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PRELIMINARY SYSTEMS REQUIREMENTS FOR THE SPACE TOILET ON THE SPACE TRAIN

Akira Tsuchida[1)]

[1)] Earth-Trcak Corporation, Japan

akira.tsuchida@earth-track.com

Amie Allison[2)], Koo Ue[3)]

[2)] Earth-Trcak Corporation, USA

[3)] Japan Toilet Laboratory, Japan

amie.allison@earth-track.com

koo_ue@toilet.or.jp

ABSTRACT

The Space Train will experience a climb and descent from and to the ground resulting in gradual gravitational acceleration changes from 1G to 0G and back to 1G. In this manuscript, the preliminary systems requirement for the Space Toilet on the Space Train is described. There are four separate Space Toilet requirements included since there are two types of trains and two Space Stations. One Train type is the limited express, called "Earth Express", bound for the "Earth View Station", which is located in 1200 km from the surface of Earth. The other Train type is the sleeper car, called "Galaxy Express", bound from the "Earth View Station" for the "Geo-synchronous Station".

1. REVIEW – JAPANESE SPACE TRAIN ARCHITECTURE[1)]

There are two manned space station called “Earth View Station”, which is located at 1,200km from the ground, and “Geosynchronous Station”, which is located on GEO. (Fig. 1)

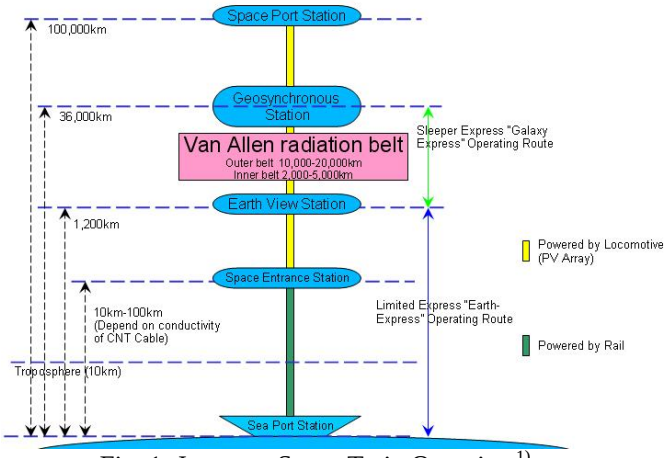

Fig. 1: Japanese Space Train Overview[1)]

For the manned Train between the ground and the orbit, there are two kinds of train are there. 1st one is called “Earth Express” servicing between Sea Port Station and Earth View Station. It takes 3 hours.

One more train is called “Galaxy Express” servicing between Earth View Station and Geosynchronous Station. It takes 60 hours.

2. MINIMUM REQUIREMENT FOR TOILET

As described above, there are 4 possible toilet places on the Space Train System. We estimate number of users (passengers, staff members) and minimum operation days as the first things to make requirement for Space Toilet. Then, we estimate amount of Human Waste.

2.1 Number of user and Minimum Operation days

Refer Table 1 in detail with each explanation below.

2.1.1 Space Train Earth Express

	Space Train Earth Express	Earth View Station	Space Train Galaxy Express	Geosynchronous Station (GEO)
Duration of use	2-3 hours	All day	60 hours	All day
Altitude	0m-1200km (1G – 0.71G)	1200km (0.71G)	1200km-36000km (0.71G – 0G)	36000km (GEO) (0G)
Number of user	18 2+16 per one passenger car	914 18 x 4 passenger cars x 4 rails x 3 + 50 staff members	12 4+8 per one passenger car	386 12 x 4 passenger cars x 1 rail x 7days + 50 staff members
Notes	There are 4 passenger cars	Passenger can stay 10 hours here	There are 4 passenger cars	Passenger can stay 7 days maximum
Minimum Operation Time (Days)	1	7	10	10
Contingency Operations Concept	Emergency re-entry and Splashdown	Stay 7 days maximum to wait for rescue team from Geosynchronous Station	Stay 7 days maximum to wait for rescue team from Geosynchronous Station	Stay at Geosynchronous Station until rescue team arrival (10 days) (Use redundant Space Train System)

Table 1 Number of user and Minimum Operation days

There are 2 cabin attendant and 16 passengers in one passenger car. Even in case of emergency, this train will do re-entry and Splashdown right a way. So Minimum Operation time is one day.

2.1.2 Earth View Station

Earth View Station is designed for the place where passengers came from the Sea Port Station visit as day trip. Each train Earth Express has four passenger cars. Assuming 4 rails are available between Sea Port Station and Earth View Station. Also assuming passenger does not go back right a way and they may take 3rd train after their arrival.

At the Earth View Station, there are 50 staff members are working.

As a result, there are total 914 people will be there. (See Table 1 in detail)

In case of Emergency, rescue will visit from Geosynchronous Station (not from the Sea Port Station). We should assume taking 7days to have rescue.

2.1.3 Space Train Galaxy Express

There are 4 cabin attendant and 8 passengers in one passenger car (Sleeper car). In case of emergency, this train will wait for rescue for 7 days.

This means nominal 3 days to travel to GEO and 7 reserved days should be added. (Total 10 days)

2.1.4 Geosynchronous Station

Geosynchronous Station is designed for the place where passengers came from the ground visit as week trip. Each train Galaxy Express has four passenger cars.

At the Geosynchronous Station, there are 50 staff members are working.

As a result, there are total 386 people will be there. (See Table 1 in detail)

In case of Emergency, rescue will visit from other Geosynchronous Station of Space Train System. We should assume taking 10 days to have rescue.

2.2 Estimation of amount Human Waste

Next step is calculation for amount of Human Waste. Assuming amount of Urine is 1.5 liters per day per person, 150g of feces per day per person.

Looking at Table 2 on Earth View Station column, amount of urine becomes 10 metric tons and 1 metric tons feces.

If we use water for flush on the Earth-View Station, almost 200 metric tons water is required.

3. VARIATION OF TOILET ON THE EARTH

One of the purpose o this study is to evaluate if we can use various of toilet technology on the Earth for Space Toilet. In this section, we will review technologies of toilet for the ground.

3.1 Summary

	Space Train Earth Express	Earth View Station	Space Train Galaxy Express	Geosynchronous Station (GEO)
A: Number of user	18	914	12	386
B: Maximum Operation Time (Days)	1	7	10	10
Total Man-days (A x B)	18	6398	120	3860
Amount of Urine (1.5 liters /day/person)	27 liters	9,597 liters (10 metric tons)	180 liters	5,790 liters (6 metric tons)
Amount of Feces (150g /day/person)	2.7 kg	959.7kg (1 metric tons)	18 kg	579 kg
Amount of flush water, if we use flush Toilet 5 flush /day/person (6 liters / flush)	540 liters	191,940 liters (192 metric tons)	3,600 liters (3.6 metric tons)	115,800 liters (116 metric tons)

Table 2 Estimation of amount of Human Waste

		Flush water	Sludge/Non-Recycled Waste	Oder manage-ment	Urine and feces separation	Processing Cycle
Flush Toilet	Sanitary Sewer	***	**	Water		
	Septic Tank	***	**	Water		
	Portable Toilet	*	**	Water		
Mountain Toilet (Including field use)	Composting Toilet (Ex.1) (Biological Processing)	*	*	Waste Isolation		Months through year
	Chemical Processing Toilet	*	**	Waste Isolation		Days
	Portable Toilet	*	***	---		
	Portable Toilet (Ex.2) (Personal Use)	Zero	****	Solidification		(Incineration)
Toilet for Disaster Situation (Ex: Earthquake)	Portable Toilet	Zero	****	---		
	Portable Toilet (Wrapped) (Ex.3)	Zero	****	Wrapping/ Solidification		(Incineration)
	Dehydration Process	*	**	Deodorizing equipment		Hours
Green Toilet for developing country (Ex.4)		Zero	*	Separation	X	Months through year
Ref: ISS Toilet		*	***	Fan	X	(Feces: Incineration)

Table 3 Variation of Toilet on the Earth

In developed country like Japan, we are using flush toilet using Sanitary Sewer. It requires much water and huge sewage disposal plant.

But even if you are living in developed country, when you go to the mountain area, you may see several kinds of toilet system which does not require sewer.

You may see composting Toilet, Chemical Processing toilet, Portable Toilets.

If you have an earthquake, sewage pipe is destroyed and many people are looking for toilet. To resolve this demand, 'Disaster Toilet' exists. One of big issue in disaster situation is Waste management. People can not find when they put

	Processing Method	Electricity	Water	Waste		Airflow
				Contents	Amount	
Processed onboard	Biological Processing	**	Zero	Filtered Solid Particle	*	Not Required
	Dehydration Processing	***	Zero	Dehydrated Powder	* (Very little)	Required
	Chemical Processing	***	***	Sludge	*	Not Required
Non-Processed onboard	Portable Toilet	Zero	Zero	Plastic Bag and Solid Waste	**	Not Required
	Portable Toilet (Wrapped)	*	Zero	Plastic Bag and Solid Waste	**	Required
	ISS Toilet (Vacuum and Stow)	**	*	Solid Feces	**	Required

Table 4 Possibility of Space Toilet Processing

	Space Train Earth Express	Earth View Station	Space Train Galaxy Express	Geosynchronous Station (GEO)
Amount of Urine (1.5 liters /day/person)	27 liters	9,597 liters (10 metric tons)	180 liters	5,790 liters (6 metric tons)
Amount of Feces (150g /day/person)	2.7 kg	959.7kg (1 metric tons)	18 kg	579 kg
Amount of flush water, if we use flush Toilet 5 flush /day/person (6 liters / flush)	540 liters	191,940 liters (192 metric tons)	3,600 liters (3.6 metric tons)	115,800 liters (116 metric tons)
Recommended Processing Methods: (Ref: Backup Chart 1)	Bring back to the Earth	Urine: Chemical Processing and water Re-generation Feces: Option 1: Bring up to GEO Station Option 2:Dehydration to reduce waste stowage volume	Urine: Chemical Processing and water Re-generation Feces: Option 1: Bring up to GEO Station Option 2:Dehydration to reduce waste stowage volume	Urine: Use for Space Agriculture garden as Liquid fertilizer with water Faces: Composted and used as fertilizer and soil improvement materials

Table 5 Space Toilet on Space Train – Trade Off

their Urine, Feces, and papers. Some type of toilet has capability of dehydration so that Human Waste can be smaller. One another problem is odor. Some type of toilet has a capability to wrap Human Waste immediately to minimize odor.

Refer Table 3 for variation of Toilet on the Earth.

4. SPACE TOILET ON SPACE TRAIN – TRADE OFF

Based on review result of Toilet for the ground, we made possibility of Space Toilet Processing list on Table 4.

Then we made recommendation for each toilet for four toilets of Space Train System on Table 5.

5. CONCLUSION

The following things should be considered as

system requirement for Space Train Toilet

- Minimize Water usage for Flush
- Urine should be recycled and re-generated water
- Volume and weight of feces should be minimized. Composted and used as fertilizer, if possible

Recommended processing methods and evaluation if we can directory use technologies on the Earth for Toilets for four facilities for Space Train System are as follows:

- Earth Express as 3 hours Express Cars
  - Can use toilet on the earth (1 – 0.7G)
  - Urine/ Feces Separation, Simple Accumulation and bring down to the Sea Port Station
- Earth View Station as a facility where many one day trip passengers visits
  - Can use toilet on the earth (0.7G)
  - Urine: Urine Processing/Water Re-generation
  - Feces: Bring up to Geosynchronous Station (possibly after dehydration)
- Galaxy Express as 60 hours Sleeper Express cars
  - Urine: Urine Processing/Water Re-generation
  - Feces: Bring up to Geosynchronous Station
- Geosynchronous Station (GEO) as a central facility of Space Train System (assumed there is Space Agriculture garden)
  - Urine: use for Space Agriculture garden as Liquid fertilizer by water added
  - Feces: composted and used as fertilizer and soil improvement materials

References

1) Akira Tsuchida, Amie Allison: Japanese Space Train Concept, 60th International Astronautical Congress, Daejeon, Republic of South Korea, 2009