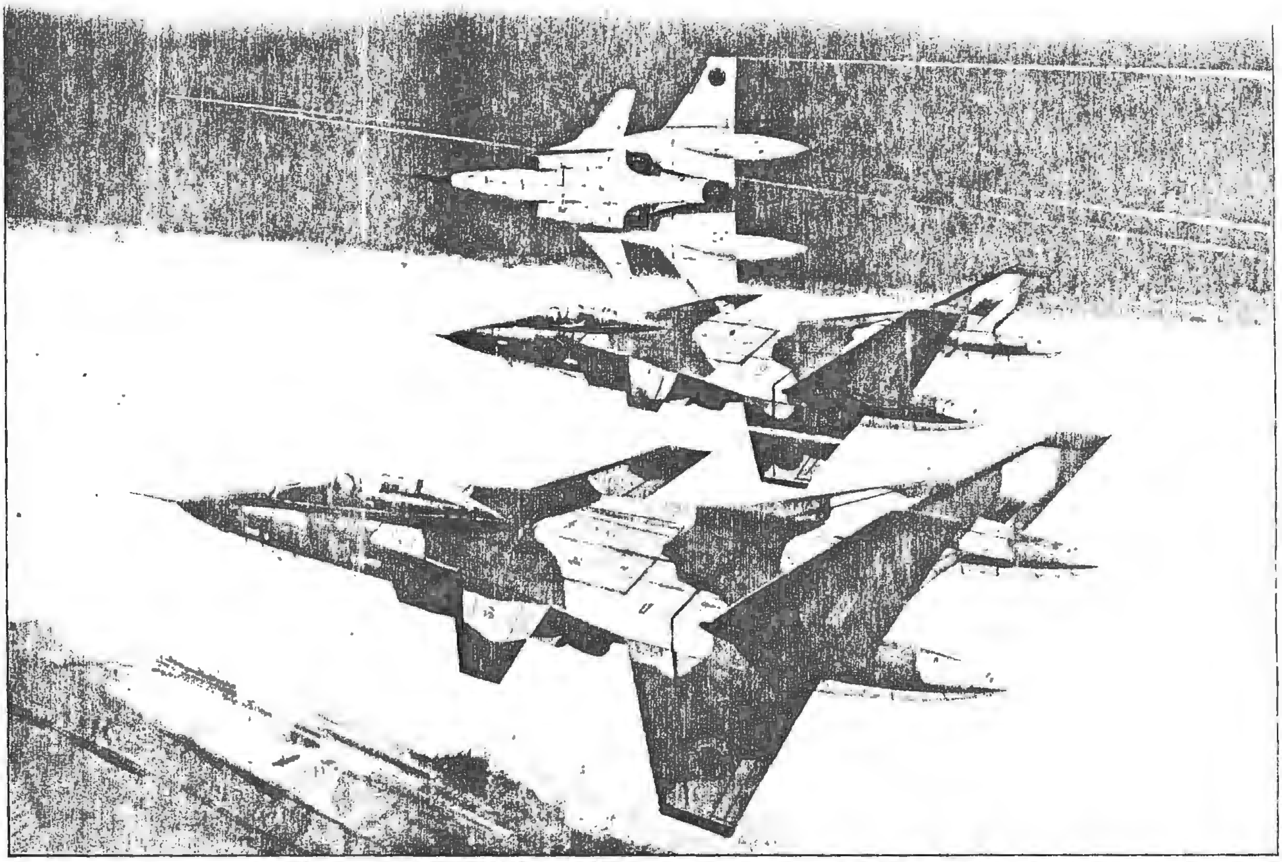


Advanced Stovl: who buys wins

Vectored thrust has always been a controversial issue. Industry is now looking ahead to Advanced, or supersonic Stovl. Will the UK and US Defence Ministries want it? **Karen Walker** reports.

Three Royal Navy Sea Harriers line up to complete their display at an air show. Noses pointed towards the crowd, they hover and perform the Harrier's party-piece, a deep bow. "That's wonderful—very British," comments a spectator.

The Pegasus engine continues to make the Harrier a natural show-stealer, one that is still seen as a British triumph. But, as with most glamorous entities, Stovl (short take-off and vertical landing) power is an evocative subject. It has ardent supporters and detractors, both in the Industry and in the military. Against this background, Advanced Stovl will be born.

The controversy is bound to continue, but it appears that support for a new-generation AStovl aircraft might be stronger on the US side of the Atlantic. Britain and America may be working together now towards a collaborative development of an aircraft, but will the drive—and the investment—remain equally shared?

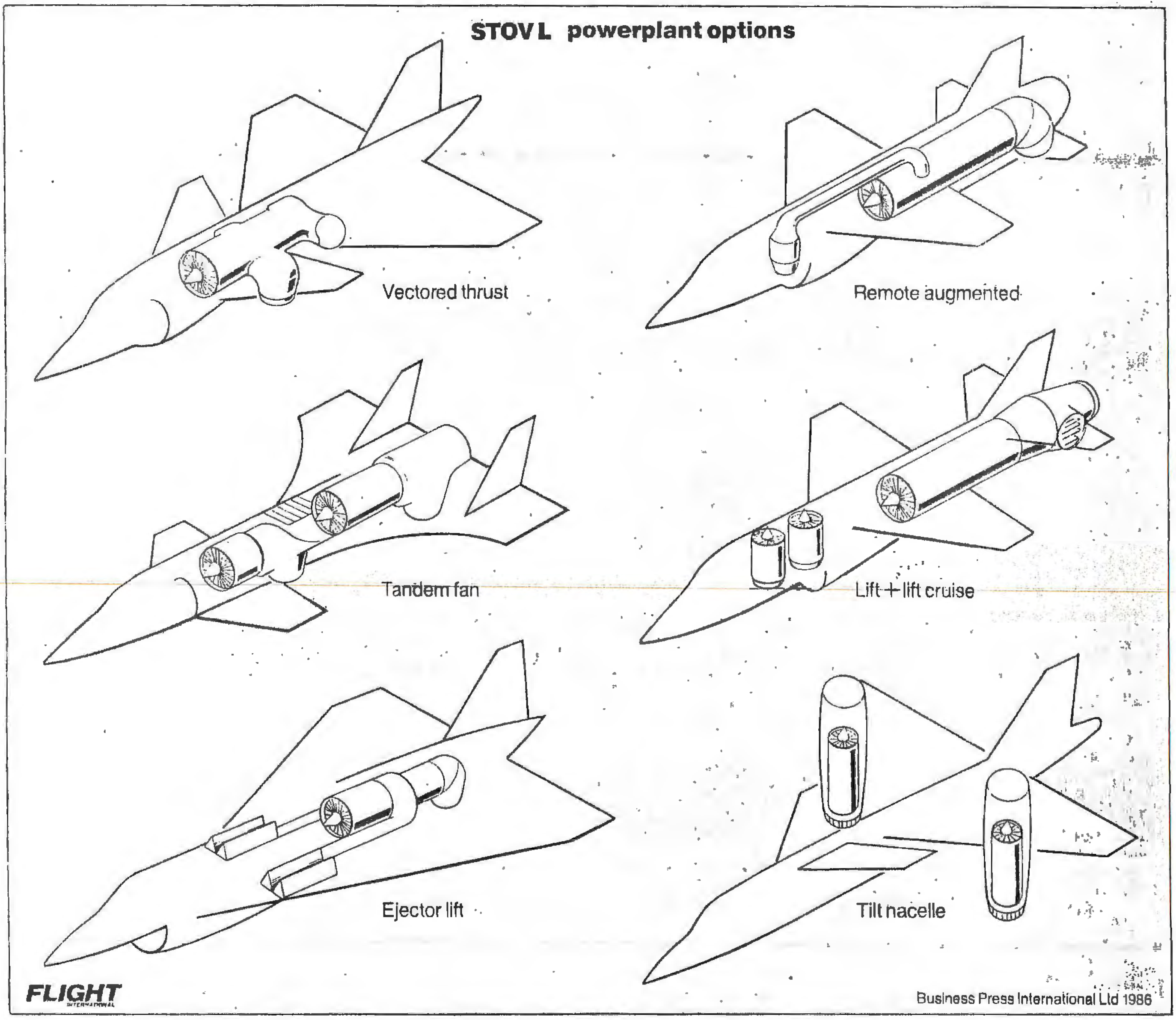
The UK and United States are both studying new concepts in propulsion for an AStovl aircraft. In 1983 Nasa and the UK Ministry of Defence held a joint symposium to raise the issue of AStovl. They were able to identify four main types of propulsion systems worthy of further investigation, and agreed to conduct their own, separate studies to assess each system's potential fully.

Those four systems are: vectored thrust with plenum chamber burning (PCB), ejector augmented lift, remote augmented lift system (Rals), and tandem fan. The study phase, funded by Nasa and the MoD and conducted by industry, will continue until the end of 1987. It should result in the selection of one or two systems with the most potential. The study results will then be analysed by Nasa and MoD for them to form their own conclusions. But as Rolls-Royce, one of the industries involved, admits: "There are no guarantees of what will happen at the end of the study phase. In the history of Stovl there has been lots of abortive work—especially in the USA".

Above *Front nozzle combustion applied to a Pegasus-type vectored-thrust engine is the most mature of the four Advanced Stovl concepts*

Enthusiasm from the United States, however, is marked, compared with Britain's cool and cautious attitude. This would not worry British industry too much so long as it ensures its own involvement in any resulting programmes—and a contract for the US Services alone would be lucrative by any standards.

The US Marine Corps is one of Stovl's loyal supporters. The story is still recounted of how, at a Farnborough Show, the doorman at the Rolls-Royce chalet walked in and said: "There are some Marines outside. They say they want to buy some Harriers". And so a deal was struck. The tale may have simplified with the passing of years, but it illustrates the Marine Corps' unique position in the US Services—comparatively small, but highly regarded and with a reputation for doing its own thing.



Advanced Stovl powerplant options

Stovl, therefore, established a foothold in the United States via the Marines. But AStovl might attract even bigger prizes. "With all respect to the Marine Corps, we would like to go further," says Rolls-Royce. "For instance, if we won a contract with the US Navy we would be talking in terms of hundreds of aircraft, rather than the Royal Air Force's tens."

Exactly what type of aircraft might develop from the propulsion studies is undefined. Any such aircraft would not enter service before the year 2000, and it is considered too early in the day to talk airframe types. But it would be a single-engined fighter/attack aircraft in the 35,000-40,000lb-thrust range that would, presumably, incorporate stealth characteristics.

Of the four Stovl concepts, PCB is the most mature, and could be regarded as a supersonic son of Pegasus. Fuel is burned in the plenum chamber, supplying engine bypass air to the front nozzles of a Pegasus-type turbofan. A 100 per cent thrust increase can be achieved for vertical take-off and landing, and supersonic speed. Augmentation is available at all nozzle angles, giving good short take-off performance.

But the PCB system has its drawbacks. It requires hot air to wash over the airframe and weapons from the nozzles, and there is a danger of engine performance being affected if the hot air from the front nozzles enters the engine intake. The system is also noisy.

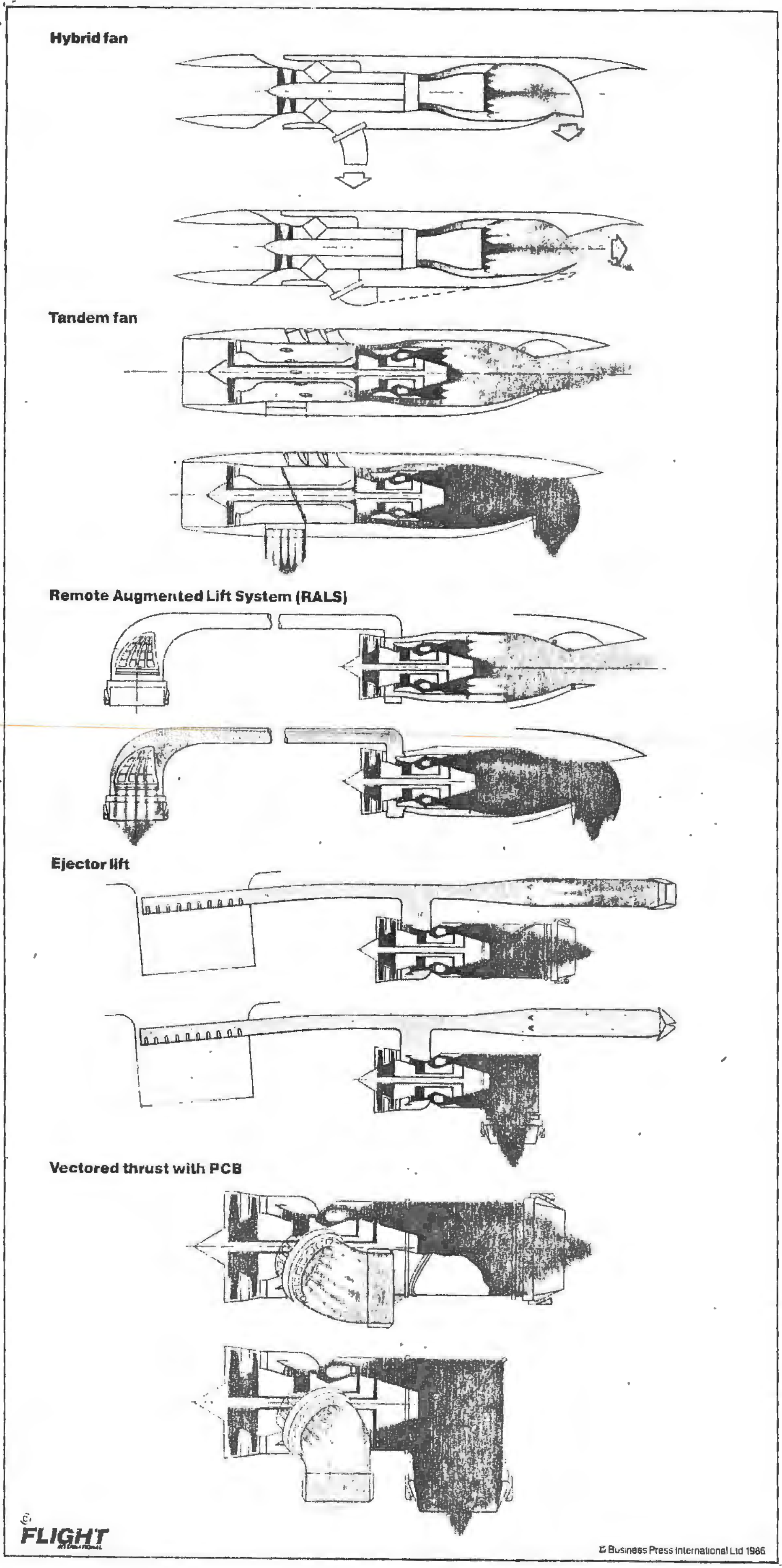
With a Rals engine bypass air is ducted forward through the fuselage to a remote combustion system, and is exhausted downwards to provide lift thrust and a means of balancing deflected core-engine thrust. In wingborne flight bypass air is ducted aft to a separate nozzle and reheated for supersonic flight, or mixed with core engine airflow and then burned. Ducts are incorporated in the Rals design to allow air to be moved in opposing directions through the fuselage.

In the ejector lift system bypass air is ducted to chordwise vertical ducts in the wing roots and exhausted through multiple nozzles. This entrains a large volume of ambient air to produce a larger, slower-moving air mass through the duct, increasing lift thrust. Up to 70 per cent augmentation is possible without recourse to reheating the bypass air, and exhaust temperatures are therefore low.

Ejector lift has the advantage of being able to employ a conventional engine design, but again there are drawbacks. Ejectors are susceptible to damage, and also use up valuable wing space, reducing the amount of armaments that can be carried.

In the tandem-fan concept the core engine drives two widely separated fan stages via a single shaft. In the transfer duct between the front and rear fan stages there is a shut-off valve, a dorsal auxiliary air inlet, and a ventral exhaust nozzle.

In wingborne flight the tandem-fan engine behaves like a conventional low-bypass afterburning turbofan. In jetborne



The four main types of Advanced Stovl will be studied on both sides of the Atlantic

flight the transfer duct cut-off valve is closed, diverting front fan flow downwards through the ventral burner nozzle. At the same time, the dorsal auxiliary inlet opens to supply air to the aft fan and core engine, to be exhausted through a vectoring nozzle at the rear. With this concept, the air available to the tandem-fan engine in jetborne flight is increased by up to 60 per cent, lowering exhaust temperatures for a given thrust.

The hybrid-fan vectored thrust concept differs in that front fan flow is diverted to Pegasus-type front nozzles, which can then be augmented, PCB-style. This variation improves the short-take-off performance of the tandem fan. While tandem fan is a complex system, it does have the advantage of a variably cycled engine which can be readily optimised for supersonic flight. Other advantages are low jet temperatures at take-off and landing, low fuel consumption at low aircraft speed, and high thrust per unit of frontal area in high speed flight.

Studies of these four concepts will take place completely independently on each side of the Atlantic, with Rolls-Royce, General Electric, and Pratt & Whitney each conducting their own investigations.

Pratt & Whitney has been awarded a three-year, $9·4 million study contract by Nasa for its research. The company's ground-based study is initially evaluating the integration of an advanced derivative of the PW5000 engine.

General Electric, meanwhile, is working under a four-year, $6·6 million contract to define and modify an F110 Stovl engine. General Electric's contract is not yet a direct part of the UK/US AStovl programme, but elements of GE's research is expected to be gleaned to become part of the common technology effort later on. The GE contract is for an engine that will be used to study the ejector/augmenter and remote augmented lift systems for supersonic Stovl. Testing of GE's engine is due to start in 1988.

Rolls-Royce is convinced that time is no problem in developing AStovl. "If we had to do, we could do it in considerably less time than we have been given," points out a project manager. We could do something by the mid-1990s if necessary."

The pacing factor will be money, and the commitment of the UK and US Defence Ministries to AStovl. Nasa and UK MoD officials will meet regularly over the next few years to assess the progress of AStovl development, streamlining the choices and then deciding whether or not to give it a full-scale go-ahead.

Rolls-Royce is wary of admitting that either side is showing more interest at the moment—in fact, it admits that there is no official interest from either Defence Ministry. "But there is a lot of interest being shown by the research and development people," Rolls-Royce points out. "They are in the same quandary as industry at the moment, wondering what is going to happen. But it has to be remembered that, from the first meeting between Nasa and the UK MoD to the time that the first answers appear on paper, it will be five years. We cannot allow the world to go by for five years and not have something to show for it." ◘