

AN EVALUATION OF LT COL JOHN R. BOYD'S

CREATIVE, PROFESSIONAL CONTRIBUTIONS TO THE USAF

Shortly after his involvement in the Korean conflict, possessing the enriching experience of teaching tactics in a CCTU at Nellis and becoming a graduate of the Fighter Weapons School (then) Capt John R. Boyd was assigned to the FWS as an instructor. Here he made his first significant contribution to fighter operations. He wrote the Air Combat Training (ACT) manual used for instruction at Nellis. He created the attendant lesson and mission plans for the ACT program. His excellent analysis of modern flight maneuvers, the first such work, published in the June 1957 issue of the Fighter Weapons School (FWS) Newsletter was to become an enduring classic.

Lt Col Boyd created many of the maneuvers included in the analysis. As a creative military analyst, he tried, developed, and evaluated many novel elements of Air Combat Maneuvering (ACM). For example, he was the first officer to formally isolate the adverse yaw problem in the F-100A, C aircraft. He had the answer (liberal use of rudder and very little aileron when at high angles of attack) and was teaching it before the test pilots of Edwards AFB isolated the problem. Lt Col Boyd was the first to question the use of very high G maneuvers so fashionable at Nellis during that period. He developed the "soft maneuver" analysis and started to explore and define the impact of the vertical dimension in fighter maneuvers.

In early 1959 Lt Col Boyd made his beginning analysis of pursuit curve trajectories. He he found the mathematical reasons for the associated

physical tracking problems. He published his results in the March 1959 issue of the FWS Newsletter -- another classic. He was to continually build on these results in later years.

In 1959-1960 just before leaving Nellis, he wrote another enduring classic, his "Aerial Attack Study." This was the first formal analysis of fighter maneuvers in which he not only catalogued the repertoire of basic maneuvers and possible counter-maneuvers but he showed their relation to tactical doctrines. In presenting the doctrines and the rationale on which they were based, he offered the art of fighter tactics one of its most powerful ideas -- that for a maneuver there is a counter-maneuver, for a tactical system there is a counter-system, and it is the understanding of maneuvers, tactical doctrines, and their possible options which will determine the outcome of airbattles. Incorporated within this study was Lt Col Boyd's analysis of the "Sidewinder" missile. He was the first to question the idea that missiles would bring an end to the maneuvering airbattle among fighters. Until Lt Col Boyd forced and indeed effected much of the analysis, the U.S. Navy had a dilettante's view of the successful delivery envelope for the missile. His work, represented by this singular study, was never matched by the contributions of other pilots at Nellis AFB.

Lt Col Boyd left Nellis in 1960 to go to Georgia Tech to get a Bachelor of Science Degree in Industrial Engineering. This education did nothing but bear more fruit in his ensuing work. He was next assigned to Eglin AFB.

At Eglin (then) Major Boyd was to initiate one of his most notorious, most widely accepted efforts -- his Energy Maneuverability analyses. Despite the considerable strain of operating in a domain where few of his peers and commanders appreciated or understood the implications of this emerging work; he completed the famous work: TR-66-4, Energy Maneuverability, Vols. I and II.

This work has never been rivaled for excellence, comprehensiveness, and substantive contribution to the analysis of the performance and maneuverability of fighter (and other) aircraft. For the first time, Air Force Commanders had available a tool which would permit comparative evaluation of aircraft in a global presentation of its capabilities. His previous work on aircraft pursuit trajectories now gave additional fruit because he was the first to question (and answer) what happened to the successful delivery envelope of a missile aircraft attacking a target that uses "S" maneuvers for evasion. These envelopes developed disturbing holes which made them look like Swiss cheese. The results made all missile contractors review their previous overly optimistic analyses. The analysis contributed toward the development of anti-SAM operations in North Vietnam, but this is another example of a "Boyd First."

Lt Col Boyd, together with the now well known Mr. Thomas Christie, developed general missile simulation programs. He deepened and proliferated his Energy Maneuverability and Attack Geometry Analysis.

By this time, his work had made him famous and notorious among the engineering and military world. In 1965, he received the "AFSC Scientific Achievement Award" at the 12th Annual Symposium for Science and Engineering

for the best Engineering Analysis. In 1966, he received the Air Force "Research and Development Award" for Outstanding Contribution to Aeronautical Engineering. He received the Air Force Association "Citation of Honor" in 1969 for Pioneering Development in Fighter Tactics and Analysis Leading to Superior Combat Capability in Fighter Aviation and Fighter Aircraft Design.

In 1966, as a volunteer to fly F-4C's in Vitenam, because of his analytical expertise, he was reassigned to the FX project in AFRDQRT at the Pentagon. Here all his previous work fructified in new analyses which modified a (then) ineffectual solution to the FX ROC to that which eventually became the existing F-15. He developed, fostered, and forced new trade-off studies and techniques which eventually identified the proper engine cycle, engine size, wing configuration and wing loading for the F-15. This result together with his parametric trade-off techniques led eventually to the specific application of the selection of the best variable sweep wing for the FX and the best fixed wing. During this period he created his "Expanded Energy Maneuverability Concept" which used in combination with the trade-off techniques proved the logical basis for choosing the fixed wing over the variable sweep wing - quite an achievement in a period where the current fashion and pressures were all to use variable sweep wings. By October 1969, he had almost completed his "Fully Expanded Energy Maneuverability Concept." Results derived from this concept not only permitted aircraft evaluation but the insights his curves displayed were very closely related to the air battle (dog fight). Now optimum fighter maneuvers

were more derivable. A new reformulation of attack geometry analysis was developed to make more perspicuous the results of terminal attack maneuvers using both guns and missiles. These results will heavily impact analysis of the role, possible employment, and development of the Short Range Missile (SRM).

He early saw the need for the rational question that must be addressed by Air Force military planners - "What is the role of numbers, aircraft quality, and training effectiveness on the outcome of an air superiority war?" His work is the only significant analytical (formula) analysis of this kind developed since the celebrated (and inapplicable) Lanchester equations. Here he showed his breadth of scope and reiterated his creativity and combat relevance.

A more specific insight into this remarkable man comes from his work on the FX, F-15 project - a project he deeply loved and greatly served. When he came to the Air Staff, he was asked to evaluate the accepted solution and Air Staff position on the FX aircraft. This concept had been given an "optimum" solution culminating in a 62,500 lb aircraft and a thrust-to-weight ratio at take-off (T/W) of 0.75, a wing loading (W/S) equal to 110 lbs/ft², with a turbofan engine of 2.2 bypass ratio. He correctly saw that this would lead to a disaster both before the Congress and before the enemy. He held forth the results of his analysis (trade-off study) and the first cut was to modify the solution to a 40,000 lb aircraft with T/W at takeoff equal to 0.97, a W/S of 110 lbs/ft². He became suspicious of the effects of high wing loading so he made an intensive investigation of aircraft drag polars. The result of this analysis was to bring the wing loading down to 80 lbs/ft² and an engine bypass ratio of 0.9. Only with

this progress did it begin to become clear that at light wing loadings a fixed wing could become competitive with a variable sweep wing. Limited engine data provided by the contractors showed that the best value of engine bypass ratio was the least possible value, 0.6. He developed new EM analyses which gave new insights in mission analysis and developed new tasks relevant rules for fuel budgeting. Now his tradeoff analyses in another iteration lead to a 40,000 lb aircraft with $T/W = 1.1$, and a W/S of 80 lbs/ft^2 for a variable sweep wing. His computations then revealed that a fixed wing of 60-65 lbs/sq ft had definite combat advantages over the fashionable variable sweep wing. This led to the definition of the F-15 as it is today. No one else in the USAF could have achieved these results.

It is interesting to realize that his achievements were not purely theoretical, analytical or military; his work was very pragmatic. He had the ethical integrity of backing his insights to save the FX concept from the original overweight, underwinged, overly expensive, overcomplex, ineffective 62,500 lbs solution being proposed by others.

His wide range of insights and abilities led him to "anticipate" the Navy move to switch from a fighter attack VFAX to an air superiority F-14. He wrote a memo eliciting his prediction for General L. L. Wilson and prepared a briefing on methods for countering the Navy ploy. This was the second time he kept the USAF FX concept viable. His insights and abilities led him to "anticipate" the current budget squeeze on the defense establishment and he took the timely and forceful action to change some specifications for the F-15 plus suggesting a list of expensive (and relatively ineffective, if fashionable) equipment for removal. The list of his fruitful actions,

He has modified, optimized, guided, and (frequently) saved the F-15 concept and program.

He has received many awards for his remarkable achievements.

He has seldom been understood or appreciated by his peers or commanders. They have frequently looked at his small human failings instead of his outstanding contributions. Despite being the most fruitful military and scientific contributor to fighter aviation in the history of TAC, he has been given rather ordinary OER's. His ratings were instrumental in retarding his progress, convincing him that he was unappreciated by the Air Force.

Lt Col Boyd has had an impeccable record of the highest professional integrity and he has had the courage of his convictions and the loyalty to his country to present them to all that were necessary, to do the right.

Fighter aviation can never be the same for the advent of Lt Col Boyd. Aircraft and battle analysis will never be the same. The entire spectrum of aircraft contractors has modified their analyses and presentations. Air combat tactics can never revert to the pre-Boyd era.

IT IS STRONGLY RECOMMENDED that every effort be expended to retain this officer in the Service. No effective organization can rationally allow itself to lose such a spectacular major contributor and expect to dominate the enemies of our country.