

Certifying the Dream, The Story of Zero-G

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ABSTRACT

For more than 40 years NASA and other government space programs around the globe have been flying parabolic maneuvers in various aircraft to give astronauts and researchers brief periods of microgravity without actually going to space. This experience was never widely available to the general public in the United States due to regulations and restrictions on commercial aircraft operations. This paper details some of the unique challenges of obtaining final operational certification for commercial parabolic flights and the applicability to new suborbital spacecraft intended for general passenger use.

INTRODUCTION

Since in 1993, the Zero Gravity Corporation (ZERO-G) has been pioneering the procedures and approvals needed to allow paying passengers the opportunity to experience parabolic flight. When co-Founders Peter H. Diamandis and Byron K. Lichtenberg walked into the Federal Aviation Administration (FAA) offices with the goal of beginning a commercial parabolic flight company, they had no idea how long it would take. NASA had been safely conducting parabolic flight since 1959 to train the Mercury, Gemini, Apollo and Space Shuttle astronauts. After more than 150,000 parabolas the process was safe and down to a science. Diamandis and Lichtenberg, both MIT graduates, as well as pilots and entrepreneurs, recognized the unique opportunity for this incredible business and began to seek a way to operate under the regulations of the FAA.

While NASA has been using this type of experience to train astronauts and conduct research for over 40 years, it has never before been certified to be offered for sale to the general public. All government aircraft are flown as "public use" vehicles and cannot take any paying passengers aboard. All passenger-carrying flight operations are certified by the FAA according to one or more parts of the Federal Aviation Regulations (FARs).

ZERO-G is certified under FAR Part 121, the highest level of safety and regulation used to govern the carriage of individual paying passengers. Many regulations apply to Part 121 airline operations that are not applicable to private, corporate, or charter aircraft. Additional regulations apply to the parabolic flight profile it is defined as an "aerobatic maneuver" in FAR Part 91.

ZERO-G chose the Boeing 727-200, manufactured under FAR Part 25 and modified to fly cargo with a Supplemental Type Certificate (STC) to fly these commercial parabolic flights. After extensive structural testing and a review of the aircraft systems, a special STC for a modification to the hydraulic system was pursued in 1998 and obtained in 2000.

The Department of Transportation was asked for a ruling on whether ZERO-G's proposed operation constituted "Passenger Carrying Operations" since the flights were to return to the same airport they departed from. The DOT ruled that ZERO-G was not a "Passenger Carrying Operation" since the flights did not cross state lines or international borders. To avoid confusion, ZERO-G refers to the occupants as "flyers" instead of "passenger". However, there are references to "passenger" in several ZERO-G and FAA documents since it is a term typically used in FAA regulations and understood by airline operators.

FAA LIMITATION FOR THE GRANT OF EXEMPTION

ZERO-G operates under FAA Part 121 regulations, adhering to the same stringent requirements as commercial airlines. For the take off, departure, approach and landing phases of flight under 10,000 feet, ZERO-G operates exactly the same as any other commercial passenger airline. Above 10,000 feet the passenger experience and crew procedures vary drastically from other commercial airline flights.. A parabolic maneuver is classified as an aerobatic maneuver by the FAA.

When ZERO-G approached the FAA about modifying a Boeing 727-200 for parabolic flight it was determined that an exemption would be required from 14 CFR Part 91.303(f) (visibility requirements for aerobatic flight) and 14 CFR Part 91.307(c) (requirement to wear a parachute during aerobatic flight). In addition, it was also noted that ZERO-G would have to modify its existing Supplemental Type Certificate (STC) to install the passenger interior. At this point, ZERO-G had already spent almost 10 years doing structural analysis and testing a modification to the 727's hydraulic system.

During the design phase for the STC process, the regulations were reviewed to ensure that the cabin modifications were within regulatory guidelines. One regulatory requirement stuck out as a potential issue. 14 CFR Part 25.1447(c)(1) requires that the supplemental oxygen dispensing units installed in the cabin of the aircraft to be automatically presented if the aircraft is operated above 30,000 feet. Since the desired parabolic maneuver profile exceeded 30,000 feet, it was determined that the entry altitude would be modified to keep the peak altitude at 29,000 feet and below the limit.

With the design phase of the STC process complete, a data package was sent to the FAA for review. The FAA contacted ZERO-G and advised that the handholds in the floating area were spaced further apart than what was previously found in compliance with 14 CFR 25.785(j). Upon further discussions with the FAA, it was determined that ZERO-G would also have to apply for an exemption from 14 CFR Part 25.785(j). Restarting the exemption process again, ZERO-G decided to ask for an exemption from 14 CFR Part 25.1447(c)(1) to remove the altitude restriction to operate at the most efficient altitude.

On May 5, 2004, the FAA granted ZERO-G an exemption (Exemption 8306) for the two regulations requested. The following is an overview of the Grant of Exemption for ZERO-G. The FAA limitations are in *italics* with ZERO-G's response following.

1. AURAL ANNUNCIATION SYSTEM

"A flight crew operated aural annunciation system that can be heard (considering ambient noise during flight) in

the floating area must be installed to indicate during adverse conditions (such as moderate turbulence) that persons must return to their seats. Appropriate procedures and limitations must be established to ensure that the flight crew signals persons in the floating area at the onset of an adverse condition and prior to landing to return to their seats. The pre-flight briefing must explain this annunciation to persons that will be in the floating area."

As part of the modifications to the aircraft, several Passenger Service Units (PSU) were designed and installed on the right and left hand side of the aircraft. These PSUs contain a "Fasten Seat Belt", "Return to Seat" and "Use Oxygen" lighted information sign as well as an interphone jack and PA speaker.

The operation of the aural annunciation system was included into the Amerijet Operations Manual and the Flight Attendant Manual.

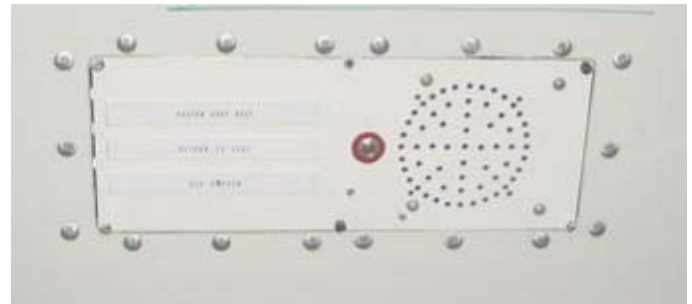


Figure 1 - Passenger Service Unit

2. AURAL ANNUNCIATION SYSTEM AUTOMATIC ACTIVATED AURAL DECOMPRESSION SIGNAL

"An automatically activated aural decompression signal immediately recognizable (considering ambient noise during flight) throughout accessible areas aft of the flight deck must be provided to notify persons to return to their seats and don oxygen masks. Operation of this signal must be automatic with flight crew manual action as a backup. This signal and the accompanying procedures for persons to return their seats, don masks, and activate oxygen flow must be included in the pre-flight briefing."

The "Use Oxygen" light was designed so that it can either be activated manually or automatically when the cabin altitude reaches 10,000 feet. The pre-flight safety briefing for flyers was modified to include required information on how to respond to the "Use Oxygen" warning horn.

3. MAXIMUM OPERATING PRESSURE ALTITUDE

"The maximum operating pressure altitude is 32,500 feet. Upon a cabin decompression event which does not occur during a parabolic flight maneuver, the pilots must make an emergency descent in accordance with Boeing Model 727 AFM procedures to 10,000 feet pressure

altitude (terrain permitting) and land at the nearest suitable airport. Upon a cabin decompression event during a parabolic flight maneuver, the pilots must terminate the maneuver in a safe manner (minimizing the initial positive g-load on the occupants to enable those in the floating area to regain their footing) and then make an emergency descent in accordance with Boeing Model 727 AFM procedures to 10,000 feet pressure altitude (terrain permitting) and land at the nearest suitable airport.”

As part of their training program, pilots were briefed on the appropriate procedures for responding to a decompression event. The emphasis was placed on a decompression event that occurs at the start of the parabolic maneuver.

Once a maneuver has commenced, it must be completed to ensure safety. The pilots are trained to fly a lunar-g parabola since it affords both partial gravity and a shorter duration to a nose-down attitude.

4. SUPPLEMENTAL OXYGEN

“Supplemental oxygen equipment with connected masks must be located so that each person in the passenger cabin can don a mask and activate the oxygen flow while seated at their seat. Additionally, six sets of supplemental oxygen equipment, each of which contains three connected masks, must be uniformly distributed throughout the floating area. The means of activating the flow must be simple. Crew and passengers must be trained in the use of the oxygen equipment.”

Using a supplemental oxygen system developed for C-130 operations, boxes containing three masks and an oxygen generator were placed under each seat assembly. These self-contained units required that the box be opened and a mask must be removed to initiate oxygen flow. The pre-flight safety briefing for flyers was modified to include required information on the operation of the oxygen boxes.



Figure 2 - Supplemental Oxygen Box under seats

5. SIZING OF OXYGEN UNITS

“The oxygen units in the passenger cabin must be sized adequately for continuous and uninterrupted use during worst-case flight duration following a decompression.”

By using standard oxygen generators found on several commercial aircraft, ZERO-G complied with this requirement.

6. FLOATING AREA FLOOR COVERING

“The floor of the floating area must be covered with at least 1.5 inches of energy absorbing protective padding (foam or equivalent), such as Ensolite.”

The entire floor area in the floating area is covered with 1.5” thick padding encased in a Naugahyde cover. The pads are sized in a manner to facilitate easy removal for cleaning or maintenance.



Figure 3 - Floor Padding

7. PROJECTING OBJECTS

“Each projecting object that would injure persons in the floating area must be padded. Means must be provided to prevent persons from obtaining burn injuries in the floating area.”

All of the protrusions in the floating area were covered with either “pit tape” or foam and pit tape. This include the actuating arms for the cargo door which protrude in to the cabin and are covered with a foam and naugahyde cover.

8. HANDHOLDS

“Handholds must be provided continuously along the length of both sides of the fuselage in the floating area to enable persons to steady themselves. The handholds must be located approximately 50 inches above the floor.”

Handholds consisting of cargo rope were installed along both sides of the floating area using a system of evenly spaced seat-track segments and D-ring fittings. That allows for adjustment and ease of removal for repair or maintenance.