Testimony of Arthur Rex Rivolo before the House of Representatives, Committee on Oversight and Government Reform

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From June 1992 to March 2009 I was the principal analyst for the MV-22 and CV-22 at the Institute for Defense Analyses (IDA), a nonprofit organization supporting the Office of Secretary of Defense, Director of Operation Test and Evaluation. In that capacity I have independently analyzed and evaluated extensive flight test and engineering data of the V-22, participated in engineering discussions with US Navy and Bell-Boeing engineers, participated in test planning working group meetings, observed flight testing, and flown as an observer aboard V-22s during routine operational missions and during official flight evaluation periods. On 13 March 2009 I terminated my employment at IDA and have since severed all relations with the organization. I am here as a private citizen expressing my personal views.

The V-22, conceived as a “transformative technology”, three decades ago promised extensive new capabilities for the US Marine Corps and US Air Force special operations war-fighting missions. Today, thirty years later, the aircraft is operational with both the US Marine Corps and the US Air Force, but the promised capabilities have failed to materialize. The aircraft has fallen well short of its design load carrying capability. Additionally, two technical idiosyncrasies make the aircraft problematic in a combat environment. This much awaited, transformative aircraft has, in my opinion, turned out to be a disappointment, falling well short of its design goals. I will address these three critical issues in some detail.

1. Limited Load-Carrying Capacity

The load-carrying issue can be summarized in the chart shown in Figure 1.

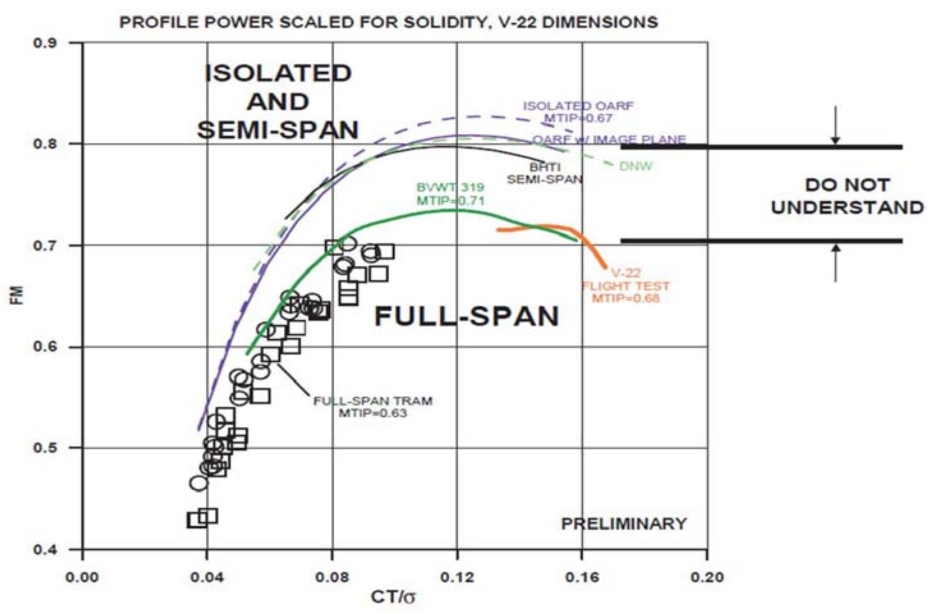

Figure 1.

The chart was presented at the Tiltrotor Aeromechanics Phenomena Conference held at NASA's Ames Research Center in 2001 following the crash of an MV-22 at Marana, Arizona.

Although the chart is highly technical it serves to illustrate the fundamental shortcoming. The graph is essentially a plot of rotor efficiency (vertical axis) verses rotor thrust (horizontal axis). What the chart shows is that the actual V-22 performance (shown by the orange line) falls well short of the design value (upper curves labeled "ISOLATED AND SEMI-SPAN") especially at the higher power levels. In addition, this difference is apparently not understood by the designers as noted by the "DO NOT UNDERSTAND" notation between the two lines indicating the difference between the expected value and realized value. This difference in rotor efficiency amounts to about 6000 pounds in load-carrying capacity.

This load-carrying shortfall has resulted in many compromises in the aircraft configuration and construction. For example, the requirement to be able to operate in a chemical, biological, and radiological (CBR) environment without the need for aircrews to wear bulky garments and respirators was compromised because the required overpressure to maintain positive air outflow in the aircraft would require strengthening the fuselage skin panels at the cost of increased weight. A second example is the decision not to replace all drive shaft segments, currently made of fire-susceptible composites, with titanium or steel because the weight increase would prevent meeting the critical mission requirements.

Despite all the compromises, V-22 still fails to meet the requirement for the critical 50 nautical mile, 10000 pound external load mission if all safety-related operational requirements are imposed. These safety requirements include landing with out-of-ground-effect hover power plus a 10% power reserve (margin) and a minimum landing fuel reserve. The practical implications of this shortfall are small as 40 or even 30 nautical miles capability for this mission could easily be compensated for by USMC commanders in the field. However, more compromising implications of the shortfall in the V-22 lifting capacity can be seen in other mission areas.

In mountain operations at high density altitudes, both the MV-22 and CV-22 have little or no capability above 8000 feet, density altitudes that are common and tactically relevant in the Afghanistan Theater of operations. As a practical example, consider a CV-22 conducting non-combatant evacuation operations (NEO) from the US Embassy in Kabul, Afghanistan on a hot summer day. Given the layout and location of the Embassy compound in Kabul, a CV-22 would require out-of-ground-effect hover power for a safe landing into the compound. Operational safety considerations imposed by Air Force regulation will require that an additional 10 percent power be available as a safety margin and further, that the aircrews calculate power available under the assumption that the engines are putting out 95 percent of rated power because of wear and tear.

Under these conditions, a CV-22 taking 24 personnel out of the Embassy compound would have enough fuel to travel about 60 nautical miles before requiring refueling. Alternatives to this are: taking a smaller number of personnel on the evacuation, landing outside of the Embassy compound in a place that allows landing without the safety power margin requirements (e.g., roadway, open field, etc.), or having airborne or ground tankers available for refueling. All of these would significantly increase risk to the mission and make demands on available assets. By contrast, a CH-53E, an aircraft considerably lighter than V-22, under the same conditions could carry the same 24 evacuees over 400 nautical miles or take 35 evacuees to a distance of 250 nautical miles.

I turn now to two idiosyncrasies of the V-22 design that make the aircraft, in my opinion, problematic in a combat environment. The first is the inability of V-22 to safely enter into or recover from an autorotative descent. The second is a controllability and maneuverability issue due to the side-by-side rotor configuration design of V-22, and the implementation of a control system whereby a flight control computer, rather than the pilot, determines how much flight control input should be made. These render the V-22 incapable of the aggressive maneuvers needed for evasion of hostile fire while in conversion or helicopter mode. The only evasive maneuver available to the V-22 is a rapid conversion to airplane mode while maintaining heading. This is clearly problematic if the threat (missiles or bullets) are coming from the front quarter, which is usually the case.

2. Lack of Autorotation Capability

Autorotation is a helicopter's version of gliding. All helicopters have the ability to glide safely to ground following a complete and abrupt interruption of power caused by either engine(s) failure or by the deliberate removal of power to the rotors by pilot action necessitated by failures within the drive system of rotors, or failures within the rotors themselves. The inability of V-22 to safely autorotate has now been acknowledged by the manufacturer and the US Marine Corps, but little significance has been given to the implication this raises, which is – *the V-22 would fail to meet basic airworthiness requirements by the FAA regulation if it were a civilian transport aircraft*. Despite this, the US Marine Corps leadership has shown no concerns over this issue and has no problem requiring young men and women to ride as passengers in the V-22 under combat conditions.

Although airworthiness requirements of the FAA do not apply to military aircraft, equivalent requirements have been imposed on all passenger-carrying military aircraft in the past. The V-22 represents the first departure from this policy within the Defense Department. In my opinion, this represents a cynical disregard for soldiers' lives in favor of supporting a blind allegiance to the cause of this aircraft. The adoption of this reprehensible stand by the Marine Corps leadership, as well as by the Defense Department acquisition executives and the Congress, via their passive consent, makes these parties complicit in any future V-22 combat loss where autorotation could have saved lives. I believe this conscious disregard of a substantial and unjustifiable risk qualifies as reckless behavior in the legal sense.

The V-22 proponents who argue that V-22 is capable of making a safe all engine out landing by converting to airplane mode are either fooling themselves or willfully distorting the facts. The V-22 requires 12 seconds to convert from helicopter mode to airplane mode. In this interval, when both engines are inoperable or one engine has failed along with the interconnecting drive shaft, a V-22 will lose about 1600 feet of altitude under ideal conditions (i.e., no pilot errors.) Thus, any complete power failure while in helicopter mode below 1600 feet above the ground will result in a catastrophic loss of the aircraft.

Additionally, the conversion process is so dangerous that the pilot's flight manual for the aircraft instructs (not recommends) pilots *not* to attempt conversion if the failure occurs while the nacelles are at or above 60 degrees regardless of altitude. Thus, in this case the flight manual, inexplicably, instructs pilots to enter autorotation, irrespective of altitude, knowing full well that the aircraft cannot safely autorotate.

3. Lack of Combat Maneuvering Capability

The V-22 is flown by a flight control computer – not the pilot. The pilot merely asks the computer for a given change of flight path, and the computer obliges by applying the necessary aerodynamic inputs to generate the requested change. Under near-equilibrium flight conditions, i.e., straight and level flight, steady turns, climbs, and descents, etc., the pilot's request and the computer's response are nearly simultaneous and the delivered inputs are exactly those requested by the pilot. However, under non-steady state conditions such as during evasive maneuvering, entry into autorotation, or unusual flight conditions such as vortex ring state, the flight control computer will attempt to protect the aircraft from structural overloads and other dynamical limits such as the flapping of the rotors (rotor disk not perpendicular to spindle shaft) by not producing the commands requested by the pilot's controls positions. This tends to significantly reduce the severity of any hard maneuver commanded by the pilot - the goal of evasive maneuvering.

The fact that the pilot has enough control authority to damage the aircraft during hard maneuvering is the reason why the flight manual places restrictions on how much flight control inputs can be used during evasive maneuvering. That a pilot actually has enough control authority to "break" the aircraft is unique to V-22. Concerns over this issue in V-22 have resulted in a significant decrease in the amount of control authority given to the pilot, making the aircraft less and less maneuverable. Key tests of combat evasive maneuvering scheduled in 2002 remain, to my knowledge, to be completed. Sending V-22 into real combat situations without the completion of these critical tests is, in my opinion, irresponsible.

Proponents argue that V-22 has been "combat proven" given its operational experience in Iraq. I cannot agree with this position as the mission in Iraq was largely one of "combat circulation", a euphemism for the logistical support of carrying passengers and cargo from one base to next in bus-route fashion. Combat assault, the mission for which V-22 was designed, remains unproven under realistic conditions. A deployment to Afghanistan would certainly serve that purpose but the risks associated with such a mission and the lack of lift capability in the Afghanistan Theater would seem to preclude such a deployment. Indeed, despite the rhetoric heard over the past five years about how V-22 is the *ideally* suited aircraft for combat operations in Afghanistan, the aircraft has not been deployed into that Theater to date. One could speculate on the reasons for this. I believe the principal reason is that operators and decision makers fully understand the risks involved both operationally and politically.

Concluding Remark

I have chosen to discuss what I consider the three major issues concerning operational effectiveness of V-22 in combat operations, as I deem these critical to the future of V-22 as a combat system. I have not discussed readiness and reliability or direct operating costs as I do not have access to recent data. However, I am well-versed in the history of these issues and I was in Iraq during the first deployment of the MV-22 and did manage to glean some information about day-to-day operations. I am prepared to answer any questions members of the Committee may have on these subjects.