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[The Red Effect, in People and Monkeys]

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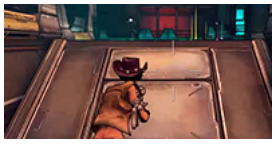
    - 

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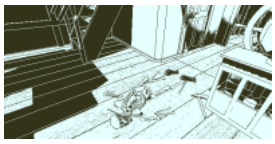
    - 

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  - **Playbook**
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  - **Underwire**
    - 

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    - 

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  - **Business**

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  - **Danger Room**

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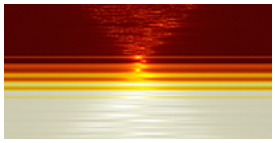

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  - [Design]

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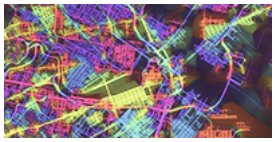

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  - [Raw File]

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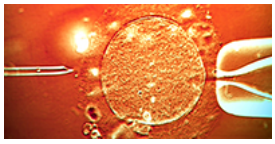
  - **Opinion**
    - 

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      Gamergate Goons Can Scream All They Want, But They Can't Stop Progress
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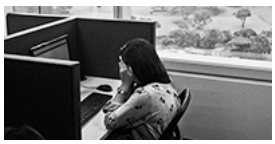
    - 

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As a kid, Kirk Goldsberry was a rabid basketball fan. But this was the 1980s, and living near Penn State meant his house wasn't quite close enough to Philadelphia to get

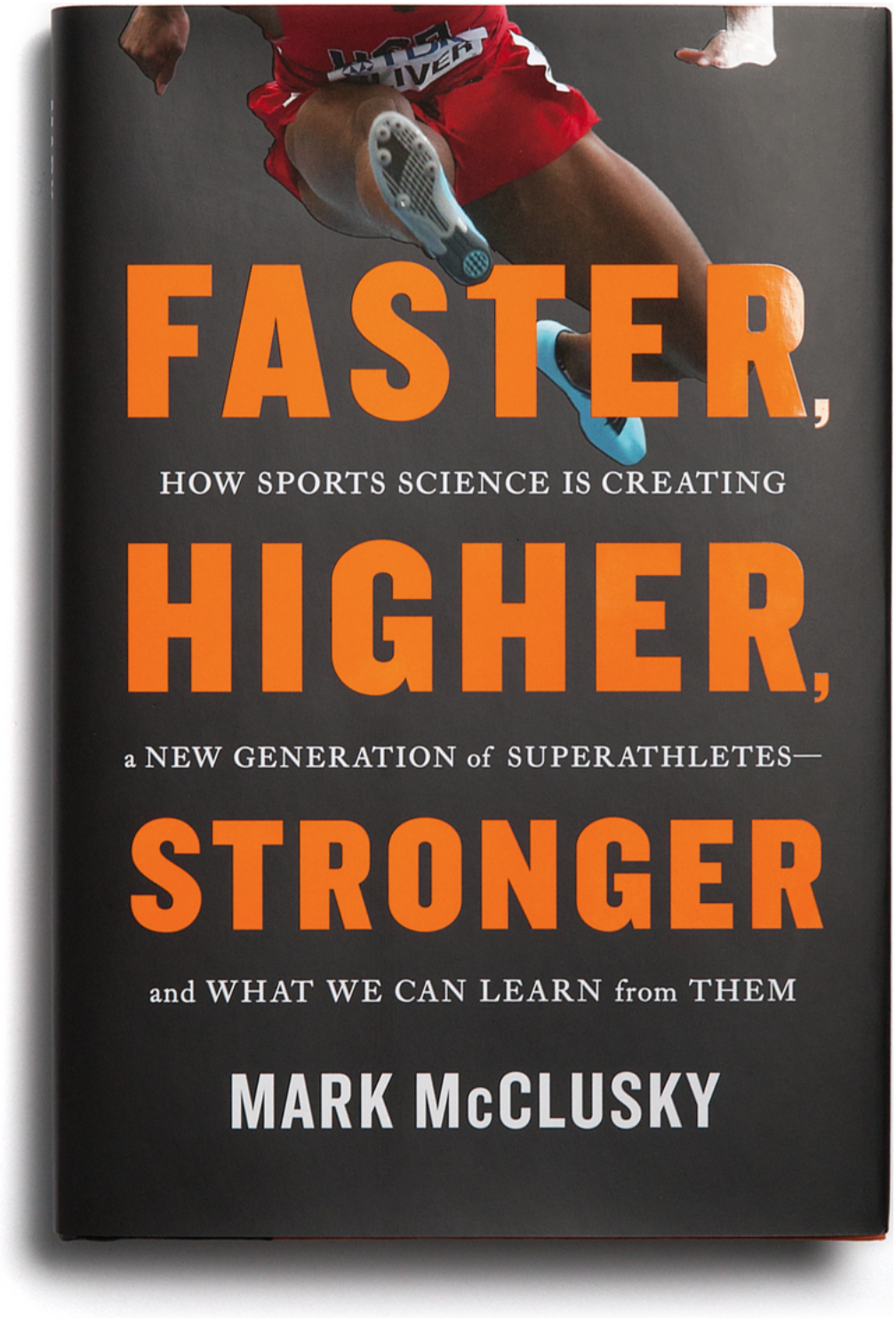
76ers games on TV. And so, casting about for a team, he latched on to Dominique Wilkins and the Atlanta Hawks. They were 750 miles away, but through the magic of superstation TBS, Goldsberry could follow them as if he himself hailed from Georgia.

Goldsberry went on to get his bachelor's degree in earth science and geography at Penn State, and then a master's and PhD in geography from UC Santa Barbara, where he wrote his dissertation on real-time traffic maps of the Internet. He was interested in finding ways to visually depict data about movement through space and time—to make numbers visible. Maps and space defined how Goldsberry processed the world. Well, maps, space, and basketball.

Kirk Goldsberry Jeff Wilson

All through his education, Goldsberry didn't just watch basketball; he played it too—recreationally, in pickup games. And as he played, he started to think about the game and how it differed from other sports. Analytics—breaking down play and performance with statistics—was starting to supplement more traditional coaching and evaluation methods like watching videotape and working on physical fundamentals.

That revolution had begun in baseball—as Michael Lewis documented in his book *Moneyball*. But baseball is, relatively speaking, a pretty simple game from a statistical perspective. It centers on a clean sequence of one-on-one confrontations between a batter and a pitcher, and each play has a defined start and end point. (A statistician would call each of those plays a "state.") Given that, and the wealth of play-by-play data available to researchers, you can do the math on any given situation in a game to predict the odds of the next event. If a team has a runner on first base with one out, there's a 28 percent chance that team will score in that inning. And so on.



Excerpted from Faster, Higher, Stronger: How Sports Science is Creating a New Generation of Superathletes—and What We Can Learn From Them by Mark McClusky. Josh Valcarcel

But Goldsberry realized that moneyball didn't work on a basketball court. Unlike the static, state-to-state action in baseball, basketball is a constant flow. Players switch from offense to defense, from posting up to double-teaming. If a baseball player is a left fielder, you know the basic area he will patrol on defense. If a basketball player is a forward, he could be anywhere on the court at any time. The game has no states, so statistically you can't determine the odds of a given outcome. Analysts thought that calculating the value of individual events the way they could in baseball was basically impossible.

In other words, basketball was like one of Goldsberry's maps—a complicated, intertwining flow of information without a beginning or end. But that didn't mean it couldn't be analyzed. On the contrary, Goldsberry realized, he just needed the right kind of data. “From my own experiences as a player, I know that I have strengths and weaknesses that vary depending on where I am on the court, and I guessed that other players did as well,” he says. Instead of focusing on the numbers that defined a state in baseball, Goldsberry began to focus on the locations and movement of objects—specifically, the players and the ball. It was a mapping problem. From that perspective, and with the help of some massive new data sets, he could do more than merely quantify what people thought they knew about the game. He could discover hidden truths about hoops, shining light into dark corners that no one even knew were corners. To understand baseball, you might need a statistician who can understand percentage and probability. But to understand basketball, you also have to understand space. You need a cartographer. Specifically, you need Kirk Goldsberry.

In 2011, when he had some spare time off from his teaching gigs at Michigan State and Harvard, Goldsberry began building his mapping system. But getting the relevant

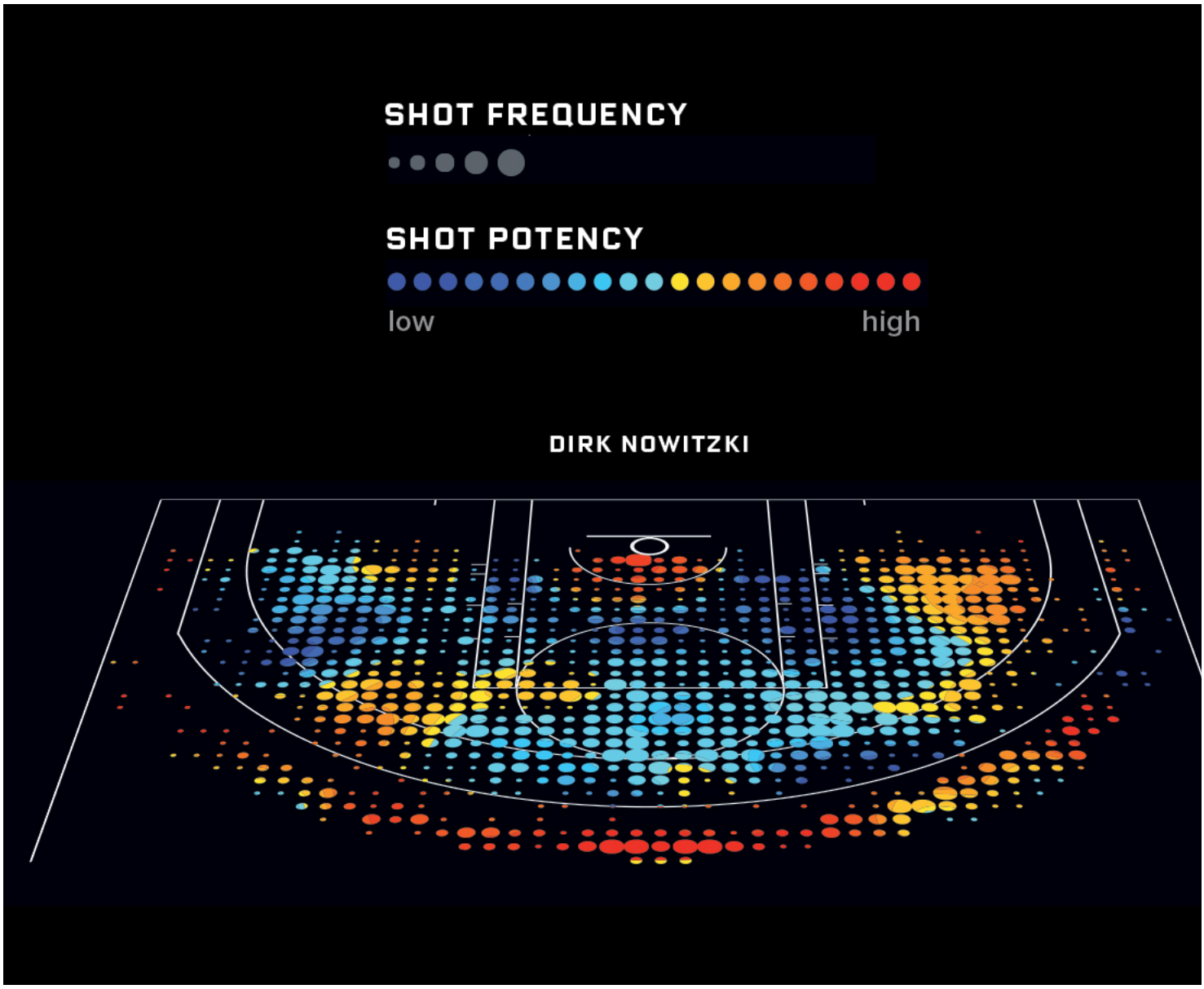
data turned out to be an obstacle. Tracking 10 players in constant motion isn't trivial. He started scouring fan sites and sports coverage, and eventually he found stats for every shot taken in the NBA. It wasn't much—just who took the shot, from where, and whether it went in. But it was a start.

The data wasn't exactly private, but neither was it public—Goldsberry scraped it from the web. Specifically, he found that ESPN.com published shot charts with the box score of each game. He found the files that powered them and grabbed their information. “They were publishing these data sets but not using them to the potential that I saw in them,” Goldsberry says.

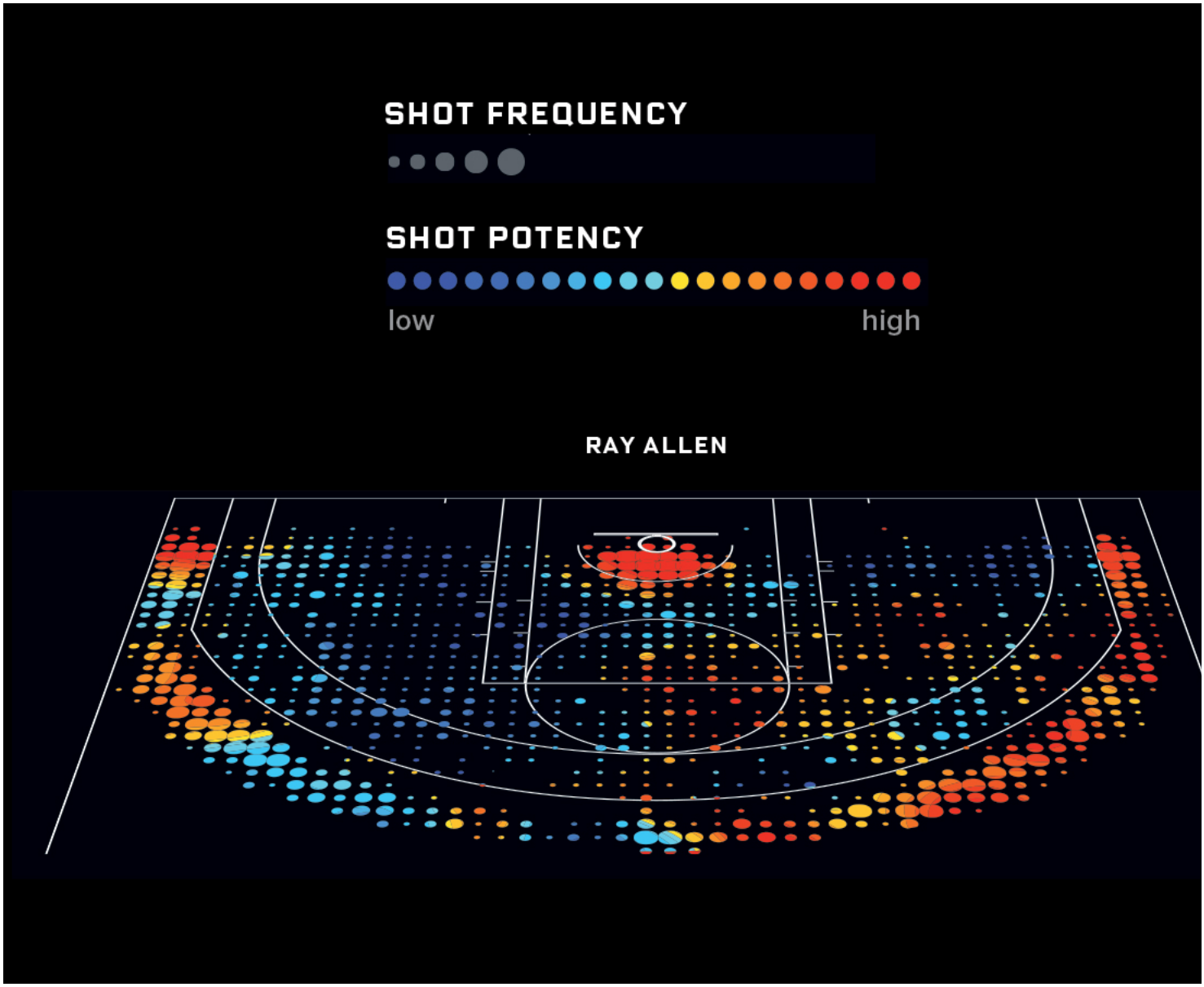
Eventually he pulled together a database with the spatial coordinates for every shot taken from 2006 to 2011—more than 700,000 of them. Then Goldsberry the cartographer teamed up with Goldsberry the hoops junkie. “I wanted to find a way to get this data to sing a new song, to tell us things like where Kobe is good and where Kobe is bad,” he says. And he wanted to do more than just crunch numbers. Goldsberry wanted to *show* people, “to communicate to players, and fans, and the media.”

Shots From Around The World

By charting the location and frequency of every shot in the NBA, Kirk Goldsberry can create a map of the strengths and weaknesses of each player’s offensive game. Here are the shot maps for two likely Hall of Famers, Ray Allen and Dirk Nowitzki.



Midrange shots aren’t very productive for most players—except Nowitzki, who loves the right baseline. Clever Franke



Even the most prolific three-point shooter of all time has relatively weak areas, like from the left wing. Clever Franke

He divided the 1,284 square feet of the court where players actually shoot—basically from just outside the three-point line and closer—into cells, like in a computer strategy game. Then he used his scraped data to generate maps that showed where a given player shot from, how often, and how effective those shots were.

Goldsberry called his system CourtVision, and it showed differences in players no one had ever quantified. Ray Allen, one of the NBA's best shooters, had several deadly hot zones from three-point range, and he barely attempted any midrange jumpers. Kobe Bryant, the Los Angeles Lakers' dynamic star, took lots of shots from all over the court, but there were places that, if you were playing against him, you'd prefer he shoot from (like the baseline, because he struggled to convert from there). Goldsberry had generated nothing less than an instant visual signature of a player's offensive game, easy to read and understand. This went way beyond what a smart analyst or coach might intuit from courtside. The more you studied the CourtVision maps, the more insights they revealed.

Goldsberry presented his work at the 2012 Sloan Sports Analytics Conference, an annual gathering of statisticians and coaches at MIT, and the basketball world basically freaked out. For the first time, fans could see the types of shots that their favorite players took, and the relative value of those shots. CourtVision didn't take into account variables like who the defender was or what else was happening on the court, but it still promised to give team management a powerful tool to evaluate players, to make sure that they were efficient and that their style fit in with a team's philosophy. After the talk Mark Cuban, owner of the Dallas Mavericks, and R. C. Buford, general manager of the San Antonio Spurs, both came up to Goldsberry wanting to hear more. As he put it: "It was sort of a moment of 'Oh my God, if I do this right, I might be able to go turn this into something that's bigger than just a thing I do on nights and weekends.'"

One of the people intrigued by Goldsberry's work was Brian Kopp, then an executive at Stats, located just outside of Chicago. A group of baseball researchers started Stats in the 1980s to gather the best statistical information they could about the game. Now the company is a behemoth, providing statistical information about professional sports in the US to teams, leagues, and the media. In 2012, Stats was working on basketball too—messing around with a new kind of data-gathering it called SportVU. Shortly after that 2012 presentation at the Sloan conference, Kopp called Goldsberry and asked if he would be interested in taking a look.

SportVU builds on computer-controlled optical technology developed by Israeli scientists to track missiles. In 2005 the Israelis adapted it to sports, mounting three cameras above a soccer pitch to watch the game and feed data to a central computer. Thanks to parallax and other computer-vision trickery, the system could track every object on the field, from the players to the ball to the officials, and plot them in three dimensions, 25 times a second. In 2008 Stats bought SportVU with an eye toward developing a six-camera setup for basketball.

The gear wasn't cheap—any NBA team that wanted this information had to pay roughly $100,000 for the installation of the cameras and computers in its arena. By the end of the 2012–2013 season, only 15 teams had done so, and the data had huge gaps—only about half the games were captured. But the data that was there looked like it

had a lot of potential. In September 2013, the NBA signed an agreement to install the system in every arena in the league.

“Brian called me and was basically like, ‘Do you want to play with this data?’” Goldsberry says. “I had the good fortune to get access when very few people outside of the NBA had seen it.” It was a jackpot, a gold mine, far more granular than the data he scraped from ESPN.com, providing a complete narrative of every possession, where and how players moved to produce the final shot. Once he had that, he could answer all sorts of questions. Want to know how far a player ran during a game? No sweat. Wondering who the most efficient passer is on your team? Easy. How does your pick-and-roll efficiency compare with the league average when you start the move with less than 15 seconds left on the shot clock? SportVU could answer that too.

But one thing that really got Goldsberry frothing was the ability to understand one of the most vexing aspects of the sport: defense. For decades, teams had relied on simple counting stats—how many steals, how many blocks—to capture a player's defensive value. SportVU gave a much more sophisticated picture. Now Goldsberry could find, objectively, the best way to play defense against a pick-and-roll, or which players were especially good at getting into passing lanes to disrupt the offense.

A year after his first Sloan conference presentation, Goldsberry went back to MIT armed with the SportVU data and a new perspective on defense. This time the room was packed—with not just his fellow researchers but also executives from around the NBA.

Goldsberry started by observing that the area right around the basket is the most important real estate on the court to defend. It's the region where offensive players sink the most shots. So Goldsberry looked at how defenders within 5 feet of the basket were able to prevent opponents from scoring. The average NBA defender allowed a shooting percentage of 49.7 in those close quarters.

He identified two classes of defense. In the first type, defenders blocked or altered their opponents' shots—that is, they reduced “shooting efficiency.” By this metric, Indiana Pacers center Roy Hibbert and Milwaukee Bucks center Larry Sanders were stars, holding opponents to just 38 percent. On the flip side, Luis Scola, then of the Houston Rockets and later the Phoenix Suns, and David Lee, of the Golden State Warriors, were defensive disasters, allowing shooters to make 62 and 61 percent of their shots, respectively. That was interesting but perhaps not particularly shocking. It was, in a sense, the flip side of the data on offense he'd presented the year before.

The second approach to defense was more subtle, and more of a surprise. Some players, it turned out, reduced the *frequency* of their opponents' shots, not just the efficiency. This was something only Goldsberry's data could show: By comparing the average rate of shots to the rate when specific defenders were guarding the area, Goldsberry could calculate when the number of shots tailed off. The lead shot-dampener was Dwight Howard, who caused teams to shoot 9 percent less often around the basket. Goldsberry called this the Dwight Effect—it was the name of his talk, actually. When Howard was protecting the hoop, Goldsberry said, his opponents took fewer close-range shots and settled for many more from the midrange—the least productive shots in the NBA.

One NBA executive in the crowd at Goldsberry's talk was Daryl Morey. Morey is the general manager of the Houston Rockets, where he's turned the organization into one of the most forward-thinking in the league, investing a great deal of time and energy in analytics and sports science. He's also an alum of the Sloan School and cofounded the event; he's still a cochair. Maybe it's a coincidence. Maybe it's not. But it's worth noting that four months after watching Kirk Goldsberry's demonstration, Morey signed Dwight Howard to a massive contract.

Every conversation about the use of statistical analysis in sports returns, as if drawn by its inescapable gravity, to *Moneyball*. Part of that is because it's such a terrific book, and its hero, general manager Billy Beane of the Oakland A's, is such a great character. And partly it's that Michael Lewis' storytelling prowess made it easier to understand the stats. *Moneyball* was the story that explained the concept of sports analytics to a mainstream audience.

And yet the statistics that underlie the moneyball effect were not new to Beane. From early researchers like F. C. Lane in the 1910s to Allan Roth in the 1940s to Earnshaw Cook and his landmark book, *Percentage Baseball*, in 1964, the game had long had a small but strong tradition of analysis. And starting in the mid-1970s, a former security guard at a pork and beans factory codified knowledge of the game in his self-published *Bill James Baseball Abstract*.

Beane's talent, then, wasn't statistical but operational. He was able to build, for the first time, an organization that capitalized on long-standing and well-known statistical information. That's to say, the competitive advantage didn't come from a novel theory of the game; it came from being able to act on it.

Now, as new technologies start to generate terabytes of data about players and tactics, that next great competitive advantage will go to the number crunchers and analysts who can make sense of all those signals. Take the statistical tsunami of SportVU in the NBA. “It's not an exaggeration to say that 85 percent of the teams don't know what to do with this data,” Goldsberry says. “The idea that this is going to revolutionize the NBA—well, I'm not sure that's true unless teams awaken really quickly to things like machine learning and data visualization.”

The 15 percent of team executives who *do* know what to do with the data? Those are the next Billy Beanes. At this year's Sloan conference, Goldsberry gave a three-peat championship presentation. Because what Goldsberry was actually doing was slicing basketball games into moments, instants, and then applying the same kind of analysis previous generations of sports analysts had applied to the states in baseball. Goldsberry and his team could then quantify the value—in terms of points—of every move on the court, from an entry pass into the post to a dribble drive.

This sort of analysis opens up a new way of evaluating everything a player does. “You'll be able to see which players are moving the needle up and which ones are moving it down,” Goldsberry says. “It's like the new microeconomics of basketball.”

This is no longer a part-time hobby for Goldsberry. He has parlayed his work into a job writing about analytics for the sports website Grantland, and although he won't confirm it, there are reports that multiple NBA teams have consulted with him. And he's still at Harvard, where he's organized a group of students that call themselves the XY Hoops after the mathematic shorthand for the coordinate system. “This wasn't my idea—it came from my students,” Goldsberry says. “It's like I'm the Foo Fighters, and they're the hot new band. I'm almost a nostalgia act already.”

The key paper that Goldsberry and his team wrote is called “A Multiresolution Stochastic Process Model for Predicting Basketball Possession Outcomes.” But for public consumption, he came up with a better title: *DataBall*.

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I dunno, one has to put these stats into the proper context. Yes, they reveal novel data points about the game, but you have to understand that there are relativistic elements of team strategy and game-specific scenarios that can influence the "game states", and are not easily quantified. For instance, in evaluating Dwight Howard's defensive prowess as a function of "shot frequency" inside the paint, you have to recognize that there is a huge variable that will factor into the shot frequency level: defensive vs offensive rebounding. In reality, if the shot frequency for the in-close grid coordinates is lower for Dwight, that may have nothing to do with his defense or his opponents reluctance to shoot against him, but rather his ability (or his opponents inability) to gather rebounds from errant shots, greatly reducing the number of attempts opponents get right at the rim. So yes, that is a good characteristic, but the analysis might be skewed, because perhaps Dwight isn't detering shots as much as he is eliminating 2nd chances, which is different than playing lock-down defense.

It's nice to quantify just how much Roy Hibbert alters point blank shot attempts, but frankly one doesn't need a colored grid to understand his influence on opposing shooters; just watch the games.

Keep in mind that for all of the accolades given to Billy Beane, his teams have never so much as even been to the World Series during his tenure, let alone won one. Beane is considered a pioneer in baseball data applications and a solid GM, but he is not considered a top 3 GM in the sport. While he's done a wonderful job squeezing out wins with a limited payroll, his teams have not been particularly successful in the post season at all.

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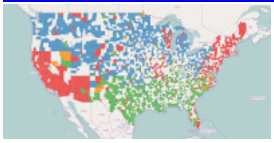

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