Express Design, Inc.

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February 22, 1995

To: All Express Aircraft Builders

Since EDI acquired the rights to the Express design we have been constantly looking for ways to make the aircraft easier to build, less expensive to acquire and to operate, and safer to fly. As a result of our investigations we believe that we have been able to make improvements to the basic design that address some or all of these characteristics.

One particular issue requires special attention . This issue has to do with the design and aerodynamic characteristics of the cruciform tail on the original design . The attached report has been generated to give you, the builder and manufacturer, the facts concerning its performance.

If, after reading and studying this information, you are interested in the corrective action suggested, please call the EDI staff for details on the tail group update program.

Sincerely,

David Ullrich
President

ATTACH(S)
- Preliminary Findings: Express Flight Characteristics - Pitching (5 Pages)
- Operational Recommendations (2 pages)

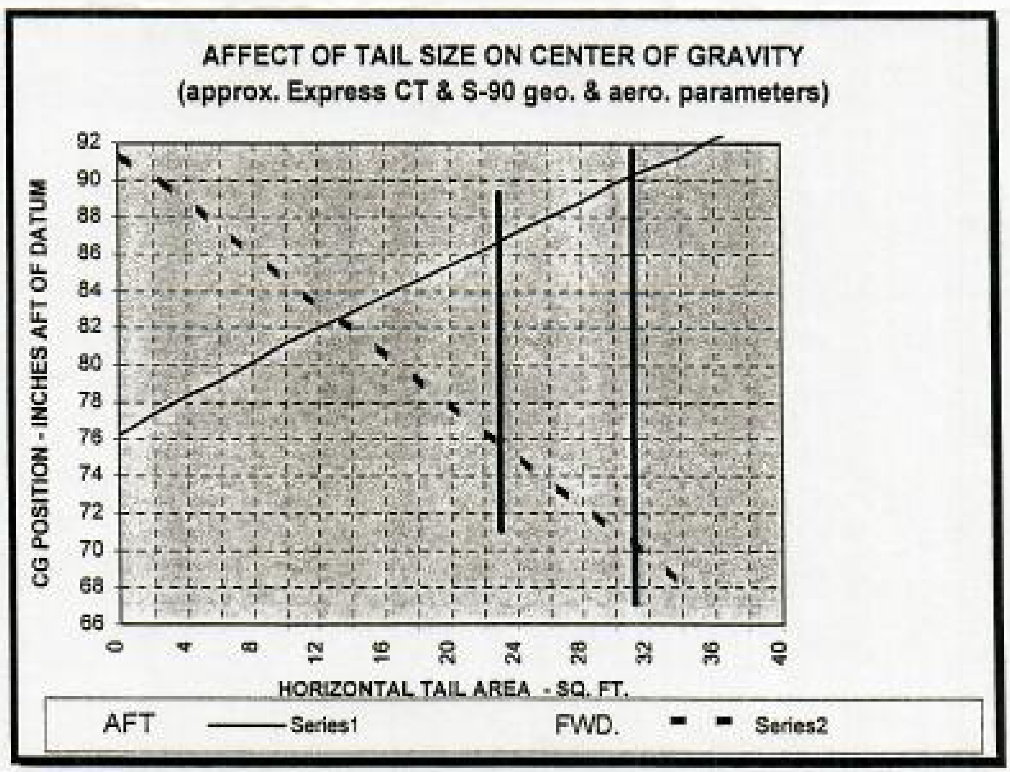
PRELIMINARY FINDINGS:
EXPRESS FLIGHT CHARACTERISTICS - PITCHING

Express Design Inc.
February 16, 1995

The purpose of this report is to pass on to owners of first generation Express airplanes and kits information that we have uncovered regarding stability issues associated with the tail. During our flying of the early Express design (we'll call it the Express CT because of the cruciform tail) we noticed that it is possible to generate an unexpected pitch down movement with the application of rudder. Upon investigation and study it became apparent that the pitch down motion was associated with the design of the tail group on the Express CT.

In order to gather still further data we asked several outside aerodynamic engineers to look at the characteristic. The results of their findings has been consistent and includes safety related information that we feel is extremely important for every builder of the Express CT to consider as they complete and fly their aircraft.

The result of the independent engineering studies is best summarized in a chart that has been generated to illustrate the effect of aircraft tail volume verses possible CG range for Express aircraft models. It is important to understand that the data points of the enclosed chart are **not** intended to be used to directly establish center of gravity limits for **normal operation of an Express aircraft**. The use of this chart is normally confined to aerodynamisist and flight test personal as a method of determining desired test CG locations during initial testing. The lines define the limits of neutral points and forward trim limits, **not normal handling and stability limits.**



This chart gives the reader an idea of the affect of horizontal tail size on CG range. As calculated by our aerodynamisist, the point at which the two lines cross is the minimum tail size possible to fly the Express CT (approximately 13 sq ft), all points left (smaller tail size) of the crossing point are less stable. As the lines deploy to the right of the crossing point the stability increases and therefore the CG range is increased. The first bold vertical line to the right of the crossing point represents the effective horizontal tail area of the Express CT (23 sq ft). The second bold line to the right of the crossing point represents the effective horizontal tail area of the Express S-90 (31 sq ft).

The points at which the bold vertical lines intersect the aft limit and forward limit lines indicate the respective CG stations as listed on the vertical scale to the far left of the chart. It must be stressed once again that the plotted crossing points are neutral points and **not operating points for the aircraft.** Under these conditions there is no stick force or "control feel" at the aft line and there is an inability to obtain enough nose up trim at the forward line.

The <u>computed</u> Express CT "neutral points & forward trim limits" are:

Forward = 75.5" aft of datum
AFT. = 86.7" aft of datum

The <u>computed</u> Express S-90 "neutral points & forward trim limits" are:

Foreword = 70.5" aft of datum
AFT. = 90.5" aft of datum

When one compares the Express S-90 range of 20 inches to the Express CT range of 11.2 inches one starts to realize how important tail size is as a design perimeter. A 34% increase in horizontal area results in a 78% increase in the "neutral point & forward trim limit" datum range.

In the real world the differences in actual CG limits are even more dramatic since the datum points of acceptable handling must be reduced measurably to account for control friction, etc. with the ratio favoring the larger tail. The result is that it is not unreasonable to expect a CG range improvement of up to 80% in the Express S-90 over the Express CT due to the S-90's modified tail configuration.

As a result, EDI has concentrated on the effects of the tail design as they relate to the handling and stability characteristics of the Express aircraft. The following excerpt from a report by one of our aero consulting firms provides additional insight into this matter.

<u>Excerpts from report</u>: ATS 92-02

<u>Stability Considerations and Recommendations</u>

The usual approach taken to examining stability and control issues is to separate the problem into two parts: longitudinal (pitch) and lateral (yaw or sideslip). It is also necessary to examine the combined case. This is an area which usually receives insufficient attention. The following sections discuss these three cases.

<u>Longitudinal Stability</u>

The primary longitudinal stability problem is usually insufficient tail area. A small tail affects many aspects of the airplane's overall performance. Only one aspect is positive, and the effect is minor. This small positive effect is that a small horizontal tail usually has less drag than a larger one. This is often touted as the primary consideration for tail sizing. <u>However, what is usually not considered is the magnitude of the effect.</u> The total drag of the horizontal tail is usually very small relative to the total drag *of the airplane, on the order of 5%. For airplanes in the size range of the Express, doubling the horizontal tail area would cause the cruise speed to decrease by about 4 mph. Any reasonable increase in tail size will lead to a negligible speed loss.*

The disadvantages of a small horizontal tail are numerous. The allowable center of gravity envelope is greatly affected by tail size. As shown on the chart on the preceding page, the tail size determines the usable center of gravity range. The forward limit is due to trim (nose up capability), and the aft limit is determined by stability requirements. Note that for this example (roughly the Express airplane) that a minimum of 13 ft. sq. of tail area are required in order to have a theoretically flyable airplane (trim and stability requirements met at one c.g. location only). Since in practice a range of allowable c.g. positions is required rather than the single point mentioned above, more tail area is necessary.

The existing tail area of 23 ft. sq. is also shown on the chart. Notice that a 34% increase in this area increases the c.g. range by about 78%. Thus even small increases in the tail area are beneficial and come with a negligible penalty to cruise speed. This is in direct contrast to modern beliefs that the tail must be as small as possible.

There are other modifications that could be made to improve the stability and trim limits, given that the tail area is not going to be changed. Such devices as downsprings and bobweights have been used in the past to improve the stability and flying qualities of airplanes with under-sized tails. However, these devices are mentioned for purposes of illustration only, and it is ***not recommended*** *that improved c.g. travel be achieved by these means. Unpleasant dynamic stability problems usually appear when large downsprings or bobweights are used.*

The low stability levels associated with small horizontal tails make airplanes difficult to fly, and have negative effects on the airplane's stall characteristics. Poor stall characteristics will lead to a higher percentage of stalls developing into spins. Since modern pilots are not required to know anything of value regarding spins, it is necessary for today's airplane designer to make the airplane more stall and spin resistant than was the case when all pilots were required to learn and demonstrate spin recovery techniques.

It is also important to understand that, at the stall, the downwash at the elevator changes dramatically. This change in downwash is equivalent to a down elevator input from the pilot, ***and reduces the tendency of the airplane to continue to pitch up during the stall. If the tail is small,*** *the effect is also small, and the airplane can* ***pitch to a higher angle of attack than is obtainable with a larger tail.*** *The tail can be so sized that the ability to achieve angles of attack above the stall is greatly reduced. One airplane that exhibits this characteristic is the Cessna 206.*

The effect of tail size may be directly seen by comparing two well known twin engine aircraft manufactured by the same company but one has a small tail (ST) and the other a large tail (LT). These airplanes are aerodynamically identical except for horizontal tail size. The ST aircraft has a smaller horizontal tail than the LT aircraft. It is extremely difficult to make the ST aircraft exhibit acceptable stall characteristics, while for the LT aircraft it is relatively easy. Note that in this case the differences in stall characteristics have nothing to do with a change in the wing, as the wings are identical. The difference occurs because the difference in tail size limits the LT aircraft to lower angles of attack than the ST aircraft.

The pilot's perception of the stability of these two airplane groups is also of interest. ***For the small-tailed airplanes the effect of c.g. location is readily noticeable, while for the larger-tailed airplanes the effect of c.g. location is perceived to be negligible.*** *The* ***strong pitchdown*** *at stall due to the larger tail effectively* ***limits*** *the angle of attack to approximately the same value,* ***regardless of c.g. position or pitch rate at the entry to the stall. The small-tailed airplane very noticeably exhibits the opposite effect.***

An increase in tail size is also ***beneficial for the trim condition****. At the forward c.g., flaps down, approach condition, a larger tail requires much less up elevator to trim.* ***Very small (and therefore heavily loaded) tails may stall on approach in turbulent conditions or upon crossing-another airplane's wake (or its own wake in a turn)*** *. **If the tail stalls in the approach condition, rapid action must be taken to avoid diving straight into the ground**. Additionally, if the tail is heavily loaded, it will probably be* ***difficult to trim*** *due to the high boundary layer thickness caused by the high loading.* ***This tends to make the tab ineffective.***

The choice of airfoil used for the tail is also important. ***Thin sections, or sections with sharp leading edges, do not make good tail airfoils, particularly for highly loaded (small) tails. Thin sharp-nosed sections will stall more easily in the approach configuration than will a less sharp-nosed airfoil.*** *Examples of airplanes that have this problem are fabric covered bush planes with powerful flaps (powerful flaps create large nose-down pitching moments). Several of these types of airplanes have crashed due to tail stall.*

Lateral Stability

In addition to under-sized horizontal tails, modern airplane builders have also opted for small vertical tails. Many problems are caused by a small vertical tail. Airplanes with small vertical tails require large and coordinated use of the rudder pedals in turns. This was acceptable at one time, but a realistic view of today's pilots suggests that it is not appropriate to ask them to use the rudder pedals in any reasonably competent manner. This requires that the airplane be built with a larger or more effective vertical tail than is now fashionable. Small increases in vertical tail area, especially when combined with an increase in vertical tail aspect ratio, lead to much improved directional stability and therefore much reduced requirement for use of the rudder pedals in normal flying situations.

Additionally, the flight loads experienced by a larger vertical tail will usually be less than those found on the same airplane with a smaller vertical tail. This is due to the increased stability of the larger-tailed airplane, which reduces its ability to attain large sideslip angles where tail loads can be very high. This is of particular importance for maneuvering airplanes. Many World War II era fighters had low directional stability and vertical fin failures were fairly common. The usual cure was to increase the vertical tail size to limit the amount of sideslip generated in maneuvers. Current kit built airplanes are usually not intended to be maneuvered in a violent manner, but poor pilot technique may make a violent maneuver out of a normal one. ***Many pilots appear to believe that all experimental airplanes are aerobatic airplanes and fly them accordingly****. Violent maneuvers combined with poor flying skills can and do create large vertical tail loads.*

Combined Longitudinal and Lateral Stability

There are areas where the choice of small horizontal and vertical tail areas produce combined lateral and longitudinal problems. These areas are very important but are often ignored by designers who somehow believe that complete separation of longitudinal and lateral considerations is reasonable.

One area is the occurrence of horizontal tail stall in yawed flight, which is usually worse for the forward c.g., flaps down case. The sideslip induces additional angle of attack on one side of the horizontal tail. If the tail is already near stall (as is the case with small highly loaded tails) this additional loading may be enough to cause it to stall. As already discussed, tail stall can be disastrous at low altitudes.

A generally neglected fact about stall characteristics is that they may be adversely affected by a small vertical tail. The vertical tail will have no effect upon stall characteristics as long as there is no sideslip, but an airplane with a small vertical tail allows sideslip to develop more easily than does a similar airplane with a larger vertical tail. In addition, pilot training now occurs in airplanes that are relatively *benign, with the result that pilots are not as careful as they once were about keeping the ball centered during a stall.*

Sideslip and the rate of change on sideslip (evidenced as yaw and yaw rate) are powerful factors in determining the type of stall which will occur. Generally, minimizing both parameters helps to achieve acceptable stall characteristics. There is very strong statistical data to support this view. One particular crop duster has good straight ahead stall characteristics, but its lateral directional characteristics are such that unless an unreasonable amount of attention is directed to keeping the ball centered, rolling and yawing motions occur at the stall which cause the airplane to spin. The conventional view of the airplane (with separable longitudinal and lateral motions) is inadequate in the case of the stall where strong longitudinal-lateral coupling can occur.

This report excerpt reflects the findings of others we have consulted and also the results of our own testing. The design of the Express CT tail group can result in an uncommanded pitch down motion of the Express CT aircraft. In-flight handling differences between the S-90 design and the Express CT further confirm our conclusions.

We believe therefore that because the Express CT can experience an uncommanded pitch down motion under certain flight conditions, that certain actions are required by EDI and by Express CT builders and owners. Specifically:

1) **To minimize the chance of uncommanded pitch down in the Express CT, EDI has revised the operational conditions under which an Express CT pilot should operate the aircraft. These revised recommendations are included in the attached document titled "Operational Recommendations."**

2) **Because certain flight conditions such as turbulent air can cause the uncommanded pitch down motion without pilot involvment, EDI believes that each owner of an Express CT kit or aircraft should seriously consider updating their kit or airplane with the S-90 tail update available from EDI. (Call the EDI factory at 503-548-2723 for details on the tail group update program.)**

We realize the burden that these recommendations place on Express CT builders and owners. We do, however, feel that we have taken a diligent and responsible path on this issue. We have investigated the effect of the original Express CT tail thoroughly, confirmed the results through separate, independent tests, designed an updated tail group which addresses the problem, and made this update available to each Express CT builder and owner. It is now the responsibility of each owner to determine their course of action with regard to the issue.

While it is true that Express CT aircraft have logged thousands of miles successfully and it is also true that certain certified general aviation aircraft experience uncommanded pitch down under certain flight conditions, EDI continues to believe that the results of the technical studies we have commissioned must still be seriously considered. The uncommanded pitch down potential of the Express CT is a potentially dangerous condition that can and should be addressed by each builder and owner.

As the final manufacturer of these aircraft, it is each builder's responsibility to decide how to address the issues presented here. We firmly believe that builders owe it to themselves and their passengers to build the best handling and safest aircraft possible.

OPERATIONAL RECOMMENDATIONS
FOR EXPRESS AIRCRAFT MODELS

NOTE: This notice applies to all Wheeler Tech. & Express Design Inc. aircraft models except the Express Series 90. All Express Pilot Operating Handbooks (POH) currently in the pocession of Express builders and/or pilots should be revised accordingly.

We at *EXPRESS DESIGN INC.* revise the specifications of our aircraft models as results of testing and actual operational data become available. The following recommendations are the results of testing and design reviews that were performed to enhance the controllability and stability of your *EXPRESS* aircraft.
It is important to realize that no two kitbuilt aircraft are identical. Certain operational limitations may be unique to each individual aircraft, therefore one must consider the following as conservative limitations and your individual limitations should not exceed those listed below.

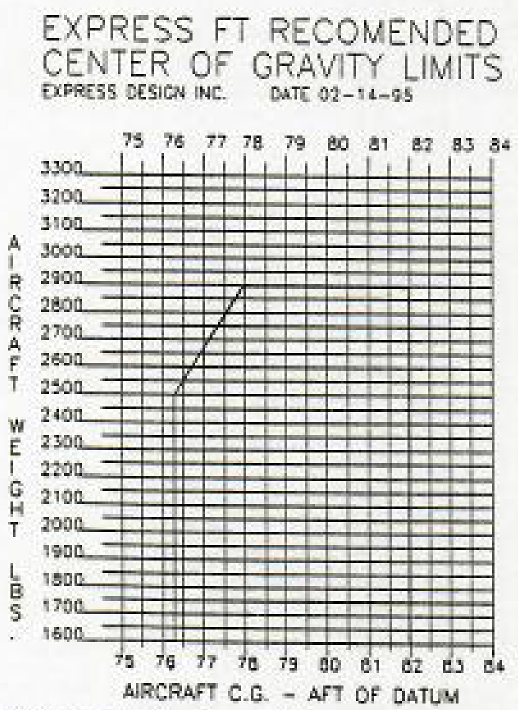
DESIGN AIRSPEEDS

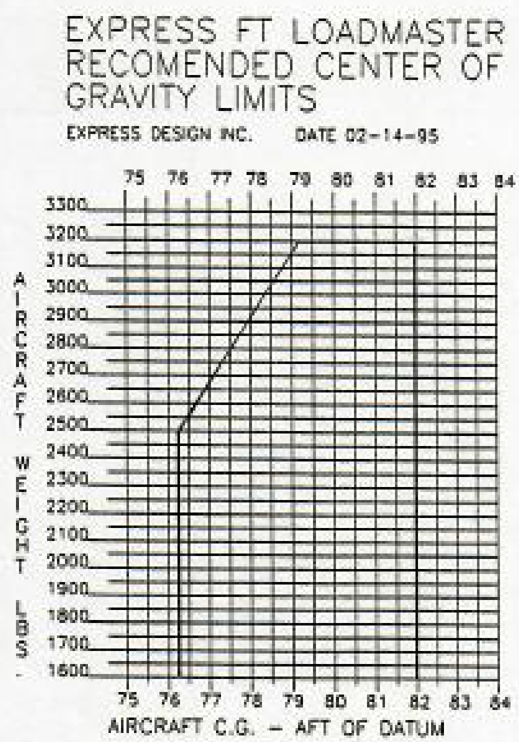
Vc =	162.5 KCAS	(Design Cruise Speed @ 3200 lbs.)
Vne=	198 KCAS	(Never Exceed Speed)
Va=	145 KCAS	(Maneuvering speed @ 3200 lbs.)
Vs=	74 KCAS	(Stall Speed Flaps- Up @ 3200 lbs.; **Calculated, Aircraft manufacture (builder) must verify each aircraft**)
Vso=	66.5KCAS	(Stall Speed Flaps - Down @ 3200 lbs.; **Calculated, Aircraft manufacture (builder) must verify each aircraft**)
Vf=	100 KCAS	(Max. Flap Speed)

WEIGHT & CENTER OF GRAVITY LIMITS

Gross Weight	2,895 lbs.	(Standard Express Models)
Gross Weight	3,200 lbs.	(Express FT Models With Loadmaster Option)

Center of Gravity Limits ; Std. Express Models & Express Loadmaster Option.





LIMITATIONS - MISC.

Flight Load Factor Limits:

1. Flaps Up: +3.8g, -1.52g
2. Flaps Down: +2.0g

Maneuver Limits:

1. **Aerobatic maneuvers**, including spins are not recommended.
2. **Yawed flight**, with or without flaps not recommended.
3. **Crosswind operation** in excess of 10 mph, not recommended
4. **Flight operations in excess of light turbulence**, not recommended.

GENERAL RECOMMENDATIONS

1. Prior to the first flight of your EXPRESS aircraft we strongly recommend that you obtain as much flight time in the like model EXPRESS as you have manufactured. Under ideal conditions, you as the manufacturer, owner, and pilot of the EXPRESS kitplane should become intimately aware of the known flight, performance, and ground handling characteristics of your type of aircraft **before** your first flight. If possible obtain the services of a professional flight test pilot for the initial flight test period.

2. As the manufacture of the Express aircraft you should remain conservative in your aircraft operating environment for a considerable period of time in excess of the required "FAA testing limitation period" since the Express aircraft is indeed a high performance aircraft . Airport selection should initially consist of runways of at least the 4,000 ft. or longer and 50 ft. wide. Reasonable density altitudes and good weather conditions should prevail well into the familiarization period. History has proven that many unfortunate incidents occur when kitbuilders with low hours of experience (in type) attempt flight and ground operations in excess of newly acquired aircraft operational skills.