

Lowest Possible Cost - Highest Efficiency Flight

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What is the Lowest Possible Cost - Highest Efficiency Flight? No aircraft has implemented all the well known factors for maximum efficiency. Lowest possible cost - highest efficiency flight for heavy lift cargo is a spanloader for standard shipping containers. laminar-flow control with the highest possible Aspect Ratio. It has been long known the most efficient design is to carry the load along the wingspan. The standard mode of cargo transportation is intermodal shipping containers. An obvious idea would be to carry them from wingtip to wingtip. The lowest cost per ton per mile may be achieved by the proposed ConcordLift™ configuration. This is a thought experiment and a call for research.

I.

Rationale

Heavy Lift air cargo has far greater potential for growth than the mature passenger model. There is a search throughout the aeronautical industry for new, better ways. The wing and tube concept has reached the end of its development possibilities. A long time ago air cargo was abandoned to a small specialty niche.

In 2016 there were a reported 34 Million Standard Shipping Containers, TEU.ⁱ In 2015 the world's container ports transshipped 560 million TEU.ⁱⁱ Barges, trains and trucks carry TEU away from those ports. Current air freight, requires TEU containers to be repacked in order to fit into the aircraft. Flight can have lower cost than truck and rail.ⁱⁱⁱ Instead of ground transportation from the interior to ocean port, containers could travel directly from interior to distant interior destinations. Moving only a small percentage of the current TEU containers would require a large number of aircraft. There are over a billion people with no access to low cost, speedy transportation. The smaller number of containers needed for an aircraft load increase shipper convenience and savings in time.

Lowest cost, efficient transportation of cargo, has to include standard shipping containers. They are used world wide, except for air cargo. In many parts of the world truck and rail are both slow and costly. Building good road and rail is difficult and costly. There is strong demand for low cost very heavy lift air cargo.

Many millions are being spent on various Hybrid Airship projects. The need is so great that the serious negative issues are discounted. There is little reason to think that they will be anything more than a specialized item for a very small market. Good profits will be scarce. Those issues are inherent in the concept. All have a large gas filled balloon that creates drag. Drag that increases geometrically with airspeed. At 100 KIAS they need four times the power, fuel as at 50 KIAS. For efficiency they must be very slow which makes them subject to ambient air flow and makes ground handling very difficult. Many Hybrid Airship proposals include vertical lift components that create high velocity downwash and outflows. Some slightly heavier than air use forward thrust for lift. That there is demand demonstrates that there is a good market for efficient heavy cargo lift.

Basic theory for high efficiency includes: the spanloader, that distributes load from wingtip to wingtip, Laminar-Flow Control: (30% increase in efficiency) termed "The Holy Grail of Aerodynamics"^{iv}, the highest possible Aspect Ratio (AR) and flight in ground effect (10% near the ground). No aircraft has implemented all these well known factors. The high air density near the ground counters the benefits of flight in ground effect. High altitude has the best efficiency.

Metric units are not normally used in this paper. Standard shipping containers are in English units. Standard shipping containers are counted in Twenty-foot Equivalent Units (TEU). The base unit measures 20 ft. long × 8 ft. wide and usually 8.5 ft. high. Most are double units - 40 ft. long, some extra long 45 and 53 ft. and some extra high 9.5 ft. The average container load is 30,000 lb. The maximum load is 80,000 lb.

II. Blended Wing Body

A BWB spanloader described by: R. H. Liebeck of The Boeing Company, Huntington Beach, California 92647 in a paper in *The JOURNAL OF AIRCRAFT* Vol. 41, No. 1, January–February 2004 Design of the Blended Wing Body Subsonic Transport.^v That suggested design is for 800 passengers and 7000 mile range. Very large passenger loads have been found undesirable. However the proposed aircraft has sufficient internal volume for 10 containers. The following changes the range in that paper from 7000 miles to 3000 miles since fuel stops are acceptable for air cargo. On the basis of that paper’s computation, ten TEU can be transported 3000 miles for a fuel burn of 100,000 lb. or 10,000 lb. each. Laminar Flow Control could reduce that by 30% for a fuel burn per TEU about 7000 lb. This is less fuel than a Highway Truck would use and would make the trip ten times faster! Trucks would also require the labor of about 25 man days.

The Blended Wing Body has great potential as a cargo air carrier.

III. ConcordLift™

The ConcordLift™ configuration was developed to design a spanloader that carried TEU inside the wing and achieve the lower possible cost per ton mile. This paper sets forth both general and specific illustrations of that configuration. There are many additional designs that could be developed. ConcordLift™ could be constructed with the technology of 1940. Nothing is necessarily complex or “high tech”. This needs to be considered as a totally new category to serve in a totally new transportation market with new appropriate regulations. There is much more that is not included in this brief paper.

Except for work on distributed load, spanloader, there are no parallels in published work. The closest spanloader research has been in high altitude solar aircraft.^{vi} They are low speed, very low power, tailless with distributed propulsion. They demonstrate it is possible to control an aircraft with ConcordLift™ parameters. Included is an illustration of a successful NASA aircraft.

The ConcordLift™ configuration and operation have nothing in common with lifting body, wing-in-ground, three wing, or flying wing. There are no papers, or prior art, to reference that would increase understanding. The name for this configuration is “ConcordLift™”, because the wings work in concord – harmony. The name is specified in Patent US20110168832.

IV. Controlling dimensions and assumptions

For a spanloader one standard shipping container, TEU, length is 20 ft. wingspan. Containers are 8.5 ft. high for a minimum wing thickness of 10 ft. A normal slow aircraft airfoil has a wing thickness about 10% of chord, that results in a chord of 100 ft. which is 2,000 sq. ft per TEU. The average container load, 30,000 lb. gives a wing load 15 lb. / sq. ft. Scaled up to the maximum airport width, 80 meters, a 260 ft. wingspan, 13 TEU, results in 390,000 lb. load. These values suggests there is potential for a very heavy lift aircraft.

The flight parameters in this paper are those of a plane with a similar wing load. There is no reason why heavier wing load, faster speed and high altitude could not be achieved. Different intended usages could lead to different flight parameters. ConcordLift™ could use the same runway length as a light plane, less than 1200 ft. at sea level.

A quick overview shows the standard configuration is unworkably large as spanloader with the normal configuration because of the great distance between wing and horizontal plane when the wing is 10 ft. thick and the cord is 100 ft. In addition a cord of 100 ft. creates a strong low pressure venturi beneath the wing near the ground. Angle of attack, rotation for take off and flare for landing are challenging to achieve. A cord of 100 ft. and span of 260 ft. has a terrible aspect ratio. The obvious problems suggest the great potential is unreachable.

The common slow airfoil has the center of lift at 1/4 cord. In the ConcordLift™ usage that airfoil must be inverted in order to obtain the lift needed, angle of attack, for takeoff. Even then the value is inadequate, additional lift is required. The center of load has to match the center of lift and the throat of the venturi beneath.

There are many airfoils, that could be used. The BWB thick laminar flow airfoils may hold more TEU and have a higher wing load, if the center of lift permits. Because those airfoils have not been studied for this usage, they are not considered in the rest of the paper. The ConcordLift™ configuration obtains angle of attack, rotation for take off and flare for landing by a pair of auxiliary wings. In order to explain and illustrate, airfoils and other design features are shown. They were selected for convenience, not because they are known to be best. The engineering issues are complex, and have not been researched. The illustrations and animation are by an artist, not an aeronautical engineer.

V. Configuration and Benefits

ConcordLift™ is a cargo carrier airfoil pod and auxiliary wings connected by vertical fins. Essentially it is a tandem wing aircraft without fuselage but with an cargo airfoil pod suspended beneath. The auxiliary wings provide the lift needed for take off and assure pitch stability. The lowest cost, highest efficiency flight is goal. At this point it has not been determined if slow and low in ground effect, or the thin air of high altitude, is most efficient. There may be versions for both applications. The light wing loading make extremely high altitudes possible. The slowest speed at the highest altitude may be the most efficient. Only the crew space would require pressurization.

Wing In Ground effect aircraft have a reputation for pitch instability. All aircraft fly in ground effect take off and landing. The ConcordLift™ deep chord wing, creates a venturi between wing and ground. When the trailing edge is closer to the ground than the leading edge, low air pressure pulls it even closer to the ground. This makes flaps and ailerons problematical. The auxiliary wings, high above, assure pitch stability. The great wingspan possible with ConcordLift™ permits it to fly safely in ground effect hundreds of feet above the surface.

A. Basic Design Form

There is no inherent limit to the span of a spanloader. The 80 meter box is the limit for passenger aircraft loading gates. The standard runway width is also 80 meters, 262 feet. That would seem to limit ConcordLift™ to 13 TEU or 260 ft. span. The passenger loading gate limit does not apply for this cargo aircraft. It is expected that in time specialized air cargo terminals will be built. It is not expected to mix in flight patterns with commercial jet aircraft. The slow, low wing load, ConcordLift™ is able to use a very short runway.

Aspect Ratio (AR) the ratio between the wingspan and the cord has powerful affect because the higher the ratio the greater efficiency. Sailplane soar without power because of their great AR. The very large wingtips of the cargo wing enable them to join together to create a higher Aspect Ratio. Aircraft could take off separately, join up in flight, cross the ocean, and separate to go to different destinations. That connection is designed in concept but is not included in this paper. The major challenge is safe separation in flight, since in between the wingtips is strong low pressure.

There is a radical alternative. Airfields could have a 1200 ft. or wider portion of runway for ConcordLift™. As a short field aircraft less than 2000 ft. length is needed. Ground handling of a very wide span aircraft could appear difficult. It would have to be given thought. The entire aircraft could be made up of interchangeable sections that separate for ground handling. Latches would join the ends of structural wing spars. Each section could have a cockpit. A 300 ft. span section would be able to fly with a poor Aspect Ratio of 3. A single section with wing extensions would be much more efficient. The wing extensions could be detachable.

B. The Auxiliary Wings - Tandem Wings, adjustable incidence, high lift devices

The two auxiliary wings are mounted on pivots so the angle of attack can be changed. Since the auxiliary wings are fixed to the fins at both ends, they need a suspension to absorb the turbulence cantilevered wings absorb by flexing. They provide the extra lift needed at take off and landing. Flaps and slots may extend their full width, since this concept may not need a portion of the wing dedicated for ailerons. The adjustable incidence is necessary to

provide flare for landing and rotation for take off. At optimum angle of attack and with full high lift devices, a wing can produce 2 ½ times as much lift as considered normal.^{vii} In this paper the auxiliary wings are considered to be 20% of the cargo carrier cord. At optimum deployment, they provide 5/13 of the total lift.

**The total lift of the ConcordLift™ is not determined by the deep cord cargo wing portion alone.
Wings work together in harmony - “Concord” - to accomplish what otherwise cannot be done.**

C. The Cargo Carrier, Slots and Spoilers

The very large, thick, spanloader cargo carrier airfoil cannot have flaps and ailerons but can have leading edge slots and spoilers. An inverted airfoil can have a maximum angle of attack, with a thickness 10% of the chord, about 5.7°. Container channels cannot fill the wing. The center of lift is at the center of lift about 1/4 cord. The ten to one thickness to cord ratio has to be kept in order to maintain the angle of attack. Loading doors are at each wingtip or underneath for fast loading times. Between the TEU channels are trusses wingtip to wingtip. Those are the wing spars, for great strength with light weight. Those trusses combined with trusses above and below the container channels comprise a very strong wing box. There is room with that airfoil for one channel at 100 ft. cord, four channels with a 150 ft. cord or with 200 ft cord six channels.

A one container channel, cargo pod wing 10 ft. thick 100 ft cord with two auxiliary wings 10 ft. cord each has a total cord of 120 ft., a 300 ft section has 3600 square feet. Fifteen 20 ft. TEU are 450,000 lb. for a net load of 12.5 lb per sq. ft. Four 300 ft. sections, 1200 ft. wingspan, 60 TEU, capacity of 1,800,000 lbs. would have an AR of 10. Six 150 ft. cord four channel would have an AR of 10 for 360 TEU, load of 10,800,000 lb. Eight 200 ft. cord six channel 2400 ft. span, 720 TEU, 21,600,000 lb. with a 37.5 lb. per sq. ft. AR of 10. The 200 ft. cord could carry 240 TEU at 12.5 lb. wing load. All need a runway less than a wingspan. Very large numbers of TEU are not necessarily desirable since a major benefit is frequent local service. Large ConcordLift™ would not be more efficient than smaller ones. The 100 ft. cord with 3 sections, 45 TEU AR of 7.5 may be the most common version. It is possible to construct ConcordLift™ for loads as small as one TEU to deliver 30,000 lb. to a small airport.

The very large size of ConcordLift™ makes visualizing the features difficult. This paper has illustrations of smaller versions that take off separately and then join. On the Web Page^{viii} there is an animation of a smaller version showing the deployment of the auxiliary wings and landing gear on take off.

People do not think big enough.

D. Laminar-Flow Control

The great cargo wing surface creates high drag from boundary layer air. Laminar-Flow Control: has been termed “The Holy Grail of Aerodynamics”^{ix}. It has been unusable in practice because aircraft wings have not had the necessary thickness and internal volume for the required duct work. The boundary layer is pulled inside the wing through slots, reducing the drag, power, fuel by 30%.^x This cargo carrier is a great void with little internal structure to restrict airflow. Ducts could be exhausted by fanjets that would add to the thrust for flight. Pulling the intake air through the perforations would reduce the intake air pressure for the fanjets. Fanjets are designed for high altitudes, low pressures. The reduced intake air pressure should not be a great problem. There are a number of other suggested ways for drag reduction that have not been utilized in the past. They also may be useful in this application.

E. Wing Extensions

The main cargo wing might only extend 5 TEU wide or less. If the deep cord cargo carrier is 100 ft wide there would be room within the 80 meter wide airport limitation for 80 ft. wings extending out the sides for a total 260 ft wingspan. A 20 ft. wide, 100 to 150 ft. cord could carry 1 to 4 TEU. Many different arrangements are possible. Extensions could be made to fold like those for use on an aircraft carrier. One illustration shows a version with a total flying width of 700 ft. with a main wing of 260 ft. and two 220 ft. extensions. The smaller wingtips of perhaps 30 ft. cord and 3 ft. thickness are much easier to join together than the large wingtips. Their small dimensions have much lower wind loads. There is an illustration of them joined for better AR.

F. Yaw, directional change, roll and pitch and more

At the front and rear of the cargo wing are vertical fins with rudders. One major function is to carry tension, lift, from the auxiliary tandem wings down to the cargo pod airfoil. They need no more area than needed for directional stability. Tension is the lightest, least space demanding load to transmit. At altitude, the ConcordLift™ will turn and bank in the normal manner. Close to the ground, yaw is controlled by variation of engine power. Power is increased on the outside end of the aircraft while spoilers automatically compensate for the increased lift, so turns can be with the wings level. The rear fins could extend to the rear edge of the main wing. An additional horizontal surface could be placed between them to serve as a tail plane to enhance passive yaw stability.

Pitch control for the cargo wing is provided by auxiliary wings. They are used independently or together to control the angle of attack of the cargo carrier. The auxiliary wings are affected less by ground effect instabilities and provide good flight pitch stability.

The multiple fins and rudders create an unusual ability. In addition to pitch, yaw, and roll, the rudders can put a sidewise force on the aircraft. This permits the aircraft to join and separate in flight.

G. Engines

Engine weight is not an issue with ConcordLift™. Since prop wash over the top of the wing increases lift, many small propellers might be an advantage. On takeoff and landing, with the auxiliary wings set for maximum lift, the vector for drag will move higher. It is necessary to mount some engines high on the fins so the thrust vector matches the drag vector. It is effective to use cables to connect the front fins to the rear fins to connect the thrust from the front engines to the drag from the back wing. The drag from cables is minimal.

Flights may last several days, over 9000 miles. Heavy, fuel efficient engines, could make for less total weight. New power sources are in constant development. Constant speed diesels with contra-rotating propellers might be desirable. The highest efficiency may be railroad diesel electric sets to power electric motors for the propellers or motor fanjets. The wing surfaces could also be covered with photocells to supplement the power.

H. Landing gear and operation for landing and take off

The force of the venturi beneath the cargo wing could be minimized with very long gear legs. It is less a problem with the shorter cord. The following may be a better solution. In addition to the normal main gear, have a set of “stabilizing gear”. The closer the cargo carrier is to the ground the greater is the danger of instability. The following is a “guess” at what might be sufficient. The “guess” is 10 ft. between cargo wing and ground is too short for safe landing. The actual dimension will be determined in engineering.

First contact with the ground is made with the cargo wing high above the runway by very large diameter wheels. The animation uses a 30 ft. height with 10 ft. wheels. The auxiliary tandem wings rotate for flare. The stabilizing wheels carry a portion of the total load, the rest is carried by the lift, while the legs are controlled to descend to the main gear.

At take off, the auxiliary tandem wings rotate for maximum lift. The ConcordLift™ lifts off from the main gear while the stabilizing gear, still in contact with the runway, carry a portion of the load. The extension of the stabilizing gear legs may be powered. The aircraft finally leaves ground with the cargo wing already high above the runway.

ConcordLift™ has two separate take off speeds. The slower speed is when it has enough lift to unload the weight on the main gear. The aircraft begins to lift off while the rest of the weight is still carried on the stabilizing gear. As the distance between the ground and main wing increases, the force of the venturi in between is reduced. The second take off speed is when the aircraft has developed enough lift to carry the total weight.

The main gear is of standard design. For example, the 300 ft. wingspan, 15 TEU, section has at least 4 sets of 4 stabilizing wheels and 8 sets of 4 main gear for a total of 48 wheels. All wheel sets caster in order to handle cross winds on take off and landing. Wheel sets for sections to be joined on the ground caster in order to travel end first until transition to mate. The heavy load distributed over the total runway surface make this capable for unpaved fields. The multitude of landing gear creates drag under the wing and reduces the force of the venturi between the wing and ground, enhances lift.

This complex two stage landing gear and process may appear unnecessary. Container Ships occasionally sink, without much media comment. The crash of one ConcordLift™ will make a very big, media event. Even though the runway distance needed is short, the slow speed will permit the time needed for the take off procedure given above. The stabilizing gear makes smooth transition to the main gear possible.

The main gear retracts into the wing in front and in back of the cargo channels. The stabilizing gear is too large to retract inside the wing. It retracts into fairings under the wing. All landing gear is attached to the wing box. The fairings could serve as floats for ocean ditching. The fairings could also be used for passengers.

I. Crew, Flight deck, automatic flight management control

If designed for high altitudes only the crew area would need to be pressurized. ConcordLift™ is intended to fly in good flying conditions. It is expected to avoid all predicted harsh conditions. Storms move faster than ships and overtake ocean shipping. ConcordLift™ is faster than storms. Weather forecasting should prevent ConcordLift™ from ever being flown into dangerous weather. In addition to the standard instrumentation this craft needs air pressure sensors located around and beneath the aircraft to measure the forces on the craft. Ground effect instabilities require immediate management. Automated landing and take off is also intended and is current state of the art for aircraft.

J. Manufacture

The cargo carrier could be a space frame for great strength and flexibility with light weight at low cost. Fifteen 20 ft. frames could be assembled into a 300 ft. section in 40 hours. The only “new” items are the stabilizing gear and controls. They are well within current abilities. Construction could be done with 1940’s technology.

K. Illustrations of selected versions

The ConcordLift™ is a configuration that can be actualized in many ways. The following illustrate some selected features. The engineering issues are complex and unknown. The illustrations are by an artist. The web site has a number of other illustrations.

ILLUSTRATION #1

Helios - NASA aircraft



ILLUSTRATION #2

This version carries 20 TEU in 4 channels of 5 each. The cargo airfoil pod is 100 ft. wide, 150 ft. cord, with 80 ft. extensions on both the cargo wing and the auxiliary wings above. Windows and doors are shown for scale.



ILLUSTRATION #3

Joined with others for improved AR.

The runway needed is less than the total wing span.

The small wingtips are easier to join than the large ends of the Cargo Pad.



ILLUSTRATION #4

This cargo pod and the auxiliary wings have 260 ft. spans, 62,400 sq. ft. This could carry passengers and their automobiles across the Atlantic at low cost. It is illustrated as a Ro – Ro, for 320 automobiles in 20 channels.

This size could carry 78 TEU in six channels of 13 each or 26 TEU in two channels. The cargo airfoil pod has a 200 ft. cord and fanjet exhausts for the laminar-flow control.

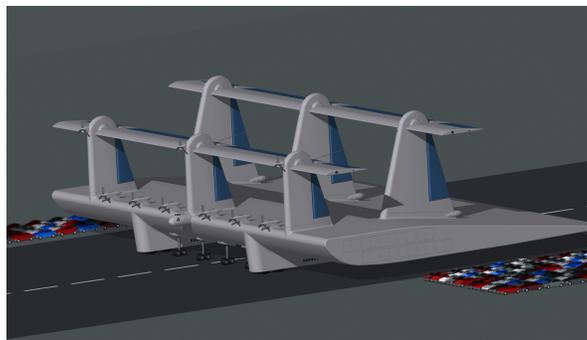


ILLUSTRATION #5

Four joined in flight, runway needed is less than the total wing span.



ILLUSTRATION #6

This has 150 ft. cord, 260 ft. span plus folding wing extensions and an additional tailplane. It could carry 52 TEU in 4 channels. The illustration below shows it with the wings folded. It could carry the eight Abrams tanks in front. A C-130 is shown for scale.

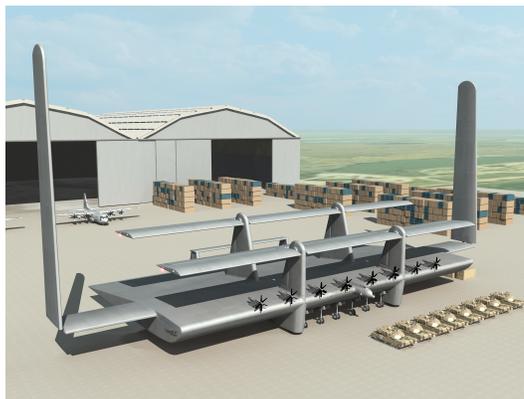
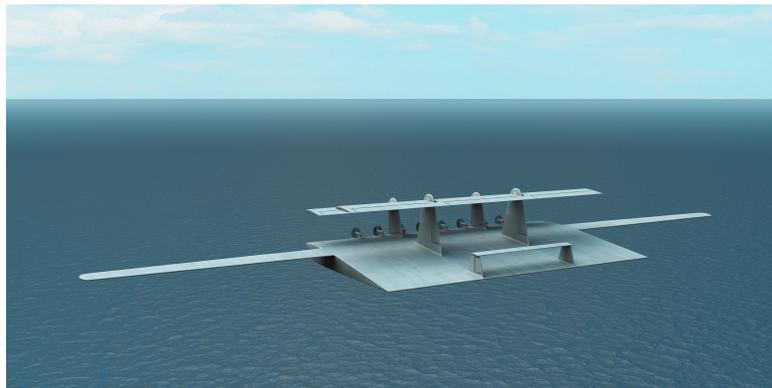


ILLUSTRATION #7

Cargo and auxiliary wings 260 ft. spans, total span of 700 ft. 69,300 sq. ft. of wing.



V. OPERATIONAL USE Air Traffic and Air Ports, Earnings, Future

ConcordLift™ is designed to fit on current large airports when there is no other traffic. It is expected specialized Container Air Ports will be built, similar to the specialized ocean Container and Ro-Ro ports. They do not need to be near population centers, just near rail and road. The size of the container handling yards will be greater than the extent of the runways. Since this is a short field aircraft, a runway pad less than 2000 feet square at sea level would allow runways in four directions. The runway needed is less than the wingspan. High speed, high altitude versions would require longer runways.

The following compare ConcordLift™ to freight rates currently charged. The target users are high value, time sensitive items: perishable foods, electronics, clothing for new trends. Those shippers who do not need priority air freight and are hampered by slow container ships. Most container shippers are expected to remain with the slow providers they now have. ConcordLift™ will be able to charge a premium because it provides fast direct service. The initial users will be willing to pay the highest premium rates. The initial buyers of ConcordLift™ will have high profits and be willing to pay the builder a premium. The initial builder will make high profits. As the market becomes saturated, rates will come down, experience will reduce costs, until the economic equilibrium is reached. It may take many thousands of ConcordLift™ to be built before that point is reached. There will remain an ongoing build to maintain and expand the fleet. No competitor is possible in the distant future. ConcordLift™ provides the lowest possible cost for heavy lift. Future developments will just reduce the cost to build and operate ConcordLift™.

First world truck rates are near \$.40 ton / mile. The ConcordLift™ 60 TEU version, at that rate, earns \$288,000 in 8 hours, providing faster delivery. First world train rates are around \$.10 ton / mile for unit trains. Railroad carry individual containers at a higher rate. The ConcordLift™ 240 TEU version, longer than a long train, at the lowest rate, earns \$288,000 in 8 hours, in many areas providing lower cost per TEU than rail.

ConcordLift™ will transform new car delivery. A Ro-Ro for new car transport holds about one month production at one car a minute. The cost is not just the cost of transport. There is the capitol cost of a month's unsold production and the inability to offer custom orders. ConcordLift™ will also be a strong competitor long distance new car rail delivery. This is expected to be the market sector quickest to convert to ConcordLift™.

The auto, truck, passenger ferry versions will transform Indonesia, the Philippines, and many other areas. This will greatly reduce transportation cost while providing good profits. Passenger, car ferries will cross the oceans and continents, providing overnight accommodations for the 24 hour trip. It will be possible to bring the personal car, for less than the price of passenger tickets, hotel and car rental.

ConcordLift™ could serve as a Sea Control, Ocean Patrol craft. It would have long endurance and cover large areas. A kind of "ship's boat" based on existing technology could land and return from the surface.

Bulk products, ore and petroleum, will not need transportation to ocean ports. Massive industrial equipment will be moved by specialized very heavy lift versions. Inaccessible places will come within reach. ConcordLift™ are far better than the hybrid airships and will open up areas that are now inaccessible.

The end of 2010 index cost to transport one 40 ft Container (2TEU) across the Atlantic including port charges, fuel and all surcharges: New York – Rotterdam: East bound was \$1810, and West bound \$2520.^{xi} The sailing, loading and unloading takes over a week. ConcordLift™ 540 TEU version, at the westbound rate, can earn \$689,000 per trip and makes 5+ trips a week. ConcordLift™ is five times faster and direct to the interior without unloading at the ocean terminal.. One runway, one 540 TEU ConcordLift™ an hour, is 14,400 TEU per day. The entire port of New York in 2010 handled 14,694 TEU a day.^{xii}

In the coming years improvements will make it more useful. The weight of structure will be lighter, stronger. The airline industry focus is on faster, higher, sexy! That can only be done at higher cost to build and operate! All interest is on sports cars but which is most useful, makes the most profit, has the highest production rate: Lamborghini or dump trucks? Which will make the most impact: offering one hour service New York – London at high price or Jakarta – Dubai for bus fare? A passenger concept for 1400 passengers is designed to make a complete turn around, passengers, baggage and consumables in a half hour. As part of this are design concepts for aircraft and container ground handling equipment. The three wings working together can be swept back and thin. Mated with a fuselage, they could provide high speed, high altitude very high capacity cargo and passenger service or for space launch.

Because of the great profit potential to the owner, the aircraft should sell at a good profit to the builder. There is no foreseeable alternative, competition. Central Asia, Africa, South America have large populations with very poor connections for heavy cargo. Just supplying the cargo needs of these and similar areas will require a large number of ConcordLift™. A combined sustained build rate of 1000 a year would be reasonable.

VI. Evolution of Concept

ConcordLift began as a spanload Wing in Ground (WIG) or Ground Effect Vehicle (GEV) for standard shipping containers. Wing in Ground has a 10% increase in efficiency for flight. The benefit is restricted to an altitude equal to the wingspan. Narrow span WIG means flight close to the surface and limited ability to fly higher. Spanloaders are known for high efficiency, the higher the Aspect Ratio (AR) the better. Many WIG designs are seaplanes. The large sponsons on ConcordLift™ began as floats. The massive damage from the wake of a heavy, high speed craft limit them to open ocean. Ships have a 6 knot speed limit in harbors. ConcordLift was changed to a land plane. The load of an aircraft on the ground is determined by the size and number of wheels. ConcordLift can have enough wheels for acceptable ground pressure. It could even be made to use unpaved fields.

Wing in Ground aircraft have a reputation for being unstable in pitch. The two auxiliary wings above the main cargo pad, instead of a tailplane, corrected pitch stability. Between the wing and the ground is the throat of a venturi, low pressure. Rotation and flare, for take off and landing, locates the rear edge of the wing closest to the surface. Flaps cause the lowest pressure to be at the rear edge of the wing. Instability beneath the wing on the ground is self propagating. Low pressure pulls the wing closer which increases the low pressure. That seemed to end the concept. The airfoil was inverted to fix the throat of the venturi under the center of lift, center of load. The angle of attack for lift is still inadequate, but the auxiliary wings can be designed to provide the lift needed.

The problem that remained was major. The Aspect Ratio was very low, inefficient. The heavy load, slow speed and narrow AR create dangerous wingtip vortices. Several solutions were considered. The center cargo pod could be just a few TEU wide with wing extensions so the combined AR would be better. Another solution would be for a number of ConcordLift aircraft take off separately and join together in flight to form a single craft with good AR. Those concepts was presented to the AIAA and posted on the Internet. They are shown in the illustrations. The animation was made with a 10,000 ft. runway, because the short field ability was considered too hard for the viewer to accept.

The mechanism for joining the separate aircraft was left for the future. It is a challenging problem. The major issue was developing a way for the aircraft to separate safely. Power is needed to overcome the turbulent low pressure between the wingtips. A process and mechanism were developed in principle. It is unpublished and proprietary. The low pressure between the smaller wingtips of the wing extensions is less powerful, easier to separate and join.

The final solution for the problem of Aspect Ratio was the realization, it is unnecessary for ConcordLift™ to be restricted to the width of a standard airport runway. Instead of joining in flight, ConcordLift™ could take off as a unit. The high AR minimizes the wingtip vortices. The runway would be wide but would not necessarily long. This is the concept presented in this paper. The thick wing does not mean high altitude is out of reach.

VII. Conclusion

This is a “thought experiment”. Research will correct, modify or disprove the concept. Since it is unique, existing engineering principles and wind tunnel data are not adequate. Even when placed in operation, the second and third generation aircraft should show further improvement.

i World Shipping Council <http://www.worldshipping.org/about-the-industry/containers/global-container-fleet> [cited 3 December 2016].

ii <http://nautil.us/issue/29/scaling/the-box-that-built-the-modern-world-rp>

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