Scouting by Numbers

by Jeremy Greenhouse

Our nationwide obsession with player evaluation went to a deeper level when Sportvision's PITCHf/x system debuted in 2006. At least it did for me—using PITCHf/x data to grade pitches has become my holy grail. We know that Roy Halladay has a great fastball, for instance, but that's because we already know that Halladay is a great pitcher. PITCHf/x data adds something else; it isolates a pitcher's process from his results. Essentially, PITCHf/x can be used to scout pitchers without ever laying eyes on them.

"Stuff" and "command" are the two most popular scouting terms in baseball ("wingspan" holds the title throughout major sports, and deservedly so), even though (because?) stuff and command remain largely undefined. On the next couple of pages, I intend to define them.

Before moving on, I should provide clearer explanations of those terms. I think of stuff as what a pitcher throws—the quality of force he exerts on the ball. In particular, that means spin and speed. Thanks to PITCHf/x, we can measure those.

Command is where he throws. You can't really fake "stuff," but command is harder to pin down. A pitcher can miss his spot and get the call, or he can locate perfectly and get hammered. So the options are to look at the location of every pitch in isolation or to attempt to divine a pitcher's intent given the situation. I'm going to give both of those approaches a try.

The goal is to objectively grade stuff and command. First, we need the data.

Pulling the Data Together

I took the data of more than two million pitches since 2007. Not only the usual data—pitcher/batter matchup, ball/strike count, pitch result—but also the advanced PITCHf/x data—velocity, movement, location at release and location crossing the plate. Still, I had to assign three additional values of my own to each pitch.

First and foremost I gave each pitch a value based on its result. In February 2008, Joe P. Sheehan and John Walsh developed a "run value" framework for individual pitches, and now FanGraphs carries that data for all major league pitchers.

Here's the concept: The average major league batter hit .258/.326/.404 in 2010. If he got to a 1-0 count, he went on to hit .273/.388/.437, but if he fell to 0-1, that fell to .229/.270/.349. By converting those lines to runs, we can estimate that throwing a first-pitch strike decreases run expectancy by a bit over 0.04 runs, while throwing a ball costs a pitcher a bit less than 0.04. In addition, if a home run nets 1.4 runs on average, then allowing a home run on an 0-1 count is equivalent to allowing 1.44 runs, compared to allowing 1.36 runs on a 1-0 count. And so on.

Secondly, I classified each pitch into types. I predetermined the number of pitches in a pitcher's arsenal, and then I used a clustering algorithm to assign pitch types based on velocity and movement. There are eight main pitch types: four-seam fastball, two-seam fastball, cut fastball, slider, split finger, changeup, curveball, knuckleball.

Third and finally, I scaled each pitch's vertical location. PITCHf/x reports the height of the pitch relative to the ground, which isn't as useful as knowing how the pitch's height relates to the batter's strike zone. The batter's listed height generally gives a good idea of his strike zone. The bottom of the strike zone can be drawn at a quarter of his height, and the top at 56 percent. In addition, stringers who work at each game mark the borders of what they perceive to be the boundaries of each batter's strike zone. That data becomes useful given a full season of at-bats for a batter.

Measuring Stuff

I began this line of thinking back in 2008 as I was being introduced to sabermetrics. Here's a snippet of an e-mail I sent that August to Josh Kalk, a PITCHf/x pioneer and former THT writer.

> *I have a question concerning fastball "rise." You hear anecdotally that a straight fastball is a bad thing, which I take to mean that a fastball with average "rise" will remain flat and be drilled. Some fastballs have been criticized for not having as much absolute vertical movement as the league average, but doesn't this just mean that they have more "sink"? My guess would be that as long as a pitcher has a difference of rise or sink a couple of inches from the mean, it may fool the batter.*

I think I've finally found a solution to my question. There's really no such thing as "more" movement, since movement is a vector quantity. Movement is described by both magnitude and direction. In turn, when we talk about pitch velocity, we actually mean speed, which is scalar, since direction has no bearing.

We need to think of movement from the ball's point of view and not the batter's. Most pitches are thrown from off-center, so for the ball to move perpendicularly to the batter's swing plane as it crosses the plate, it would have to have tailed after it left the pitcher's hand. Hideki Okajima is virtually the only pitcher who throws from such an over-the-top arm angle that would allow a straight pitch to travel parallel on the pitcher-batter plane.

Let's try an exercise. The average fastball runs 91 miles per hour with six inches of horizontal movement and eight inches of vertical movement (as compared to a theoretically spinless pitch). Fastballs can move up and down, side to side, or somewhere in between. A pitch that has more upward vertical movement than average is called a rising fastball. The rising fastball has long stood as a baseball myth, since rise is a misnomer. It is physically impossible for a human to put enough backspin on a pitch for it to defy gravity. But people naturally throw baseballs with some backspin (eight inches of vertical movement), so we call that resulting movement "rise". Even sinking fastballs generally "rise" a bit in that sense, just not more than eight inches.

A tailing fastball runs more than half a foot back toward the pitcher's arm side. Finally, a cut fastball continues to move across a pitcher's body after he releases the ball, causing it to only move a couple inches horizontally. To generate rise or sink or tail or cut, pitchers try to hold the ball off-center or find a special grip.

The worst type of fastball is one that has no special movement. The only way to describe such a fastball is "average," because it falls directly in between all other fastballs. Therefore, a fastball with average movement—six inches of tail and eight inches of rise—is actually a substandard pitch.

To prove this, I took all fastballs with average velocity, average horizontal movement, and average vertical movement, and put them in a bucket. I also made buckets of similar average fastballs, holding two of the components constant while adjusting the third. Here is how each bucket ranks according to run value, and an example of a pitcher who throws such a fastball.

Rank	Trait	Example
1	Cut	Yovanni Gallardo
2	Rise	Johan Santana
3	Fast	Clay Buchholz
4	Tail	Trevor Cahill
5	Sink	Mike Pelfrey
6	Average	Carl Pavano
7	Slow	John Lannan

As you can see, the only way to make a fastball with average movement worse is by decreasing velocity. Any type of movement that deviates from the norm is beneficial.

Grouping similar pitches into buckets is called binning. A more sophisticated and efficient type of statistic is regression analysis. Because there's no linear relationship between run value and movement—again, the nature of movement being a vector quantity—I used local regression instead of a linear one. Local regression fits models on localized subsets of data to build up a function that describes the entire data set. Essentially, local regression creates all of the buckets necessary that would be used in binning, but it smooths them out, adding precision along the way.

But stuff ain't that simple. Left-handed pitchers in general don't throw as hard as right-handed pitchers, since being left-handed is an advantage in itself. If southpaws don't have to throw as hard as righties to achieve the same levels of success, then perhaps that shouldn't be held against them in a measure of stuff. The same tenet holds true for sidearmers and submariners.

Therefore, I made a second computation splitting left-handed pitchers and right-handed pitchers and also including arm angle as a variable. In addition, some pitches, like the sweeping slider, are filthy against same-handed batters, but to opposite-handed batters, they're eminently hittable. In my final calculation I split the data up by same-handed matchups and opposite-handed matchups to adjust for the platoon advantage that exists in some types of pitches.

Measuring Location

Ever since I played Ken Griffey Baseball, I've loved the idea of batters having hot and cold zones. Dave Allen wrote an article in the Annual last year in which he graphed "heat maps"—the value of a pitch based on its location. I was looking at one of those heat maps and thought, Well, why not give each pitch that value? What I mean by that is that if a pitcher can hit that spot, then who cares about the result? He did his job, and just as a pitcher has no control over his defense, he also can't control the hitter. Again, using local regression, I predicted run values depending on the location of each pitch while controlling for the count, the pitch type, and the batter/pitcher handedness combination.

Still, a down-and-away fastball might be a bad pitch if it was meant to be thrown up and in. Fortunately, pitchers are creatures of habit. They repeat their delivery, their arm speed, their pitch grips, and more often than not, their intended locations. For every pitcher, I grouped all of his pitches based on the pitch type, the count, and the batter handedness. Then I measured the standard deviation in pitch locations. (Doing this gives us insight into the types of pitches that might be

easiest to command. Curveballs and splitters have the largest spreads, while fastballs are the tightest.)

The resulting numbers from these analyses were expressed as runs and inches, which are meaningless to most people, so I'm not going to report those. Instead, I decided to put the numbers on the 20-80 scouting scale. What I did was Z-Score the values so that 50 was average, 60 was one standard deviation above the mean, and 20 was Daniel Cabrera. With that, I can at last turn to scoutspeak.

The Best Stuff on Earth

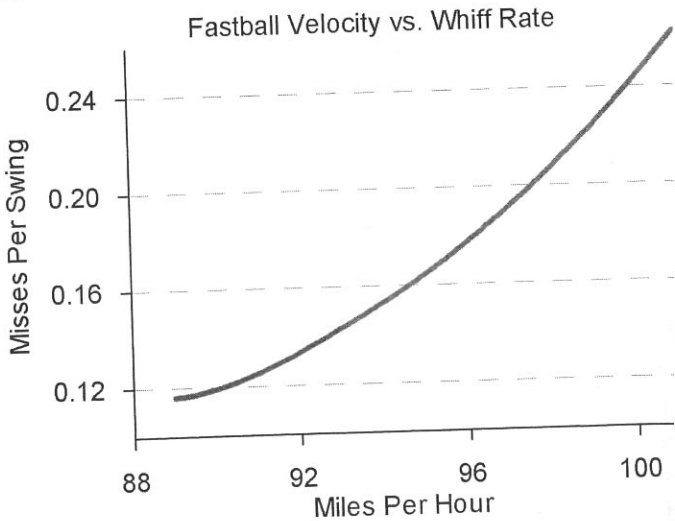
Here is a list of the 20 pitchers with the best stuff in the majors—the top ten score 80s in my system.

Best Stuff
Aroldis Chapman
Joel Zumaya
Daniel Bard
Matt Thornton
Henry Rodriguez
Jordan Walden
Kevin Jepsen
Stephen Strasburg
Jason Motte
Ryan Webb
Greg Holland
Jenrry Mejia
Neftali Feliz
Andrew Bailey
Brian Wilson
Evan Meek
Ronald Belisario
Brandon League
Billy Wagner
Chris Sale

Their stuff is *tripleplusgood*. The list more or less reads as a velocity leaderboard for the 2010 season. I touched on what makes an effective fastball earlier, but just to illustrate the importance of fastball velocity, I graphed the whiff rate of all fastballs by their velocity at the top of the next column. As you can see, the faster the fastball, the more unhittable it is.

A Star is Born

Strasburg is the only starter to score an 80 in stuff. He hits 98 mph with his four-seamer, while achieving plus command. His two-seamer at 97 mph has good life. His curveball is a visual marvel; baseballs aren't supposed to



bend that way. Candy Cummings would have accused Stras burg of sorcery.

And it's tough to call a changeup "nasty," since changeup tend to rely on deception. But his 90-mph changeup actu ally has negative vertical movement! That means the pitc is thrown with topspin, making it most physically simil to a Brandon Webb or Chad Qualls sinker, and there's r other off-speed pitch like it. Half the time a batter swung Strasburg's change, he whiffed.

I'm not saying that Strasburg could have scrapped one his four pitches and still have been one of the best pitchers the game. I'm saying he could have scrapped two.

Chapmania

Before September 2010, no left-handed pitcher in t PITCHf/x era could say with confidence that he had ev thrown 100 miles per hour. Sure, David Price, Billy Wagn and Matt Thornton throw hard, and Chris Sale came throwing gas. Randy Johnson used to hit triple-digits in prime, but that was back when radar guns were the unst dardized standard. But Aroldis Chapman is playing a diff ent game.

On Sept. 24, he hit 105 mph: The Fastest Pitch E Thrown. And his average fastball is four standard dev tions above the mean for southpaws. I wouldn't even comfortable using a 20-80 scouting scale on Chapm heat.

The Chad Bradford All-Stars

LOOGY, short for Left-Handed One Out Guy, is a fa ite acronym among seamheads. But what good is an a nym without an accompanying metric? I compared the s numbers on same-handed matchups to those on oppo handed matchups to come up with expected platoon sp Submariner Chad Bradford retired this year, but he was

perfect example, a pitcher whose stuff graded out as an 80 against righties and a 20 against lefties.

Left-handed relievers Joe Thatcher and Randy Choate jump out as the most obvious LOOGY candidates, while Brad Ziegler, Joe Smith, Darren O'Day, Justin Masterson and Fausto Carmona all have huge expected platoon splits, too. Masterson and Carmona are the only ones not currently in the 'pen. Their sinker-slider repertoires are neutralized by lefties.

The Best Location on Earth

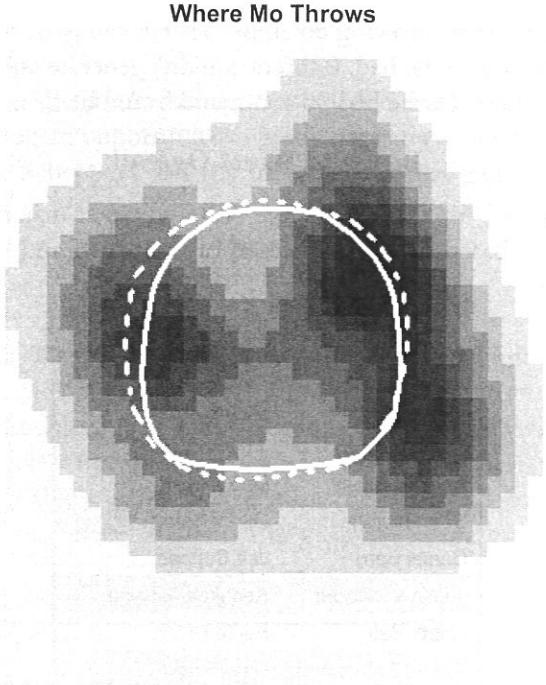
Command is harder to nail down than stuff. Nobody rated 80 on command, though Carl Pavano, Mark Buehrle, Cliff Lee, Andy Pettitte and Wilton Lopez were at least 65s this year. Going back a couple of years, Mike Mussina, Curt Schilling and Greg Maddux topped the leaderboards.

Here's the current pitcher top 20:

Location
Carl Pavano
Mark Buehrle
Cliff Lee
Andy Pettitte
Wilton Lopez
Joel Peralta
Roy Halladay
Jered Weaver
Rafael Betancourt
Shaun Marcum
Kevin Slowey
Jason Vargas
Koji Uehara
Matt Belisle
Josh Johnson
Edward Mujica
Zack Greinke
Ricky Nolasco
Dan Haren
Matt Capps

All of those guys have (and had) great command, but to give you an idea of one issue in my rankings, Mariano Rivera, who unquestionably has the best command I've ever seen, scores only a 60. Mo is to command what Chapman is to velocity. In the same way that batters must choose whether to sit on a Chapman fastball or slider, they have to choose which half of the plate to concede against Mo. A picture of his 2010 pitch locations tells the story.

Where Mo Throws



The darker points represent locations of higher frequency. The solid white line represents the league's strike zone, while the dashed line represents Mo's.

There are two flaws evident that reveal why my numbers underrate Rivera. First, he is able to expand the strike zone. Pitches on the corners are more valuable for Mo than pitches on the corners for anyone else, so comparing Mo's cutter locations to the league's averages undervalues him.

Secondly, it doesn't make sense to measure the overall variance in Mo's pitch locations since he obviously targets two distinct zones. Not many pitchers make it as clear as Rivera, but I can name a few other pitchers with outstanding "bimodal distributions." Jamie Moyer, David Huff, and Shaun Marcum locate their fastballs to both sides of the plate exceptionally well.

90>95?

Arm speed is not easily taught. So how can a pitcher compensate for a 5 mph difference in pure velocity via other means?

I found that pitchers cannot survive throwing 90 mph fastballs up in the zone. Their only recourse is to stay low and away. Ninety-five mph fastballs can thrive up and in, yet down and away, they are rendered no more effective than 90 mph fastballs. Furthermore, a 90 mph fastball with about half a foot of movement away from average is equivalent to a 95 mph straight fastball.

David Robertson and Joakim Soria are two guys who hit 90 mph regularly but have fastballs with electric movement.

And although he didn't pitch this year, Daniel Cabrera is the poster-boy for throwing an empty 95. He had good velocity, but that was all he had. Cabrera couldn't generate any movement, and saying he had 30 command would be generous.

Best and Worst Overall

Here are top 20 lists for the best and worst major league pitchers, based on a combination of their stuff and location scores:

Overall Best	Overall Worst
Matt Thornton	Dontrelle Willis
Josh Johnson	J.C. Romero
Andrew Bailey	Dan Meyer
Sean Marshall	Oliver Perez
Daniel Bard	Jeff Suppan
Justin Verlander	Kenekoa Teixeira
Heath Bell	Fu-Te Ni
Rafael Betancourt	David Riske
Mariano Rivera	Sean White
Grant Balfour	Jason Marquis
Joe Thatcher	John Maine
David Price	Will Ohman
Felix Hernandez	Francisco Rodriguez
Mat Latos	Billy Buckner
Joaquin Benoit	Scot Shields
Zack Greinke	Matt Palmer
Brian Wilson	Greg Smith
R.A. Dickey	Bob Howry
Bobby Parnell	Mike Ekstrom
Casey Janssen	Andrew Miller

Things Change

Over the course of an offseason, arms can improve or deteriorate. Many thought that Francisco Liriano's knockout slider was lost after he underwent Tommy John surgery in 2006, but his slider returned to Brett Anderson levels of awesomeness this year.

Likewise, Tim Hudson, after recovering from injury, restored his fastball to 2007 levels. Hudson picked up the 1 mph that he had dropped over the 2008 and 2009 seasons, plus he added an inch of sink. His slider was also breaking across the plate by a couple more inches.

Other than recovering from injury, the easiest way to gain velocity is by going to the bullpen, where most pitchers add about 1 mph to their fastballs. Joba Chamberlain isn't like most pitchers. He lit the world aflame by throwing 97 mph as a late-season call-up by the Yankees in 2007. The next year, having established himself as the team's setup man, he settled in at 95, still throwing a plus fastball. But he was moved to the rotation in 2009 where his velocity fell under 93, a precipitous decline. It bounced back to near-2008 levels when he made his return to the pen in 2010.

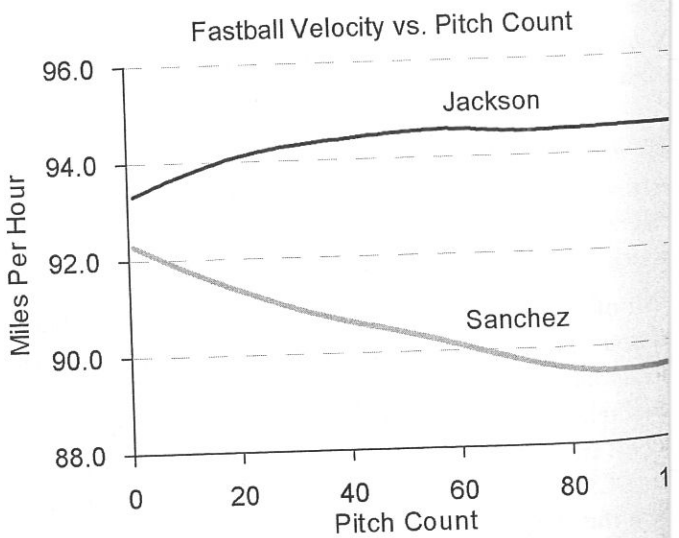
Finally, altering a pitch grip can do wonders. Roy Halladay changed his changeup from a straight change to a split-finger grip, and as a result, he added five extra inches of tumble. Batters are whiffing three times as often when they swing against Halladay's off-speed pitch as they did last year.

On the other hand, a couple of Dodgers who had 80 stuff a year ago fell to mere 75s this year. Although they still struck out more than a batter per inning, Jonathon Broxton and Clayton Kershaw saw their velocity diminish substantially. Kershaw gained fame through his curveball, which Vin Scully dubbed "public enemy No. 1," but Kershaw has wisely moved away from that pitch and gone to a dynamite slider. His slider is 10 percent faster than his curve, which means that it has less time in the air to move. Still, Kershaw's slider breaks more than his curve horizontally. His curve isn't a bad pitch, but his slider has crazy movement.

Fellow former phenom Tim Lincecum continued his downward descent in fastball velocity—he threw 94 mph when he came up but now throws 91.

Endurance

Pitchers can be compared from year to year, game to game, or better yet, within games. Who maintains their stuff throughout a game and who loses steam? Edwin Jackson and Jonathan Sanchez fastballs start out the game within a mile per hour of each other, but finish with a gap of 5 mph.



Justin Verlander and CC Sabathia can also push themselves to another level, whereas Zach Duke and James Shields have lesser stamina.

Rookies with the Stuff

Scouts are most useful in reporting on amateurs and minor leaguers, since there's no PITCHf/x data available at those levels. But with regard to rookies, PITCHf/x numbers stabilize quickly enough to draw some conclusions about them. We already know about Strasburg and Chapman, but there are other young rookies to discuss.

At the same time that Strasburg came up, Drew Storen burst upon the scene. Storen's slurve is the pitch most similar to Strasburg's curve, but he nonetheless prefers to throw a tighter slider. Jeremy Hellickson flashed great command, especially of his changeup. Jenrry Mejia's fastball grades out as an 80. It is not unlike Mariano Rivera's cutter, although the edge in velocity Mejia has on Rivera is insignificant compared to the difference in their command.

Also, PITCHf/x data was recorded at the Futures Game, providing an opportunity to grade the game's top prospects. Tanner Scheppers had the best stuff in that game, and he profiles as an A.J. Burnett 2.0 with an awesome fastball and curve.

What's to Come

2010: The Year of the Pitcher. We may never know what caused runs per game to fall from 5.14 in 2000 to 4.38 this year (though Steve Treder has some good observations in his article). But with another decade of PITCHf/x data, we'll be able to directly compare the stuff and command of pitchers from 2020 to the guys we so love watching today.

Postscript: What can Catchers' Gloves Tell?

by Nick Steiner

Measuring a pitcher's skill locating the ball is a dream of PITCHf/x analysts. The trouble is that we can't deduce a pitcher's intent from the data—we can only guess at it. As great as PITCHf/x data is, they do not tell us anything about the pitcher's intended location.

So, until the day Sportvision creates "MINDf/x," we're going to have to find alternate ways of guessing the pitcher's intent. Jeremy Greenhouse has taken a good stab in the "Scouting by Numbers" chapter, but I had another idea. We can see the position of the catcher's glove before the pitch is thrown, right? Aren't pitchers supposed to hit the catcher's glove as nearly as possible? Is it possible to measure this?

As far as I know, there are no such data available, so I decided to get it myself. I watched every pitch thrown in a Cardinals vs. Mets game on April 16 this year, choosing this particular game because it featured one great starting pitcher (Chris Carpenter) and one not-great one (Oliver Perez). Watching two such different pitchers gave me a diverse set of pitches to measure.

Also, as an unabashed Cardinals fanboy, I'm proud to say that the camera angle for St. Louis home games is perfectly dead-center, eliminating any parallax issues.

I experimented with different ways of measuring glove location. First, I entertained the idea of precisely measuring the exact location with a ruler or something, but I quickly found out this would be impractical due to the time constraints and the fact that the position of the camera often changed between innings. After watching several innings, I realized that there were really only a few distinct places where the catcher set up—five places across the horizontal, and four across the vertical.

Obviously, some of the pitches required a judgment call as to which "catcher glove bin" they fell into, but overall it was pretty easy to mark where the catcher was setting up.

There were 281 pitches thrown in the game, and I felt comfortable charting the catcher's glove in 271 of them. The pitches were thrown by eight different pitchers, each with a pretty distinct repertoire. Before we try to measure each of pitcher's command, let's look at how the two catchers, Yadier Molina and Rod Barajas, called the pitches. Below is the percentage of pitches out of the total that each catcher called in each bin (from the perspective of the pitcher):

Yadier Molina	Left	CenterL	Center	CenterR	Right
Letters	0.00	0.00	0.00	0.00	0.00
Waist	0.01	0.02	0.02	0.01	0.00
Knees	0.07	0.33	0.15	0.21	0.11
Below Knees	0.01	0.02	0.01	0.02	0.01

Rod Barajas	Left	CenterL	Center	CenterR	Right
Letters	0.00	0.00	0.01	0.01	0.00
Waist	0.00	0.01	0.01	0.09	0.02
Knees	0.01	0.20	0.13	0.25	0.04
Below Knees	0.01	0.08	0.04	0.07	0.00