<u>OPERATIONS</u>
EXTERNAL LOADS

Carrying loads outside the helicopter is often convenient and sometimes necessary. It does, however, introduce some potential safety-of-flight problems that pilots, operators, and engineers should be aware of.

The most common way of carrying an external load is on a single cable. With this system, it is relatively easy to attach and detach the load, and if necessary to jettison it in flight. Many types of cargoes, though, ride on a single line like an untamed mustang. This can lead to spectacular accidents. Listen as a couple of pilots describe how things can go wrong.

Horrible example No. 1 (From a letter to me.)

" I attempted to sling a small helicopter from a larger helicopter and found myself in such a pickle that I had to drop the load to avoid it looping over us.

"For some reason, at about 70 knots, the small helicopter turned away from the relative wind and began to travel laterally from our flight path, reaching a point where it would turn and accelerate back the other way with increasing speed and force. After about a minute of this, the situation had deteriorated so badly that I had to release it.

"My employer and I are being sued for damages due to 'said' negligence on our part. While I feel partly responsible, a good share of the blame should rest on the parties who rigged the load."

Horrible example No. 2 (From the book, *Chickenhawk* by Robert Mason.)

" I saw this maintenance ship take off carrying a damaged rotor blade attached to the sling hook, to carry it out to sea and drop it.

"As the ship took off, it became obvious that carrying a rotor blade dangling vertically beneath the ship was not going to work. It swung wildly under the ship as it gained speed.

"I saw the blade whipping around under the ship at 300 feet. Apparently, the pilot could not tell the blade was gyrating under him. Before he reached the beach, the blade slashed up behind the ship, knocking off a section of the tail rotor. He flared back, trying to slow the ship, but it was of no use. As he flared, the blade knifed forward under the ship swept up and hit the main rotor. The damaged main rotor flew off. Time seemed to stop, and I saw the ship nose down, invert, and then disappear behind some tents and smash onto the beach."

Safe at any speed?

Some external loads will behave themselves up to a reasonable speed on a single line. These include heavy spheres and cubes and loads with good weathervane stability such as airplane fuselages with the empennage (tail section) still attached. Most other loads, however, will stay put only up to a certain speed and then begin to oscillate as the aerodymamic forces increase. The oscillation is often unstable, building up to such an amplitude that the pilot feels he must jettison the load as in the first example.

Wind tunnel tests show that a rectangular or oblong load on a single line will first orient itself broadside to the wind as in the photograph on the next page and then will go into a steady oscillation with combined yawing and side-to-side motion. The faster the tunnel speed, the higher the amplitude of oscillation.

One experienced pilot has told me that he could interrupt the swinging of the load by suddenly lowering the collective pitch. This apparently decreases the tension on the line and temporarily

Oblong Loads On A Single Line Tend To Orient Broadside To the Flight Path

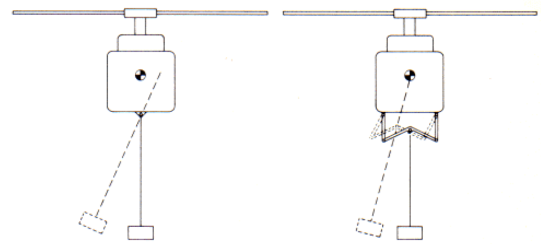
changes the dynamics of the system enough to break the vicious cycle. In some cases, by jury-rigging a vertical stabilizer or attaching a drogue chute, enough stability may be obtained to make the load straighten up and fly right.

Even after the load has been delivered, a potential problem exists in that, at high speed, an unloaded cable can fly up and wind itself around the tail rotor.

On most helicopters, the strong point for cable attachment is some distance below the center of gravity (CG), so that a swinging load will produce a pitching or rolling moment on the aircraft as shown in the next figure. This makes the helicopter seem to fly differently than when it is not carrying a load and the pilot must adapt his flying technique for each loading condition.

Locating the attachment point near the CG would alleviate this additional complication or using a special trapeze arrangement as shown is another possibility.

Rolling Moment Caused By Load Displacement



Actually locating the attachment point near the CG is done on the Sikorsky Skycrane by mounting the strong point to the bottom of the transmission as shown on the next page. On the Skycrane's younger--and stronger--brother, the Sikorsky CH-53E, the same effect is achieved by bringing the cable up through a hatch in the floor to a special fixture that can be swung into place when needed for longline operation.

Multiline

Supporting the load on two or more lines is one way to improve stability. It does, however, introduce the potential problem of a nonsimultaneous release in case jettisoning becomes necessary.

Some schemes have been tested involving attaching the cable to the lower ends of "active arms" which, controlled by a special black box, move in such a way as to oppose the motion of the load. An even surer way to control the load is to snub it up tight to the bottom of the helicopter. This is the most practical when the helicopter has been designed with this feature in mind. For instance, the long landing gear on the Sikorsky Skycrane can straddle a load on the ground while being attached. Helicopters without this type of landing gear might be able to snub their load, but it would have to be done from the hover.

Cable Attachment Point (Near CG) Of Sikorsky Skycrane

Vertical bouncing

Another possible problem when using a flexible cable is a “pogo” mode where the load starts bouncing up and down, and shakes the helicopter enough that the pilot cannot help moving his collective control in a way that reinforces the plunging motion. This situation requires that the natural frequency of the load on the line be between two and four cycles per second.

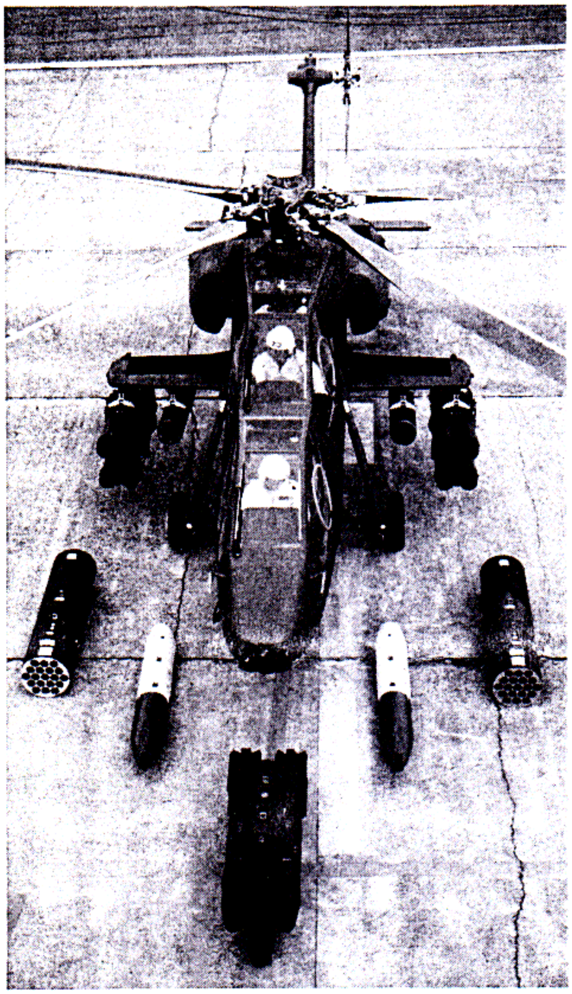
In this frequency range, the time lag in the pilot’s reflex action is such that no matter how hard he tries to stop the motion, he will do the wrong thing at the wrong time and increase it. Many sling loads have been jettisoned as the amplitude of the plunge increased to a frightening level.

A less drastic cure is to lock the collective with friction and then leave it alone. A possible way of skirting the problem is to install a soft spring in the line so that the natural frequency is below two cycles per second, slow enough that the pilot can control the system with normal actions.

Shaky wings

Attack helicopters usually carry expendable stores or ferry tanks on their stubby wings, which can get into special dynamic problems because of the changing natural frequency of the wing in bending as stores are released or fuel used. The photograph on the next page shows some of the things that can be mounted on the wing of the Agusta A129.

Wing Stores That Can Be Carried By The Agusta A129



A fully loaded wing will have a natural frequency considerably lower than when the store stations are empty. If, in the process of going from full to empty, the wing natural frequency coincides with one of the frequencies caused by rotor rotation, the wing will be in resonance and may bend up and down or twist at large amplitudes. These critical frequencies can correspond to once per revolution of an unbalanced main rotor--or to higher frequencies corresponding to the number of blades per revolution, or to twice or four times the number of blades.

Because of the large combination of wing store loadings possible, it may not be practical to forewarn the pilot when he might expect resonance but a fairly straightforward way of getting out of it is to release yet one more store or to transfer fuel from one tank to another.

Multihelicopter lifting

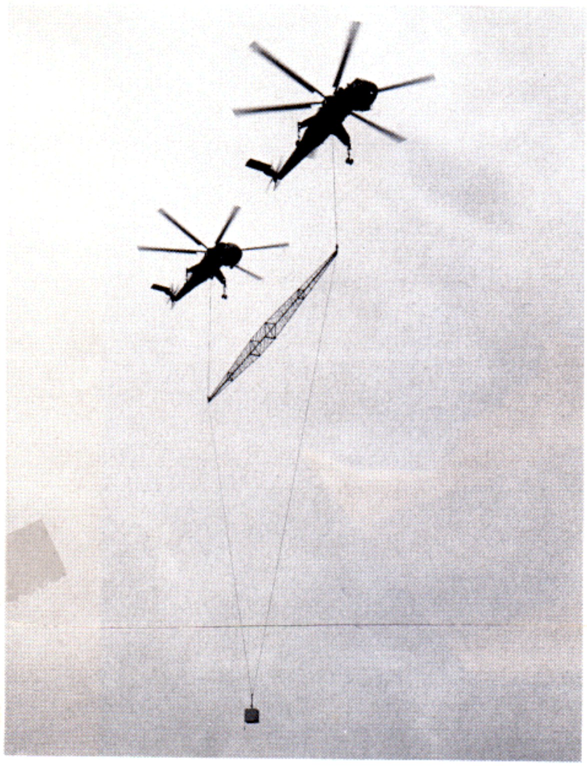
What does an operator do when he is asked to lift a one-piece load just beyond the capability of his helicopter? If he wants the business, he can try and find a bigger helicopter.

The alternative is to harness two of his machines together so that they can do the job. The photographs on the next page show how this has been done in the past. This bihelicopter lifting capability has not become standard operating procedure because close pilot coordination is a difficult job. With the development of helicopters with extensive electronic help for control, it now becomes feasible for one pilot to fly two (or more) helicopters information while the other pilot(s) simply monitor the safety aspects.

It appears to me that this is a better way to occasionally lift a very big load such as an army tank than using one gigantic helicopter, since between heavy lifts the individual machines could transport smaller loads in several directions.

From *Rotor and Wing*, September 1985 and Chapter 14 of *More Helicopter Aerodynamics*

Two Sikorsky CH-54Bs Team
To Transport A 35,000-Pound Cargo



Two Bell 206Bs Carrying A Utility Pole
Neither Could Lift Alone