

Tribute To John R. Boyd

By **Harry Hillaker** Posted 28 January 2015

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As I sat sipping an after-dinner drink in the Officer's Club at Eglin Air Force Base in the Florida panhandle, I was distracted by the antics of three pilots, still in their flight suits, standing at the bar. One of them, tall with dark curly hair and a cigar in his mouth, talked in a loud animated manner. He used his hands to emphasize his words as fighter pilots are prone to do. I commented to my host, a colonel and chief of development planning, "There's a guy who obviously thinks he's the world's hottest fighter pilot."

"That's John Boyd, who may well be one of the hottest fighter pilots," my host responded. "You should meet him."

I wasn't too interested because I don't cotton much to loud, showy people. My host, however, insisted. It turned out that Boyd didn't cotton to me either. Upon learning that I was from industry and working on the F-111, he really blistered me.

"You call the F-111 a fighter?" he asked.

"It's designated a fighter-bomber," I countered, which didn't placate him.

"You guys in industry this, and you contractors that," he ranted. He thought I didn't know "beans" (not the exact word he used) about fighters. The atmosphere, to say the least, was icy. Our lively discussion continued. As we bantered, we slowly began to understand each other. We parted on somewhat amiable terms.

Little did I realize how profound that meeting would be. A few days later, back home in my office, I received a phone call from an associate of Boyd's who also knew me. Boyd had decided that I knew more than a little about aircraft conceptual design and wanted to know if I would be interested in meeting with him again. This time for a more productive purpose: to help him translate his new energy-maneuverability theory into relevant and meaningful aircraft parameters.

I had gleaned just enough from our fiery discussion to pique my curiosity. I agreed, and thus began a long and extremely satisfying and productive association. Over the next six years, I participated in many all-night sessions in Washington DC with Boyd and his small elite group. The group came to be known as the "Fighter Mafia" because of its close-knit underground operation. The mafia dissected and analyzed every facet of air combat and its relevance to aircraft parameters. In the process, we defined a concept for what became known as the Lightweight Fighter, progenitor to the F-16.

Boyd, as a combat pilot in Korea and as a tactics instructor at Nellis AFB in the Nevada desert, observed, analyzed, and assimilated the relative energy states of his aircraft and those of his opponent's during air combat engagements. For nearly five years at Nellis, he flew two to three times a day against other fighters, mostly F-100 SuperSabres. He found that he could gain the advantage under one set of maneuvering conditions and that his opponent could gain the advantage under another set of maneuvering conditions.

He also noted that, when he was in a position of advantage, his energy was higher than that of his opponent and that he lost that advantage when he allowed his energy to decay to less than that of this opponent. By applying this knowledge, he sharpened his skills to such a high degree that he became known as "Forty-Second Boyd." He had a standing bet that in forty seconds or less, he could wipe out anyone who would take to the skies against him. He never lost the bet. All were astounded and humbled by his incredible skill.

Boyd himself was not overwhelmed by such feats. He fully understood that his knowledge of how to use the strengths and weaknesses of an airplane to his advantage enabled him to prevail over his opponents and not necessarily his pilot skills, as good as they may have been. He had a passion for insight and an unbending commitment for truth and understanding. He sought to

understand the intricacies of maneuvering flight—What was it about an airplane that would limit or prevent him from making it do what he wanted it to do?

To gain a finer understanding, he probed the principles of thermodynamics. He wanted to understand the states of energy; their conversion and their equilibrium. He knew that, when turning from a steady-state flight condition, the airplane under a given power setting would either slow down or lose altitude or both. The result meant he was losing energy (the drag exceeded the thrust available from the engine). From these observations, he concluded that maneuvering for position was basically an energy problem. Winning required the proper management of energy available at the conditions existing at any point during a combat engagement.

This train of thought led Boyd to develop a means of quantifying pertinent maneuver parameters into a meaningful form, a form that became the yardstick for identifying and measuring areas of advantage of opposing fighters within the combat arena. The parameters could also be used to establish areas of maximum maneuver potential in the design of new aircraft. His concept is based on "fast transients," that is, quick changes in speed, altitude, and direction. By "fast" he didn't mean speed. He meant time. The idea of "fast transients" advances the theory that, to win or gain superiority, you must get inside the adversary's time scale. Boyd called this time scale the OODA loop (OODA, for Observation-Orientation-Decision-Action).

Boyd postulated that all engagements of opposing forces can be divided into four essential elements: (1) observe and interpret the situation, (2) become oriented to the condition and intensity of the situation, (3) make a decision as to what response to make, and (4) put that response into action. The key is to obscure your intentions and make them unpredictable to your opponent while you simultaneously clarify his intentions. That is, operate at a faster tempo to generate rapidly changing conditions that inhibit your opponent from adapting or reacting to those changes and that suppress or destroy his awareness. Thus, a "hodge-podge" of confusion and disorder occur to cause him to over- or under-react to conditions or activities that appear to be uncertain, ambiguous, or incomprehensible.

Put more succinctly, deny your opponent the use of his maneuvering advantages against you while you convert your strengths into an advantage over him and cause him to make a wrong move, one that can be easily defeated. Time is the dominant parameter: the pilot who goes through the OODA cycle in the shortest time prevails because his opponent responds to actions that have already changed. In very simple terms, be unpredictable; operate at a pace and pattern that allows you to get him before he gets you.

This approach favors a fighter that is superior in its ability to gain or lose energy while out-turning an opponent; a fighter that can initiate and control any engagement opportunity; and a fighter that has a fast transient capability to stay inside a hard-turning opponent when you're on the offensive (you are attacking him) or to force an overshoot of an opponent when you're on the defensive (he is attacking you). The F-16 Fighting Falcon has just that kind of agility, plus the situation awareness to capitalize on that agility.

Boyd's theories didn't make him too popular within the Air Force. Many couldn't accept his premise that speed was not as important as agility nor his criticisms of how the Air Force conducted itself on certain matters. His direct, forthright manner, often very blunt on controversial issues, didn't help his popularity much either.

Many people saw Boyd as either a madman or a genius. Boyd savored that image as a tactical advantage. He was always seeking ways to seize the advantage and keep a firm grip on it. For Boyd, conversation was often a contact sport. With a booming voice, he would engage others nose-to-nose, thrusting his forefinger into a chest to emphasize a point and punctuating his conversation with, "Do you hear what I'm saying?" or "Do you get my meaning?"

At other times, he would talk in a measured tone with careful, deliberate wording, pausing at times to let what he was saying sink in. When his voice became soft, almost inaudible, watch out, you'd just been caught in a contradiction or an inaccuracy. If you attempted to equivocate, you would be greeted with an explosive, "Ho, ho!" followed by, "Now you're waffling," or "How does it feel to have to squirm?" On such occasions, he was often called "Genghis John" in addition to his forty-second nickname because of his challenging and conquering exploits. He was also called the "Ghetto Colonel" because of his Spartan lifestyle.

Boyd's "energy-maneuverability," or energy management theory, emphasizing the use of differential energy states first showed promise on a fateful day in April 1965 over North Vietnam. On that day, North Vietnam MiG-17s attacked a formation of four USAF F-105 Thunderchief fighter-bombers making a bomb run on the Than Hoa bridge. Two of the F-105s were immediately shot down. A third was hit and smoking as it sought escape. The fourth, flown by a command-level pilot, attempting to cover the crippled F-105 found himself helplessly in the clutches of one of the MiG-17s. All efforts to shake his tormentor were unsuccessful. As his situation became increasingly desperate, he recalled something he had rejected as being totally ridiculous the day before. A captain from the Fighter Weapons Center at Nellis had briefed this same F-105 squadron on the best maneuvers for air-to-air engagements against opposing MiGs. One of the suggested defensive maneuvers was to snap roll the F-105.

"Ridiculous," snorted this very pilot, "any idiot knows the F-105 is a dog in that maneuver." With the MiG-17 still clinging tenaciously to his tail, the surviving F-105 pilot needed a miracle. So, he initiated a snap roll. The maneuver caused his airplane to decelerate at such a high rate that the MiG-17 over-shot him, exactly what the captain had said would happen. The American pilot found himself on the MiG's tail. He was so surprised by the result that he blew his chance to shoot down the MiG with his 20mm gun. The "idiot" pilot from Nellis was, of course, John Boyd.

Boyd continued to refine his theory and saw it used to a limited extent to enhance the capabilities of the F-15. From that effort, Boyd's theories gained some recognition. Subsequently, the Air Force awarded small contracts to General Dynamics and Northrop for a "Study to Validate Expanded Energy-Maneuverability Through Trade-Off Analysis."

At the completion of the study, each contractor was required to give a briefing on the results of its efforts to USAF officials at Wright-Patterson AFB in Dayton, Ohio. Being project leader of

the study, I gave the briefing. Afterwards, I was complimented on the results and particularly on how I handled "that major" with his continuously probing and challenging questions. What they didn't know was that "that major," John Boyd, and I had spent the previous evening orchestrating the presentation. We devised the questions and answers to emphasize the important and meaningful points. Boyd was willing to be used to make a point for the cause.

The study showed that it was possible to have a fighter that was twice as maneuverable with twice the mission radius of the F-4D Phantom while weighing only 17,050 pounds. The study generated enough interest and gained enough attention to be a candidate for then Deputy Secretary of Defense David Packard's directed "experimental prototype" program. The rest is history: an airplane that has made history.

Boyd's theories are now used as a yardstick for measuring and comparing the maneuvering capability of all modern fighters. He planted the seeds for the Lightweight Fighter, cultivated those seeds, and helped harvest them in 1972 while playing a major role in defining the requirements that were put into the request for proposal for the Lightweight Fighter. The proposal led directly to the YF-16 and YF-17 technology demonstration prototypes. His influences can be seen in world-class fighters such as the F-15, F-16, and F/A-18.

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Many years after that chance meeting in Florida, the F-16 has done John Boyd proud. It will continue to honor his memory. Boyd died of cancer in Florida on 9 March 1997 at the age of seventy. He was laid to rest in the Arlington National Cemetery with full military honors on 20 March. John left his mark, wanting only to do what he thought was best for the Air Force, his air force. He changed the complexion of air combat and fighter design. No F-16 would be flying today were it not for his tenacious efforts. His legacy lives on in the hundreds of F-16s that grace the skies worldwide.

Harry Hillaker, the chief designer of the F-16, died on 8 February 2009. For more on the design origins of the F-16, see the article ["F-16 Design Origins."](#)