



Submission No 25

Review of the Defence Annual Report 2010 - 2011

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**ISSUES WITH THE VERIFICATION, VALIDATION AND
ACCREDITATION OF MAN-IN-THE-LOOP SIMULATIONS**

INTRODUCTION

The Defence sub-Committee has recently heard submissions from witnesses and has received written submissions on the classification and verification and validation of simulations of future air combat involving the F-35 Joint Strike Fighter.

REPSIM recently was sent a copy of a Lockheed-Martin Aeronautics presentation titled 'Modeling and Simulation Applied in the F-35 Program'. Annex A includes extracts from this presentation, noting that the material is designated as 'Non-Export Controlled Information Releasable to Foreign Persons'.

The presentation assists the assessment of the veracity and validity of Man-In-The-Loop (MITL) simulations discussed before the Committee, but does not resolve the issues of the types of opponent being assessed, nor the classification of the simulation content and results.

This submission addresses these issues.

OPPONENTS BEING ASSESSED – 'REFERENCE THREATS'

While the Lockheed Martin and ADO witnesses refused to advise the Committee which aircraft types were being assessed as potential adversaries on the ground that such work is 'classified', the choice is clear and there is no defence for 'classification' of any selection – no nation's security is affected by making the obvious choice of opponents.

The criteria for selection of opponents can be determined by criteria such as:

- a. the aircraft should be 'real' and be a competitive air combat contender;
- b. purchase quantity should be large enough to pose a capability threat; and

- c. the opponent should be in-service in countries about the same time as the F-35 becomes operational; at this stage it is assessed that the JSF needs to be running Block 3 software, which puts its Initial Operational Capability (IOC) date at 2018 or later if further software development issues arise.

One obvious air combat contender is the Su-35S, now entering service with the Russian Air Force, which has ordered 90 to be delivered by 2020. This aircraft is expected to be an 'interim' capability while the clearly superior Sukhoi PAK-FA / T-50 is developed.

http://english.ruvr.ru/2012_05_14/74675229/

China has been reported as seeking 48 Su-35S, but the sales has been reported as being denied by Russia due to disputes over earlier cancelled orders and intellectual property issues. Nonetheless, the Su-35S is being offered for sale world-wide by Rosoboronexport.

Annex B provides extracts from the Sukhoi Su-35S marketing 'buklet', noting that this material is dated 2007 and the aircraft could be more developed in its design at Initial Operational Capability.

UNCLASSIFIED QUESTIONS REGARDING MITL SIMULATIONS OF THE F-35 JSF

Lockheed Martin's presentation advises that its F-35 MITL simulation is 'high fidelity' and that it has 'verified and validated' its modelling of the F-35. Has this claim been independently audited by an expert in the field?

A much harder task is the verification and validation of a potential adversary's aircraft. However, much useful work can be done on the verification process (ensuring the simulation represents the entities behaviour) using technical assessment and intelligence and a sound understanding of the Laws of Physics and aerodynamics.

Validation is an area where a simulation with an otherwise excellent level of verification can produce results that misrepresent the 'real world' outcomes of an engagement between (say) a flight of JSFs and a flight of Su-35Ss. Validation bias can be largely overcome using a 'Blue Force and Red Force' environment where the only constraint placed on either side is the physical performance of the entities in air combat.

When the ADO and Lockheed-Martin asserted to the Committee that the answers to several very basic questions were 'classified', they have prima facie established, on the public record, that they are misusing the classification system to conceal failures and avoid public embarrassment. This is actually unlawful conduct in the United States.

If the ADO and Lockheed-Martin had nothing to hide, they would have provided the Committee with a comprehensive and detailed brief.

Instead, they have endeavoured to introduce a maximum of confusion and uncertainty, unnecessarily so, into what should have been a simple explanation of what work was being done.

The uncertainties which the ADO and Lockheed-Martin have introduced are numerous. They could be dispelled if the following questions were answered substantively, with supporting evidence to validate their claims.

The UNCLASSIFIED questions:

- a. Is the Su-35S one of the 'Reference Threats' being evaluated by the Lockheed Martin F-35 MITL simulation?
- b. With eight 'seats' available, are 4 versus 4 simulation being run; how are the 'High Fidelity' cockpits being assigned and how capable are the 'Low Fidelity' cockpits, presumably assigned to Red Force aircraft as the JSF cockpits seem to be 'hard-wired'?
- c. Does the Air Combat MITL simulation include a full representation of an Integrated Air Defence System (IADS) on both sides?
- d. Does the Red Force IADS (if present) include the full range of sensors now being deployed; e.g. HF Skywave Radar, VHF AESA Radar (noting that Russia has ordered 100 NEBO-Ms for delivery by 2020); passive sensors such as the Kolchuga and VERA-E Electronics Surveillance Method (ESM)?
- e. Are the Red Force Team, acting as an Aggressor Force, selected from the highest rated air combat pilots; Fighter Weapons Instructors from the USAF Nellis AFB Fighter Weapons School would be prime candidates?
- f. Have the RED Force Team been given the time and military intelligence to become fully competent pilots of the Reference Threats? *Comment: I installed a MITL simulator at the RAAF's Williamtown Fighter Base in 2001, and the results were highly dependent on the skills of the simulation operators.*
- g. Does the Red Force Team have full autonomy to fly the mission in the most survivable and lethal profiles and weapons fit?
- h. Considering the Su-35S as a Reference Threat, has the 'Offensive Crescent' formation been flown, with Flight Lead (One) and Deputy Lead (Three) being spaced line-abreast at 60 Nm, with the element

wingmen (Two and Four) flying displaced between One and Three by 20 Nm and lagging by 10 Nm? The purpose of this formation is to view the JSF from angles where it has higher observability.

- i. Is the Red Force IADS cueing the Offensive Crescent formation to place the incoming Blue F-35 JSFs in the Crescent's 'Kill Zone'?
- j. Is the JSF signature being modelled in all dimensions and across all sensor wavelengths, so that when (say) flying into an Offensive Crescent, there will be observable oblique views of the JSFs?
- k. Is the Su-35Ss IRBIS-E ESA radar being full modelled, including the power-aperture and the ability of the radar's articulated head to cover 240 degrees around the nose of the Sukhoi? An 'Upper' and 'Lower' Radar Range versus Radar Cross Section is shown in this plot for the IRBIS-E with detectability ranges on the F-35 covering about 30 to 100 Nm? (See Annex B for a plot of the IRBIS-Es assessed Detection Range Versus Radar Cross Section.)
- l. Is the Infra-Red Search and Track (IRST) OLS-35 fitted to the Su-35S being fully modelled including the assessed detection ranges of 50 Km from head on and 90 km tail on?
- m. Does the simulation include the Sukhoi Intra-Flight communication system, where target information is shared across the Flight?
- n. Are the Su-35S being flown at its most advantageous profiles compared with the JSF; e.g. air combat altitude, typically 55,000 feet and Mach 0.9 on the ingress, and as fast as Mach 2+ on a tail-chase?
- o. Are the F-35 JSF Aim-120Ds being fully modelled including the missile's kinematic capability against 'range at first shot', high altitude, highly manoeuvrable targets?
- p. Are Aim-120D and R-77M / R-73 Probability-of-Kill (PK) being assigned as a simple fixed number or is PK computed depending on the dynamics of the engagement (speed, altitude etc), countermeasures and manoeuvres being employed (see q.)?
- q. With what fidelity are the following countermeasures modes modelled in the simulation: self / mutual jamming, group jamming, cross-eyed jamming, towed decoys, missile-approach warning systems, rear and forward firing chaff, towed decoys and terminal manoeuvre assisted by vectored thrust?

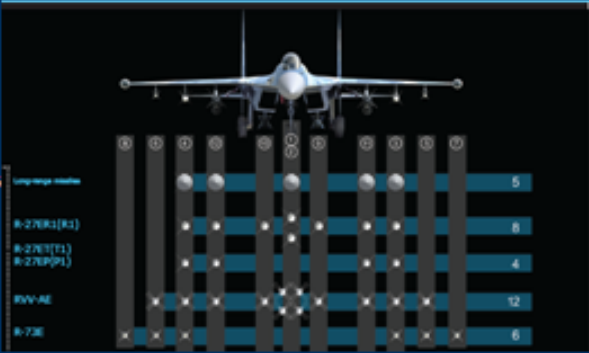
- a. In air combat, is the Su-35S model equipped with the full fidelity of the KNIRTI SAP-14 and SAP-518 countermeasures equipment, especially in terms of modes, waveform fidelity, angular and band coverage, and do weapons load-outs include 2 * R-73 or 74 WVR missiles, 8 * R-77M BVR missiles with a mix of Active and Infra-Red seekers, plus the GSH-301 30mm cannon?
- r. Are Russian tactics being employed, e.g. firing of pairs of missiles at a target, with the R-77 Active Seeker being fired first, followed a few seconds later by an Infra-Red Seeker missile?
- s. Do the simulations include operations in an IADS-contested airspace where the JSF's may have to simultaneously contend with flights of Su-35S, VHF AESA Radars and 'shoot and scoot' SAMs like the S-300VM and S-300PMU2 systems?
- t. Are the simulations constructed so that each side has to consider fuel reserves as part of the engagement, especially the ability to disengage from a highly agile, high fuel flow fight?
- u. Are the simulations being allowed to run to finality such that the end result is demonstrated, or are they being terminated when one side starts to lose?
- v. Are simulations being replicated often enough to produce a reliable 'best estimate' in a simulation environment where complexity inevitably produces variability of results; a corollary is that 'inconvenient' results must not be discarded as bias will result?

Each of these questions represent a factor affecting capabilities, especially survivability and lethality in future air combat engagements. There is a complex interaction between these factors, and only a fully developed simulation, properly verified and validated, can produce a 'Reasonable' (within a tolerable level of accuracy) and 'Representative' (indicative of future 'Real World' air combat) result.

Finally, the Raptor's Edge article in Aviation Week and Space Technology disclosed that the loss Exchange Rate (LER) between the JSF and the Su-27 / MiG-29 was of the order of 3:1. However, as noted by RAND Corporation regarding the lethality of the Su-35S versus earlier versions such as the Su-27SK: 'It's not your father's Flanker':

"It's not your father's Flanker"

- Flanker is a big, tough Russian aircraft
 - Large internal fuel capacity
 - Large load carrying capability
 - Modular/evolutionary design philosophy makes upgrades relatively easy and inexpensive
- Latest Flankers (e.g. Su-35BM) have large, diverse air-to-air missile loadout
 - Standard loadouts include options for up to 14 AAMs
 - Current Chinese SU-27/30/J-11 carry "only" 10
 - Likely most will be upgraded to SU-35BM standard by 2020
 - Most missiles come in active radar and IR versions
 - Long range anti-LD/HD missiles have advertised range of up to 215 nm
- Standard Russian and Chinese tactics call for multiple mixed-seeker missile salvos
 - Controls even include a switch to automatically launch salvo with correct sequence and timing



RAND Air Combat 11/11/38

In the unlikely event that a fully verified and validated MITL F-35 versus Su-35S with a representatively skilled 'Red Force' produces a favourable LER for the JSF, the next essential question is: **how will a JSF fare against the PAK-FA / T-50 IOC about the same time and when will the Lockheed Martin MITL simulator assess this emerging threat?**

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