OFFICE MEMORANDUM ◇ STAR LABORATORY

March 20, 2001

To: Diane Shankle

From: Tony Fraser-Smith

Subject: Ph.D. Quals Question, January 2001

Determining the Depth of the Ice on Europa

As was the case last year, the student is given the following information concerning NASA's latest discoveries with respect to Europa, the fourth largest moon of Jupiter: (1) images acquired during recent spaceprobe flybys show a surface covered with ice (discolored ice in some places) and the layer of ice appears to be quite thick, and (2) magnetic and gravity measurements suggest very strongly that there is a liquid ocean beneath the ice. Liquid oceans are very unusual in the solar system, and the existence of one on Europa suggests the possibility of life. NASA has therefore placed the highest priority on a mission to Europa to see what can be learned about life in the ocean. First, however, NASA has to access the water under the ice, and even before it can reach the water it has to determine the thickness of the ice.

Question: What methods might NASA use to determine the thickness of the Europan ice? Remember that it may not be pure. Remember that it may be very thick. And remember that NASA has somewhat limited resources and there is no possibility whatsoever of a manned expedition to Europa.

Answer. To get full marks for this question, the student was expected to, first, discuss the many possible methods that might be used to determine the thickness of the ice and then, second, to discuss the most feasible appearing methods in greater detail.

Possible methods could include (1) flying a drill rig to Europa and using it to drill through the ice. But it should have been decided that this was infeasible due to the weight and size of the rig; (2) measuring the attenuation of a radio signal passing between a satellite orbiting Europa and the Earth as the satellite becomes occulted by Europa (i.e., passes behind it); (4) landing a probe on the surface of Europa and carrying out a seismic sounding experiment; (5) landing a probe on the surface and carrying out an acoustic sounding experiment; (6) landing a probe on the surface and having it melt its way through the ice; (7) landing a probe on the surface and carrying out an electromagnteic sounding experiment; (8) landing several probes at different distances apart on the surface and transmitting various kinds of signals between them to probe the surface.

The student was expected to consider what kind of frequencies would be best for the electromagnetic probing methods. For this they would have their attention drawn to the discolorations in the ice and the likelihood that the ocean had salts dissolved in it – in other words, the ice is probably somewhat contaminated with salts.