

## IE 361 Lab#8/ 1<sup>st</sup> Paper Helicopter Study and Process Capability

\_\_\_\_\_  
**(Name)**

In this lab, we're going to collect some "paper helicopter flight time data" for two purposes. First, we'll do this as practice with the mechanics of making, flying, and timing flights of paper helicopters, so that we can use them in upcoming labs to illustrate "experiment design and analysis" methods. Second, we'll use the data collected today in some "process capability" calculations.

Begin by making a single paper helicopter and weighting it with a single paper clip. Take the helicopter out into the hallway to measure some "drop from 6 ft times." Use the yardstick to measure up 6 ft from the floor and attach a piece of string to the wall at that height with a piece of masking tape (one of your team members may need to hold the tape in place). Extend the string out perpendicular from the wall to establish a launch location. Assign one team member to act as the timer. This person will tell the person launching the helicopter whether the string appears to be parallel to the floor, use the stopwatch, give the "5,4,3,2,1, launch" command sequence, and be responsible for announcing the flight time for each trial. Assign another team member to do the data recording.

After making a few trial runs, begin official data collection and collect  $n = 10$  consecutive drop times. Record them in the table below.

<b>Trial</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
<b>Time (sec.)</b>										
<b>Moving Range</b>	--									

1. Compute the sample mean and standard deviation of these initial values and record them below.

$$\bar{x} = \underline{\hspace{2cm}}$$

$$s = \underline{\hspace{2cm}}$$

2. Module 16/Section 4.4 of *SQAME* suggests that if we were not prepared to guarantee that launch and measurement process conditions were constant over the period of data collection here, a possible way to estimate a "short term launch and measurement"  $\sigma$  is using an average moving range. Compute the 9 moving ranges for the launch data and estimate  $\sigma$  using

$$\hat{\sigma} = \overline{MR} / 1.128$$

How does this compare to your value for  $s$  from 1?

$$\hat{\sigma} = \underline{\hspace{2cm}}$$

Now return to the classroom and make 11 additional helicopters of the same design. Write on these helicopters the serial numbers: 01,02,03,...,10,11 (each helicopter gets its own unique serial number). We're going to study the "helicopter production process."

Based on your pilot study with the single prototype helicopter, what seems like a good "target mean 6 foot drop time" for helicopters of this type? Write this value below as your mid-specification, and we will establish this value  $\pm .3$  sec as our engineering specifications for helicopter flight times.

target flight time = \_\_\_\_\_

$U$  = upper specification for flight time = target + .3 = \_\_\_\_\_

$L$  = lower specification for flight time = target - .3 = \_\_\_\_\_

Return to the hallway and (perhaps after a couple of practice drops with the original prototype to "get back in the groove") measure flight times **once each** for the 11 new helicopters. Record those in the table below.

Serial Number	01	02	03	04	05	06	07	08	09	10	11
Time (sec.)											

**Considering helicopters 01 through 10**, compute the sample mean and sample standard deviation of the flight times and record those below. (Until the 11<sup>th</sup> time is used in the last part of problem 8, we will pretend that we have only the data from these 10 cases.)

$\bar{x}$  = \_\_\_\_\_

$s$  = \_\_\_\_\_

3. After class, enter the flight times for helicopters 01 through 10 into JMP and using the Analyze Distribution routine, make a "normal plot" (a "normal quantile plot" in JMP jargon) for these data. (After choosing to analyze the column containing times, click on the red triangle on the resulting report to go to Display Options and choose a Horizontal Layout. Then again click on that red triangle and choose Normal Quantile Plot.) **Attach a printout** of your plot to this lab before turning it in. Material on making and interpreting these plots is found in Section 5.1 of *SQAME* in case you need a refresher from Stat 231. From this plot, **does it appear** that it's sensible to model your helicopter production and testing process as producing at least approximately normally distributed flight times? Explain.

4. Find 95% confidence limits for the "process capability"  $6\sigma$  of flight times (based on helicopters 01 through 10).

5. Find 95% confidence limits for the process capability ratio  $C_p$ .

6. Find 95% two-sided confidence limits for the process capability ratio  $C_{pk}$ . The so-called "Six Sigma" goal for process performance is exactly a goal of  $C_{pk} \geq 2.0$ . What do your confidence limits say about whether you are a "Six Sigma" helicopter producer?

7. Presumably, strictly speaking a  $\sigma$  associated with a capability assessment should really only include "process" or "part-to-part" variation (and not be inflated by measurement variation). In light of the sample standard deviations recorded on pages 1 and 2 of this lab, do you think "measurement noise" in flight time is negligible in this study? If it were not negligible, how would you expect it to affect your capability assessments? (Would they be unaffected, optimistic, or pessimistic?)

8. Make two-sided normal distribution 95% prediction limits for the observed helicopter 11 flight time based on those from helicopters 01 through 10. Were those limits in fact successful in bracketing the flight time for helicopter 11?

9. Make two-sided normal distribution 99% tolerance limits for 95% of all flight times produced by helicopters made by your group.