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NASA - Langley

ROTARY-TYPE RECOVERY SYSTEMS

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The Langley Research Center has tested, or is currently testing, several types of rotary devices with applications for recovery systems. The first slide is a chart of these systems showing the areas where data are presently available and the areas where research is still required. (Slide.)

The vortex ring parachute resembles a Maltese cross when viewed from above. Deployment, stability, and performance tests have been completed. A report containing this data is in the review stage now and will be available soon. This system is not intended to glide, however as for most parachutes, it can be forced to produce a small amount of L/D.

The flexable rotary wing consists of strong cables at the leading and trailing edges with parachute type material stretched between them. A weight at the tip provides centrifugal force to maintain all components in tension while rotating. Some preliminary deployment tests have been conducted using a 4 bladed 6 foot diameter model. The cloth rotor blades were attached to a 32 inch diameter vortex ring parachute which was used to provide the initial rotation for the system. After the deployments, the rate of rotation increased, indicating that the blades were autorotating and were not being driven by the rotating parachute. Performance data have been obtained for a 2 bladed 4 foot diameter rotor, most of it for the vertical autorotative descent condition. For these tests, the blades were attached to a short wooden paddle wheel type of hub arrangement. A few tests at lower angles of attack have indicated that this system does have gliding capabilities although how well it will glide is not known.

The conventional rotary wing is the helicopter type system. This is the configuration for which a vast amount of performance data are available, including data for gliding flight and flared landings. This is the configuration for which most of the tests on stability in vertical autorotation descent have been conducted. No deployment tests have been conducted, and none are planned.

The folding and the telescoping rotary wings are essentially the same as the conventional rotary wings, but they are intended for a more compact stowage of the system. Deployment tests are planned for both of these systems. The effects, if any, of the telescoping joints or the folding hinges on the performance is not known. A few stability tests have been conducted using 4 foot diameter models with telescoping and folding type construction. (Slide off.)

I would now like to discuss some of the areas of this chart for which data are available. A short film will be presented next which shows a vortex ring parachute being deployed while in free fall and rotating. (Film.)

As you have seen in the movie, the parachute is very stable with oscillations of less than 1°. The next slide shows the variation of the coeficient of drag with the incedence setting of the individual blades (canopy segments). (Slide.) The drag coefficient is based on the total cloth area of the parachute. The high drag (C_D=2.1) obtained with this particular parachute would mean that for a given payload the rate of descent would only be 60 percent of what it would be if a conventional parachute of the same cloth area were used. (Slide off.)

A few preliminary deployment tests of flexable fabric blades have been conducted and have pointed out some of the problem areas which will have to be studied and corrected. A short film showing one of these problem areas will be shown. This film was taken at approximately 1500 frames per second and will be projected at 24 frames per second. Therefore, the motions seen are approximately 60 times slower than they actually occurred. The deployment of the blades takes place in about one quarter of a second. The steady state motion seen after the deployment, was taken approximately 6 seconds later. It is part of the same test. (Film.) It is believed that the problem illustrated in this film can be solved with a controlled slower deployment of the blades.

Experience in the Recovery Systems Branch has indicated that use of a rotary wing recovery system may involve problems of dynamic stability. Parametric tests are being conducted at Langley to determine how much effect the various parameters have on the stability of a rotary wing in free vertical autorotation descent. Some of the parameters which have been very briefly examined and have been shown to have an effect on the stability of this system are listed in the following slide. (Slide.) There are other variables which quite likely effect the stability also, such as, solidity ratio, number of blades, blade weight, blade incidence angle, and payload configuration.

The next film will illustrate a rigid rotary wing on an apollo type capsule in vertical autorotative descent. The first sequence is an unstable configuration. By varying one of the parameters (in this case hub inertia), the stability was increased as seen in the second sequence, however, it was still only marginally stable. A further modefication produced a completely stable configuration. (Film.)

A few tests have been conducted with a 48 inch diameter rotor, considering only two variables, hub inertia and disk loading. The results are presented in the next slide. (Slide.)

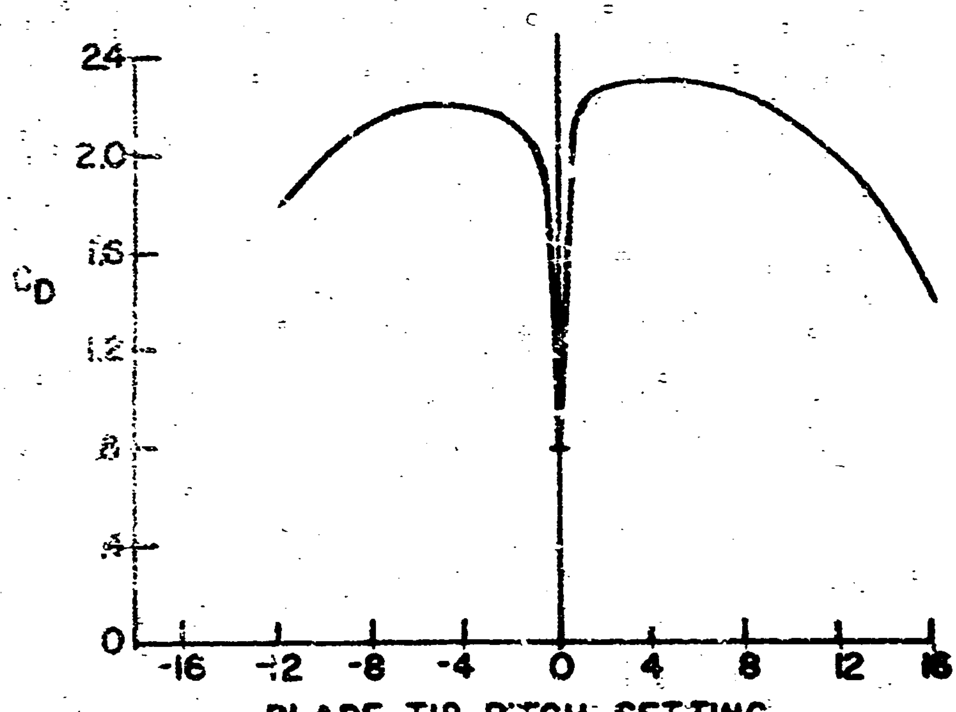
As can be seen from this slide, as the hub inertia is increased, the disk loading must also be increased to maintain stability. If some of the other parameters are changed, this curve will be shifted. For instance, decreasing the blade hinge angle will shift the curve downward.

In conclusion, it can be said that rotary type recovery systems can be made inherently stable, can produce high drag, fair gliding capability, and near zero vertical and horizontal speeds at landing.

ROTARY-TYPE RECOVERY SYSTEMS

	DATA AVAILABLE			GLIDING CAPABILITY
	DEPLOYMENT	STABILITY	PERFORMANCE	
VORTEX RING PARACHUTE	YES	YES	YES	NO
FLEXIBLE ROTARY WING	SOME	NO	SOME	YES
CONVENTIONAL ROTARY WING	NO	SOME	YES	YES
FOLDING ROTARY WING	NO	SOME	NO	YES
TELESCOPING ROTARY WING	NO	SOME	NO	YES

VARIATION OF C_D WITH BLADE PITCH SETTING FOR 64" DIA VORTEX RING PARACHUTE



PARAMETERS WHICH EFFECT THE STABILITY OF ROTARY WING RECOVERY SYSTEMS

1. DISK LOADING
2. HUB INERTIA
3. BLADE HINGE ANGLE
4. DISTANCE BETWEEN BLADE HINGE AND AXIS OF ROTATION
5. VERTICAL LOCATION OF CENTER OF GRAVITY

STABILITY BOUNDARY FOR A 48" DIA ROTOR IN FREE VERTICAL AUTOROTATIVE DESCENT