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MANNED PARAGLIDER FLIGHT TESTS [redacted]

By

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The current interest in utilizing the paraglider concept as a means of effecting a soft landing for the Gemini capsule prompted the Flight Research Center to design and construct a manned paraglider vehicle with which to conduct a limited, qualitative research program. This vehicle differs from paragliders that individuals, Langley Research Center and the Ryan Aircraft Company have flown in that it is manned, unpowered and towed aloft for release like the conventional glider.

The primary objective of the FRC flight test program is to demonstrate the approach, flare and landing capability of a paraglider vehicle with a high wing loading (W/S = 7 psf) and a low L/D (L/D = 2.5).

To meet this objective, the Paraglider Research Vehicle, PARESEV-1, was constructed in a manner to provide the maximum information in the shortest time. As you can see from the slide - (Slide of PARESEV-1) the design was simple and allowed for quick modifications if necessary.

Comments:
- Wing Sweep Angle 45°
- Fabric Plan Form 50°
- Area = 150 square feet
- Fabric -- Doped Irish Linen
- Battens -- 2/side
- Rigid control linkage
- W/S = 3.55
- Control available α 25° ± 10° lateral = ± 15°
- Two tow points -- high and low, no noticeable difference so chose low one
- Wing attach point -- 47.5% of keel aft of apex
- Communications -- FM radio
- Foot pedals for nose wheel steering only

Automobile powered tows up to heights of 200 feet and airplane powered tows to altitudes of 2500 feet were made with PARESEV-1. Satisfactory landings were made from free-flight with estimated sink rates of 2-4 fps at touchdown attained. The rod control system has its inadequacies, however, due to flexibility in the system there was considerable response lag and some question as to whether or not the amount of stick displacement corresponded to the proper amount of input to the wing. This, plus the inherent problems of being towed, resulted in major damage to the vehicle during checkout of a new pilot. I might add that the pilot was not injured during this incident.

The craft was rebuilt and considerably modified to incorporate a cable and pulley control system and better shock attenuation in the landing gear as seen from the next slide. (Slide of PARESEV-1A).

Comments:
- Wing Sweep Angle 45°
- Fabric Plan Form 50°
- Area = 150 square feet
- Fabric -- 6 oz. unsealed dacron
- Battens -- 5/side
- Cable and Pulley Control system
- W/S = 4.25
- Control available α 25° ± 10° lateral=± 7.5°
- Pivot Point = 47.5% aft of apex
- Communications -- VHF radio
- Foot pedals for nose wheel steering only

This control system eliminated the slow response in that the response is now governed by the pilot's ability to overcome the inertia forces.

To date, PARESEV-1A has been flown numerous times by 4 different pilots of varying backgrounds and experience, and the general concensus is that the craft maneuvers and handles quite well at a W/S of 4.25 and a L/D maximum of 3.8.

At the present time, flight testing is being conducted at a W/S of 6.3 and an estimated L/D of 2.9. This change in W/S and L/D was accomplished by decreasing the wing area from 150 square feet to 100 square feet.

To obtain the end W/S value of 7.0, the present plans are that additional weight will be added to the undercarriage.

Flight data have been obtained on PARESEV-1A and is presented on the next slide. (Slide of Longitudinal Performance of PARESEV-1A).

Data points were obtained during stabilized glide by a relatively simple method. Altitude callouts were timed by stopwatch during descents of 2000' or more at constant airspeed. Angle of attack was obtained by measurement of wing incidence angle relative to fuselage and fuselage inclination (attitude). V_v with this wing varied from 16 to 33 fps with γ's of 14.5 to 21.5° in the IAS range investigated higher airspeeds were not investigated due to high stick force.

The next slide (slide of Predicted Longitudinal Performance of PARESEV-1B) shows the predicted performance of the PARESEV vehicle with a 100 square foot installed. Our designation for this vehicle is PARESEV-1B. Some preliminary results indicate an L/D of less than 3 between glide speeds of 50 and 60 KIAS.

The last slide (slide of Control-System Force Gradients) shows a non-dimensional stick force plot against IAS. As indicated, the forces increase rapidly with deviations from trim airspeed. The upper dotted line shows how the force curve can be shifted by moving the pivot point forward of the cp. This could be done in flight, however, our vehicle requires ground adjustment prior to flight. The curve can be shifted downward into the push force region by moving the pivot point behind the cp. Push forces, however, were not considered desirable due to an apparent reduction in longitudinal stability. Bolt rope can also be used to adjust the pivot point-cp relationship. Increase in percent of bolt rope used moves wing cp aft.

Stick position versus IAS is not shown, but is approximately linear and normal.

The wing appears in flight to be exceptionally stable and not appreciably effected by rapid control inputs or turbulence. The lower fuselage response, however, is noticeable to the pilot and similar to helicopters, in that lateral and longitudinal motions involve linear accelerations rather than angular accelerations. Because of this it would seem that some stability of the lower fuselage or payload about the a.c. of the vehicle would be desirable for our vehicle and could be included in the design, such as a membrane between forward and aft keel cables to improve zero damping.

Response to a control input is first noted by the undercarriage moving, followed by total vehicle motion.

The vehicle possesses longitudinal stick fixed static stability. Longitudinal motions are highly damped in this condition.

The vehicle does not possess longitudinal stick force stability, hence dynamic motions have not been investigated.

In the stick fixed case, the lateral and directional modes are statically stable and the dynamic motions are lightly damped.

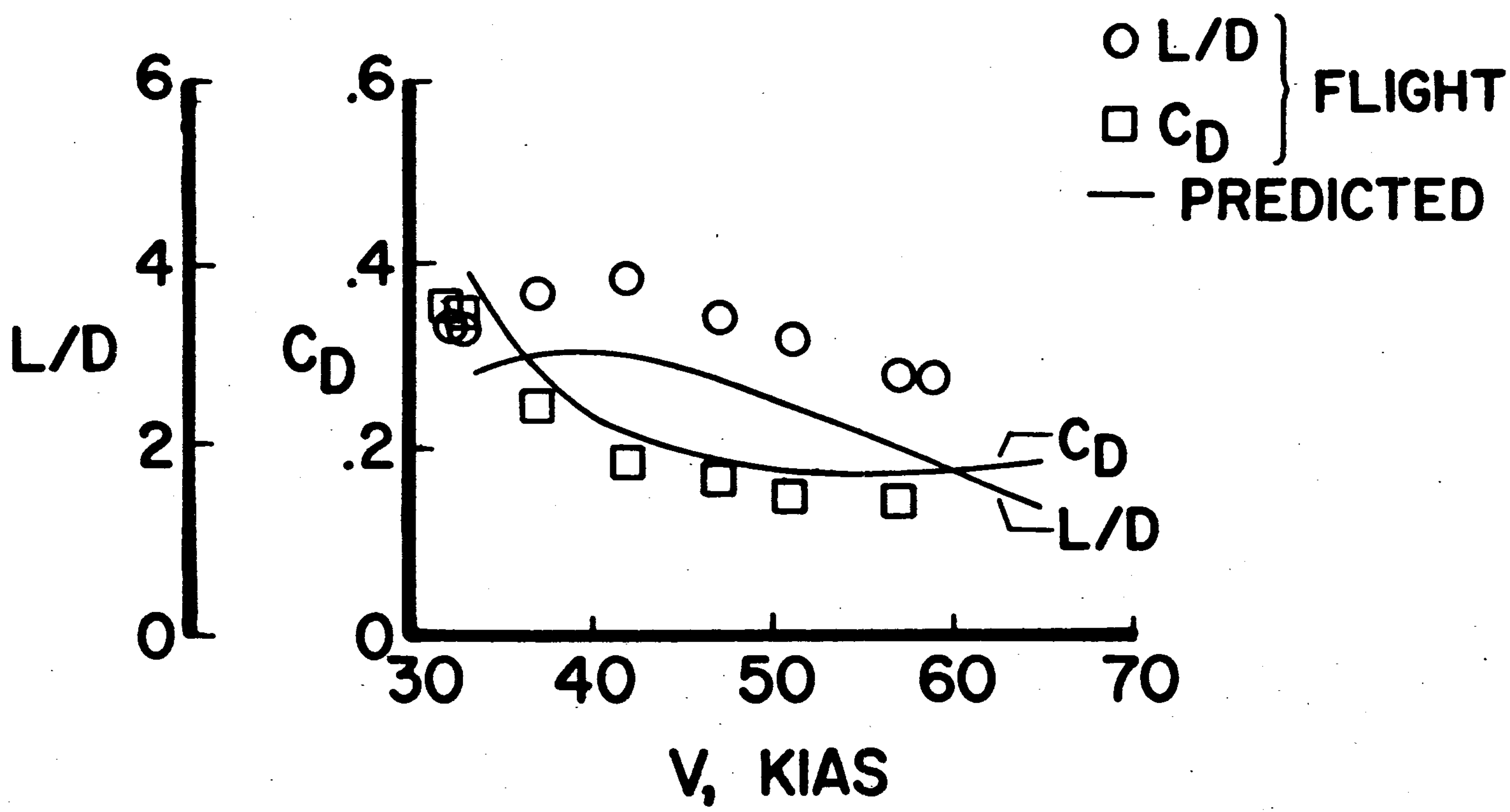
Oscillations have only been encountered as a result of external stimuli (turbulence or tow rope) and result in coupled lateral-direct lower fuselage responses. Higher magnitude turbulence has induced coupled motions about all three axis.

More than 70 landings have been made from stabilized free flight conditions. About 40 were from release altitudes of 100 to 300' and 30 from releases above 1000'. Only one landing resulted in structural damage and this was due to flare being initiated at approximately the IAS for L/D maximum with the 100 foot wing. All other landings have been accomplished with less than 10 fps vertical velocity at touchdown and 75% of those are estimated at less than 5 fps by the pilot and observers. To achieve a satisfactory flare, about 10-12 kts. above the IAS for L/D maximum must be obtained prior to flare initiation. L/D maximum for large wing occurs at approximately 42KIAS and IAS used prior to flare initiation was 50 to 55 KIAS. For small wing, IAS for L/D maximum is estimated at 48 KIAS and successful flare have been accomplished starting from 60 to 65 KIAS. Excess energy is used to adjust flare rate during flare or to adjust altitude (second flare) after achieving zero vertical velocity. Approximately 3 seconds elapse from flare initiation to touchdown. Only visual perception of closing rate with labeled surface has been used to determine flare initiation point.

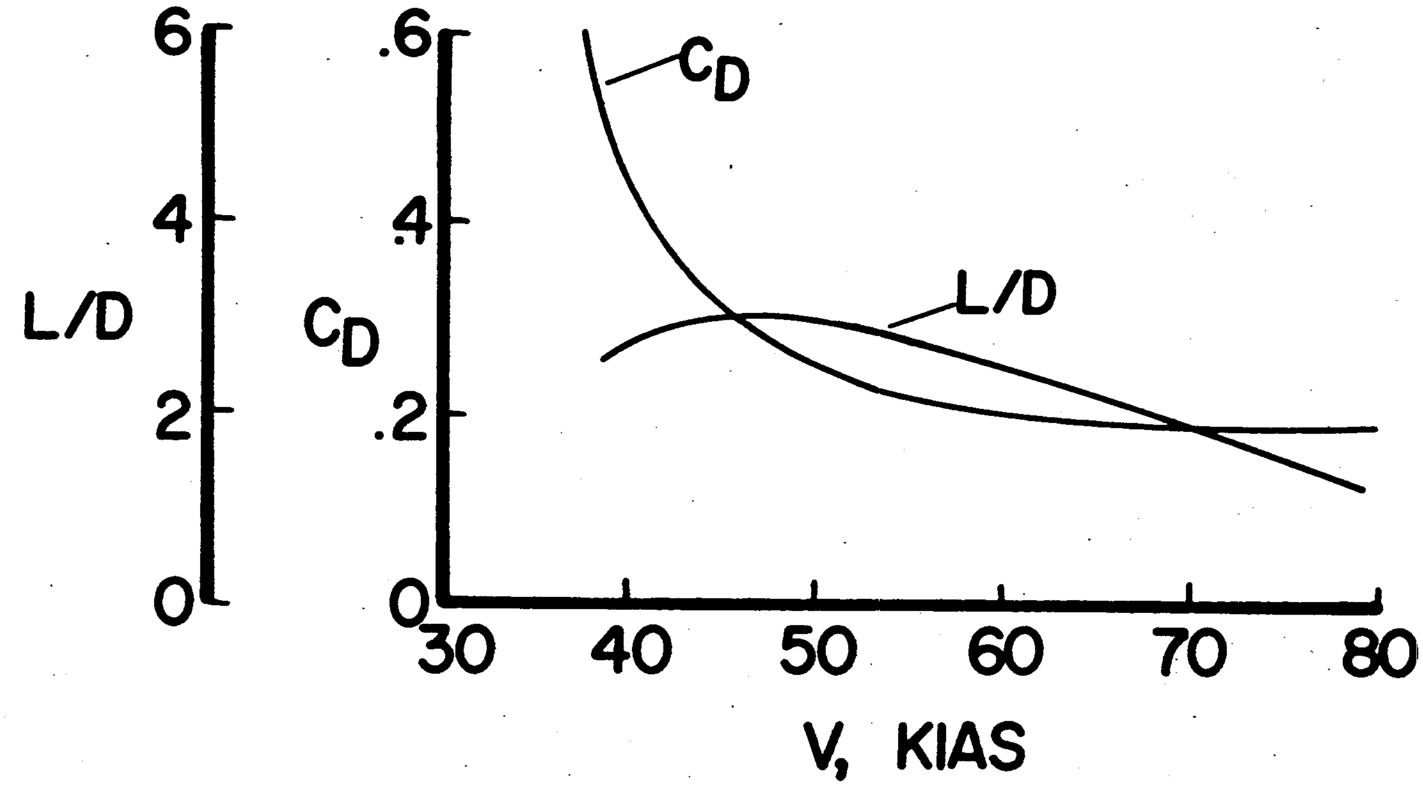
Towing the PARESEV is not a real problem but does require pilot familiarization with tow line dynamics.

Under the present plans, due to manpower requirements for other projects, the PARESEV program will be terminated after the flight data are obtained with the PARESEV-1B configuration. However, if problems arise in specific areas where the PARESEV could be of benefit, the project would be revived. I might add that the knowledge gained from short-term, relatively inexpensive test programs of this nature cannot be over-estimated.

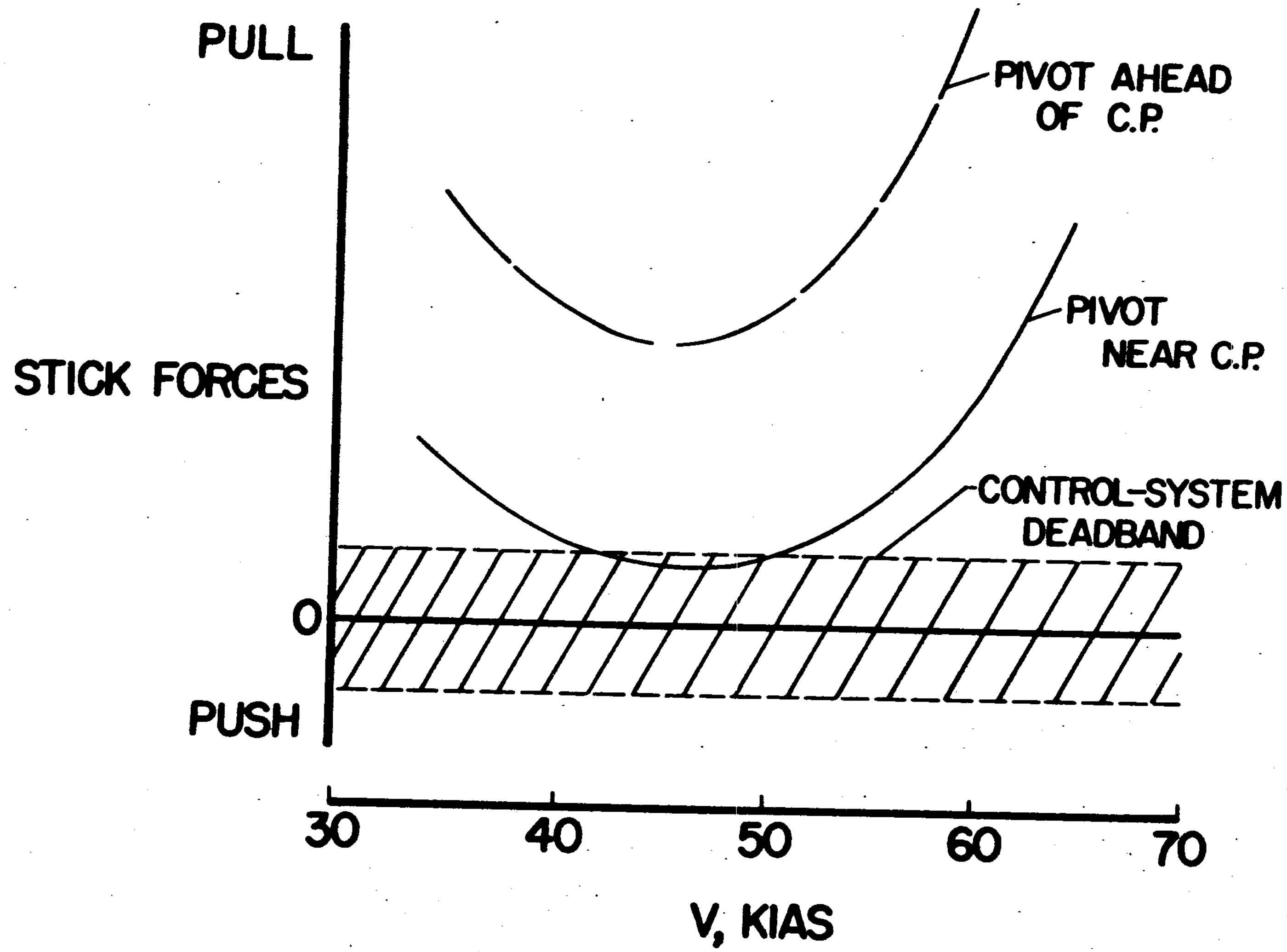
LONGITUDINAL PERFORMANCE OF PARESEV IA



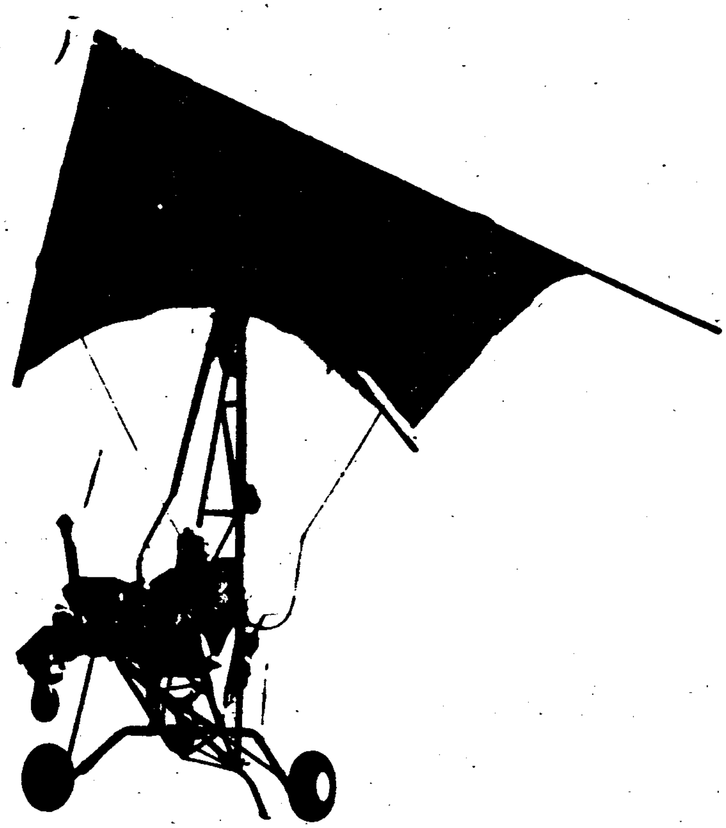
PREDICTED LONGITUDINAL PERFORMANCE OF PARESEV IB



CONTROL-SYSTEM FORCE GRADIENTS



PARAGLIDER RESEARCH VEHICLE I



PARAGLIDER RESEARCH VEHICLE IA