

# DC-10 Type Certificate Lifted

**FAA action follows finding of new cracks in pylon aft bulkhead forward flange; crash investigation continues**

By David M. North

Washington—Suspension of the McDonnell Douglas DC-10's type certificate last week followed a separate grounding order from a federal court as government investigators were narrowing the scope of their investigation of the American Airlines DC-10 crash May 25 in Chicago (AW&ST June 4, p. 12).

The American DC-10-10, registration No. N110AA, crashed shortly after takeoff from Chicago's O'Hare International Airport, killing 259 passengers, 13 crewmembers and three persons on the ground. The 275 fatalities make the crash the worst in U. S. history.

The controversies surrounding the grounding of the entire U. S. DC-10 fleet and, by extension, many of the DC-10s operated by foreign carriers, by Federal Aviation Administrator Langhorne Bond on the morning of June 6 revolve around several issues.

The first issue involves the grounding of all DC-10 models, when most of the problems being found in the aft pylon area have been attributed by the FAA primarily to the DC-10-10. The second issue, and the most critical in terms of how much time it will take U. S. airlines, McDonnell Douglas, the National Transportation Safety Board and the FAA to get the DC-10s flying again, is the cause of cracks being found in the forward flange of the DC-10's pylon aft bulkhead.

A further issue is likely to erupt among detractors of the FAA as to why the agency did not ground the aircraft immediately after a U. S. district court judge issued a temporary restraining order grounding the aircraft on June 5.

The first issue, that of the FAA suspending the type certificate of all DC-10 series aircraft, brought an angry response from McDonnell Douglas.

One company official said: "We are making every effort to assure a prompt return to service of the DC-10, and will take whatever steps are necessary to accomplish that goal. Today's FAA action is more sweeping and drastic than circumstances warrant because the pylon aft bulkhead cracks found during inspections have all been on DC-10-10 aircraft, because they have involved aircraft that may have suffered from maintenance procedures at variance with the manufacturer's recommendations and because no such cracks have been found on DC-10-30 or DC-10-40 aircraft."

When asked last week why he was grounding all DC-10s, Bond responded that the DC-10 series aircraft had "sufficient design commonality to raise suspicions," and that he would rather "err on the side of safety" in the grounding of all series of aircraft.

As to why he was now suspending the certificate of the DC-10, when earlier he grounded the aircraft and then released it for flight, Bond answered that he had gone from a "certitude of a high likelihood of no risk to a sufficient likelihood of risk."

The emergency order of suspension for DC-10s not only grounded the 138 U. S.-registered aircraft, but also most foreign-registered aircraft. Those countries having bilateral agreements with the U. S. covering aircraft certification were required under the agreement to ground the DC-10s registered in their country. Those countries not included in bilateral agreements were being notified by the FAA last week that the DC-10s operated under their registration could not fly into a U. S. airport or use U. S. airspace. Foreign countries were being told that they could

ferry their aircraft to their home maintenance bases.

The suspension order grounded all DC-10s immediately, with domestic airlines not allowed to ferry their aircraft. Meetings were being held at FAA headquarters on June 6 to determine a procedure that would enable U. S. carriers to ferry their DC-10s to their maintenance bases.

Bond and the FAA base their suspension of the type certificate of the DC-10 on two cracks found in the aft bulkhead forward flange of two American Airlines DC-10s in San Francisco on the evening of June 5 and to possible gaps in the original fail safe certification analysis. The cracks had not been located during earlier inspections, which raises the question of whether the cracks had been there during the earlier visual inspections and not seen, or whether the cracks, found in this case by dye penetrant inspections, were new ones. The answer to these questions will determine the procedure the FAA will have to use to restore the DC-10's type certificate.

The initial response of the safety board in finding a fractured forward thrust link attach bolt at the accident site was to suspect this bolt as a possible cause of the DC-10 accident. The FAA issued an airworthiness directive on May 28 or-

## Boeing, Lockheed Prepare for Pylon Inspection

Boeing Co. last week was making initial preparations in anticipation of a Federal Aviation Administration order requiring a one-time inspection of engine-pylon mounting systems on all U. S. wide-body transports.

The company wired its 747 customers regarding a planned meeting that would discuss wording of a Boeing service bulletin that would be issued in the event of such an FAA move.

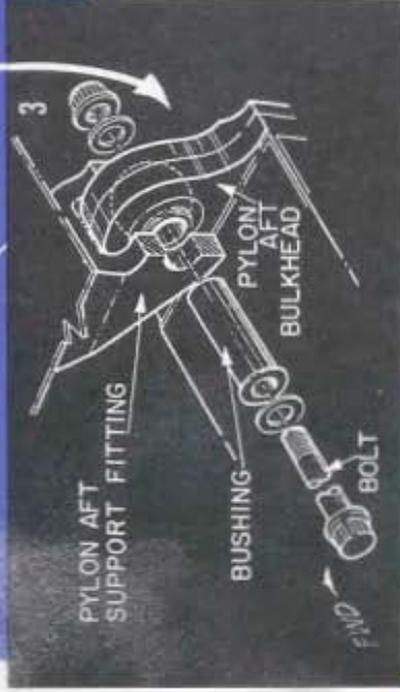
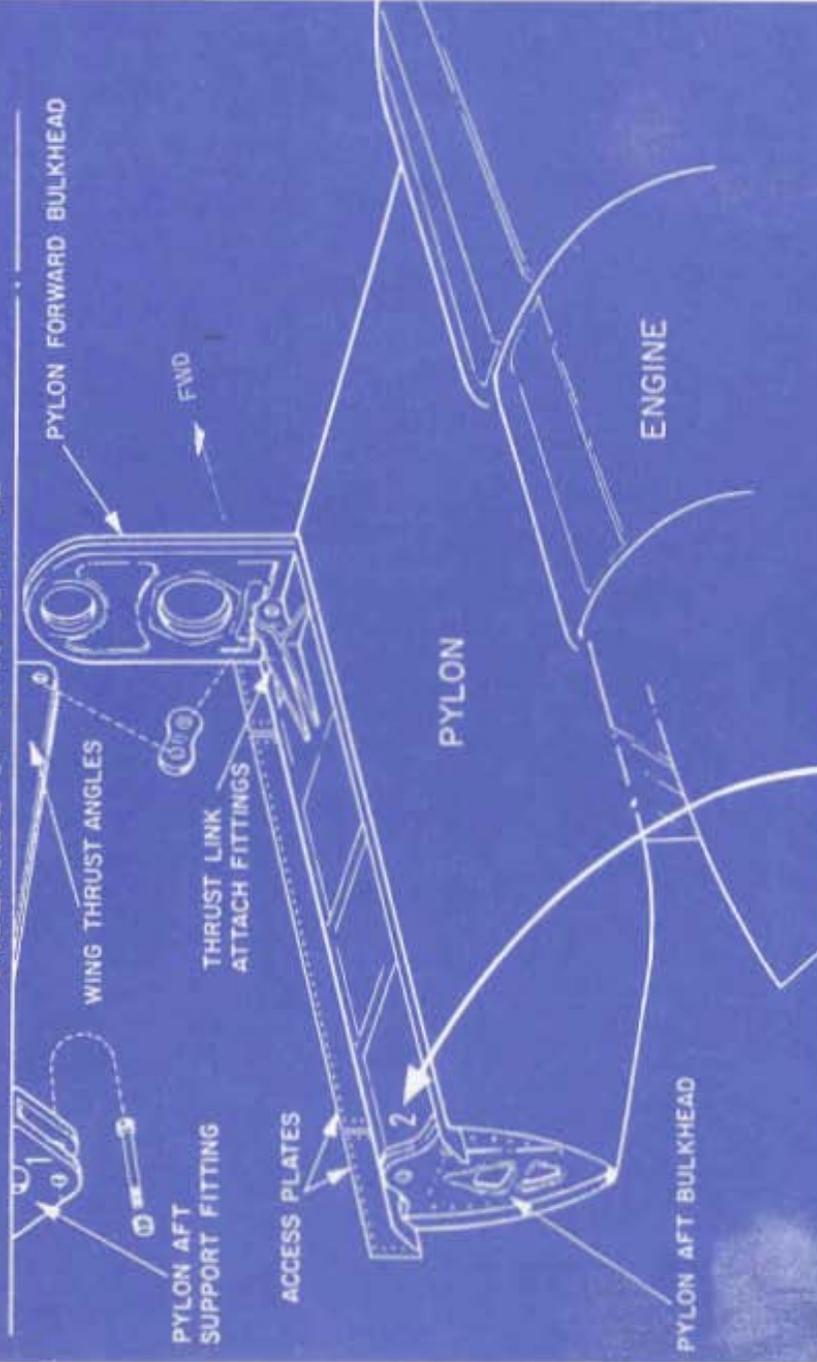
Meanwhile, no immediate action was taken as a result of a Boeing-FAA meeting May 31 during which inspection procedures and certification data relating to 747 engine pylons were reviewed. FAA officials said they would study the data and contact Boeing again on the subject.

In the wake of the American Airlines DC-10 accident in Chicago, Boeing officials emphasized that it has not been necessary for the company to issue any service bulletins relating to 747 pylons. Regarding published reports that 37 747 engine pylon "problems" had been reported to FAA during a five-year period, Boeing officials explained that these "normal service difficulty reports" are required by the FAA for any work done outside normal maintenance. They include items as minor as removal of a spot of corrosion, the company said.

Lockheed Corp. planned to issue a service bulletin to its customers late last week or early this week outlining a special process designed specifically for a one-time inspection of L-1011 engine mounts. Final wording of the statement was to be coordinated with the FAA and airline customers.

Although the L-1011 engine mounting design is different from that of the McDonnell Douglas DC-10, Lockheed wired a similar statement to customers more than one week ago referring them to portions of the aircraft manual dealing with engine mount inspections. The latest statement is viewed as a means of formalizing a detailed list of recommendations to airlines.

## UNDERSIDE OF WING SURFACE



Current National Transportation Safety Board and the Federal Aviation Administration investigations are centered on cracks found in the forward flange on the pylon aft bulkhead fitting. The safety board said the 2-in. and 5-in. cracks found in the flanges of two American Airlines DC-10s and the 10-in. crack found in the crashed DC-10 could have been caused by the pylon aft support fitting (1) impacting the upper flange assembly (2) when the pylon, with engine attached, was lifted for assembly to the wing by a forklift. Fig. 3 is a detailed drawing of the assembly, with flange cracks directly beneath the attachment fitting.

## Engine Pylons Are Straightforward Design

Long Beach, Calif. — Engine pylons used on the McDonnell Douglas DC-10 wide-body transport are of a relatively straightforward design using the cantilever principle to connect the engines to the wings.

The pylons are of box beam construction, using titanium and steel primarily, along with some aluminum components.

Each pylon is attached to the wing at three points, all of which are well aft on the engine/pylon assembly. The attachments include:

- Forward support bulkhead, which juts out of the top of the pylon and connects to a titanium mount on the main (front) wing spar. The pylon forward support bulkhead had two holes—a 4-in.-dia. hole on the top and a 6.25-in. hole beneath it—that line up with two similar holes in the titanium mount on the front wing spar. Steel plugs are inserted in these plugs and then clamped on either end to hold the pylon bulkhead to the wing. This attachment point absorbs vertical loads, side loads and torque loads.

- Thrust link, located on the top of the pylon just behind the pylon forward support bulkhead. This is a hardened steel plate 8.5 in. long, about 3 in. high, and  $\frac{1}{4}$  in. thick, with a hole in each

end. One end is connected to a clevis on the top of the pylon, while the other end is connected to a clevis on the bottom of the wing. This link absorbs both fore and aft thrust loads from the engine. It is the channel through which the thrust of the engine is transmitted to the wing to pull the aircraft forward in flight or to stop in on landing. If the thrust link fails, the lower attach point on the pylon forward support bulkhead is designed to absorb the full thrust load, along with the vertical, side, and torque loads it normally handles.

- Aft attach point, or aft support bulkhead, which is a small abutment with a hole in the middle at the rear of the pylon. This connects to a titanium clevis on the underside of the wing. Like the front support bulkhead, this is designed to absorb vertical and side loads.

All of the five attach points—the two on the pylon forward bulkhead, the two on the thrust link and the single one on the aft support bulkhead, use a monoball bearing inside the attachment holes.

Both of the pylon bulkheads consist of two separate steel plates joined together. Either plate can fail and the other is designed to carry the full load.

dering that the bolts be inspected or replaced and that the forward flange of each wing engine pylon aft bulkhead be inspected for cracks.

Subsequent inspections of the DC-10 fleet revealed further cracks in the wing pylon area, which prompted a supplementary airworthiness directive by the FAA on May 29, grounding the aircraft until the required inspections were completed. The supplementary directive required operators to conduct a visual inspection of the entire remaining pylon-to-wing attach area not covered by the original directive.

On May 31, a safety board official said the crack in the pylon forward thrust link attach bolt was not due to fatigue, but to stress, which fractured the bolt.

### Emphasis Switched

At the same time the emphasis of the investigation was switching to the possibility that cracks in the pylon's aft bulkhead forward flange could be the main problem in the pylon-to-wing attachment. The cracks were being attributed by the safety board to maintenance procedures used by American Airlines and some others in removing and reinstalling the pylon with the engine attached.

In its recommendation to the FAA on June 4, the safety board said:

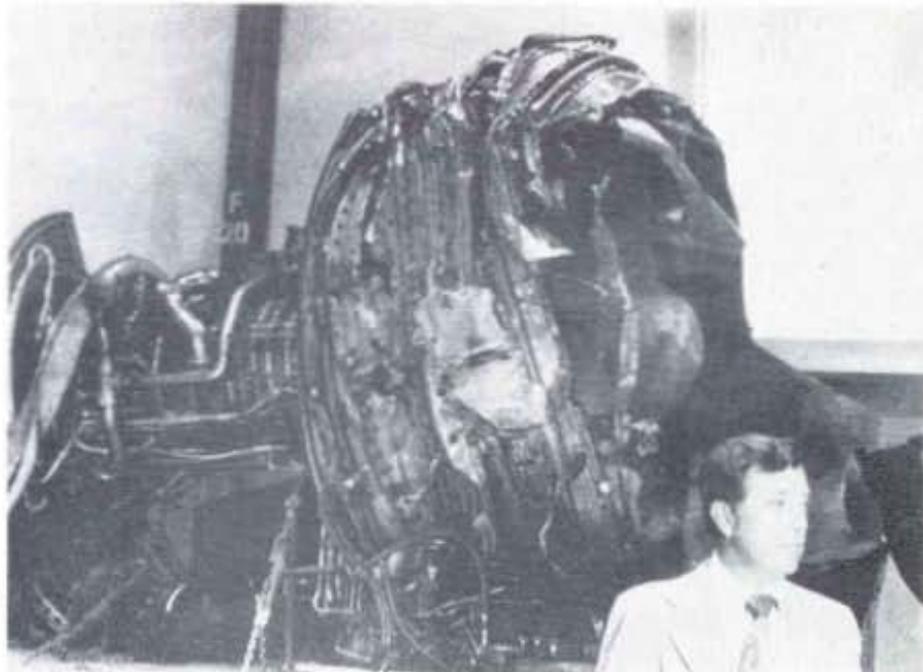
"While complying with the FAA's initial airworthiness directive requiring inspection of the engine pylon mounting structure of DC-10 aircraft, American Airlines found two aircraft in their fleet, N106AA and N119AA, with damage to the pylon aft bulkhead. The aft bulkhead is the structural element that contains the spherical bearing that carries the aft attachment of the pylon to a mating clevis on the wing structure. This fitting provides the major reaction to vertical and side loads imposed on the pylon.

### Physical Impact

"The damage observed on both N106AA and N119AA was a crack in the center of the horizontal upper flange directly beneath the attachment bearing. The crack on N106AA was reportedly 2 in. long and the crack on N119A was reportedly 5 in. long. When inspected visually, it was apparent that the crack on N106AA was caused by physical impact. Further investigation disclosed that this impact probably occurred when the pylon was installed during previous maintenance.

"American Airlines had begun a program last fall to comply with Douglas Aircraft Co. service bulletins 54-48 and 54-49 when the aircraft were undergoing periodic checks at their maintenance facility in Tulsa, Okla. This maintenance was performed on N106AA on Dec. 7, 1978, and on N119AA on Mar. 19, 1979."

The safety board recommendation to the FAA also said: "Compliance with these service bulletins requires that the pylon be lowered from the wing structure



General Electric CF6 engine from the American Airlines DC-10 Chicago crash is inspected at American Airlines' maintenance center in Tulsa, Okla. (Wide World)

for the installation of new bearings in the forward and aft bulkhead fittings. American Airlines procedures for removing and reinstalling the pylon consisted of lowering and raising the pylon with the engine still attached, by supporting the entire assembly by a forklift placed under the engine.

"Board personnel who observed this procedure noted that the forklift operator had limited control in the precise placement of the aft bulkhead fitting into the wing-mounted clevis during reinstallation of the pylon. Vertical misalignment of a fraction of an inch can result in the pylon aft bulkhead upper horizontal flange assembly striking the forward ear of the wing-mounted clevis, causing the flange to crack.

"The board believes that this occurred on both N106AA and N119AA. The installation geometry of the pylon aft bulkhead and the lower wing structure is such that an inspector cannot observe the

crack easily. Thus, any damage which has occurred as a result of the installation process procedure is likely to be undetected."

More specifically on the DC-10 accident, the safety board's recommendation to the FAA said: "While the investigation of the accident involving N110AA is continuing, preliminary evidence indicates that the forward flange on the No. 1 pylon aft bulkhead fitting had failed completely. Metallurgical examination disclosed that there was a preexisting crack about 10 in. long in the same area where cracks were evident on the other two aircraft. N110AA had been subjected to the engine removal and reinstallation procedure on Mar. 30, 1979. The aircraft had accrued 430 flight hours since that time."

Although the Douglas service bulletin specifies removal of the engine before reinstallation of the pylon to wing attachment fittings, the safety board is aware that

## DC-10's Previous Problems Detailed

McDonnell Douglas DC-10 that crashed in Chicago had experienced what the Federal Aviation Administration called seven "undesigned landings" in the past seven years as a result of various engine and hydraulic system problems.

The malfunctions were "not too unusual" for an aircraft that is flown at such a high daily rate, an FAA official said. In all cases, the aircraft was "easy to land," he added.

The problems were:

- Inoperative stick shaker and landing-edge flaps that would not move because of a malfunctioning computer in the autopilot.
- Broken hose in the No. 1 hydraulic system.
- Fire warning in the No. 3 engine because of a loosening of the compressor duct clamp on the pressure regulator valve that led to leaking of hot air.
- Top-of-the-scale temperature on the No. 2 engine caused by an unknown foreign object in the compressor.
- Flameout in the No. 3 engine because of a malfunctioning fuel control plunger.
- No. 3 engine fire warning caused by a broken cooling duct in the compressor.
- No. 2 engine fire because a clamp on the thrust reverser had moved.

## Groundings Rare in U. S. Air Transport History

Washington—Government agencies grounded two other commercial transports in the last 48 years before the Federal Aviation Administration last week suspended the McDonnell Douglas DC-10 from flight.

An FAA predecessor, the Aeronautics Branch, Dept. of Commerce, suspended the certificate of the Fokker F-10A, an aircraft that crashed in 1931, taking the life of Notre Dame football coach Knute Rockne.

Inspectors blamed moisture inside the wooden wing that caused the wing structure of the F-10A to separate.

The FAA suspended the certificates of the Lockheed Constellation from July 11 to Aug. 23, 1946, while the Constellations were examined for the cause of engine fires, later to be blamed on problems in the induction and exhaust systems.

Operators took voluntary action and grounded at least two other commercial aircraft, the Douglas DC-6 in 1946 for engine fires and the Martin 202 in 1948 for a wing separation problem, the FAA said.

The Lockheed Electra 188 was not grounded, but the FAA imposed operational limits on speed and altitude and required a thorough examination of the wing boxes that put the aircraft out of service for an extended period, FAA said. The cause of the wing problem was later ascribed to a "whirl mode," the effect on the base wing structure brought about by the turning of the propeller.

several operators are using the same procedure as American Airlines.

In the June 4 recommendation, the NTSB asked the FAA to issue a telegraphic airworthiness directive requiring an immediate inspection of all DC-10 aircraft in which an engine pylon assembly has been removed and reinstalled during the recent inspections and another recommendation that the practice of lowering the pylon with the engine attached be discontinued by the DC-10 operators.

### 'Gratuitous and Unnecessary'

In response to the claims by McDonnell Douglas that airlines are using maintenance procedures not authorized by the manufacturer, which also could be applicable to the safety board's claims that American Airlines did not follow McDonnell Douglas service bulletins, American said last week that McDonnell Douglas charges were "gratuitous and unnecessary."

Donald J. Lloyd-Jones, American's senior vice president for operations, said engine and pylon installations are performed by other U. S. airlines in the same manner followed by American. He added that two representatives of the McDonnell Douglas product support department were present when American changed its first DC-10 pylon on Apr. 17, 1977, in Los Angeles and at another change 10 days later.

"McDonnell Douglas representatives have been present on subsequent occasions when pylon changes have been made," Lloyd-Jones said. "Our people are skilled in the procedure, and we have no reason at all to believe that it is in any way responsible for the defects that our rigorous inspections have uncovered.

"We are perplexed and disturbed that McDonnell Douglas has taken aim at an industry procedure that it has been aware of, has participated in and never objected to."

Following the June 4 safety board recommendation, the FAA on the morning of June 5 issued its second supplement to its original airworthiness directive. The supplementary directive said:

"Reports have been received that some DC-10 operators have removed and reinstalled engines and pylons as an assembly. It has been observed that in reinstallation of the pylon assembly, the aft bulkhead forward flange can be damaged by impact with the pylon aft support fitting."

The supplement was directed at those operators who had used the pylon and engine assembly procedure, and required they perform a new inspection of the pylon aft bulkhead and reinstall the pylon and engine separately prior to further revenue flight. The directive was believed by FAA to be applicable to six DC-10s, four of U. S. registry and two foreign registered.

Early last week, the FAA was receiving the tally of the problems found on U. S. registered DC-10s, required in its original directive and the supplementary directive. The total was 59 items that were applicable to the general area of the pylon-to-wing attachment. These items included:

- Loose bolt web structure—18 items.
- Thrust link bushings—8.
- Monoball bolt loose—5.
- Monoball cracked—5.
- Huck bolt sheared—4.
- Rear mount cracks—3.
- Cracked pylon structure—3.

The next event in the forthcoming grounding of the DC-10s occurred on June 5 when the legal counsel of the Airline Passengers Assn. filed for a temporary restraining order against the FAA in the U. S. District Court for the District of Columbia. The judge issued the temporary restraining order at 4:45 p. m., and at approximately 9:00 p. m. on June 5, he issued a stay on the order until the next morning so that FAA counsel could gather its evidence to present to the court to stop the order.

According to one FAA official, between 9 and 11 p. m. on June 5, American Airlines found two cracks in two pylons' aft bulkhead forward flanges by using a dye penetrant test in the 100-hr. check required by the earlier FAA directives.

"What scared us was that these two aircraft did not come under the final supplementary directive covering those aircraft that had their pylons and engines removed as one unit during earlier inspections," he said. "This would lead us to believe that unless they were missed in the earlier inspections, they are new cracks, and the maintenance procedure reason for the cracks will not hold up."

In the emergency order of suspension, the FAA said:

"Moreover, the preliminary findings of an FAA post audit of the model DC-10 aircraft type certification data indicate that the wing pylon assembly may not comply with the type certification basis set forth in FAR 25.571."

"What that means," the FAA official said, is that in the original certification data, the "pylon's aft bulkhead forward flange was not considered to be a problem area, so that it either was not included in the fail safe analysis or we do not have enough data on the original analysis."

It was this realization plus the two cracks that prompted FAA's Bond to ground the DC-10s and return from a London meeting on June 6 for a press conference the same day.

The FAA's dilemma and Bond's is that if the cracks found in the American Airline's DC-10s are new since the last inspection, there could ensue a long process of design change and fail safe analysis. If it is discovered that possibly the cracks had been in the pylon during the earlier visual inspections and not caught until the more thorough dye penetrant inspection, the FAA's solution could be faster and limited to fewer aircraft.

### Length of Grounding

During his press conference, Bond could not be pinned down by repeated questions directed at how long the grounding was to last. Also, in response to questions regarding the court's temporary restraining order, which was finally imposed against the FAA and the DC-10 on June 6, Bond said that the agency's grounding was independent of the court's actions.

The Airline Passengers Assn. counsel disagreed, saying: "We do not think that the FAA would have grounded the DC-10 if it had not been for the temporary restraining order."

Concerning the other wide-body transport aircraft, the FAA is forming a special certification review team that will evaluate the wide-body manufacturers' and operators' compliance with all applicable directives on the engine-to-pylon-to-wing attachments. The agency also is drafting directives that would require inspection of the other wide-body pylons.