NEW REVELATIONS, ACHIEVEMENT AND INNOVATIONS

SUMMARY

The first 50 years of the Bristol Aeroplane Company have been well recorded by John Burleigh.

Here some comparable history of the second fifty years of design and manufacture is recorded, based on my Australian lecture given to celebrate BAC100. It reveals many things not generally known: in particular how the Aircraft Company was saved from bankruptcy in the 1960s, the origin of a World Changing technology at Bristol, and measures to free British manufacturing industry from Third World price competition.

The exhibitions at the new Bristol Aerospace Centre must adequately reflect these innovations and their legacy.

David Farrar
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THE SECOND FIFTY YEARS OF DESIGN AND MANUFACTURE AT BRISTOL AIRCRAFT

THE 1950 SITUATION

The Bristol Aircraft company was engaged on the Bristol Freighter design and manufacture, which would keep the company solvent for years ahead, and the Brabazon non stop transatlantic civil aircraft. Transatlantic range was achieved by two innovations:

1. Advanced structural design methods which I devised in collaboration with the Royal Aeronautical Society staff. Considerable weight saving was based on simultaneous structural failure under load in all possible modes.

2. Active gust relief by power controlled aileron movement, as used today on one airliner. At the time it was opposed by R.A.E. Farnborough.

The aircraft company had also commenced a guided weapons project, in collaboration with Ferranti Ltd., to defend the British nuclear deterrent. It was top Priority nationally.

Helicopters, Bristol Cars and plastics fabrication were also under development, making Bristol the largest aircraft site in the U.K.

THE BRABAZON AIRCRAFT

The aircraft was getting into fatigue problems; as I had predicted the steel tube joining engine pairs cracked early in its life. Anti-vibration mounts were introduced to ease this problem. However, repeated gust loads were likely to limit the life of much of the structure. These problems would equally affect the turboprop powered Brabazon 2, and the project was cancelled.

Piston engine aircraft were becoming more efficient and would soon cross the Atlantic with only a single stop.

Achievement 1 - The Correct Siting of Engines on Civil Aircraft

The policy of the British Government at the time was to bury aircraft engines in the wing.

Farnborough aerodynamicists thought a long range aircraft in cruise should only have exposed fuselage, wings, tail surfaces and nothing else, to achieve minimum drag. (Their TUNNEL VISION ignored favourable aerodynamic interference possibilities and the need for thin wings at high cruising speed, as well as practical considerations such as engine servicing. GROUP PSYCHOLOGY made them influential and single minded.)

Thus Britain lost the emerging jet transport aircraft market. Britain did, however, have a role in putting the engines in the right place.

In the late 1940s I was responsible for the structure of Britain's biggest landplane, the Brabazon - aimed at crossing the Atlantic non-stop instead of the two or three stops then needed. It had a huge wingspan and the tip could easily be moved up and down at about one cycle per second. There had to be concern that wing flutter would not destroy the aircraft, so its modes of vibration had to be known.

To support the complex calculations I devised a vibration model with the right stiffness and mass distribution, whose vibration modes could be measured by light reflections from small mirrors. The laboratory had to be dark and was known as the ‘Marriage Agency’ - with good cause!

I showed what we were doing to The Chief Designer of Boeing, George Schairer, who visited Bristol. When he got home he took the idea much further. First he encased the device in the right aircraft shape. He then wind-tunnel tested it to find out directly whether it would fail by ‘flutter’. Finally, he tried various places to put the engines, ending up in front of and below the wing, which could then be full of fuel.

The rest is history.

THE BRISTOL BRITANNIA

Bristol won the contract for a small medium rang aircraft for BOAC but were aware it was the wrong aircraft; the airline took time to realize that they really needed a longer range and faster aircraft. Eventually a longer range turbojet powered aircraft was authorized. After some manufacture it became possible to develop a version which could cross the Atlantic non stop.

Its design is now acknowledged as the definitive turboprop aircraft, but the delays and accidents severely compromised its sales bringing the aircraft division to the point of bankruptcy.

THE BEGINNING OF GUIDED WEAPONS

There were formidable skills needs in this new field. They included transonic and supersonic aerodynamics, hot structures, guidance and control, radars and systems noise - to name only a few.

UK had little or no background in such fields, but the Farnborough librarian Mr. Root had good access to American data which he analysed and made available.

Achievement 2 - Giving Staff the Skills the Project Needs

I arranged for all my GW staff to have a yearly interview to ascertain their skills needs, with action taken to ensure they acquired them.

Many of them attribute their brilliant later careers to this innovation.

Achievement 3 - Faster Development Through Mutual Criticism

A further factor was constructive mutual criticism by the two industrial teams. This was identified by a Government working party as a prime reason that Bloodhound 1 went into service before its competitors, thus achieving a foreign sales order just in time to prevent Bristol Aircraft becoming bankrupt.

BRITISH AIRCRAFT CORPORATION POLITICS

In pre-merger discussions English Electric aimed to acquire all guided weapons interests. Neither the Vickers nor the Bristol Aircraft board were in a strong position on aircraft and readily went along with this policy.

Government working parties disagreed with it; weapon sales made the Bristol-Ferranti collaboration Britain's largest and most successful weapons team and Government working parties said they should continue. Despite this, corporation politics overrode; years later Sir George Edwards apologised to the writer for this.

The subsequent history of guided weapons was written to please English Electric, and therefore omitted many important Bristol achievements.

Just before government initiated further mergers, George Jefferson was forced from the main Board for breaking his promises to Government, and Sir Arnold Hall re-authorized guided weapons engineering at Bristol.

Much of the guided weapons history at Bristol went unrecorded during this period, but is now made available to the Bristol Aerospace Centre.

Achievement 4 - Saving the Bristol Aircraft Corporation from Bankruptcy

For more than fifty years it has been a closely kept commercial secret that in the late 1950s Bristol Aircraft Ltd. would have been legally bankrupt but for one thing. Without that, there would have been multiple redundancies, and in the prevailing climate the company might not have survived afterwards. The *one thing* was the Swedish Bloodhound contract.

The Company did survive, and was able later to join the British Aircraft Corporation as a junior partner. It would not have been able to do so but for one thing which was to able to retain, as profit, the large outcome of Bloodhound 1 and 2 manufacture for several customers.

With the passage of time these matters can now be disclosed, which, as the only surviving Director of Bristol Aircraft, I have now included in the BAC 100 website as: "Now It Can Be Told." It is the story of Bristol Aircraft and Bristol Guided Weapons; without the other, neither would have survived the 1950s.

I was to be the founder and leader of Bristol Guided Weapons.

Achievement 5 – Last and First

It was to prove critical to Bristol survival that the Bloodhound, despite all expectations and started last, should be the first into service. We made it, just in time for the Swedes. As a neutral country, Sweden was self reliant on defence and had an excellent policy. Fighters could land on roads anywhere to hide in bomb hardened shelters. They had tried to develop a transportable missile defence system, but unsuccessfully.

Achievement 6 – Becoming Transportable

It took Greville Beale only a short time to make the rest of our system transportable to the Swedish requirements. With money in the bank, they negotiated with us and ordered a complete system including radars and first and second line support equipment and workshops. ‘Taffy’ Higginson negotiated a down payment so huge that Ferranti Wythenshawe worked on negative capital employed for years afterwards.

Recent research by Professor Keith Hayward has shown that de Havilland and Hawkers had no interest in Bristol other than the Concorde design team. Thus the factory would have closed with no production, and the G.W. team would have been unable to survive on its own against predatory takeover bids.

The official record of the Bristol situation at that time ignored Guided Weapons and stated:

> **"Sir Matthew Slattery Bristol Aircraft 23rd October 1959**
>
> - Have sold all but one of production Britannias, loss of £7-8 million.
> - Progress on SST studies and 188 research aircraft.
> - Hope to produce competitor to VC11 and 121, but need at least 50% from government."

Sandys had to be frank and was obliged to look unfavourably towards the Bristol solution. The likelihood of the company obtaining government money for the project was extremely remote. Slattery referred to HSG talks, but they felt there was no point in merging unless good reason, such as the SST contract. He admitted the aircraft group was virtually in liquidation. Sandys said he favoured the HSG merger, Bristol also wanted it, but doubted if the terms would be very favourable to his company.

English Electric saw the opportunity to eliminate a competitor by closing down Bristol GW including the Bloodhound along with its profits in their own Division together with other GW acquisitions. Despite its successes and its unique weapon systems capability the Bristol GW team had no new project and was vulnerable; attempts to eliminate it had previously been made.

At that time, English Electric's guided weapon team had commenced the development of a weapon with second generation continuous wave radar (CW) guidance.

Achievement 7 – Rapid Creation of Bloodhound 2

We, with Ferranti who had developed a CW ground radar, rapidly modified a Bloodhound 1 missile to CW guidance, and when launched it achieved a direct hit which destroyed the target aircraft. The other contractors had not reached this stage, so the longer range road and air transportable Bloodhound 2 was developed for the Royal Air Force, and bought by Sweden and Switzerland. Its advanced features were to give it a very long service life. Bristol with Ferranti became the largest and most successful guided weapons team in the country.

Achievement 8 – Joining British Aircraft Corporation

Bristol could not have joined British Aircraft Corporation without more money in the bank. Where it came from was another deeply kept secret. It did not come from aeroplane sales or Government contracts. During Bloodhound development Jack Jeffries, the Production Manager G.W., worked with the engineers to simplify the design and make it suitable for economic manufacture. He set up a production factory in Cardiff, trained new operators, and introduced new methods. When Ferranti were having trouble with output, he advised them and their costs reduced dramatically. At both factories, costs fell dramatically below those allowed by the British Government in setting prices.

At Ferranti this difference could not be concealed, leading to the Ferranti Affair. They were made to refund a large sum to the Government. For this reason Sir Reginald Verdon Smith arranged for the Bloodhound profits not to be visible in the accounts, and kept them outside the British Aircraft Corporation. In the British Aircraft Corporation merger negotiations Sir George Edwards also had a weak hand of cards, and was forced to give English Electric a free hand on guided weapons to maintain his own position. He later admitted this and apologised to the me for the effect of this on Bristol GW.

On the formation of the Corporation, Bristol Aircraft joined as a junior partner, with all guided weapon work assigned to English Electric. Corporation policy was then for the Bristol GW engineering team to be closed down, with only limited possibilities of employment for its large staff elsewhere in the Corporation.

Achievement 9 – Creation of the Guided Weapons Division

We refuse the deal - The Bristol GW team fiercely opposed this policy. I and leading engineers refused to be moved, and our reputation was such that a prolonged stalemate ensued during which the team, which had a good reputation with the Government and the R.A.F. based on its achievements, pursued further missile study and development contracts.

After several months James Harper, the Bristol Managing Director, who was terminally ill at the time, won the support of Sir George Edwards for creating a Guided Weapons Division, comprising the Stevenage and Bristol sites. It would have some Bristol based Directors, initially James Harper and myself. While the Bristol GW plant was to survive, for the Bristol Directors it did not work out; within two years they had gone.

GUIDED WEAPONS ACHIEVEMENTS.

Government recommended that adoption of the mutual criticism methods in Bloodhound 1 was not followed in industry. Indeed the project review by English Electric of the Rapier design study was described by the Ministry as a "hymn of praise" with the launcher electronics volume being underestimated by 100%.

Achievement 10 – Spending of Bloodhound Profits

The large profit from Bloodhound 1 and 2 manufacture had to be concealed for many years. It was eventually released and funded the development of the Corporation's first aircraft, the BAC 111.

FURTHER MISTAKES BY GOVERNMENT

Today, project review procedures are even less effective, often being undertaken by management graduates who cannot read drawings. Little or nothing has been done about this.

Achievement 11 – Origins of the Rapier Missile

The Bristol team had previously studied the short range air defence options for the German Government, and had recommended a system similar to Rapier. If the French had played ball this could have become the European system, vastly superior and cheaper than the American one they purchased. Corporation politics withheld this information from the British Government when Rapier design studies were commenced.

Achievement 12 – On Time, On Cost

The improvement of methods of project design and development continued at Bristol, particularly in the fields of project review and methods of design for economic manufacture. As a direct result the development of the Bloodhound 2 was achieved **on programme and on cost.** This achievement was repeated on two Space projects which followed.

The British Ministry of Defence has shown absolutely no interest in the methods which underlay these achievements, which have now been recorded for publication.

Achievement 13 – Cost Reductions Needed Now, Available Now

The huge cost reduction of Bloodhound 1 was the result of some fifty methods at the time. Today there are nearly 200 methods of reducing product cost through design. These methods are sufficient to see off Third World price competition which is steadily destroying British manufacturing industry.

The methods require that a discipline be applied to management graduates with no understanding of design, who have caused the loss of much British manufacture.

Achievement 14 – Process Control by Digital Computer

Bloodhound 2 included a *World First* which has caused major changes in nearly every house and business in the world, and therefore will dwarf all other exhibits in the Bristol Aerospace Centre.

It is Process Control By Digital Computer which can be viewed in the Bloodhound 2 Launch Control Post (LCP) and will be displayed due to the no small efforts of the Bloodhound Missile Preservation Group (BMPG).

Every house now has examples of it, most industries now employ it, and Concorde manufacture would have been nearly impossible without it.

I am delighted to have been made Honorary President of the restoration of this historic innovation, which was initiated under my leadership.

Achievement 15 – Reducing Overspent and Delayed Projects

With the unique Bristol experience of selling and supporting complete weapon systems, including operational control and servicing support, it rapidly became clear to the British Government that this know-how was badly needed in two key strategic areas of British defence policy:

- the nuclear deterrent submarine missile launch system
- and the British engineered warhead re- entry system which it later carried.

In both cases the Bristol team led the project, introduced changes and educated the contractors so that the problems were overcome.

Many of the team members were honoured for that work.

Achievement 16 - Billion pounds cost saving at Rolls Royce Bristol

At my suggestion Rolls Royce Bristol appointed a cost engineer, Ken Dangerfield, reporting to the Managing Director for engine cost reduction.

In ten years he rescued a loss making engine project and produced total aero engine cost reductions of £1.000,000,000.

The company decided to make his methods mandatory but Rolls Royce Group politics forced Board changes which stopped further savings.

Ken Dangerfield's conclusions:

1. The procedures, results and conclusions are also valid in these other industries.

2. Non technical directors have great difficulty in accepting design as a profitable investment. Designers lack the credibility and directors have a lot to learn about design's cost potential.

3. Design as an investment - Investment in machine tools brings returns of about 20 to 50% per annum. Investment in design cost engineering brings returns never less than 100% per annum, and commonly 200 to 500% per annum.

4. Typical value to a company - Nontechnical managers should evaluate engineering costs up 10% and manufacturing costs down 20%. Typically operating profit is trebled and return on investment more than trebled.

Ken was never honoured for his achievement in any way.

Achievement 17 – Concorde: no Buyers, no Profit

When I became Engineering Director Concorde the British Government asked me to investigate rising costs and programme delay. In my report I found that the aircraft cost had been so underestimated that it was unlikely that any aircraft would be purchased by the airlines. As a result they had to be given to the two airlines, but even so neither airline was able to make an overall profit from operations.

My correct findings led to personal unpopularity with the contractors.

Achievement 18 – Getting Space Shuttle Right

I led three teams in the design of the Space Shuttle, which had an even lower payload fraction than Concorde, and I advised on means of avoiding the problems which plagued Concorde where the first two aircraft were incapable of crossing the Atlantic with no payload! By the correct use of margins the first Space Shuttle had nearly all the intended payload.

A HISTORIC BLUNDER

Institutional actions were planned as the result of Ken Dangerfield"s work. They included:

- Workshops on the subject with SBAC and CBI. The questionnaires to be used dealt with the problem of company managers not acting in the field. Success with workshops might eliminate the need for other actions.
- Measures to make cost engineering more effective in companies.

Political problems at, and between, British Institutions caused these courses not to be given at all.

The direct outcome over the next fourteen years was the abandonment of the subject in four British professional institutions, no inclusion of it in education or short courses, preventing improved practice in medium and large companies.

The cost to the Nation may well have been 1000,000,000,000 pounds, and the loss of British manufacture in several industries, over the thirty years which followed.

Achievement 19 – Cost Reduction Through Design

Having taught cost reduction by design for many years at Cranfield University, and on short courses, I was aware that too many British companies failed to act on it. In large

part this was due to failure to manage cost during design, when 80% of product cost has been committed.

30% cost reduction was commonly available if it was so managed.

N.K. Gardner, a Government Chief Economist, identified the cause as management education's lack of coverage of design, and advised on changed short course content and disciplines to correct this.

The outcome was successful and for the Australian Government the following Open Learning items have since been developed:

Introduction, cost reduction by design, designer skills, production learning, on time on budget, and a one day course covering all aspects.

These open learning packages, which I developed in Australia with the help of three American Universities, can now be now made available via the Internet to protect British manufacturing industry against Third World low cost competition.

The Bristol Aerospace Centre should draw attention to their availability, the great successes from their application, and collaborate with the Institution of Engineering Designers on making them available to British companies.

Giving Credit

The Bristol Aerospace Centre exhibition can, and must, record all the listed achievements and honour the engineers who made them possible. This should be not only at exhibit level but in several cases must be mentioned at overall level in particular:

- Saving the company from bankruptcy
- The world-changing innovation of digital process control
- Open learning

There are numerous educational issues arising from the GW exhibits, in particular the need for a wide range of skills to be developed by design engineers.

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