

The six-paneled official FIFA 2014 football

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The official football used in the 2014 FIFA World Cup in Brazil had six panels. Watching the match on television, I couldn't keep my mind off that ball, called the Adidas Brazuca, wondering how the panels were shaped and how they were assembled. Past experience had taught me that footballs are truncated icosahedrons, so it seemed strange that thirty-two faces could be reduced to just six.

This is a difficult thing to grasp from a photograph, so I purchased a (miniature) ball so that I could hold one in hand. It was indeed designed from six panels based on a cube. Each panel is cross-shaped, but closer examination shows that they are something like a swastika. There are two each of blue, green, and orange panels. If you consider the center of each panel as the center of a cube face, it is easy to see that there are indeed six panels.

The evolution of official FIFA balls is similar to the mathematical evolution of increasing division of the surface of a sphere to form polyhedra. The *New York Times* showed this well in an article called "The Evolution of the World Cup Ball." The standard from 1930 through 1966 was a regular hexahedron, the same shape as a volleyball. The six faces in this shape are formed by sewing together twelve or eighteen pieces of leather. The standard from 1970 through 2002 was a truncated icosahedron, with twelve pentagons (black) and twenty hexagons (white), for a total of 32 pieces of sewn leather.

There are five kinds of regular polyhedra: those with four, six, eight, twelve, and twenty faces. The fact that only these five exist can be proven using knowledge from basic geometry alone, and doing so is a task that I encourage my readers to attempt. There are also quasi-regular polyhedra, which can be formed by loosening the conditions on the component regular polygons. Truncated icosahedrons are formed by clipping the vertices of a regular icosahedron, thus giving the name of this 32-faced shape. There is a duality relation between the dodecahedron (12 sides) and

the icosahedron (20 sides).

While the patterning on footballs has changed, its formation from twelve pentagons and twenty hexagons long remained unchanged, because that gives the ball an approximately spherical shape. The first significant change came with the 2006 World Cup in Germany, with the Adidas Teamgeist. This ball was formed from six "propeller" shapes and eight "rotor" shapes, for a total of fourteen panels. The Adidas Jabulani, used in the 2010 World Cup in South Africa had eight panels, and the 2014 Brazuca set a new minimum, with just six panels of identical shape.

Over the eighty-year history starting from 1930, the leather panels were at first hand sewn, then later assembled by thermal bonding to allow play in the rain, making them even more closely approach a spherical shape. This leads to new problems with balls that don't spin as easily, but fewer panels makes them more suited to mass production.

Looking at the evolution of official balls as polyhedrons, we have a hexahedron from 1930–1966, a truncated icosahedron from 1970–2002, a hexahedron in 2006, a truncated tetrahedron in 2010, and another hexahedron in 2014; we've thus both started and ended with a hexahedron. While a truncated icosahedron is indeed a good approximation of a sphere, I imagine that sewing thirty-two panels together into a regular sphere is quite challenging.

FIFA official balls are designed and sold by Adidas, a German company. Germany won the World Cup in 2014, making me wonder if this was a coincidence. If the Japanese team is to aim for the top, we can't leave things up to the players alone; scientists and football research will also play an important role.

