Aircraft Survivability:
A Look into the Crystal Ball
(A Composite Sketch)

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To:

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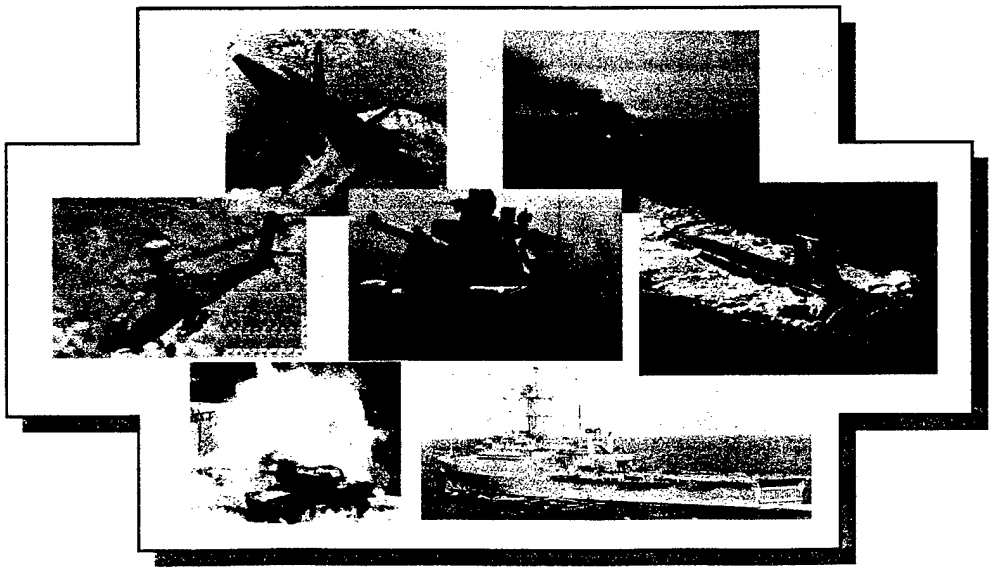

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Equal Factors

"Many factors influence aircraft survivability. Detection and tracking, susceptibility, performance and agility, and types of weapons used.

All play a role, as do an aviator's skills and the effectiveness of his tactics. But even if all our susceptibility reduction techniques work perfectly, **the odds are we will still take some hits.**

Therefore, **minimizing physical vulnerability is an equally important factor** in the overall survivability equation."

Rear Admiral John F. Calvert
PEO Tactical A/C
Navy Assistant Secretary, RDA
A/C Survivability magazine
September 1990, p. 6

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Misperceptions About Aircraft Survivability

1. Reducing aircraft vulnerability always has significant weight penalties.

2. Susceptibility reduction does not constitute the addition of significant weight.

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Misperceptions About Aircraft Vulnerability

(continued)

3. Vulnerability reduction and susceptibility reduction are mutually exclusive.

4. Aircraft always will be flying when subjected to threats.

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Misperceptions About Aircraft Vulnerability

(continued)

5. We won't get hit.

6. Vulnerability reduction applies only to damage caused by combat.

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Misperceptions About Aircraft Vulnerability

(continued)

7. There is no need to quantify vulnerability is one sufficiently can quantify susceptibility.

8. An aircraft hit is an aircraft killed.

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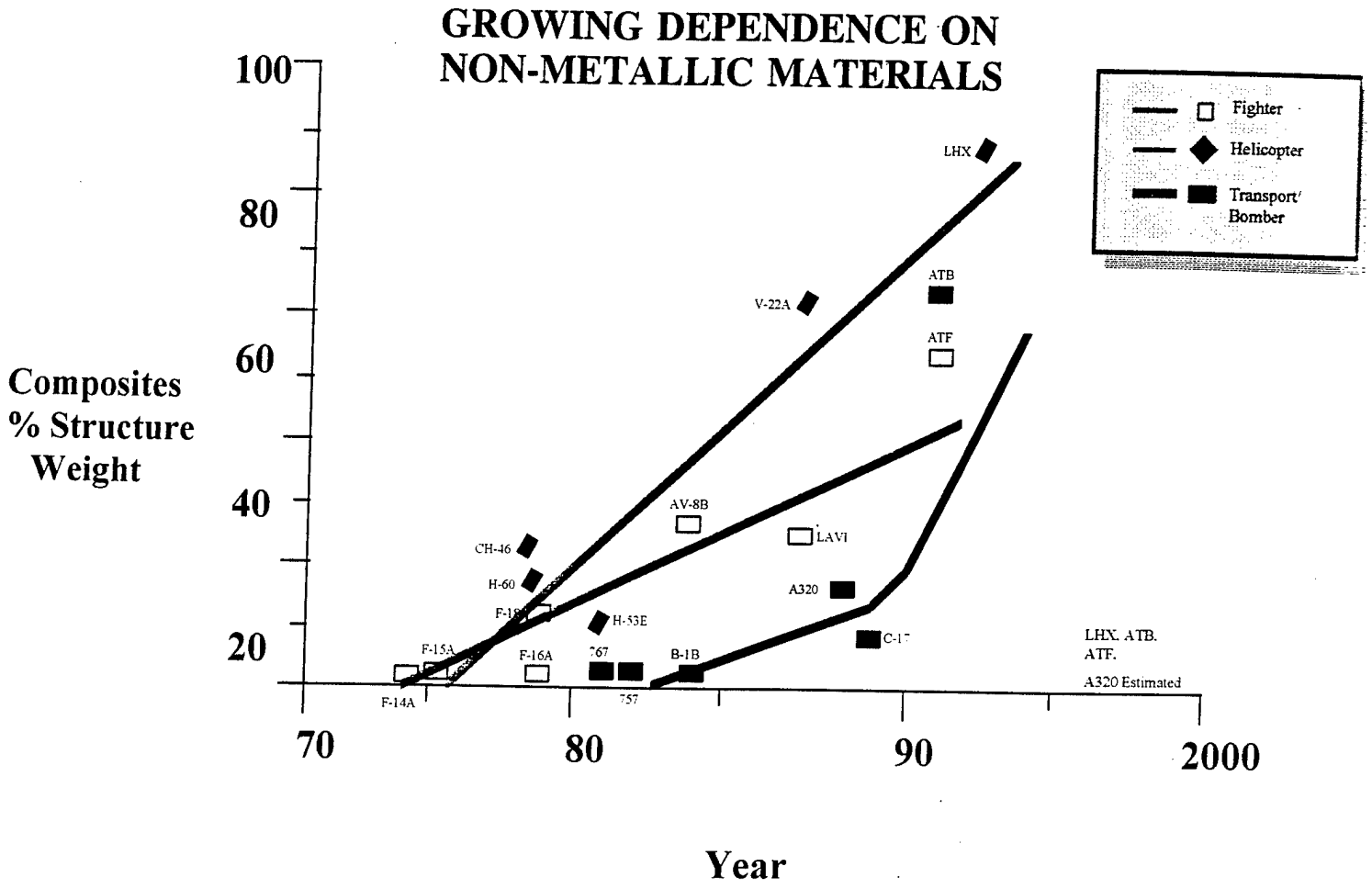
10 TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

GROWING USE OF NON-METALLIC MATERIALS

- O INADEQUATE DATA BASE
- O DANGERS OF EXTRAPOLATION FROM METALLIC DATA BASE AND FROM LOW VELOCITY IMPACTS ON COMPOSITES
- O DIFFICULTIES IN DIAGNOSING VULNERABILITY (E.G. DELAMINATION)
- O ADDED COST OF MANUFACTURE
- O ADDED COST OF MAINTENANCE
- O ADDED SUSCEPTIBILITY TO RF AND LIGHTNING DAMAGE


GROWING DEPENDENCE ON
NON-METALLIC MATERIALS
Composites
% Structure
Weight
100
80
60
40
20
70
80
90
2000
Year
Fighter
Helicopter
Transport/
Bomber
LHX
V-22A
ATB
ATF
AV-8B
LAVI
CH-46
H-60
A320
H-53E
F-15A
F-16A
767
B-1B
C-17
F-14A
757
LHX. ATB.
ATF.
A320 Estimated

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

INCREASING USE OF COST / BENEFIT

- O UNDER-ESTIMATION OF BENEFITS
- O VALUE OF HUMAN LIVES SAVED OFTEN NOT INCLUDED
- O NO EXISTING METHOD IS ABLE TO CAPTURE THE VERY REAL BUT NON-QUANTIFIABLE BENEFITS

Quantifying the Value of a Life

The Department of Transportation uses several methods:

1. Lifetime earning power lost to the family.

2. Economic loss to the organization from which the individual came.

3. Anticipated amount of money an insurance company would award if life was lost.

4. Punitive costs expected to be paid by an agency found at fault for loss of life.

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VULNERABILITY T&E PAYOFFS

INSIGHTS & FIXES YIELD NOT ONLY REDUCED ATTRITION IN COMBAT <u>ALSO YIELDS</u>

- O MORE DURABLE ROBUST A/C IN PEACETIME
- O LONGER A/C LIFESPAN
- O HIGHER TOLERANCE TO FOD, BIRDSTRIKES
- O HIGH TOLERANCE TO HARD LANDINGS
- O INSIGHTS WHICH CAN RESULT IN BETTER TACTICS (DIFFERENT COMBAT EXPOSURES)
- O DESIGN LESSONS FOR APPLICATION TO FUTURE AIRCRAFT
- O BATTLE DAMAGE AND REPAIR INSIGHTS, PRACTICE AND PROCEDURES
- O ADDED DISCIPLINE TO THE T&E PROCESS
- O DATA TO REVISE / CORRECT / CALIBRATE M&S TOOLS FOR BOTH FUTURE DESIGNS & DIAGNOSTICS & BETTER DIAGNOSTIC TOOLS FOR ASSESSMENT OF PAST A/C FAILURES

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

GROWING RELIANCE ON STEALTH

- O LESS TRADE SPACE LEFT FOR VULNERABILITY REDUCTION
- O MANY STEALTH MATERIALS NOT OPTIMIZED FOR STRENGTH
- O ADDED WEIGHT TO ACHIEVE LO
- O POTENTIAL TECHNOLOGICAL BREAKTHROUGHS IN TARGET ACQUISITION COULD NEGATE STEALTH
- O LITTLE TO NO PAYOFF IN PEACETIME
- O HEAVY MAINTENANCE BURDEN
- O SMALL HITS - LARGE RCS GROWTH
- o COSTLY INVESTMENTS IN STEALTH LEAVING LESS $ LEFT FOR VULNERABILITY REDUCTION TRADES

Stealth According to Kasich
(continued)

- Stealth is not invulnerability or invisibility. It is management of the aircraft's signature.

- Just as there is no "free lunch," Stealth is a compromise.

- The stealthier an aircraft, the more likely it is to degrade other desirable combat characteristics, such as speed, maneuverability or payload.

- Stealth is inherently expensive and difficult to maintain; the coating degrades with each mission. Stealth is not an all aspect cloak of invisibility. It is optimized to defeat radars ahead of the aircraft, but is less effective from other angles."

John R. Kasich
Washington Post
July 19, 1995

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Stealth According to Kasich
(continued)

Historically, weight growth/cost growth has been attributed unjustifiably to primarily vulnerability reduction.

"The risk/benefit trade space for stealth also has very significant procurement cost, weight, performance and maintenance penalties, which must be integral to any cost/benefit study."

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

GROWTH OF "PEACETIME VULNERABILITY" LOSSES

- O BIRD STRIKES
- O LIGHTNING STRIKES
- O WIRE STRIKES
- O FOD
- O TRAINING ACCIDENTS

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

HEAVIER RELIANCE ON MANEUVER

- O GROWING G-LOADING (BOTH + AND -) ON AIRFRAME
- O GROWING G-LOADING (BOTH + AND -) ON PILOT(S) (GLOC / ALOC IMPLICATIONS)

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

CHANGING NATURE OF THE THREAT

- NOT JUST BIGGER, BETTER, FASTER
- FROM BULLETS TO SMART BULLETS
- FROM MISSILES TO SMART MISSILES
- FROM BALLISTIC TOWARD DIRECTED ENERGY
- EMERGENCE OF "NICHE WARFARE"
- SOFT KILLS BECOMING AS CRITICAL AS HARD KILLS

Scope of LFT&E Threat Considerations

Some Ballistic Threat Types	Some Non-ballistic Threat Types	Non-LFT Threat Types
Small Arms	Lasers	Nuclear
Fragmenting Projectiles	Incendiaries	Thermonuclear
Shaped Charges	Blast/Fuel Air Explosives	Chemical
Kinetic Energy Rods	Charged Particle Beams	Biological
Self-Forging Frag	High Powered Microwaves	
High Explosives		

Traditional ← → Non-Traditional

Conventional ← → Unconventional

Covered By Live Fire Requirements ← → Not Covered

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Future Trends in LFT&E

* New systems are becoming more complex:

Computer-based + Light weight

=

Easier shock kills

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* Testing needs to rethink what it is trying to find out:

Live Fire Test design must account for the "soft" kills
and
partial kills
not Live Fire and Brimstone

Live Fire Testing

≠

Live Fire & Brimstone Testing

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

TREND TOWARD MORE INTERNALLY STOWED MUNITIONS

- O INCREASES STEALTH AND RANGE
- O SIGNIFICANTLY INCREASES A/C VULNERABILITY
- O A/C MUST BE TREATED AS TOTAL SYSTEM - INCLUDING STOWED MUNITIONS

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

HEAVIER RELIANCE ON M&S

- O MODELS STILL INADEQUATE TO PREDICT VULNERABILITY, AT THE COMPONENT LEVEL, LET ALONE AT THE FULL-UP SYSTEM-LEVEL
- O INADEQUATE ARCHITECTURES TO YIELD MEASURABLE AND COMPARABLE OUTPUT METRICS
- O SOME PHENOMENA NOT MODELED ADEQUATELY OR AT ALL (FOLLOW-THROUGH FIRE, ULLAGE, HYRDO RAM, SPALL, RICOCHET, RF. ETC)

DOT&E/LFT&E SUPPORT TO M&S

1. LFT&E / JLF

o SHORTER TERM
o WEAPON / PLATFORM SPECIFIC
o TEST DRIVEN w/ PRE-SHOT PREDICTIONS
o PRIMARILY FROM EMPIRICALLY BASED MODELS

2. TILV

o MID-TERM
o MORE TARGET GENERIC (A/C, SHIPS, COMBAT VEHICLES)
o TEST & MODEL DRIVEN

3. DOT&E/LFT&E / DOE ASCI MOA

o LONGER TERM
o MOST TARGET INDEPENDENT
o "PHYSICS-BASED MODELS" VALIDATED BY REALISTIC LFT&E TEST OPPORTUNITIES

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

MOVE TOWARD COMMERCIAL SPECS AND STANDARDS

- O LESSONS BEHIND EXTANT MILSPECS NOT OFTEN AVAILABLE OR HEEDED
- O POTENTIAL LIABILITY TO A/C MANUFACTURERS IF ATTRIBUTABLE LOSS OF A/C AND/OR LIFE TO "POOR" DESIGN
- O PEACETIME MENTALITY PERVADING A/C MINDSET

TRENDS AND CONCERNS IMPACTING THE AIRCRAFT SURVIVABILITY COMMUNITY

MOVE TOWARD MARGINALLY STABLE / AERODYNAMICALLY UNSTABLE AIRCRAFT

- O IMPACT OF DAMAGE TO CONTROL SURFACES
- O EFFECT OF DAMAGE / DEGRADATION TO FLIGHT CONTROLS & SOFTWARE, POSSIBLE LOSS OF CONTROL
- O AI IMPLICATIONS

Objectives of LFT&E

- To enable the Secretary to make informed system acquisition decisions
- To gain insights into potential design flaws so that they can be corrected before entering full-rate production
- To ensure that knowledge of system survivability and lethality is based on realistic testing of the system configured for combat against expected threats
- Primary emphasis on testing vulnerability with respect to potential user casualties
    - Individual Soldiers
    - Armor Crews
    - Aircraft Crews
    - Ship Crews
    - Tactical Vehicle Crews

Lessons Learned from F-22 LFT&E

F-22 wing box test alone (less than $5M), conducted in September 1992, at Tutalip, near Seattle, resulted in a wing redesign which **reduced the vulnerable area of the aircraft by more than half** and added 120 pounds to the aircraft (adding titanium spars).

The average presented area of the aircraft for all six views is 536 square feet, $32 million for all LFT&E, max takeoff weight of A/C is approximately 58,0000 pounds, 50,000 over the target.

John Ogg and Hugh Griffis
F-22 SP and WPAFB
April 3, 1997

NEW LFT&E AND TRAINING INITIATIVE (LFT&TI)

- O ADDRESSES SECDEF'S T&E THRUSTS
- O SUPPORT FROM CONGRESS INITIATED IN FY97 AND GROWING
- O TAKING LFT&E RESULTS, TESTS, OPPORTUNITIES, INSIGHTS AND PROVIDE THESE TO THE TRAINING COMMUNITY FOR THEIR BENEFIT
- O TAKING TRAINING OPPORTUNITIES TO GATHER FURTHER LFT&E INSIGHTS

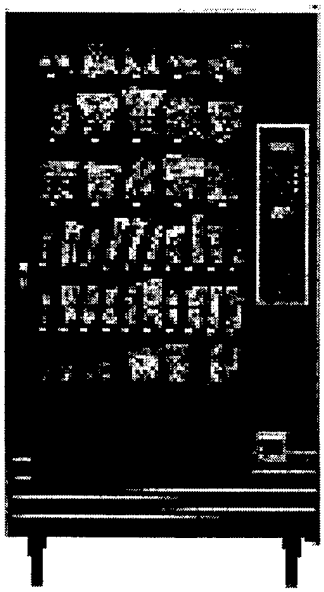
LFT Payoffs

- Provides the data necessary to make fully informed acquisition decisions
- Provides insights into vulnerability and/or lethality of systems in development
- Adds discipline to the test design process
- Provides battle damage and repair insights for training
- Provides spare parts stockage level data
- Teaches tactics lessons
- Feeds operational test assessment
- Provides necessary input to overall survivability analysis
- Provides basis for P_K's for force-on-force models (procurement mix)
- Leverages future weapons designs
- Produces data used as inputs to training simulators

It saves lives!

Change

Change is inevitable,
except from a vending machine.



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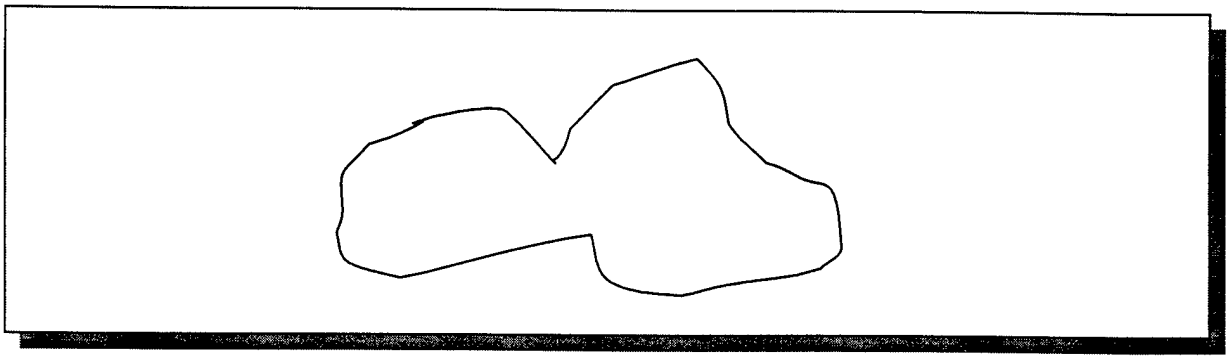

THINK ASYMMETRICALLY

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OUTLOOK

A PERSONAL VIEW

"PEACE IS THE TIME
BETWEEN CONFLICT
WHEN NATIONS TAKE
TIME TO RELOAD"