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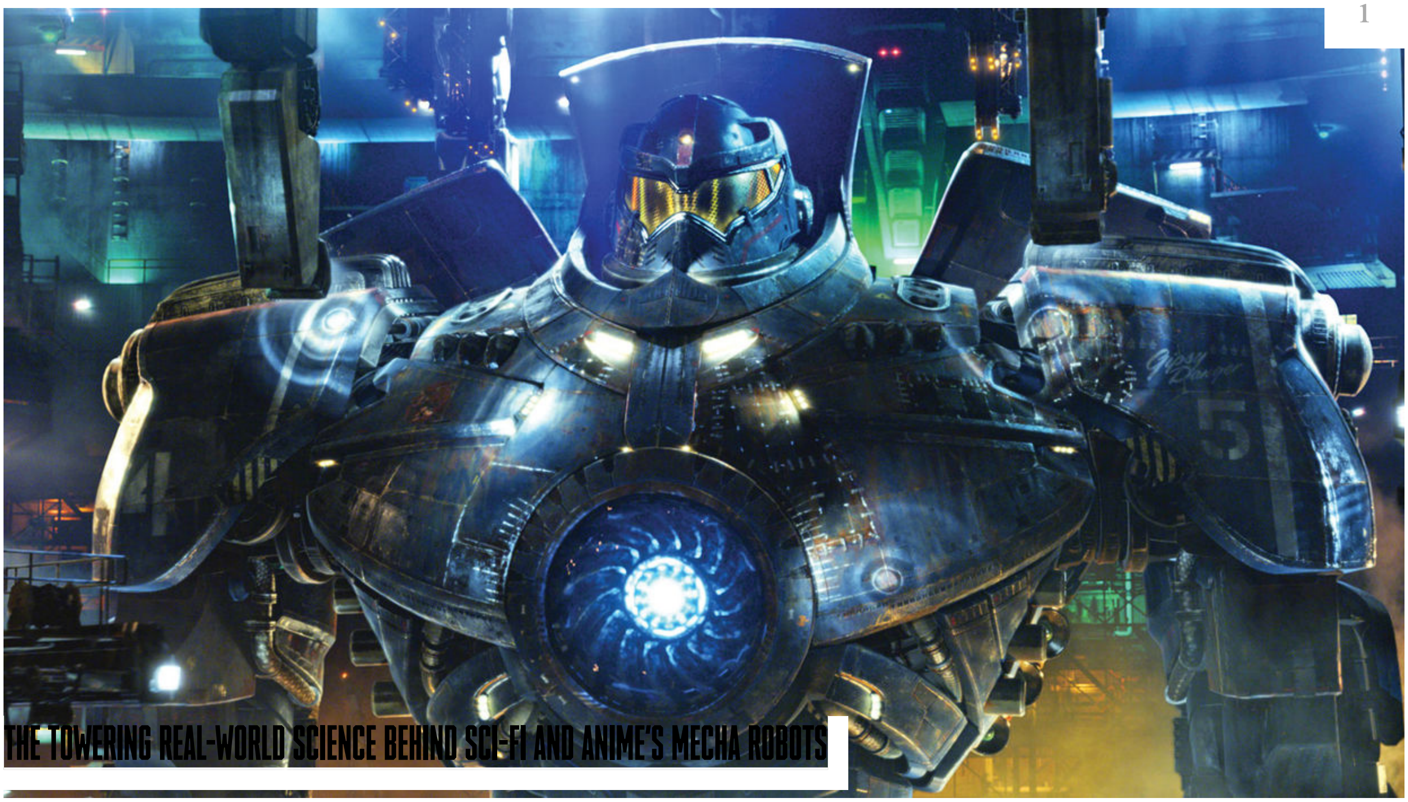

THE TOWERING REAL-WORLD SCIENCE BEHIND SCI-FI AND ANIME'S MECHA ROBOTS

Whether it's a Stryder Titan from , an EVA Unit from , or a good old-fashioned Gundam suit, mechas are the gold standard of sci-fi tech, along with hyperdrives and lightsabers. Now that the highly publicized MegaBots vs. Suidobashi mecha battle in our own world, with Eagle Prime repping the US and Kuratas fighting for the Japanese, battle mechs have come a lot closer to reality.

Though these real-world mechas moved more like geriatric forklifts than true engines of destruction, Eagle Prime v. Kuratas was the world's first giant robot fight, and it demonstrated some of the major technological challenges facing the construction of real-life mecha.

Here are the big ones.

Looking at Eagle Prime and Kuratas, you'll notice two things: First, they don't walk around on two legs, and second, they're very, very slow. It turns out true bipedal movement is incredibly difficult the larger (and heavier) something becomes. In fact, has run the numbers and found that a robot the size of a Jaeger would be practically impossible. An engineer named JJ Duncan says this:

"No known materials would be able to support the stress of that much activity in the robot, especially in the joints... High strength steel alloy has an ultimate strength of 760 MPa (megapascals) and carbon fiber has an ultimate strength of 6,370 MPa. But if a robot is punching a monster, jumping, and running, the G forces created are big numbers."

According to , a robotics postdoctoral associate at MIT, a mech's building material is going to be one of the biggest hurdles to overcome because any material strong enough to allow a giant robot to be dexterous and nimble is going to be too heavy and rigid to actually pull it off. However, he says the substance beryllium would be a potential option, as well as titanium and carbon-reinforced plastic.

You might think that had the right idea: Don't build robots, grow giant humans and retrofit them with robotic parts, sort of like one of the military is experimenting with. The human body is actually for dealing with rough terrain and carrying heavy weights, but the problem isn't design, it's proportions.

, as height doubles, weight increases eightfold, and as size and weight increase, the amount of energy to move it all goes up exponentially. This is actually one of the principles that limited the growth of the dinosaurs, according to Andy Ruina, a professor of robotics at Cornell University: "When [dinosaurs] got bigger they had a harder time dragging around their own weight. It's a little bit counterintuitive — you'd think it'd balance out but it doesn't."

If the issue of building materials can be conquered, the next big challenge will be power. Unless robots are walking around with long umbilical cables like an EVA Unit, they're going to need an energy source that's powerful and relatively small. According to Thangavelautham:

"Portable fission reactors are used to power aircraft carriers, but they would still need to be miniaturized and power density significantly improved to even have these robots just walk… Exotic energy sources are both the main challenge and breakthrough technology that could make this type of stuff reach reality."

By "exotic energy," Thangavelautham means nuclear power or dark matter. But even if we find an energy source that could do the heavy lifting, we might not have the technology to actually the heavy lifting. In , Daniel Wilson brought up a major engineering problem: "I don't know how any actuator would be able to keep such a giant structure upright in a high wind, much less move it with enough dexterity to walk."

Even lifting a Jaeger's arm parallel to the ground due to the incredible amount of torque required: around 81 million pound-feet. For comparison, the most powerful hydraulic systems in the world can only put out about 1.3 million lb.-ft.

From a practical perspective, giant robots are just too big for their own good.

Putting aside the pitfalls of construction, most mechs rely on some kind of neural connection between pilot and robot: , has neural links, has its synch rate, and Gundams (thought it depends on the canon) — eneral nilateral euro-Link ispersive utonomic aneuver.

It might sound like sci-fi, but Boston-based start-up Neurable is already working on the ability , and have even called that's completely thought-controlled. Paired with games like , where you pilot a VR mecha via a headset, controlling a ten-story-tall robot with only your mind starts to sound pretty doable.

The concept of neural links gets even more believable when you learn that the University of California and even full sentences. Of course, both the Neurable and University of California devices require electrodes attached to the skull, so a pilot will need to wear a helmet — just like they do in science fiction.

You might wonder how a single person can coordinate the movements of an entire robot, since claims it's too complex for one mind to handle, but it turns out walking and moving around is actually pretty easy. by Robin R. Murphy, "... locomotion is becoming one of the easiest functions to totally delegate to a robot."

The secret, Murphy says, is CPGs, or "central pattern generators', a biological mechanic found in most legged animals that allows them to coordinate the movement of their feet. Scientists have been using artificial CPGs to make robots walk since the 80s, and Boston Dynamics' Atlas has by itself.

The final question is how much money the world will have to slam down to make this happen. At roughly 20 feet tall and 28 tons (in the case of), the Titans from aren't too different from Eagle Prime, Megabot's flagship robot. Eagle Prime of a light tank, a race car, and a military aircraft all mixed together: it's got a V8 engine with 340 horsepower, it's capable of exerting 4,600 lb.-feet, its hydraulic pressure runs 4,000 psi, and it crawls around on custom Ripsaw tracks.

The Eagle , while its Japanese counterpart the Kuratas was previously . Meanwhile, France's AMX-56 Leclerc main battle tank, the most expensive tank in the world, . For something like Titanfall's small-scale mechs, we might expect them to cost in the tens of millions.

But what about a Jaeger or EVA unit, which can stand anywhere from 200 to 288 feet tall? To wrap our heads around a machine of this scale, a good comparison might be the new , the . It weighs in at 90,000 tons, is about 1,106 feet in length, and like a Jaeger, the carrier is nuclear-powered. The cost $13 billion to build, which gives us a ballpark estimate for the amount of dosh needed to defend ourselves from kaiju. Meanwhile, SciencePortal ran some numbers and found that creating a Gundam from the ground-up (including materials and computers) would .

director Guillermo del Toro , "There is something to having something really, really large destroying a lot of little things." $700 million and one sequel later, it seems he was right — there is something about watching a giant robot committing cataclysmic acts of property damage that brings joy to millions.

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