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DEVELOPMENT OF THE SPACE TOILET CALLED "SPACE BENKING" 2023

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Abstract

The era of commercial space travel has begun, and the time has come for people all over the world to go to space. As more and more space travelers will be venturing out into space, training for using the toilet in space will become important, and it will be necessary to become accustomed to using it on a regular basis. In Japan, there is a simple toilet called “BENKING” for disaster use. ASTRAX is developing the “Space Benking” together with a company that develops and sells the “BENKING” in order to enable space travelers and commercial astronauts to use more comfortable toilets during space flight.

In this paper, we present the latest development status of the “Space Benking” and the progress of the plan.

Keywords: Toilet, Space Toilet, BENKING, Space Benking

Glossary

BENKING: Styrofoam-made simple toilet for disasters use made in Japan

Washlet: Common toilet flushing shower (bidet) in Japan

1. Introduction

ASTRAX is constantly challenging how to explore space with the power of the private sector, using commercially available consumer products, without incurring costs.

A prototype was built based on the results of a conceptual design study of a space toilet "Space Bengking" summarized in section 4 of the paper presented at the International Astronautical Congress held in Paris in 2022 (see paper [56]). This time, however, it is intended for use on the ground.

In this paper, we summarize the process of improvement from BENKING to Space Benking. Section 2 describes the policy of improvement that needs to be added to BENKING, and Section 3 summarizes the status of the actual prototype.



Fig. 1 BENKING



Fig. 2 Image of BENKING use

2. Improvement policy to make BENKING into a Space Benking

The main body of the BENKING shall be modified to add a urine hose, urine cup, urine tank (plastic bottle), portable Washlet, sterile wet wipes for cleaning, fixing belt, deodorizer, and sound deadening function. The contents of each of these additions are described below.

2.1 Main body of BENKING

The main body of the BENKING will not be modified and will remain in use.

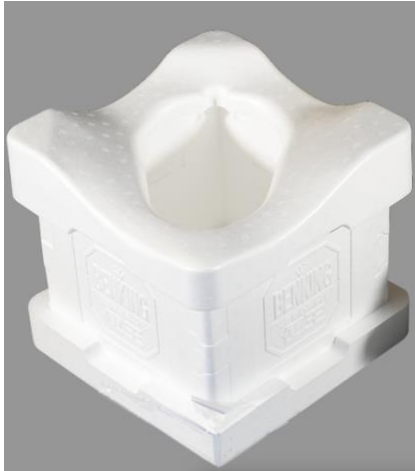


Fig. 3 Main body of BENKING

2.2 Hose, cup, and tank for urine

A urine hose and cup are connected to the BENKING. Use an emergency portable toilet made by MiusenMadoka.



Fig. 4 Piss Cup and Hose

2.3 Portable Washlet

Washlets are common in Japan, but they are not yet common in the world, or of course in space. This function is important from a hygienic point of view, so we would like to add the function of a bidet, but since developing a bidet for space use would be too expensive, we will use a non-electrical handheld bidet.



Fig. 5 Image of Handy Washlet in use

2.4 Deodorizer

To maintain the environment and prevent the spread of odors, deodorizing fans should be provided. deodorizing purifiers made by TOTOSHASHA are used.

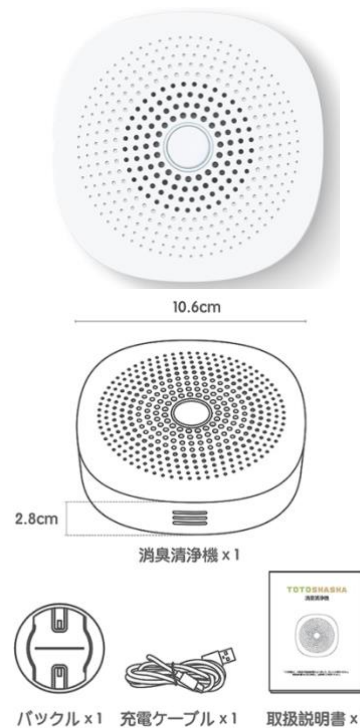


Fig. 6 TOTOSHASHA deodorizing purifier

2.5 Sound deadening function

To maintain privacy and relaxation, a sound deadening function was added: a toilet onomatopoeia device (muffler/flushing sound generator) manufactured by Zhenghua was used.

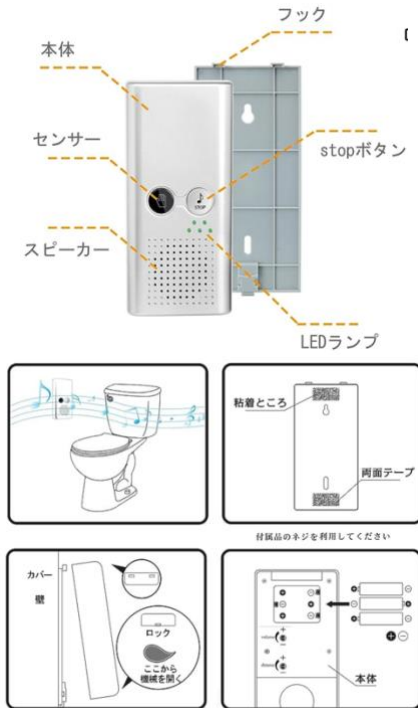


Fig. 7 Toilet onomatopoeia device made by Zhenghua

2.6 Fixation belt

To prevent the body from floating in zero gravity, a fixation belt should be provided.

2.7 Privacy curtain

To ensure privacy, privacy curtains should be provided.



Fig. 8 Image of privacy curtain use

3. Trial production results of Space Benking

3.1 The Space Benking main body

The main body of the Space Benking was used as BENKING is, with no particular modifications.



Fig. 9 Image of Space Benking use

3.2 Hose, cup, and tank for urine of the Space Benking

A commercially available emergency urine cup was connected to the Space Benking. The urine was allowed to accumulate in a 1-liter plastic bottle.



Fig. 10 Hose and cup connection diagram for urinal of Space Benking

3.3 Portable Washlet of the Space Benking

A commercially available portable washlet can be attached to the Space Benking for immediate use as needed.



Fig. 11 Portable Washlet Connection Diagram

3.4 Deodorizer of the Space Benking

A commercially available deodorizer was installed inside the Space Benking.



Fig. 12 Deodorizer installation diagram of the Space Benking

3.5 Sound deadening function

A commercially available sound deadener was attached to the outside of the Space Benking.



Fig. 13 Silencer installation diagram of the Space Benking

3.6 Fixing belt

The plan was to use a fixing belt on the Benking for use in space, but since it was decided to use the toilet only on the ground for trial at this time, the fixing belt was not used.

3.7 Privacy curtain

A commercially available privacy curtain was supposed to be used to ensure privacy, but it was decided to be used in a private room, so the privacy curtain was not used this time.

4. Consideration

First, a conceptual design model of the Space Benking was prototyped by combining the Benking, a simple toilet for disaster prevention, with various functions required for a space toilet that are easily available on the market.

In order to be used in the actual space environment, it is necessary to pump urine and excrement, assuming zero gravity, but this model does not yet include such a function. This is because we believe it is first important that the general public, who may become space travelers, become familiar with the use of such a simple toilet. Of particular importance is the issue of privacy. In the limited space of the spacecraft, people have to do their business with other people around them, and they may be concerned not only about their appearance but also about sounds and smells.

It is also important to become accustomed to the handy Washlet, which is not usually used. In any case, the most difficult problem is how to use the toilet comfortably in an environment with people around. We believe it is important to focus on how to solve this problem first.

Also, if, at this stage of improvement, it becomes possible to use a collection toilet without worrying about privacy, it will be possible to use it in times of disaster in a flexible manner. After becoming accustomed to using simple toilets at this stage, the next step is to make space toilets usable in the zero gravity environment in space. This will be discussed in future research.

5. Conclusions

In this study, a prototype of a space toilet (Space Benking) was developed based on the reference paper [56]. Since it is still at the first prototype stage, it does not have functions for use in space (in zero gravity environment), but we plan to gradually improve and develop it so that it can be used in space.

As mentioned in section 4, it is important not only to develop the space toilet itself, but also to familiarize the astronauts with the use of the toilet in the special environment of a commercial spacecraft (with little privacy). We plan to summarize this area in a future paper.

ASTRAX will continue to take on the challenge of making space a comfortable place to live with the help of the private sector, using commercially available consumer products as much as possible and at as little cost as possible.

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IAC-23-E5.4.3

DEVELOPMENT OF THE SPACE TOILET CALLED "SPACE BENKING" 2023

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Abstract

The era of commercial space travel has begun, and the time has come for people all over the world to go to space. As more and more space travelers will be venturing out into space, training for using the toilet in space will become important, and it will be necessary to become accustomed to using it on a regular basis. In Japan, there is a simple toilet called “Benking” for disaster prevention disaster use. ASTRAX is developing the “Space Benking” together with a company that develops and sells the “Benking” in order to enable space travelers and commercial astronauts to use more comfortable toilets

during space flight.

In this paper, we present the latest development status of the “Space Benking” and the progress of the plan.

アブストラクト

民間宇宙旅行時代が始まり、世界中の人たちが宇宙に行ける時代がやってきました。これからたくさんの宇宙旅行者が宇宙に飛び出していくようになると、宇宙でのトイレの利用のトレーニングが重要になり、普段から使用することに慣れておく必要があります。日本には、防災 & 災害用の簡易トイレとして「ベンキング」というものがあります。形状は発泡スチロール製のトイレで、排泄物を固めて捨てられる構造になっているため、水洗トイレとは異なり、水や電気がなくても利用できるものです。ASTRAX では、この「ベンキング」の開発・販売企業と共に、宇宙旅行者及び民間宇宙飛行士が宇宙飛行中のより快適なトイレが利用できるようにするために、「宇宙ベンキング」の開発を進めています。本論文では、「宇宙ベンキング」の最新の開発状況や計画の進捗状況を発表します。

Keywords: Toilet, Space Toilet, BENKING, Space Benking

Acronyms/Abbreviations

ベンキング: 発泡スチロール製災害用簡易トイレ
ウォシュレット: 日本では一般的なトイレ用洗浄シャワー

本論文では、ベンキングから宇宙ベンキングに改良していく過程をまとめる。2 項で、ベンキングに追加する必要がある改良の方針について、3 項で、実際に試作したものの状況をまとめる。

1. Introduction

ASTRAX では、いかにコストをかけずに、市販されている民生品を使って、民間の力で宇宙開拓を行なっていくかということに日々挑戦している。

2022 年にパリで開催された国際宇宙会議で発表した論文(参照論文「」)の4 項でまとめた宇宙用トイレ「宇宙ベンキング」の概念設計検討結果に基づいて試作を行なった。ただし、今回は地上での使用を想定している。



図 1 ベンキング



図 2 使用イメージ

2. ベンキングを宇宙ベンキングにするための改良方針

ベンキング本体を改造し、小使用ホース、小使用カップ、小使用タンク(ペットボトル)、ポータブルウォシュレット、清掃用除菌ウェットティッシュ、固定用ベルト、脱臭機、音消し機能を追加することにする。それぞれの追加項目についての内容を以下に示す。

2.1 ベンキング本体

ベンキング本体は改修を加えず、そのまま使用する。

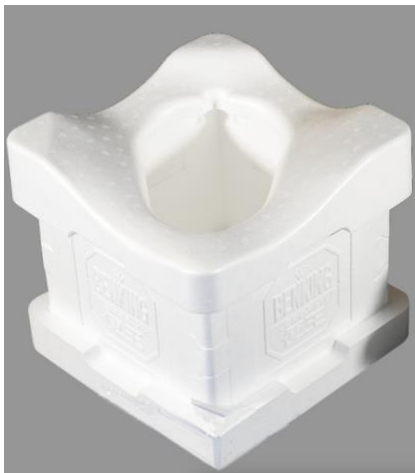


図 3 ベンキング本体

2.2 小使用ホース・カップ・タンク

ベンキングに小使用ホースとカップを接続して使用する。小便是ペットボトルに蓄積されるようにする。MiusenMadoka 製非常用携帯トイレを使用。



図 4 小使用ホースとカップ

2.3 ポータブルウォシュレット

日本ではウォシュレットが一般的であるが、世界でも、もちろん宇宙でもまだウォシュレットは一般的ではない。この機能は衛生的に重要であるため、ウォシュレットの機能を追加したいが、ウォシュレットを宇宙用に開発するとコストが高いため、電気を使わないハンディウォシュレットを使用することにする。KOKUBO 製 BotLLet 携帯用おしり洗浄具を使用。



図 5 ハンディウォシュレット使用イメージ

2.4 脱臭機

環境維持と臭いの拡散を防ぐために、消臭ファンを備え付けるようにする。TOTOSHASHA 製の消臭清浄機を使用。

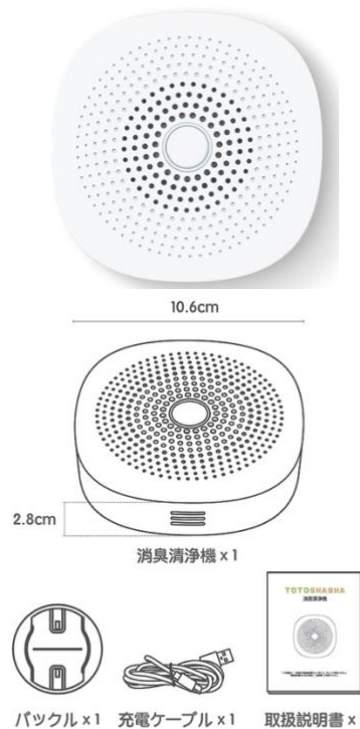


図 6 TOTOSHASHA 製の消臭清浄機

2.5 音消し機能

プライバシーの維持とリラックスのために、音消し機能を追加する。Zhenghua 製のトイレ用擬音装置 (消音器・流水音発生器)を使用。

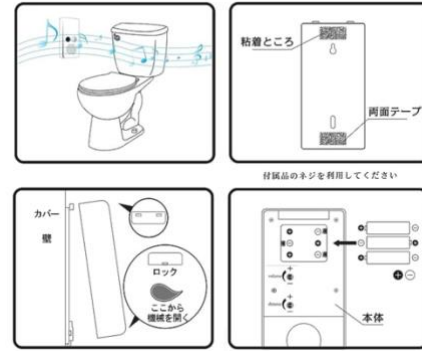


図 7 Zhenghua 製のトイレ用擬音装置

2.6 固定用ベルト

無重力で身体が浮かないように、固定用ベルトを備え付けるようにする。

2.7 プライバシーカーテン

プライバシーを確保するために、プライバシーカーテンを備え付けることにする。



図 8 プライバシーカーテン使用イメージ

3. 試作結果

3.1 ベンキング本体

ベンキング本体は特に改修を加えず、そのまま使用した。

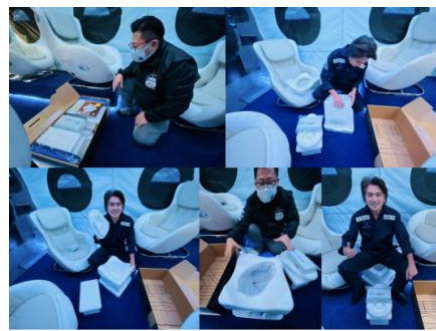


図 9 宇宙ベンキング使用イメージ

3.2 小使用ホース・カップ・タンク

市販の緊急用小便カップをベンキングに接続した。小便は1リットルのペットボトルに蓄積されるようにした。
(写真は差し替える予定)



図 10 小使用ホース・カップ接続図

3.3 ポータブルウォシュレット

市販のポータブルウォシュレットをベンキングに装着できるようにし、必要に応じてすぐに利用できるようにした。
(写真は差し替える予定)



図 11 ポータブルウォシュレット接続図

3.4 脱臭機

市販の脱臭機をベンキングの内部に装着した。
(写真は差し替える予定)



図 12 脱臭機装着図

3.5 音消し機能

市販の消音器をベンキングの外部に装着した。



図 13 消音機装着図

3.6 固定用ベルト

宇宙での使用を想定し、固定用ベルトをベンキングに固定する予定だったが、今回は地上試験での使用にとどめることになったので、固定用ベルトは使用しなかった。

3.7 プライバシーカーテン

市販のプライバシーカーテンを使い、プライバシーの確保を行う予定だったが、今回は個室で使用することにしてプライバシーカーテンは使用しなかった。

4. 考察

まずは防災用簡易トイレであるベンキングに、宇宙トイレとして必要となるさまざまな機能のうち、市販品で簡単に手に入るものを組み合わせて宇宙ベンキングの概念設計モデルを試作した。

実際の宇宙環境で利用するためには、無重力状態であることを想定して、小便や大便をポンプで吸引する必要があるが、今回のモデルではまだその機能は含んでいない。まずは、このような簡易なトイレを、宇宙旅行者となる可能性がある一般人が使い慣れることが重要だと考えているからである。特に重要なのは、プライバシーの問題である。宇宙船内の限られた空間の中で、周りに他人がいる状態で用を足さなければならないが、姿だけでなく、音や臭いも気になるだろう。

また、普段は利用しないハンディウォシュレットに慣れることも重要である。いずれにしても、周りに人がいる環境の中で、いかに快適にトイレを利用するかということが1番難しい問題である。まずはその部分をいかに解決するかについて重点的に対応することが重要であると考えます。

また、ここまでの改良の段階で、プライバシーを気にせず回収型のトイレができるようになれば、災害時なども臨機応変に利用することができるようになるだろう。ここまでの段階の簡易トイレを使い慣れた上で、次の段階として、宇宙での無重力環境において、宇宙用トイレが利用できるようにする必要がある。それについては、今後の研究の中で検討していく予定である。

5. 結論

今回は、参考論文「」に基づいて、実際に宇宙用トイレ（宇宙ベンキング）の試作を行った。まだ、最初の試作段階であるため、宇宙で（無重力の環境で）使用するための機能は有していないが、今後徐々に改良・開発を行なっていく、宇宙で使用できるようにしていく予定である。

また、4項にも書いたが、宇宙用トイレ自体の開発だけでなく、民間宇宙船の中という特殊な環境（プライバシーがほとんどない状態）の中で、トイレを使うということに慣れておくことが重要で、そのための体験設備や訓練施設を作ることにも必要となってくる。その辺りについては、今後の論文でまとめていく予定である。

ASTRAX ではこれから、なるべく市販の民生品を使って、極力コストをかけずに、民間の力で宇宙を快適に生活できる場にしていくことに挑戦していく。

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50 以上の宇宙事業を含む ASTRAX の宇宙事業の概要

【3】 ASTRAX Zero Gravity Flight Services In Japan,
日本における ASTRAX 無重力飛行サービス

【4】 ASTRAX Lunar City Development
Project, ASTRAX 月面都市開発プロジェクト

【5】 ASTRAX Space Services Platform By Using
Blockchain Technology,
ブロックチェーン技術を活用したアストラックス
宇宙サービスプラットフォーム

【6】 ASTRAX Universal Service Platform By Using
Blockchain Technology,
ブロックチェーン技術を活用した ASTRAX のユニ
バーサルサービスプラットフォーム

【7】 Mission Control Center To Support Commercial
Space Missions And Passenger S Activities Inside Of
The Cabin,
商業宇宙ミッションと乗客の機内活動を支援する
ミッションコントロールセンター

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Space Flight Support Educational System,
ASTRAX ACADEMY と宇宙ビジネス・宇宙飛行支
援教育システム

【9】 Mission Support Control Center And Suborbital
Spacecraft Simulator To Support Commercial Space
Missions And Customer Activities,
商業宇宙ミッションと顧客活動を支援するミッシ
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ミュレータ

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Support Commercial Space Missions And Customer
Activities Inside Cabin,
Zero G-Naut と商業宇宙ミッションと顧客活動を支
援するミッションコマンダー（船内）

【11】 Space Scooter”: Space Mobility System Used
In Space Hotels And Space Stations,
「スペーススクーター」宇宙ホテルや宇宙ステー
ションで使用する宇宙移動システム

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2020,
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Using Blockchain Technology,
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市経済システム

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宇宙旅行のための ASTRAX 宇宙サービスカタログシステム

【15】 ASTRAX Universal Service Platform By Using Blockchain Technology,
ブロックチェーン技術を活用した ASTRAX ユニバーサルサービスプラットフォーム

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日本の COVID-19 問題から得た経験と教訓、そして宇宙旅行への適用

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ゼロ G 飛行士とミッションコマンダーが、商業宇宙ミッションと顧客活動を機内でサポートする

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スペースフライトアテンダントと SFA アカデミーという新しいビジネスの創出

【19】 The Importance Of Kimono In Space, 宇宙での着物の重要性

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【23】 Initiative of development of the Solar System Economic Bloc by Using Blockchain Technology
ブロックチェーン技術を活用した太陽系経済圏構築構想

【24】 Space Fashion and Space Culture in the Age of Space Travel and the Possibilities of "Space Hagoromo"
宇宙旅行時代の宇宙ファッションと宇宙カルチャー及び 宇宙羽衣”の可能性

【25】 Making ASTRAX ACADEMY Online and Multilingual
「ASTRAX ACADEMY」のオンライン化と多言語化

【26】 Potential Future Plan of Space Izakaya as a Place to Create New Private Space Business
新たな民間宇宙ビジネス創出の場としての宇宙居酒屋の将来性

【27】 Fostering Universal Human Resources and Super Newtypes for the Space Age
ユニバーサル人材の育成と宇宙時代のスーパーニュータイプの養成

【28】 Demand and Supply Matching by the ASTRAX LUNAR CITY Business Community and Residence Club
ASTRAX 月面シティのビジネスコミュニティとレジデンスクラブによる需要と供給のマッチング

【29】 Outline of ASTRAX Private Space Business Creation Education and Training Center
ASTRAX 民間宇宙事業創出教育訓練センターの概要

【30】 Prototype plans for various commercial spacecraft training simulators
さまざまな民間商用宇宙船訓練用シミュレータの試作計画

【31】 Experiments on Coloring Soap Bubbles under Microgravity
微小重力下でのシャボン玉の着色に関する実験

【32】 Study of the selection of location for commercial spaceports in Japan
日本における商業宇宙港の立地選定に関する研究

【33】 Space Radiation Shielding by Water Dome in ASTRAX Lunar City on the Moon
ASTRAX 月面シティのウォータードームによる宇宙放射線の遮蔽

【34】 Introduction of a practical example of ASTRAX Lunar City mapping with Minecraft and its linkage to Economic Activities on Earth
マインクラフトを使った ASTRAX 月面シティのマップングの実践例と地球上の経済活動との連携の紹介

【35】 Development of a Civilian Spacecraft Interior Simulator Using Minecraft
マインクラフトを用いた民間宇宙船内部シミュレーターの開発

【36】 Proposal to Add a Space Economics Subcommittee to the UN Office for Outer Space Affairs' Committee on the Peaceful Uses of Outer Space(COPUOS in UNOOSA)
国連宇宙局の「宇宙空間の平和利用に関する委員会」(COPUOS in UNOOSA)に「宇宙経済小委員会」を追加する提案

【37】 The Gender Gap and Its Impact in Manga, Anime and Other Space Creations
マンガ・アニメなどの空間演出におけるジェンダー・ギャップとその影響

【38】 Career Design in Space - From Challenged to Challenging
宇宙でのキャリアデザイン - 挑戦者から挑戦者へ

【39】 The Effects of Using Minecraft to Teach Children about Space

マインクラフトを使って子どもたちに宇宙を教える効果

【40】 Maintaining the Health of Pilots and Crew
パイロットとクルーの健康維持

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月面ビレッジでの鶏卵市場の創設についての検討

【42】 Consideration of the future prospects of the Space Flight Attendant (SFA) profession with the expansion of space travel marketing
宇宙旅行マーケティングの拡大に伴うスペースフライトアテンダント (SFA) という職業の将来性についての考察

【43】 Problems and Solutions that are Preventing More Women from Becoming Space Tourists
宇宙旅行者になる一般女性を増やすことを妨げている問題点と解決方法

【44】 人工衛星を使用した宇宙時代の平和思考と社会経済学 (ワンスマイルファンデーションシステム)

【45】 最新型宇宙サービスアクセスアプリケーションツール「ASTRAX U2U (Universal User Interface)」

【46】 Development of a Teripper for intra-spacecraft transportation,
宇宙船内移動用テリッパの開発

【47】 Possibility of Zero-Gravity Flight Service by MRJ (Mitsubishi Regional Jet),
MRJ による無重力飛行サービスの可能性

【48】 Development of ASTRAX commercial spacecraft education and training simulator,
ASTRAX 民間宇宙船教育訓練シミュレーターの開発

【49】 Development of Space Shower,
宇宙シャワーの開発

【50】 Production of space suits and replicas for space travel,
宇宙旅行のための宇宙服とレプリカの製作

【51】 ADVANCED SPACE SERVICE ACCESS APPLICATION TOOL "ASTRAX UNIVERSAL USER INTERFACE (ASTRAX U2U)",
先進の宇宙サービス利用アプリケーションツール
「ASTRAX Universal User Interface (ASTRAX U2U) 」

【52】 ASTRAX Solar System Economic Bloc Concept using NFT and Metaverse Technologies,
NFT とメタバース技術による ASTRAX 太陽系経済圏構想

【53】 Development of a Real-life (Analog) ASTRAX Lunar City Construction Project in Japan,
日本におけるリアル (アナログ) ASTRAX 月面シティ構築計画

【54】 Multilingualization of ASTRAX ACADEMY,
ASTRAX ACADEMY の多言語化

【55】 Possibility of zero-gravity flight and space flight by people with disabilities,
障がい者による無重力飛行と宇宙飛行における可能性

【56】 Development of Space Toilet "Space BENKING" in Japan,
宇宙用トイレ「宇宙ベンキング」の開発

【57】 Disaster prevention and evacuation technologies on Earth and their application to space travel,
地球上の防災・避難生活技術と宇宙旅行への応用

【58】 Cleaning Methods for Reusing Clothes in Space,
宇宙で衣類を再利用するための洗浄方法

【59】 How to Go to Space with Different Hairstyles,
さまざまなヘアスタイルで宇宙へ行く方法

【60】 Research on Psychological Changes and Growth of Children through Education Related to Commercial Space Business,
商業宇宙事業に関連した教育による子どもの心理的变化・成長に関する研究

【61】 What do they need for a space museum?,
宇宙ミュージアムに必要なものは？

【62】 Establishment and development of a lunar community and activity space by children for children,
子どもによる子どものための月面コミュニティ・活動空間の構築と発展

【63】 video editing services for space travellers,
宇宙旅行者のためのビデオ編集サービス

【64】 technologies on a transparent restroom could be used for lunar habitats,
透明なトイレの技術は、月面基地にも応用できる

【65】 ASTRAX Lunar City Project 2022,
ASTRAX 月面シティプロジェクト 2022

【66】 The need for a space version of hand signals, a communication tool for space travelers,
宇宙旅行者のコミュニケーションツール、宇宙版ハンドシグナルの必要性

【67】 Photography services and techniques required for space travel,
宇宙旅行に必要な写真撮影サービス・技術

【68】 On images of the universe influenced by manga and anime,
マンガやアニメの影響を受けた宇宙像について

【69】 A space education program to solve the shortage of commercial space teachers in Japanese schools,

日本の学校における民間宇宙講師不足を解消するための宇宙教育プログラム

【70】 How to capture the cosmic diversity that is coming,
これからやってくる宇宙の多様性をどう捉えるか

【71】 The Role of Space Flight Attendants in Large, Long-duration Space Travel,
大規模・長期間の宇宙旅行におけるスペースフライトアテンダントの役割

【72】 Proposal for a business model that enables and encourages older adults to travel to space,
高齢者の宇宙旅行を実現・促進するビジネスモデルの提案

【73】 Development of ASTRAX Zero Gravity Aircraft Education and Training Simulator
ASTRAX 無重力飛行機教育訓練シミュレーターの開発

【74】 Developing technology for drinking chilled carbonated beverages in space
宇宙で炭酸飲料を飲むための技術開発

【75】 Development of commercial spacecraft education and training simulator using the Metaverse
メタバースを利用した民間宇宙船教育訓練シミュレーターの開発

【76】 Construction plan of ASTRAX LUNAR CITY Simulation Facility in Japan
日本における ASTRAX 月面シティシミュレーション施設の構築計画

【77】 Development of the space toilet called "Space Benking" 2023
宇宙用トイレ「宇宙ベンキング」の開発 2023

【78】 Introduction of commercial space R&D center "ASTRAX LAB" in Japan

日本における民間宇宙開発センター「ASTRAX LAB (アストラックスラボ)」の紹介

【79】 Analysis of passengers' needs and demands of ASTRAX Zero Gravity Services and application for space travel services
無重力飛行サービスに対する乗客のニーズ・要望の分析と宇宙旅行サービスへの応用

【80】 The senses and creativity that can be achieved by bringing entertainment in space
宇宙空間でエンターテインメントを実現することで得られる感覚と創造性

【81】 Technology, problems and solutions for drinking alcohol in space
宇宙空間でお酒を飲む際に必要な技術と問題点および解決方法

【82】 Technology, problems, and solutions for space travel meals as represented by "yakitori", grilled chicken
焼き鳥に代表される宇宙旅行での食事に必要な技術と問題点および解決方法

【83】 The Possibility of Developing Japanese Culture through "NATTO" in Space
宇宙空間における納豆を通じた日本文化の展開の可能性

【84】 Local revitalization project to turn my hometown, Komono Town, into "space town"
故郷の菰野町を「宇宙の町」にする地方活性化プロジェクト

【85】 Methods and Practices for Introducing Private Space Education Programs into Japanese Schools
民間宇宙教育プログラムを日本の学校現場に導入する方法と実践

【86】 Development of a "lunar pattern okonomiyaki" baking method to help promote tourism in a lunar city

月面シティの観光振興に貢献する「月面模様お好み焼き」の焼き方開発

【87】 Space Education and Nutrition Education Using
"Solar Planet Takoyaki
「太陽惑星たこ焼き」を利用した宇宙教育と食育

【88】 Application of activities on luxury cruise ships
to space tourism vessels
豪華客船内アクティビティの宇宙観光船への応用

【89】 Astrology in the Space Age: What will happen
to the horoscopes of those born on the Moon?
宇宙時代における占星術 月生まれの人のホロスコープはどうなるの？

【90】 Exploring the Concept and Potential of Space
Museums for Preservation, Education, and Tourism
保存・教育・観光のための宇宙ミュージアムのコンセプトと可能性を探る

【91】 Building a Lunar Community for Children:
Challenges of Cooperation and Simulating Team
Building 子どものための月面コミュニティづくり：
協力への挑戦とチームビルディングの模擬体験

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