Notes on Demonstrator Engine Dynamic Tests

1. General

The engine was mounted on a dynamic test rig enabling it to be “flown” on a rotary bearing. The test rig comprises a carefully levelled and balanced beam, supporting the engine on one side, and an instrument platform on the other. This beam is mounted on a Loadpoint 10 inch air bearing type D03099, mounted in a sub frame. Mains power is supplied to the centre of the beam via flexible wires coiled such that the operation of the test rig is limited to a small number of turns.

The total beam weight is 100kg.The tests therefore simulate the engine moving a 100Kg spacecraft in weightless conditions. The programme included acceleration and deceleration runs in both directions.

Analysis of the runs enabled the dynamic thrust of the engine to be derived from the acceleration, by use of Newton’s second law equation. The dynamic thrust results confirmed the thrust levels measured in the static tests and that they were in the opposite direction, as predicted by Newton’s third law.

The dynamic tests therefore conclusively proved that the engine obeys all Newton’s laws, and that although no reaction mass is required, the engine is not a reactionless machine. Reaction occurs between the EM wave and the reflector surfaces of the resonator, and the law of conservation of momentum is maintained with the transfer of the momentum of the EM wave to the engine.

2. Notes on DEM 188 Test video:

1. The high Q of the resonator gives rise to very high field strengths within the thruster that equate to a power level of 17MW. Signal leakage causes EMC effects within the fixed video camera. This leads to the apparent vertical movements, once resonance starts within the thruster.
2. The audio track contains the sound of the compressor which provides air to the bearing. Also included are comments indicating “on” and “off” of the magnetron HV power supply. The radiated leakage signal is detected on a spectrum analyser and the i.f. signal frequency is given in comments on the audio track. Note that the resonant frequency of the engine gives an equivalent i.f. frequency around 23 MHz.
3. The engine only starts to accelerate when the magnetron frequency locks to the resonant frequency of the thruster, following the magnetron warm up period. This illustrates that it is not electromagnetic or thermal spurious forces causing acceleration.
4. The rotary air bearing supports a total load of 100kg, with a friction torque resulting in a calibrated resistance force of 8.2 gm at the engine centre of thrust. Calibration runs to determine the friction torque are carried out prior to each dynamic test run. These use a standard weight to provide the calibration force along the thrust axis.

5. All test and calibration runs are recorded on video, enabling performance results to be processed from an analysis of the angular movement and elapsed time data.
6. For each engine test, telemetry data is recorded on the laptop attached to the instrument platform. Telemetry data includes power, current and temperature measurements.
7. For this test a thrust of 96 mN was produced for an input microwave power of 334 W.