

**WORKING TOGETHER - INTERNATIONAL AERO ENGINES' V2500 PROGRAM**

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Only a handful of figures can truly be said to have shaped the history of aerospace. Theodore Von Kármán falls into this category. He was a man whose pioneering work with high speed aerodynamics charted the path to supersonic flight and whose influence has been truly global.

In the slipstream of those achievements International Aero Engines is proud to be the eighth recipient of the Von Kármán Award from the International Council of the Aeronautical Sciences.

In qualifying for this award, IAE has, in the words of the citation, "demonstrated exceptional achievements in international cooperation in the field of aeronautics." Those of you familiar with the pressures that a multinational consortium can generate may feel the ability to survive is itself deserving of recognition!

I would like to talk to you today about who IAE is, where we have come from, and most importantly for now, the lessons we have learned along the way that might help others.

IAE - The Reason Why

In the early 1980s our partners independently identified an opportunity in a large market sector which was supplied by a single, unchallenged manufacturer.

They also identified that the cost of developing a new engine for this purpose was prohibitive for any single company and felt it desirable to pool their resources to fund the "entry fee."

On the market side, the civil aviation scene was becoming more global in nature and to market products successfully, international alliances were

being considered the tool to break into those markets.

In addition, world recessionary cycles mean that aviation products, with life cycles of over 20 years, are prone to at least two periods of recession per product cycle. This plays havoc with our ability to do business planning. By entering into a collaboration IAE's shareholders felt able to spread this risk.

For all these reasons, these various companies decided to join together to develop the V2500.

Strong Partners

Thus, on March 1, 1983 a grouping of some of the world's leading aerospace companies from three continents signed an agreement unique in aviation history. The size and strength of the Corporations behind IAE today are enormous.

<u>IAE Partner</u>	<u>Parent Corporation(s)</u>	<u>Total Assets</u>
Pratt & Whitney	United Technologies	} \$107.7 Billion (1994)
Rolls-Royce	Rolls-Royce plc	
MTU	Daimler Benz	
Japan Aero Engines Corp.	IHI	
	MHI	
	KHI	

I should add that FIAT (of Italy) was a founding shareholder in 1983, but have recently become a major subcontractor, still producing the engine's gearbox.

Although other aerospace projects had involved international partnerships, this was the first time that an aero engine collaboration had been established which was genuinely worldwide, and

the first time that such a venture in the civil sector had involved partners that, in other market segments, were competitors. Nothing as broad as this had ever been attempted in our industry. The engine name was derived from the Roman "V" signifying the five original partners, and the digits "25" were chosen to represent the initial engine thrust of 25,000 pounds.

Headquarters for IAE were established in Connecticut, and from there the V2500 turbofan, designed to power the world's 120-180 seat aircraft, was launched on New Year's Day 1984.

### Sharing Strengths

IAE's task was to combine the leading technology of America, Europe and Asia to produce the most technically advanced family of new commercial aero engines in the world. They would be more efficient, more economic, quieter and cleaner than anything before.

The V2500 design drew on the best aspects of our partner company programs including Rolls-Royce's RB211-535E4 and Tay, and Pratt and Whitney's PW2037 and PW4000.

Each of the original five shareholder companies was given the task of developing and delivering one of the five engine modules.

JAEC was responsible for the fan and low pressure compressor; Rolls-Royce the high pressure compressor; Pratt and Whitney the combustor and HP turbine; MTU the LP turbine and FiatAvio the gearbox.

Final assembly takes place at Rolls-Royce in Derby and Pratt and Whitney in East Hartford.

The V2500 scored a number of "firsts" in advanced technology features for an engine in its thrust class. These included the first use of the wide-chord fan blade, three-dimensional airfoil designs, the "floatwall" combustor, single crystal turbine blades, powder metallurgy disks and a Full Authority Digital Engine Control.

These technologies have now become the standard for aero engine design, but the V2500 was the first time all these technologies came together in one product. The engine was thus designed for the highest efficiency, with the highest technology - something that doesn't necessarily happen today.

First engine run came in December 1985 and was followed by a comprehensive program of development testing in five countries. In May 1988 the V2500 made its first flight on a B720 flying test bed and the V2500-A1, rated at 25,000 lb. take-off thrust, was awarded certification on June 24, 1988.

The engine made its first flight on the A320 the following month, and after an Airbus test program of 319 flights totaling 637 hours, revenue service began in May 1989.

Today there are eight variants of the V2500 with thrusts from 22,000 lb. to 33,000 lb. providing power for the Airbus Industrie A319, A320 and A321 family and the McDonnell Douglas MD-90.

Adjusting the data entry plug to set thrust levels is the only change needed on mechanically identical V2500s across the Airbus single-aisle range.

These variants have identical turbomachinery and differ only in their externals and mounting system. The -A5 is designed for under wing mounting on the Airbus A320 family; the -D5 for fuselage side mounting on the MD-90. In fact, it is the only modern, high bypass, side mounted engine available today.

We are now developing our highest thrust engine yet, the V2533, at 33,000 lb. thrust, for service entry next year.

V2500 engines have flown over three million hours and the order book, for more than 1,600 engines, stands in excess of \$10 billion.

IAE's customer base has grown steadily and is still expanding. The V2500 has been chosen by some 60 operators around the world from major airlines to lease companies.

### Quiet and Clean

By design, the V2500 set out to address the two main areas of environmental concern - noise and chemical emissions. It was the only new civil engine of its generation freshly designed and developed to maximize these goals.

Gaseous emissions are distributed around the world wherever aircraft fly. They are difficult to measure accurately, long lasting, accumulate in the atmosphere - and are largely invisible.

Noise, on the other hand, is extremely obvious, localized, and easily measured. It dissipates quickly but is a highly identifiable nuisance to airport communities in particular.

The V2500 design team concentrated on absorbing noise before it reaches the outside environment. The engine has noise absorbent linings and a full-length nacelle. Mixing the slow moving air from the bypass with the high speed jet from the core using confluent nozzles has reduced jet noise dramatically, lowering levels well ahead of any legislative requirements, current or envisaged. The V2500 on the MD-90 surpasses cumulative Stage 3 noise limits by at least 25 dB, making that airliner the quietest in the world in its class.

As regards chemical emissions, our mission is simply to achieve the lowest possible overall level. A concentration on NOx limitation, for instance, ignores the fact that pushing down levels in one area of emissions produces penalties elsewhere. The V2500 combustor technology targets a balanced approach which today sees the engine's NOx level 50% below legislative requirements with further reduction possible.

At the same time, levels of remaining pollutants such as water vapor, carbon dioxide and carbon monoxide, remain suppressed, producing an overall "green" result which means we meet our goal for the V2500 as cleanest in its class.

#### Today's Market For New Commercial Aero Engines

A cautious optimism has been around for some time in our industry, but I believe we are all now buoyant on the rising tide. Large leasing company orders like the ones by ILFC and GECAS act as our barometer readings.

V2500 sales last year were a record \$1.5 billion. We have set ourselves what I believe is a realistic target of matching or exceeding that in 1996.

A forecast published by the FAA predicts worldwide air travel will more than double over the next 20 years, increasing at an annual rate of 5.7%. Airlines will have to double the size of their existing fleets, buying 15,000 to 17,000 new aircraft to accommodate the expected volume of passengers and cargo by the end of the year 2016.

Boeing predicts 15,900 new airplanes worth \$1.1 trillion. About 75% of these aircraft are for growth and 25% for replacement. But in the V2500 market the impending transition to Stage 3 (or more) noise regulations means additional replacement market, perhaps including re-engining.

Of particular concern in Europe is the drive towards further environmental controls, if not by consensus regulation then by individual environmental taxes. The V2500, being designed from the outset as the cleanest and quietest in its class, is well appreciated by our European customers as it protects them against future regulation.

However, market needs, be they driven by growth, replacement or environmental concerns, are one thing. It is another for the customers to be able to afford this \$1.1 trillion of new equipment.

In fact, there is a perception that a new airliner is simply too expensive for what it is able to deliver. Bob Crandall's quote that unless the world changed, American Airlines would never buy another airplane summed up the mood.

The recognition of this situation has led all the leading manufacturers to target aggressive productivity improvements. Most manufacturers (airframe and engine) are targeting cost reductions of at least 25% over the next four to five years. This is necessary to achieve a better balance between market price and cost, and is creating a climate where available technologies may not be pursued in new products due to the accent on cost and value.

As a result of all these forces shaping our future, we may presume that consolidation or collaboration will be a way of life for most of our industry. Let us help those considering this path by exploring some of the lessons IAE has learned in our 12 years of global collaboration.

#### Lessons Learned

Two years ago 400 CEO's and senior executives gathered at a Conference Board forum in New York. The forum was called "Making International Strategic Alliances Work." It produced two very interesting findings:

1. 70% of business alliances terminate within 7 years. (Of these, three quarters are purchased by one of the parties.)

2. Most CEOs agreed that taking global partners from multiple countries into a consortium arrangement is extremely difficult to achieve successfully under the best of conditions.

How has IAE achieved what has eluded so many others - a successful multinational alliance?

Let us measure our strategy and positioning against the six criteria developed at that same forum.

Criteria 1) Start with a solid business opportunity:

IAE saw a clear opening for this size of engine against a single competitor in a growing market for short to medium haul aircraft. The business opportunity was, and still is, clear.

Criteria 2) Partners should make comparable contributions to the new enterprise:

Although the percentage shareholdings varied, all partners were comfortable with their commitments and each had important technical contributions to make. The partnership identified core competencies and played to the strengths of its team members.

Now, I have to say there is a good case to be made for one shareholder taking overall leadership and thus avoiding "consensus decision making." IAE chose not to do this for pragmatic reasons, in that our two major shareholders still competed in other markets. Instead IAE was set up to represent the interests of all shareholders; and in doing so maintain the involvement of all shareholders in this program. Incidentally, CFMI also have an "equal shareholding" partnership, and like IAE, that seems to work well.

Criteria 3) The new enterprise should have a well defined scope and no major conflicts among the partners:

The scope for the V2500 was very clearly defined to avoid competition with existing partner company engines, although changes in the market place over the years have meant both the collaboration, and its partners, have had to employ flexibility in that definition. Although Pratt and Whitney and Rolls-Royce still compete head to head at many points in the market there is a mutual benefit in the V2500 arrangement where

there was, and continues to be, no competition between the two.

Criteria 4) Trust is the single most important ingredient of a joint venture:

I would tell you from my extensive personal experience that this is the most important message I can give you today. And it's not an easy one to enact. In our case, although IAE was in itself a new concept, the partners were not strangers to each other. Mutual trust - or a potential lack of it - was not an issue, nor has it been as we have changed management personnel in the partnership over the years. Unless you have trust between partners, your collaboration will fail.

Criteria 5) An autonomous operating team should be formed:

This, of course, was the genesis of the IAE team, and it proved a powerful stimulant. Management needs to be free to develop its own entrepreneurial spirit. IAE created dedicated teams including sales and marketing and product support operating from its own headquarters. These teams are made up of people from the shareholders, but once they came together old enemies became instant colleagues in support of the V2500, and unleashed a whole new creative energy that had been dormant in their old jobs.

Criteria 6) Responsibility for joint ventures cannot be delegated. It must include the CEO's or board level individuals from the partner companies who can make decisions:

This is my second most important lesson to teach you. The IAE board is drawn from senior executives of the partner companies and has complete decision-making powers. IAE's President and CEO has control of day to day running of the business, reporting to the board. The board members must also employ Criteria 4 amongst themselves, and in our case, they do.

### Conclusion

The world of aviation is constantly changing and only those who can adapt will survive. IAE has matured from an ambitious young collaboration in the mid 1980s to the substantive supplier of engines to the world's airlines that it is today.

Along the way we became significantly more focused on our customers' requirements than we were a decade ago, and this must be the key to any successful business, collaborative or otherwise.

In the Von Kármán tradition, the V2500 team's international vision and energy will continue to reap the rewards of successfully "Working Together."