Free-standing and quadrupedal walking (or raising a foot and taking a step) of Gundam and Zaku as they engage in sumo wrestling

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February 27, 2015

1. Preliminary Remarks

While this design proposal includes content from published works of other authors, I believe this use to be permissible under Article 30.3 of Japan’s Copyright Law (“Exploitation in the course of an Examination”) [1].

I would also like to note in advance that although my proposal calls for the creation of a Zaku robot in addition to Gundam, I don’t consider this to be in violation of the requirements. While the requirements for the Real Entertainment Section of the Gundam GLOBAL CHALLENGE explicitly call for movement of an 18 m-high Gundam, they do not state that a Zaku cannot be created.

Fig. 1 Gundam and Zaku locked in battle in a *gappuri-yotsu*-like position (*gappuri-yotsu* is a sumo hold in which two wrestlers are locked together, each with a firm grip with both hands on the other’s belt)

2. Overview of Proposal

•When I heard that a full-scale Gundam has to move, I assumed that both Gundam fans and non-Gundam fans would expect the robot to be free-standing and walking.

•However, achieving free-standing motion of a humanoid robot even at human-size remains a serious research challenge, to which enormous time and effort continues to be invested. It would therefore be very difficult to achieve free-standing and walking of an 18 m-high, 40-ton robot by 2019.

•In light of the above observations, I decided to try and create both a Gundam robot and Zaku robot and combine them so that they are locked together in a tussle, in the style of a gappuri-yotsu sumo hold, thereby effectively creating a single quadruped robot that is free-standing and moves without any support other than that of their four legs.

•The main points of appeal of this solution are as follows.

- Since quadrupedal movement can ensure that three-point support can be maintained at all times, it enables more stable motion than bipedal movement.
- Zaku (MS-06 Zaku II) is a well-known (Mobile Suit) robot of the Gundam series, second only to Gundam (RX-78-2) in terms of popularity and recognition, so there are high hopes that a full-scale statue of Zaku will also be created. This design proposal fulfills these hopes.
- The idea of Gundam and Zaku grappling with each other and performing quadrupedal movement avoids the technically difficult challenges of bipedal movement, but at the same time the sight of the two robots pressing against each other offers dramatically compelling action that can enhance entertainment value.

•Finally, based on the idea of using two robots to achieve a quadrupedal structure, this design proposal narrows down its goal for movement to “raising a foot and taking a step,” in order to lighten the technical demands of the challenge.

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3. Combining Gundam and Zaku for quadrupedal movement

3.1 Expectations of a moving Gundam

When the 18 m-high full-scale statue of Gundam was completed, Gundam fans were obviously very excited, but non-Gundam fans too seemed to be overwhelmed by the statue. On the other hand, when I spoke to an acquaintance who is not a Gundam fan about the giant statue, his immediate response was to ask, "Does it walk?" Of course, anyone with a certain amount of engineering knowledge would realize that an 18 m-high robot could not possibly free-standing and walk on two legs. At the same time, for Gundam fans the sight of a full-scale standing Gundam robot is so exciting that they are left satisfied. Undeniably, though, to ordinary people a huge Gundam that does not move might as well be made of papier-mâché. This is how I see it, at least. That is why I want the next full-scale Gundam series robot to be free-standing-and-moving, and that is also what many people expect.

3.2 Bipedal and Quadrupedal Movement

It is only natural that humanoid robots walk on two legs, just like humans. The release in 2000 of the ASIMO bipedal motion robot by Honda [2], which is free-standing and moved its two legs and performed various other physical actions, was big news. The creation of biped walking robots has been a long-held dream and a great deal of energy is still being poured into research in this field. Robots such as PETMAN [3] and ATLAS [4], [5], by Boston Dynamics and the Defense Advanced Research Projects Agency (DARPA), respectively, have achieved natural walking motion, as opposed to the sliding style movements typical of previous biped robots. Although such natural biped motion is possible at human scale, it cannot be done with a huge 18 m-high robot. In bipedal walking, it is necessary to move the upper body in synch with leg movement. (If you pay close attention while walking, you will note that when you lift one foot, your upper body will shift towards the other foot, which remains on the ground.) We have to find solutions for the response speed for this and other actions, for shifting weight onto one foot, for the influence of wind, etc. In addition, the potential destruction caused by the huge robot toppling over due to an earthquake or sudden gust of wind would make it necessary to satisfy a very stringent level of safety to avoid the slightest risk of the robot falling over. It is therefore extremely difficult for now to make an 18 m-high robot is free-standing and walks. It might be possible to create the illusion that the robot is free-standing and walking on two legs, utilizing some kind of external support, like the parallel safety bars used for walking rehabilitation, but the presence of such supporting structures close to the huge Gundam would adversely affect the look of photos or video, and the impact of the robot's motion would be greatly reduced. And if support wires were used it would be difficult to achieve walking-style movement. Since the current Gundam statue has already been free-standing since 2009, the next giant Gundam robot should also be expected to stand and function without any external support.

An alternative method of robot movement and motion makes use of more than two legs. Another robot created by the previously mentioned Boston Dynamics is the four-legged Big Dog [6], [7], which has drawn considerable attention for its speed of movement and its remarkable stability—it does not topple over even if kicked hard. Obviously, quadrupedal movement is inherently more stable than bipedal movement. It is particularly good that this robot is able to maintain three points of support while moving. Like the fundamental technique taught in mountain climbing, securing three points of support before proceeding to the next foothold, three-point support can create sufficient stability to prevent falling over. When there are only two points of support, there is always a risk of falling over across the line directly connecting the two points. In the case of three-pointed support, however, if the center of gravity is located within the triangular plane defined by the three grounded points (here "grounded" is not meant in the sense of electrical earthing, but rather refers to the points of contact with the ground), the moving body will be statically stable and therefore will not fall over. At about three minutes into the linked video of BigDog [7], the robot can be seen moving over a simulated heap of rubble with unstable footholds, but even here we see that as it moves three of its legs always remain grounded, while the remaining leg seeks the next foothold. Another thing is that in the case of bipedal motion, the maximum weight that has to be carried by one foot is equal to the full weight of the robot. On the other hand, since three feet always remain in contact with the ground in the case of a two-robot quadrupedal motion, the maximum weight load carried by one foot is only two-thirds (2/3) of the robot weight—significantly less than for bipedal motion. When it comes to supporting a weight of tens of tons, this reduction in load of one-third the robot weight is very important. For all these reasons, I concluded that it might be possible to employ quadrupedal motion to produce free-standing-and-walking of an 18 m-high robot.

3.3 Method for achieving quadrupedal movement

Since Gundam is a biped, it can only be made to perform quadrupedal motion by putting it on all fours and getting it to crawl. It would no longer be a standing statue, however, and such a sight would be of little interest to anyone. Therefore, I opted to create Zaku, a second full-scale robot, and combine it with Gundam to create what is effectively a single quadruped motion robot structure (2 legs × 2). More specifically, as shown by Fig. 1, the idea is to have the two robots facing each other and locked together like two sumo wrestlers applying the gappuri-yotsu hold on each other. Thus, two robots are joined to create, in effect, a single quadrupedal motion robot. Note that the Zaku referred to in this design proposal is MS-06 Zaku II. Conceivably, if the robots could be joined by their arms the supporting parts (steel frame) would be invisible from the outside, resulting in a natural appearance. Strength would probably be an issue, though, so the idea is to put them into a gappuri-yotsu position to bring their chests and waists together and to join them at these locations using supporting parts. This would enable the load weight to be distributed over three feet. Of course, it is desirable for the design to skillfully connect the two robots with steel plate inserted in their arms.

If it were possible to connect more than two robots together, shoulder to shoulder, like in the "war cry" performance seen in the opening of the latest episodes of "Gundam Reconguista in G" that are currently being broadcast in Japan (as of Feb. 2015), greater stability could be achieved, but this is not feasible because it would make the cost of robots excessive.

3.4 Significance of creating Zaku

In order to create a quadruped motion robot structure from two robots locked in the gappuri-yotsu position, an additional humanoid robot close to 18 m in height is needed. Zaku is a mobile suit (MS) robot that appeared in the Mobile Suit Gundam anime series. Over the whole Gundam series, Zaku is the second most recognized MS after RX-78-2 Gundam. I guess that is why many Gundam fans began hoping that a statue of Zaku would also be built after the full-scale Gundam statue was unveiled. In the series, Zaku is an MS of the Principality of Zeon, the enemy organization, so it would not be unnatural for Zaku to be engaged in battle with Gundam of the Earth Federation, to which the main protagonist of Mobile Suit Gundam, Amuro Ray, belongs. In other words, this design is consistent with the Gundam worldview. (Note that "worldview" here refers to the world as portrayed in the fictional series.) To summarize, then, I adopted Zaku as my second humanoid robot because of the existing hopes for the creation of a full-scale Zaku statue, because a sumo-like struggle between Gundam and Zaku is consistent with the narrative of the anime series, and because the height of the top of Zaku's head is specified to be 17.5 m [8], which is a well balanced with the size of Gundam.

There are actually a number of types of Zaku, but in terms of recognition level and worldview, the two types below are the most suitable for my purpose.

1. MS-06F Zaku II (Fig. 2)
2. MS-06S Zaku II Char Custom (Fig. 3)

In the first episode of Mobile Suit Gundam, titled "Gundam Rising," the MS-06F Zaku II piloted by Gene of the Principality of Zeon was the first ever MS to fight with Gundam in an MS battle. Since this green Zaku is a mass production model, it continued to appear from time to time in Gundam, and it is one of the most widely recognized types of MS amongst non-Gundam fans. In an event to demonstrate a full-scale Gundam and full-scale Zaku in motion, I would suggest playing the audio from the very first contact between the two in this first episode, to greatly enhance the entertainment value.

The second Zaku, MS-06S Zaku II Char Custom, is an MS piloted by Char Aznable, a character appearing in Mobile Suit Gundam. This Zaku, which is shown in Fig. 1, also enjoys strong recognition amongst non-Gundam fans. This MS is red, the distinctive personal color of Char, but a good number of the non-Gundam fans that I know think that a Zaku is always a red robot. In addition, the character of Char is a rival of the main protagonist Amuro Ray, and in terms of recognition level is on a par with or only slightly behind Amuro. If MS-06S Zaku II Char Custom is adopted as the second robot, a new audio recording of an exchange between Gundam and Zaku could be made to be played when the robots are in motion to enhance the entertainment value. I suggest an exchange something like:
Amuro: "Just a mere Zaku. Watch how easily Gundam pushes you back!"
Char: "Whoah! The Earth Federation's mobile suits are real monsters!"

My personal feeling is that of the many non-Gundam fans with just a little knowledge of Gundam, the only characters and robots they recognize are Gundam, Zaku, Amuro, and Char. They tend to know that Amuro is someone who was never hit by anyone, not even his father, and that Char always wears a mask and loves the color red, but they don't understand the difference between a Zaku and a Gouf. I believe that the design should be enjoyable for these kinds of people and even for people with absolutely no awareness or knowledge of Gundam. To enable this, the visual impact of seeing an 18 m-high robot "walking" is essential. And despite the fact that Gundam and Zaku are weapons of war, a sumo-like physical duel without use of weapons presents a relatively peaceful image, which is a desirable thing.

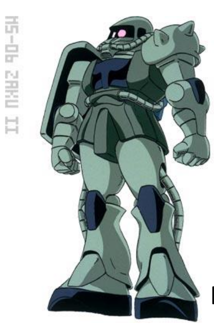


Fig. 2 MS-06F Zaku II [9]

Fig. 3 MS-06S Zaku II Char Custom [9]

3.5 Practicability of leg movement

Here I will examine the question of whether it is possible to move the legs of a giant robot using currently conceivable technology, by a bold approximation that treats the moving leg as a single rod. A detailed design is left as a challenge for the Open Platform stage of the Gundam Global Challenge (GGC).

I determined the torque required for movement based on the angular movement (pitch = forward/backward movement of a leg) at the hip joint, where the load incurred by movement is highest. From the GCC design reference materials [10], I measured the length of Gundam's leg to be approximately 11 m. The total weight of the full-scale Gundam statue, based on an Internet search was about 35 tons, though figures varied between information sources[11], [12]. Since the weight of a human leg is reported to be 18.5% of total body weight [13], we can estimate the mass of one of Gundam's legs (assuming it is a uniform rod) to be $m = 35 \times 10^3 \times 18.5/100 \simeq 6.5 \times 10^3$ [kg], and the length to be $l = 11$[m]. We take the axis of rotation to be the top end point of the rod, which is assumed to be positioned vertically. The moment of inertia around the top point of the rod in the direction perpendicular to the length is $J = ml^2/3 \simeq 262 \times 10^3$ [kg m^2] [14]. The angle of displacement of the leg in a counterclockwise direction from the vertically downward position is θ [deg]. Let's assume that the leg accelerates from the point of θ = 0 to an angular speed of 1deg/sec in 10 seconds, and from thereon continues moving at constant speed up to θ = 30. This seems sufficiently fast to make it interesting to watch Gundam in motion. For a fictional giant robot this might be too slow, but it is fast for the movement of an object weighing tens of tons. If the angular speed increases linearly from ω = 0 to ω = 1 [deg/s] in 10 seconds, the acceleration is $d\omega/dt = 0.1$ [deg/ s^2]. The total angular movement after 10 seconds would then be given by the following equation.

$$\int_0^{10} \omega \mathrm{d}t = \int_0^{10} 0.1t \mathrm{d}t = 0.1 \times 10^2/2 = 5.0 \text{ [deg]}$$

Since the force of gravity is $mg \times \sin\theta$ at the center of gravity of the rod, i.e., at a position 1/2 from the top point, the moment applied by gravity at the top end would be $mg(l/2) \times \sin\theta$, where g is acceleration due to gravity, 9.8 [m/ s^2]. The maximum torque T while the angular speed is increasing can be determined by the following equation.

$$\begin{aligned} T &= J\frac{\mathrm{d}\omega}{\mathrm{d}t} + mg\frac{l}{2}\sin\theta \\ &= 262 \times 10^3 \times 0.1 \times \frac{\pi}{180} + 6.5 \times 10^3 \times 9.8 \times \frac{11}{2} \times \sin\left(5.0 \times \frac{\pi}{180}\right) \\ &\simeq 31 \times 10^3 \text{ [Nm]} \end{aligned}$$

The torque necessary for static equilibrium when the leg is raised to 30 degrees can be calculated as follows.

$$\begin{aligned} T &= mg\frac{l}{2}\sin\theta \\ &= 6.5 \times 10^3 \times 9.8 \times \frac{11}{2} \times \sin\left(30 \times \frac{\pi}{180}\right) \\ &\simeq 175 \times 10^3 \text{ [Nm]} \end{aligned}$$

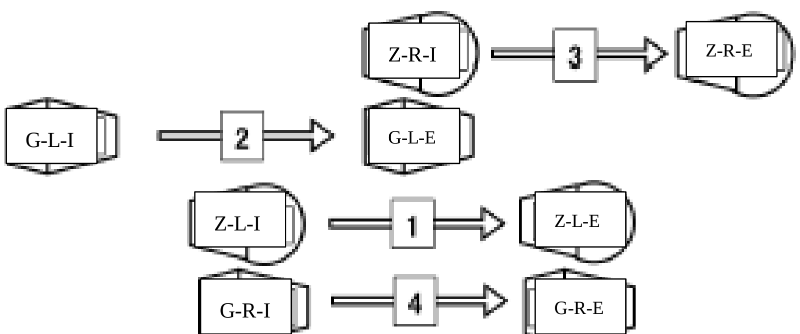
I tried finding a motor capable of producing this maximum torque T = 175 [kNm]. To start with, this is a low-speed, high-torque application, unlike that of the wheels of electric trains or automobiles, which rotate at high speed. Thus, I thought that a hydraulic motor (e.g., plunger motor), of the kind used in cranes and excavators could be suitable. As an example, the Hägglunds motor by the Bosch Rexroth Group [15] seems to fit the requirements. According to the data sheet, the CBM 2000 model reaches a torque of 657 [kNm] at 30 [RPM], i.e., a rotational speed of 180 [deg/s]. The motor diameter is 1,460 [mm], its axial length is 872 [mm], and its weight is 4,100 [kg]. Setting aside the size, the weight appears to present a problem, but a similar hydraulic motor matched to our speed and torque requirements would be smaller and lighter, and might even fit inside the robot structure.

Up to now I have considered generating movement using a motor, but for moving and bending a heavy object that weighs many tons, it is probably more realistic to use an actuator driven by a cylinder that uses a link mechanism, like those employed in back hoes. In fact, Kuratas, a 4 m-high, 4-ton giant piloted robot made by Suidobashi Heavy Industry, which has attracted a lot of attention, utilizes hydraulic cylinders to bend the large joints of the robot[16]. Exposing cylinders inevitably changes the external appearance and might even ruin the design, but I believe it is possible to achieve movement with actuators based on hydraulic cylinders.

3.6 Movement pattern

The quadrupedal motion that I am considering in this proposal is different to the kind of quadrupedal motion that is typically aimed at by robot researchers because it does not need to function on a variety of unspecified surfaces. That is, the aim in creating normal quadrupedal motion robots is usually to take them to some unpredetermined terrain and get them to free-standing move. In this challenge, however, it is possible to predetermine the place of operation (within the event venue) and movement pattern, and it is sufficient to ensure stability within a very limited area of operation. If we think of a way to ensure basic stability with three robot feet fixed on the ground, and a way to move the remaining foot without any movement of the "grounded" feet, commands to the actuator that moves the foot can be approximately controlled by means of feed forward, so that only the final fine adjustments need be made by feedback control using sensors. Fig. 4 shows the proposed movement pattern. This illustrates how movement is possible if three feet are "grounded" so as to form a triangle (acute triangle). To return to the original position, the movements can be performed in the reverse order.

<TOP TO BOTTOM, LEFT TO RIGHT>



Schematic diagram of movements in order, as seen from above. G = Gundam, Z = Zaku, L = left foot, R = right foot, I = initial position, E = position at end of movement.Arrows indicate direction of movement; numbers indicate order of movement.

Fig. 4 Movement pattern

3.7 Fixing of feet

An 18 m-high static statue is the kind of structure that requires an application for certification to verify that it conforms to the Building Standards Act, so it would require foundations to ensure sufficient stability. (If the structure moves, however, it may no longer qualify as a structure fixed to the ground.) Since the positions where the feet of the robots are "grounded" are determined in advance, foundations (substructures) can be built at the "grounding" positions. Furthermore, it is also possible to provide a mechanism that keeps the foot fixed to the ground each time the foot moves by means of attachment to the underside of the foot. In this case, the motion would not look like walking, but rather successive linear movements along a channel. It might also be possible to supply electric power externally via the undersides of the feet.

3.8 Potential design problems

Here I want to mention some of the parts of the robots that pose potential design problems, based on my observations when I created the *gappuri-yotsu* pose shown in Fig. 1. The plastic Gundam figures (GUNPLA) I used to stage the photo in Fig. 1 are a RG 1/144 RX-78-2 Gundam (JAN code: 4543112632807) and a RG 1/144 MS-06S Zaku Char Custom (JAN code: 4543112-65511-0). It should be noted that these are problems I noted when looking at this 1:144 scale model from the side and from above. It is unclear whether these points would also pose a problem when looking up at a full-scale version, or whether looking up might reveal different problems. Potential problems when looking up need to be checked by creating a CG model I believe.

• Zaku's shoulders

Both Zaku's shield and spike might obstruct the view of Gundam's face. If this proves to be the case, possible solutions could be to make these items smaller, or else through collaboration with the Virtual Entertainment Section to create the Zaku without a shield and spike and make them visible only to people with a monitor device by means of augmented reality, or alternatively to create the Zaku with a shield and spike but remove them only for people with a monitor device by means of diminished reality.

- Power pipes on Zaku's legs

These power pipes may interfere with Gundam's legs during movement. If there is obstruction, a solution would be to create the Zaku without power pipes and then re-create the pipes using augmented reality.

- Beam sabers in Gundam's backpack (*randoseru*)

These beam sabers pose the opposite problem of Zaku's shoulders, because they might obstruct the view of Zaku's face. Gundam is usually equipped with two beam sabers, but it is possible to create Gundam without a beam saber on the side that obscures Zaku's face.

- Skirt

The skirt may cause interference when a leg is moved, so it is necessary to create the skirt using relatively light material and also to insert a cushioning material between the leg and skirt.

3.9 Area needed for movement

The distance between the toe of the right foot and the ankle of the left foot of the Gundam figure in Fig. 1 is approximately 8 [cm], and the distance between the outside of Gundam's right foot and the outside of Zaku's right foot is approximately 9 [cm]. Since the scale of these plastic models is 1:144, the corresponding distances for full-scale robots would be about 0.08 × 144 = 11.5 [m], and 0.09 × 144 = 13 [m]. For the sequence of movements described in Fig. 4, Gundam and Zaku would together move a total distance of 46 [m] in four steps. Multiplying this by the perpendicular distance of 13 [m] gives 600 [m^2] for the total area necessary for the movements.

3.10 Ensuring the safety of spectators

Considering the potential risk of a falling object or of physical contact with the foot of a robot, spectators need to be prevented from entering the area of movement, as defined in 3.9. However, when there is no movement, I think it is desirable if people can get close to the robots to enjoy a better view, and in terms of visual impact it is undesirable to build an enclosure from the outset to physically prevent people from entering the area. If entry to the area is permitted then, it is essential to ensure that the robots can be immediately stopped in the event of an emergency. Fortunately it is always supported by three feet, so even when one foot is raised, it can be stopped reliably at any moment. Detecting the presence of any person over the whole of the movement area could be achieved, for example, with an intruder detection system that uses Leaky Coaxial Cable[17] or a foreign object detection system like those used for airport runways[18].

4. Practicability of proposal

Up to now I've considered the idea of walking-like movement, but when I think of actually trying to make such movement look smooth and natural, I realize that actuators would be necessary not just for the legs, but for the whole body of the robot. I am somewhat skeptical, however, about whether this could be possible by 2019. In addition, since there is no precedent for the motion of an 18 m-high humanoid robot, it's hard to know what laws are applicable to this project. Since the robot is not moving on a public road, there should be no need for a number plate, like in the case of Patlabor, but unfortunately I just don't know if the creation of such a moving robot structure is permitted or not.

Thus, staying with the idea of combining Gundam and Zaku to create a robot structure with four feet (3 + 1), I thought about how a "moving Gundam" could be practicable. I concluded that by narrowing my focus, Gundam could, at the very least, be made to "raise a foot" and "take a step."

To do this, I propose that one leg of Gundam and both legs of Zaku are completely fixed to the ground and that Gundam and Zaku are joined together so that the structure is supported at three points on the ground, leaving one of Gundam's legs to be operated like an ordinary robot arm so that Gundam "appears to be taking a step."

Constructing a statue of Gundam and Zaku by building one of Gundam's legs and two of Zaku's legs over foundations is possible, by simply extending the concept by which the full-scale statue of Gundam was built in 2009. The laws applicable to the construction would most likely be the same too. Another advantage is that the expertise from that project could be reused. And if it is possible for the whole weight of the robots to be completely supported on three feet, the remaining leg would not need to support any weight apart from its armor, making it unnecessary to use heavy, strong steel frame. That is, the structure could be made very light, and thus the actuator load would be relatively low. The one moving leg alone could then be considered like a normal floating robot arm. In 3.5 I wrote that the robot leg length is approximately 11 [m]. This happens to be about the same length as the robot arm used in the Japanese Experiment Module (Kibo) of the International Space Station [19]. Although this arm is not designed for use under gravity, just knowing that something similar has already been made lends credibility to the practicability of moving the robot leg.

Now, let's briefly consider the weight of Gundam's armor. Let's assume the armor is made of fiber-reinforced plastic (FRP) with a density of 2 [g/ cm^2] [20]. Approximating the leg as a cylinder of radius 1 [m] and height 11 [m], and assuming an armor thickness of 5 [mm], the armor volume is $2\pi \times 1 \times 11 \times 0.005 = 0.35$ [m^3] and its total weight would be $3.5 \times 10^6 \times 2 \times 10^{-3} = 700$ [kg]. Although this is just a casual analysis based on the uncertain thickness, if we consider that an additional weight of about 1 ton is applied to the arm, a mechanism something like a hydraulic back hoe would be suitable. The fact that an arm weighing tons might sway while in motion obviously means that careful engineering calculations need to be performed for the "three-legged" structure, but this appears to be quite a practicable solution.

Somewhat more ambitiously, I would like to suggest a solution in which only one leg of Gundam and one leg of Zaku are fixed to the ground to support their own weight, while the other legs of the robots are both moved. I would also be happy if the upper bodies of the robots could be moved along with each leg, although the issue of twisting might be difficult to resolve. At the very least, I think it would be possible to rotate the heads.

In terms of expense, on top of the cost of the full-scale Gundam erected in 2009, we would have to budget for the expense of designing and constructing the Zaku, as well as designing and constructing an operation and control system for moving one or more legs.

Although changing the goal from "walking" to merely "lifting a foot and taking a step" to substantially increase practicability would be a downgrading of ambition level, it would still represent "one small step" to realizing future science and technology dreams, in the sense of the famous words by Neil Armstrong on landing on the moon.

5. Other hopes

In this design proposal I have described expectations for the next Gundam "statue" around the theme of "walking," but some other expectations are as follows.

- I would like to see the grinding movement of Gundam's manipulators (fingers).
- I would like to be able to climb up to the cockpit position. Even if it's not possible to enter the cockpit, it would be great just to see the view from up there. Perhaps it would be possible to offer this experience like an amusement park attraction or adventure playground feature.

6. Selection criteria and verification of project requirements

6.1 Plan evaluation

- Does the idea match the worldview of Gundam?

As I described in Chapter 3, most specifically in 3.4, the sight of Gundam and Zaku grappling with each other in battle is very consistent with the Gundam "worldview."

- Is the idea enjoyable as a form of entertainment?

As I explained in Chapter 3, most specifically in 3.1, the next "moving Gundam" (Real Entertainment) is widely expected to lift its feet and take steps. In 3.4 I also explained that there are hopes that a full-scale statute of Zaku will also be created. This design proposal satisfies these requirements for the 2019 Real Entertainment Section.

6.2 Technical evaluation

This design proposal only offers a broad overall plan and provides only a very approximate examination of practicability. For a detailed design, many issues remain to be resolved at the Open Platform stage. Nonetheless, at the very least the technical requirements of the proposal to "raise Gundam's foot" in Chapter 4, which builds on the creation of the full-scale Gundam "statue" of 2009 and avoids as far as possible new technical challenges requiring verification, should be quite easy to meet.

•Safety, durability, impact on environment and people, and legal feasibility

It should be possible to create the design proposed in Chapter 4 without any problems, because it does not differ very substantially from the full-scale Gundam statue project of 2009 in terms of any of the above factors. Legally, this should still fall under the structure defined in Enforcement Order No. 138 of the Building Standards Act, and it should be possible to create it in conformity with this act, in line with Article 138.2 of the Enforcement Order.

•Feasibility of systems design (validation plan), power supply, control, development scheme, development schedule

These factors are only very crudely examined in this design proposal. Many challenges and much effort remain before the idea can be realized.

•Technological development potential, ripple effect on society, etc.

This design proposal sees free-standing and bipedal motion of a full-scale Gundam as a remote goal, focusing instead on the more readily achievable goal of quadrupedal motion, or at least getting Gundam to raise its foot. Basically, progressing from the 2009 Gundam, which stands bolt upright, to a Gundam whose leg can be moved, will inspire and drive many people towards realizing the dream of achieving free-standing bipedal movement of a full-scale Gundam. The expertise acquired by moving a full-scale leg can be applied to subsequent stages of development.

7. Impressions

When I actually set sight on the full-scale Gundam robot for the first time, I felt very moved and happy. I therefore have high hopes for the 2019 moving Gundam. I am ready and willing to lend my support to everyone involved in this project.

References:

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