

Air to Air Combat

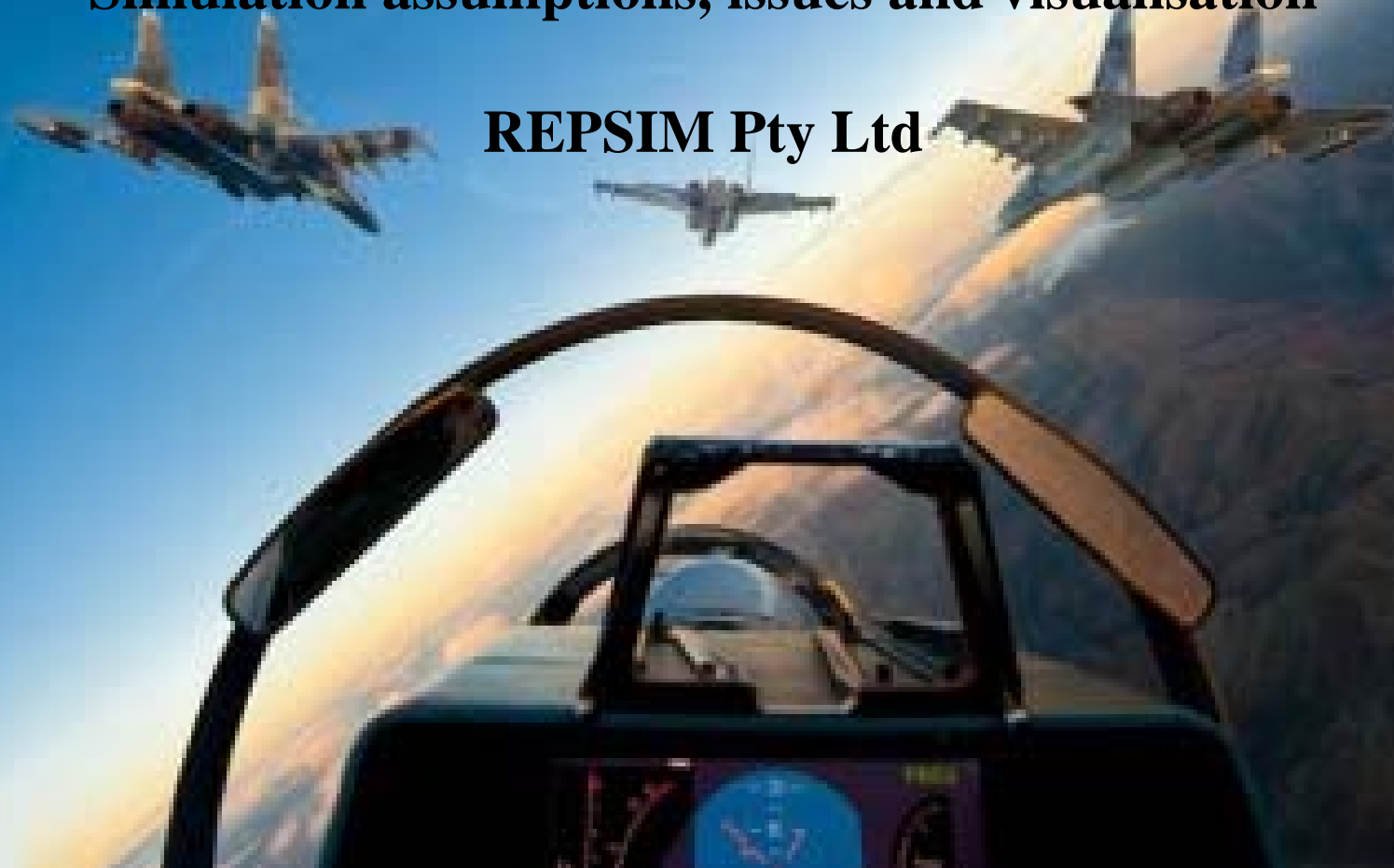
Answers to the 07 February 2012

Defence Sub-Committee of the

Joint Standing Committee on Foreign Affairs, Defence and Trade

Simulation assumptions, issues and visualisation

REPSIM Pty Ltd



Pacific Vision 2008 – Revisited

- USA v China:
 - basic assumptions
 - Okinawa and Taiwan assets were mostly neutralised by ballistic and cruise missile attacks;
 - US Forces attempt to gain air superiority over Chinese combat aircraft before sending in reinforcements;
 - Simulation explores comparative analysis of Force-on-Force air combat in the emerging environment of integrated, high technology warfare.



PROJECT AIR FORCE

Air Combat Past, Present and Future

John Stillion

Scott Perdue

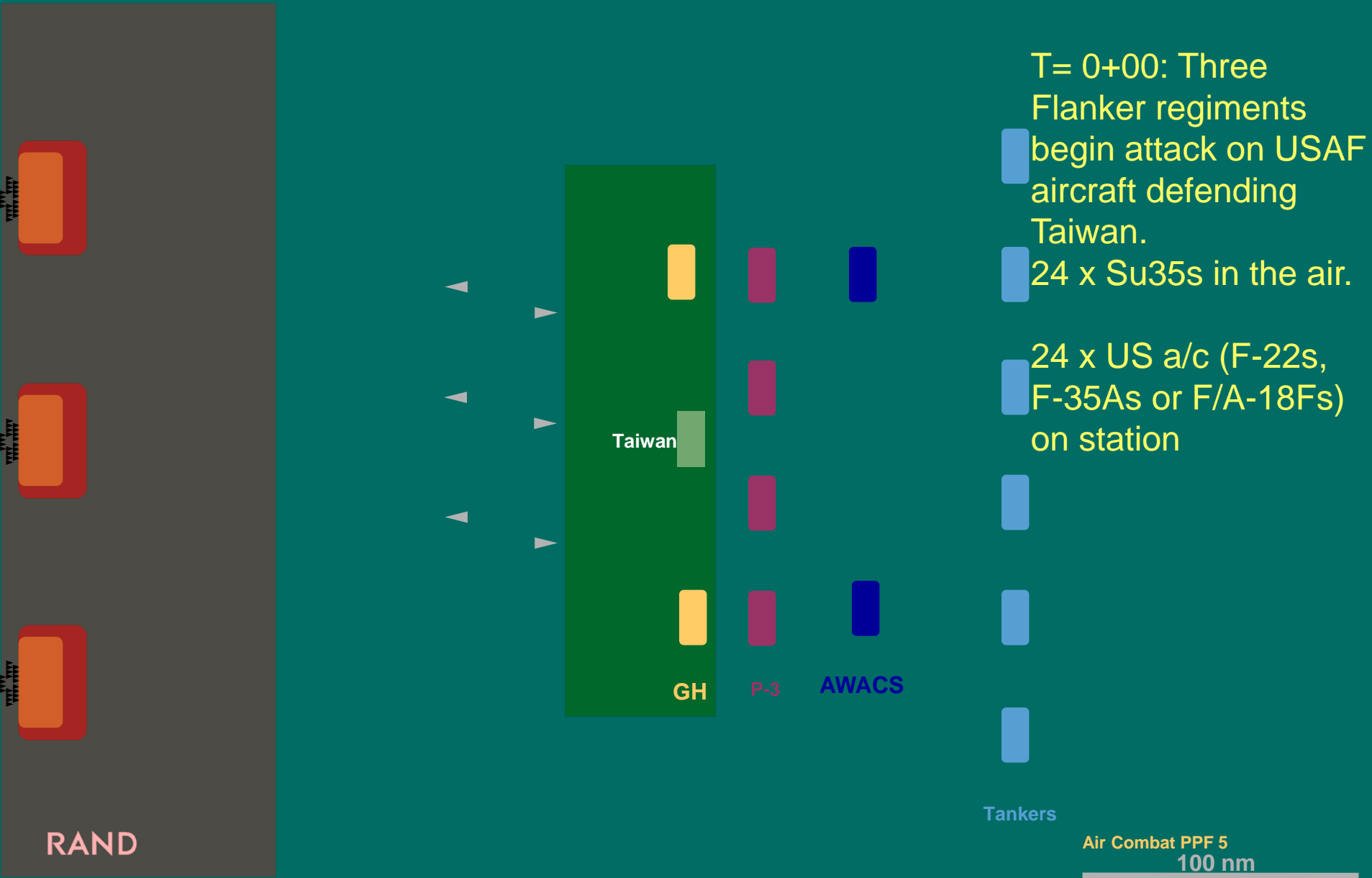
July 2008

FOUO/Sensitive

Pacific Vision 2008 – Background

- In 2008 the RAND Corporation produced a scenario for consideration by Pacific Command (PACOM) staff and others using the F-22 and the F-35A against projected Chinese capabilities;
 - RAND, however, did not have the tools or skills to build a constructive simulation of the scenario that included High Frequency Over the Horizon Radar (HF OTHR) and selective mission profiling in an integrated combat arena,
 - RAND staff sought assistance from REPSIM to convert their data into a H3 MilSim simulation that was reasonable and representative of the scenario, and
 - the only elements not shown in the simulation is the P3 Orion and RQ-4 Global Hawk aircraft as they contributed nothing but losses and added clutter to the presentation.
- REPSIM included the F/A-18F Super Hornet in the revisit because of its recent purchase by Australia, (ever wonder why no other country in the world has bought the aircraft?)

2020 Employment Example



Simulation Opening Dispositions

Chinese

OTH Radar

C3I Centre

Air bases

SAM sites

Su-35s

HALE UAV

USA

Okinawa

SAM sites

CVNBG

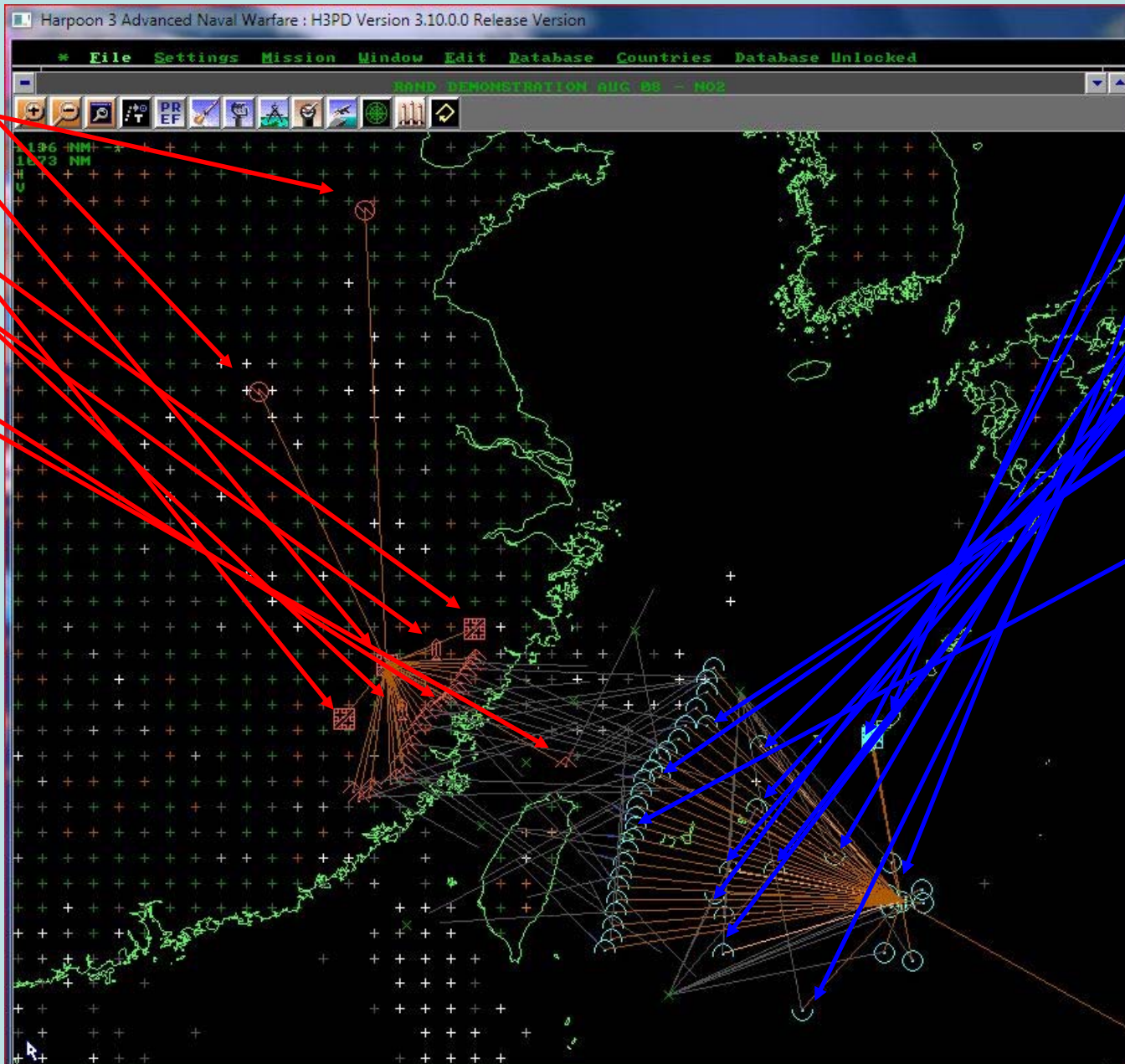
SSNs

KC-10As

E3-Fs

**F-22s, or
F-35As, or
F/A-18Fs.**

Guam



Chinese Tactical Assumptions

- Chinese forces focus on destroying the enabling US air assets such as Airborne Early Warning & Control (AEW&C) and Air to Air Refuellers (AAR) as top priority.
- Once the AEW&C are neutralised and the US aircraft lose operational situational awareness, designated combat aircraft streak through to interdict the AAR aircraft – dangerous and lethal leakers that US combat aircraft cannot detect or defeat.
- Chinese aircraft operate with mixed weapon loads, active and passive sensor missiles, in a widely dispersed formation with aircraft about 20nm apart to maximise their ability to counter US stealth and network-centric capabilities.
- The Chinese would rely on **High Frequency Over The Horizon Radar** (HF OTHR) to vector their aircraft towards US stealth aircraft until their organic sensors such as Electro-Optical (EO), L-Band Radar and networked Radio Frequency Direction Finding (RFDF) enabled them to engage.

Su-35



US Tactical Assumptions

- US Forces would not conduct large scale missile attack on mainland China, at least initially;
- US aircraft would operate in a widely dispersed formation, about 20nm apart, to maximise their stealth and network-centric capabilities; and
- The F-22 and the F-35A would be limited to internal fuel and weapons to exploit their tactical stealth.

F-22



F-22 v Su-35

- H3MilSim can be used analytically to establish the parameters within which further, more detailed work needs to be conducted.
- Data output from H3MilSim scenarios, in Distributed Interactive Simulation (DIS) format, can be used in other systems or used for detailed analysis.
- The scenarios can be run from the perspective of both sides to eliminate any bias in the software.

F-22 Blue and Su-35 Red

Harpoon 3 Advanced Naval Warfare : H3PD Version 3.10.0.0 Release Version

* File Settings Mission Window Edit Database Countries Database Unlocked

Zoom Map 2

The screenshot displays a tactical map of the Pacific region, including the Philippines, Taiwan, and the Japanese archipelago. A network of orange lines radiates from a central point on the right side of the map, representing the sensor and communication ranges of an F-22. A blue aircraft icon is visible near the center of this network. Another network of orange lines is visible on the left side of the map, representing the sensor ranges of Su-35 aircraft. The map is overlaid with a grid of white crosses. The interface includes a menu bar at the top, a toolbar with various icons, and a status bar at the bottom.

427 NM
426 NM

ted.

Increasing Messages

Difficulty Setting: Full Realism
Difficulty Setting: Aircraft Logistics Enforced
User Option 'VerboseWeaponDetection' is on.
User Option 'UseNukes' is on.
User Option 'ExtraVerbosePointDefense' is on.

Game Status

Game Time: 13:00:00 Zulu
Game Date: 15 February 2018
Time Compression: 0 Paused

Su-35 Blue and F-22 Red

Harpoon 3 Advanced Naval Warfare : H3PD Version 3.10.0.0 Release Version

* File Settings Mission Window Edit Database Countries Database Unlocked

View Map 1

627 NM →
426 NM
U

Increasing Messages

Difficulty Setting: Full Realism
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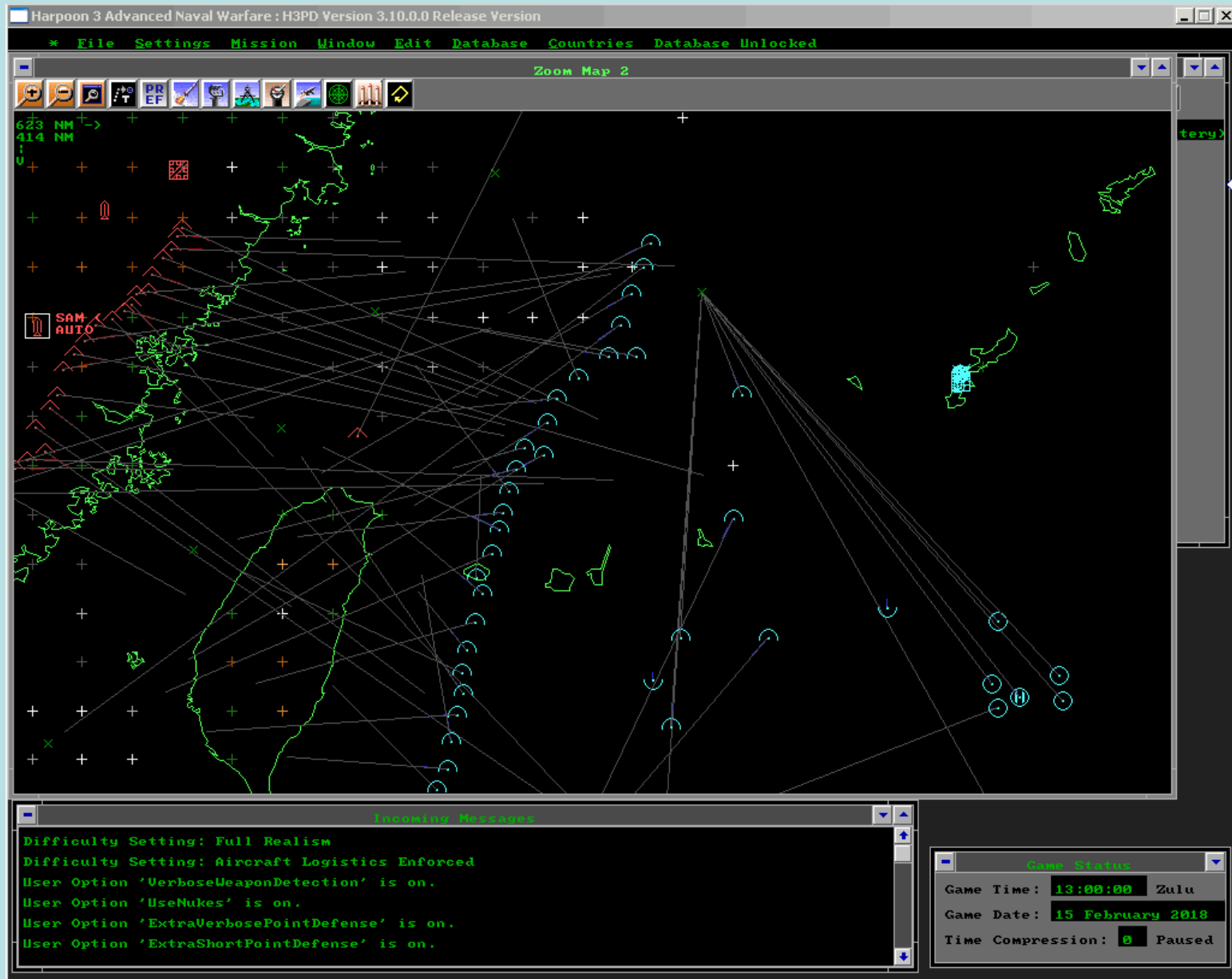
F-35A



F-35A v Su-35

H3MilSim entities are established in a database independent of the application which enables many different databases to be loaded and used on the same scenario – thus presenting differential outcomes based upon variations in the data values for a wide range of elements from aircraft weight, drag index effect on speed and/or altitude, rate of climb or sensor frequencies and ranges as well as many other data sets. This also applies to ships, submarines and weapons.

F-35A Blue and Su-35 Red



Su-35 Blue and F-35A Red

Harpoon 3 Advanced Naval Warfare : H3PD Version 3.10.0.0 Release Version

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Game Map 1

Unit Status

DATABASE	REPORT
Name :	PLA HALE (China-25k)
Tag :	R268
Side :	China
Course :	23
Speed :	650 (Cruise)
Altitude :	50001m (SubOrb)
Fuel :	52611:06:40
EMCON :	ACTIVE
Mission :	IRON EAGLE
Task :	Patrolling
Loadout :	Minimal
Sea State :	4
Clouds :	Clear
Precip :	Clear
Act. Comm :	6000
Pas. Comm :	6000
Light :	Darkness

Incoming Messages

Difficulty Setting: Full Realism
Difficulty Setting: Aircraft Logistics Enforced
User Option 'VerboseWeaponDetection' is on.
User Option 'UseNukes' is on.
User Option 'ExtraVerbosePointDefense' is on.
User Option 'ExtraShortPointDefense' is on.

Game Status

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F/A-18F



F/A-18F v Su-35

Using H3MilSim and the Satellite Tool Kit is a very cost efficient way to move from the general to the specific without large overheads.

H3MilSim development time is less than many other simulations and has substantial advantages over more limited simulations that do not adequately represent the majority of systems in their application which may result in incomplete or inaccurate outcomes.

These deficiencies may have significant policy implications.

F/A-18F Blue and Su-35 Red

Harpoon 3 Advanced Naval Warfare : H3PD Version 3.10.0.0 Release Version

* File Settings Mission Window Edit Database Countries Database Unlocked

Zoom Map 2

639 NM →
426 NM
U

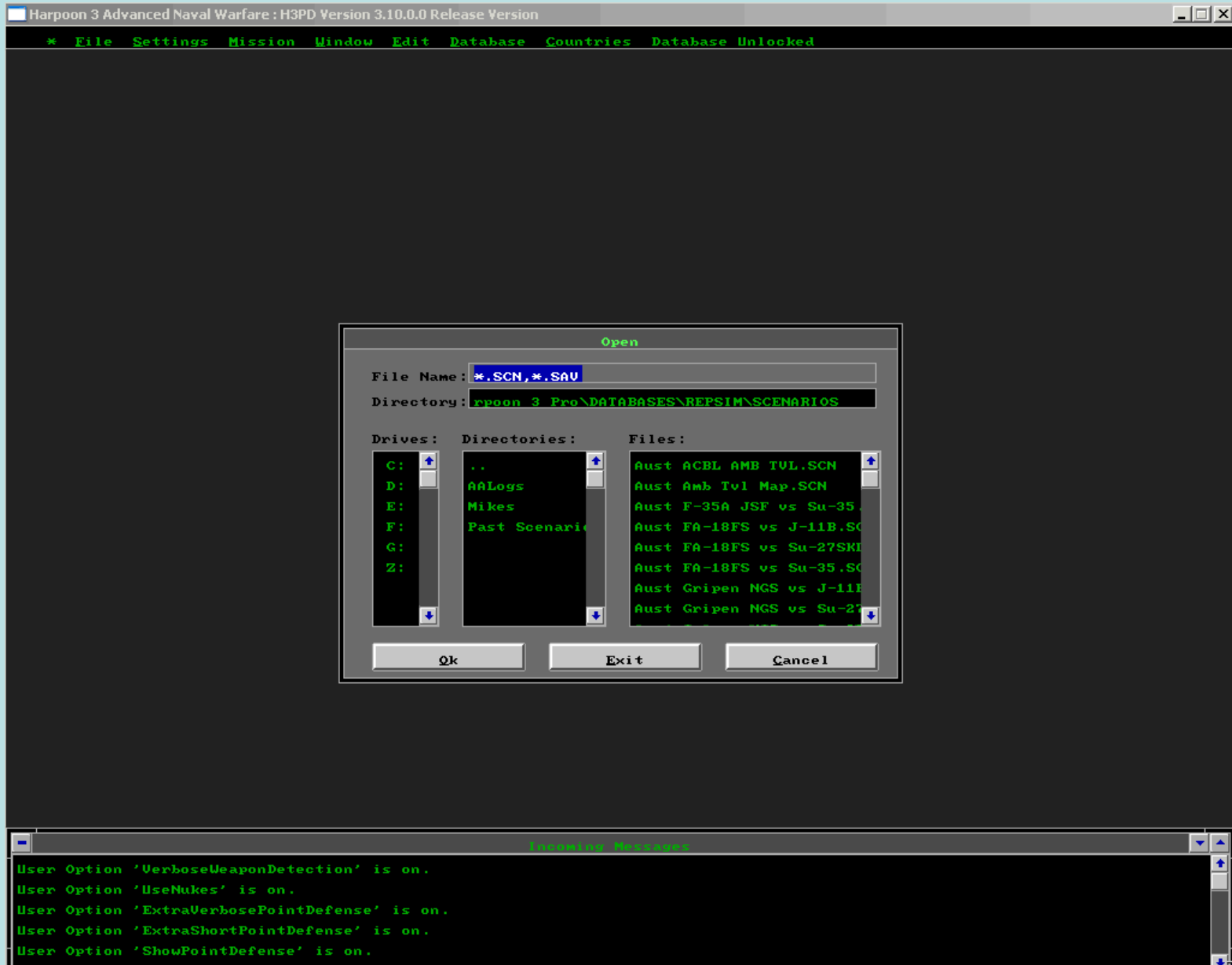
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Su-35 Blue and F/A-18F Red



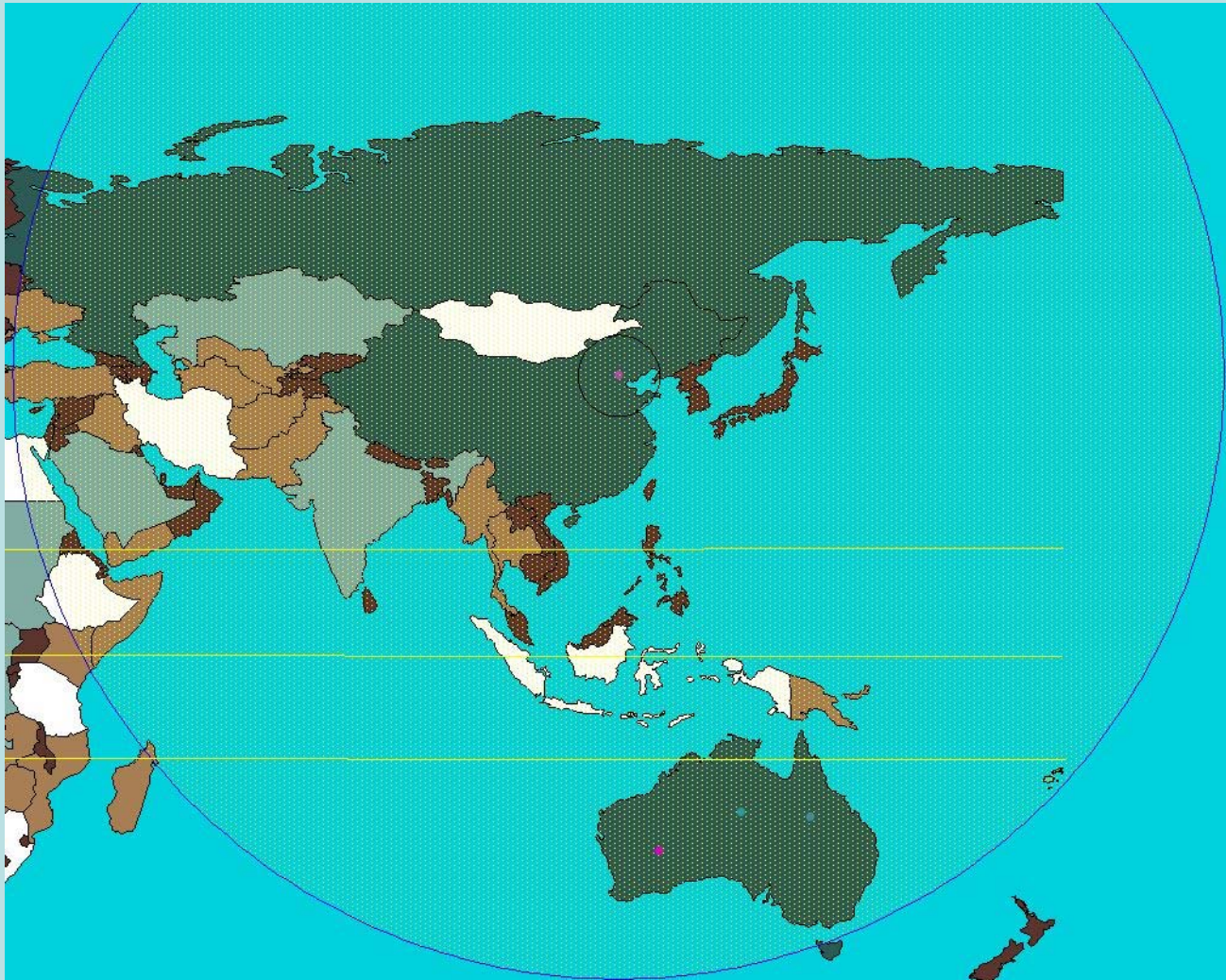
Changing paradigms

- Surveillance – Chinese Over The Horizon Radar (OTHR) can track F-22, F-35A and F/A-18F from Okinawa, Guam or aircraft carriers out to a range of 4,250nm.



Representative Chinese Antenna Farm

What Chinese Over The Horizon Radar (OTHR) coverage could mean for Australia in the near future and our Defence capabilities threat of interdiction.



Weapon Systems Issues

- Longer range Russian or Chinese air-to-air missiles, fired in salvos of different seeker types (radar, passive anti-radiation and infrared);
- Better air-to-air missile launch profiles, up to 15k ft above target altitude, results in higher probability of target acquisition in beyond visual range (BVR) mode;
- Long range radars, sophisticated ESM (coordinated DF), lower frequency L-Band radar and infrared scan and track sensors on aircraft when cued by HF OTH radars that can track current generation stealth aircraft, effectively negate Stealth, especially over water where there is no “fog of war” in which to hide;
- Current and next generation SAMs (S-400, S-500 types) can, with new ballistic profiles, exploit long range ESM and interferometric HF OTH radar systems for mid-course updates; and by using their large organic radar in the terminal phase of the engagement gain a plan-form view of the aircraft thus significantly increasing the probability of interdiction and destruction with their larger, improved warhead.

Simulation Configurations

- Sn35BM x 8** 48 Flares & 48 I/K Chaff + 150 rds 30mm Gun
SPS-170 ECM pods and 2 x KEDR Towed Decoys
5 x R-72 LRAAM, 1 x AA-10D LR IR, 2 x AA-11 WVR
- Sn35BM x 8** 48 Flares & 48 I/K Chaff + 150 rds 30mm Gun
SPS-170 ECM pods and 2 x KEDR Towed Decoys
4 x R-27 TE, 4 x R-27 EP, 2 x AA-11 WVR
- Sn35BM x 8** 48 Flares & 48 I/K Chaff + 150 rds 30mm Gun
SPS-170 ECM pods and 2 x KEDR Towed Decoys
4 x R-77 T, 4 x R-77 P, 2 x AA-11 WVR
- F-22 x 24** 48 Flares & 48 I/K Chaff + 480 rds 20mm Gun
6 x AIM 120D & 2 x AIM 9X
- F-35A x 24** MIRFS ECM + 180 rds 25mm Gun
4 x AIM 120D + L-Band DEW
- F-18F x 24** 48 Flares & 48 I/K Chaff + 578 rds 20mm Gun
3 x 480gal tanks 6 x AIM 120C & 2 x AIM 9X +2 x ALE 55 (V)

Aircraft Combat Profiles

F-22s operate at 65,000 feet Above Sea Level (ASL) to maximise their air-to-air weapons kinematic range when launched at Mach 1.5 against the Su-35 and also allows the F-22 to maximise its radar potential against the Su-35. The higher altitude allows the F-22 to 'perch' and accelerate in a shallow dive against the lower flying aircraft.

This altitude also maximises the proposed AIM-120D engagement envelope based upon Su-35 maximum sustained combat operating height of 55,000 feet ASL.

The AIM-120D will use gravity-assistance to accelerate to its target at 55,000 feet and therefore increase its effective No Escape Zone (NEZ), compared with a co-altitude engagement range against the Su-35 of less than 35 nautical miles (nm).

The F-22 also employs a lateral spacing of around 20nm between aircraft to ensure that no Su-35 can effectively engage more than one F-22 at a time.

Aircraft Combat Profiles

Su-35s operate at 55,000 feet ASL to maximise their air-to-air weapons kinematic range when launched at maximum speed and also to maximise radar potential against the F-35A and F/A-18F. It allows the Su-35 to ‘perch’ and accelerate in a shallow dive against the lower flying aircraft. The Su-35 has L-Band radar in the wing leading edges to detect aircraft ‘stealthed’ at the higher X and Ku Band frequencies. It’s IRBIS-E radar can sense targets 240 degrees around the nose, while US AESA radars are limited to 120 degrees – thus the Su-35 can track and fire while opening range.

The Su-35 55,000 feet altitude also minimises the proposed AIM-120D and AIM-120C engagement envelopes based upon F-35A maximum sustained combat operating height of 40,000 feet ASL. The F/A-18F operates at about 43,000 feet ASL.

The AIM-120D and AIM-120C will expend a good portion of their energy just to reach 55,000 feet and therefore reduces the effective No Escape Zone (NEZ), compared with a co-altitude engagement range against the Su-35 to less than 30 and 15 nautical miles (nm) respectively.

The Su-35 also employs a lateral spacing of around 20nm between aircraft to ensure that no F-35A can engage more than one Su-35 at a time and that the “nose on, co-altitude” stealth qualities of the F-35 are marginalised in a multi ship engagement.

The Result

Transition from the John Boyd era of “Energy Management” concepts, aircraft and weapons to the evolving era of “Battle-space Dominance”

Energy management is now primarily about defensive ability to avoid BVR missiles, by positioning countermeasures such as expendable decoys, towed decoys or directed energy, if detected.

Supremacy is now with the lowest detection profile, the broadest spectrum of sensors, the highest instantaneous turn rate, the best situational awareness and most potent, multi-sensor BVR and WVR weapon capacity and capability and effective countermeasures.

Overall Loss Exchange Ratios (LER)

How many aircraft you lose compared to the enemy

F-22 v Su-35	F-35A v Su-35	F/A-18F v Su-35
1 to 2.1	2.4 to 1	8.0 to 1
Not bad at all	Depressing	Devastating
E3-F & KC-10A	E3-F & KC-10A	E3-F & KC-10A
Losses	Losses	Losses
2.0 & 3.6	2.0 & 4.2	2.0 & 6.0

Two out of three:

can't turn,

can't climb,

can't run

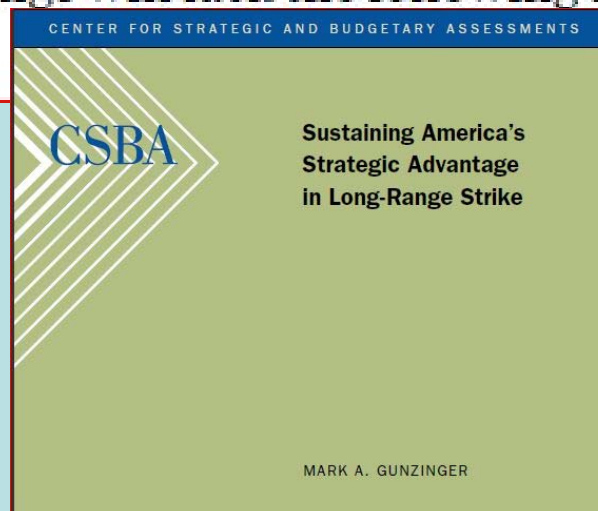


Are these assessments harsh?

Read on:

Today, the Navy's F/A-18E/Fs provide the nation with a powerful instrument for precision strike in non-contested operating environments at very short ranges, or at longer ranges when enabled by aerial refueling. As for survivability, low-observable F-35s will be better able to operate in future contested environments compared to the F/A-18E/Fs that the Navy will continue to procure through FY 2013. Even when F-35s begin to join the fleet over the next several years, the Navy's air wings will be challenged to strike targets more than a few hundred miles from their carrier decks in contested environments, even if enemy threats do not prohibit aerial refueling. Thus, without changes to the program of record, US carrier air wings will lack the following attributes needed for high-end A2/AD scenarios:

Source:
CSBA Report
September, 2010



Not only cannot the EA-18G keep up with a strike package, but it isn't designed to survive combat against today's 2012 benchmark threats of Su-30s / S-300s.

So what about tomorrow's threats like the Su-35 / S-400 and the T-50 / S-500 in the near to mid term?

The EA-18G, based on the two-seat F/A-18F fighter, lacks the range, persistence and survivability to support US strike platforms that penetrate deep into contested airspace. In an assessment of a 2012 Major Combat Operation, the Institute for Defense Analyses determined that the EA-18G was "not designed to survive within defended airspace" and thus must provide AEA from standoff distances, a concept of operations that is ill-suited for supporting penetrating strike platforms.¹⁵⁸

¹⁵⁸ See "Tactical Systems and Missile Defense," Institute for Defense Analyses, accessible online at <https://www.ida.org/researchareas/systemevaluations/tactical%20systems%20and%20missile%20defense.php>.

REPSIM Pty Ltd

- So, compared to independent, expert third party work, REPSIM has demonstrated the skills, experience and knowledge to produce simulations with quantitative data that are consistent with their conclusions.
- Our work is based upon *the reasonable and representative test* - not a ‘best guess’, ‘situating the appreciation’ or ‘leaving out the bad bits’ approach.
- We have the professionalism, independence and objectivity to provide Parliament with useful results tailored to Parliament’s needs, *not marketing material*.

How can you get substantially different simulation results for similar scenarios?

- Five areas in simulations, individually or collectively, can give results that fail *the reasonable and representative test*.
- They are:
 - Scenario bias;
 - Tactical bias;
 - Data bias;
 - System bias; and
 - Cultural bias.

Scenario bias:

- Use a simulation, or simulations, that cannot include in its representations all of the assets, threats or risks that need to be evaluated to come to a reasonable and representative outcome.
 - Take the partial outcome of the simulation(s) and then extrapolate the answer to give a favourable outcome.
 - For example, use an air-to-air simulation that does not include geography or HF OTH radars or air defence assets and disregard network communications from ground sources to alert or control airborne adversary aircraft to assess say, the F-35A likely outcomes in air-to-air combat.

Tactical bias:

- Develop a simulation, or simulations, that represents the best circumstances that favours the preferred choice and places the enemy in an unrepresentative ‘worst-case’.
 - For example, in air-to-air simulations for the F-35A set the altitude for combat for all aircraft at 30,000ft with a speed of Mach 1.2 and a 20nm spacing for the F-35A aircraft and a 500m spacing for the adversary aircraft – this ensures the best combat performance for the F-35A but against say an Su-35 it represents the least favourable combat profile when engaging an F-35A type aircraft compared to a more reasonable 55,000ft, Mach 1.8 and 20nm spacing.

Data bias:

- Develop a simulation, or simulations, that do not fully represent the system limitations or maximum performance opportunities.
 - For example, in air-to-air simulations for the F-35A, use the maximum fuel capacity as the limiting factor for combat endurance rather than the minimum fuel holding value required for heat dissipation for F-35A systems;
 - for an adversary aircraft like the Su-27 or Su-30, limit the number of semi active radar homing (SARH) missiles able to be fired and controlled to only 1 (one) at a time rather than the number the system is actually capable of firing.

- A simple example – Radius of Action (ROA):
 - the JSF Project Office briefing to the Norwegian government in 2007 claimed a F-35A ROA of **740nm**.
 - the US DoD specified ROA for the F-35A was specified at **590nm** (minimum) and **690nm** (objective).
 - the current F-35A achieved ROA from the US DoD SAR 2010 is **584nm**.
 - USN data specification dated February, 2012 which states the F-35A minimum ROA as **450nm**.

Guess which one might be used in a simulation?

System bias:

- Use a simulation, or simulations, that allow process steps to hide critical deficiencies.
 - For example, in air to air simulations for the F-35A use a simulation that registers a weapon ‘hit’ as equal to an aircraft ‘kill’ irrespective of the simulation engagement geometry, aircraft area ‘hit’ systems vulnerability and possible weapon terminal effects.
 - This approach allows aircraft with less ordnance capacity and inferior weapon capability to achieve higher kill rates against larger adversary aircraft with multiple redundant systems than would be reasonable and representative in real combat.

Cultural bias:

- Use a simulation, or simulations, with criteria that have no real value but contribute to simulation outcomes.
 - For example, in air-to-air simulations for the F-35A use a simulation that provides numerical values for morale, commitment, and aggressiveness that have little influence, if any, on Beyond-Visual-Range air-to-air combat where the result is more dependent on missile-on-aircraft performance, not pilot-on-pilot attitudes.

Remember:

**All official F-35A simulations
are classified so
you'll never, never know
because
they will never, never show!!**

Summary

**Currently, it could be well argued that Australia
has a White Paper (2009) based upon**

WISHFUL THINKING

rather than

OBJECTIVE ANALYSES

What if:

- **The US employed a new more stealthy, tail-less aircraft employing twin thrust vector control engines? and / or**
- **The US aircraft had better missiles like RB-107 Meteor? and / or**
- **The US aircraft BVR missiles had Imaging InfraRed (IIR) or passive anti-radiation (PAR) seekers or combinations thereof?**

What if:

- **The Chinese aircraft had SD-10Mk1 and SD-10Mk2 dual sensor BVR missiles (Radar/Passive Anti-Radiation (PAR) or IR/PAR)? and / or**
- **The Chinese had a new aircraft similar to the PAK FA (T-50) – like the J-20 / J-21? and / or**
- **The Chinese deployed plasma cloaking to sections of the airframe and systems?**

REPSIM Pty Ltd provides one source of independent analysis available today without any restrictions.

Parliament defines what it wants evaluated (maybe the future – near or far) not the Department of Defence.

Simulation is one means available to assess the relative combat performance of aircraft, ships, submarines, weapons, etc whilst they are in the development phase.

Defence Strategy and Force Structure

There are three simple precepts for these concepts:

- 1. to know strategy, know tactics;**
- 2. to know tactics, know technology; and**
- 3. to know technology, know numbers.**

Observation

“... somewhere along the way we appear to have lost the ability to do the numbers properly ...”

Questions?

REPSIM Pty Ltd

at your convenience