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Wheels Are Square

Tim Brady
U.S. Air Force, bradyt@erau.edu

Wheels are SQUARE. (Air cushion landing system)

by Maj Tim Brady illus tab 12-15

You'd have to look with jaunticed eye at someone who came up to you and said, "Hey Mister, lemme tell you something; wheels are square. I've got something here which'll turn that Herkything into an airplane that'll land on water, a beach, marshland, or just about anything else that doesn't have something funny like a tree or a mountain in the middle of it. Matter of fact, this beauty can taxi over stumps, ditches, rocks, and even the Great Dismal Swamp."

About now you're convinced the guy is some kind of a weirdo as he whips out a large sheet of butcher paper with a surprisingly accurate likeness of a C-130 sketched thereupon. Except it looks kind of funny; y'know . . . strange! Upon closer examination, an unusual feeling begins to creep in and finally overwhelms you. The tears begin to roll, a tremor starts at the tip of your toes and works itself upwards, finally you break out in uncontrollable laughter.

No wheels! I mean the thing has no rollers. It just has this big rubber doughnut whatzit that looks like an elongated inner tube on the bottom of the airplane. And the airplane is supposed to land on that thing? And taxi?

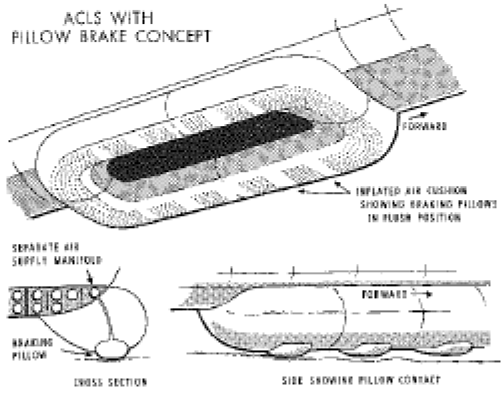
In your well-founded skepticism, you send the nut off to the loony bin, casting after him quips dredged from wisdom such as: "If it don't roll, it won't fly," and "Wheels are beautiful," and "Your grandmother wears an inner tube." You concede, begrudgingly, that the last remark was more emotional than born of wisdom, but after all, what a ridiculous idea.

Months later you pick up a copy of AVIATION WEEK AND SPACE TECHNOLOGY which announces "Air Cushion Landing System to be evaluated jointly by the U.S. and Canada." The doughnut on the bottom of the test airplane looks familiar.

THE AIR CUSHION LANDING SYSTEM

Using its own funds, Textron's Bell Aerospace Division instituted a development and flight test program to evaluate the practicality of the Air Cushion Landing System (ACLS), using a modified LA-4 (Lake Amphibian) as a test-bed aircraft. Then in 1969, the Air Force Flight Dynamics Laboratory awarded a contract to Bell for continuation testing of the ACLS equipped aircraft. During the tests, the LA-4 aircraft was successfully operated from a variety of surfaces including snow, ice, water, rough surfaces, mud, obstacles up to 9 inches, a water-filled ditch, and standard concrete runways. The tests proved the feasibility of ACLS on light aircraft and the next, logical step was to consider the application of the system to medium and heavyweight aircraft.

In all honesty, the air cushion contact medium idea is not all that new. Presently, the English operate an air



cushion surface vehicle on daily runs across the channel. This monster weighs in at 163 tons or about twice the weight of a C-130. Here at home, the Navy has a 30 ton ACV and the Army has operated an 8 ton ACV in Viet Nam. The Air Force has been studying the concept and its application to aircraft since 1966. The Air Cushion Landing System is based on the "ground effect" principle which employs a stratum of air instead of wheels as the ground contact medium. A large rubber trunk (pneumatic bag) encircles the bottom of the fuselage, providing an air duct and seal for the air cushion. The bottom of the trunk contains hundreds of small vent holes (jets) which allow escaping air supplied from an on-board power source to form an "air cushion" beneath the aircraft. The on-board power source causes air pressure higher than atmospheric to be exerted on the area directly below the aircraft. This additional pressure produces a force equal to the weight of the aircraft. Because of the low ground over-pressure, the ACLS will enable an aircraft to operate from surfaces of very low-bearing strength. Additionally, the air bag is retractable, though not in the traditional conventional landing gear sense. After airborne, as the air bag is depressurizing, the rubber contracts and hugs the fuselage like a glove.

AIRCRAFT HANDLING CHARACTERISTICS

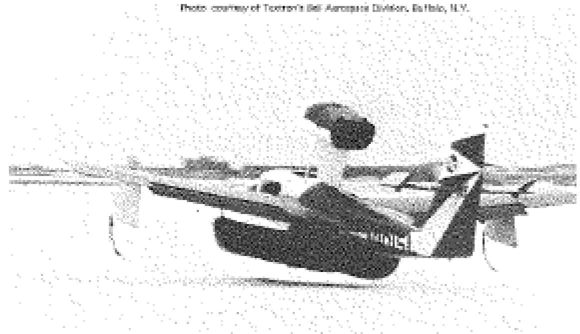
The only flight-test data available thus far on the handling characteristics of an ACLS equipped aircraft comes from the flight tests of the LA-4 aircraft. Of course many studies have brought out the anticipated performance of an ACLS-equipped tactical transport and in May of this year, the joint U.S-Canadian test of an ACLS-equipped C-115 (DeHaviland Buffalo) will get under way and will, undoubtedly, bring in a ream of data. In the meantime, using predicted performance coupled with LA-4 flight test info, we can take a look at the expected handling characteristics.

TAKEOFF

Let's turn first to the LA-4 test pilot's comments. "The handling and control qualities in the takeoff 'roll' are satisfactory. Steering control becomes more positive and simple as aerodynamic effect increases with speed. The aircraft can easily maintain a track along the runway centerline, and after transition to the airborne condition, requires less changes in attitude and heading to continue flight than the standard aircraft."

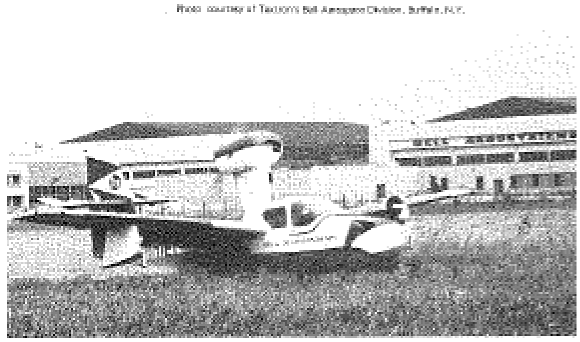
The takeoff distance of an ACLS equipped aircraft should be somewhat less than that of a comparable wheeled aircraft. The parasite drag of the smoothly contoured ACLS is about equal to the drag on a conventional gear but the momentum drag of the ACLS is less than the rolling resistance of wheels.

Photo courtesy of Textron's Bell Aerospace Division, Buffalo, N.Y.



The LA-4 modified with ACLS taking off over water.

Photo courtesy of Textron's Bell Aerospace Division, Buffalo, N.Y.



The modified LA-4 taxiing over an open farm field.

LANDING

New techniques and procedures are going to have to be learned by the pilot in order to handle the landing in the ACLS aircraft, especially to counter a crosswind situation. The LA-4 test pilot made these comments concerning a crab landing. "The true effect of the gradient winds could be observed during approach. On the grass landing, the wind was 90 degrees cross from the left at 10-15 knots. The selected grass area paralleling (the runway) was at least 10 feet below the runway level. A constant decrab was required as the aircraft settled into the depression downwind from the runway. The very steep wind gradient resulted in a "stalled" landing. On a wheeled gear landing this would have been a very hard landing. The ACLS absorbed the impact with no undue pitch oscillation and was under good control during rollout. The crab angle developed during heavy crosswind landing and rollout might look alarming to an external viewer, but from inside the aircraft they are the view a pilot would expect from a good to perfect crosswind landing gear or when "sailing" a sea plane to and from dock."

If you've never "sailed" a seaplane to and from a dock, it's obvious that landing an ACLS aircraft in a crosswind is going to call for a new bag of tricks.

TAXIING

With no wheels on the beast, the term "nosewheel steering" plummets out of the vocabulary. Consider for a moment the situation where you're parked on a standard ramp with aircraft on both sides and with a brisk 20 knot wind blowing from right to left. You start the engines, then flip a switch to inflate the ACLS. The ACLS becomes pressurized and the aircraft rises slightly as it's supported by the air flow underneath. With no additional inputs on your part, the airplane will begin to move downwind. Why? There's little or no friction between the ACLS and the ground and the force of the wind will move the airplane. So, again, a new bag of tricks is going to have to be learned. Differential power and brakes will have to be used to steer the airplane on the ground and counter any crosswinds. Brakes?

The brakes on the ACLS consist of a series of pads (or pillows) on the bottom of the cushion which, when activated by the pilot using the standard controls, will press against the surface. Studies indicate the same braking efficiency can be achieved with this system as with normal wheeled braking systems.

GROUND HANDLING

The maintenance troops are going to have their hands full with an ACLS airplane. With no wheels on the bear, it's going to make dragging the airplane around the patch somewhat of a chore. Also with nothing to support the airplane, once the ACLS is depressurized, the big machine is about as mobile as a beached submarmine. So, first, some method to support the airplane must be incorporated in the ACLS design. One method to accomplish this is to provide an inner bag which remains inflated once the ACLS is depressurized. Then, in order to give the airplane some ground mobility (without restarting the ACLS power supply engines), some attach points on the fuselage to hook up a set of wheeled dollies will, most probably, be provided. The ground handling problem appears to be the most severe limitation of the ACLS concept.

COST

The basic mission of tactical airlift is to provide transportation of personnel and equipment to the forward tactical locations within the theater of operations. It is essential that the cargo, whether air-dropped or air-landed, be delivered as close to the objective area as possible. To indicate the cost feasibility of ACLS, the Air Force Flight Dynamics Laboratory analyzed the cost effectiveness of ACLS over present resupply methods in maintaining a 5000 man fighting force in a forward, austere area. The following chart summarizes that study.

SUMMARY OF DELIVERY SYSTEMS

	MODE OF DELIVERY				
	AIRDROP		AIRLAND		
Cost Criteria	CDS*	LAPES**	+CLG (prepared runway)	+CLG (AM2 MAT runway)	ACLS
Max tonnage per mission	17.5	25	12.8	25	25
Operational cost per mission	$9,000	$1,200	$ 16,290	$ 500	$500
Operational cost per ton	$ 520	$ 50	$ 1,300	$ 20	$ 20
Fixed cost of site preparation	Negligible	Negligible	$457,000	$2,757,000	Negligible
Fixed cost per ton (8,000 men for 3 months)	Negligible	Negligible	$ 13	$ 220	Negligible
Total cost per ton (8,000 men for 3 months)	$ 520	$ 50	$ 1,313	$ 240	$ 20

* Container Delivery System

** Low Altitude Parachute Extraction System

\+ Conventional Landing Gear

When concerned only with mission cost, it's clear that an ACLS equipped tactical transport will gain startling savings over any delivery method presently being employed. The closest thing to it is LAPES (Low Altitude Parachute Extraction System) which costs $50 per ton (5000 men for 3 months) as compared to $20 per ton for ACLS. Note the site preparation cost of an unsurfaced runway and an AM2 MAT runway. ACLS practically eliminates site preparation cost.

SUMMARY

To call upon a familiar cliché, this has been a "broad-brush" look at ACLS. Not all of the factors which affect development, testing, and employment are presented. There are limitations to the system which haven't been fully explored here, and which, indeed, may not surface until the testing program gets under way. But, should the tests with the C-115 Buffalo prove the concept to be practical, and the decision is made to so equip tactical airlift aircraft, the impact on the mission of airlift will be astounding. It will open vast areas of the battlefield that have previously gone unexploited by tactical transports. It will make airfields out of cornfields, lakes, beaches, swamps, snow, ice, and most other terrain features with a relatively smooth surface. The entire complexion of the battlefield will change.

Keep your eye on it.