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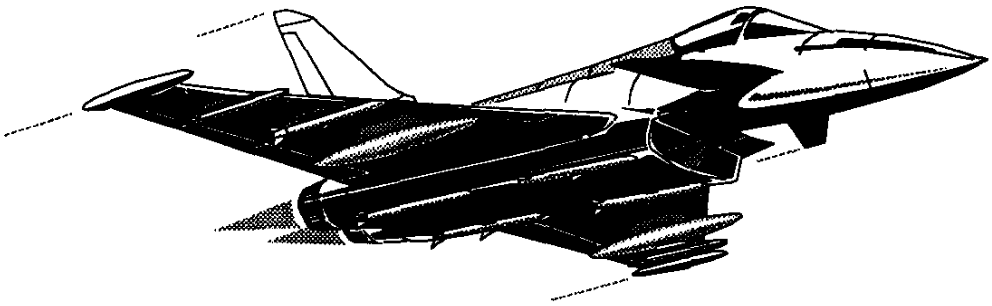
THE EUROPEAN FIGHTER AIRCRAFT EF2000 FLIGHT TEST PROGRAMME OVERVIEW AND MANAGEMENT CONCEPT

Michael Herr and Paul Butcher
Eurofighter Jagdflugzeug GmbH
Am Soeldnermoos 17
D-85399 Hallbergmoos, Germany



SUMMARY

The Eurofighter 2000 (EF2000) Flight Test programme began with first flight in 1994. The aircraft will enter service at the beginning of the next century.
In addition to the challenge of basic certification of the airframe with many different Air-to-Air and Air-to-Ground stores configurations, Eurofighter Partner Companies are also conducting testing to fully integrate the new developed Radar (ECR90) and Engine (EJ200). This paper constitutes a description of the EUROFIGHTER Weapon System, the flight test programme management, an overview of the test programme plan and progress to date and discussion of unique challenges during testing.

Up to now the EF2000 flight test programme has proceeded as planned and in-service certification should occur on schedule. The achievements reached so far can be attributed to a well designed and built aircraft, a comprehensive test plan, a very reliable data system, and the personal efforts of thousands of people in four different countries.

1. INTRODUCTION

The EF2000 Development is a four nation programme (Germany, Italy, Spain, United Kingdom) - as shown in Figure 1 - in response to the European Airstaff Requirement issued December 1985 for an Air Superiority Fighter with a Secondary Role Capability for Ground Attack.

The prime contractor for the development is the Eurofighter Jagdflugzeug GmbH which manages the project activities of the four partner companies Alenia (ALN), British Aerospace (BAe), CASA and Daimler- Benz Aerospace (Dasa).
The Aircraft is a single seat, twin engine, aerodynamically unstable delta-canard design embodying latest technology in structures, systems, engine and avionics optimized for the air-to-air role. Design emphasis is placed also on operability, reliability, maintainability and testability as well as low mass and low radar signature. The radar is optimized for air-to-air with reliable operation in a high density ECM environment.

The Flight Test Programme consists of 7 Development Aircraft plus 5 Instrumented Production Aircraft shared between the partner

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companies to develop the design through initial operational certification to the final standard.
Advanced Flight Test Instrumentation and Analysis Methods will be used for cost effective and economic flight testing.

2. EF2000 PROGRAMME BACKGROUND

Full-scale development of the Eurofighter 2000, formerly called European Fighter Aircraft, began in 1988 by the United Kingdom, Germany, Italy and Spain. A consortium to develop the aircraft was formed with the shares of the industrial partners - British Aerospace and Daimler-Benz Aerospace at 33%, Alenia at 21% and CASA at 13% - in proportion to each country's expected requirements for the aircraft. Eurojet, the company responsible for developing the engine, reflects the same breakdown.

Similar workshare principles are arranged for production where e.g. Dasa build the centre fuselage, British Aerospace the front fuselage, (incl. cockpit, and canard foreplanes) and the vertical tail. CASA build the right wing whereas the left wing is built by Alenia with the rear fuselage shared by BAe and Alenia.

A total of more than 600 aircraft are to be ordered by the four air forces, with close and beyond visual range (BVR) air-to-air combat as their primary role. A life-time of 6000 flight hours (or 25 years, whichever comes first) is envisaged. The aircraft basic empty mass is defined to be around 10 t. A high thrust to weight ratio will be achieved with two engines of the 90 kN thrust class.

The basic design features are as follows:

o Delta canard configuration, aerodynamically unstable platform;

o quadruplex digital fly-by-wire flight control system;

o Chin intake;

o Use of advanced materials;

o Single-seat configuration;

o advanced mission avionics;

o state of the art cockpit design.

The two-seat version is to include the same basic dimensions for commonality across airframe and systems.
As regards industrial aspects, the worksharing principles are:

o All key technology aspects to be equally shared by the partners;

o Duplication to be avoided;

o Final assembly lines in each nation;

o Flight testing to be carried out at each company.

3. EF2000 TECHNICAL LAYOUT AND ASSOCIATED FLIGHT TEST ACTIVITIES

3.1 Aerodynamic Concept and Flight Control System (FCS)

The Delta-Canard Configuration
The delta-canard configuration proved to be superior to competing designs with respect to point and mission performance. Detailed design studies and trade-offs were carried out to achieve on overall balanced design within the stringent constraints. The main advantages offered by the delta wing configuration, when compared to trapezoidal planform were in the sub-sonic regime, include higher maximum lift due to the large wing area, and in the supersonic flight regime, reduced aerodynamic centre shift resulting in lower trim drag and better sustained turn rates with higher specific excess power.
The delta wing configuration also provides low weight per unit area, high volumetric efficiency (fuel content) and a long moment arm for effective flap, trim and control power.

All-Moving Foreplane
The longitudinal instability of the airplane is achieved by the all-movable foreplane (canard). With the correct and favourable foreplane-wing interaction, maximum lift is increased while lift-dependent drag at high angles of attack is reduced. The foreplane is used to trim the aircraft for maximum performance.

The aircraft is inherently unstable in the longitudinal axis in the subsonic regime, and becomes longitudinally stable and directionally unstable in the supersonic area. The modern digital flight control system provides artificial stabilisation.

As an overall result, the EF2000 concept offers a significantly better supersonic turning performance, when compared with a conventional design with trapezoidal wing and aft tail.

Flight Control System (FCS)
The flight control system is a full-time, full-authority quadruplex digital fly-by-wire system. It provides excellent handling qualities and carefree manoeuvring in all stores configurations. The pilot can use the stick, rudder and throttles in any combination in the knowledge that maximum manoeuvre performance will be provided without risk of loss of control, overstress or engine surge. The variation of fuel state and the firing or jettison of weapons are automatically compensated. Voice warnings are issued if the pilot allows the airspeed to drop below safe values.

The stick is centrally mounted, with small displacements and light stick forces. In pitch, the pilot perceives neutral static stability except for landing where artificial positive static stability is provided. In manoeuvre, stick force per g is constant in the g-limited envelope. The roll response is controlled to respect both loading and handling limitations. Above 2g, wind axis rolls are commanded for minimum sideslip. The rudder pedal is used only to kick-off drift on landing.

Flight Test Aspects
The primary objective of evaluating the general flying qualities of the aircraft is to provide a "carefree" service clearance (i.e. no loss of control or overstressing) for operational agile manoeuvring in all store configurations.

Beside the "classic" assessment of system characteristics (A/C + FCS + pilot) in closed loop manoeuvres (e.g. air to air tracking, in-flight refuelling, landing, aerobatics) special emphasis is laid on the "carefree" part. This will be done by evaluating the handling qualities at maximum AOAs, g's, roll rates and with operational representative manoeuvres to check the capability of the FCS to protect the A/C from loss of control due to excessive AOA, sideslip or roll rate.

Until the carefree protection is proven the test aircraft will be equipped with special safety devices, including anti-spin parachute and emergency power supplies (EPS). The Flight Control System (FCS) will feature a recovery mode to prevent undesirable control movements should a spin occur.

The FCS Software (S/W) in addition to the S/Ws for Avionic and Utility systems are fed "stepwise" into the Flight Test Programme, i.e. the provided S/W for a certain programme phase should provide the functionality to satisfy programme objectives. The advantages compared to a direct approach are mainly seen in the facts that the overall technical risk can be managed easier and intermediate steps can be reached with less risk.

3.2 Structural Concept

The concept to achieve minimum weight is to optimise loads, extensively use advanced materials and maximise structural integration. This leads to a saving of approximately 25% compared to conventional techniques. For the optimised loads concept the flight control system provides precise control of normal acceleration and roll parameters to control structural loads. This allows a reduced ultimate factor for stressing calculations, further reducing weight. Advanced materials (carbon fibre reinforced composite, improved aluminium alloys and aluminium lithium alloys) are extensively used throughout the A/C. More than 70% of the wetted surface and about 40% of the basic structure are made from Carbon Fibre Composite (CFC).

Flight Test Aspects
Related to the A/C structure the main objectives of the flight test programme are on Flutter, Structural Health Monitoring, validation of design loads, structural temperatures and vibrations/ acoustic noise.

The EF2000 requires a "classical" flutter evaluation but the configuration places special requirements on the flight test technique. In particular, the foreplane is a critical surface for flutter, however its sensitivity to mass precludes the use of traditional excitation by pyrotechnic devices ("bonkers"). Fitting a "bonker" pack for excitation would invalidate the flight test results. Therefore the FCS is used as the excitation method for flutter flight trials. A special flight test facility called the FBI ("frequency and bias input") injects frequency sweeps or impulse signals into the control surfaces, tailored according to the predicted characteristics of the surface under test.

Although mandated by the foreplane characteristics, the FBI is used for excitation of all surfaces. Therefore, since there are no excitation system consumables, the number of tests achievable per flight is limited only by the aircraft's fuel endurance.

The FBI is also used to excite the A/C for measurement of structural coupling and Air Data System (ADS) effects in flight allowing the FCS structural filters to be optimised for the wide range of weapon configurations.

The EF2000 will be equipped by a Structural Health Monitoring (SHM) system which utilises airframe response parameters to provide an on-board record of cumulative fatigue damage occurred at various airframe locations. Parametric and strain gauge data will be recorded by Flight Test in all phases of flight as a "ride along" exercise to develop and verify the operation of the SHM.

A very special FTI equipment is used for measurement of A/C loads. One development A/C will be fitted with a matrix of piezo-resistive pressure transducers distributed all over the external skin of wing, foreplane, fin and fuselage. By measuring the static surface pressure with this so called "pressure plotting survey" the aerodynamic loads can then be calculated via pressure integration.

3.3 Engine

The EJ200 engine is tailored specifically to match EF2000's mission requirements. In particular it offers a combination of very high thrust - around 90 kN in full reheat and 60 kN in full dry power - and low fuel consumption and carefree handling. As with the airframe, great emphasis is put on reliability and maintainability, low cost ownership, and growth potential.

The EJ200 is a two-spool turbofan with modular construction for ease of maintenance and support. The broad blades of its wide-chord fan are light and aerodynamically efficient as well as possessing a high level of resistance for foreign object damage. Both the high and low pressure compressors are driven by single stage advanced air-cooled turbines, featuring the latest single crystal blade technology. Low smoke and emission characteristics have been designed for the main, annular combustor which incorporates air spray fuel injectors. The reheat system features radial burners and a hydraulically operated convergent/ divergent nozzle. All accessories, including the full authority digital engine control unit (DECU), are self-contained and engine mounted. An auxiliary gearbox on the underside of the engine provides drive for the accessories.

Flight Test Aspects

Before the first flight of an EJ200, about 3000 hours of Ground Testing with 11 Development Engines was performed. This large amount of test experience - compared to former programmes, e.g. RB199 on Tornado - allowed a very rapid progress in flight testing the engine. Additionally, the EJ200 proved its very rugged design and extraordinary reliability at this early stage in the flight test programme. For the flight development programme about 30 engines in three different standards will be delivered.

The anticipated trials to verify and validate the engine integration with the EF2000 weapon system are, in general, straight forward, i.e. engine handling, vibration, oil system etc..

Nevertheless, a special EJ200 feature should be highlighted. The engine control and Health Monitoring System are fully integrated into the architecture of the A/C digital inter-system communication. The advantages for that lies in mass reduction, quicker response and lower deadbands compared to former hardwired links like used on Tornado. Also the autopilot demands are routed directly to the Digital Engine Control Unit (DECU) from the Flight Control System (FCS) avoiding any mechanical interface in the loop.

In flight test, where different S/W standards will be tested during certain programme phases, the compatibility between interfaces (e.g. FCS/ DECU) must therefore be assured and validated.

Beside engine performance tests to evaluate the installation losses also thrust-in-flight measurements will be performed. Based on a theoretical model - verified by Sea Level Test Bench and Altitude Test Facility Calibration - in-flight thrust can be calculated for all flight conditions in the flight envelope by measuring certain engine parameters. This is of significant importance for validation of A/C drag and performance.

To verify the windmill and assisted relight envelope DA3 will be equipped during the time of relight testing with an Auxiliary Power Unit (APU) operative in flight. The APU is used as a flight safety device only in case a double-engine-flameout occurs to provide an adequate and engine independent source of hydraulic power. It also can unload the engine from mechanical load thus increasing the relight capability in windmilling conditions.

3.4 Utility Control System (UCS) and General Systems

General
To fulfil the requirement of single crew operation design activities concentrated on low workload, high performance capability, high availability rates and good maintainability. The various systems have been incorporated within a fully integrated architecture.

The Utilities Control System (UCS) controls all general systems with the exception of the Flight Control System (FCS). It provides continuous controlling, monitoring and fault finding of all these sub-systems. The utilities control system comprises essentially 6 computers and a Maintenance Data Panel (MDP).

The MDP forms a major contribution to the mission readiness concept of the aircraft. It offers a clear text indication of each LRU-failure diagnosed on board. It shows level status of usable items, allows refuelling and defuelling services and also the initialisation of Build-in Test (BIT) of the systems. A transportable data carrier module is provided for data analysis. If required, further equipment can be connected to the UCS data bus for data evaluation.

Flight Test Aspects
All main systems are tested on ground test rigs prior commencement of flight tests to generate confidence in the system functionality and reach a flight clearance status. Most of system flight tests will be carried out "ride along" in conjunction with Performance (flight envelope), Handling (max g / AOA) and Engine trials (Relight trials).

Beside the general flight test objectives e.g. demonstrate compliance with the design goals and with the requirements of the specification, the following system trials will receive special consideration:

- Environmental Control System (ECS):
Hot/cold weather trials to check satisfactory operation of the system at world wide extreme temperatures.

- Hydraulic Generation System:
The satisfactory performance of the hydraulic system will be demonstrated in simulated flight emergency conditions. Also failures of individual utility systems will be simulated during the flight.

- Fuel System:
To demonstrate the ability of the fuel transfer sequencing to control the aircraft centre of gravity within the specified limits and to demonstrate the correct operation of fuel computers including software for system management, gauging and monitoring function. Emphasis of this testing will be laid on critical flight conditions for the fuel supply, e.g. climbs, dives, negative and zero 'g' and low fuel states.

In-flight refuelling tests to validate fuel system and A/C Handling in a variety of configurations and against different tankers. This ability is essential to the flight test programme with respect to extend sortie length and trials flight time.

- Secondary Power System:
To check the ability to provide sustained hydraulic/electric power and assisted relight capability, during one engine flame out case (cross bleed operation).

- Aircrew Equipment Assembly:
To assess the complementing "g-clothing" (e.g. pressure breathing, full coverage anti-g trousers etc) under extreme g-onset rates and maximum g values, to prevent "G-Loc" Problems.

3.5 Avionic System

Avionics Systems Integration
High mission effectiveness and survivability of EF2000 will be realised through an integrated avionics system comprising seven functional sub-systems - all working together to give the pilot an autonomous ability to assess the tactical air situation and fight the battle. The individual systems are difficult to describe in isolation simply because of the degree with which they are integrated - and it is due to this sharing of information between the sub-systems that the pilot will be presented with a much more comprehensive picture of his air environment than he has previously been used to.

Functional Subsystems
As the whole avionic system is to be operated by a single crew member, an acceptable workload has to be assured by automating the system functions and moding as far as possible.

The avionic system is an integrated system that can be divided into the following subsystems:

o Armament Control System (ACS)
o Attack and Identification (A & I)
o Communications (COMMS)
o Defensive Aids Sub System (DASS)

o Displays and Controls (D & C)
o Integrated Monitoring and Recording System (IMRS)
o Navigation (NAV)

During the early development phases of the programme, the Customer Operators were involved in agreeing the Man-Machine Interface (MMI) aspects of the cockpit layout, and the associated cockpit moding, as shown in Figure 2. This Customer involvement has since extended to manned-simulation assessments of a representative EF2000 cockpit. Software loads for these assessments have been representative of both the Initial Operational Clearance (IOC) version, and the Full Operational Clearance (FOC) standard of production aircraft. This close co-operation with the Customer has been extremely useful in helping to ensure that the complex interaction between the pilot and the Weapon System is fully optimised to suit the specific needs of the 4 Air Forces involved in the EF2000 programme.

Flight Test Aspects
Some highlights out of the complex, integrated Avionic System trials are e.g.:

- To demonstrate satisfactory operation and performance of the functional subsystems in accordance with the A/C Specification.

- Look at all operationally important areas e.g. attack/weapons/displays/defensive aids systems including jamming scenarios in order to identify any problems.

- To achieve an IFR Clearance and navigation accuracy data at an early stage of the EF2000 flight test programme to ensure efficient progress.

- To test and demonstrate satisfactory data display, handling, pilot interaction and workload ("Man-Machine-Interface").

- To demonstrate system operation and degradation in the case of equipment failures in the primary and reversionary modes.

- The Defensive Aids Sub-System (DASS) will be checked inflight for its capability of suppression management and selection of appropriate counter measures against specific threats.

- The Multi-functional Information Distribution System (MIDS) will be evaluated under certain threat scenarios to check the secure exchange of tactical information with users on a common network.

- The overall integration aspect of the Avionic System layout is extremely evident in the requirement for sensor fusing of target data derived from several different sources, namely Radar, MIDS, FLIR, DASS and Identification Friend / Foe (IFF). The objective of flight trials will be to evaluate the capability to provide the pilot with an autonomous capability to assess the air situation and fight the air battle. This should be provided by association, correlation and fusion of data from the on-board sensors and from the off-board data received via MIDS.

- The Weapon Aiming System will be checked for providing of adequate data and aircrew operating guidance for use of Air-to-air and Air-to-ground weapons.

3.6 Radar

The ECR 90 radar is being developed by Euroradar, a consortium led by GEC Marconi of UK, with ENOSA of Spain, FIAR of Italy, and Dasa of Germany. It is an advanced pulse-doppler system with high technology features throughout, particularly within the transmitter, antenna, and signal processor. Much of the technology has been derived from the highly successful Blue Vixen radar.
DA5 will be the first of four of the development aircraft to be fitted with the ECR 90 radar.

Flight Test Aspects
Specific objectives with respect to programme milestones planned to be reached in a stepwise approach are:

- Clearing the Air-to-Air Radar modes in manoeuvring flight within the carefree handling envelope, versus manoeuvring fighter aircraft in a non Electronic Counter Measures (ECM) environment.

- Clearing the unrestricted operation in all Air-to-Air Radar modes in an agreed ECM environment

- Clearing Air-to-Surface Radar Modes.

Beside of testing the Radar on-board of EF2000 prototypes, the Radar manufacturers' "Hack" aircraft (BAC1-11) is available to support EF2000 Flight Trials for specific investigations at Radar sub-system level, in addition to rig testing.

Testing of the EF2000 Radar will be closely interwoven with Attack and Identification System proving, Weapon (e.g. AMRAAM, Gun) and Navigation system trials.

Assessment of Air-to-Air / Air-to-Surface Radar performance will require the provision of airborne/ground targets of defined Radar Cross Section (RCS) with operational capability in specified envelopes and incorporating the facility to simulate a variety of hostile ECM techniques.

4. MANAGEMENT ASPECTS

4.1 Flight Test Programme Construction

The flight test programme is required to be shared between the 4 participating partners. The worksharing was defined initially through the number of aircraft allocated to each Flight Test Centre. Then the task allocation was defined taking into account the known expertise of the partners, while ensuring that the overall programme progresses consistently on a "broad front".

This led to a programme comprising 7 Development Aircraft (DA) and 5 Instrumented Production Aircraft (IPA), together performing more than 4000 flights - as shown in Figure 3. The allocation to partners is:

ALN	2 DAs	(DA3 + DA7)	and 1 IPA
BAe	2 DAs	(DA2 + DA4)	and 2 IPAs
CASA	1 DA	(DA6)	and 1 IPA
Dasa	2 DAs	(DA1 + DA5)	and 1 IPA.

The programme adopted the classical risk reduction measure of allocating every task a backup aircraft as well as a prime aircraft, and every aircraft backup tasks as well as prime tasks. Additionally, the first 2 DAs are fitted initially with the well proven RB199 Tornado engine. The definitive EJ200 engine is fitted to DA3 and the subsequent aircraft, and will be retrofitted to DA1 and DA2 about 3 years after their first flights.

The first 3 Development Aircraft are now flying and the remainder will progressively join the flight test programme during 1996.

The flight test tasks of the aircraft can be summarised as follows:

DA1 will be devoted to handling trials and, after retrofit of EJ200 engines, engine development.

DA2 is the airframe envelope expansion vehicle, and will develop and prove the carefree handling capabilities of the FCS.

DA3 is the lead aircraft for engine development and was the first aircraft to fly with the EJ200 engine. It is also the lead aircraft for stores envelope expansion, stores release and jettison testing and gunfiring trials.

DA4 is a two seater and will be the last Development Aircraft to fly. This is because it is undertaking extensive ground trials ahead of flying, including lightning strike testing, Defensive Aids ground testing and calibration of the structural health monitoring system. Once flying, this aircraft is the prime aircraft for avionics integration and radar development.

DA5 is planned to be the first aircraft to fly with radar installed and radar development will be its prime task, together with avionic and weapon system integration testing.

DA6 will actually be the fourth aircraft and the first twin seater to fly. Its prime tasks will be twin seater handling, performance and envelope expansion, followed by development of avionics and systems with particular emphasis on the twin seater capabilities.

DA7 will primarily carry out performance and weapon system integration testing.
Five aircraft from the first production batch will be fitted with FTI and join the flight test programme as Instrumented Production Aircraft. The tasks of these aircraft will be to provide final verification of the Development Aircraft results, plus continuation of the development of the final standards of weapon system software.

4.2 Flight Test Programme Management

The flight test programme described above is complex and highly integrated with multiple dependencies between aircraft and between the four partners. Each partner company is responsible for operating its own aircraft day-to-day, within the medium and long term programmes established centrally by Eurofighter. This obviously requires careful management and a close working relationship between the four flight test centres. This is achieved through the Flight Test Panel which is formed by the Flight Test Managers of the four partners, plus Eurofighter (Figure 4 refers).

This Panel was established in the earliest days of the project to lay down the principles of the flight test programme, and it continues to manage the active trials and future planning.

The close working relationships and team spirit built up the Flight Test Panel ensure that the flight trials progress as efficiently as possible, and that problems are overcome with the minimum long term impact.

Specialist sub-groups are established to review progress and exchange information at the more detailed level, under the supervision of the Flight Test Panel.

The four National Official Test Centres (OTCs) are integrated into the Contractor's flight test programme to a greater extent than has been seen on earlier programmes in the Eurofighter Partner Nations. The OTCs have wide ranging access to the contractor's flight test data and have established teams of their own engineers at the Contractor's flight test centres. The OTCs have been consulted during the early planning of the contractor's flight testing and have the right to contribute to the detailed planning so that the contractor flying contributes as much as possible to the Official Service Release Recommendations.

Periodically the OTCs will perform Official Previews and Assessments, where the aircraft is operated from the Contractor's base but the testing is specified by the OTCs. The first Official Preview was performed at Manching on DA1 in March/April 1996.

Additionally, Official Aircrew can perform up to 10% of the contractor's trials distributed throughout the programme. The aim is to maximise the involvement of the Officials in the integrated flight test programme, while maintaining the Contractor's responsibility for completing the development programme in a fixed price contract.

The formal interface for flight test matters between the Contractor (EF) and the Customer (NETMA) is the Operational Requirements and Flight Test Group (ORFT). This group is responsible for reviewing progress in the programme, establishing objectives and ensuring that the necessary external support equipment and facilities are provided as necessary.

A series of maturity criteria and major milestones have been established to allow the progress of the overall development programme to be measured, many of which naturally arise from flight testing. Additionally, short term objectives are declared and tracked to allow progress in flight trials to be assessed.

4.3 Advanced Flight Test Techniques - Real Time Analysis (RTA)

All four partners (through their other projects) are well experienced in the use of telemetry / real time monitoring to improve the productivity of flight test sorties. In order to achieve further improvements in overall cost effectiveness for EF2000, all 4 partners have made significant investments to extend this into true real time analysis. This is used to minimise the turnaround time between the execution of the test and the delivery of the fully analysed engineering result. In many cases this turnaround time can be measured in seconds, allowing the most rapid progress of trials. Real Time Analysis also makes a positive contribution to safety in flight trials by allowing a more detailed understanding of the test just completed, and thus a firmer basis for decision making.

Real Time Analysis has been initially applied to the air vehicle testing performed by DA1-3. Specific highlights have been:

o flutter testing on DA2, with fully analysed frequency and damping results produced within seconds of the end of a test run, with trend analysis in comparison with predictions and previous results immediately available

o handling qualities measurements, where pre-flight predictions of manoeuvre response are stored in a database, to be recalled to the screen and compared directly with the flight responses.

o airdata calibration tests, with on-line comparison of the measured coefficients with the allowable tolerances

o loads estimation, with on-line modelling of loads from flight mechanics parameters and comparison with allowable boundaries - with an alarm if the allowable boundary is exceeded

As the later aircraft join the flight test programme, new real time analysis techniques have been developed for avionic and weapons system trials.

These include:

o real time datalinks from remote instrumented ranges for instantaneous comparison between reference data and aircraft measurements

o the exploitation of differential GPS to allow "ranges" to be established in the local areas of the flight test centres to avoid dependence on radar ranges

o sortie management displays including multiplexed video telemetry of the cockpit head up and head down displays, aircraft and target position displays for situational awareness and aircraft sensor coverage representations

o real time sensor performance assessments through real time sensor emulations in comparison with reference data

o auto selection of test timeslices for the database through monitoring of the combination of aircraft data and intercept profile condition monitoring.

5. FLIGHT TEST STATUS

5.1 Current Flight Test Status

The maiden flight of EF2000 Development Aircraft 1 (DA1) took place on 27 March 1994 from Dasa Flight Test Centre at Manching. DA2 followed shortly with its first flight from BAe Flight Test Centre at Warton.

The maiden flight of the third prototype, DA3, followed on 4 June 1995, from Alenia's Flight Test Center at Caselle, near Turin, Italy.

As of 19th August 1996, the three Development Aircraft involved in flight test so far, have accumulated about 200 hours in 225 flights. More development aircraft are scheduled to be flying within the next few weeks. DA6, the first two-seat Eurofighter 2000 and the first built by CASA of Spain, is now undergoing ground engine tests and is slated to make its maiden flight end of August.

DA1 resumed flight test recently with the latest control system upgrade. With this "2A standard" further expansion of the envelope, e.g. to high angle of attack will be possible. It will also allow "carefree handling" with a "clean" aircraft. A "2B standard" is to be ready by next year, which will allow for carefree handling with weapon stores. It will also introduce the autopilot modes.

The flight envelope opened so far comprises about 90% of the specified speed and Mach values, 70% of altitude and 70% of the AOA/g envelope - as shown in Figure 5. The engine EJ200 behaviour was explored up to supersonic speeds and about 70% of the maximum operational altitude throughout the thrust range.

The first pair of flight EJ200 engines were life expired after completing approximately 118 hours running time each. Their serviceability was exceptional for this early stage in the flying programme, and they have behaved extremely well in the testing. The engine in-flight testing will get more momentum with DA6 flying, which has the next pair of EJ200 engines fitted. The RB199 engines currently still on DA1 and DA2 will be replaced by EJ200 at beginning of next year.

DA4, 5 and 7 are in the final stages of build in preparation for their first flights later this year. Each of these aircraft brings new features to flight testing eg radar (DA5 and DA4), Navigation System (DA7).

About 14 pilots - inclusive 4 OTC pilots - have assessed the aircraft characteristics. Throughout the explored flight envelope the aircraft was described as easy and pleasant to fly. Many pilots expressed their surprise about the great potential the A/C shows even at this early stage of development.

Of course, the operating experience shows also snags in areas of e.g. equipment development or equipment reliability. But all these problems have been investigated and will be resolved by introducing upgraded versions of Hard- and Software.

5.2 Way Ahead

With 3 prototypes flying, the flight test programme has made a solid start in the air-vehicle assessment. The next step will be the addition of the two-seater aircraft to the programme. This will be followed by the start of the intensive and extensive assessment of the highly complex avionic and weapons systems with the later development aircraft.

The participating governments and companies are now in the midst of negotiating the details of a production investment contract.
A memorandum of understanding is expected to be completed by the end of the year. Actual production investment contracts would then be awarded next year.

The long term aim of the programme is to provide the Customer's Air Forces with a highly capable, operationally credible aircraft on the day of the first delivery into service. The addition of the 5 IPAs from the production off-take will allow the conclusion of the development phase and the clearance of the full operational capability of the aircraft in the shortest possible interval thereafter.

6. CONCLUSIONS

Our experience, we believe, led to an excellent standard of collaboration between the EF2000 Flight Test Centres of four different companies, located in four different countries. It illustrates confidence in the ability of the Eurofighter Partner Companies (EPCs) to meet their design targets within the given programme structure and time schedule, provided interface requirements are adequately defined, harmonised and agreed at an early stage like it is done in Flight Test.

All this is happening successfully because of the spirit of cooperation of the many people involved on four sides.

ILLUSTRATIONS:

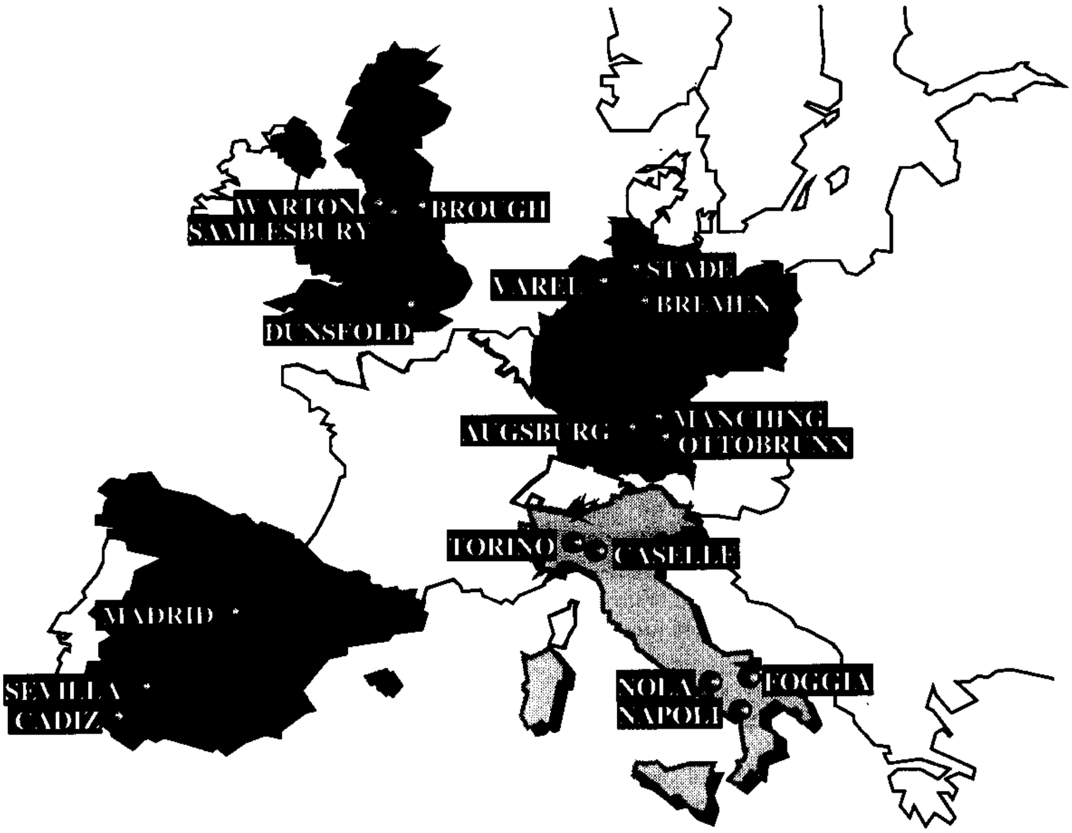

Figure 1: EF2000 Manufacturing Locations

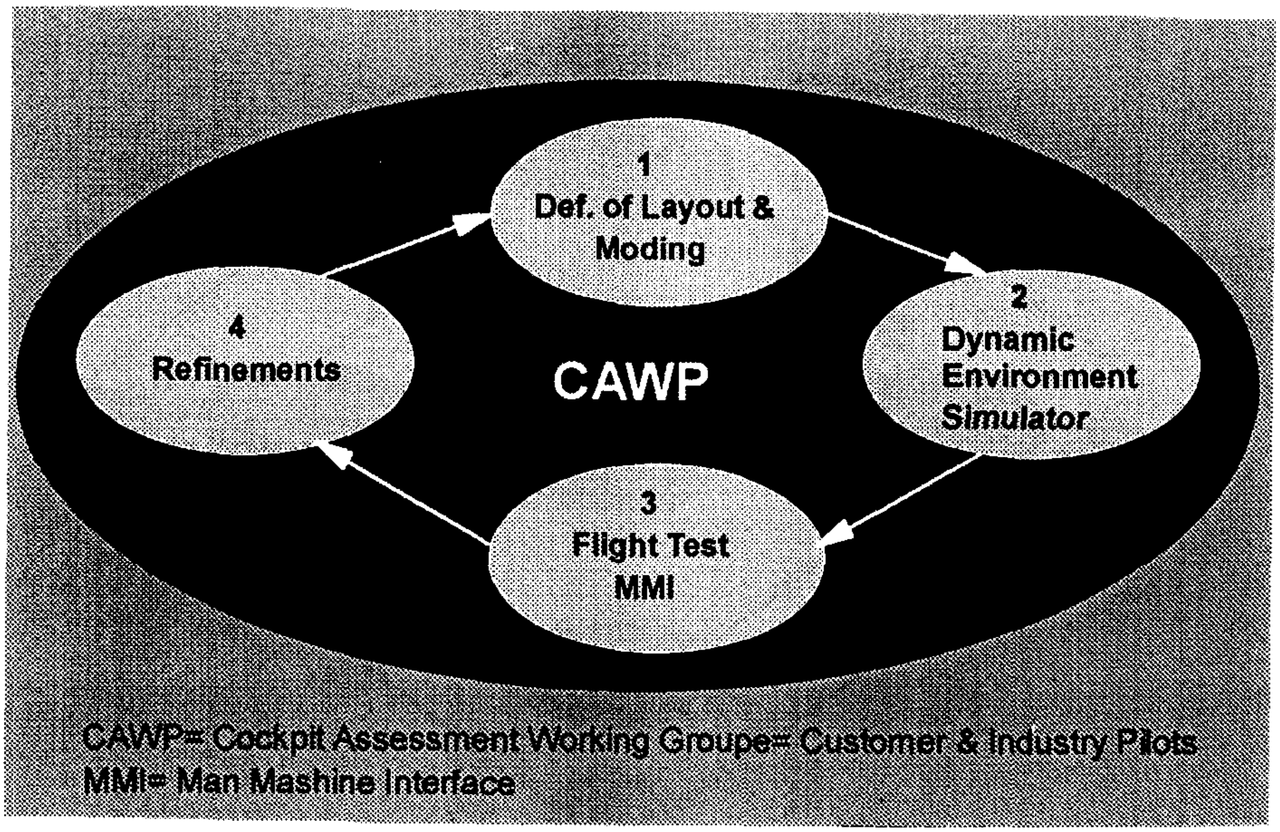

Figure 2: Avionics / Cockpit Development Process

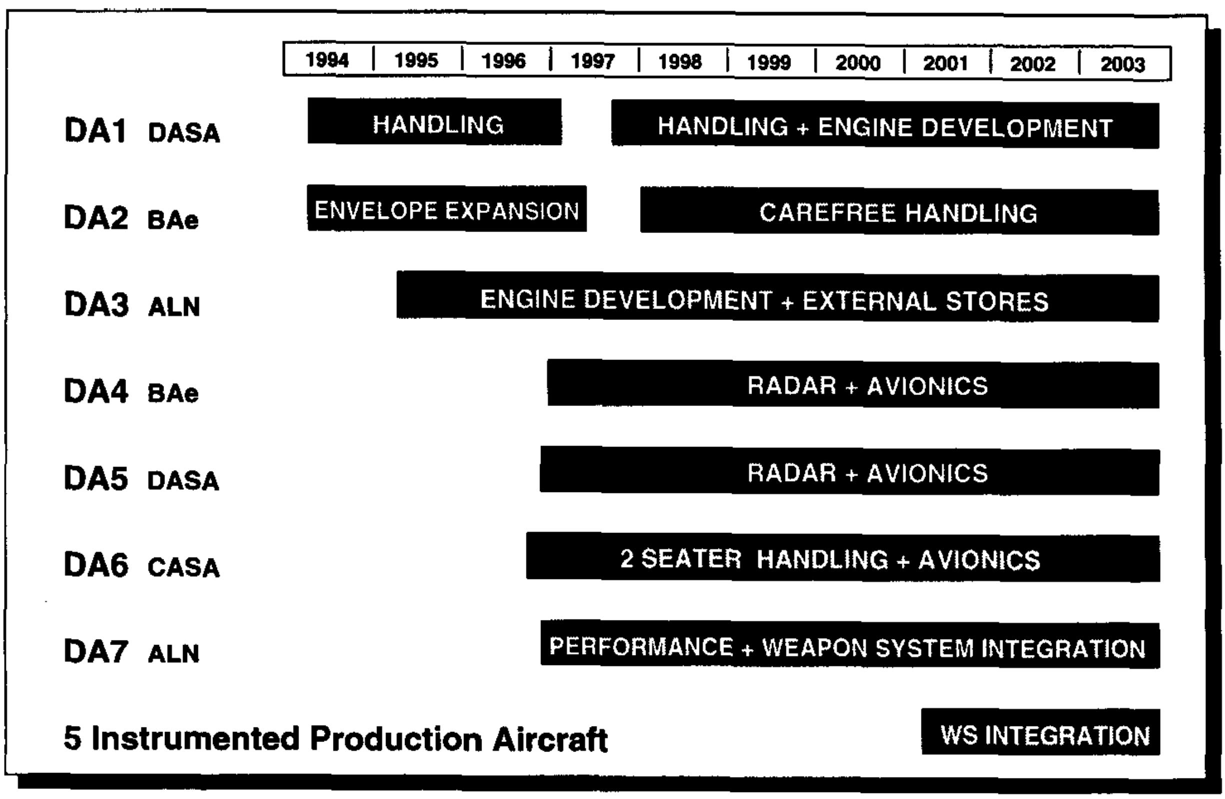

Figure 3: EF2000 Flight Test Programme

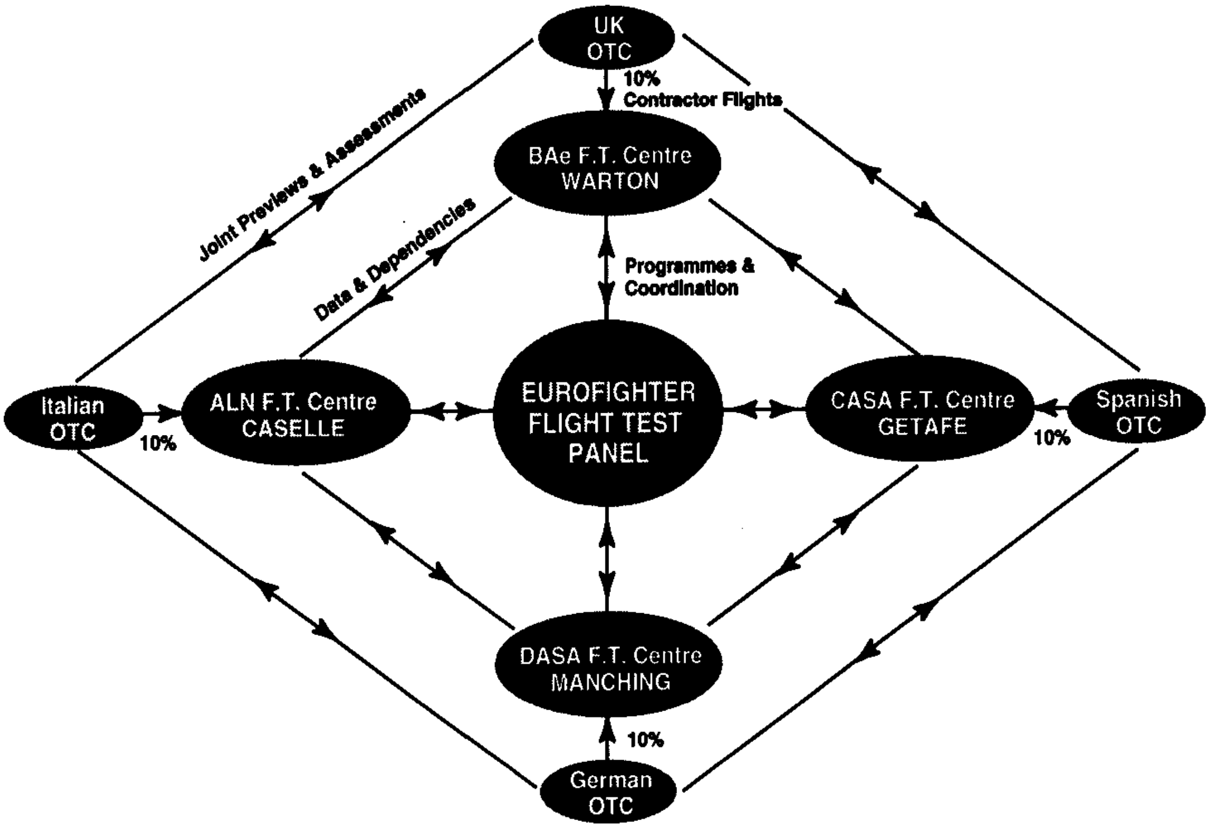

Figure 4: Flight Test Programme Management Structure

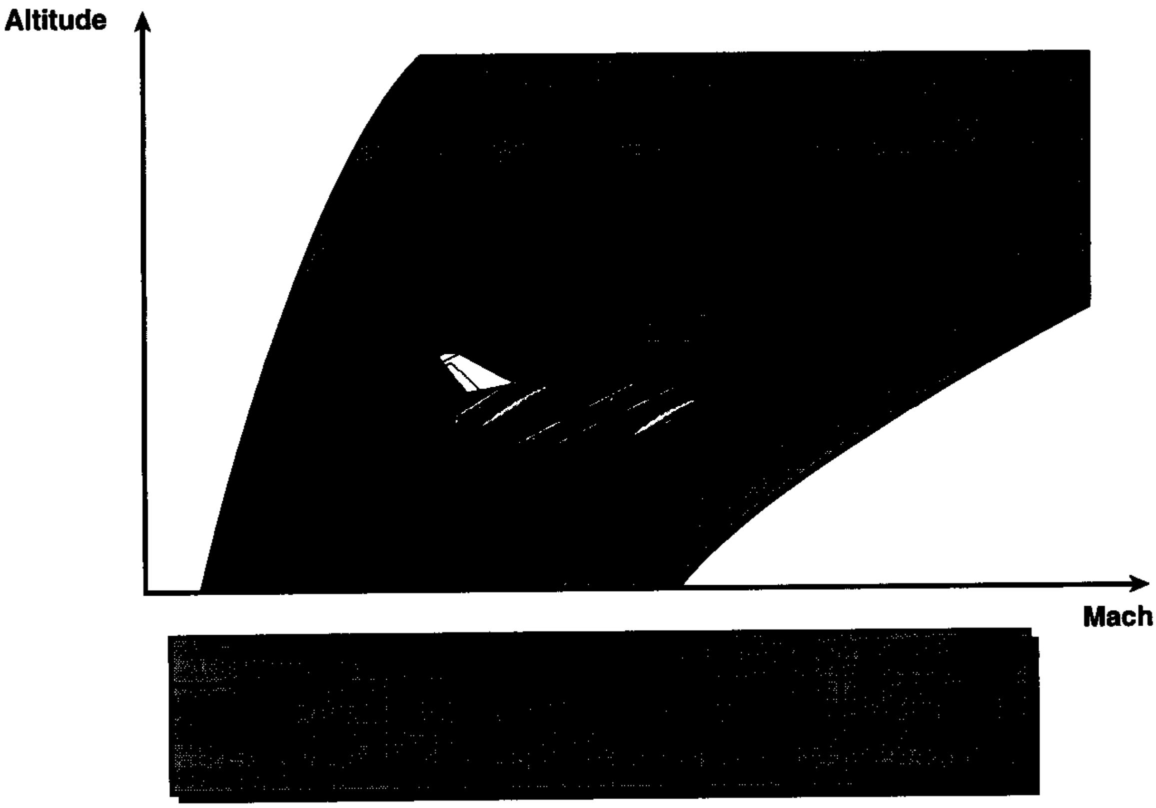

Figure 5: Flight Test Status