The Challenger Disaster Revisited

The Challenger Disaster

On January 28, 1986 the space shuttle, *Challenger*, had a catastrophic failure due to burn-through of an O-ring seal at a joint in one of the solid-fuel rocket boosters. This was the 25th shuttle flight. Of the 24 previous shuttle flights, 7 had incidents of damage to joints, 16 had no incidents of damage, and 1 was unknown. (The data comes from recovered solid rocket boosters—the one that was unknown was not recovered.) The question we wish to examine is: Could an estimate of the probability of an O-ring failure be created from the results of previous launches?

Damage to Booster Rocket Field Joints

Below are data from the Presidential Commission on the Space Shuttle *Challenger* Accident (1986). The data consist of the flight, temperature at the time of launch (°F) and whether or not there was damage to the booster rocket field joints (No = 0. Yes = 1).

Flight	Temp	Damage	Flight	Temp	Damage	Flight	Temp	Damage
STS-1	66	NO	STS-9	70	NO	STS 51-B	75	NO*
STS-2	70	YES	STS 41-B	57	YES	STS 51-G	70	NO
STS-3	69	NO	STS 41-C	63	YES	STS 51-F	81	NO
STS-4	80	???	STS 41-D	70	YES	STS 51-I	76	NO
STS-5	68	NO	STS 41-G	78	NO	STS 51-J	79	NO
STS-6	67	NO	STS 51-A	67	NO	STS 61-A	75	YES
STS-7	72	NO	STS 51-C	53	YES	STS 61-B	76	NO
STS-8	73	NO	STS 51-D	67	NO	STS 61-C	58	YES

The temperature when STS 51-L (*Challenger*) was launched was 31°F.

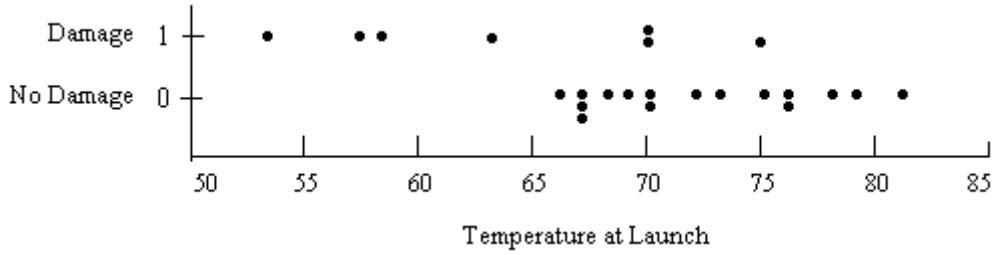

Figure18: Plot of Incidence of Booster Field Joint Damage vs. Temperature

Using the techniques of this section, we can fit a logistic model to the Challenger data. We will regroup the data by temperature into intervals of 5 degrees, using the midpoint of each interval for the independant variable. We also adjust the probabilities a bit, replacing 0 with 0.01 and 1 with 0.99, so we can take logarithms for the logit fit. Thus, we have the following data: .

Interval	(51, 55)	(56, 60)	(61, 65)	(66, 70)	(71, 75)	(76, 80)	(81, 85)
Temp	53	58	63	68	73	78	83
Prob	0.99	0.99	0.99	0.20	0.25	0.01	0.01
Logit	4.595	4.595	4.595	-1.386	-1.099	-4.595	-4.595

The graph of the transformed data with the linear fit is shown below. The linear model is $\ln\left(\frac{p}{1-p}\right) = 25.386 - 0.369\,Temp$.

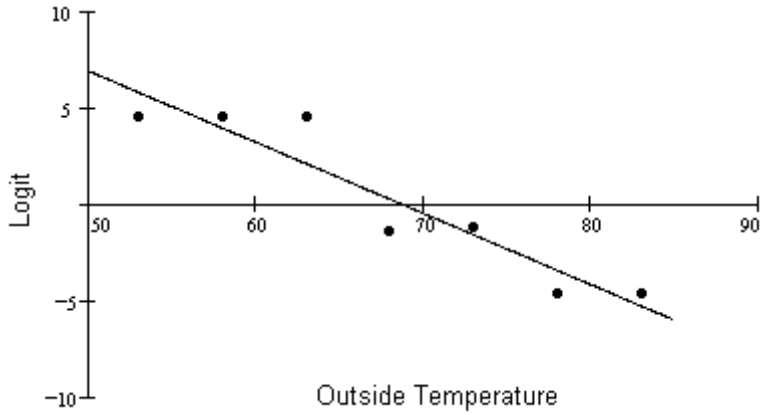

Figure 24: Logit re-expression and linear model

The logistic model is $P = \frac{e^{25.386-0.369Temp}}{1+e^{25.386-0.369Temp}}$. This graph is shown below.

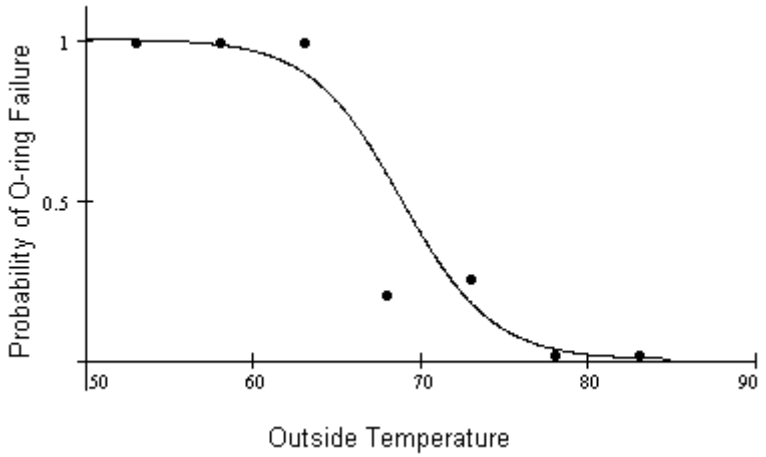

Figure 25: Logistic Model $P = \frac{e^{25.386-0.369Temp}}{1+e^{25.386-0.369Temp}}$ graphed against the data

From the model we can see that failures will occur approximately half of the time if the temperature is below 68 degrees. At 31 degrees, the probability is essentially 1 for an O-ring failure.