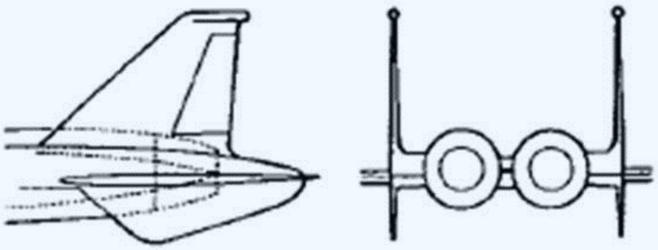
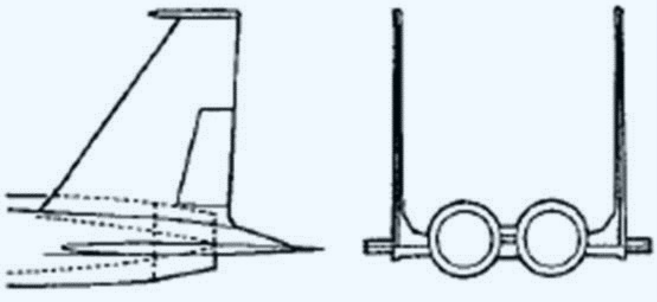
F-15 EAGLE--PRELUDE TO FLIGHT

A TALL TAIL TALE

JACK M. ABERCROMBIE



PROPOSAL (JULY 1969)



FINAL (APRIL 1971)

F-15 EAGLE--PRELUDE TO FLIGHT
OR
A TALL TAIL TALE

1969. That was the year U.S. astronauts walked on the Moon for the first time. In 1969, the country installed a President who pledged "Peace with Honor" in Vietnam. In 1969, during the middle of the Cold War, the F-15 Eagle was born.

F-15 CONCEPT FORMULATION

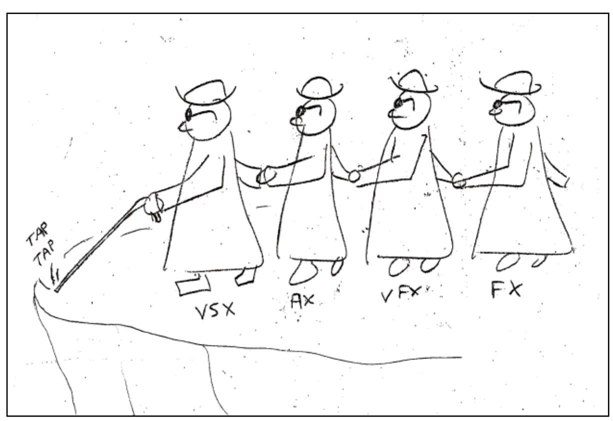
To explain the rationale for the F-15 and how crucial it was to the future of MCAIR (the McDonnell Aircraft Company component of the McDonnell Douglas Corporation) and to my career, it's necessary to delve briefly into some programmatic issues to "set the stage" for the remainder of the story.

The F-15 was conceived during Air Force and Contractor studies for an "FX" (Fighter, Experimental) aircraft. These studies began in 1965 and continued for nearly four years. Four distinct, sequential study contracts were awarded during this time—McDonnell won some of these contracts and lost some. These studies, addressing the Soviet threats by the Mig-21, Flagon A, and the Mig-25 "Foxbat," established the need for a USAF fighter with improved avionics and armament suitable for both long-range (beyond-visual-range missiles) and close-in (the old "dog-fight" scenario) combat, the ability to operate in any weather, and with vastly improved, even un-precedented, flying qualities (flying qualities are airplane characteristics defining the "drive-ability" during all kinds of maneuvers), and combat capabilities over a large flight envelope. The flight envelope extended to Mach 1.2 at sea level and Mach 2.5 at altitude. In addition, the airplane needed sufficient "legs" to fly out a certain specified distance, perform combat maneuvers, and return to home base with adequate fuel reserves. (Stealth—low radar, infra-red, and acoustic signatures—was not a requirement. Low radar return techniques were being explored at this time in "Black" programs, e.g., the forerunners of the F-117 fighter).

The four-year Concept Formulation study stage culminated in Requests for Proposals (RFPs) being issued in December 1968 to three airframers—MCAIR, Fairchild-Hiller, and North American Rockwell—for a Contract Definition effort leading to designing, building, and testing the FX, now designated as the F-15. Some 127 aircraft could potentially be delivered in the near-term by the winning contractor.

STRATEGY TO WIN

The competition to win this "last ever fighter airplane" was something fierce. The corporation had recently lost three major combat aircraft competitions—the VSX (S3-A) to Lockheed (a proposal by our new partners, Douglas Aircraft Company—had DAC won, the work would have been transferred to MCAIR), the AX Prototype (A-9 and A-10) to Northrop and Fairchild-Hiller, and the VFX (F-14) to Grumman (Grumman started out way ahead of us on this one. They had been in partnership with General Dynamics with the ill-fated carrier-based version of the F-111 which Grumman helped kill in favor or their own F-14 design). A cartoon circulated around the work stations at MCAIR showing the blind leading the blind in our combat aircraft efforts.



The loss of the F-14 competition hurt badly. After 30 years of being the premier fighter factory for the Navy, we were dead-in-the-water. And now, the Air Force version of the McDonnell F-4 Phantom was to be replaced by the newer, more capable F-15. In order to survive, a major over-haul of our *modus operandi* was essential.

We were fortunate to have a top-notch Program Manager for the F-15—Don Malvern, previously an aerodynamicist and flight test engineer. Don had successfully led the F-4 program for a number of years before joining the F-15. He and Corporate V.P. for Marketing, Bob Little, brought in a high-priced, well-respected, defense management consultant, Jim Beveridge and Associates, Inc. Beveridge laid it on the line to both MCAIR and Corporate top management. His criticisms of company practices included:

- Use of “shot-gun” approaches to competitive bidding rather than concentrating on the big one with a dedicated effort.
- “Reacting” instead of “acting” on several fronts.
- A lack of total commitment.
- Not understanding Program Management and no single-point of contact for key issues.
- The reception of suggestions for improvement likened to “a large amorphous sponge.”
- “Each move you make is slow and deliberate…and compromised…too little and too late and too wishy-washy.”

On and on, Beveridge criticized the company and made several recommendations to help us win:

- Switch the plant from Navy cognizance to that of the Air Force. (Every defense contractor has representatives from one of the services located permanently in the plant). Since we were still turning out Air Force Phantoms, this would be a logical move.
- “Make programmed customer contact the number one effort…” *at all levels.*
- Emphasize the importance of good, well-written Proposal reports.
- Examine each paragraph, each visual in the Proposal for the message it delivers. Let each graphic deliver its own message.

About the same time, our Corporate V.P. for Engineering and Research, Ken Perkins, took the company to task for not having enough aerodynamicists and that the ones we had were seriously overloaded (recognizing this as a problem throughout the industry as a result of the then-current emphasis on space astronautics in the nation’s universities).

Obviously, the company was in trouble. It was widely accepted that to achieve a win, drastic changes were needed. And changes were made, including promotional schemes within the company to make everyone a part of the “Think F-15” effort. This had never been done before at MCAIR.

CONCEPTUAL DESIGN and PROPOSAL EFFORT

I was assigned to the F-15 project in January 1969 as a young Senior Group Engineer . I had joined the company in 1957 (followed almost immediately by a three-year leave of absence to serve my time in the USAF as a flight test engineering officer at Eglin AFB, Florida). At the time of my assignment to the F-15, I was considered to be at the mid-level of engineering—five steps up from the entry level, five steps below the V.P. level.

My previous jobs had pretty well covered the field of Aerodynamics—high lift characteristics for the F-4 Phantom take-off and landing configurations; advanced design studies for the F-4; drag, performance, stability and control for various hypersonic, sub-orbital aircraft advanced design studies; a brief assignment on the ill-fated VSX program (joining after proposal submittal); heading a small Methods group developing three-degrees-of-freedom computer programs for flying qualities evaluations; and a brief assignment on the proposal effort for the VFX (which we lost).

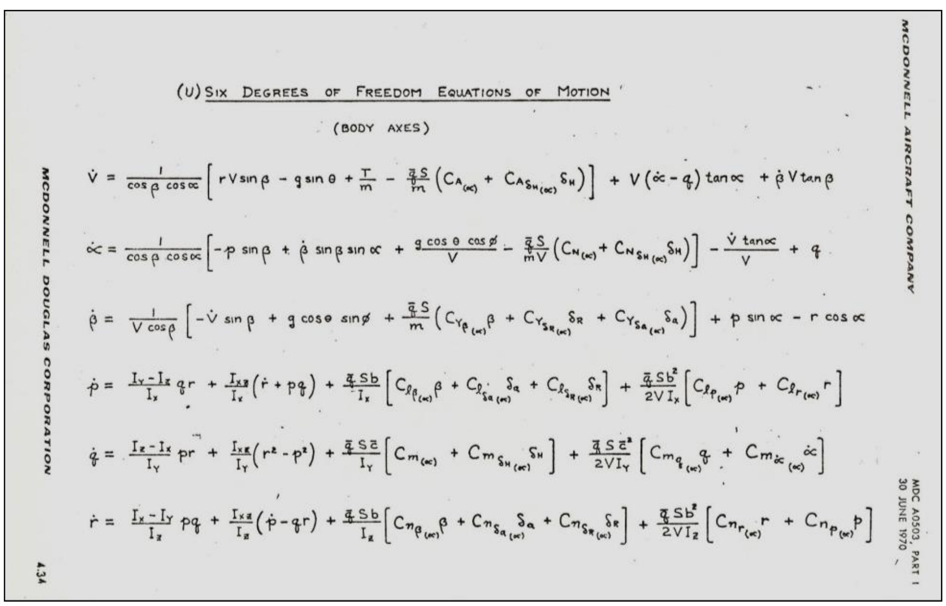
By the time I joined the program, MCAIR's F-15 configuration concept had been mostly defined. The process used for concept development throughout the industry is to:

- Define the key mission and combat performance requirements.
- Assume a size/shape/power plant based on engineering experience and judgment.
- Establish preliminary values for the fuel fraction, structural weight, thrust and drag, and wing size.
- Crank out performance capabilities and iterate, iterate, iterate until the lowest weight (cost) airplane satisfying the requirements emerges.

During our effort, wind tunnel tests of various models (800 configuration variants including 74 different wings and 58 different wing variable camber devices) were conducted. The results were fed into the above discussed iteration process. We had developed an innovative Computer Aided Design and Evaluation (C.A.D.E.) program for the iteration effort. In the process, thousands of concepts were evaluated to arrive at a near-optimum. I should note that all the aerodynamic work was done without the aid of Computational Fluid Dynamics developed later—even today, CFD has limited application to fighter aircraft.

My technical job on the F-15 was leading a small group evaluating the lateral-directional flying qualities (airplane rolling rotation about the longitudinal axis, yawing or directional rotation about the vertical axis, and lateral <side> motion *along* the left/right axis are intimately related—collectively referred to as "lateral-directional"). This effort included determination of spin characteristics, developing control schemes/laws for the flight control system, supervising wind tunnel tests in support of those areas, and writing my portion of the Proposal which was due in five months.

The calculation tools we used were primitive by today's standards—in the days before PCs, we relied mainly on the use of slide rules and some simple three-degrees-of-freedom flying qualities computer programs previously mentioned. But because of the stringent maneuvering requirements imposed on the F-15 over a larger flight envelope than ever before encountered, for some calculations, we needed to use ***six***-degree-of-freedom (pitch, roll, yaw, up-and-down, fore-and-aft, and sideways) computer programs which had been developed a little more than a decade earlier. It's a formidable task to even think about motion in six degrees, let alone the job of solving the six simultaneous equations. At one time, I had the 6-DOF equations of motion memorized. Of course, the punched-card computer facilities were primitive at the time—it was usually an over-night job for only a few runs of four or five seconds of (real) time history providing one had sufficient priority to pre-empt others desiring use of the computer facility/personnel.


(U) SIX DEGREES OF FREEDOM EQUATIONS OF MOTION

(BODY AXES)

$$\dot{V} = \frac{1}{\cos\beta\cos\alpha}\left[rV\sin\beta - g\sin\theta + \frac{T}{m} - \frac{\bar{q}S}{m}\left(C_{A_{(\alpha)}} + C_{A_{\delta_{H(\alpha)}}}\delta_H\right)\right] + V(\dot{\alpha} - q)\tan\alpha + \dot{\beta}V\tan\beta$$

$$\dot{\alpha} = \frac{1}{\cos\beta\cos\alpha}\left[-p\sin\beta + \dot{\beta}\sin\beta\sin\alpha + \frac{g\cos\theta\cos\phi}{V} - \frac{\bar{q}S}{mV}\left(C_{N_{(\alpha)}} + C_{N_{\delta_{H(\alpha)}}}\delta_H\right)\right] - \frac{\dot{V}\tan\alpha}{V} + q$$

$$\dot{\beta} = \frac{1}{V\cos\beta}\left[-\dot{V}\sin\beta + g\cos\theta\sin\phi + \frac{\bar{q}S}{m}\left(C_{Y_{\beta(\alpha)}}\beta + C_{Y_{\delta_{R(\alpha)}}}\delta_R + C_{Y_{\delta_{a(\alpha)}}}\delta_a\right)\right] + p\sin\alpha - r\cos\alpha$$

$$\dot{p} = \frac{I_Y - I_Z}{I_X}qr + \frac{I_{XZ}}{I_X}(\dot{r} + pq) + \frac{\bar{q}Sb}{I_X}\left[C_{l_{\beta(\alpha)}}\beta + C_{l_{\delta_{a(\alpha)}}}\delta_a + C_{l_{\delta_{R(\alpha)}}}\delta_R\right] + \frac{\bar{q}Sb^2}{2VI_X}\left[C_{l_{p(\alpha)}}p + C_{l_{r(\alpha)}}r\right]$$

$$\dot{q} = \frac{I_Z - I_X}{I_Y}pr + \frac{I_{XZ}}{I_Y}(r^2 - p^2) + \frac{\bar{q}S\bar{c}}{I_Y}\left[C_{m_{(\alpha)}} + C_{m_{\delta_{H(\alpha)}}}\delta_H\right] + \frac{\bar{q}S\bar{c}^2}{2VI_Y}\left[C_{m_{q(\alpha)}}q + C_{m_{\dot{\alpha}(\alpha)}}\dot{\alpha}\right]$$

$$\dot{r} = \frac{I_X - I_Y}{I_Z}pq + \frac{I_{XZ}}{I_Z}(\dot{p} - qr) + \frac{\bar{q}Sb}{I_Z}\left[C_{n_{\beta(\alpha)}}\beta + C_{n_{\delta_{a(\alpha)}}}\delta_a + C_{n_{\delta_{R(\alpha)}}}\delta_R\right] + \frac{\bar{q}Sb^2}{2VI_Z}\left[C_{n_{r(\alpha)}}r + C_{n_{p(\alpha)}}p\right]$$

MCDONNELL DOUGLAS CORPORATION

MCDONNELL AIRCRAFT COMPANY

4.34

MDC A0503, PART I
30 JUNE 1970

Besides my technical assignment, I and one other engineer (a structural type) were given the task of providing technical liaison between our engineers in St. Louis and our counterparts in the Air Force

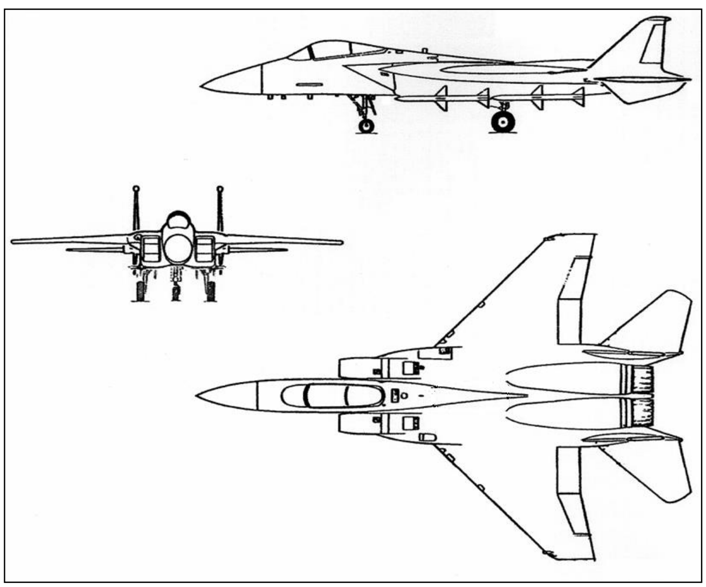
System Program Office (SPO) at Wright-Patterson AFB in Dayton, Ohio as part of the company's "programmed customer contact" effort. It was required that we coordinate also with non-SPO personnel in the event they would be assigned to the Proposal Evaluation Team. My specific job was to represent the disciplines of Aerodynamics, Guidance and Control, Propulsion, Thermodynamics, and C.A.D.E., but the job frequently expanded into the overlapping disciplines of Air Data, Fuel Systems, Contracts, and Marketing.

Some aspects of my Dayton job were both enjoyable and educational. I learned more about what the Air Force wanted and was able to convey these wants to the St. Louis technical community. I learned a bit about the disciplines outside of Aerodynamics. At the same time, I developed trusting relationships with the USAF technical people.

I was supposed to be in Dayton at least three days a week, but I managed to minimize nights away from home by making two (sometimes three) trips a week. During this period, I attended a two-day proposal writing seminar in New York City conducted by the same consultant, Jim Beveridge, previously discussed.

The technical coordination job was, of course, in addition to my St. Louis job of being an Aerodynamics Engineer and Proposal writer. For six months, we worked usually 12 hour days, often seven days a week analyzing wind tunnel test results, calculating/documenting airplane characteristics, and writing our portion of the Proposal. For the duration of the Proposal effort, all vacations of F-15 personnel were cancelled.

Finally, after spending 2.5 million man-hours, the Proposal (37,500 pages in 382 separate subject volumes) was wrapped and delivered. The doors of the SPO were generally closed to the competing contractors (except for USAF-requested meetings) for the six-month Proposal Evaluation period.



After a short vacation, I got back to work as an engineer—that's when the fun began!

LATERAL-DIRECTIONAL PROBLEMS

Our wind tunnel tests had continued during the proposal preparation effort and through the summer. In addition, NASA conducted tests on the proposed configurations of all three contenders in a "fly-off" of sorts. When our configuration was tested complete with its complement of external weapons throughout the flight envelope, a problem was revealed—the airplane was seriously lacking in directional stability at the previously untested higher subsonic angles of attack (above about 20 degrees nose high relative to the oncoming wind) and at high supersonic (above about Mach 1.4) conditions.

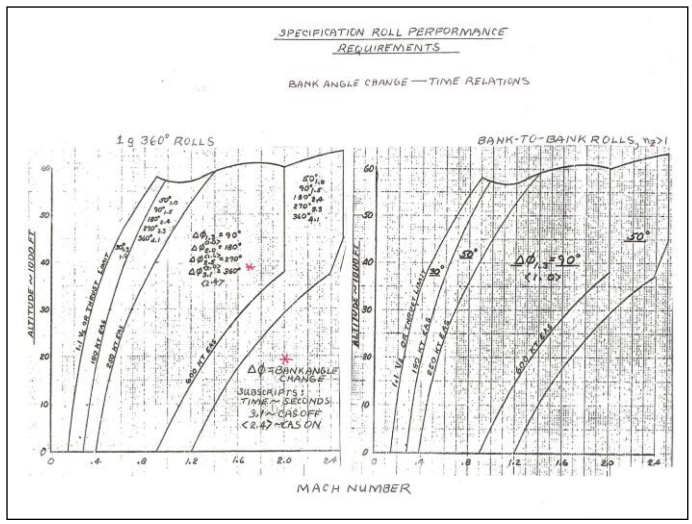
Directional stability is necessary to keep the airplane nose pointed forward into the wind; it is achieved with aft-mounted vertical surfaces as in the tail feathers of an arrow. A directionally stable airplane will tend to rotate about its center-of-gravity always pointing towards the relative wind like a weather vane about its support.

The high angle of attack problem arose as a result of adverse airflow characteristics in the vicinity of the vertical tails caused by the flow separation around the engine inlets and the inboard portions of the wings. The aft fuselage wide body prevented the airflow from recovering before reaching the tails.

The supersonic problem resulted from ineffectiveness of the lower surface ventral fins located almost directly behind the fuselage-mounted missiles. At these conditions, the ventrals were just along for the ride in the missile wake creating nothing but drag.

In addition to weak directional stability, we learned that the configuration exhibited a greater amount of "adverse yaw" due to roll control surfaces than had been anticipated. (Adverse yaw is when the airplane will initially yaw about its vertical axis in a direction *opposite* to the desired direction of turn requested by the pilot application of roll control—e.g., right stick results in initial left yaw). Many airplanes have some level of adverse yaw. To counter it, pilots are taught to coordinate their control inputs with a blend of stick and rudder pedal inputs.

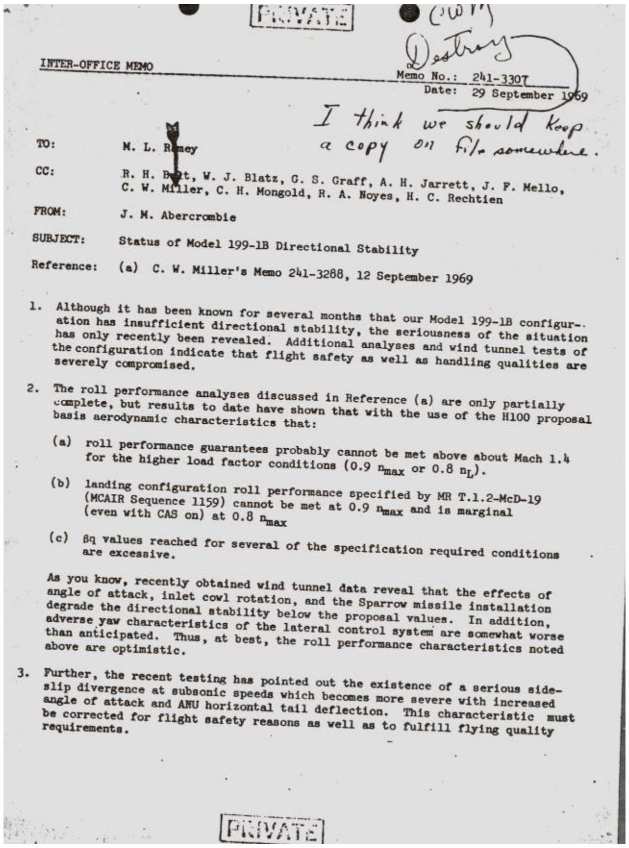
The F-15 basic specification requirements, however, were to be able to roll the airplane (rapidly) with "feet on the floor"—no rudder pedal input. Further, the spec required that this be accomplished without the aid of electronic, computer controlled inputs to the control surfaces. In other words, the airplane control surfaces had to be able to respond to pilot input using only a mechanical control system (push-rods, linkages, hydraulic actuators). An electronic Control Augmentation System (CAS) was provided, but it was to be merely "frosting on the cake." These mechanical control system requirements were imposed because at the time, electronics and computers for such application were primitive and unreliable compared to those of a decade later.



Well, I was quite alarmed at these developments. Not only could the airplane not achieve the flying qualities characteristics we (***I*** in particular) had promised the Air Force, in some flight conditions, the characteristics could be life-threatening to the air crew. I concluded that the configuration had to be changed. My voiced opinion was not very popular, needless to say—a configuration change in the midst of a proposal evaluation was something to be avoided.

However, I knew my counterparts at the SPO were examining the same wind tunnel test data as was I, and I didn't feel we had the luxury of ignoring the problem. So, in desperation, I put my job on the line and wrote an interoffice memorandum to the V.P. of Engineering Technology, "Pete" Ramey with copies to a number of high-ranking engineering management individuals, including the V.P. of Engineering, George Graff. George was probably the most respected of all the engineering managers at the time. He was (and remained) one of my most respected mentors having advanced through the Aerodynamics organization to become VP of Engineering. In the memo, I outlined the problems, suggested appropriate modifications to the airplane, and recommended a wind tunnel test devoted to the specific issues.

George didn’t seem to think that flagging the directional stability problem while the USAF was still evaluating our Proposal was a good idea. He instructed the Chief of Aerodynamics (who I worked for—three levels below George) to DESTROY THE ORIGINAL AND ALL COPIES OF THE MEMO. (Through the rest of my career, that memo was known as the “Burn Memo”. However, not all copies were destroyed—a few years later when I became Chief of Aerodynamics, I found that the then Chief, Chet Miller, had hung on to his copy, so I resurrected it).



PRIVATE

(own)

Destroy

INTER-OFFICE MEMO

Memo No.: 241-3307
Date: 29 September 1969

I think we should keep a copy on file somewhere.

TO: M. L. R[illegible]ey

CC: R. H. B[illegible]t, W. J. Blatz, G. S. Graff, A. H. Jarrett, J. F. Mello, C. W. Miller, C. H. Mongold, R. A. Noyes, H. C. Rechtien

FROM: J. M. Abercrombie

SUBJECT: Status of Model 199-1B Directional Stability

Reference: (a) C. W. Miller's Memo 241-3288, 12 September 1969

1. Although it has been known for several months that our Model 199-1B configuration has insufficient directional stability, the seriousness of the situation has only recently been revealed. Additional analyses and wind tunnel tests of the configuration indicate that flight safety as well as handling qualities are severely compromised.

2. The roll performance analyses discussed in Reference (a) are only partially complete, but results to date have shown that with the use of the H100 proposal basis aerodynamic characteristics that:

   (a) roll performance guarantees probably cannot be met above about Mach 1.4 for the higher load factor conditions (0.9 n_{max} or 0.8 n_L).

   (b) landing configuration roll performance specified by MR T.1.2-McD-19 (MCAIR Sequence 1159) cannot be met at 0.9 n_{max} and is marginal (even with CAS on) at 0.8 n_{max}

   (c) βq values reached for several of the specification required conditions are excessive.

As you know, recently obtained wind tunnel data reveal that the effects of angle of attack, inlet cowl rotation, and the Sparrow missile installation degrade the directional stability below the proposal values. In addition, adverse yaw characteristics of the lateral control system are somewhat worse than anticipated. Thus, at best, the roll performance characteristics noted above are optimistic.

3. Further, the recent testing has pointed out the existence of a serious sideslip divergence at subsonic speeds which becomes more severe with increased angle of attack and ANU horizontal tail deflection. This characteristic must be corrected for flight safety reasons as well as to fulfill flying quality requirements.

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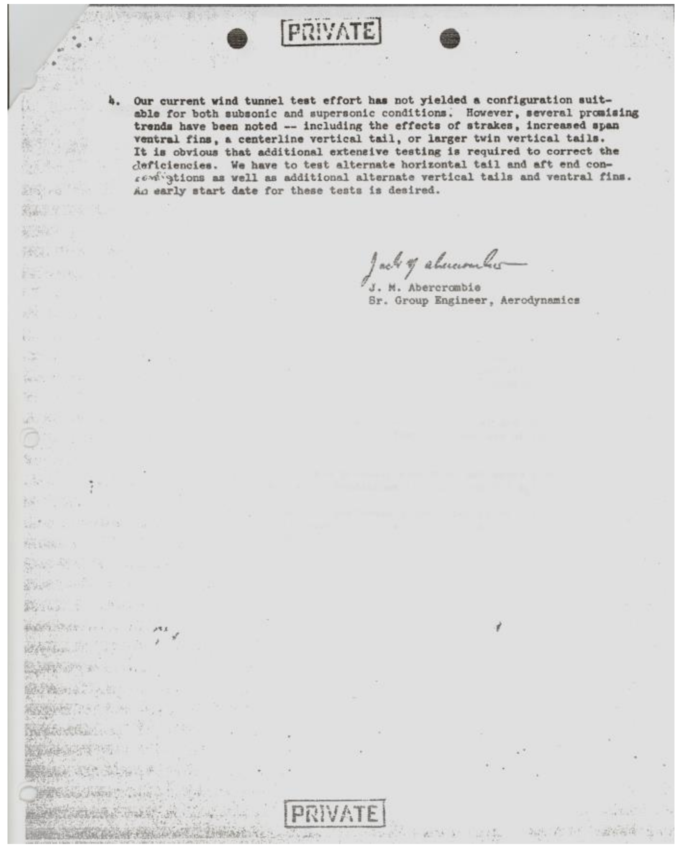

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4. Our current wind tunnel test effort has not yielded a configuration suitable for both subsonic and supersonic conditions. However, several promising trends have been noted -- including the effects of strakes, increased span ventral fins, a centerline vertical tail, or larger twin vertical tails. It is obvious that additional extensive testing is required to correct the deficiencies. We have to test alternate horizontal tail and aft end configurations as well as additional alternate vertical tails and ventral fins. An early start date for these tests is desired.

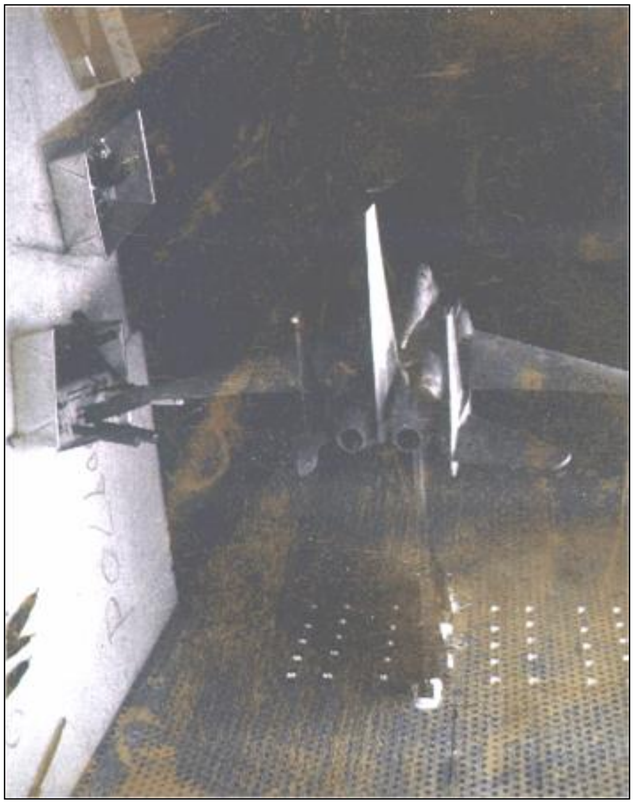
Jack M Abercrombie
J. M. Abercrombie
Sr. Group Engineer, Aerodynamics

PRIVATE

A second reaction to the memo was the approval (thanks to Graff) of a modest, 80 occupancy-hour wind tunnel test in our Polysonic Wind Tunnel (PSWT) to evaluate my suggestions and, also, to look for some “magic” minor configuration refinement that would seem insignificant on a 3-view drawing (we at the working level called such inconspicuous changes “postage stamps”) and, thus, would not advertise the problem. A third reaction to the memo was my own—a fear that my job was in serious jeopardy.

Wind tunnel tests began in mid-September ’69. The one authorized test of a 4.7% scale model (2 feet wing span) in the PSWT quickly developed into two simultaneous tests including the Low Speed Wind Tunnel (LSWT) utilizing a larger, 13% scale model (5 feet, 6.5 inches wing span). The two tunnels operated in three shifts, around-the-clock, seven days a week for a period of six weeks and 2100 occupancy-hours—26 times the original 80 hour authorization. In addition to the large number of wind tunnel Laboratory personnel, we worked 12 Aerodynamics engineers, one Project Aerodynamicist, two Section Managers, the Chief of aerodynamics, and a few consultants from other projects. Most participants worked their shifts then went home, but not I. In addition to my intimate involvement with test planning and data analysis, I was required to have a report (hand-written since secretarial help wasn’t available in the wee hours) summarizing the previous 24-hour happenings on the desks of the V.P.—Engineering Technology Pete Ramey, the F-15 Deputy General Manager-Technology Bill Blatz (also a V.P.), the F-15 Director for Configuration Development Al Jarrett, and my own functional supervision by the time they came to work at 0800. And then, a daily three to four hour meeting was held with the same personnel beginning at 0900.

We tested a lot of major configuration changes as well as “postage stamp” devices consisting of some 56 strakes/fences, 11 aft fuselage contour fairings, 38 variations to the vertical tails, 23 variations to the ventral fins, and nine horizontal tail variations in addition to combinations of these variables. We performed various airflow surveys to document the confused flow at the transonic (M=0.9) high angle of attack (25 degrees) conditions (breaking one model off at its support due to the violent shaking—total destruction).



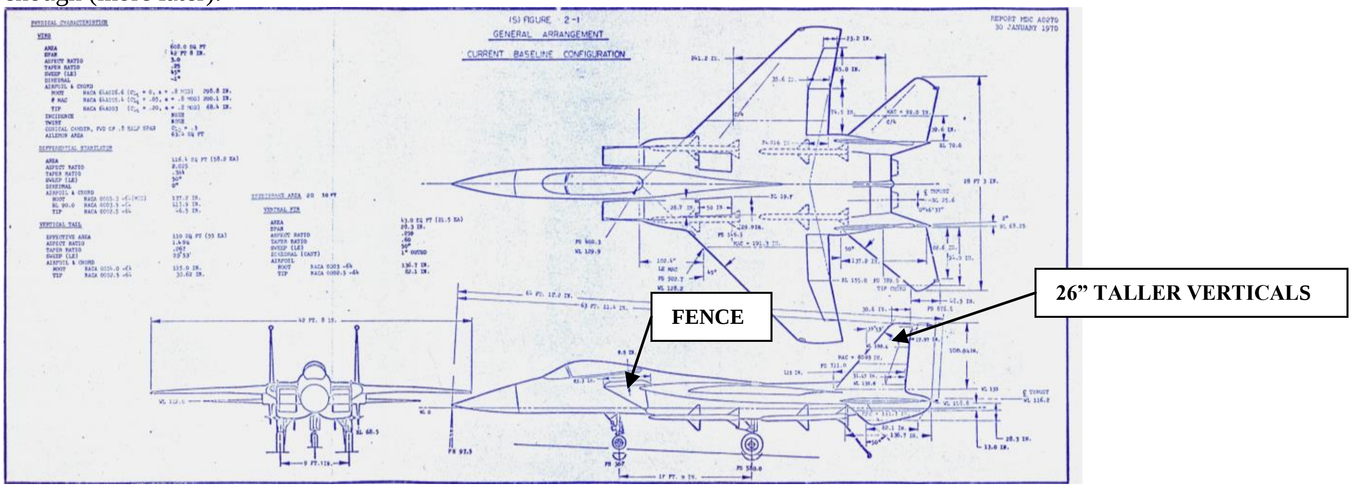
Testing concentrated on three critical conditions (M=0.9 high angle of attack and supersonically at M=1.6, and M=2.25) with additional explorations at both higher and lower speeds. In my way of thinking, the primary area of concern was the high supersonic conditions—without adequate directional stability and with a roll control input, the airplane could turn sideways and break up, as indeed, our analyses showed (although at the time there were uncertainties about aeroelastic effects on the empennage and on control surface hinge moment characteristics).

The other critical condition (e.g., M=0.9 at high alpha) was not where the airplane would necessarily break up if it got out of control, but it was where the airplane would either not respond adequately to pilot input to roll the airplane, or, at worst, would depart from controlled flight and possibly enter a spin. This condition was the subsonic, high angle of attack flight regime.

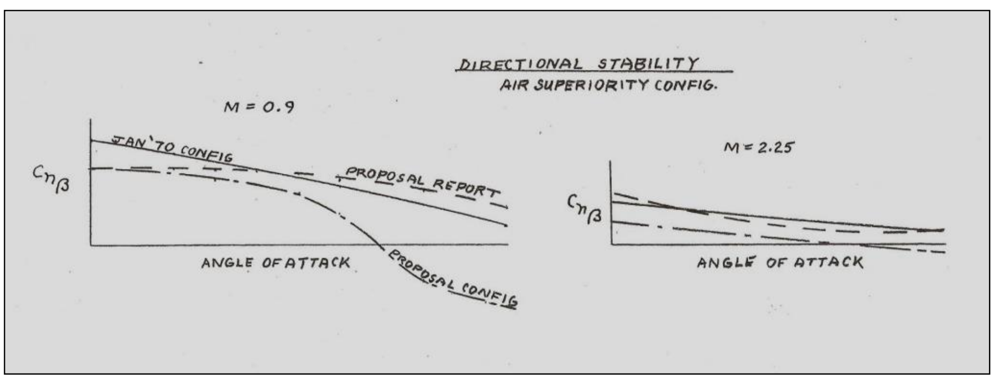
The solutions to both these problems, I believed, based on the wind tunnel test results obtained thus far, were taller, larger vertical tails (of course at the risk of changing the airplane appearance!).

During a portion of this time, the NASA wind tunnel test results were being analyzed by the F-15 SPO. In October, 1969, we were summoned by the SPO to discuss the NASA test results. It was obvious that my concern about the lateral-directional problems was shared by the potential Customer.

After nearly three months of frustrating testing, analyses, discussions, and presentations, finally, in a flash of brilliance, our F-15 Director for Configuration Development decided on a solution—we would merely “lift the vertical tail tips upwards 26 inches.” This was his idea of making a change without being too obvious! There were some other “coupon” changes (fences on the outside of the nacelle inlet), but, of course, the increasing of the vertical tail size by 33 percent helped the most. But even this change was not enough (more later).



Of course, I continued to fear for my job security. But a few days before Christmas, our company stock shot up, a Long Island (home of one of our competitors) senator started complaining about the program, and we started getting reports of extreme pessimism from our other competitor in California. These were good indications that we had won! Two days before Christmas ’69, the Air Force announced its decision—the winner of the F-15 competition was McDonnell! We had a great celebration party that evening (I interrupted a long-delayed vacation to attend), and for the first time in several months, I felt job security—at least for awhile.

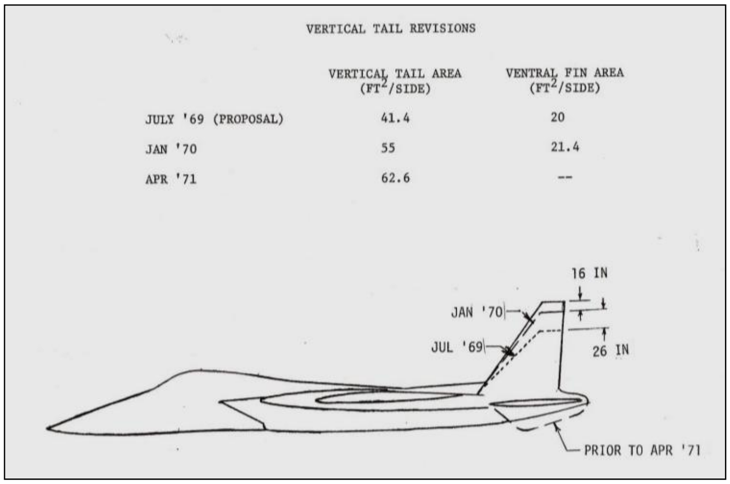


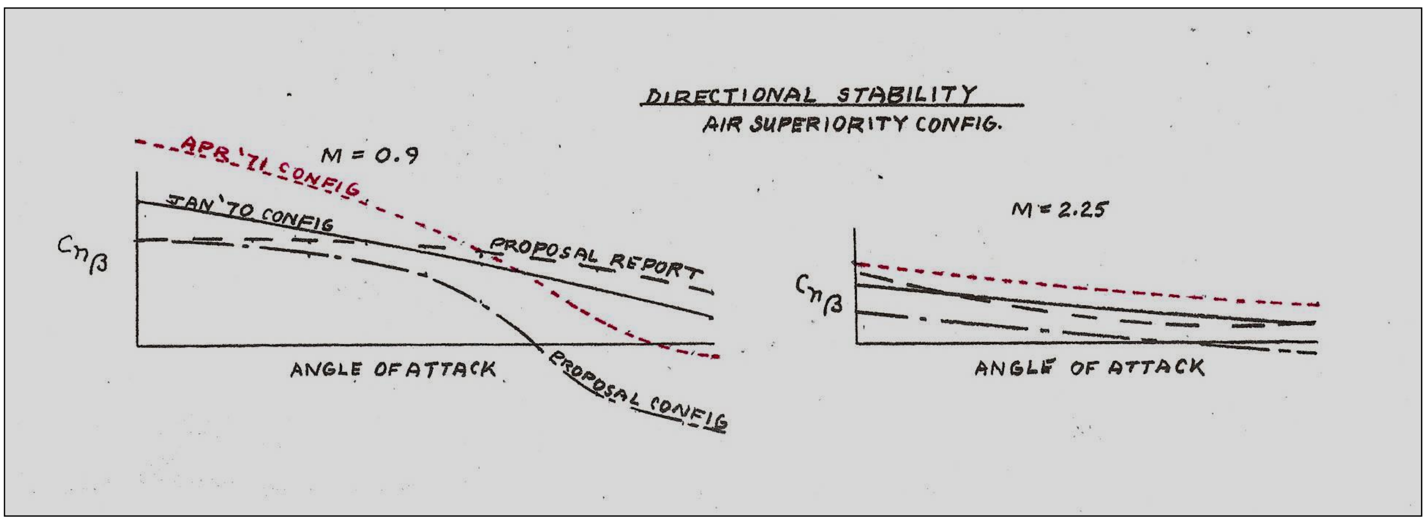
Less than a month after the win announcement, we formally presented the new configuration with the vertical tail height/area increase and the nacelle fences.

DETAIL DESIGN

For the next year, we continued wind tunnel testing, analyzing, and documenting the airplane characteristics while Detail Design activities ramped up. I made several trips to Government wind tunnels at NASA Langley, NASA Ames, and the Air Force AEDC. But the *supersonic* level of directional stability, although improved with the January ’70 increase to the vertical tail size, still was not enough.

We knew from our 1969 wind tunnel tests that the ventral fins in the presence of the missiles mounted on the lower corners of the fuselage (ahead of the ventrals) were ineffective at supersonic conditions. (I likened the ventrals to being about as useful as the rear fender fins on a ’56 De Soto). One of my functional supervisors, being more politic than I, had kept that information in his pocket for more than a year. I never understood the reason for his inaction until the spring of 1971—at this time, he used the information in bargaining with the Director for Configuration Development and the V.P. of Engineering for a further increase in vertical tail size while *completely eliminating the ventral fins.* As a result, besides helping the directional characteristics, he could save a few counts of drag and a few pounds of structure for improved performance. Thus, the vertical tail tip was again lifted upward another 16 inches (now higher by 42 inches than in the Proposal configuration of 1969) for a further increase in tail size (of course, once again, barely noticeable!). With this change, the directional stability was marginally acceptable based on our understanding of the aeroelastic characteristics and the control surfaces hinge moments at the time.





My supervisor was credited with improving the airplane performance through drag and weight reductions. I was transferred to a different job. I never knew if my transfer was intended to be a reward or punishment.

That's how the Eagle got its tall tails!

EPILOGUE

The project to which I was transferred was still with the F-15, but in an Advanced Design F-15 group whose task was to promote the airplane by inventing modifications for improvement, new weapons carriage concepts, performance enhancements, etc. Among the potential changes we worked on were increased fuel with low subsonic drag "strap-on" Conformal Fuel Tanks (CFTs) on the sides of the fuselage below the wings (in the "armpits").

For the next year, I split my time between Advanced Design and the Project. In March ’72, I transferred back into the Project full-time in preparation for the Flight Test program. A few weeks before the first flight, I joined the test team at Edwards AFB, a team which eventually grew to about 500 employees working for outstanding leaders such as Bill Ross, C. E. “Bud” Anderson, Hermon Cole, Irv Burrows, Bob Grogan, and many notable individuals.

The first-flight occurred on 27 July 1972. The flight test program utilized a dozen airplanes at Edwards (plus one at Eglin, FL) over the three-year test period. It was one of the most successful flight test programs in modern history.

Jack Abercrombie
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