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Splashdown and Sea-Surface Dynamics of the Huygens Probe

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Introduction: Considerable interest in splashdown dynamics attended the development of manned US space capsules Mercury, Gemini and Apollo, since the ocean surface afforded a large target with relatively uniform, predictable and favourable mechanical properties. Little work on splashdown has been performed in the three decades since those programs. Here I review the splashdown dynamics literature with particular reference to the imminent arrival of the Huygens probe at Titan, and its possible splashdown into a hydrocarbon ocean [1].

Testing: In support of the Huygens SSP investigation, scale models of the Huygens descent module have been constructed (approx 1/7 and 1/14 scale) and instrumented with accelerometers. Splashdown tests have been performed into water and kerosene - the author is unaware of any published experiments into non-water fluids - and further tests in other liquids are planned. The sharp deceleration pulse during the contact phase is in agreement with the 'added-mass' modeling approach used in Apollo, although new insights can be gained by studying the post-contact phase. The initial deceleration peak only removes part of the impact velocity - the vehicle continues to move downward until drag and buoyancy arrest it and it bobs back to the surface. An interesting and unexpected result is the prominent acoustic signature in the accelerometer data of the entrainment of a large bubble in the target fluid when the back end of the probe passes the pre-impact 'waterline'.

Additional experiments to study post-impact dynamics have been conducted in the Pacific Ocean near UC Santa Cruz. These illustrate unanticipated behaviours of the probe in a realistic wave spectrum, and when exposed to surf and the littoral environment. Further experiments are planned in pools with simultaneous wave height measurements to assess how well the wave profile can be reconstructed from accelerometer data.

Reference: [1] R. Lorenz, Huygens Probe Impact Dynamics, ESA Journal, 18, 93-117, 1994