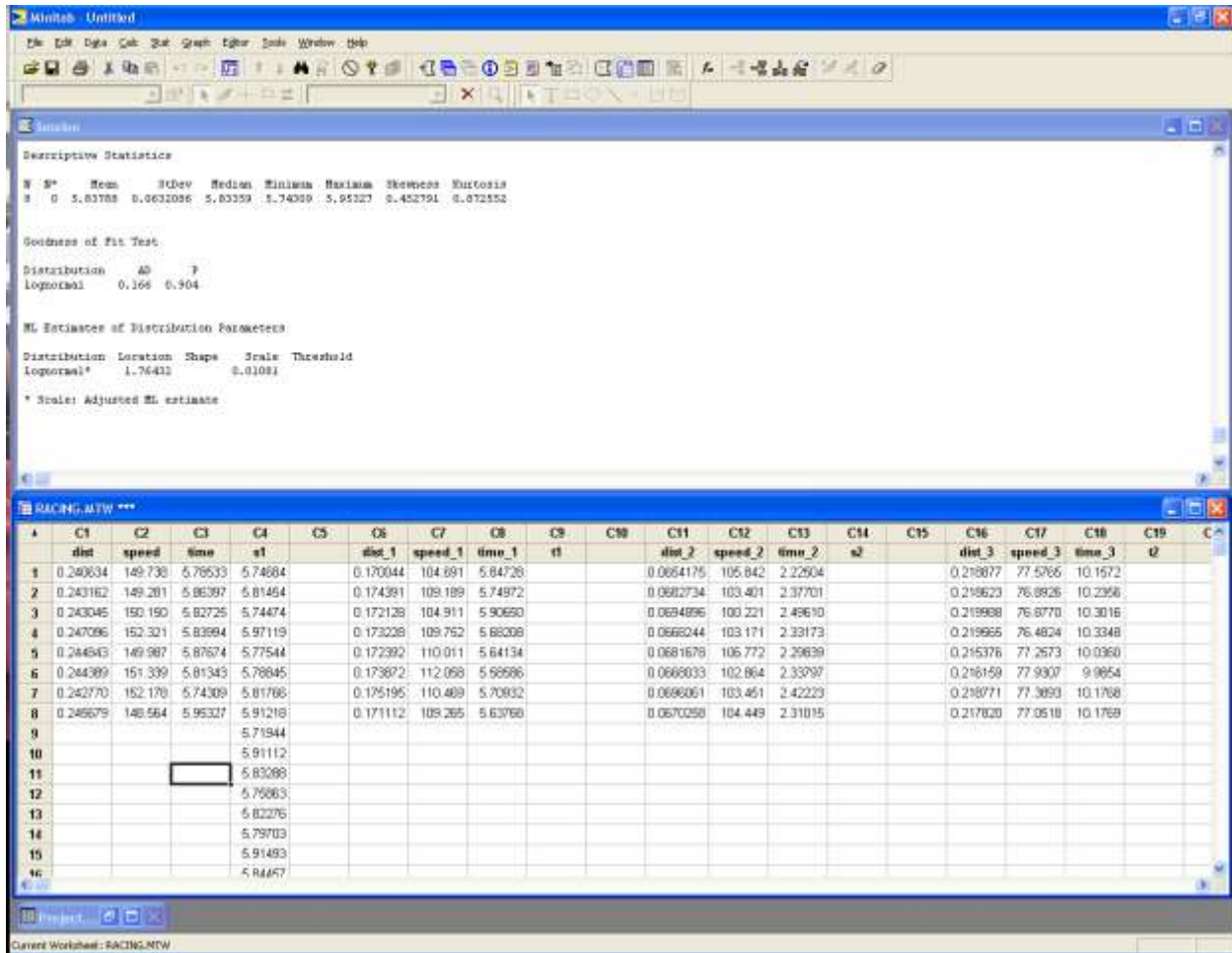
Number of rows of data to generate:

Store in column(s):

Location:

Scale:

Threshold:



This is repeated for each section of the track.

We can now add up all the distributions to give us the total lap time distribution.

The screenshot shows the Minitab software interface. At the top, the 'Calculator' window is open, displaying the following statistics:

Statistic	Mean	Stdev	Max
Mean	18.0611	2.82478	7.90438

Below the calculator window, the 'Minitab' window shows the 'M Estimation of Distribution Parameters' for a Lognormal distribution:

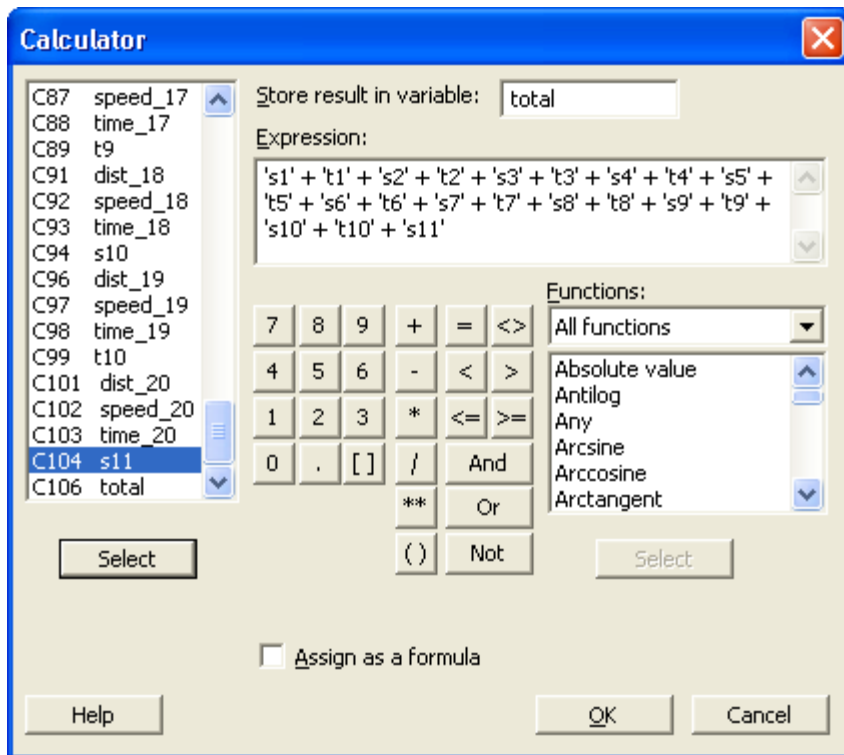
Distribution	Location	Shape	Scale	Threshold
Lognormal*	2.21224		0.27558	

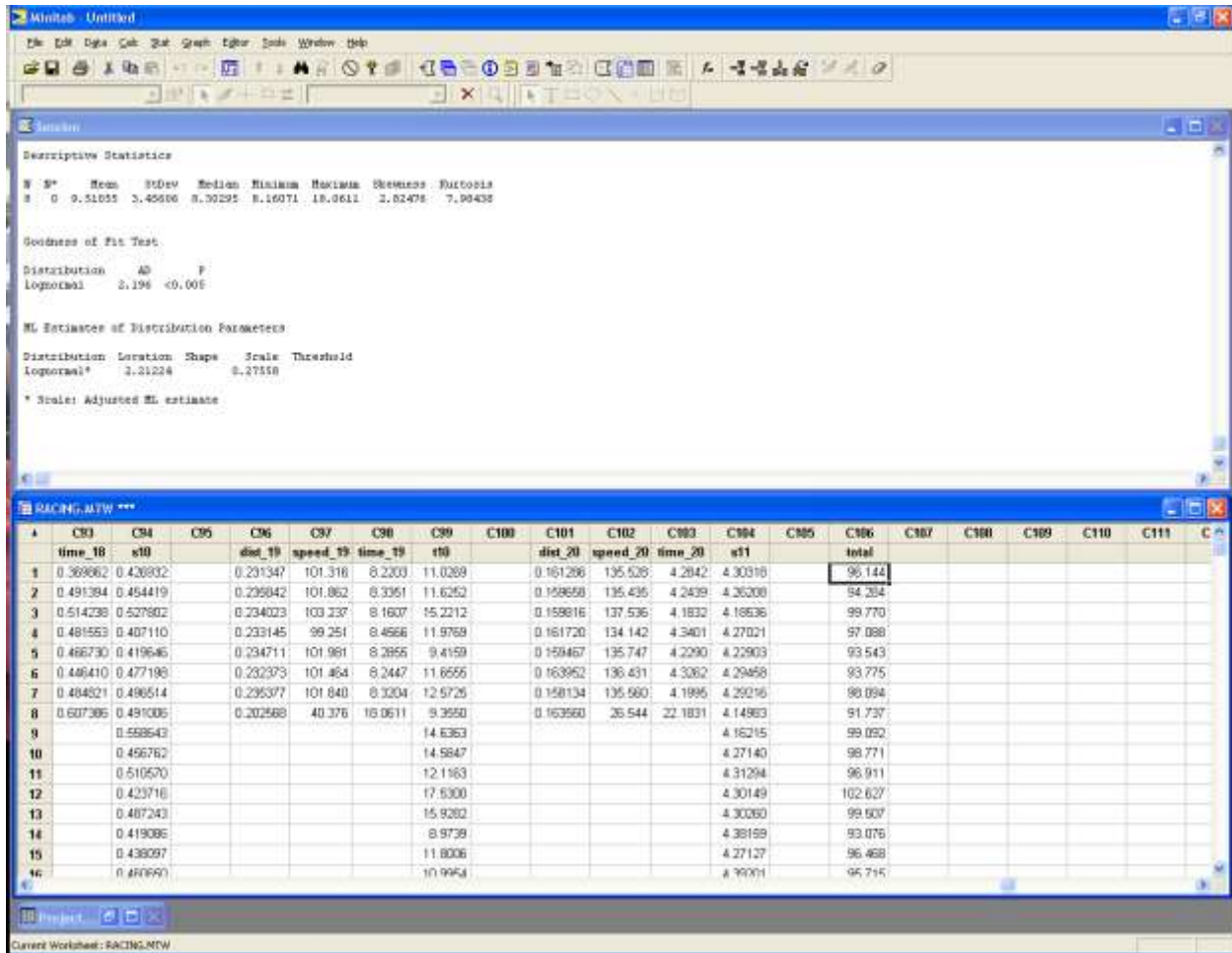
\* Scale: Adjusted M estimate

The main window displays a data table with columns C00 through C100. The data is organized into groups of three columns (dist, speed, time) for years 18, 19, and 20, followed by a 'total' column. The rows represent individual data points from 1 to 16.

	C00	C01	C02	C03	C04	C05	C06	C07	C08	C09	C100	C101	C102	C103	C104	C105	C106	C107	C108		
	dist_18	speed_18	time_18	s18	dist_19	speed_19	time_19	t19	dist_20	speed_20	time_20	s11	total								
1	0.0102701	99.963	0.309892	0.426932	0.231347	101.316	8.2203	11.0269	0.161296	136.520	4.2642	4.30318									
2	0.0138662	101.998	0.491394	0.454419	0.236842	101.862	8.3361	11.6262	0.199660	136.436	4.2439	4.26200									
3	0.0147126	102.998	0.514238	0.527802	0.234023	103.237	8.1607	16.2212	0.199816	137.536	4.1832	4.18536									
4	0.0136122	101.763	0.481563	0.407110	0.233146	99.261	8.4566	11.9769	0.161720	134.542	4.3401	4.27021									
5	0.0136020	104.915	0.466730	0.419646	0.234711	101.981	8.2655	9.4169	0.199467	136.747	4.2290	4.22903									
6	0.0127346	102.896	0.446410	0.477198	0.232373	101.464	8.2447	11.6565	0.163962	136.431	4.3262	4.29468									
7	0.0139616	100.670	0.464821	0.496614	0.236377	101.840	8.3204	12.6725	0.198134	136.680	4.1996	4.28216									
8	0.0087366	51.782	0.607386	0.491006	0.202968	40.376	18.0611	9.3560	0.163660	26.544	22.1831	4.14983									
9				0.558643				14.6363				4.16216									
10				0.466762				14.6847				4.27140									
11				0.519670				12.1183				4.31294									
12				0.423716				17.5300				4.30149									
13				0.407243				16.9282				4.30260									
14				0.419086				8.9739				4.38159									
15				0.438097				11.8006				4.27127									
16				0.469650				10.9964				4.39701									



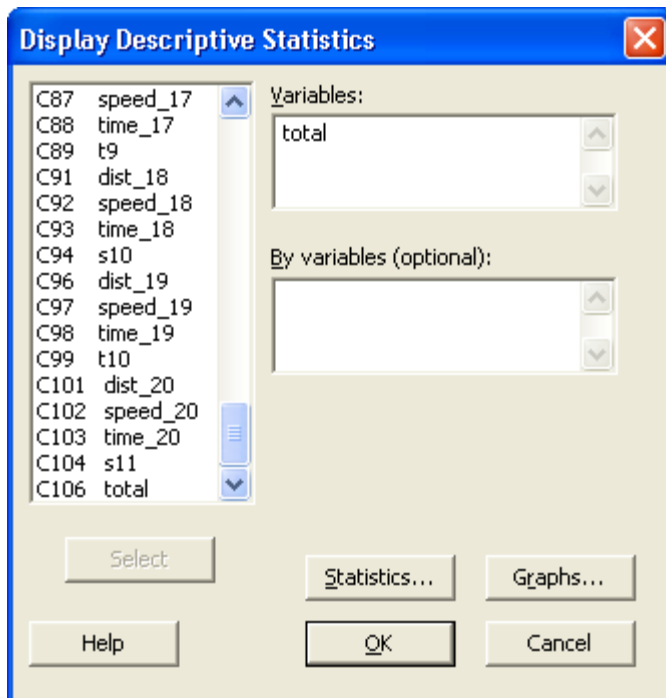


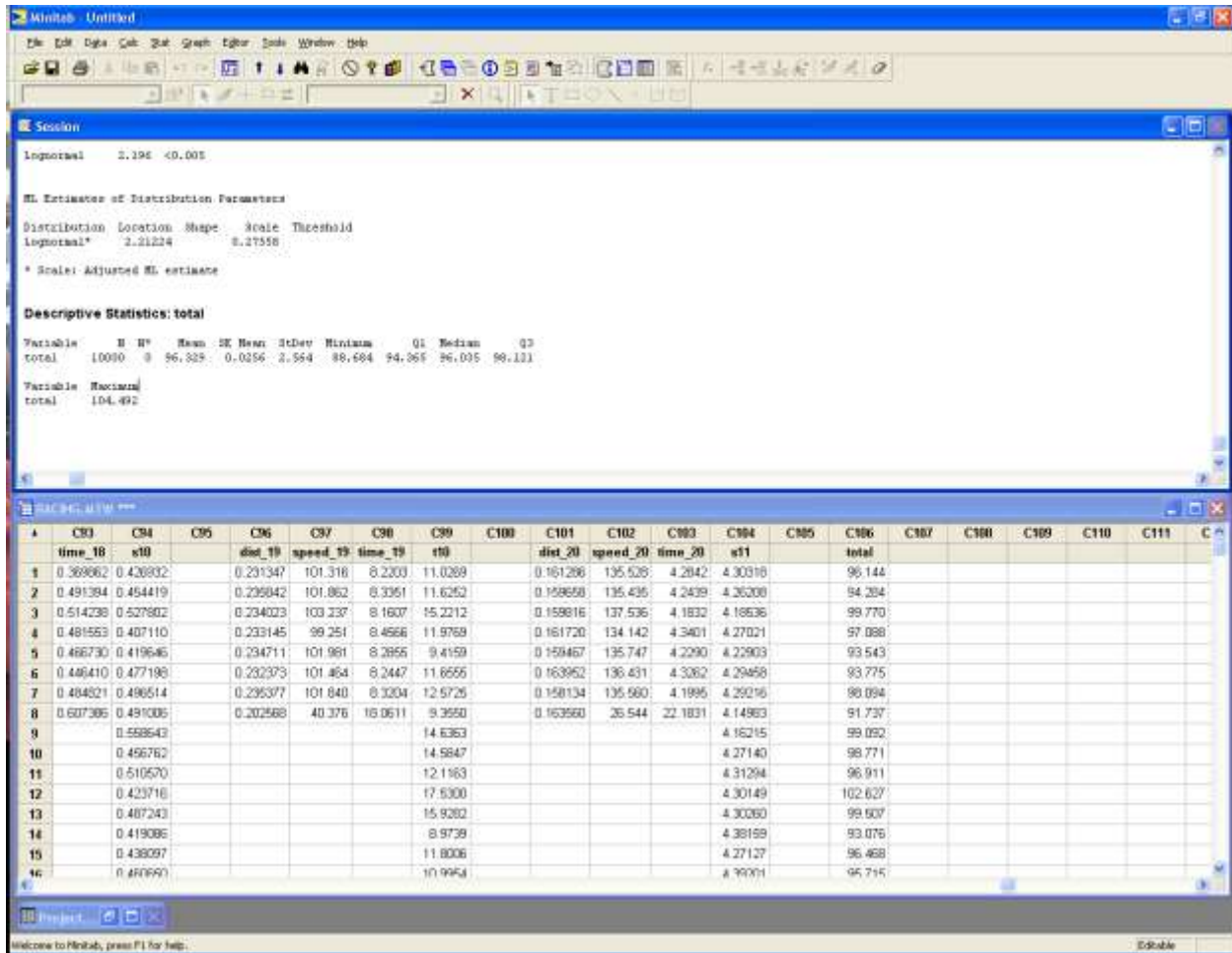


Lets now look at the descriptive statistics of the total lap time

The screenshot shows the Minitab software interface. The 'Stat' menu is open, and the path 'Basic Statistics' > 'Display Descriptive Statistics...' is highlighted. Below the menu, the 'Descriptive Statistics' window is partially visible, showing fields for 'N', 'N\*', 'Mean', and 'StDev'. The main data window, titled 'RACING.MTW', contains a table with 16 rows and 17 columns. The columns are labeled C03 through C11, with an additional 'total' column. The data represents various lap metrics for 16 different laps.

	C03	C04	C05	C06	C07	C08	C09	C100	C101	C102	C083	C084	C085	C106	C107	C108	C109	C110	C111	C
	time_18	s10		dist_19	speed_19	time_19	t10		dist_20	speed_20	time_20	s11		total						
1	0.369862	0.420832		0.231347	101.318	8.2303	11.0289		0.161286	135.528	4.2842	4.30318		96.144						
2	0.491394	0.454419		0.235842	101.862	8.3351	11.6252		0.158658	135.435	4.2439	4.26208		94.204						
3	0.514238	0.527882		0.234023	103.237	8.1607	15.2212		0.159816	137.536	4.1832	4.18636		99.770						
4	0.481553	0.407110		0.233145	99.251	8.4666	11.9769		0.161720	134.142	4.3401	4.27021		97.088						
5	0.466730	0.419646		0.234711	101.981	8.2855	9.4159		0.159467	135.747	4.2290	4.25903		93.543						
6	0.446410	0.477198		0.232373	101.464	8.2447	11.6555		0.163952	136.431	4.3262	4.29458		93.775						
7	0.484821	0.486514		0.235377	101.848	8.3204	12.5725		0.158134	135.560	4.1995	4.25215		88.094						
8	0.607385	0.491005		0.202568	40.376	16.0611	9.3550		0.163560	25.544	22.1831	4.14863		91.737						
9		0.558543					14.6363					4.16215		99.092						
10		0.456762					14.5847					4.27140		98.771						
11		0.510570					12.1163					4.31294		96.911						
12		0.423718					17.5300					4.30149		102.627						
13		0.487243					15.9282					4.30060		99.507						
14		0.419085					8.9739					4.38159		93.075						
15		0.439097					11.8006					4.27127		96.468						
16		0.481690					10.9454					4.29001		95.715						



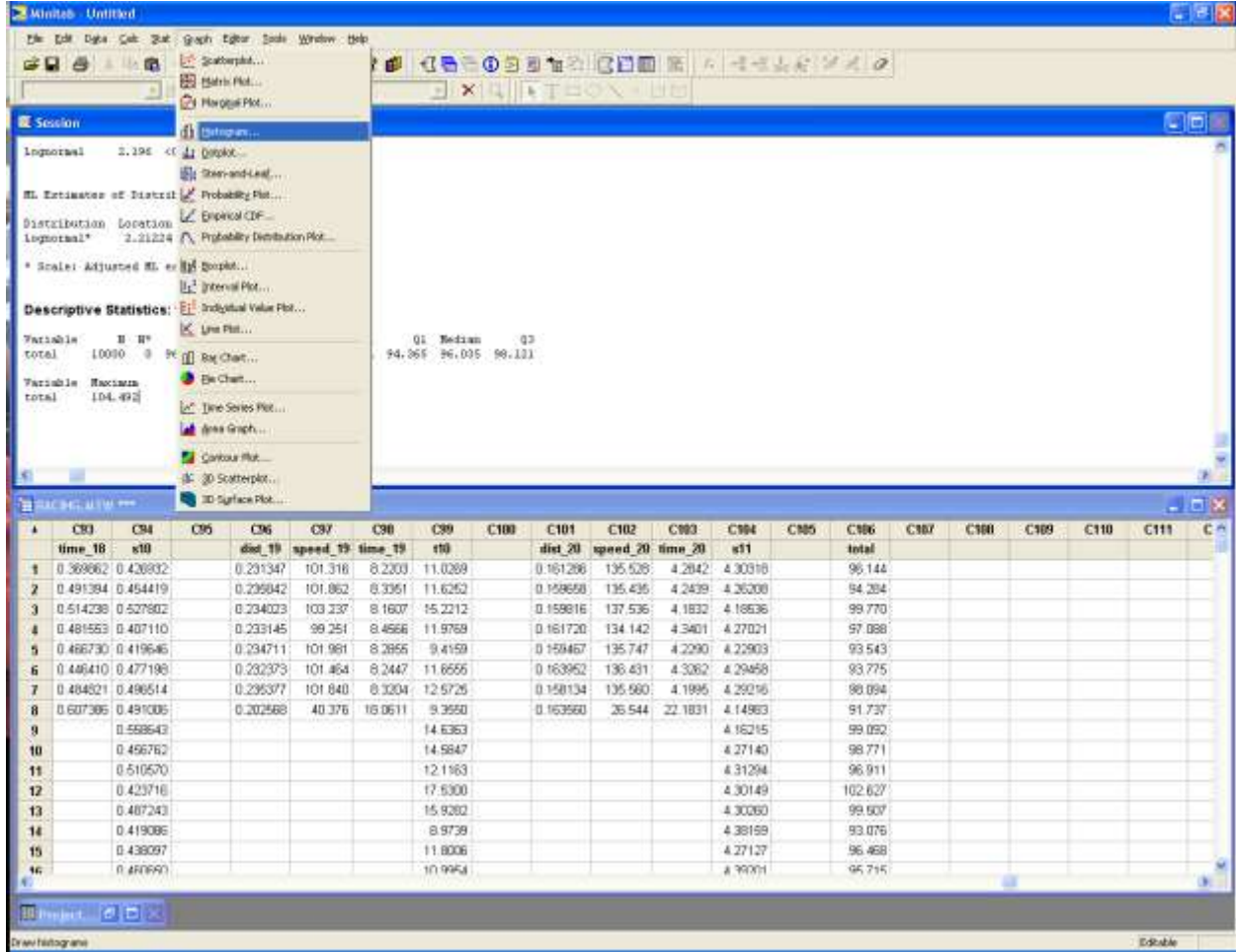


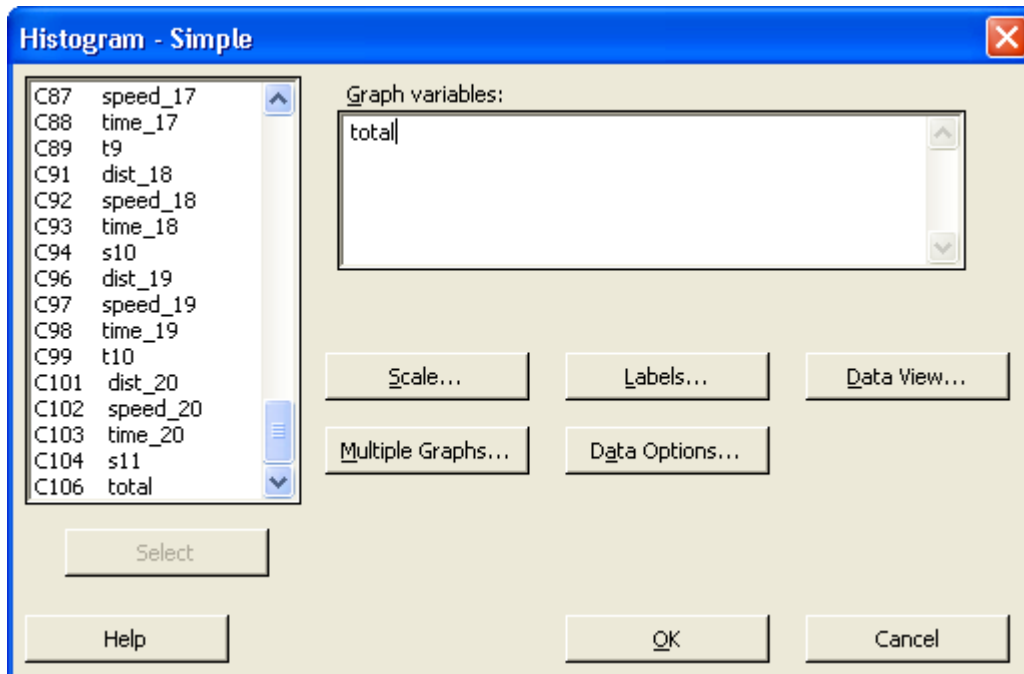
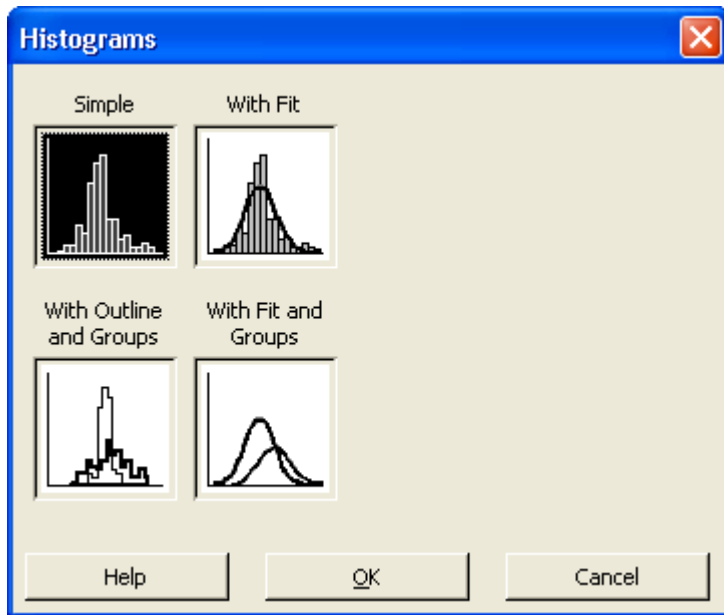
### Descriptive Statistics: total

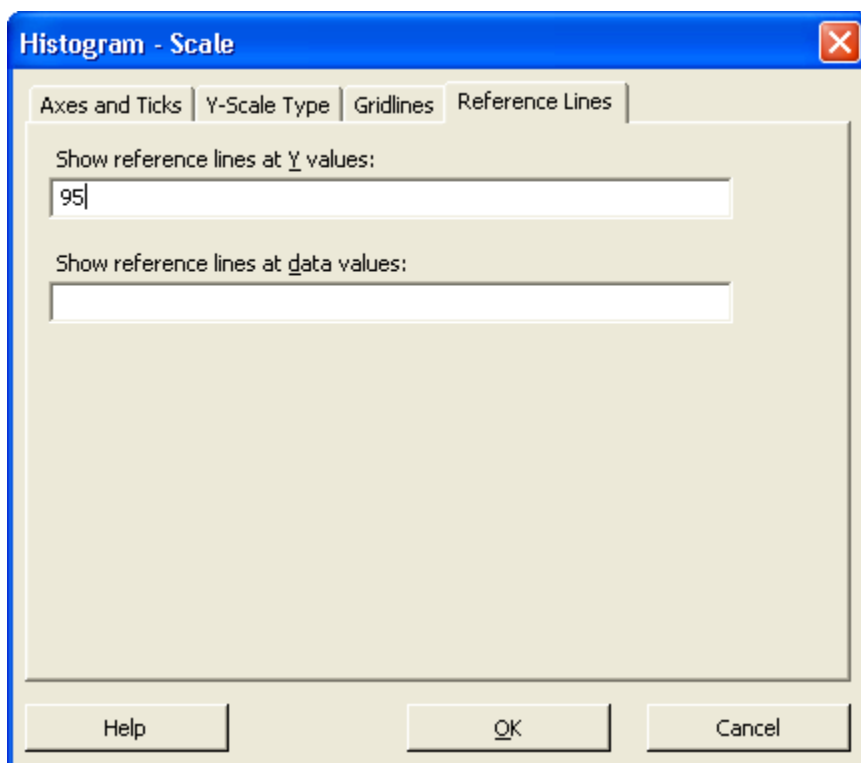
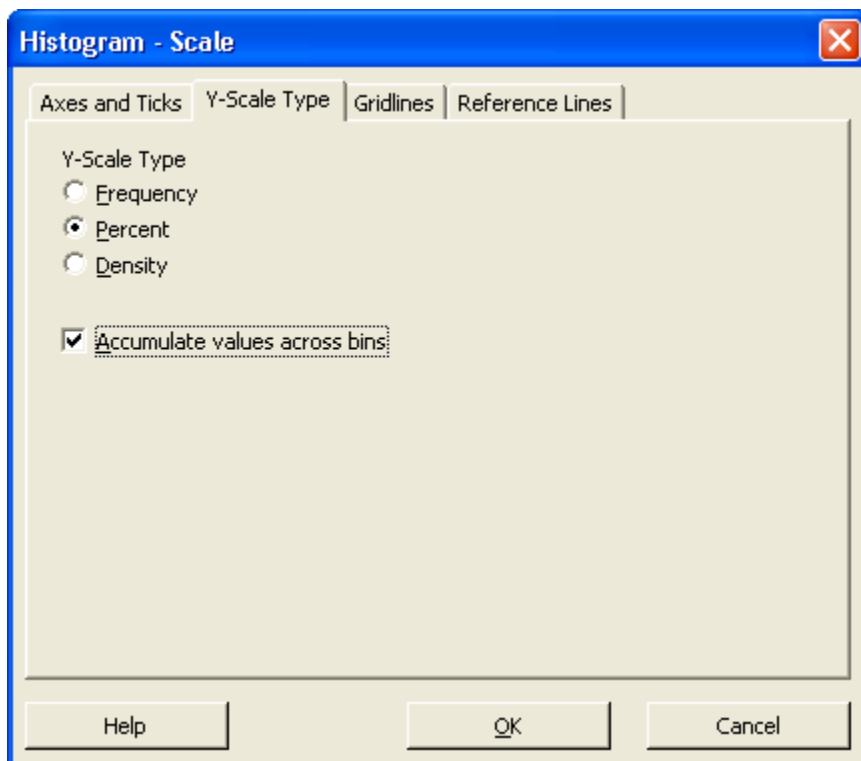
Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3
total	10000	0	96.329	0.0256	2.564	88.684	94.365	96.035	98.121

Variable	Maximum
total	104.492

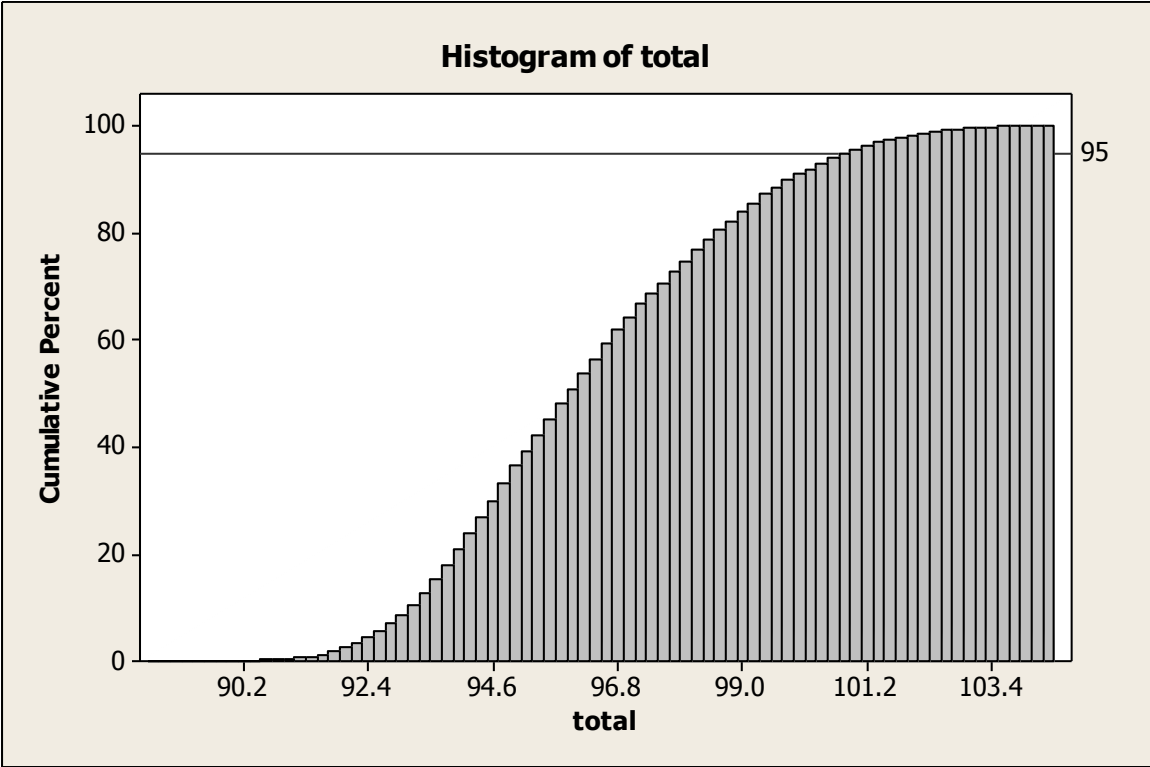
Let us look at the histogram





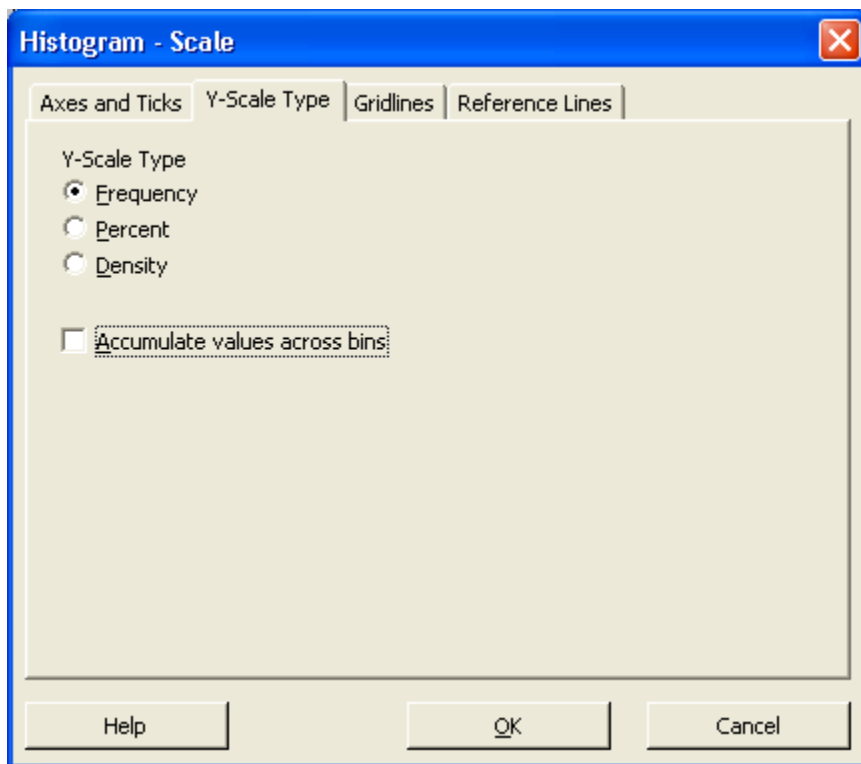


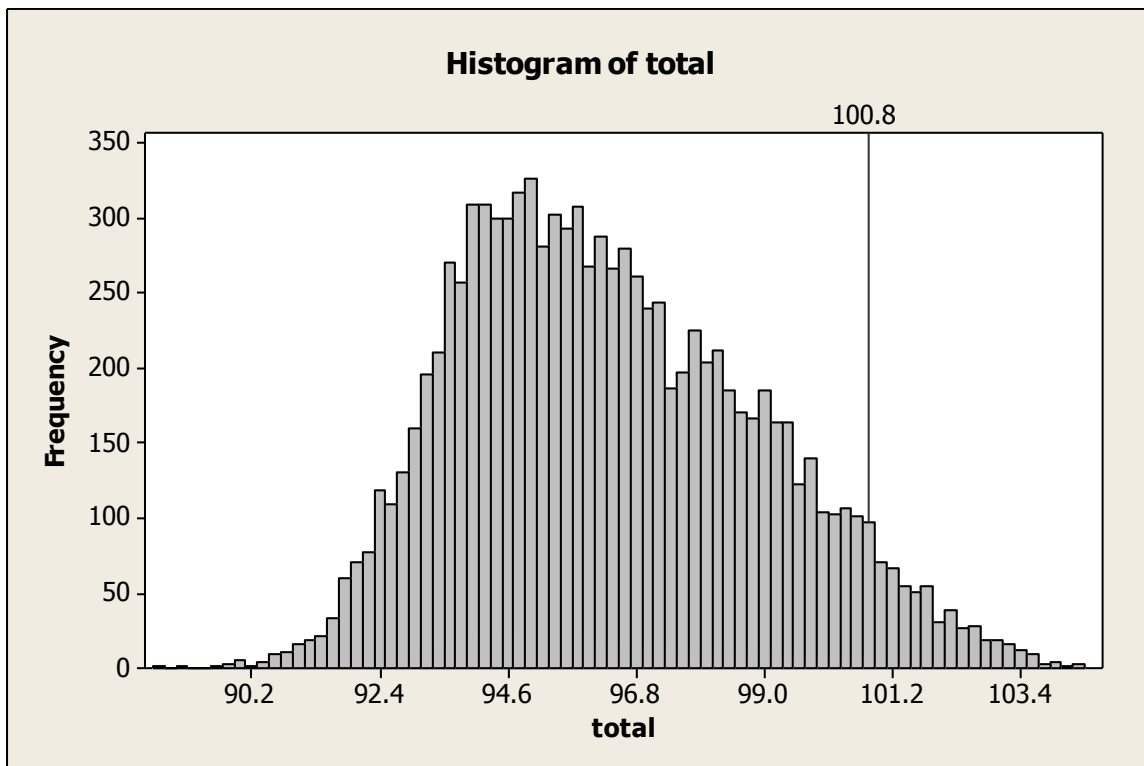
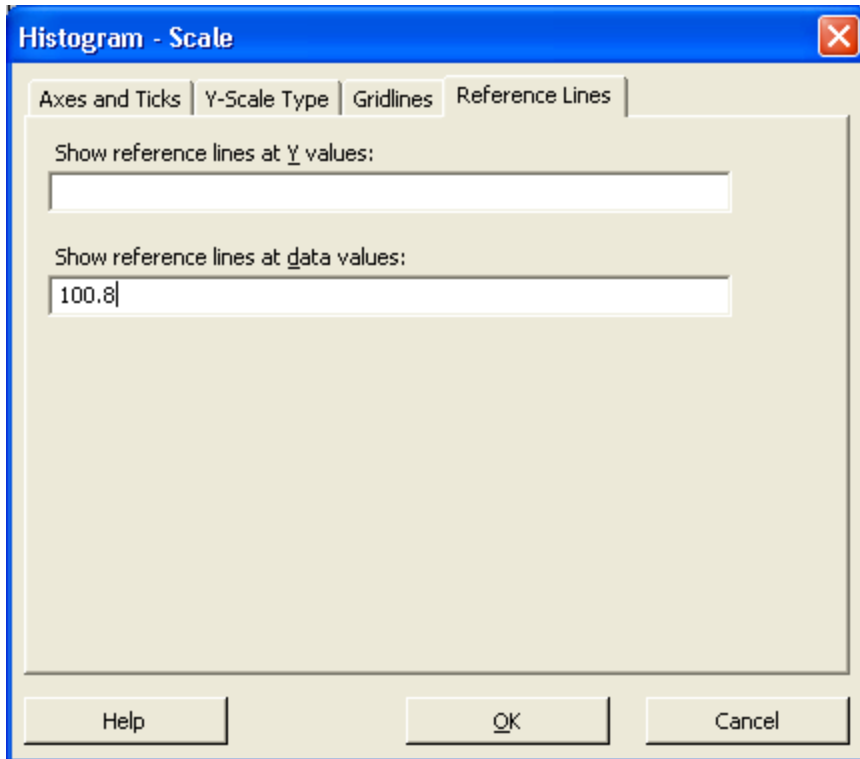




Note that you can change the scale on the axes, titles on the axes, the title of the diagram, the color of the bars, the lines, you can add gridlines etc etc to whatever you desire

Alternately we could have drawn a regular histogram to summarize our data





Some questions to consider

What is the probability we can get 102 seconds lap time from this vehicle/ driver ?

What would be range of lap times over which we can expect to see ? [confidence interval]

If it was claimed this car can runs an average lap time of 105 seconds, is this claim credible?

How would you test that the times can be improved by hiring a more aggressive driver ?

Conclusion:

So using the 95<sup>th</sup> percentile we can say this race driver can traverse one lap in 100.8 seconds. So it is now up to your race team principal or race engineer or whoever has the final say on technical matters to make the call as to whether this race car is performing as designed. You may also want to go back to each individual section and come up a strategy for it. Then see where improvements can be made and re-run the analysis and see what you new anticipated performance will be.