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Reduced Gravity Program at FRL Using the NRC Falcon 20

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National Research Council Canada | Conseil national de recherches Canada | Canada

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Outline

- Falcon “reduced gravity” Flight Profile
- Modifications to the Falcon 20 to support reduced gravity
- CSA’s “Parabolic Flight User’s Guide”
  - Falcon Capabilities
- Example Projects

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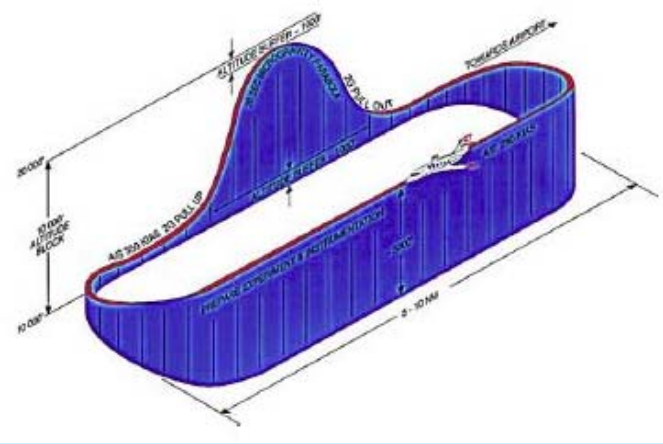
Reduced Gravity

- Typical Parabolic Flight Trajectory



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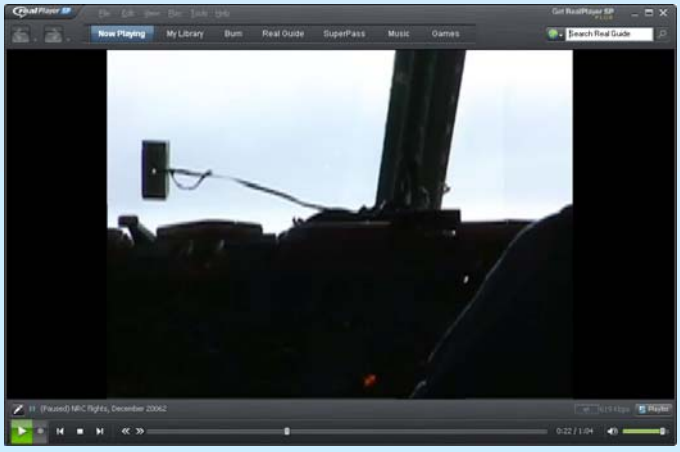
Maintaining Reduced Gravity Conditions



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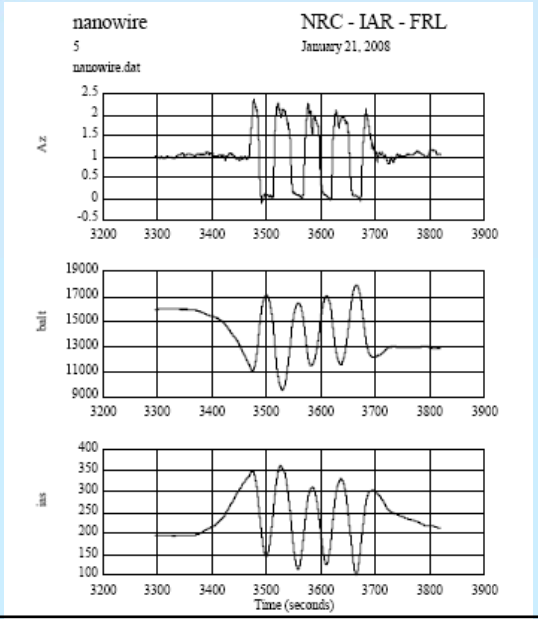
Reduced Gravity

- Data plots of reduced gravity, altitude and airspeed



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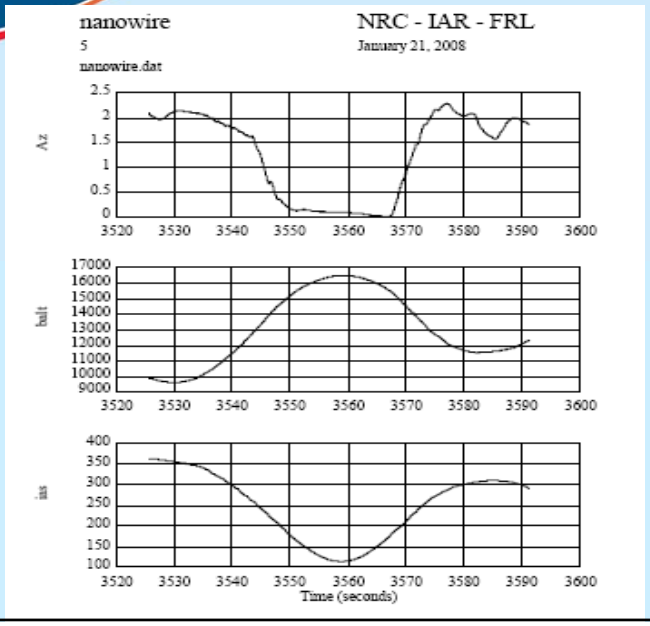
Reduced Gravity



Modifications to the Falcon 20

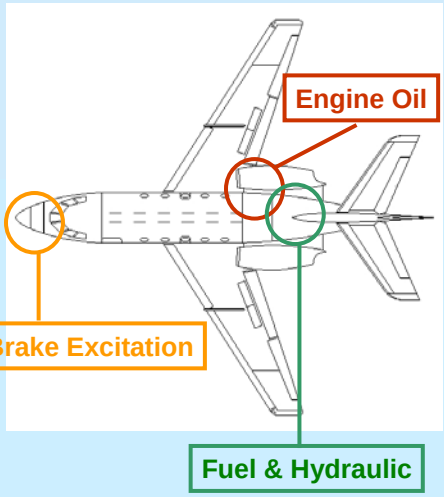
- The following systems were modified to allow operation at reduced gravity:
  - Fuel System
  - Hydraulic System
  - Engine Oil System
  - Brake Excitation System

Modifications to the Falcon 20 (2)

Aircraft fluids behave differently under reduced gravity conditions.

Buoyancy forces are virtually eliminated and fluids no longer settle to the bottom of containers.

These changes can adversely affect the aircraft fuel, hydraulic and engine oil systems.



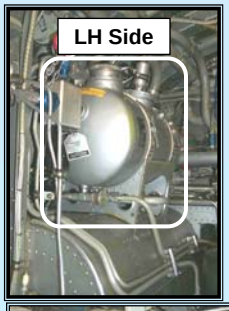
Fuel System Modifications

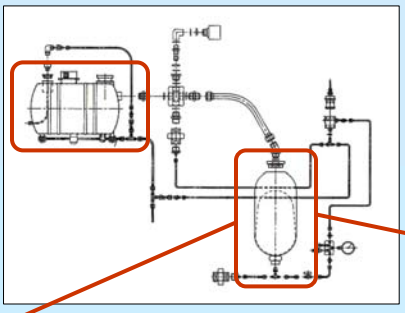
Problem: Engine flameout Two General Electric CF-700-2D2 engines, each fuelled from:

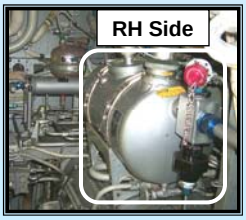
LH/RH feeder tanks (64.5 US gallons each)

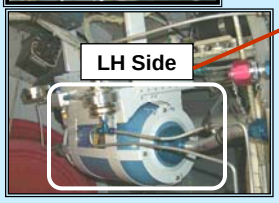
Solution: Bladder-type fuel accumulator provides engines with 13 seconds of continuous fuel supply during each parabolic manoeuvre.

Hydraulic System Modifications









Bladder Type Hydraulic Accumulators provides aircraft with continuous hydraulic supply during parabolic maneuvers

Brake Excitation Reservoir

Problem:	Wheel brake exciter fluids lost from reservoir. Similar experience on T-33 aircraft.
Solution:	Spiral-wrapped tube installed on top of the brake excitation reservoir to eliminate fluid loss.

Engine Oil System - Modifications

- When performing parabolic (reduced gravity) manoeuvres in support of the Canadian Space Agency (CSA), approximately 2 or 3 pints of engine oil are vented overboard from the Falcon 20. In order to stay within safe engine oil levels, the aircraft was limited to no more than 4 or 5 parabolas each flight.
- To extend the number of parabolas per flight, the aircraft has been extensively modified to install two engine oil level sensors (one per engine), two replenishment oil tanks/oil pumps and a display and control panel in the cockpit centre console.

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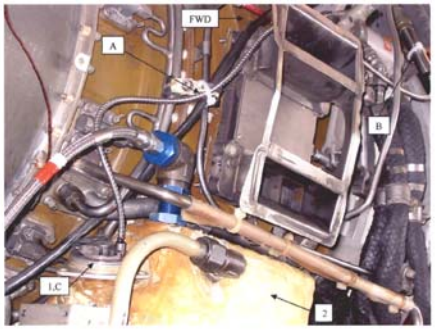
Engine Oil System - Modifications

VIEW OF REMOVED OIL QUANTITY MEASURING SENSOR



VIEW LOOKING ON STARBOARD ENGINE

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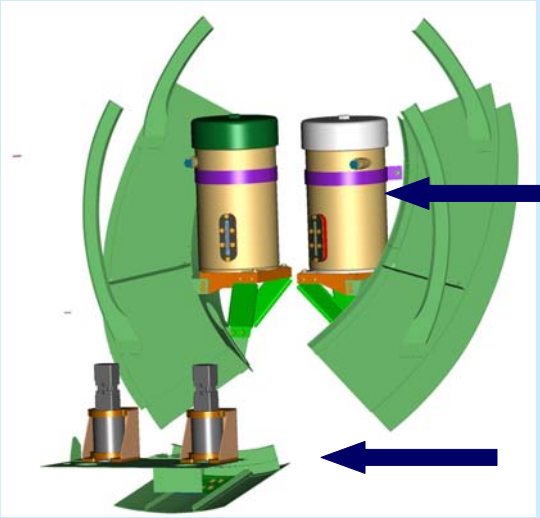
Engine Oil System - Modifications



Left hand engine oil reservoir and supports

Hydraulic tubing and electrical wire harnesses

Model # HRT-519-519-BRO-S Parker (Oildyne) Positive Displacement Pump

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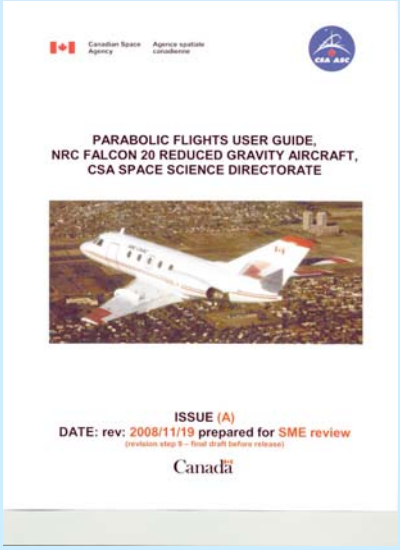
Reduced Gravity Flights User Guide

- A User Guide has been produced by CSA with input from NRC.
- Provides information on the NRC Falcon 20 and requirements and timeline for a reduced gravity campaign.
- Leads researcher in writing of a Test Equipment Data Package (TEDP).



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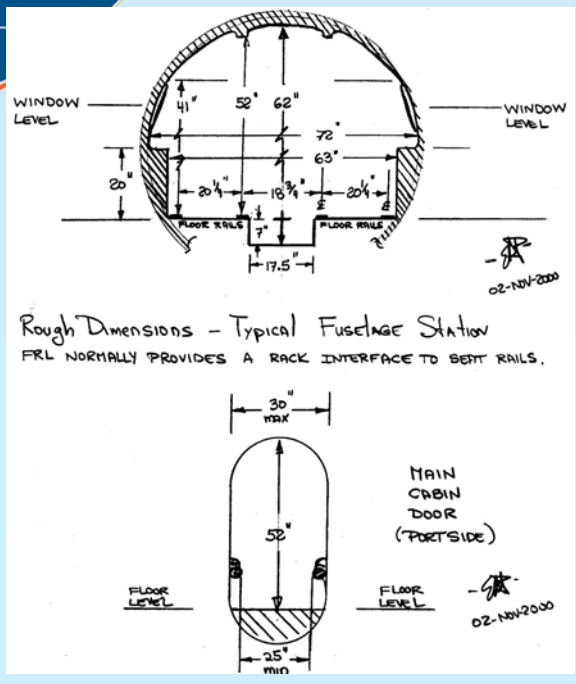
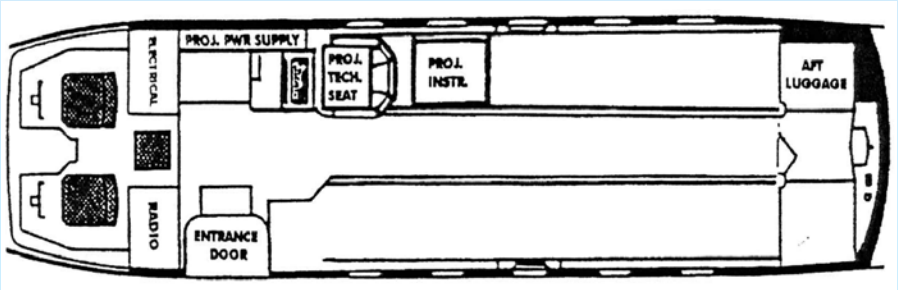
Falcon 20 Interior Dimensions

Cabin Volume
14.2 cubic meters



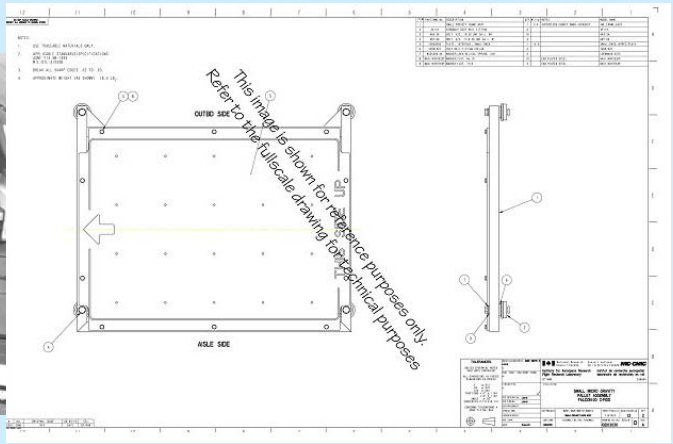
Falcon 20 Floor Plan



The general dimensions of the cabin are 5.0 x 1.5 x 1.5 m (*lwh*).

Mounting of experiment in the Falcon

FRL provides a standard interface to mount the user's experiment in the Falcon using the cabin seat rails.



Power Available to the Experimenter

- 120 Volts 60 Hz AC — Two 7.5 Amp supplies
- 28 Volts DC — Two 50 Amp Supplies; One 25 Amp Supply

Falcon Data Acquisition System

- Aircraft Parameters sampled and recorded at 32 Hz.
  - Includes aircraft position, attitudes and accelerations.
- There are 16 analog data channels available to the experimenter to record parameters from their experiments synchronous with the aircraft data.

Selected Projects from 2007-2010

- University of Ottawa and University of Calgary
  - Gasless Laparoscopy In Weightless Conditions During Parabolic Flight
- University of New Brunswick
  - APEX Cambium Experiment
- McGill University
  - Constant Pressure Reduced Gravity Combustion of Non-Volatile Particulate Suspensions

*Note: Information on the following slides have been copied from the TEDP documents provided by the experimenters.

U of O and U of C Gasless Laparoscopy

- Medical emergencies requiring surgery will be required as humans spend more time in space.
- Investigate the possibilities for Minimally Invasive Surgery in space.
- Minimally invasive surgery (MIS) is a surgical technique involving the use of miniaturized television cameras to permit complex operative procedures inside the body cavities, thus reducing the surgical trauma. To perform abdominal MIS procedures, gas is introduced under pressure into the peritoneal cavity to create the operative “domain”.
- Liabilities of using pressurised gas in a space setting warrant an examination of the potential for using “gasless” laparoscopy in weightlessness.

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U of O and U of C Gasless Laparoscopy

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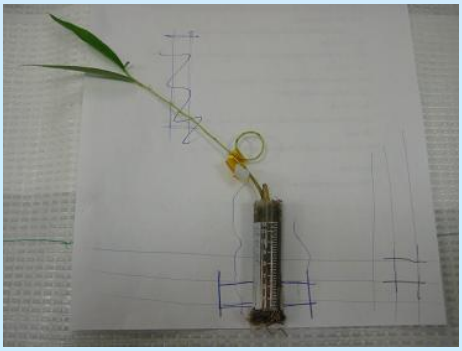
UNB APEX Cambium Experiment

- The purpose of the parabolic testing is to gain insight into any difficulties attending hand manipulations to be performed on living plants in the weightless environment of the International Space Station.



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McGill Combustion Experiment

- Studying the combustion of particulate suspensions in oxidizing media is of great practical importance in a wide variety of industries and modern technologies (e.g., coal-fired power plants, fire safety in chemical, pharmaceutical, mining, and food industries, combustion material synthesis, propulsion, etc.).
- It is difficult to perform combustion experiments with particulate suspensions at normal gravity.

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Questions?


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