Fast Facts – Reduced Gravity Education Flight Program

Rev B

14 Sep 2010

National Aeronautics
And Space Administration

Lyndon B Johnson Space Center
Houston, TX 77058

Revisions

REV	Date	Description	By
A	17 May 2010	1. Document significantly revised.	KDK
B	14 Sep 2010	1. Added Revision Page. 2. Added item 47 to Structural section limiting strap loads to 2000#. 3. Added item 27 to Design section addressing welds.	KDK

FAST FACTS – REDUCED GRAVITY EDUCATION FLIGHT PROGRAM

General:

1. Please number all pages of your reports. An accurate table of contents doesn't help much if there are no numbers to reference.
2. When writing your TEDP, please keep your audience in mind:
   a) The reviewers of the document know nothing of your experiment outside of what you put in this report. The reviewers were not part of the selection process. This report is the ***only*** thing they have, prior to your arrival, to assess its design, construction and suitability for flight aboard a NASA aircraft (you are treated the same as any other experimenter/researcher). You should provide enough detail to allow them to fully assess your hardware without actually having the hardware in front of them.
   b) Please keep in mind when writing your report that what is obvious to you after working on your hardware for weeks or months will not be obvious to the reviewers.
   c) The report will be read by several groups, each with their own specialty, that do not necessarily work together on a day-to-day basis and are not at the same location. The entire report will not necessarily be read cover to cover by every reviewer as this would simply take too much time (we average 14 teams a flight week). Please write and group information in the report accordingly.
3. ALL materials used in the experiment must be listed in the TEDP. Even the materials you think are trivial or incidental and are not critical for the experiment must be listed.
4. Please read *all* of the required AOD and Zero-G Corp. documents. Yes, I know it's tedious but it really will answer a lot of your questions. You'd be surprised how many people tell me the floor attachment allowable is 5000# because that is what the bolt is rated at. *Hint: it's not*.
5. All calculated units must, without exception, be provided in the in/lb/sec system. If you'd like to include metric units as well, it will not count against you.
6. All exposed edges, threads and corners will need to be padded prior to loading on the aircraft.
7. You are responsible for providing the padding, even when using the Education Office provided 'Glove Box'.
8. When using laptops, cameras, etc., ensure the equipment will continue to operate when subjected to reduced gravities. Some equipment is automatically configured to turn off when sensing a 'fall'. This feature must be disabled prior to flight if you want to get any data.
9. Some of the 'erector set' structural framing systems have a locking feature inherent in the design. It should be noted, however, that the use of this locking feature assumes a

proper torque value be applied to the fasteners (meaning get a calibrated torque wrench when installing them).

Design:

10. Insure all equipment is fully restrained in all six of the principle directions.
11. Wood is **not permitted** for use as a structural component except in very specific circumstances. The use of wood is strongly discouraged for all flight hardware due to flammability issues. If you feel wood is required for proper operation of your experiment, please contact the Reduced Gravity Office (RGO) to discuss your concerns.
12. The use of both straps and bolts for attachment to the aircraft is not permitted. You may use one or the other.
13. Aircraft fastener mounting holes should be drilled to a diameter of 7/16”….no more, no less.
14. All fasteners must have a locking feature. Locknuts are preferred over locking washers, when possible.
15. Threaded fastener lengths should be sized such that at least 2 full threads, but not more that 5 full threads extend beyond the installed nut.
16. Adequate minimum edge margins should be maintained when installing all fasteners:
    a) Metals – 2.0 x fastener diameter
    b) Polycarbonates – 4.0 x fastener diameter
17. The use of plastics as structural components (non-containment) is strongly discouraged. If plastics are used, select the higher strength plastics (polycarbonates, etc.) over the lower strength variety (acrylic).
18. When using plastics (polycarbonates, etc.), often only the material tensile properties are provided by the manufacturer. For design, unless manufacturer data is available, assume a shear strength = 40% of tensile strength.
19. When using plastics, large radius washers should be used instead of regular washers.
20. Lightweight equipment (~2.0# or less) may be secured using Velcro and “Zip” ties. Both methods are required, however, with Velcro resisting shear only and the ties resisting tension.
21. When using Velcro, the heavy duty variety should be used.
22. When using non-hazardous liquids in quantities greater than 6oz., the liquids must be fully double contained.
23. When using hazardous liquids of any quantity, the liquid must be fully triple contained.
24. Even when planning on bolting to the floor, unless highly accurate methods are used to locate the mounting holes (i.e. CNC machining), it is strongly recommended that provisions for strapping the experiment to the floor and the analysis to substantiate this

method of attachment be provided as well. This provides you a backup plan should the drilled holes not line up with the aircraft mounting points. It substantially decreases your risk of not being able to fly should a problem be discovered when you arrive.

25. Any hardware, equipment or support structure that is positioned such that it could intentionally or unintentionally be used as a pushing or pulling surface or handhold (both in 1g and/or 0g) should be designed for a 100# ultimate load acting in any direction unless other criteria are more severe.
26. When using attaching hardware on COTS equipment such as cameras, please keep in mind that although the insert that the screw attaches to on the camera may be metal, the material the insert attaches to is often plastic. Unless you can substantiate the pullout strength of that insert in the plastic, you should provide another means of mounting the camera or make provisions for stowing it during takeoff/landing.
27. Welding is, in general, strongly discouraged for primary load path structures. If equipment is welded, it must be done by a certified welder. All welds shall, at a minimum, be inspected using a dye penetrant method. X-ray of all welds is strongly encouraged. Be sure to account for reduced material allowables in the heat affected zone when doing structural analysis of welded joints.

Structural:

28. In general, most of your reviewers will have several years experience in structures. It is not necessary (or desirable) for you to derive the equations used for the analysis…in the analysis. Just provide the equation used, a reference and move on. If they need more info, they'll ask for it.
29. If your structural analysis is written in paragraph form, it is either wrong or contains lots of information that is not required in a structural analysis. In general a structural analysis is equations, math and diagrams. Words should only be used for clarification or short descriptions. If you're having to describe what you did in paragraphs, you haven't provided enough numbers.
30. Free body diagrams have numbers. A picture with arrows is not a free body diagram.
31. A 'complete stress analysis' of your instrument does not mean the analysis of the completed instrument; it means a complete analysis of every component of your instrument. This means all boxes, beams, clips, *joints*, fasteners, etc.
32. Pay particular attention to the joints. Given the typical instruments/hardware flown by students, we're fairly confident the beam is not going to be the weak point.
33. Analyzing everything in terms of stresses is not required. Calculating margins using loads is perfectly acceptable (when appropriate) and in some cases preferable (and faster and easier). For example, why calculate a bolt stress and compare it against the

bolt material allowable (4-6 calculations) when you have the bolt load and the bolt allowable load (2 calculations)?

34. ALL materials and fasteners used, along with the appropriate material/fastener allowables must be explicitly stated in the structural analysis.
    a) Stating that the values can be found in XYZ's catalog does not meet this requirement. It is, obviously, permissible to reference the manufacturer's data. However, the relevant information should be presented (and referenced) as part of the stress analysis document.
    b) Providing an internet link does not meet this requirement. You should not assume that the report will be read while online.
35. Pay attention to the joints.
36. Most of your analysis can probably be done without FEA.
37. When using a finite element analysis program, a screen shot of the output with no other data does not constitute structural substantiation.
38. When a finite element analysis is used for structural substantiation of systems possessing a high degree of redundancy (multiple load paths), the internal loads should be extracted from the finite element analysis and hand techniques used to determine the final margins of safety.
39. If using an 'erector set' system for buildup of your instrument, the availability of a particular fastener, plate or corner bracket does not necessarily mean it can support your loading condition. These systems, while convenient and easy to use, are, in general, designed for use in the '1g pointing downward' world. This is not meant to discourage its use as it has been used successfully many times. However, please analyze and substantiate its use, particularly at the joints and corners which are often neglected.
40. A Margin of Safety (MS) is not the same as a Factor of Safety (FS or FOS). We want the Margin of Safety.
41. The Margin of Safety is defined as the ratio of the strength of the member (or fastener) to the applied load multiplied by any factor(s) minus 1. The Factor of Safety is a multiplier to be used when calculating the Margin of Safety. (confused?) The equation for Margin of Safety is:

$$MS = \frac{\text{Allowable Stress } (\textit{or Load})}{\text{Actual Stress } (\textit{or Load}) \times FS_1 \times (FS_2) \times (FS_n)} - 1$$

42. More than one multiplier or FOS may be required when calculating MS.
43. The MS must be positive (>0.0).
44. A 1.25 Mass Factor (an additional factor of safety) should be used for equipment when the actual/measured center of gravity is not known.

45. Whether you use bolts or straps, you must provide the floor attachment loads (tensile and shear).
46. It is recommended that you perform a critical bolt out analysis for the floor attachment. This provides for the possibility that one of your mounting holes don't line up with the aircraft. This will save lots of effort/panic of having to run new floor loads on the fly after you arrive.
47. Did I mention to pay attention to the joints?
48. Strap loads are currently limited to 2000#/strap due to mounting ring limitations.

Electrical:

49. Equipment labels or markings must be used to warn for specific hazards such as voltage, current, thermal or radiation.
50. All equipment cables or wires must be of the appropriate size/gauge for the intended current draw across the wire. The table below lists wire gauge & rating.

MAXIMUM CURRENT	MINIMUM WIRE GAUGE
5A	18
10A	16
15A	14
20A	12
25A	10
30A	8
50A	4

51. Insulation that is flammable, produce smoke or emit toxic fumes when exposed to combustible or high-temperature environment shall not be used in the research equipment assembly. The following materials are not acceptable for use in experiments to be carried aboard the aircraft:
    - Polyester
    - Nylon
    - Polyvinyl Chloride (PVC)
    - Polyethylene (PE)
    - Polypropylene
    - Polyurethane
    - Kapton (Polymid Resin)

    Note: you will not be required to rewire COTS hardware to meet this requirement

52. The equipment "Emergency Kill Switch" must be located so that accidental contact by personnel will not operate the switch but easily accessible by the crew so power may be shut off during an emergency situation.
53. Equipment that is capable of radiating Electro Magnetic Interference (EMI) must be properly shielded.
54. Any experiment EMI transmission must not interfere with any aircraft equipment. The equipment should **not** radiate in the frequency range 10KHz-40GHz. If your equipment will radiate within this range, you must contact NASA JSC AOD Engineering. Note: you will probably be required to perform additional testing once you arrive.
55. Exposed power conductors and terminals must be properly insulated.
56. Small numbers of AA & D type alkaline or "button" Ni-Cd batteries can be used without special approval. All other battery usage on the aircraft requires approval by NASA JSC AOD Engineering. Unless your application absolutely requires otherwise, select benign battery chemistries with hermetically sealed cell designs from the following:
    Alkaline (Zn/MnO2)
    Silver-Zinc
    Nickel Cadmium
    Sealed Lead Acid ("starved electrolyte" or "immobilized electrolyte" type)
57. Use the smallest size (minimum capacity) battery suitable for the intended application. This minimizes the stored energy and electrolyte quantity brought aboard the aircraft.
58. All batteries must be doubly contained to prevent leakage of electrolyte into the cabin.
59. Label battery housings with applicable safety warnings such as "Corrosive/Caustic Liquid", "Flammable Gas", "High Voltage" or the current capability.