日本発の再使用型有翼サブオービタル機とマイクログラビティ応用について

○眞鍋顕秀，留目一英，大山よしたか，保田晃宏，浅井達郎，淺田正一郎，大貫美鈴，辻正隆
(SPACE WALKER)，米本浩一，藤川貴弘（九州工業大学）

Japanese Reusable Winged Suborbital Plane and Its Application to Microgravity Experiment

○Akihide MANABE, Kazuhide TODOME, Yoshitaka OYAMA, Akihiro YASUDA, Tatsuro ASAI, Shoichiro ASADA, Misuzu ONUKI, Masataka TSUJI (SPACE WALKER), Koichi YONEMOTO and Takahiro FUJIKAWA (Kyushu Institute of Technology)

1. Introduction

SPACE WALKER Inc. is one of the space development startups recently established in Japan, which undertakes the development and operation of fully reusable winged suborbital plane (Fig. 1).

SPACE WALKER takes over the Japanese reusable space transportation engineering heritage such as winged suborbital rocket HIMES studied by ISAS of Ministry of Education and unmanned orbital space shuttle HOPE-X by NASDA of Japan, the former agencies of JAXA, and their enhancing technologies based on the experimental winged rockets development by Kyushu Institute of Technology since 2005 in cooperation with Japanese aerospace and non-aerospace companies [1].

SPACE WALKER has a top management executives consisting of both the young generations entrepreneurs with new business ideas so-called “New Space” and the former executives and engineers involved in space development called “Legacy Space” (Fig. 2). The young “New Space” executives have been working as creative director, accountant, investment consultant, finance manager, lawyer, and so on. The “Legacy Space” executives, on the other hand, have contributed to the important space development programs of Japan since the 1980's including satellites and expendable rocket development, and reusable space transportation researches [2].

Fig. 2 SPACE WALKER employees of new and legacy generations

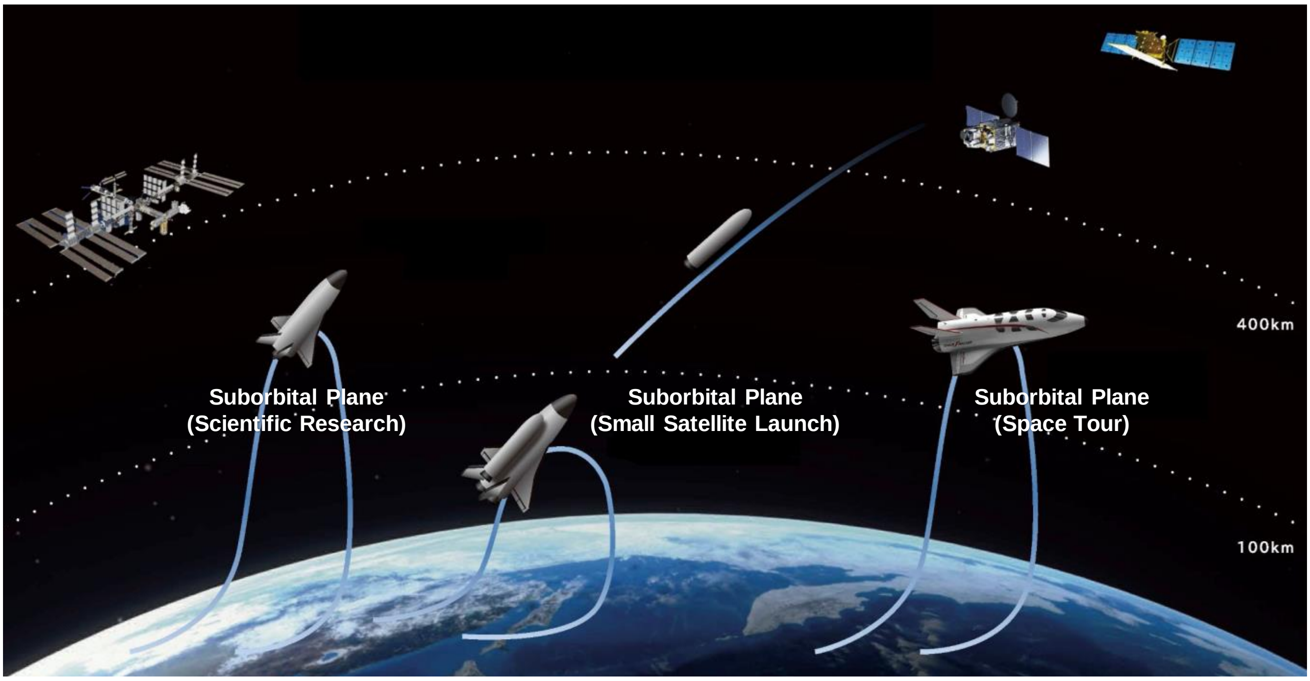
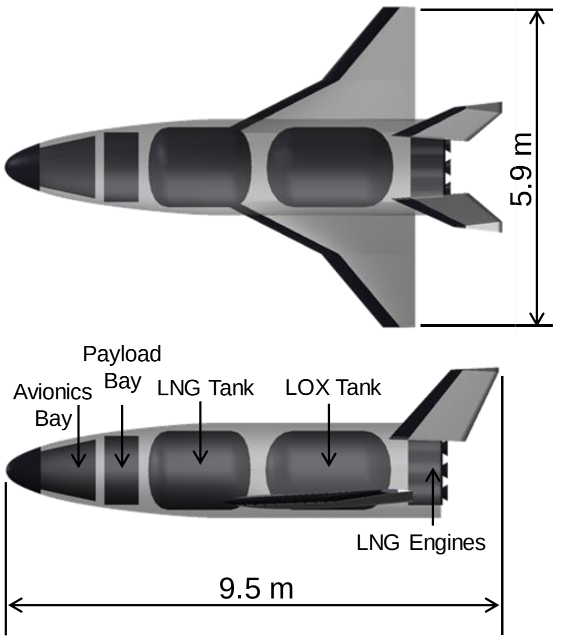


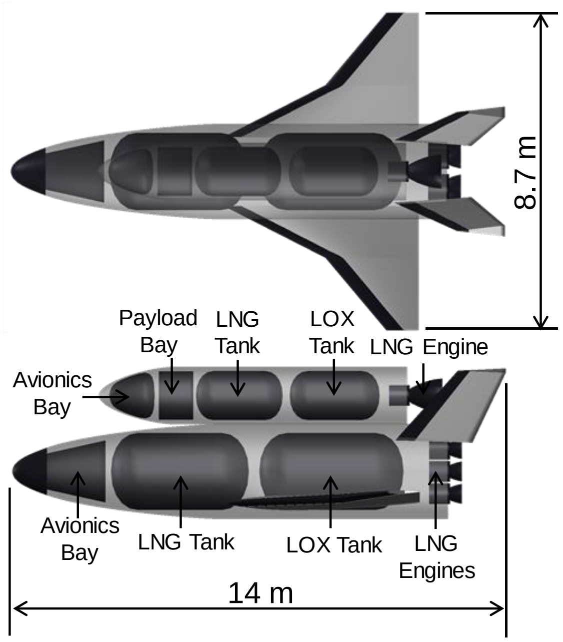
Fig. 1 SPACE WALKER’s suborbital planes

2. Development and Business Plan

SPACE WALKER aims at the development and operation of a simple unmanned suborbital plane for the purpose of scientific research such as microgravity experiments, ignorosphere observation, astronomy, remote sensing and education, then a larger size suborbital plane for both the small satellite launch to the low earth or sun synchronous orbits and higher altitude suborbital service for scientific purpose, and finally a manned suborbital plane for space tourism (Fig. 3).

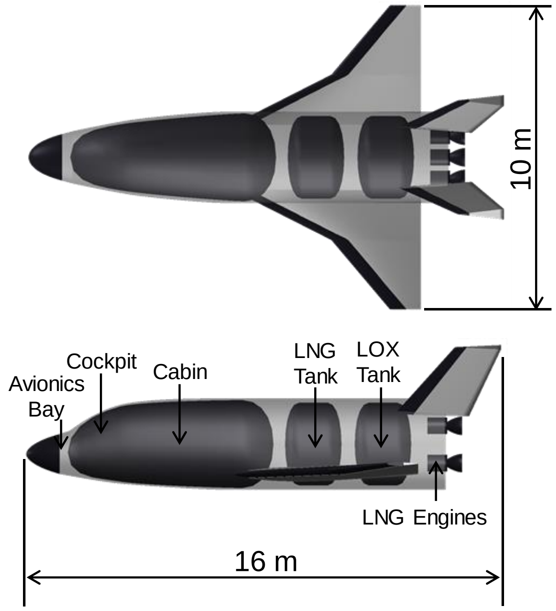


(Scientific Research)



(Small Satellite Launch)

Fig. 3 Two-view drawings of suborbital plane (to be continued)



(Space Tourism)

Fig. 3 Two-view drawings of suborbital plane (to be concluded)

The main specifications of suborbital planes are summarized in Table 1.

Table 1 Specifications of suborbital plane

Missions		Scientific Research	Small Satellite Launch	Space Tourism
Payload		100kg	100kg	2 Pilots 6 Passengers
Operation		Altitude 120km	SSO*1 700km	Altitude 120km
Takeoff & Landing		VTHL*2	VTHL	HTHL*3
Length		9.5 m	14 m	16 m
Span Width		5.9 m	8.7 m	10 m
Initial Mass		6.3 ton	30.2 ton	18.7 ton
Propellant		LOX*4 /LNG*5	LOX/LNG	LOX/LNG
Engine	Thrust (vacuum)	23 kN	97 kN	97 kN
	I_{SP}(vacuum)	273 sec	338 sec	338 sec
	No.	4	6	3
	Expansion Ratio	4.6	25	25

*1 Sun-Synchronous Orbit
*2 Vertical Takeoff and Horizontal Landing
*3 Horizontal Takeoff and Horizontal Landing
*4 Liquid Oxygen
*5 Liquid Natural Gas

The first flight of the suborbital plane for scientific research will be in 2023 and put into operational services from 2022. The development and operation related facility cost is estimated around 100 million US$. The next suborbital plane for small satellite launch will have its first flight test in 2025 with the total development cost of 500 million US$. The development cost of the suborbital plane for the space tour is estimated around 1 billion US$, and it will have the first flight test in 2027 and commercially operated from 2028.

3. Microgravity Conditions

The trajectory and flight profile of suborbital plane for the scientific research is shown in Fig. 4 and Fig. 5 respectively.

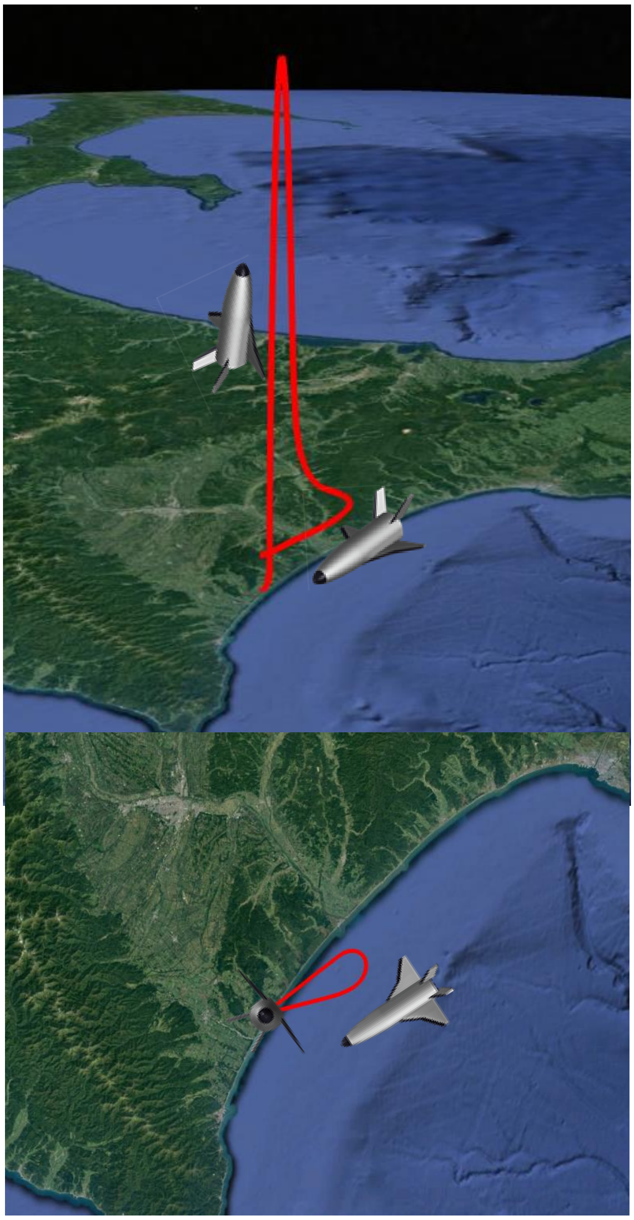


Fig. 4 Trajectory of suborbital plane for scientific research

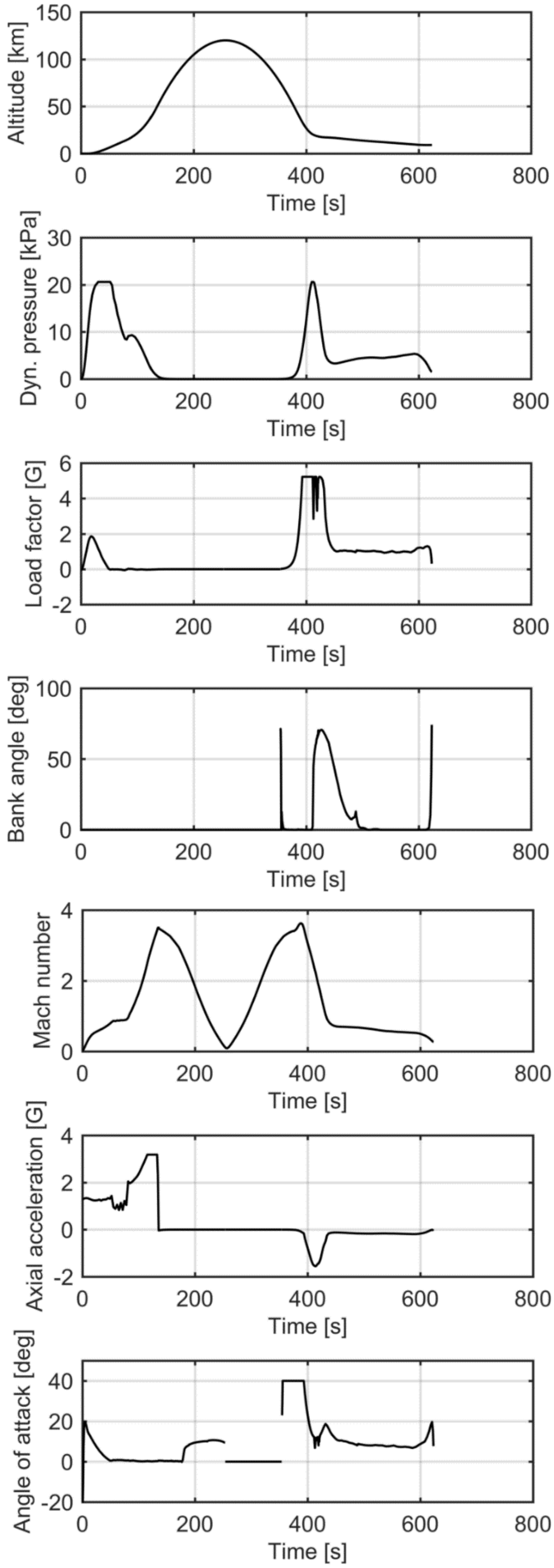


Fig. 5 Flight profile of suborbital plane for scientific research

The suborbital plane has the payload volume of around 1,200 liter (container diameter 1.3 m×width 0.6 m) and provides the microgravity duration of 175 sec for the 10^{-3}G and 210 sec for the 10^{-2}G respectively. The payload can acquire the onboard reference time, flight condition data (position, velocity, attitude, acceleration, angular velocity and etc.) , and the payload integrator can monitor the payload real time condition using the downlink radio frequency and transmit the operational command by the uplink.

The tentative payload interface is summarized in Table 2.

Table 2 Payload interface conditions

Payload Mass	100kg
Payload Space	Container Diameter 1.3m×Width 0.6m (1,200 Liter)
Late Access	3 Hours before Takeoff (TBD)
Takeoff Static Acceleration (see Fig. 6)	X_P-Axis : 3G±TBD @Takeoff Y_P-Axis : ±0.6G (TBD) @Reentry Z_P-Axis : 5.5G±TBD @Reentry
Vibration Environment	TBD
Power Supply	Payload has Own Power
Microgravity Condition	10^{-3}G : 175 sec 10^{-2}G : 210 sec
System Bus Interface Data	・Reference time ・Position ・Velocity ・Attitude ・Acceleration ・Angular velocity and etc.
Downlink	payload real time monitor data (TBD)
Uplink	payload operational commands (TBD)

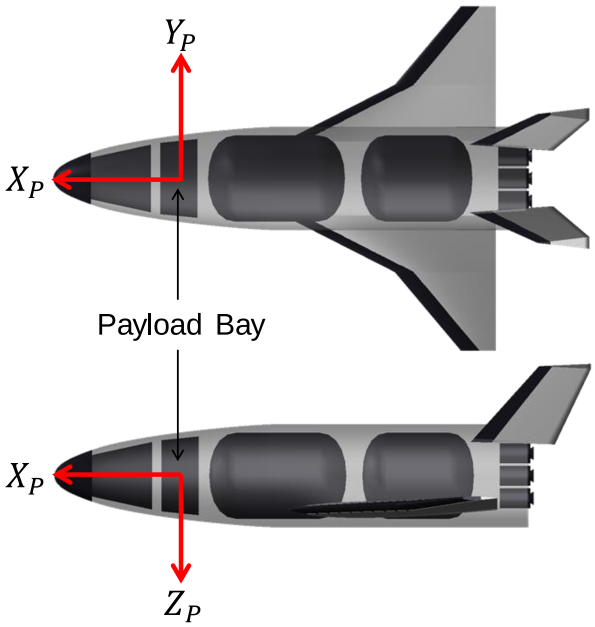


Fig. 6 Payload bay coordinate axes

4. Concluding Remarks

The authors deeply express their gratitude for having an opportunity to introduce the new space startup SPACE WALKER, the outline of its development and business plan, and the microgravity conditions for the scientific mission.

References

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2) Yonemoto, K., Todome, K., Oyama, Y., Manabe, A., Yasuda, A., Asai, T., Asada, S., Tsuji, M., Asada, T., Onuki, M., and Fujikawa, T., "A New Spaceplane Venture Company "SPACE WALKER" in Japan - Challenges In the Last Frontier both Development and Business," 69th International Astronautical Congress, Business Innovation Symposium (E6), Entrepreneurship and Innovation: The Practitioners' Perspectives (1), IAC-18.E6.1.8x47241, Bremen, October 1-5, 2018.