Title: The Remotely Piloted Vehicle as an Earth Science Research Aircraft

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Within the next two years NASA could be flying small scientific experiment payloads on remotely piloted vehicles (RPV) that are now becoming available through various military and industry development programs. A brief study was conducted at the Goddard Space Flight Center (GSFC) during winter 89/90 to identify existing RPV capabilities and to determine if the use of an RPV was advantageous and practical for Earth science investigations.

We conducted only an informal survey that was limited to the Earth Sciences Directorate at the GSFC due to time and budget constraints. The results of the survey were much larger and more enthusiastic that anticipated. A total of 17 instrument systems were identified that involved the following specific investigations or measurements:

(1) atmospheric studies - chemical sampling, boundary layer measurements, drop buoys, vertical profiles of temperature, pressure, moisture, and wind;
(2) crustal dynamics - laser ranging to retroreflectors
(3) ice studies - topographic profiles of Greenland and Antarctic ice sheets, and sea ice structure;
(4) ocean color monitoring;
(5) physical oceanography - wind and wave structure and dynamics;
(6) sensor calibration - visible and near-infrared spectrometer observations; and
(7) vegetation studies - polarization properties and bidirectional reflectance.

In assembling this list we found that RPVs were considered especially valuable for the dangerous missions, e.g. (1) flights through volcano plumes and hurricanes; (2) long duration profiles over inaccessible regions such as the Antarctic; and (3) very low altitude ($\leq$ 50 m) ocean profiling missions.

Instruments for the proposed science missions were grouped by their needs for aircraft altitude, payload weight, and electrical power. There were 9 instruments proposed that weighed between 2 and 111 kg and were targeted for low-to-medium altitude (50 m to 6 km) missions; 4 instruments were very heavy (175 kg to 900 kg); and the remaining 4 instruments required very high altitude (~ 10 km or above) and weighed between 4 kg and 22 kg. As expected, the power requirements were an increasing function of payload weight. There were 8 instruments that required less than 100 watts; 4 between 100 & 500 watts; and 4 over 1000 watts.

We also found that most payload concept sponsors required what amounted to approximately 1000 watts and 90 kg of basic flight hardware infrastructure to support their science mission. This infrastructure was selected from a list that included: autopilot with inertial reference; central flight guidance computer; digital avionics monitoring and control system; mission logic control unit; Global Positioning System receiver, aircraft nose camera television; satellite transceiver; video data recorder; atmospheric environment monitoring system; and the RPV command, control, tracking, and telemetry system.

Six separate RPV systems were investigated as practical carriers for our array of Earth science payloads. This list included one tethered aerostat and the following five aircraft: (1) the Developmental Sciences Corp. SKYEYE R4E-50; (2) the Litton Applied Technology Division Optionally Piloted Vehicle; (3) the Teledyne Ryan Aeronautical Model 324 SCARAB; (4) the Teledyne Ryan Aeronautical BQM-34A/S FIREBEE; and (5) the Boeing Corp. CONDOR. Detailed capabilities and performance specifications for these systems will be presented. From cost estimates provided by the respective manufacturers, it also became apparent that the initial investment will be on the order of at least $1 M for each RPV and a ground station cost of $1.25 M to $ 5 M for the launcher, tracking, control, and retrieval subsystems. The individual RPVs are, of course, reusable, but the mean time between failures and loss of the RPV is typically 50 missions. Thus, at present, the RPV technology does not appear to compete effectively with manned research aircraft on a dollar per flight hour basis. We believe, however, that the RPV may be a solution for extending the envelope of possible remote sensing missions and could become a valuable adjunct to the NASA Earth science aircraft program as costs come down with mass production and RPV reliability improves.