1.0 INTRODUCTION

The Miura fold (Miura-ori) is famous all over the world. It is an element of the ancient Japanese tradition of origami and reaches as far as astronautical engineering through the construction of solar panels. Miura-ori is a method of folding a flat surface such as a sheet of paper into a smaller area. This fold technique is named after its inventor, Japanese astrophysicist Koryo Miura. Miura-ori has a unique folding pattern using parallelogram shapes and zigzag pattern that makes it suitable for rigid bodies. Miura-ori technique has a lot of applications, the most popular of which is in astronautics. Miura-ori is applied in large solar panel arrays for space satellites in the Japanese space program before launch and then spread out in space [1].

2.0 HISTORY AND BACKGROUND

In 1985, Japanese astrophysicist Koryo Miura proposed a form of rigid origami, a style of folding paper (or other materials) that allows each section to remain flat—a necessary condition for stiff materials, like some solar panels [2]. As mentioned before, the ‘Miura’ in Miura folding is derived from Koryo Miura, the man who devised it. It was some time ago, but it is understood that this folding method occurred to him when he was researching aerospace structures while enrolled at Tokyo University’s Institute of Space and Aeronautical Science [3]. Miura-ori separates itself from regular folding patterns because the folds form parallelograms as opposed to rectangles or squares. In one direction, the creases lie along straight lines, with each parallelogram forming the mirror reflection of its neighbor across each crease. In the other direction, the creases zigzag, and each parallelogram is the translation of its neighbor across the crease. Each of the zigzag paths of creases consists solely of mountain folds or of valley folds, with mountains alternating with valleys from one zigzag path to the next. Each of the straight paths of creases alternates between mountain and valley folds [1].

3.0 MIURA FOLD INSTRUCTIONS

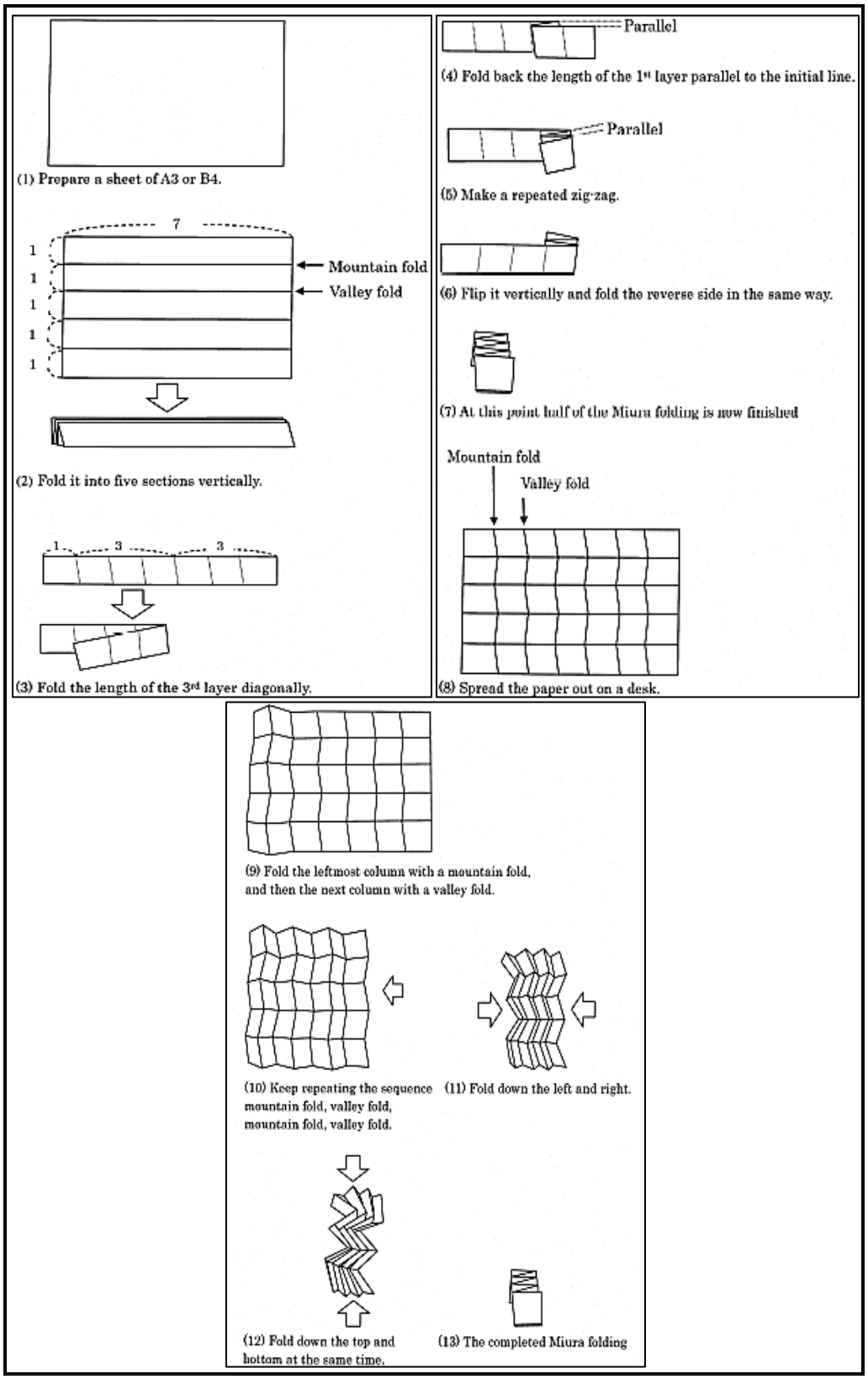

Figure 3.1: Miura-Ori Fold Instructions [3]

4.0 CURRENT APPLICATIONS FOR MIURA-ORI

As mentioned previously, the Miura-ori currently has a lot of applications. The most popular application is for the solar panels used in some space satellites launched by the Japanese space agency, JAXA. Rockets launched into space make use of the Sun's energy while they fly. The devices that gather this solar energy are solar panels, but these panels cannot be opened until after the launch. The solar panels are folded down as much as possible in order to pack them into the rocket, and then after the rocket blasts into outer space they quickly unfurl. When the rocket returns to the Earth's surface, they must be folded down and re-stowed [3]. The idea of Miura folding was realized after thinking about how this sequence of actions could be achieved not by humans, but by robots. Miura-ori, was used in Japan's Space Flyer Unit (a satellite launched in 1995), and has influenced the development of other folds that allow materials to be packed into a compact shape and then unfolded in one continuous motion. Miura folds are considered shape-memory origami because the fold can be "remembered"—that is, after unfolding, the sheet can easily be re-folded and returned to its compact shape [2]. A folded Miura fold can be packed into a compact shape, its thickness reflecting only the thickness of the folded material. Folded material can be unpacked in one motion by pulling on its opposite ends, and likewise folded by pushing the two ends together. In the solar array application, this property reduces the number of motors required to unfold this shape, reducing weight and complexity [1].

5.0 FUTURE APPLICATIONS FOR MIURA-ORI

Compact packing is an important aspect in different walks of life from shipping packages and mail all the way to space travel. With this in mind, it is no surprise that there are a myriad of conceptual ideas implementing the Miura fold for different purposes. Some potential applications for this fold include surgical devices such as stents and flat-foldable furniture. Think of surgical stents that can be packed flat and pop-up into three-dimensional structures once inside the body or dining room tables that can lean flat against the wall until they are ready to be used. The concept behind these ideas takes into account several factors, including the stiffness of the folded material and the trade-off between the accuracy of the pattern and the effort associated with creating finer folds – an important characterization because, these shapes are all folded by hand using Miura fold derivatives [4]. Because these are just conceptual ideas, there are no examples or prototypes to show. However, this shows the importance and versatility of Miura-ori.

6.0 REFERENCES

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