The Joint Strike Fighter – An International Enterprise

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INTRODUCTION

From the beginnings of flight to the present, there have been international aircraft programs undertaken by most of the countries represented in this room. Those programs were frequently co-assembly or co-production efforts in which the purchasing country manufactured an existing aircraft using production tools and techniques from the country of origin. In the last 40 years, we have seen a number of true collaborative efforts to design and develop an entirely new aircraft using the intellectual capital from two or more countries. Europe has been a key leader in these programs with the Jaguar, Tornado and Eurofighter on the military side and the spectacular success of the Airbus consortium on the civil side. While the United States has engaged in numerous co-assembly and co-production dating back to World War II, it has been only recently that we have engaged in co-development efforts similar to the European ventures of the 1960s and 70s.

The F-35 Joint Strike Fighter is the largest single multi-company aircraft development program ever attempted in the U.S. and, indeed, in the world. At present, there are nine partner nations actively involved in the design and development of this next-generation fighter. This massive undertaking is not without it "challenges" a popular euphemism for "difficult and perplexing" but there are also some very bright spots and reasons for optimism.

Let me show you the construct of this program, what we intend to build and, most importantly, what it promises for all of the partner countries sharing in this massive enterprise.

1.0 THE JOINT STRIKE FIGHTER CONCEPT

The Joint Strike Fighter arose from three separate programs to build a next generation fighter for the United States Navy, Marine Corps and Air Force.

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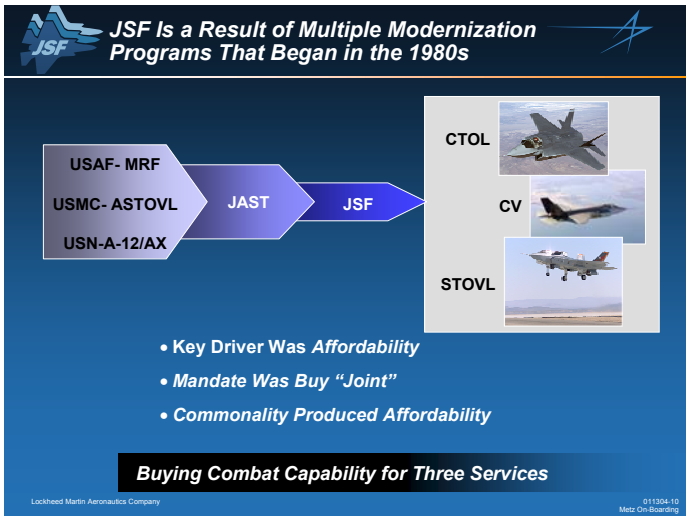

Figure 1: Evolution of the JSF

The Advanced Attack Program or "AX", the Advanced Short Take Off and Vertical Landing or "ASOTVL" and the Multi-Role Fighter of "MRF" were slated for the Navy, Marine Corps and Air Force respectively. Each of these programs was being studied and, in the case of the Navy, developed independently. It soon became apparent that the costs to develop three separate airplanes, their avionics or mission systems and supporting logistics and infrastructure were more than the services and the nation could afford.

In response, the three services were directed to combine their programs into a single aircraft or family of aircraft that were highly common in order to reduce total costs for the next generation fighters. The result was the Joint Advanced Strike Technology or "JAST" program that was subsequently shortened to the Joint Strike Fighter or "JSF" of today.

While sounding like a reasonable compromise to the politicians, the engineering realities of an airplane optimized for carrier operations, vertical flight and conventional runway operations was not only daunting but not supported by history. While there are sterling examples of single-mission fighters adapting to other missions (the P-51 Mustang, F4U Corsair, F-4 Phantom in the U.S.), fighters designed at the outset for multiple missions have not been as successful. The F-111 in the U.S. was intended as a multi-service (Navy and Air Force) and multi-mission (air superiority and ground attack). It did neither well. A similar conclusion may be appropriate for the Tornado in the same roles. Despite these harbingers of history, the JSF program determined in 1996 that two teams should demonstrate their ability to create such a machine and compete to build such an aircraft for the three U.S. services.

First flight of the Boeing X-32 took place in September 2000 and one month later the Lockheed, BAE and Northrop Grumman team launched the X-35 on its maiden flight. Both companies demonstrated that the three missions (conventional runway operations, aircraft carrier operations and vertical operations) could be achieved with a similar airframe and that the sophisticated sensors worked and could be wrapped in a small, stealthy airframe shape. The X-35 emerged the winner to become the F-35.

While the multi-service aircraft concept worked, world events after September 11, 2001, caused a rethinking of the strategy of our military weapons and our interdependencies on our friends. The Joint Strike Fighter became a focal point for coalition operations and a new form of conflict to become known as "net-centric"

warfare. In this new construct, the world wide emergence of terrorism meant that the civilized world must work together to combat a pervasive and elusive enemy. Technology would be harnessed to allow many sensors and many platforms to network their information into electronic databases of knowledge. This gave the battlefield commander an expansive knowledge of the enemy's position and movement. If battlefield weapons could be coupled to this data base, then response to the enemy could be rapid and, as seen by the use of precision weapons, directed against a specific person or site. The concept was for warfare to be conducted from a position of "all knowing" and "all seeing" and then respond with rapidity and precision. All future weapons and supporting systems were to become a part of this "net-centric" web and the F-35 was to be on the leading edge of this conversion. Hence, the Joint Strike fighter, while nominally an air-to-ground attack machine, was emerging as a multi-role, multi-service, multi-nation component in the war on terror. Nine nations have combined their collective talents to design, test and field the Joint Strike Fighter as shown in Figure 2. Two nations, Singapore and Israel intend to purchase the F-35 but are not directly involved in its development.

Figure 2: JSF Partners

1.1 THE F-35 DESIGN

The F-35 Program is actually composed of two distinct products. The F-35 itself is obvious but no weapon is effective when it is grounded for maintenance. For that reason, an Autonomic Logistics system was conceived to ensure the airplane was easily maintained, readily supportable anywhere in the world and affordable over its lifetime of 20-30 years.

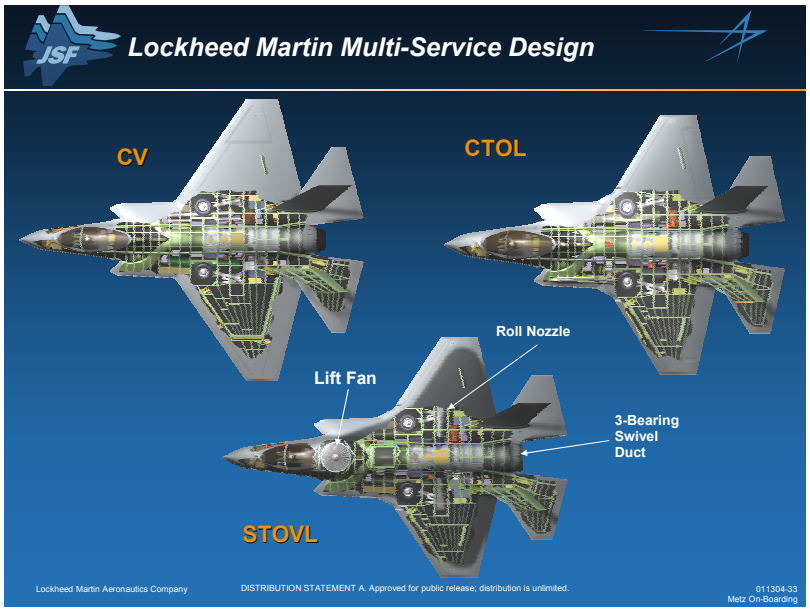

Figure 3: F-35 Variants

The F-35 variants (Figure 3) are built around a similar structural arrangement and incorporate the same avionics suite and the same or similar subsystems. The prominent lift fan of the F-35B STOVL sits in the fuel bay of the F-35 A and the F-35C CV achieves the larger wing for slower approach speeds to the carrier by attaching larger leading, tips and trailing edges to the F-35A wings. The Pratt and Whitney F135 and the General Electric F136 engines are totally interchangeable and use a common core for all three variants. The digital FADECs allow the engines to be tailored so that they perform identically to the pilot. The airplane is a stealthy design to reduce detection in the visual, thermal and radar spectrums, a significant advantage in air combat.

The sensors in the F-35 remain highly classified but provide radar, infrared and visual detection, tracking and targeting of a wide range of ground and air threats. Displays provide the pilot an intuitive view of the world by fusing multiple sensors into a coherent single pictorial of the battlespace. His visor-projected imagery allows him to see a day-like view of the outside world in the night and all weather conditions.

The most technologically challenging problem was presented in the STOVL variant of the airplane. This picture illustrates the problem of lifting a 30,000 pound airplane vertically with an engine producing 25,000 pounds of thrust.

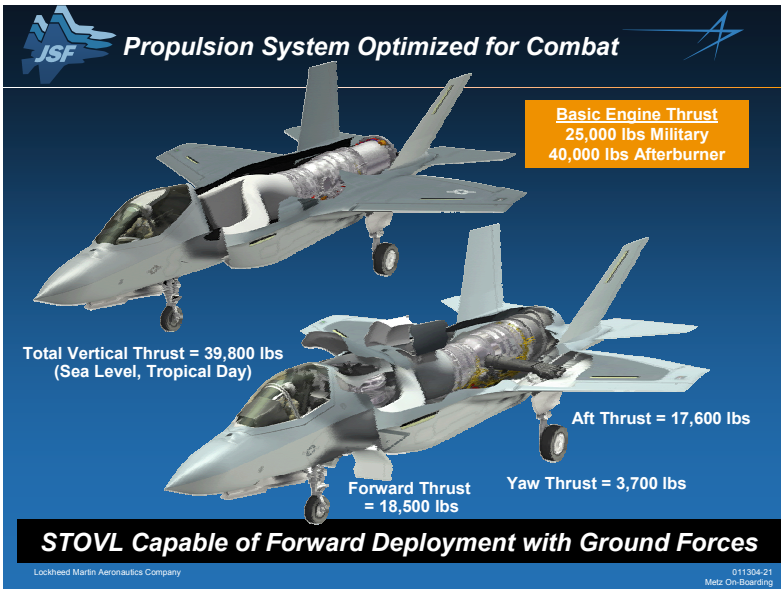

Figure 4: The STOVL Challenge

The ingenious solution was to use a lift fan driven by the core engine. The fan extracts thrust from the jet exhaust to create over 18,000 pounds of lift force. The exhaust nozzle is simultaneously deflected downward to create over 17,000 pounds of lift at the rear of the airplane. Small roll exhaust or "posts" on each wing give lateral balance and the net result is the ability to lift approximately 40,000 pounds of weight starting from a basic 25,000 pounds of engine push force. Since the F-35 is capable of carrying internal and external loads far heavier than 40,000 pounds, it can takeoff using the fan and vectored nozzle and a "running start". By first accelerating to 60 knots, the STOVL variant can lift more than twice its empty weight in a very short takeoff run, hence the "S" in "STOVL".

Since this symposium's theme is *Sharing Knowledge and Experience*, I must say a few words about the multi-national aspects of the JSF program. While there are nine partner countries developing the JSF, there are only two countries that are today committed to buying the F-35, the United States and the United Kingdom. While it is anticipated that the other countries will bring the F-35 into their inventories (see figures 5 and 6), their involvement in the program today is for two distinct purposes.

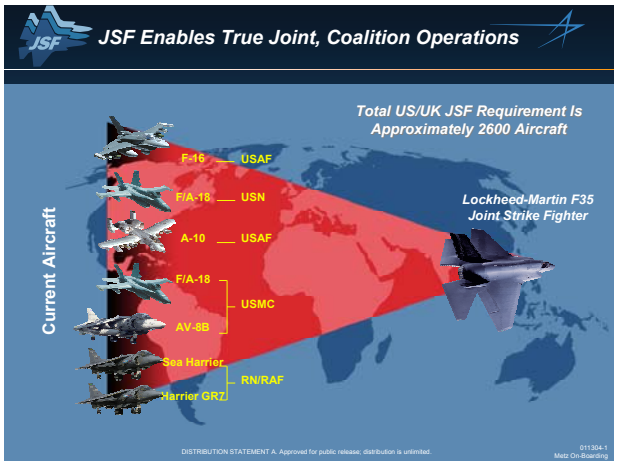

Figure 5: US and UK Fighter Replacement

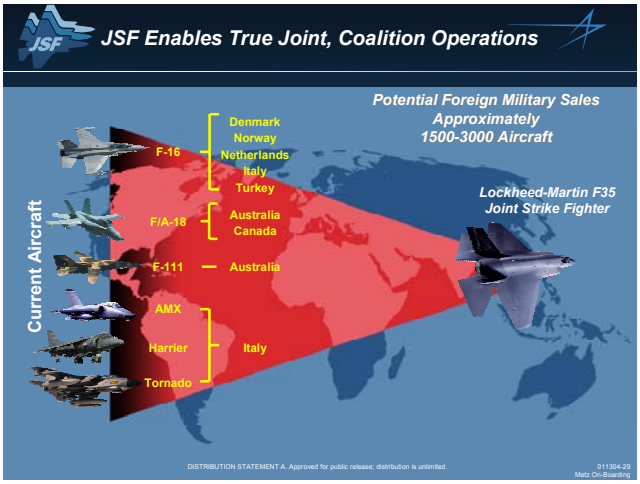

Figure 6: Partner Fighter Replacement

First, the partners share in a cutting edge technological development that enhances their own technical base at home. Second, the companies within each partner country have the opportunity to compete for business in products and services to the JSF program. I use the work "opportunity" deliberately for the JSF program, unlike many international programs in the U.S. is not an "offset" program. Indeed, there is no assurance that any work will be placed in a partner country. Business opportunities are presented to each partner but obtaining the work is on a "best value" basis. That is, the partner must demonstrate that their quality, cost and performance make them viable competitors for this business. To date, $7B of business has been placed in the hands of our partners. This can be compared to the entire value of the F-35 development program at $19B.

Any undertaking as large as the F-35 will have difficulties in execution and I would be less than candid if I didn't give you the good and bad of our struggles to blaze new trails in this business. First, the good. The partner countries have provided us their "best and brightest" and it is a genuine pleasure to work with and socialize with the talent that exists around this world. For our U.S. engineers, this is for many, the first time to actually be closely working with Italian, Dutch, Aussie, Canadian, Danish, Brits, Norwegians or Turkish

engineers and craftsmen. Americans, by their nature, enjoy differences and they relish the time spent with their counterparts from another country. For example, each July 4th we have all of the JSF team and their families gather for a picnic and games. Despite being severely beaten by the UK each July in our first two annual July 4th soccer matches (figure 7), we thoroughly enjoy our associations. Since we consider ourselves a nation from many nations, we felt it only proper to enlist the Italians and Dutch who seem to have a knack for this strange form of football. I am happy to report that the "American" team was able to turn back the British scourge this past July.

I would say that on a one-to-one level, this program is a highly successful and it this emphasis on balancing work and play that puts a human touch to the not only the program but the people we work with.

Figure 7: JSF – Making It Fun!

But all is not as easy or enjoyable at the higher levels of the program. First, it has been difficult to exchange information at a technical level. Restrictions on technology transfer have proven to be far more cumbersome and impenetrable than originally envisioned and require the bureaucracies of the federal government to approve even unclassified information exchanges. This hampers partner involvement and places a huge administrative burden on the individual team members who must ensure that all information is releasable under penalty of jail terms-not a conducive atmosphere for co-engineering a product.

While some partner companies have received satisfactory business contracts, we have fallen short in a few other countries. This is due to a variety of factors:

- Desire for work in technology areas ITAR-controlled as "US Only"….radar, EW, mission software
- Affordability...many companies are not used to global competition and are entitlement (off-set) minded.
- Some US companies and JSF IPTs are biased for US industry vice having "level playing field" opportunities for intl. industry.

- International companies usually look for short term ROI vice long term investment to secure work.

Finally, the concept of sharing logistics assets, the so-called "Global Sustainment" portion of the program has been far more difficult than envisioned. There is a natural reluctance to enter into a true coalition of partners in terms of our collective defense against terrorism or any other threats. National priorities, national aspirations and national defense, unrelated to the war on terror, have always been areas of autonomous action by sovereign nations. Having common training bases, common logistics centers and common spares causes some uneasiness about the future. Balancing the reduced cost to all partners of commonality with the desire to retain autonomy of action is a difficult issue that has little parallel in history. It will be a major obstacle to solve with the JSF program but one which has huge payoffs.

1.2 CONCLUSION

The F-35 Joint Strike Fighter is the largest multi-service, multi-variant, multi-nation development program in history. The concept is rooted in lower costs for ever-increasingly sophisticated weapons of war. The complexity of future conflicts in the war on terror envision weapons like the F-35 which are able to operate in concert with many other weapons and sensors. This net-centric warfare allows the F-35 to be used in powerful coalition operations as well as in the more traditional autonomous battlefield.

The F-35 program has drawn together nine partner countries to develop this next generation fighter. Despite some difficulties at the national level in establishing strategies and methods of cooperative exchanges, the partners have gathered together the finest engineering and technical talent in their professions and they are working (and playing) extremely well together. The F-35 and it's support Autonomic Logistics system are maturing rapidly and the original concepts remain sound. The first development aircraft is in assembly and will fly in the fall of 2006. By the year 2012, the F-35 will enter operational service and be a powerful new military tool in our future conflicts.