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COPY

# REPORT TO GENERAL H. H. ARNOLD

BY H. E. HARTNEY

AFFIDAVIT

By

Vincent Justus Burnelli

In the early summer of 1943, the undersigned was advised by Colonel Harold Hartney to attend a meeting in General H. H. Arnold's Office at the Pentagon for the purpose of discussing a glider aircraft contract for a design covered by Burnelli patents for license to the General American Transport Company of Chicago. At this time, the Burnelli Company was in litigation due to the illegal acquisition of control of this company by foreign interests and this restricted the company from engaging in business with the Government under Section J of the Aircraft Procurement Statutes.

At the meeting in General Arnold's office, the undersigned, on the advice of counsel, agreed to cooperate in every respect in the interest of helping the war effort, and permission was given for General American Transport Company to build Burnelli type gliders under license.

After disposing of the glider license project discussion, General Arnold stated that he would like to have a complete report drawn on the Burnelli design situation to clarify the history of Burnelli developments and relationship with the U. S. Army Air Corps. At General Arnold's request, the undersigned agreed to make available to Colonel Hartney the Burnelli Company's files in their entirety. Then General Arnold called in an Assistant and issued instructions that Colonel Hartney should have access to the U. S. Army Air Corps/Burnelli Company files in the Pentagon, and also at Wright Field.

Later in the summer, Colonel Hartney advised that he had completed his report to General Arnold and that it had been marked "Confidential" and placed in the U. S. Army Air Corps files.

Colonel Hartney died after World War II. Shortly after that, the undersigned received advice from Mrs. Irene Hartney that she was cleaning out some of her late husband's personal effects, and came across the referred to Hartney Report on the Burnelli Company's history, along with a large file on General William Mitchell. She felt that the undersigned would be interested in having this information and turned the report and the file over accordingly.

The undersigned states that, to the best of his knowledge, this is an accurate description of the events surrounding the Report of Colonel Harold E Hartney as prepared for and submitted to General H. H. Arnold, dated July 3, 1943.

Vincent Justus Burnelli

WITNESSED THIS DATE July 25-1961

IN THE DISTRICT OF COLUMBIA

Shirley D. Reese
Notary Public DC.

My Commission Expires May 14-1963.

BIOGRAPHICAL SKETCH OF LT. COL. HAROLD EVANS HARTNEY, CONSULTING AERONAUTICAL COUNSEL, DECEASED, TAKEN FROM WHO'S WHO IN AVIATION, 1943, A PUBLICATION OF BIOGRAPHICAL SKETCHES OF PERSONS WHO HAVE CONTRIBUTED TO THE GROWTH OF AVIATION IN THE UNITED STATES.

B. Pakenham, Ontario, Canada, April 19, 1888; entered U. S. 1917, naturalized 1923. P. James Harvey and Annie Evans (Cuthbert) Hartney. Educ. Sch. of Practical Science, 1906, B.A. 1911, Univ. of Toronto; Barrister Univ. of Saskatchewan, Canada, 1914. M. Irene McGeary of Toronto, Nov. 11, 1914. Pilot record: Learned to fly Norwich, England, 1915; mil. aviator; logged hrs. 1,100; placed fifth N. Y. to Toronto Race 1919; placed sixth Transcontinental Reliability Test 1919; placed second Pulitzer Race 1920; entrant Pulitzer Race 1921. Aviation business record: Organizing sec. and first gen. mgr. N.A.A.; assisted in organizing the Nat. Exchange Clubs embracing 800 local organizations in U. S.; del. to Internat. Chamber of Commerce on Comml. Aero., Rome, Italy, 1929; tech. adviser for Senate Air Safety Comm. 1935-38; dir. Aviation Sect. N. Y. Bd. of Trade, 1929; tech. Advisor for Sikorsky Aviation Corp., Gen. Airways System Inc., Argonauts, Inc., Generalair Beacons, Inc., Sky Advertising Corp. of America, Aviation Bus. Bur., Inc., Airport Lighting, Inc., Airport Advertising, Inc., Aero Service Pick-up Corp., Aviation Development & Finance Corporation, Air Cruisers Inc., Donaldson Holding Corp., Century Rotary Motor Corp., Seabeacons, Inc., Pa.-Central Airlines, Amer. Airship Co., mem. Advisory Comm. on Aero, N. Y. World's Fair 1939; consulting aero. asst. C.A.A. 1938-40; consulting aero, counsel since 1940. Military record: Advanced through grades from pvt. to Capt. R.F.C. Canada, 1915-17; Comdg. Off. 27th Aero Squadron, U.S. Army Air Service 1917-18; Group Commdr. First Pursuit Group 1918; Maj. 1917, Lt. Col. 1919, A.E.F., Chaumont, France; chief of training, acting chief operations, Chief of civ. affairs, Office of Chief of Air Service, U. S. Army Air Corps, 1919-21; Lt. Col. U. S. Army Air Corps Res. Awards: Distinguished Service Cross, Silver Star, Order of the Purple Heart, Legion of Honor, Croix de Guerre with three palms, Italian Silver Medal for Valor, British War Medal, Aero. Club Medal of Honor, McKay Silver Medal for Civ. Flying Mem. Early Birds, N.A.A. Aviators Post Amer. Legion, Inst. of the Aero. Sciences, Amer. Inst., Quiet Birdmen, First Res. Aero Squadron Assn., Inc., Exec. Comm. Amer. Sect. Ligue Internationale des Aviateurs, Nat. Air Pilots Assn. Club: Exchange Club of N. Y. Author: Up and At 'Em (Co-author George Sutton Jr.), 1940; The Complex Flying Manual, 1940; Aircraft Spotters Guide, 1942; What the Citizen Should Know about our Air Forces 1942.

July 3, 1943

General H. H. Arnold, Chief
U. S. Army Air Forces
Washington, D. C.

RE: Burnelli Type Lifting Fuselage All-Cargo Airplane

WHY HAS THIS PLANE NOT BEEN PRODUCED IN QUANTITIES IN ENGLAND, CANADA OR HERE?

My dear General Arnold:

While I have been watching this development in a precursory manner for many years from a personal interest only and since December 1st, 1942, intensively on behalf of a client, I have this week put on a special drive to survey and obtain the answer to this challenging question.

There is nothing sinister in this whole situation. There are dozens of mitigating, if not discouraging, facts which I shall enumerate, but I will try in the following sentence to give one answer which is back of it all.

ANSWER: Until the Air Transport Command got under way, despite our own domestic and foreign air line operations where DC-3's and Clippers were used more or less exclusively, THERE WAS NO DEMAND FROM A RESPONSIBLE AIR CARRIER EITHER MILITARY OR CIVIL justifying the heavy cost of a prototype and as you well know prototypes do cost money - the DC-4 - two million, and the Martin Mars - six million dollars. Consequently, this type of plane did not appear in any of the military or civil carrier's specified categories, and by "this type of plane" I mean one embracing the Burnelli unique safety, cargo space and miscellaneous loading and other features found in such a Burnelli cargo plane, in addition to the accepted high performance shown in Burnelli planes already flown and tested officially. In another portion of this report I have listed these unique features which through the globular operation in all countries have been found imperative (see Page 6). Verbally I shall personally give you all this report in detail, but I feel its importance merits investigation and action by your regular staff. Therefore, I shall outline it in writing to facilitate matters for you, with your permission, divide it into three parts.

PART I: Why not built in England, Canada and the United States?--giving specifically the many reasons in each country.

PART II: The unique safety and other features peculiar to this type of plane disclosed or divulged by the remarkable world-wide operations of General George's A. T. C. as being absolutely essential in an all-cargo plane. These began to show up from about June, 1941, when you so prudently established the Ferrying Command under the late Major General Robert Olds, U.S.A.F.

PART III: My personal recommendations, for what they are worth. (You have not asked for these and I may be presumptuous in giving them, but I sincerely believe that if acted upon they will help the war effort immeasurably, and I feel you will be glad to consider them.)

## PART I

(Answer to specific questions of yours -- Why not followed through (a) in England, (b) Canada, (c) in the United States?)

(a) In England. Last Tuesday I had a conference with Air Chief Marshal Sir Christopher Courtney, R.A.F., with a view to find out why the plane was not produced in quantities in England. The answer is basically the same there as in Canada and here. Had the war not come along it would have gone into production in England, and Cunliffe Owen personally plans now on continuing, after the war if possible, not only with production of the one DeGaulle has been flying, but on one of 135,000 lbs. gross (see report Appendix "A"). Official British Boscombe Down report

on this plane, November 1939. Also see some comment from Lord Beaverbrook's former aviation technical advisor now in this country, Norman Edgar, with whom I feel you are acquainted, giving his opinion on that report showing the specific changes made to meet them and embraced in the UB14 being demonstrated this month in New York City. The Burnelli was apparently the only all-metal skin-stressed plane actually finished in England. But it was built in what is known as a "fringe" plant. The tests at Boscombe Downs, Wilts, were not completed until three months after the war broke out in Europe and all "fringe" plants were ordered to stop everything and take on repair, parts, etc. There appeared to be nothing basically or technically wrong with the ship, there were some minor "bugs" and adjustments always present in the first edition of any prototype, but, on the whole, the Burnelli plane flew exceptionally well. I was surprised to find it about equal to a Douglas Airliner of the same class in speed and handling but much better, of course, in landing speed and in overloaded condition. DeGaulle, wanting a small transport, was assigned the Burnelli British UB14 despite the fact there were no spare parts. The Perseus engine is now out of production but the last word received apparently was that it was still flying and already had used up a number of engines. (N. B. Demonstration and test flights of a similar Burnelli but with all the recommended changes is being made about July 10th next at Long Island and the Air Transport Command plan on having observers there.) Sir Christopher admits in effect that some might allege with some degree of foundation at this time that the RAF should have foreseen the importance of all-cargo planes but the Burnelli was not built to fit in with any official specified Military requirements having been constructed on what is known in England as 'private venture' the same practice as Mosquito was built by DeHavilland.

(Attention is invited to the following comments on the UB14, which may be of value to your engineers:

Appendix "B" Norman Edgar's comments on UB14

Appendix "C" Structural Review of UB14 design

Appendix "D" Report of Lieut. Col. Lewis T. Reichers

Appendix "E" Comparison by Mr. Rex M. Hoyes, dated January 3, 1938, between the Burnelli type and the orthodox.

Appendix "F" Burnelli's comments on British report of November 14, 1939).

(b) In Canada. The demand for cargo planes in Canada has always been great. Some 17,000,000 pounds of express were flown in one month in 1937 as compared with only 2,000,000 on all our airlines put together. (Air express here was throttled by the illegal contract which until this year existed between the wholly-owned Railway Express Agency and 21 domestic airlines. By this contract the airlines gave express rights exclusively to that railroad owned company and were not permitted to offer express facilities except through REA and rates were fixed at not less than twice the railroad express rates. The great demand for express service in the far northern undeveloped rich field of Canada, where no other satisfactory media of transportation exist, brought about a demand in the Dominion North of us for an all-cargo plane with practical peacetime or civil characteristics. To meet this the Canadian Car Company about 1937 contracted with the American Burnelli Company and partly engineered a 34 passenger all-cargo Burnelli design in 1938. The Minister of Transportation, however, lent little encouragement because his office evaluated it as too large. Unfortunately, the plane was never built. Not discouraged, this Canadian Company decided to await the tests of the British UB14 and possibly go into production on that. At the same time they worked with the Central Aircraft Corporation -- The American Company--and, according to Mr. Semple, Assistant to the President of Canadian Car Company, unwittingly found themselves in control of the American Company, Central Aircraft Corporation, owner of all the basic Burnelli patents. (Incidentally, the Canadian Company is willing to duly turn this control back to the American Company under equitable terms at any time. The license from the American Company is all they require or desire).

In so far as was consistent with the neutrality laws then in existence, the Canadian Company, now greatly preoccupied in war efforts, continued their interest in Burnelli designs by helping Burnelli personally from time to time - a relationship which still exists. Canadian Car officials still believe implicitly in this design and

its outstanding value for cargo purposes. From the outbreak of war in September 1939 Canadian Car was in close touch with all the North Atlantic flying and spent a great deal of money in the engineering of a wooden conversion of the UB14 utilizing their experience gained in the most successful conversion of the Avro-Anson into wood, over 1400 of which have already been manufactured by Canadian Car and sold into the British War Service. They have also partly engineered a twin-engine job of the class of our own C-76 in wood. In 1941 this design was presented to the U.S. Air Forces.* Air Transport Command (Then the Ferrying Command) had hardly got started and in this country an Air Corps Board headed by Colonel Street (Now Major General) on September 17, 1941, with York, Snodgrass, Phillips, Bogart, Major Wolfe and Anderson was unable to find a military category for it at that time. In Canada, probably because of this Board's finding, The Canadian Car, who were ready to construct the same design on their own funds and on private venture, were stopped by the Joint Board. I personally would rather see this particular two engine Burnelli MB2 type constructed than our own C76 because structural problems in wood of a conventional fuselage type cargo plane of such gross weights, speeds and stresses should cause the latter's design to to defeat itself. Bonded plywood is not as uniform as metal. Compound curves, vibrations, resonance problems, etc., may not be practical in wood in the C76 conventional type whereas the big box girder structure of the Burnelli, with its flat panels and a certain amount of steel fittings apparently is quite a simple problem.

Canadian Car has also engineered a large six-engine job. Some wind tunnelling has been done and an opinion has been had by them from Max Munk, prominent American engineer. His report is attached as Appendix "G".

Canadian Car has now been offered an order for twenty-five of the UB14 to be made out of non-critical material for use in Brazil. They will shortly be applying for permission to build these and for many reasons which I can give you in a separate report, we in this country should lend every encouragement so that the Joint Board (Mr. T. P. Wright in this country and Mr. Ralph Bell in Canada) may give its 100% cooperation. (Joint War Production Committee - C. E. Wilson, Chairman).

China Defense Supplies, Inc., over the last few months, has had several conferences with Burnelli, once with officers of Canadian Car here in Washington. I understand from Hon. T. L. Soong, that with Lend-lease aid they would consider the plane in quantities, subject to the coming tests of the UB-14, as most appropriate for their efforts in China subject, of course, to 100% approval by the U. S. Army Air Forces especially the active officers of the Army Air Transport now serving them so well to the limit of equipment available for the Burma route.

American facilities are available for meeting any demands the Chinese may have and "Canadian Car" offer to cooperate with any substantial American group and lend their proven experience in wood fabrication. The plan, now yet submitted for approval, contemplates using only surplus motors, accessories and non-critical materials in the air frame and in no manner impinge on our established war production program.

(c) In the United States. The picture in the United States has been rather puzzling and long drawn out. But to any expert thoroughly experienced in U. S. aeronautical research, development, production and finance of aircraft there appears nothing inauspicious or bad. One can readily understand the tyro outsider with but a precursory knowledge of the outstanding (a) aerodynamical features (see Appendix "I"), Report dated September 19, 1939, prepared by Lyons, Timberlake and Goulet, engineers at Wright Field, and I believe signed by you; (b) the advanced safety features; (c) the lower cost of construction, - can jump at the conclusion that Burnelli has been ignored or that the Air Corps was not alert. Such allegations, of course, are not true. As General Echols stated in one report that the Air Corps has spent the equivalent of the time of one man working for ten years on its consideration. This surely reflects cooperation on the part of the War Department. You and I know how long it took to bring into production and daily use such improvements as the retractable landing gear, hydraulic equipment, constant speed propeller, de-icer for airfoils, propellers and carburetors, high out-put power plants, the high efficiency in power plants, high octane fuels, flaps, skin-stressed surfaces, the applications of ultra-high

* MB-2 See Appendix "H"

frequency in radio for navigation and many other modern advanced features that made todays flying what it is. All took demand, technique, vision, money but above all--time.

As I glance back over the history of Burnelli's efforts, I cannot but be struck with two facts, namely: Burnelli himself as a technician was a real pioneer ranking with the best from Orville Wright on down. His lifting-wing fuselage principle is sound and will prevail sure. He himself deserves nothing but the highest praise even though he has been unfortunate and unlucky. His successive business associates have been either financially inadequate or have failed in selling the Army, Navy or Commerce on the value of the product sufficiently to get it placed in an official category of requirements. Except for the case of one individual who did some financial manipulating, selfishly of benefit to himself only, none of these backers of Burnelli can be accused of being tricky or insincere. Take the case of Uppercu. Mr. Uppercu, like Burnelli was a real pioneer himself both in operations and in manufacturing, but the awful depression came along about 1932 and he too became financially embarrassed. A loan was made from the Reconstruction Finance which proved the undoing of Burnelli's basic American company. Britishers then became interested in Burnelli's principle. It will be remembered that Burnelli, before he could do business with them or give a foreign license, acquainted Wright Field with the fact that he would be forced to do so. General Robbins wrote him a letter thanking him for his attitude but stating that "due to higher authority" the Army Air Corps was not able to do anything at that time. Burnelli's greatest blow came and with it the disastrous stopping of his development in the United States when the RFC foreclosed their loan. Canadian Car dealt with RFC. All the assets of Central Aircraft Corporation (successor of the Burnelli Company), both patents and factory equipment, went to Canadian Car as a result, while Burnelli himself was in England completing the Cunliffe-Owen job. Burnelli found himself with common stock only in what was a shell of a company -- Central Aircraft Corporation. He has since succeeded in arranging to have the patents brought back to the American company, and Burnelli now has an option to get control back into American hands so that there will be no violation of Section J of the Procurement Law, when Central Aircraft Corporation gets under way again.

The design bomber contract is a most interesting situation. Under Section "10K" Canadian Car backed him in this situation and through the good offices of you personally a design contract, amounted to $20,000, was put through. It is indeed unfortunate, in my opinion, that this was not followed through to production but there is nothing untoward in this when one considers that the war was actually on at the time with all its attendant problems. (See a comparison of that plane VGBI with Mosquito and the Ventura, Appendix "K").

Credit to Burnelli: Besides technical credit for Burnelli, I feel that there is business conduct for which he certainly should get a little recognition and his critics, if he has any, should give them weight. Burnelli has never permitted the sale of a light of the present cost of prototypes, this is a remarkable performance. He was aloof from the financial debacle of 1929--something few can claim--when a billion dollars of securities sold to an innocent public shrank overnight to one hundred thousand! Included in the planes he has built was the safety plane for the Guggenheim contest, where some very interesting technical improvements were made (see below). One particularly--I am told authoritatively, that he controls the patents on the three-wheel landing gear principle, although the patents were taken out around the four-wheel structure. He has never pooled his patents and, as mentioned above, he has never had government money other than the $20,000 Bomber Fighter design contract.

You personally are quite familiar with his efforts during the expenditure of this amount but, for one unacquainted with his work, here is a short synopsis. He is responsible for the engineering of the Lawson airliner in 1919 and flew in it personally all about the country taking up the Secretary of War, Newton D. Baker, six Senators, and notables of all kinds--often thirty passengers aboard--without fatality. Then, after a law was passed by Congress authorizing the Postmaster General to carry mail by air at railroad rates, he found to do that he would have to have more space in the cabin for bulky loads and conceived the idea of turning the fuselage sideways, widening the nacelle and putting the engines within the cabin for overhaul in flight, making the fuselage or airfoil profile--hence the Burnelli lifting fuselage or quasi-full-wing design with its patentable features.

Then came the Remington Burnelli (RB1) 32 passenger Biplane semi-lifting fuselage, the first ever built anywhere, powered by two Atlantic Galloway engines built in Scotland for bombing flights Berlin-bound for the British in World War I. Scores of pilots flew this plane including the writer (once as co-pilot), Acosta, Berteau, Stinson, Randolph Page, Ed Johnson, Rhinehart and others of the old-timers. The wide fuselage in this and the biplane RB2 (built in 1924 loaded with an Essex automobile and flown everywhere for sales purposes over the country) were not completely full-airfoil fuselage but an approximation thereto and an odd crash demonstrated that the box-like structure could take an awful beating, save life and limb, etc. The slow take-off, landing and fair climb amazed me - it still does when I recall it had fixed-pitch propellors, obsolete engines, etc. One must remember that some of these airplanes were in the regime of the XB1A, the Barling Bomber, and the MB1A really to appreciate the ingenuity of Burnelli himself. The RB2 was equipped with two Rolls-Royce Condor engines (625 h. p. each and had a gross weight of 32, 000 pounds).

Next in line of the Burnelli "Flying Wings" was the CB16. Here Burnelli had new backing, Chapman of shipping fame (not an aviation man) owner of the U. S. Lines. For the first time it seemed to Burnelli that American engines were at last large enough for his purposes and he fitted the Curtiss Conqueror (liquid cooled) developed by the Air Corps - 675 h. p. each, the engines were mounted close together and therefore the plane was the first U. S. job able to maintain its altitude up to 3,900 feet with almost full load on one engine and, possibly, the first airplane in the world which could do this. One interesting feature was its retractable landing gear. But this feature was abandoned later on the UB20 because everyone thought them "gadgety" and impracticable.

After this he built the safety plane for the Guggenheim contest, mentioned previously. This contributed greatly to the art, not only in the landing gear features but particularly in the flaps and the employment thereof.

Then in 1930 came the UB20 equipped with two 800 h. p. Packard engines similar to that used by the Army in the Verville Racer flown by Moseley. Like its predecessor, this one carried an automobile (this time a Ford) tank-like under the fuselage. It was flown by Lt. Col. Reichers AAF now in ATC.

Then he designed and built the UB14 in 1935 powered by two Pratt and Whitney Hornets of 675 each. In performance this plane was right up with the Douglas and others in structure and performance enjoying in addition the wide fuselage, safety features, etc. These designs of Burnelli labored under an unfortunate psychological but very real handicap symbolized in a remark a pilot once made to me at the Cleveland races in 1935, "it seems to be the cargo ship of the future all right, but it sure is an ugly duckling in appearance." But, as an officer in ATC remarked the other day, "we don't care what a plane looks like so long as it meets the requirements which globular operation dictates -- safety, performance, cargo space loading, etc." Pilot or designer whims will no longer, in the stress of war, stand in the way.

The most outstanding work of Burnelli since the production of the UB14 has been the fighter bomber VGB (See Appendix "L"). The wood conversion engineering on the UB14 and the six-engine all-cargo airliner reported on by Munk (Appendix "G") -- gross weight 220, 000 pounds. Incidentally, I believe this air transport with modifications will fit in exactly with the demands of the A. T. C. and of the civil airlines of this country.

## PART II

Safety and other features recently found to be necessary in globular air cargo operations. How the Burnelli type seems to meet them.

Either converted civil airliners or military bombers are now used in both the Navy and Army transport operations. This extensive flying has laid bare some very definite requirements. For the over-water long jump there is still some controversy as to whether land or boat type craft should be employed, but otherwise everyone seems agreed on the following. Respectively is indicated opposite each requirement how the Burnelli type plane fills the bill. (Comparative Costs Appendix "M").

| Air Transport Requirements | The answer in the lifting-type fuselage |
|---|---|
| 1. For over-water operations at least four engines are required. | 1. Either the semi-lifting wing or all-wing type of airplane is better suited for the multi-engine cargo plane. Structural strength and weight increase so greatly to enable the outboard engines to be carried that this presents a problem and makes for heavier wing loading. |
| 2. The wing loading must be brought down, if possible, and this means that over-loading must be kept to a minimum. | 2. See Munk Report (Appendix "G") I consulted with Hon. E. T. Warner of C.A.B. and, while he did not appear to want to go as far as Munk in the efficiency of the Burnelli type because he felt there would be a certain reduction on account of the thickness-ratio on the fuselage when used as an air foil and because he felt there would be a slight interference at the root of the wings with the main body. He did concede its great possibilities. |
| 3. Stalling speed, length of run on take-off, and rate of climb follow very high wing loading but must be improved if possible. | 3. Again refer to Munk report for proof as to the great reduction in wing loading which shows clearly how the Burnelli meets this requirement. |
| 4. Structure must be such that the fuselage will not break in two in the event of a crash. | 4. From experience in actual crashes, the box-like structure of the Burnelli fuselage hangs together perfectly. |
| 5. The craft must be capable of floating after it makes a forced landing on water. | 5. The pencil-like conventional fuselage design sinks promptly after it lands in the open sea--sometimes immediately, sometimes it takes as long as four or five minutes, but it is obvious that the Burnelli type would float indefinitely. |
| 6. The engines must not have to bear the overload on the take-off one second longer than is essential to get airborne. | 6. Once the Burnelli type wing is airborne the engine can be throttled back because the lower wing loading does not give such a precipitous drop as to make for out-of-control conditions. |
| 7. Time for loading must be reduced to a minimum. This means that the sills of the plane must be as near to the ground as possible and as standard for all types of craft as is possible. Means must be provided for battening down the cargo conveniently. | 7. It is readily seen how the shape of the Burnelli fuselage facilitates standardization in ramps and other features for loading. Low-weight battening down devices are possible in the Burnelli squared interior. Outside extension cranes and pulleys for simple loading of bulky freight from ramps or trucks are practicable. |
| 8. The greatest care must be provided in the placement of burden within the fuselage, especially in overloading condition. | 8. It is readily seen that in the Burnelli full-wing fuselage the same care does not have to be exercised in the placement of cargo burdens. |

| Air Transport Requirements | The answer in the lifting-type fuselage |
|---|---|
| 9. So-called plumbing accessories and appliances must be available from within the fuselage or wing structure. | 9. The large cabin fuselage permits of wide dispersion of instruments, appliances and gadgets, making accessible in flight many connections and items which are now unattainable in the conventional cramped condition. |
| 10. Cubic space must be the maximum possible with no lost space or curvatures. | 10. Obvious. The roomy cabin with flat sides, renders all interior space available for cargo storage in flight. |
| 11. Engine nacelles must be as close together as possible to make practical and safe sustained flight after engine failure. | 11. Possible in the Burnelli. |
| 12. Especially in long flights large planes are necessary rather than a series of the smaller type. Congestion is in dangerous traffic at terminals during overcast conditions when the fuel of the incoming planes has been used up. One large plane can be brought in safely, but several make for confusion and hazard. | 12. See Burnelli design referred to in Max Munk's Report (Appendix "G"). |
| 13. Maintenance problems away from maintenance depots must be reduced to the utmost minimum and simplicity. | 13. Obvious maintenance simplicity in Burnelli type. |
| 14. Standardization of parts, instruments and accessories must be improved greatly, not only through simplicity in basic design of the structure but in the hundreds of items over all types of planes. | 14. Facilitated in Burnelli. |
| 15. Utilization period of aircraft--the number of hours a plane can operate per day, day in and day out, must be boosted. | 15. Equal to the conventional. |
| 16. Change of motor; overhaul and inspection of the whole craft must be facilitated through simplified design. | 16. Better than the conventional. |
| 17. Landing gear design and operation must be simplified and strengthened but at the same time reduced in weight. | 17. Wider fuselage makes for simpler and less complicated retractable under-carriage. |
| 18. While the dollar-cost is ignored in wartime--the law of "economy of forces" is paramount. Therefore, globular operation by ATC indicates that every attempt must be made to reduce initial cost, spare parts cost, and maintenance and running cost to the minimum. | 18. It is estimated the initial cost will be 25% less than on the conventional fuselage type craft. Other lower costs follow. |

Air Transport Requirements

19. Flak or enemy aircraft MG fire is encountered now and then. Having no defensive armament the structure of the transport is weakened by the successive hits and resulting flak holes in the skin stressed surface. Transports should therefore have more strengthening bulkheads or transverse members to relieve the stress on punctured skin surfaces.

The Answer in the lifting-type fuselage

19. The huge box-girder structure with deep bulkheads in the Burnelli automatically takes care of all this.

## PART III

## RECOMMENDATIONS

First I recommend that you direct a memorandum to the Joint War Production Committee suggesting that planes of the Burnelli type be put on the integrated program of requirements.

As I see it, any attempt in Canada or here to build either experimentation models or to build quantities on order for any of the United Nations will be disapproved by the Joint War Production Committee unless this is done. Lack of this already in the case of the MB-2 stopped MB-2 development (See first paragraph- Page 3).

Take the necessary steps to procure from an American company (Burnelli preferably if he shows facilities and evidence of control of the patents) one or more MB-2 planes as a "hedge" should the C-76 program prove impossible.

Take steps to secure a prototype of the 220,000 lb. all-cargo land type plane reported upon by Munk provided this fits in with the program of the Air Transport Command.

It may be advisable to specify that except for the motors, accessories, and appliances these orders must not interfere in any manner with the present production program; also, these two planes might afford an opportunity to try out what the British call "private venture procurement" which worked out so successfully with Mosquito.

Again, if Wright Field is preoccupied and unable to take this Civil Aeronautics would be glad to do so. In the event C. A. A. is entrusted with the task recommend it be done on what you have worked out before satisfactorily with them on a "Certificate of Airworthiness" basis.

In making these recommendations I submit that you will, by so doing, be making an attempt to (a) - secure safer airplanes; (b) - obtain less expensive aircraft.

With respect to (a) - Safety, wing loading has been going up at such a dangerous rate of late that an effort of some kind must be made to stop it. With increased wing loading the impact in a crash, from greater speed, mounts up so rapidly that the chances of passengers surviving diminishes about as the square of the increased pounds per square foot loading, something most distressing which few seem to appreciate. (b) Cost, aircraft, already so expensive when compared to the cost of automobiles, is actually mounting up with quantity production. In speaking of a Navy Plane recently in the Senate during the debate on Naval appropriations (May 1943), Senator Thomas referred to one airplane which has been in production for three years in the Navy as an example citing for it a cost of $75,800 in 1941 to $112,000 in 1943. Hasty calculation would seem to indicate that this airplane, after modifications, is costing close to $20. per lb. as compared to automobiles at $. 15 per lb. - over one hundred times as much!

The structure of these Burnelli planes permits the use of wood, common alloys of steel, and magnesium. There actually is a surplus of magnesium at the present moment, - 40 million pounds being produced monthly with indications that 50 million will be produced monthly by the first of January 1944.

Construction of these planes should not in any manner embarrass the present production program. In fact, there appears to be everything to gain and nothing to lose by encouraging both in Canada and here the building of these airplanes.

Respectfully submitted,

Harold E. Hartney, Lt. Col.
(Inactive)

## APPENDICES TO HARTNEY'S LETTER


| | |
|---|---|
| Boscomb Downs Official Report on UB14 (Nov. 14, 1939) | Appendix "A" |
| Norman Edgar's Comments | Appendix "B" |
| Structural Review UB14 | Appendix "C" |
| Reichers' Report | Appendix "D" |
| Hoye's Analysis of Lifting Fuselage (Jan. 3, 1938) | Appendix "E" |
| Burnelli's Reply quoting Edgar on Boscomb Downs Report | Appendix "F" |
| Munk Comparative Performance Report Burnelli vs. Conventional (March 1943) | Appendix "G" |
| Military Air Transport - MB2 | Appendix "H" |
| Air Corps Engineering Report (Sept. 19, 1939) | Appendix "I" |
| Comparison Burnelli Bomber Fighter VGB, Mosquito and Ventura | Appendix "K" |
| Comparison of Conventional Fuselage and Burnelli Airfoil (July 3, 1943) | Appendix "L" |
| Cargo Airplane Comparison (Costs, Operation) | Appendix "M" |
| Pangborn Report (March 14, 1936) | Appendix "N" |
| Pangborn Letter (Dec. 8, 1941) | Appendix "O" |
| British Civil Evaluation applied Burnelli design | Appendix "P" |
| Klemin Report (Nov. 19, 1940) | Appendix "Q" |


## ILLUSTRATIONS


| | | |
|---|---|---|
| Burnelli | | RB-1 (1920) |
| Burnelli | | RB-2 (1924) |
| Burnelli | | CB16 (1927) |
| Burnelli | | UB20 (1930) |
| Burnelli | | UB14 |
| Burnelli | | UB14 |
| Burnelli | (Bomber Fighter) | VGB |

APPENDIX "B"

NORMAN EDGAR'S REPLY TO ITEMS QUESTIONED BY BRITISH ENGINEERS IN THE BOSCOMB DOWNS REPORT, BRITISH REPORT DATED 14 NOVEMBER 1939.

| | British Cunliffe-Owen Burnelli UB14 | American Burnelli being tested July 1943 |
|---|---|---|
| 1. | Pilot's cabin..is uncomfortably warm at low altitudes in summer weather. Neither ventilation nor heating provided. | Ventilation is provided on American UB14. |
| 2. | Main Cabin..doors are of somewhat flimsy construction and open against air stream, so that their use in an emergency is doubtful at high speed. | Parachute not required for transport civil use. Door frames stronger. |
| 3. | View..large blind areas are formed on the forward part of both sides by the engine nacelles...the wings obscure most of the view below. ...no view is obtainable directly rearwards, but this could be improved by insertion of transparent panel in the roof in the locker to rear of pilots cabin. | Now improved structurally. UB14 has rear hatch. Employment generously of Lucite panels will correct all this. |
| 4. | Controls..aileron control is rather stiff in operation. | Agreed, rectification made as recommended by Pangborn. |
| 5. | Engine Controls..Satisfactory..except for gill-control which is very low on throttle box and is awkward to reach. Petrol cocks operable in flight..not possible to read direction indicator plates from pilot's seat. | These are visible and can be reached by American pilot or co-pilot on UB14. |
| 6. | Flaps....no indicators are provided and position of center flap cannot be observed from the cabin. | Flaps now visible from pilot's seat; indicators also are fitted. |
| 7. | Brakes..differential action is coarse. | Agreed that larger brakes are necessary and are being provided. |
| 8. | Trimmers..no indicators are fitted to show trimmer settings..lack of trimmer indicators constitutes a danger at takeoff. | Provided on American built UB14. |
| 9. | Instruments..in bottom row are difficult to read through, being out of pilot's line of sight. | Agreed. Panel now raised to CAA requirements. |
| 10. | Ground Handling..satisfactory except that maneuvering in small spaces is not easy to be improved by fitting tail wheel lock and stopping a turn, both due no doubt to the short distance of the tail wheel from the main wheels. Coarse action of differential braking also contributes to difficulty in turning. Brake and throttle levers cannot be operated simultaneously owing to relative positioning. | No hand brake lever on American UB14. |
| 11. | Take off..initial climb is satisfactory, but longitudinal instability together with heaviness of controls renders difficult counter action of air disturbances. | Compares favorably with most aircraft. Also now corrected by improved static balance. |

| | |
|---|---|
| 12. Controls. . . Trimmer gives sufficient trim for all conditions of flight except on the glide with forward position of center of gravity. | Corrected on the American model UB14. |
| Rudders are very heavy at all speeds. . . rudder movement. . . adversely affected when wing flaps are lowered. In general controls are not well harmonized. . . elevator being noticeably heavier than aileron. Ineffectiveness of rudder is not much consequence. | Design was changed in United Kingdom. American UB14 considered well harmonized. |
| 13. Stability. . . Aeroplane is unstable on climb at all C. G. positions. . . at intermediate G. G. positions, aircraft appears to be just stable. | American UB14 considered "highly satisfactory" in this respect. |
| . . . Cof. G. Aft climbing condition being only state in which more than normal concentration regd. | |
| 14. Stall. . both flaps and u/c down right wing drops firmly followed by nose. It is not possible to pick up with aileron. | There is no indication of this on the American UB14. |
| Approach landing. . . . . view, except ahead, is bad to presence of engine nacelles, wings, etc. | Lateral view improved. |
| 15. Comparison with other types. Performance of this aeroplane conforms reasonably well with that of more orthodox types. It is not considered to be outstanding in climb or load carrying capacity and take-off run is rather prolonged. | British built UB14 1200 pounds increase in structural weight over American UB14. |

Above substantially correct as related to H. E. Hartney by Norman Edgar

STRUCTURAL REVIEW
UB-14 DESIGN

---

APPENDIX "C"

The UB-14 was one of the first large airplanes built in the United States that used smooth skin all metal construction and retractable landing gear. At the time this airplane was designed, the C.A.A., Army or Navy had no data established to compute and approve this type of structure. There has also been an improvement in the strength and reliability of the metals used and a large amount of basic research work done so that we now have a much more accurate idea of the behavior of metal under various loading conditions. This is also true for plastic bonded plywood design.

1. In the design of the wings of the UB-14, the covering and supporting structure is considered as taking chord and torsion loads only. As the skin between spars is rather heavy (.032 or better) and the stringers closely spaced, a considerable amount of bending is also taken by the skin.

2. Because of the meager data on the behavior of the structure, conservative assumptions were used in the design of the UB-14.

In computing the load factors, an ultimate multiplying factor of safety of 1.5 is used, while in the design of the structure the yield stress, or less, is taken as the allowable load. 17ST is given an allowable of 30,000 lbs., slightly less than the yield strength of 32,000; the allowable is 55,000. 24ST is given an allowable of 40,000. In some cases of large loads, only 30,000 is used as against a yield of 40,000 and an allowable of 62,000.

If all 24ST were used in the wing construction, the allowable loads could be increased from 55 per cent to better than 100 per cent.

3. In computing the effective wing area, a figure of 683.8 sq. ft. is applied. This figure uses a body area of only 90 per cent of the root chord of the wing times body width. Wind tunnel tests run at N.A.C.A. show that the whole body area is effective area. This gives an area of 2 x 263.17 - 12.5 x 23 equalling 818 sq. ft. The new wing loading would be 14,000/818 = 17.12 against 20.5 used in the analysis (Report W-2).

A further substantiation of this is given in British Air Ministry Report A. & A.E.E./747/CA. This gives an actual corrected stalling speed of 61 MPH with an all up weight of 18,000 lbs.

Based on 683.8 sq. ft. this gives a stalling $C_L$ with flaps of

$$C_L = w/s \frac{(Vs\ \ )2}{(19.77)}$$

$$= 26.3/9.6 = 2.64$$

This is high for this type of flap wing combination; using an area of 818 sq. ft. the $C_L$ drops to

$$C_L = 22/9.6 = 2.3$$

which still shows a very effective flap action, but is in closer agreement with test data available.

4. Therefore, it will be possible to increase the load on the wings by at least 50 per cent without increasing the weight of the structure, through the employment of present approved methods. In fact there is every indication that the wing might be reduced somewhat. This is accomplished by:

1. Redesigning to make better use of the material distribution.
2. Using all 24ST in the structure and design to the ultimate strength.
3. Using the actual effective wing area of 818 sq. ft.
4. Reducing the margins of safety where they are excessive.

The above summary has been determined from a study of the available stress analysis of the UB-14 and its relation to present approved methods of calculation of the C. A. A. Handbook CAR04.

From the above study it is possible to increase the gross weight to at least 18, 500 lbs. without materially increasing the airframe structural weight.

Using SIE2G Pratt and Whitney engines developing 850 HP takeoff and 750 HP normal, the weight empty will be approximately 9, 100 lbs. which gives a disposable load of 9, 400 lbs.

The performance at critical altitude with these engines will be

| | |
|---|---|
| Maximum Speed | 230 M. P. H. |
| Cruising Speed 65% | 192 M. P. H. |
| Climb | 900 ft/Min. |
| Stalling Speed | 62 M. P. H. |

These figures are substantiated by British Air Ministry Flight Test Report No. A. & A. E. E. /747/C. A. dated November 14, 1939.

## REVISION TO PLASTIC PLYWOOD FREIGHTER

By increasing the fuselage width to 15' and using Pratt and Whitney twin wasp engines developing 1200 HP take-off and 1050 HP normal, the weight empty will increase to about 10, 500 but the performance will increase somewhat even with a gross weight of 21, 000 lbs. This is due to the fact that the wing goes up only 1 1/2 lbs. /sq. ft., while the normal power loadings go down from 12. 4 to 10 lbs. /HP.

| | |
|---|---|
| Weight Empty | 10, 500 |
| Crew | 400 |
| Fuel 550 Gals. | 3, 300 |
| Oil 50 Gals. | 350 |
| Freight | 6, 450 |
| Total | 21, 000 |

| | |
|---|---|
| Maximum Speed | 235 M. P. H. |
| Cruising Speed | 195 M. P. H. |
| Climb | 1, 000 Ft. /Min. |
| Stalling Speed | 64 M. P. H. |

### WEIGHTS OF LOCKHEED - 14 WITH P & W HORNET SIE2G ENGINES 850 HP (Take Off)

| | | |
|---|---|---|
| 10, 100 | pounds | empty |
| 340 | " | crew |
| 120 | " | stewardess |
| 120 | " | life preservers and rafts |
| 300 | " | oil - at 7. 5 pounds per gallon |
| 3, 000 | " | gas - 6 pounds per gallon |

Maximum gross load under general conditions - 17, 500 pounds

Less the above total 13, 980 "

3, 520 " pay load

APPENDIX "D"

REPORT OF LOUIS T. REICHERS

Transport Pilot #2347, A.P. rating U. S. Army Air Corps, F.A.I. rating...

RE BURNELLI AIRCRAFT

(Col. Reichers is now Chief of the Engineering Section of the Air Transport Command of the United States Army Air Forces)

This is to certify that I have flown airplanes of the Burnelli type design for a period of about 180 hours as a test pilot and demonstrator. My impressions here relate principally to the UB-20 model of 91 foot span, powered with two 750 horsepower Packard engines, 18,000 lbs., gross weight, and applies to the question of VISION for day and night operation, SAFETY and general flying arrangement.

1. FORWARD VISION.

The forward vision provided in the Burnelli design is excellent. When this ship was constructed no other plane permitted the same unobstructed view ahead, but since then the Boeing and Douglass transports enjoy this feature but with slightly more nose interference due to the fuselage extension forward. A good clear unobstructed view, straight ahead, is of great value to the pilot, particularly when taking off, either in a confined space, or in formation. This vision also is important on cross country flights, for navigation purposes, as well as an aid to the pilot in bad weather or when flying military missions, such as bombing, aerial photography, or reconnaissance. The above mentioned planes do not equal the Burnelli in straight ahead down vision, however, the pilot with side by side seats has better down vision on one side as compared with the Burnelli. The Burnelli in my opinion, has superior forward and downward vision because of the central arrangement and no nose interference at high angle of attack.

2. OVERHEAD VISION.

Being a high wing monoplane, with the pilot's cockpit raised above, the entire hemisphere is completely unobstructed. This is of importance for both military and commercial flying.

3. REARWARD VISION.

This rearward vision in my opinion is a very important one and is sufficiently downward on both sides, to be of value for any type of service. This is possible because the pilot's hatch has been raised well above the upper contour of the airfoil body, with no fuselage interference rearwards. This enables the pilot to look backwards on either side, before making a turn, as well as before taking off, to assure him that no other ship is in the process of landing. In formation flying, this vision is not only desirable but necessary. The Burnelli is the only enclose cabin plane that provides this feature. Pilots will appreciate this, particularly in bad weather, night flying or in formation.

4. LATERAL SIDE VISION

The pilot's head is in line with the leading edge of the wings and the wings are tapered, lateral sidewise vision, over the motor cowls is not bad. In fact, it is comparable to any of the modern low wing monoplanes or bi-planes, that have large motor housings at opposite sides of the pilots. This vision could be improved if desired by raising the pilots six to twelve inches.

5. LATERAL DOWN VISION

Can be provided for the Burnelli type by placing windows or an opening in the floor alongside the pilot's cockpit, extending to the nose. My experiences in flying the Savoia-Marchetti, twin hull S-55 model, that I flew on a passenger airline, between New York and Boston, where no lateral down vision was provided for, was not the handicap it at first appeared. The two hulls on the Savoia, jut out in front of the center section and wings, and are a far greater interference to the pilot's vision, than the two motors as installed in the Burnelli. When circling for a landing, the bank permitted a good view to the side and down. On cross country flights, and if at any time I wanted to look to the side and down, I would drop a wing and look over the motor cowl. This, of course, would not be satisfactory for a military ship, in formation, so the abovementioned windows, in my opinion would answer the purpose.

6. LATERAL DOWN AND REAR VISION

Openings provided in the bulkhead, back of the pilot's cockpit, permit the pilots to see through the cabin windows, in the side of the airfoil body providing satisfactory down and back vision on both sides, for either pilot. No low wing monoplane, or bi-

plane provides this unique feature, of vision not only above, but below its wings.

7. VISION SUMMARY

My first flights in a cabin airplane, left me with unfavorable reactions. The cabin plane seemed too confining, but this feeling rapidly wore off. Pilots must accustom themselves to the enclosed type planes. This I say from my own experience, and knowledge of others. When a pilot has once adjusted himself to the cabin plane, he never wants to fly an open cockpit ship again, provided of course that his vision has not been too seriously handicapped. During the 180 hours that I flew the Burnelli transport, at no time did I feel that the question of vision was of any serious consequence. This, however, I cannot say about the many other multi-engined ships I have flown. For example, the tri-motored Ford and Keystone Patrician, that I have flown extensively, provided no rearward vision, a restricted forward vision due to the nose motor interference, and really only complete lateral down vision on my side. At the present time, I am flying military and commercial machines, and the absence of bulky flying gear, plus the comfort of a heated cabin for high altitude and winter flying, make the cabin plane such a pleasure to fly, that I wonder why they still build planes of the open cockpit class that in my opinion reduce pilot efficiency.

8. NIGHT FLYING

Reflection of ground lights on the cabin windows, is not any more of an annoyance than in an open cockpit job. In the open cockpit, the pilot must wear goggles, and no matter what direction he looks, he must look through glass. Cross country flights at night are aided by the unobstructed vision to the rear. It assists the pilot in holding his course, for he can glance back and align himself with the lights of some city or town that he has just passed, or in the case where he is flying over a lighted airway, and the going is a little tough, because of poor visibility, he can turn his head and see the last beacon light, and before that has passed out he can pick up the next one ahead. Landing at night is much easier than with a tri-motored plane. The pilot has excellent vision not only ahead, but down and propeller glare has been entirely eliminated by painting the backs of the blades. As a matter of fact any three motored plane as well as single engined jobs, require the pilot to look through the blades in a landing, and it has been my experience that flying with the sun at my back was always a greater annoyance to the eyes than night landings, and this was solved by spraying the backs of the propellors a dull brown.

9. SAFETY vs. VISION

It may be for increased front gun protection and military purposes, that sitting the pilots further out, in a nacelle, would improve the lateral vision, but at the sacrifice of safety to the personnel. The Burnelli is the only cabin plane that I ever felt safe in, in the event of a forced landing, or a bad landing on my part, at night. With the undercarriage retracted it would be impossible to nose over, and with the wheels extended, in the event of a ground loop due either to a flat tire, or locked wheel, strong cross wind, etc., going up on the nose, the pilots would enjoy the protection afforded by the motors, both of which would absorb the shock. This is not true of any other twin engined ship built to date. Going up on the nose, or nosing over, either due to landing too high or hitting a ditch, or some other obstruction in a forced landing, might result in either death or serious injury to the crew. The question of safety to the pilots, in my mind, is a very important one, particularly as the trend in design is for faster ships, with higher landing speeds. The sacrifice of a questionable amount of lateral down vision, has been more than compensated for by the additional protection afforded the pilots, by sitting them between and back of the power plants. Also keeping in mind that fact that the propellers in the Burnelli design are well ahead of any structure. In that event of any propeller failure, due to any cause, it would be impossible for any of the fractured parts to injure either any of the crew or damage structure in any way. This feature should be of particular importance in a military plane one that is subjected to enemy fire, where a shell fragment or bullet might cause a failure. In some cases of propeller failure, the power plant has been torn out, resulting in wing failure and a crash. In the Burnelli design, if a propeller should fail, and even if a motor should be torn loose, nothing of major proportions should occur, either to plane or crew.

Other safety features that impress the pilot are:

A. Accessible engines for minor repairs and inspection in flight.

B. Accessible retractable landing gear, visible from the pilot's cockpit making possible minor repairs in flight. My experiences with a Lockheed Altair, equipped with

a retractable undercarriage, the inability to do anything when the wheels would not lower, was a constant source of worry, particularly as I had to depend upon warning lights to inform me if the wheels were down or not, and often these lights failed to function, forcing me to come in for a landing hoping that the wheels were down.

C. Gas tanks out of line and in a different structure from the power plants.

D. The ability to land on water with the wheels retracted, without nosing over. This I also speak from personal experience, having landed my Lockheed in the Irish Sea, at night, after crossing the Atlantic. The wide body could be arranged that by making it water tight, the plane would float indefinitely.

My experience in aviation since the war covers military service, bombardment and pursuit, Army Air Corps, and at present Air Corps Reserve 369th Squadron, Mitchell Field. Since resigning from the Army, my experience covers air transport, test and operations on airways. High speed cross country demonstrations and aerial photography flying and engineering.

(signed) Louis T. Reichers
Transport Pilot #2347
A. P. Rating U. S. Army Air Corps
F. A. I. Rating

APPENDIX "E"

TO: Mr. Rex M. Hoyes
FROM: V. J. Burnelli
DATE: January 3, 1938
SUBJECT: Analysis of lifting fuselage multi engined design versus orthodox nacelle types based on reasoned opinion by various experts in England and the United States.

| | Compared with present low wing Nacelle type designs Military and Commercial. |
|---|---|
| Aerodynamic efficiency based on equivalent cabin volume and pay load per horsepower. | Superior |
| Structural efficiency and weight based on equal load factors and cabin volume. | Superior |
| Construction economy and mass production qualities. | Superior |
| Flight efficiency and control with one engine operating. | Superior |
| Inherent safety relative engine location and strength of cabin structure in event of crash. | Superior |
| Inherent safety of power plant structure in the event of propeller failure | Superior |
| Fuel tanks in relation to engine location for minimum fire hazard. | Superior |
| Accessibility of engine equipment controls and landing gear in flight. | Superior |
| Maintenance efficiency based on accessibility and compactness of installations. | Superior |
| Passenger load distribution relative balance variations in flight. Moment of inertia. | Superior |
| Cabin height applied to aircraft of 16,000 lb. weight. 6 ft. maximum headroom. | Equal |
| Floor space per passenger seat. | Superior |
| All around stability and control qualities. | Equal |
| Landing gear, ground qualities and simplicity. | Equal |
| Pilots view forward hemisphere. | Equal |
| Pilots view rearward hemisphere. | Equal |
| Pilots lateral down view with radial air cooled motors. | Inferior |
| Passenger view compared to low wing types. | Superior |
| Minimum size, span length and height based on equivalent load per sq. ft. and lifting area per horsepower for storage purposes. | Superior |
| Adaptability of design for military convertibility or sea plane conversion involving minimum changes in drawings stress analysis and production equipment | Superior |

NOTE: The fact that the lateral down view is the only point of this design that is considered somewhat inferior to conventional types, the combination of the far more important factors of basic design and arrangement indicates the outstanding practical advancement of this type of airplane.

The aerodynamic relation is based on thorough wind tunnel comparative investigation of the structural weight relations determined by relative stress analysis comparison.

The question of lateral down view only exists to an inferior degree with the installation of high radial aircooled engines. Lowering the engines 9" as recommended will remove this view restriction sufficiently for the lateral down view to depress about 15° below the horizon which compares very well the view over the side nacelles of the conventional low wing types.

APPENDIX "F"

REPLY TO COMMENT CONTAINED IN MARTLESHAM TEST REPORT RELATIVE TO BRITISH BUILT BURNELLI UB-14 DATED NOVEMBER 14, 1939, AS SUBMITTED BY CAPTAIN NORMAN EDGAR TO BURNELLI.

1. The C-0 UB-14 apparently did not provide the degree of ventilation that the U. S. model had and which was considered satisfactory for hot weather. Heating had been provided for by a shroud on the exhaust pipes which are located below and within three feet of the pilot section, making for light and simple installation.

2. The doors of the UB-14 are double surfaced and of much stiffer form than the C-0 model. Doors to open against the wind stream for parachute use are not required for passenger planes.

3. The new designs developed from the UB-14 have substantially corrected the limitation of lateral down view. This is based on extensive experience in operation and expert pilot opinion. The improvement being made is by raising the pilot's hatch about nine inches and the engines lowered about one foot. This gives about double the angle of side down view over the engine cowls. On the C-0 model the engines were raised and this made the side view less than with the UB-14. This view is considered of main importance for ground taxiing in close quarters. A report by Colonel L. Reichers of the Air Transport Command regarding vision is attached. While applying to the larger UB-20 it bears close relation to the design being considered. As to the rear view the C-0 model did not provide a transparent rear hatch section. The UB-14 hatch was considered very satisfactory in this respect permitting overhead, rear and down view.

4. The present UB-14 Ailerons while rather light are to be substantially improved as recommended by Pangborn through applying latest practice of narrowing the ailerons with increased aspect ratio and improved slot design. Pangborn and other pilots state that the UB-14 ailerons, and especially the C-0 model are effective at the stall and improvement will be made.

5. The UB-14 flaps are visible from the pilot's seat. However, it is planned to also provide a dashboard electric selenoid indicator for the fuselage and wing flaps.

6. The UB-14 type requires twin brakes and wheels of increased size and brake capacity such as are now available. The C-0 model had a lever control, whereas the UB-14 has foot-pedal brakes according to A & N requirements. The above will thoroughly correct this element.

7. The UB-14 is provided with a trimmer indicator. The C-0 model we understand did not provide this.

8. It has been arranged in the new instrument panel layout to raise same to a height more in line with the pilot's straight-ahead vision. A & N requirements are to be met.

9. This effect is largely influenced by correct brake action. The short coupled tail wheel is not of influence in this respect from our experience. Locking the tail wheel will assist ground handling in heavy cross winds, as with any type. The UB-14 does not have a brake lever, therefore the throttle interference referred to does not exist.

10. The element of longitudinal instability in climb was not considered different in comparison with any type of conventional airplane during climb and rough air. Correction of heaviness of controls by improved aerodynamic and static balance has been

referred to. The UB-14 when operating before the changes made abroad was declared to be very light on the controls.

11. More correct CG location and increased trimmer movement, which is easy to provide for, will correct this condition, though same was not considered a factor on the UB-14 from test pilot reports.

12. The rudders on the UB-14 were changed abroad and therefore require about 25% aerodynamic and static balance than has been provided through making the change. This is a routine design matter for correction to lighten same. Also applies to condition when flaps are lowered. The UB-14 controls were considered very well harmonized from test pilot's comments. Refinement of balance referred to will improve same.

13. Present air transports are of only neutral stability at certain angles of trim and load condition. The automatic pilot relieving the pilot of required correction. The UB-14 during CAA tests was considered highly satisfactory in this respect and especially regarding shifts in the cargo CG. We are not familiar with the exact balance and trim conditions of the C-0 model. The stability and control requirements of the aircraft being projected from the 1935 model UB-14 will be arranged to meet the requirements of Section 04-7 of the CAA Air Worthiness Manual, Part 04.

14. As outlined in Item 3, the lateral side view is to be improved. It is generally agreed that the forward down view which is excellent with this type is the most important for aircraft operation. Again, the report of Colonel Reicher's and others by Clyde Pangborn are referred to.

15. Structural weight and stress analysis investigation recently directed to the UB-14 indicates that the C-0 model is much overweight in comparison with requirements for this type of airplane. This was outlined by the Cunliffe-Owen Company because, as they advised us, they wanted to avoid extensive static testing for the first British model and prepare for overload conditions. This accounts for the reduction in percentage of disposable load in comparison to what proves to be practical to achieve. A summary of the weight and stress investigation referred to is being attached to technically outline and account for the fact that about 1200 pounds should be added to the disposable load and which would make the estimates of load capacity superior to that which is possible with conventional nonlifting fuselage designs and according to the comparison with the Lockheed 14, which is included.

Mr. Pangborn has advised me that the take-off tests and over barrier climbs were made from a sod field and that compared to present transport types operating from concrete can be considered excellent. This should be so as the wing loading is about 20 per cent lighter than applied with present nonlifting fuselage designs.

Burnelli

COMMENT AND REFERENCE

It must be borne in mind that a practical airplane which combines the maximum of the most important features required for an Advancement in aerodynamic efficiency, increased percentage of load carrying capacity, inherent design safety, and more economical construction and maintenance qualities must be based on a compromise in regard to various less important details. The following reports are attached to more clearly outline basis for judgment in this regard:

Report by Colonel Louis T. Reichers re Vision 1937 (Appendix D)
Safety Comparisons and Flying Qualities-Pangborn-March 14, 1936 (Appendix N)
Review Comparison of Major Design Features, Air Ministry, England, January 3, 1938.
Structural Review UB-14 Design, May 10, 1943. (Appendix C)

# APPENDIX "G"

## COMPARATIVE PERFORMANCE COMPUTATIONS OF TWO TRANSPORT PLANE PROJECTS

Prepared for the Canadian Car & Foundry Co., Ltd.
March, 1943. Max M. Munk, Brentwood, Md.

### Principal Characteristics of Projects.

| | Conventional | Burnelli |
|---|---|---|
| Designation | V | B |
| **Dimensions** | | |
| Span ft. | 220 | 220 |
| Area Sq. ft. | 4400 | 5888 |
| **Power** | | |
| No. of engines | 6 | 6 |
| HP take-off | 20,000 | 20,000 |
| HP cruise 45% | 9,000 | 9,000 |
| Consumption lbs/HP hour | .45 | .45 |
| **Weight** | | |
| Total lbs. | 220,000 | 220,000 |
| Empty lbs. | 120,000 | 105,000 |
| **Propeller** | | |
| Diameter ft. | 16 | 16 |
| Tip speed T.O. ft/sec | 1,000 | 1,000 |

### Computed Performance

| Designation | V | B |
|---|---|---|
| **Take-off** | | |
| Run, ft. | 2750 | 2300 |
| **Climb T.O. HP** | | |
| S.L. ft/min | 1130 | 1200 |
| 15,000 ft. ft/min | 1000 | 1070 |
| 15,000 ft min | 14 | 13.2 |
| **Cruising** | | |
| Altitude, full w. | 22000 | 25000 |
| MPH, full weight | 218 | 230 |
| Altitude, 4500 M | 25000 | 25000 |
| MPH 4500 M. | 220 | 230 |
| Fuel, 4500M lbs | 70,500 | 66,000 |
| Freight, 4500M lbs | 29,500 | 49,500 |
| Range, no freight | 6800 M | 9,000 M |
| **Max. Speed** | | |
| S.L., 75% HP MPH | 245 | 250 |
| 25,000 ft. alt, 75% HP, MPH | 300 | 310 |
| **Stalling Speed** | | |
| Start, MPH | 99 | 82 |
| 12 hrs, MPH | 87 | 73 |

Computed Aerodynamic Characteristics.

| Designation | V | B |
|---|---|---|
| Drag Computation | | |
| Wing area sq ft | 4,000 | 5,888 |
| Wing drag coeft | .0125 | .010 |
| Drag area sq ft | 104 | 90 |
| Span factor | .925 | .925 |
| Virtual span ft | 203 | 203 |
| Cruising | | |
| Lift/Drag | 17.7 | 19 |
| Init. Dyn. Press lbs/sq ft | 60 | 59.5 |
| Prop. efficiency | .80 | .80 |
| W/ (spec. cons.) M | 11,750 | 12,700 |
| Take-off | | |
| Prop. efficiency | 72% | 72% |

Comment regarding determination of drag.

By "basic" drag is meant the drag portion not dependent on the lift coefficient nor on the angle of attack. Its prediction has to be based on somewhat doubtful and controversial data. The comparative results are far more certain than the results themselves.

Project V. Only the actual wing area has been used for the computation of the wing drag.

The wing sections being relatively thick throughout the region nearer the fuselage, a correspondingly large basic drag coefficient has been used.

The fuselage drag has been computed from its surface.

The wing drag has been increased to allow for interference between wing and fuselage.

Project B. The fuselage wing sections are thick but not excessively so. The interference between fuselage portion and lateral wing panels is probably much smaller than with a round fuselage, also the boom-wing interference is not expected to be large. A slightly smaller wing drag coefficient has therefore been used for the wing-fuselage combination than with the V project.

The additional drag, coincident to the change of the angle of attack, has been assumed to be alike for both projects. It finds expression in replacing the actual span by a "virtual" span. This substitution takes care of a friction drag, not of an additional induced drag.

Propeller efficiency.

While propeller efficiencies of 85% and even more are found in literature, these figures do not include interference. Also the drags used do not include all cooling and engine mounting losses, and some of this may well be charged directly to the propeller. A figure of 80% is therefore more likely to give a correct prediction of the performance.

The same propeller efficiency has been used for the two propellers.

Stall.

The stall velocity has been computed for both projects with a maximum lift coefficient 2.2. Larger maximum lift coefficients are found in literature, but they refer to all span high lift devices of special kind, and it is doubtful how far the wind-tunnel tests are reproduced at large scale. It is well known, on the other hand, that unsteady landing conditions tend to increase the maximum lift coefficients. The values computed are therefore considered conservative.

Maximum Speed.

These values depend to a large extent to the exact prediction of the drag. In absence of many details that determine this, the figures given form a reasonable estimate for comparison. They have to be checked as the design progresses.

Climb.

The climb figures have been computed with the entire take-off HP. This horsepower can be maintained for a short while only, and the climb with 75% of the horsepower will be considerably smaller. The figures give a good comparison, and are valuable for indicating the manner of taking-off.

Cruising.

Most economic cruising in quiet air has to be carried out at or near a definite angle of attack. The lift/drag ratio at that angle determines the drag. An upper velocity results from that in conjunction with the available horsepower. The altitude resulting in the best flying angle at that maximum velocity would then be the most economical altitude.

In the table of performances, the velocities and the corresponding flying altitudes are given for the beginning and for the end of a fully loaded 4500 M trip. No allowance has been made for a variation of the propeller efficiency, or of the fuel consumption, or for any wind.

Result.

The B project has a smaller drag. This is the natural consequence of the substitution of two small booms for a large fuselage. The total wing area is larger, but there still remains a balance in favor of the B project, although the difference by itself is not striking.

Both projects having the same weight and span, and both projects having a wing plane view reasonably close to an elliptical one, it can be confidently expected that both projects will give equal induced drag under equal conditions.

The B project requires furthermore a lighter structure only, thus having a larger capacity for freight.

Since thus the B project exceeds the V project in every respect, in smallness of drag, in smallness of weight of the structure, and also in some other ways that are not within the scope of this report, but tend to decrease the drag farther, it results that the B project is the better one. It exceeds the V project in all performance items. The superiority is particularly pronounced in its cargo carrying capacity over long distances. This is aided by the smaller structural weight, and to a lesser degree by the somewhat smaller drag. The B project carries more than one and half times the freight of the V project over 4500 miles.

It is well to keep in mind that the superior performance of the B project is not in any way obtained by sacrificing a small landing speed, but on the contrary: the B project has a smaller wing loading and in consequence will definitely land much slower than the V project. It is doubtful whether the high landing speed of the V project will make it suitable for commercial operations. Increasing the wing area of the V project for the purpose of bringing its landing speed down to the landing speed of the B project will further increase its drag and its structural weight. A comparison between such modified V project and the B project would be more fair to the B project. It would show even larger superiority of the B project over and in comparison with the conventional design.

APPENDIX "I"

September 19, 1939

The basic principle of the lifting fuselage as developed by V. J. Burnelli since 1919 is now in such an advanced stage that it is extremely important for the Air Corps to experiment further with it with a view to reducing it to military practice.

From studies of the research made by the Burnelli Co., the NACA and the Air Corps, the military adaptability of the basic design has the following advantage over the orthodox streamlined deadweight fuselage.

1. The coefficient or drag is the lowest known for any useful airplane today.

2. The coefficient of lift is greater.

3. The lifting fuselage has distinct advantages for the installation of power plants, bombs, armament and all other accessories over the streamlined fuselage.

4. From wind tunnel tests already conducted by the NACA and NYU the performance is exceptionally good in every phase.

5. The design embodies extremely good factors of safety--considerably higher than the streamlined fuselage type.

6. The design is simple of construction and in the opinion of the Air Corps lends itself to high speed production better than any design and therefore the valuable time element involved in all production contracts can be taken advantage of to its fullest extent.

7. It is apparently a cheaper airplane to build because of the time element referred to in 6 above.

It is to be remembered that Mr. Burnelli was the first to reduce to practice the use of smooth skin surface on airplanes in cooperation with the Material Division under Maj. Carl Green's supervision.

We understand that the present company has no affiliation with the British Company manufacturing under the Burnelli patents. We are informed by the company that the British have built onecommercial article under the designs of a ship built by Mr. Burnelli in 1929, and that this design only resembles the designs submitted to the Air Corps in basic principles. We also understand that this airplane was tested at Farnsborough by the RFC with excellent results, substantiated by a cable from the British manufacturer, a copy of which we have.

We have also seen articles in various British technical magazines that are extremely flattering to the basic design involved and the report of the test pilot, Mr. Clyde Pangborn, would indicate that the design embodies extremely good flying qualities under all conditions of a very severe flight test required by the RFC.

It is, therefore, the opinion of the Air Corps that this project should be carried through to its fullest experimental possibilities and probably to the ultimate conclusion for the purchase of a prototype.

I am informed by the Burnelli Company that in an effort to cooperate with the Air Corps they have proceeded with the required work and at this moment it is seventy percent completed.

In my opinion it is essential, in the interest of the national defense, that this procurement be authorized.

---

COPY of letter prepared by officers of Engineering Division at Washington for signature of General Arnold to Secretary of War.

APPENDIX "K"

COMPARISON OF BURNELLI VGB, MOSQUITO AND VENTURA

(This Burnelli tunnelled at NACA and won design competition Wright Field 1940)

| | VGB | MOSQUITO | VENTURA |
|---|---|---|---|
| Gross Weight | 25, 500 | 18, 800 | 28, 800 |
| Power Plant | 2x2200 | 2x1275 | 2x2000 |
| Cruising Range | 1804 miles | 1260 miles | 1000 miles |
| Pay Load (normal) | 2500 | 2200 | 2500 |
| Wing Loading | 34 | 42 | 48 |
| Armament | 2 cannon<br>8 - .50 C | 4 .20 mm<br>4 .30 mm | 8 - .50 mm |
| Top Speed | 472 MPH*<br>451 MPH | 400 plus | 300 |
| Crew | 2 | 2 | 5 |
| Structure | Dural | Wood | Dural |
| Landing Speed | 80 MPH | 70 MPH | 90 MPH |
| Cost Estimated | $75, 000. 00 | $74, 000. 00 | $190, 000. 00 |

* Without allowing for compressibility

APPENDIX "L"

# COMPARISON OF AN UNUSUALLY GOOD CONVENTIONAL FUSELAGE WING COMBINATION VERSUS A BURNELLI AIRFOIL FUSELAGE TYPE AIRCRAFT

(Edited by H. E. Hartney - July 3, 1943)

(Contains where pertinent factual reference to confidential N. A. C. A. Report 1939. after tunnelling. Upon strength of this N. A. C. A. Report General Arnold's memorandum was prepared (Appendix "I" ) and a $20, 000 design order was awarded Burnelli by the Air Corps. )

## 1. Purpose

The purpose of the following report is to compare the advantages and possibilities of the Burnelli Lifting Fuselage type aircraft with the modern conventional streamline fuselage and wing combination. The aerodynamic effects are limited to minimum drag only.

## 11. Aerodynamic Qualities - Minimum Drag

### A. Bare Fuselage and Wings

1. The first comparison is between an ideal conventional streamline body and wing combination versus a lifting fuselage wing combination with booms that was designed for practical purposes. Both models are devoid of any excrescences such as hatches, coolers, and control surfaces which should effect both models in a similar manner.

Wing Area (Streamline Fuselage Model) = 150 sq. in.
Wing Area (Burnelli Airfoil Fuselage Model) = 1538. 5 sq. in.
Total Volume of Streamline Fuselage = 127 cu. in.
Net Effective Volume of Streamline Fuselage = .6 x 127 = 76. 2 cu. in.
Net Effective Volume of Streamline Fuselage (Same scale as Burnelli Model) = 76. 2 x 10 3/2 = 2409 cu. in.
Eff. Volume of Burnelli Model fwd. of Bulkhead #3 = 2700 cu. in.
Volume of Two Engine Compartments = 250 cu. in.
Net Eff. Volume of Burnelli Model = 2450 cu. in.

1-a. From N. A. C. A. Report 540, combination 186 of Table Page 33, is one of the best ideal conventional fuselage wing combinations.

Area of the model = 150 sq. in. (Pg. 8 above report)
Aspect ratio = 6. 86 ( " " " )
Span efficiency factor = .90 (Table V " " )
Reynolds No. = 3, 100, 000 (Pg. 4 " " )
$C_{D_e}$ (Minimum) (Effective Profile Drag = .0115 (Tab. V " " )

At Minimum Drag

$$C_{D_e} = C_{D_o} - C_{D_i}$$

$$C_{D_i} = \frac{C_L^2}{\pi AR \times \text{Span Eff. Factor}}$$

and since $C_L = 0$ for min. drag, $C_{D_e} = C_{D_o}$

1-b. From N. A. C. A. Confidential Report dated May 8, 1939, and a practical design airfoil fuselage type airplane including swept back wings and also booms.

Area of Model = 1538. 5 sq. in. (Total Lifting Surface)
Aspect ratio = 5. 57
Span Efficiency Factor = .90
Reynolds No. = 1, 951, 000
$C_{D_o}$ Minimum (Fus. + Wings) = .0126 (Test 7 at $\alpha$ = $-2^o$)
$C_{D_o}$ Min. (Fus. + Wings + Nac. + Hatch + Booms) = .0119 (Test 4 at $\alpha$ = $-2^o$)
$C_{D_o}$ Min. (Fus. + Wings + Nacelles + Hatch) = .0110 (Test 5 at $\alpha$ = $-2^o$)
$C_D$ Due to Booms = .0119 - .0110 = .0009
& $C_{D_o}$ Min. (Fus. + Wings + Booms) = .0126 + .0009 = .0135

It is assumed that the $C_D$ is constant at both Reynolds numbers.

B. Bare Fuselage + Wings + Engine Nacelles.

To A 1-a and A 1-b engine nacelles of the best type are added and the minimum drag for the combination is listed below.

1-a. From N. A. C. A. confidential note Feb. 1939, "Preliminary Model Tests of a Wing-Duct Cooling System for Radial Engines"

$C_{D_p}$ (Nacelle Drag Coefficient) = .05 (Fig. 23) (No cooling)

It is assumed that the frontal area of the fuselage nacelle for this ideal airplane is 6 sq. ft.

Based on the Burnelli model whose full scale nacelle frontal area is 6 sq. ft. per engine; and whose scale is 1:7,

$$\frac{\text{Nacelle Frontal Area}}{\text{Total Lifting Area}} = \frac{6 \times 144}{(7)^2 \times 1538.5} = 1.146\%$$

$C_D$ (2 nacelles) based on wing area = $\frac{.01146 \times 150 \times 2 \times .05}{150} = .0011$

$C_{D_o}$ (Fus. Wings Nacelles) = .0115 + .0011 + .0126 at 0°

$C_{D_e}$ (Fus. Wings Nacelles) = .0117 + .0011 + .0128 at $C_L$ = .15

From II A 1-a,

$$C_{D_i} = \frac{.15^2}{\pi \times .9 \times 6.86} = .00116$$

$C_{D_o}$ (Fus. + Wings + Nacelles) = .0128 + .00116 = .01396

1-b. From Reference of A 1-b. Test No. 6. Burnelli Lifting Fuselage.

$C_{D_o}$ (Fus. Wings Nacelles) = .0104 at -2.0° and + .1°

$C_{D_o}$ ( " " " ) = .0112 at $C_L$ = .15

$C_{D_o}$ ( " " " + Booms) = .0112 + .0009 = .0121 at $C_L$ = .15

Note - Burnelli model includes the $C_{D_i}$ due to the $C_L$

AS THESE are test results.

C. Hatches, Windshields and Tail Surfaces.

The drags of these items for both type airplanes are the same and no further comment is needed.

D. Radiators, Oil Coolers, Intercoolers, Turbo Installations & Air Cooled Engine Cooling Ducts.

For normal installations the drag values for these items are identical. However it is found that all of these parts can be installed in the airfoil fuselage in cooling ducts exactly similar to the ducts recommended by the N. A. C. A. in confidential reports on cooling, as ideal installations with the least possible drag.

It may be possible to use similar installations on the conventional type aircraft, howeve the airfoil fuselage, due to the expanded depth, chord and large cubic capacity, lends itself to ideal installations with resultant drag reductions.

E. Miscellaneous Items.

Manufacturing irregularities, rivet drag, etc., are the same for both type aircraft and require no further comment.

F. Summary of Drag at High Speed.

The most useful comparison of the two type aircraft is that at high speed. From paragraphs II B 1-a and II B 1-b it is shown that the Burnelli type model is superior to the conventional type model at high speeds, namely at a lift coefficient $C_L = .15$ for both models.

$C_D$ at $C_L = .15$ Burnelli Type $= .0121$

$C_D$ at $C_L = .15$ Conventional Type $= .01396$

Since these values are taken directly from wind tunnel tests conducted by the National Advisory Committee on Aeronautics and include all interferences that each particular type aircraft inherently possesses, the above comparison is an exact and true one.

In addition to the basic comparison, it is shown in paragraph II D that further drag advantages may be obtained due to room available for ideal installations.

G. Single Engine Performance.

The Burnelli type aircraft is definitely superior in this condition since the engines are spaced as close as the diameter of the propellers permit; for the conventional type aircraft the engines are separated by the diameter of the propellers plus the width of the fuselage. Therefore, failure of one engine produces a much greater turning moment for the conventional aircraft which is very serious in take-off and landing, and which increases the drag at flying conditions on one engine due to an increased rudder deflection to compensate for the yaw. The increase in drag may effect the range of the aircraft flying on one engine.

III. Structure

1. Span Load.

As seen in N. Y. U. Wind Tunnel Test No. 887 H, dated December 1937, a similar Burnelli type model was tested with the wings detached from the model and lift and drag values were obtained with the wings in presence of the fuselage. The experimental span load distribution checked within experimental error with the conventional method of span load distribution as described in ANC-1.

Therefore, the conventional method of span load distribution is employed in all analyses of the Burnelli type aircraft; on this basis, the following results were noted.

1-a. The wings of a Burnelli type aircraft correspond to the outboard panels of a conventional airplane. Since more of the lifting surface area is on the airfoil fuselage than in on the inboard panels of a conventional aircraft, for the same span the Burnelli wings are smaller and therefore lighter.

1-b. The air loads on the lifting fuselage are reacted at their point of application by the dead weight items distributed thru-out this section. Also the increased depth of the airfoil fuselage gives a maximum of strength with a minimum of structural area. Therefore, the airfoil fuselage is lighter than the combination of the inboard panels and forward fuselage section of a conventional combination.

1-c. The twin booms generally associated with the Burnelli aircraft are two simple relatively small tubes with no cut-outs. The aft end of a conventional fuselage is larger than either of the booms and usually is slightly more complicated than the booms. However, the aft end of the conventional fuselage should be slightly lighter than the two booms, since the booms and stabilizer form a portal frame whose ability to take side load is greater than a single cantilever tube.

1-d. The vertical surfaces of the twin boom aircraft for twin surfaces are more rigid since they are directly connected to the main supporting members and their installation should be simpler and lighter than the conventional twin surface arrangement.

1-e. The horizontal tail surfaces for the twin boom arrangement are lighter since due to end plate effect of the twin vertical surfaces, the horizontal area is less for the same degree of longitudinal stability. However the horizontal surfaces for this installation are built into the booms at either end and are therefore a fixed beam with end fixity which results in a material saving of weight over the conventional cantilever beam type of the surface.

1-f. Twin tail wheels are used in conjunction with the twin booms. Each tail wheel is assumed to take .60 of the normal single wheel load and the installation of the two wheels is therefore heavier than the conventional single wheel.

1-g. Summary of Structure.

The total over-all weight factor is in favor of the Burnelli type fuselage since this type is lighter in all the major weight items and is only at a slight weight disadvantage in the minor weight items.

APPENDIX "M"

## CARGO AIRPLANE COMPARISON

(This comparison of the cost of operating all cargo planes, the first two being land planes, the last a flying boat, has been prepared by Harold E. Hartney basing all costs on the average cost of operating DC-3 aircraft in the month of May 1942 on three airlines in the United States - Chicago & Southern, Eastern, and American. Note: These estimates are for a 750-mile non-stop run.)

| Cost Factors and Assumptions | Burnelli lifting fuselage - 6 engines of 3,000 HP ea. (not yet built) | Conventional type Martin Airplanes - 10 engine land plane of 2,000 HP (not yet built) | Martin "Mars" 4 engine of 2,000 HP ea. Flying Boat (already flying) |
|---|---|---|---|
| Gross Weight, Lbs. | 220,000 | 300,000 | 155,000 |
| Weight Empty, Lbs. | 105,000 | 171,631 | 71,205 |
| Aver. Cost of one Overhaul per engine | 1,270. | 1,270. | 1,617. |
| Aver. No. Hours between overhauls | 650 | 500 | 500 |
| Life of Engines - Overhauls | 12 | 10 | 10 |
| Specific Fuel Consumption Lbs. H.P. hr. | .43 | .48 | .487 |
| Specific Oil consumption Lbs. H.P. hr. | .012 | .015 | .015 |
| BHP per engine (cruising) | 1550 | 1192 | 1300 |
| Price of fuel - gal. | .105 | .127 | .127 |
| Price of oil - gal. | .35 | .40 | .40 |
| Initial cost of airplane Lb. (G.W) ($) | 2.5 | 4.2 | 2.83 |
| Initial cost of airplane Lb. (wt. empty) ($) | 4.50 | 7.44 | 6.17 |
| No. of airplanes built in one lot | 10 | 15 | 22 |
| Initial cost of airplane ($) | 262,500. | 1,278,100. | 439,800. |
| Initial cost of Eng. & Prop ($) | 225,000. | 249,900. | 120,000. |
| Initial cost of total ($) | 487,500. | 1,528,000. | 559,837. |
| Life of Airplane - hours | 20,000 | 27,900 | 27,900 |
| Life of propellers - hours | 5,000 | 5,000 | 5,000 |
| Captains base pay - $ year | 2,400. | 2,400. | 2,400. |
| Captains hrs. per year | 950 | 950 | 950 |
| Captain's hourly rate | 4.60 | 4.60 | 4.60 |
| Captain's Bonus rate (¢ mile) | 1.05 | 1.05 | 1.05 |
| First Officer's Annual pay ($) | 3,000. | 3,000. | 3,000. |
| Second Officer's Annual pay ($) | 2,800. | 2,800. | 2,800. |
| Flight Engineer's Annual pay ($) | 2,250. | 2,250. | 2,250. |
| Cockpit Crew - hrs. yr. | 900. | 900. | 900. |
| Crew Expenses - hr. (total) | 6.00 | 6.00 | 3.00 |
| Steward's Annual Pay ($) | 1,800. | 1,800. | |
| Crew Insurance - (man hrs.) | .55 | .55 | .55 |
| Fire & Windstorm Insurance (and deprec. value) | .000004 | | |
| F & W & Crash Ins. (x initial val.) | .0000143 | .00001935 | .00001935 |
| Loss, Damage & Misc. (x deprec. value) | .000005 | (included in ground service) | |

| Characteristics | Burnelli -6 Eng. | Martin Airplane (Non-stop 750 mile schedule) | Martin Mars Dev. |
|---|---|---|---|
| Take-off, BHP/Eng. | 3,300 | 2,000 | 2,300 |
| Landing Gear | Conventional | Conventional | Tip Float Fly. Boat |
| Pressurized Cabin | Optional | No | No |
| Cruising BHP | 1,600 | 1,192 | 1,300 |
| Cruising Altitude (ft.) | 14,000 | 12,000 | 5,000 |
| Cruising Speed (MPH) | 230 | 200 | 195 |
| Block Time (hrs) | 3.50 | 4.15 | 4.25 |
| Block Speed (MPH) | 205.0 | 180.5 | 176.0 |
| Wt. of Fuel (lbs) | 40,875 | 35,000 | 12,420 |
| Wt. of Oil (lbs) | 3,645 | 1,612 | 717 |
| Wt. of Crew | 1,300 | 1,189 | 680 |
| Payload (sht. tons) | 40,000 | 38,000 | 33,000 |
| T.O. Power loading (lbs. BHP) | 12 | 16 | 16.8 |
| Wing Loading (lbs. sq. ft.) | 32 | 41 | 42.1 |

Direct expenses (750 mile trip e.g. N. Y. - Chicago

| Direct Flying Costs* | $/Hr. | $/Hr. | ¢/mi. | $/Hr. | c/mi. |
|---|---|---|---|---|---|
| 1. Main and Overhaul | 26.00 | 108.78 | 60.27 | 48.60 | 26.48 |
| 2. Fuel and Oil | 84.75 | 121.35 | 67.23 | 53.41 | 30.35 |
| 3. Flying Personnel | 33.14 | 33.14 | 18.36 | 23.14 | 13.15 |
| 4. Insurance | 1.90 | 29.80 | 16.51 | 11.07 | 6.29 |
| 5. Incidental Expenses | 2.00 | | | | |
| 6. Depreciation (a) Airplane | 30.00 | 41.20 | 22.83 | 14.19 | 8.06 |
| (b) Engine & Props | 21.18 | 49.99 | 27.70 | 24.00 | 13.64 |
| (c) Communication Equip. | .75 | | | | |
| 7. Investment | 4.00 | 11.50 | 6.37 | 4.21 | 2.39 |
| Total Cost | 203.72 | 395.76 | 219.14 | 176.61 | 100.36 |
| Payload (tons) | 40,000 | 48,000 | | 33,000 | |
| Vb. - MPH | 205 MPH | 180.5MPH | | 176.0MPH | |
| Cost - ¢/ton mi. | 2.92 cents | 4.535 Cents | | 3.026 Cents | |

Special Important Comparisons

| | | | |
|---|---|---|---|
| Landing Speed (MPH) (end of flight) | 72. | 87. | 90. |
| Cruising Altitude | 14,000 | 12,000 | 5,000 |

*This cost does not include cost of selling traffic.

APPENDIX "N"

CLYDE E. PANGBORN

March 14, 1936

Burnelli Aircraft Ltd.
Keyport
New Jersey

Gentlemen: Re: Safety Comparisons

Supplementary my reports relative to the high performance and unusually satisfactory stability and control qualities of the Burnelli UB14 Transport, I am pleased to outline my opinion and reasons for the superior degree of safety inherent to this design, based on the lifting fuselage principle, the feature of your type--

(1) The engines are ahead of all structure. This is very important to safety in the event of accident, as the engines and their strong mounts would absorb a large degree of the impact, thereby protecting the cabin and passengers. The pilots section, being located rearward and not in line with the engines, offers maximum safety for the crew.

(2) The propellers operate ahead of all structure and are not attached to the lighter outboard wings. This is an important safety factor in the event of propeller failure, as no parts would strike into the structure or cabin sections, or affect any sustaining surface through the tearing loose of the engine mount.

(3) The propellers operate close together with no body in between, as is conventional. The advantage of this quality though obvious for flying with one engine stopped, is immediately noticeable in the more efficient flying and control qualities of the plane, as the corrective use of controls to overcome the offset propeller thrust augmented by the stopped propeller drag, is practically nil and right or left turns easily made. This is a "premium" factor in view of the U. S. Department of Commerce requirements whereby a twin-motored plane must be licensed according to "ceiling" and "pay-load" capacity when operated with but one of its motors and under satisfactory control characteristics, as practical flight on one motor, with safety, is the main purpose demanding the use of multi-engined designs.

(4) The broad airfoil form of lifting-fuselage of the Burnelli design is surrounded by all of the major load-carrying structure; the engine-mounts are forward with a strong metal bulkhead between; the wing-beams are across the ceiling; landing-gear-structure at the sides unlike the long tubular fuselage construction of the conventional transport-type, which forms mainly a streamline housing for the cabin section, with the main-load carrying elements not contributing to the strength thereof. Further, the compact airfoil body section of the Burnelli design possesses far greater resistance to buckling on impact, than a long tubular body with engines rearward, in which the bending loads are maximum at the passenger section and which is weakened to a certain extent by the windows and doors. Further, the landing gear and tail wheel of the Burnelli design contribute no direct shock to the lighter outboard wings or tail group, the landing strains and taxiing shock loads being directly applied to the deep sectioned body, thus imposing no landing strain though the more delicate wings and tail elements as in contrast to conventional designs.

(5) The fact that the body actually lifts 25% of the gross weight, as per the approval of the National Advisory Committee of Aeronautics for A. T. C. license purpose, makes it clear that the wings are proportionately reduced in required area and relieved of load with substantial relief of bending stresses throughout, as the lift forces peak, in the center of the airplane, instead of being reduced in this critical load section by the addition of a non-lifting body element. With the body supporting 25%, or 3400 lbs., which is equal to body structure plus the engine weight, it is understandable that the plane should ride through rough air, or maneuver with less shock and landing strain throughout, and also that the compactness of weight provides better stability and control qualities in its operation.

(6.) Ease of inspection and maintenance is an important factor of safety and the human element will always be a problem in this respect. The Burnelli ship is in a class by itself in this feature -- because not only are all the engine details, fuel and instruments, loads and controls, more compact and easily accessible in the nose of the wide body, but the distinct feature of these elements being visible to the pilot and accessible in flight also, must be appreciated as a most desirable maintenance and safety feature. The retractible landing gear is not only visible to the pilot, in flight, but accessible for inspection or adjustments, another exclusive advantage.

(7) An interesting inherent safety quality of the design for over water operation is the fact that the wide body, made water tight, will serve as a boat bottom for distress landing and float indefinitely, as the body will provide adequate buoyance with required stability serving as a life raft. The wings can be easily arranged for quick release to entirely achieve this purpose. It is generally recognized that the land plane is of higher performance and economy than the more cumbersome flying boat which depends on side floats for marine stability.

The arrangements for the pilot and visibility provided is entirely satisfactory and in certain respects superior to present transport practice. Also, and a very important feature, is the unobstructed passengers vision, due to the high wing arrangement.

With modesty I state that my judgment is established on over fourteen thousand hours of flying covering all the types of aircraft and operations of same including the latest types.

I have piloted the UB14 through its test and demonstrations covering about one hundred hours flying, and know it to represent a distinct advance in aircraft design, in consequence of which I have selected the Burnelli UB14 Transport for my projected non-stop refueling flight-around-the-world.

With continued assurance of my confidence in the advancement represented by your type, I remain,

Very truly yours,

/s/ Clyde Pangborn

P/H

APPENDIX "0"

Montreal, December 8th, 1941

Major General H. H. Arnold
Chief of Army Air Forces
Washington, D C.

Dear General:

I understand that the Air Corps has been interested in various flight test reports and operating opinion, regarding the Burnelli type of all Wing design.

Based on severe testing in this country and the rigid I. C. A. N. tests in England as well as demonstrations in Holland, I am convinced that this type of airplane offers many structural advantages for design improvement, and I particularly refer to flying qualities of multi-engined designs.

The important element of maximum protection for the crew, accessibility of most of the detail engine equipment and the retractible landing gear.

In fact, during the testing of the first modification of the American prototype, I arranged a rope and pulley system for emergency lowering of gear, due to the bad hydraulic system as installed in England. The hydraulic jack being accessible for disconnecting from the cockpit.

I also installed a flap across the fuselage with which I could control the plane in all longitudinal attitudes including landing, a valuable contribution in case of damaged or otherwise unserviceable tail surfaces.

The larger the size of this particular design, the more accessible the various parts.

It has always been difficult for me to realize that such a practical and important design advancement has been delayed in acceptance for so long, however, the same has applied to most design improvements which have later become necessary.

From my experience this type of airplane appears to be the most practical change to make to substantially improve basic design in comparison with the best jobs I have been flying, which include the latest deliveries to England by air.

I feel obliged at this crucial time to encourage its practical application for aviation advancement.

You might be interested to know that I have been busy the past year, delivering P. B. Y. 's to Manila P. I. and Hudsons and Liberators to England, I was also with the crew which brought Lord Beaverbrook to Washington and returned him to England.

Just returned last week from England and am due out again in a couple of days. Bernt Balchen was with me on the Manila job as you, no doubt, know.

The R. A. F. Ferry Command's loss was the Air Corps' gain. He is a "great guy" and a most versatile individual.

With kind personal regards I am,

Yours very truly,

/s/ Clyde Pangborn

CP/ml

APPENDIX "P"

## BRITISH CIVIL EVALUATION

### Analysis of the Burnelli Lifting Fuselage multi-engined design versus orthodox nacelle types

| | Compared with present low wing nacelle type designs Military and Commercial. |
|---|---|
| Aerodynamic efficiency based on equivalent cabin volume and pay load per horsepower. | + |
| Structural efficiency and weight based on equal load factors and cabin volume. | + |
| Construction economy and mass production qualities. | + |
| Flight efficiency and control with one engine operating. | + |
| Inherent safety relative engine location and strength of cabin structure in event of crash. | + |
| Inherent safety of power plant structure in event of propeller failure. | + |
| Fuel tanks in relation to engine location for minimum fire hazard. | + |
| Accessibility of engine equipment controls and landing gear in flight. | + |
| Passenger load distribution relative balance variations in flight. Moment of inertia. | + |
| Maintenance efficiency based on accessibility and compactness of installations. | + |
| Cabin height applied to aircraft of 16,000 lb. weight, 6 ft. maximum headroom. | = |
| Floor space per passenger seat. | + |
| All around stability and control qualities. | = |
| Landing gear, ground qualities and simplicity. | = |
| Pilots view forward hemisphere. | = |
| Pilots view rearward hemisphere. | = |
| Pilots lateral down view with radial air cooled motors. | - |
| Passenger view compared to low wing types. | + |
| Minimum size, span length and height based on equivalent load per sq. ft. and lifting area per horsepower for storage purposes. | + |
| Adaptability of design for military convertibility or sea plane conversion involving minimum changes in drawings, stress analysis and production equipment. | |

\+ Superior

= Equal

\- Inferior

APPENDIX "Q"

REPORT OF ALEXANDER KLEMIN, DEAN OF THE FACULTY OF AERONAUTICS, NEW YORK UNIVERSITY, MADE IN A LETTER TO LEON HENDERSON of NOVEMBER 19, 1940

"Mr. Vincent J. Burnelli has asked me to set down my opinion regarding the Burnelli Principle of Aircraft Design. As I have had the advantages of several years study and wind tunnel experimentation on this Principle, I am happy to set down my well considered views.

1. The Basic idea is that the conventional fuselage shall be eliminated and housing space shall be provided within a lifting airfoil while tail surfaces are supported at the end of appropriate booms.

2. From the elimination of the fuselage which is an element of purely parasitical drag, there follows reduction of aerodynamic resistance. This logical conclusion has been checked again and again in wind tunnel tests made under my direction here, and in other tunnels.

3. From the reduction in aerodynamic drag, there follows improvement in performance, that is in high speed, climb and fuel consumption for a given weight of the airplane and horsepower. This conclusion has been checked by several performance calculations carried out in classical fashion from the impersonal findings of wind tunnel tests.

4. An approach is made to the aerodynamic idea of a "flying wing" airplane.

5. All other aerodynamic characteristics of an airplane such as longitudinal stability and control, lateral stability and control, remain those of the best modern practice.

6. The specific employment of the airfoil in lieu of the conventional fuselage permits the volume of housing capacity to be largely increased without any sacrifice of aerodynamic efficiency.

7. Increased housing capacity is particularly useful for modern bomber design. The bomber carries bombs, racks, instruments, accessories, supercharger intercoolers, etc., an enormous and complete installation which it is very difficult to install efficiently in the conventional fuselage. From the point of view the Burnelli bomber designs which I have had occasion to study offer great advantages in military aircraft design as distinct from the aerodynamic advantages to which I have referred previously. All other military requirements such as vision and range of gun fire are fully retained.

8. The Burnelli bombers definitely add to our air defense possibilities.

9. The ability to increase space for passenger accomodation in the air transport plane without sacrifice in aerodynamic efficiency is equally important and makes the Burnelli principle valuable in the design of large passenger transports.

10. For the same reason Burnelli designs are well adapted to serve as troop carriers.

11. From the main principle of design there derive logically and inevitably certain other important advantages which will be enumerated as briefly as possible:

(a) The central portion of the wing or lifting airfoil fuselage carries an appreciable proportion of the total weight of the aircraft, thereby the stresses at the root of the outer wings are reduced and structural weight is saved, as has been demonstrated by careful analyses submitted to the Civil Aeronautics Authority.

(b) The elimination of the structural unit of the fuselage results in further saving of structural weight and with appreciable advantage in manufacturing economy.

(c) The streamlined fuselage has difficult compound curves. Its elimination results in simpler and less expensive construction.

(d) The substitution of the airfoil for the fuselage places the engines of a twin-engined machine in direct access to the crew which is a distinct advantage.

(e) Placing of engines ahead of all occupants is a safety measure.

(f) Since the useful load, (passengers, installation, etc.) does not have to be spread out along the longitudinal axis of the aircraft the longitudinal maneuverability is increased.

(g) The large undersurface of the central portion of the wing provides excellent housing for the landing gear.

(h) The general structural design is such that there is concentration of stress and support points which is as it should be.

12. The general conclusion is inescapable: The Burnelli principle offers an advance in the art, in efficiency and economy.

Sincerely yours,

Alexander Klemin

There are illustrations and appendices missing from this report, but it is believed the missing material is generally contained in the attached article cut from the March 1942 issue of Air News, a publication largely devoted to U. S. Army Air Force matters.