4th Down

Kick a field goal? Punt? Or risk it all and “go for it” on the 4th down? Teams rarely go for it on the 4th down, but past NFL game data and math might advise differently. Bill Burke, a sports fan and closet math enthusiast, has compiled years of NFL game data and published a study called the 4th Down Study. His hypothesis: team should go for it on the 4th down more often. His article (theory) tells coaches when to go for it, when to punt and when to kick on 4th down during normal game conditions. In this activity we will explore his theory and determine when to go for it on the 4th down.

Expected Points

To understand Bill’s theory, you first have to understand the concept of expected points. EP is the average potential points teams can expect during various game situations. When the offense will usually score next, EP is positive. If the defense will usually score next, the EP is negative. Here is the EP graph for a 1st down at each field position. These EP values are based on data from 2,400 NFL games from the 2000-2008 seasons. Only data from the 1st and 3rd quarters were used.

An important part of the expected points concept is that a first down on a team’s own 27-yard line is worth 0.7 points. We have to keep that in mind when a team scores a touchdown or field goal. Since, after a score they are returning possession to the other team, typically to the 27 yard line this affects the actual value of a TD and field goal. A TD is actually worth 7 - 0.7 points or 6.3 points and a field goal is actually worth 3 - 0.7 points or 2.3 points.
1. Give the expected points for the field positions listed in the table below. After completing the table make sure to check in with a classmate to make sure you agree on each situation.

<table>
<thead>
<tr>
<th>Distance to End Zone</th>
<th>Expected Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 yards</td>
<td></td>
</tr>
<tr>
<td>73 yards</td>
<td></td>
</tr>
<tr>
<td>20 yards</td>
<td></td>
</tr>
<tr>
<td>1 yard</td>
<td></td>
</tr>
</tbody>
</table>

2. Did any of the field positions have a negative value? If so, what does that mean?

Using the data that Bill Burke has compiled we can determine the amount of expected points for any scenario in a game. Bill has also compiled historical data punts, field goals and 4th down conversions. We can use this data to better predict what we can expect when a team kicks a field goal, punts or goes for it. This data is compiled in the three graphs below:
3. What do you notice about the relationship between distance to end zone and punt distance?

4. Lets make sure you are able to read the graph correctly. At what distance to end zone does putting distance start to level off (not increase as much)?

5. What do you notice about the relationship between line of scrimmage and field goal percentage?

6. If the line of scrimmage is at the 30-yard line about how often should we expect a field goal to be made? To be missed?
7. Make some observations in regards to the relationship between “distance to go” and conversion percent. How does field position play effect the conversion percentage?

8. Describe a team’s chances of making a first down on 4th and two (no matter the field position).

So now we that have all this real NFL game data at our fingertips we can better understand what to expect in 4th down situations. When a team decides to go for it, kick or punt, we have a clearer idea of the likelihood of what will happen and what that will result in in expected points. By putting these two things we have a better idea of our expected outcome for each situation.

**Expected Outcomes**

To understand Bill Burke’s 4th down strategy you must first understand the concept of expected outcomes. Here is a way to think about it. Below we have three spinners. Lets say you can only spin one spinner and you get to keep the amount of money that you spin. Which spinner would you choose and why?
Spinner A is a safe play. You should always expect to win 50 cents.

What should you expect to win on Spinner B? Imagine if you spun the spinner 12 times. You would expect to win $10 six times and lose $2 six times. Thus the math could break down as

\[(6 \cdot 10) + (6 \cdot -2) = 60 - 12 = 48 \text{ over 12 spins or } 48/12 = 4 \text{ per spin}.

Lets use the same method for Spinner C. In 12 spins, you would expect to win $3 nine times and lose $2 three times. The math would break down as

\[(9 \cdot 3) + (3 \cdot -2) = 27 - 6 = 21 \text{ over 12 spins is } 21/12 \text{ or a little less than 2 per spin}.

Lets look at what we did there. To find the expected outcome for each spinner we used the following formula:

\[(\text{chance of win} \cdot \text{value of win}) + (\text{chance of loss} \cdot \text{value of loss})

Expected value can be applied in 4th down situations since we know the historical chances (experimental probability) of making a 4th down conversion or of making a field goal and we know the expected value of converting a 4th down, making a field goal or punting. Bill Burke uses the following example on his website:

Let's say you're the coach of a team facing a 4th down and 3 from the opponent's 37. It's early in the second quarter and the score is tied. Should you call a punt, attempt a FG, or go for it? In reality, coaches have called for the punt 100% of the time in close games early in the second quarter. But is this the best thing to do?

Let's start with a punt. From the 37, we would expect a net punt distance of 23 yards, coming to the 14 yd line on average. The 14 yd line corresponds to -0.2 EP for the opponent, which is +0.2 EP for your team.

A FG attempt would be successful 45% of the time. A made FG would yield 2.3 EP factoring in the kickoff. A missed FG would give the ball to the opponent at his own 44. This is worth 1.1 EP to him and therefore -1.1 EP to us. The total expected point value of a field goal attempt would be:

\[(0.45 \cdot 2.3) + ((1-0.45) \cdot -1.1) = 0.4 \text{ EP}

A 4th down and 3 conversion attempt from that part of the field would be successful 56% of the time. A successful conversion would mean a 1st down at at least the opponent's 34, which is worth 3.0 EP. A failed conversion attempt gives the opponent a 1st down at his own 37, worth 1.1 EP to him and -1.1 EP to us. The total expected point value of going for it would be:

\[(0.56 \cdot 3.0) + ((1-0.56) \cdot -1.1) = 1.2 \text{ EP}
So in this example, the best decision is to go for the 1st down. In simple terms, it's worth the risk in the long run. It's not even close.

From *The 4th Down Study* by Bill Burke

**Decision Time**

Lets use Bill Burke's 4th down theory to determine what to do in some relatively common and disputed game situations. For each situation you may need to refer to any of the four graphs in this activity (Expected Points, Punt Distance, Field Goal Percentage and 4th Down Conversions) to find the expected outcomes for each situation.

9. A team has the ball on the opponent’s one-yard line. It is 4th down and goal to go (they must get to the end zone). Teams usually kick a field goal here. Find the expected outcome for kicking a field goal and for *going for it*. Mathematically, what should the team do?

10. A team has the ball on the opponent’s 10-yard line. It is 4th down and four yards to go for a first down. Find the expected outcome for kicking a field goal and for going for it. What should the team do?

11. A team has the ball on the opponent’s 25-yard line. It is 4th down with five yards to go for a first down. Find the expected outcome for kicking a field goal and for going for it. What should the team do?
12. A team has the ball on their own 40-yard line (60 yards to the end zone). It is 4\textsuperscript{th} down with one yard to go. Find the expected outcome for punting and for going for it. What should the team do?

13. Pick your own 4\textsuperscript{th} down situation. Pick a line of scrimmage and number of yards for a first down. Find the relevant expected outcomes for the situation.

Bill Burke has put this graph together that sums up what teams should do under normal game conditions. Teams should go for it on or below the line.
14. Study the graph. What surprises you? What seems different then what NFL coaches typically do?

15. Using the graph give a few scenarios that seem a bit extreme (maybe a little crazy) in which a team should go for it.

16. Check your answers for questions 7 -11. Did you come up with the same recommended option (punt, kick or go for it)]

17. After reading this graph what advice would you give NFL coaches in regards to 4th down situations?