Aircraft Structural Integrity Program (ASIP) for Long Term Sustainment

U.S. AIR FORCE

Mike Aimone
AF/A4/7
18 Nov 06

Background

Rapidly delivering war-winning capability

- Numerous USAF initiatives outline approaches for addressing reliability and availability issues
  - SecAF Memo (7 Nov 05)
  - eLog21
  - CBM+
  - AAIP
- Existing data collection systems directly support near term maintenance needs, but do NOT provide key information for improving reliability and availability
  - Existing systems provide reactive information, not predictive

Background - ASIP Report

Summary of Structural Integrity Process Deficiencies

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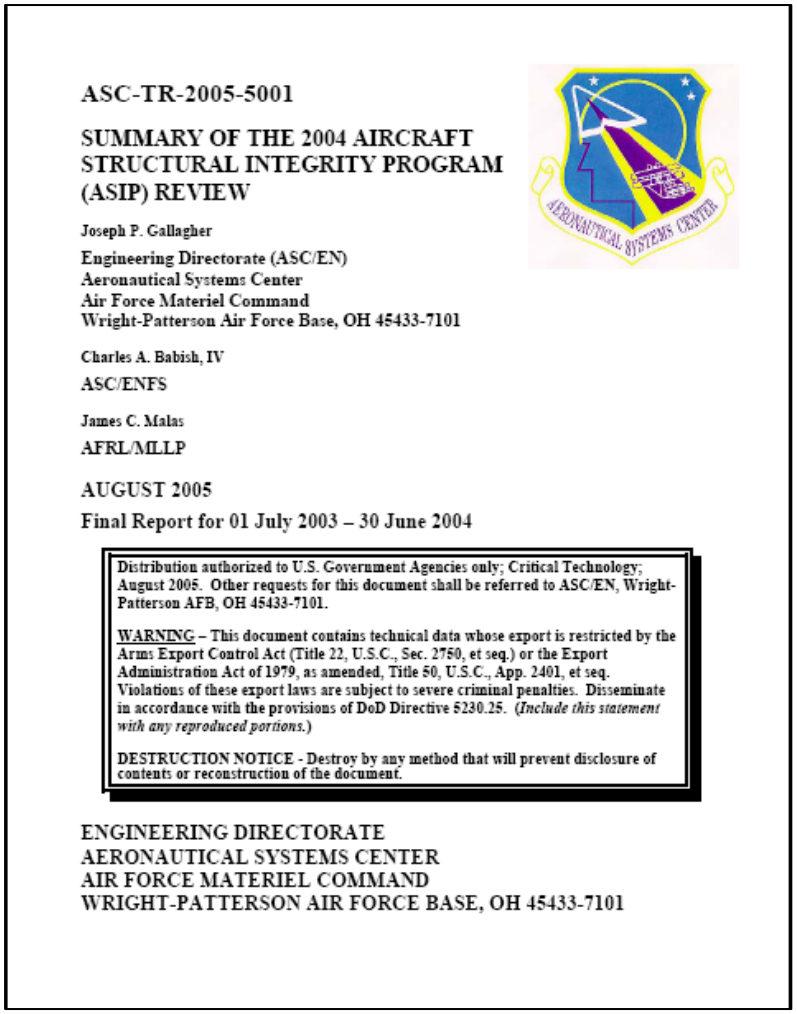

ASC-TR-2005-5001

SUMMARY OF THE 2004 AIRCRAFT STRUCTURAL INTEGRITY PROGRAM (ASIP) REVIEW

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AUGUST 2005

Final Report for 01 July 2003 – 30 June 2004

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ENGINEERING DIRECTORATE
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AIR FORCE MATERIEL COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-7101

- USAF's structural integrity track record is good, but …
  - **Multiple aircraft have ASIP process deficiencies – similar to those identified by the SecAF's Memo**
  - **As the fleets continue to age, the risks of structural failure increase**
- An effective ASIP can help to define/mitigate these risks
- However, ASIP reviews have identified:
  - **Process problems which directly impact our ability to anticipate and control the risks of structural failures**
  - **Technology needs to enhance the process**

Goal-Aircraft Availability

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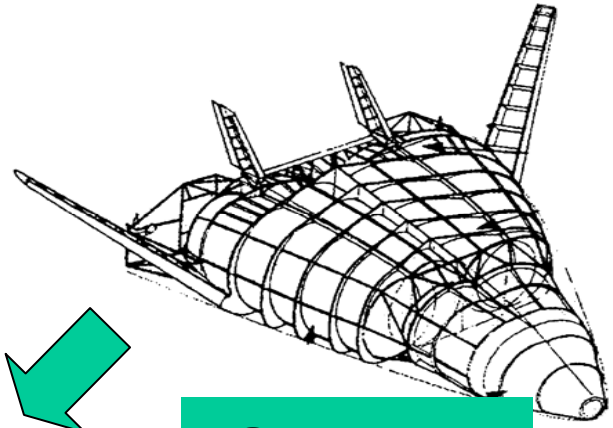
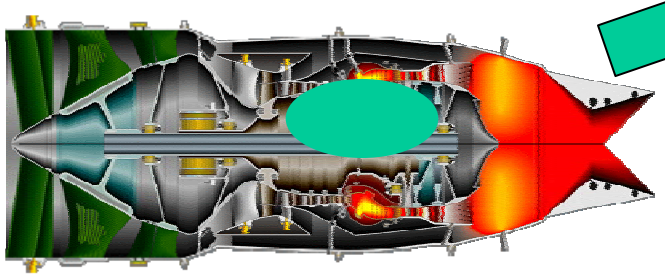
Flight Controls

Corrosion



Structures

Risk Assessment Capability



Propulsion Systems

Inspection Intervals / Maintenance Actions / Residual Capability

Avionics

Current CBM+ System

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"The best current CBM+ system is a well-trained, well equipped, very experienced maintenance technician who has the time and inclination to correspond in meaningful terms with the AFETS and Engineering people. Don't take that wrong. What I mean is that the closest thing we have to a system that can predict when a system will fail is the dedicated, expert technician." Air Force Maintenance Officer

AF TOA, Fleet Age and Fleet Size History: From the Collapse of the USSR to FY13

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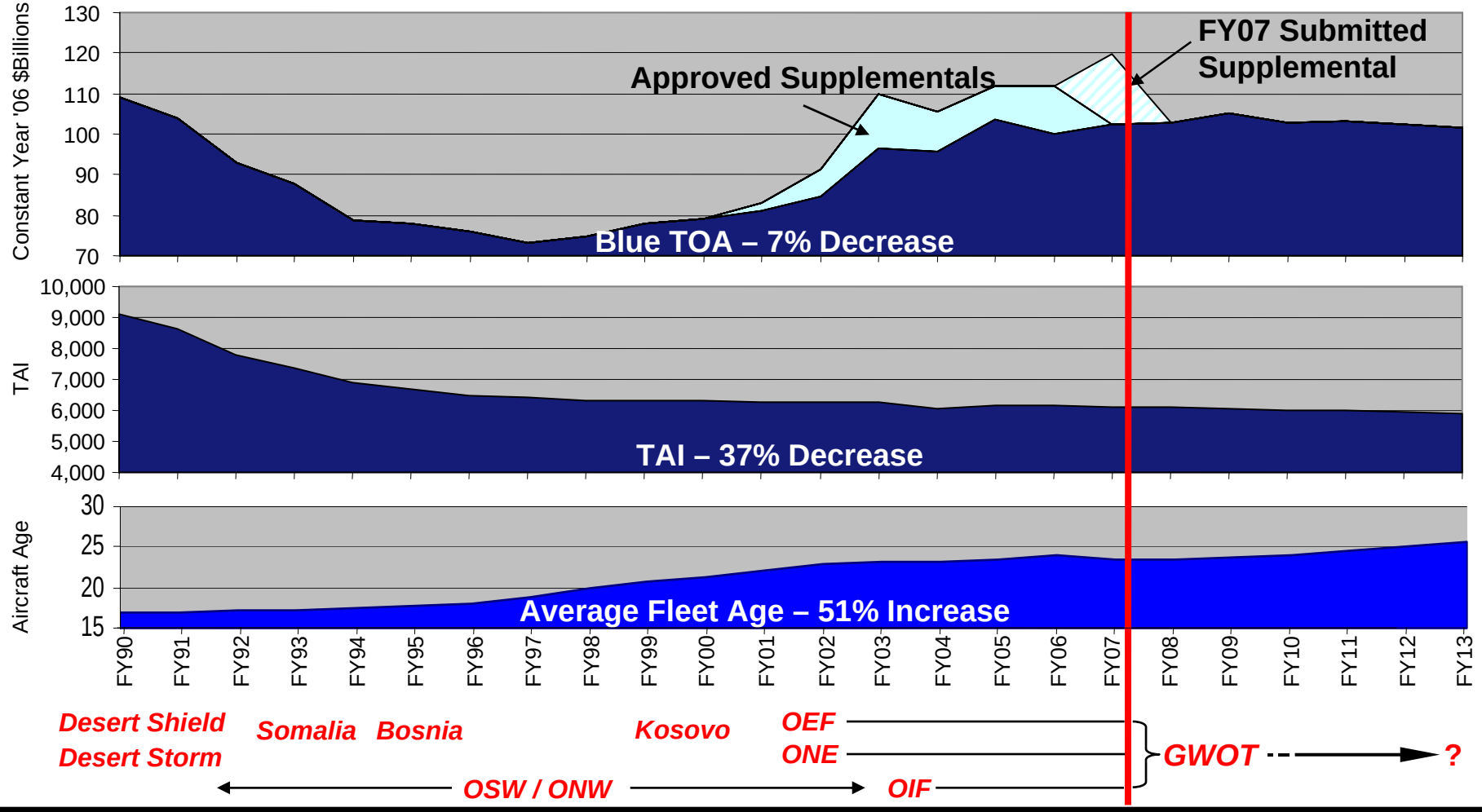

The AF Has Been At War For 16+ Consecutive Years…

Reliability/Availability Issues

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- Delivery schedules (decrease cycle time)
  - Improve Mx processes
  - Eliminate non-value added Mx tasks
- Aging Fleet
  - Data deficiencies
  - Insufficient analytical tools
  - Non-integrated data systems
  - Inability to adequately project fleet health
  - Inability to anticipate aging related failures
  - Corrosion
- Technology Related Efforts
  - Limited sustainment technology insertion
  - Lack of focused approach
  - No central technology clearing house
  - Bridge the chasm between development and implementation
    - Just-in-time technology products with required levels of maturity

Reliability/Availability Issues

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- New Aircraft ASIP systems are not consistent
  - F-22 records data, but usage is not immediately available to users
  - F-35 records data and makes usage data avail to users in near real time
    - Usage data sortable by acft, unit, pilot
    - Will allow management to balance usage on the entire F-35 force
  - C-17 Records flight dynamics, but not as-loaded condition
    - Does not provide acft usage data
  - KC-X Boiler-plate requirement for ASIP program

- Bottomline:--- Even on our newest acft, there is no coherent ASIP program to assist the maintainer

Availability/Reliability Concerns

Structures

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- Numerous C-130 aircraft grounded until cleared by TCTO inspections/repairs
- NDI miss indications continue to be reported
  - Previously assumed 90/95 detectable crack sizes (a_{NDE}) for eddy current surface scan are too small
  - Increasing a_{NDE} would result in more frequent inspections
  - However, must ensure that in-service inspections provide at least two chances to detect a crack before it reaches critical crack size
- Inadequate/non-existent:
  - Usage monitoring and recording/storage of usage data
  - Maintenance data collection/storage to support ASIP
  - Engineering analysis tools to interact with usage and maintenance data to proactively predict trends, manage fleet, and perform maintenance planning

Using ASIP to Accurately Anticipate Structural Failures

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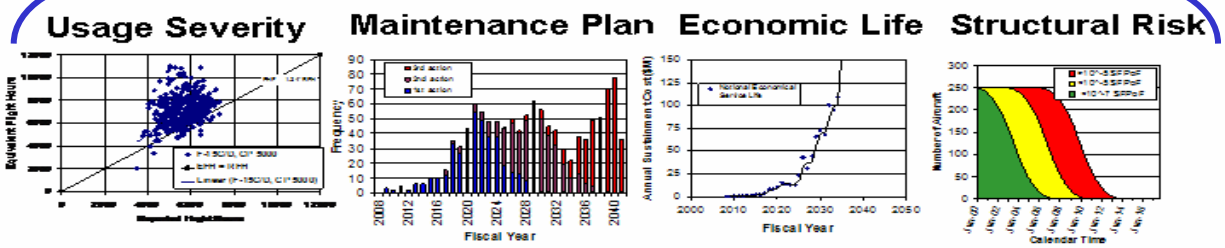
Required Information

This framework is general!
Note the focus is on Predicting

- Usage Monitoring
- Structural Models
- Actual Fleet Condition
- Inspection Fidelity
- Damage Findings
- Assessment
- Reporting



MUST CONSIDER A SYSTEMS APPROACH

Combining Usage & Mx Data

Serial Number Tracking (Aircraft & Components)

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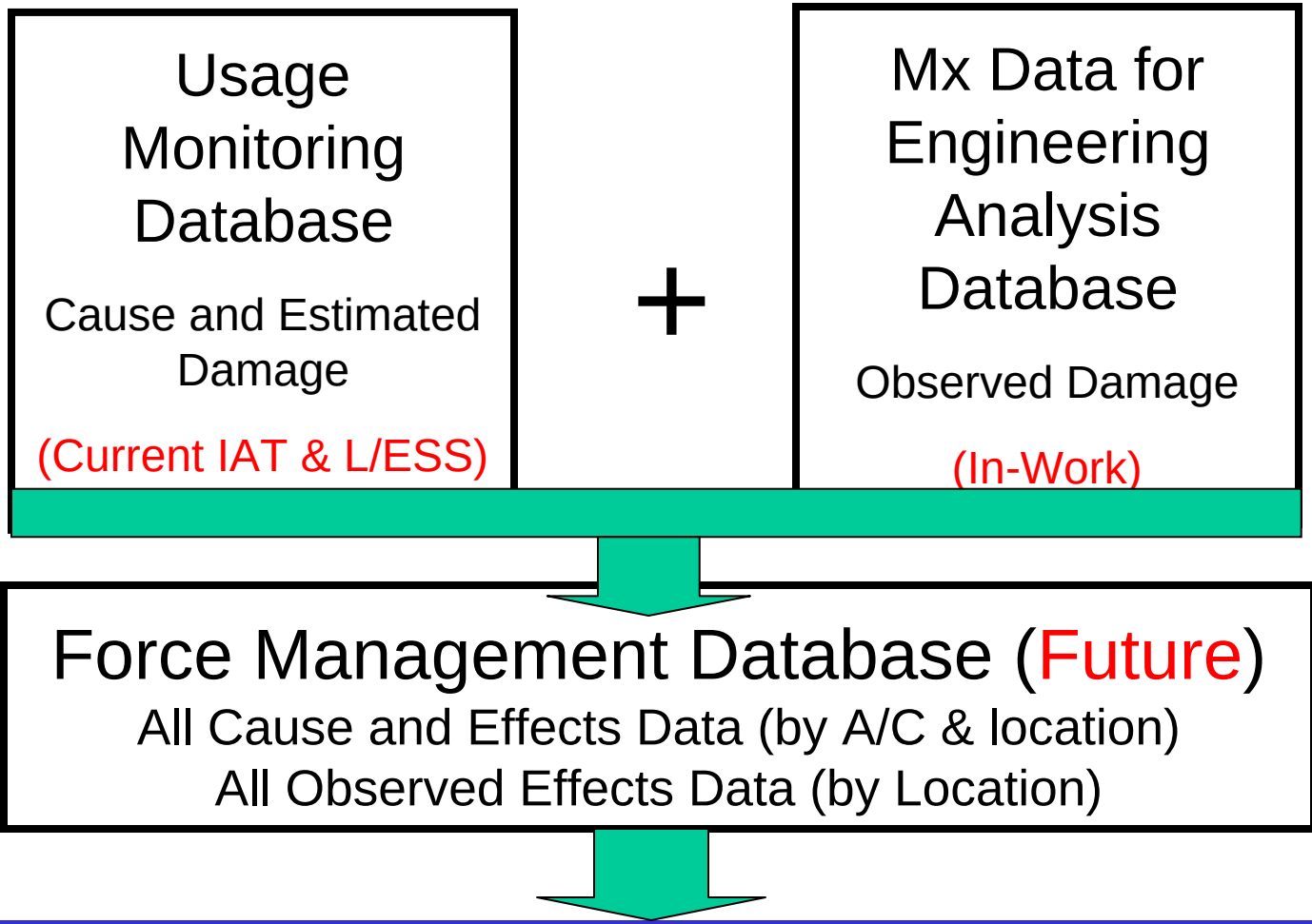

Anticipate Issues and Maintenance Actions by Calendar Time Through a Viable CBM+ Program

Combining Usage & Mx Data

Serial Number Tracking

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Cause and Estimated Damage Database (Current)

Usage monitoring data
- Flight Characteristics, Missions, Landings, Flight Loads, Calendar Time
- Effects By Fatigue Critical Location
  - Equivalent Flight Hours
  - Crack Size Estimates

Observed Damage Database (In Work)

Damage/Aging data for Engineering:
- Crack sizes, locations, configurations
- Corrosion characteristics, type, location, configuration
- Repairs by location, type
- Replaced structural elements

Combined IAT Database (Future) for Force Management

All Cause and Effects Data (by location)
All Observed Effects Data (by Location)

Tracks Aircraft and Serial Numbered Components

Combined Usage & Damage Data

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OUTCOME

- Improves the accuracy of anticipated aging damage, the scheduling of effective maintenance and clear definition of which aircraft by serial number should be retired
- For new corrosion and cracking locations, rapidly identifies the causes
- Builds confidence in anticipated structural maintenance requirements (including retirement) to address aging issues.

Next Steps

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- Focus: Address institutional problems that impact
  - continued availability of mission essential high-risk aircraft
  - reliability and availability for all USAF aircraft

- Key Elements:
  - Flesh out the future CBM+ program
  - Pilot programs to support aircraft with known serious reliability problems
  - “Test Bed”-like programs that generate solutions to known reliability problems and that implement products that eliminate classes of problems

- Need to effectively fund and support from Program Office.

- Extensive coordination required to provide an integrated set of solutions

We Must Prevent This!

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C-130A
17 June 2002
Walker, CA
3 fatalities

- Aircraft operated **within** limits
- 12” fatigue crack covered by OEM-installed doubler
- Crack could have been found (at ~0.75” long) by NDI
- Inspection interval should have been 12 times more frequent than USAF’s
- No depot-level inspection requirement

Back-Up

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Control Point Usage Severity

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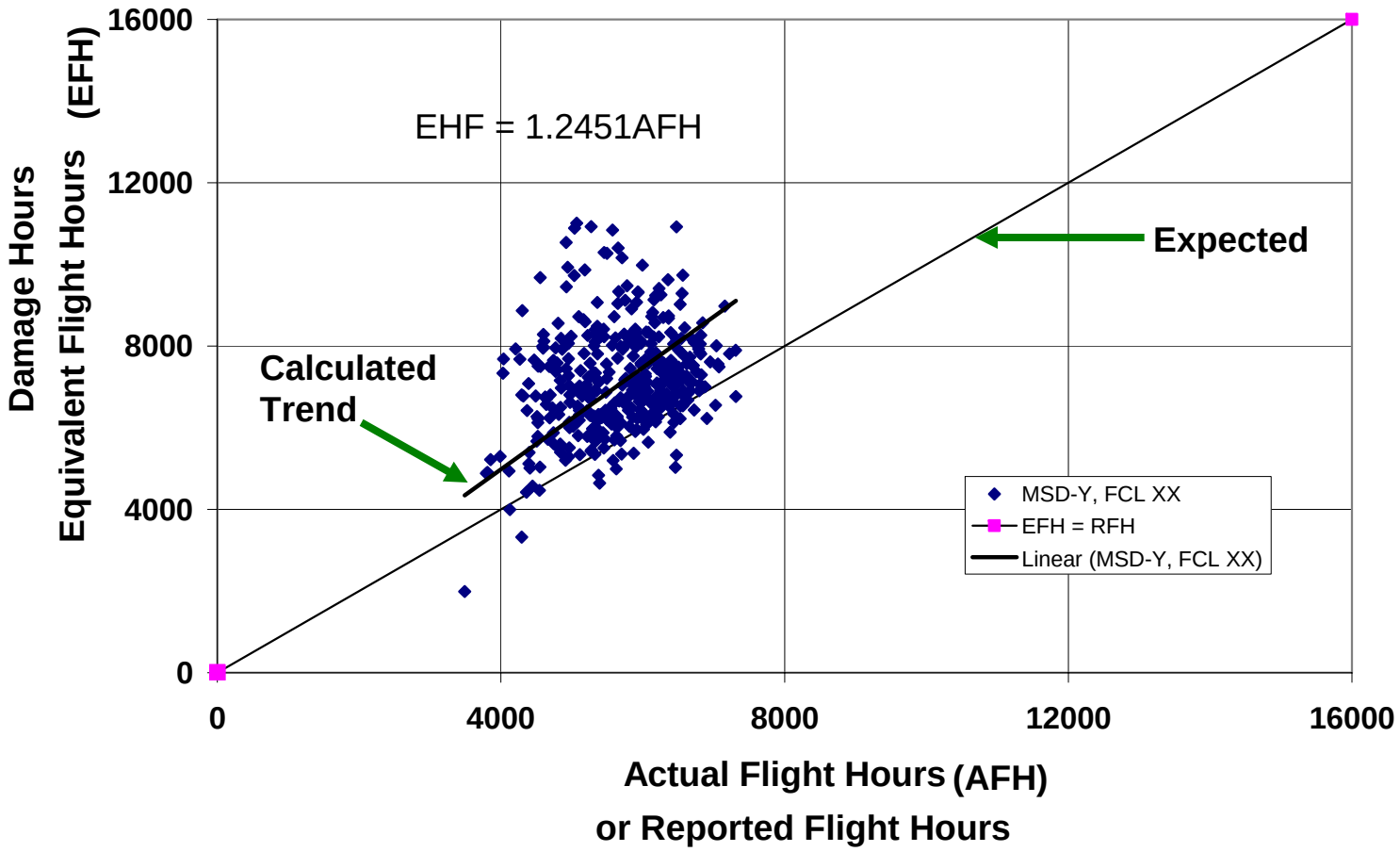
Distribution of
Equivalent Flight Hours (EFH) vs. Actual Flight Hours (AFH)
All aircraft in MDS (or Wing, Squadron)



Ratio of EFH to AFH = Severity Factor for the control point

Statistics of Severity Factor for One Control Point

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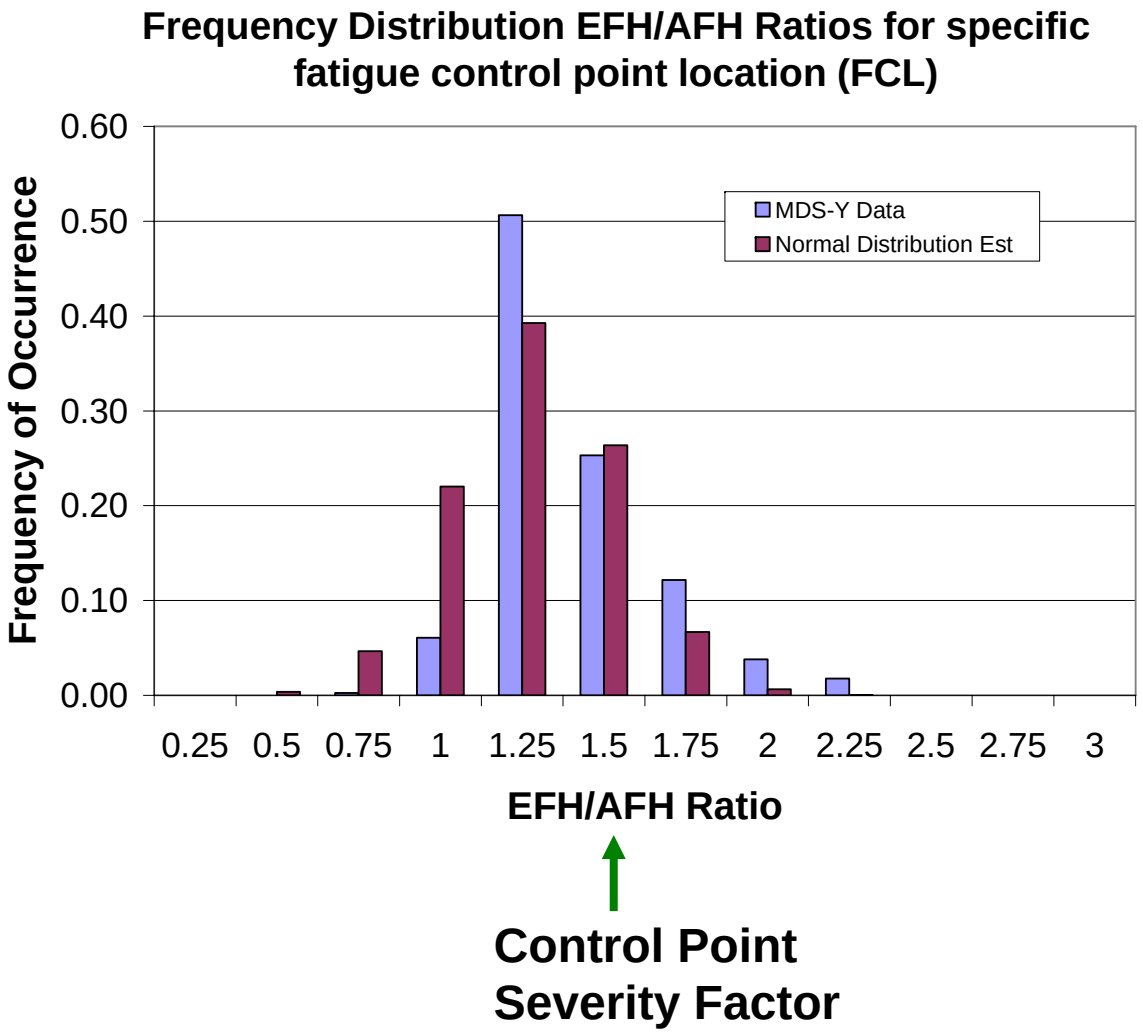

Based on statistical evaluation of data the average EFH/AFH = 1.27

Used in Projections

Number is Severity Factor for Control Point

Average Aircraft Predictions

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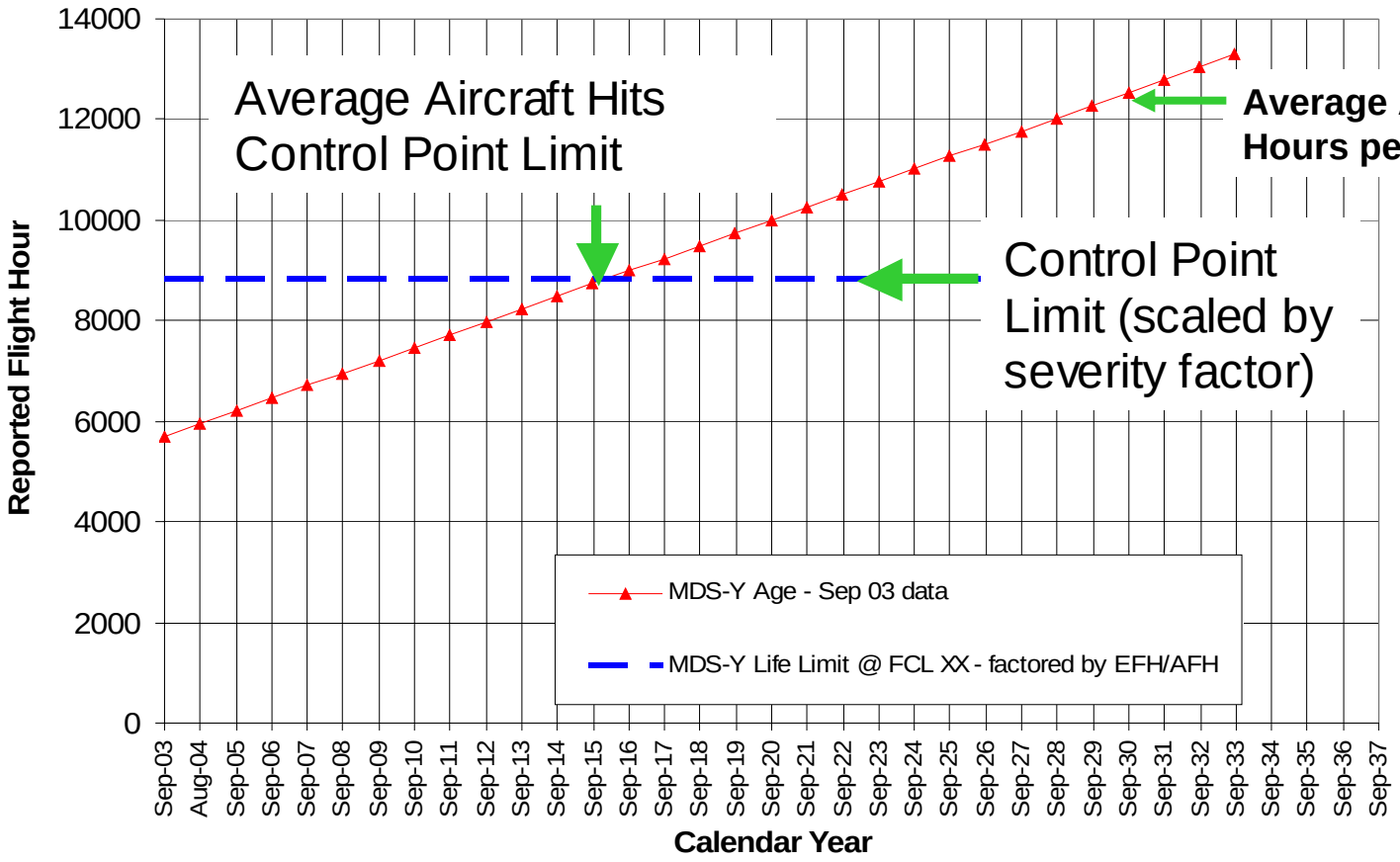
MDS-Y Age Progression, Limit for Control Point XX



Based on Average Cum-to-Date Flight Hours;

Usage as of 30 Sep 2003

Number of Aircraft Reaching Control Point Limit

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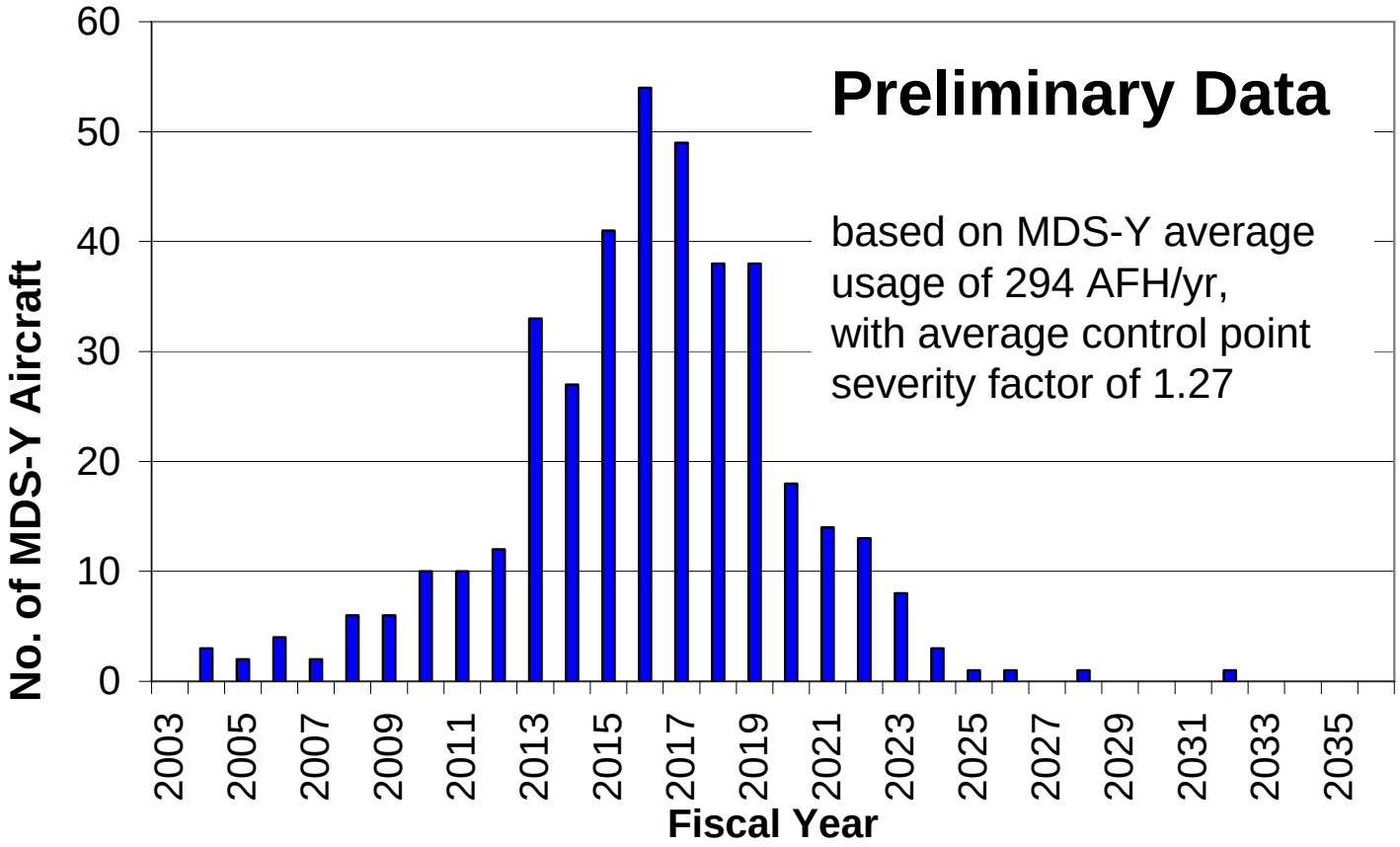
Estimated Calendar Times to Achieve Critical Condition (EFH = CRIT hrs) for MDS-Y Fleet



Overview

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- Aircraft Structural Integrity Program (ASIP)
  - Process for managing Aging in Fielded Aircraft
- Products of the process
  - IAT Standard Outputs
    - Severity Factors and Life Projections
    - Usage Summaries
- Risk Assessment Methods
  - Objectives of Workshop (30 Jun-1 Jul)
- Finalizing the AFIs

Next Steps

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- Continue to work with B-2, B-52, C-17, E-8C, C-5, C-141, F-15, A-10 and F-16 SPO ASIP Managers to incorporate best concepts and formats covering:
  - Aircraft Life Limit Projection Schemes
  - Usage Definition Schemes

  for MAJCOM ASIP reporting
- Communicate Best Practice IAT data summary schemes to all Weapon Systems
  - Define impediments to implementing best practice
  - Address impediments
- Address Data Collection Issues
  - Incomplete aircraft usage records

Background

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- ASC/EN report (Aug 05)
  - Aircraft structural integrity program (ASIP) process health
    - Information deficiencies lined up with SecAF Memo
    - #1 common deficiency was usage monitoring
- AF/IL & AF/CA Hosted AA TIM (Mid Oct 05)
  - "Test Bed" suggested as approach to demonstrate benefits of new technologies for sustainment
    - Challenged participants to establish better way
- SecAF Memo (7 Nov 05)
  - Dissatisfied with current data and projection capability to make reliability & structural integrity projections
    - AFMC/CC is poised to review 90 day plan with SecAF
    - Plan addresses usage monitoring deficiencies

Why Collect Engineering Data?

Demonstrate importance of capturing aging data

- Conduct risk assessments
- Build models for demonstrating effectiveness of existing life prediction processes
- Determine the level of aging damage in each aircraft
  - Anticipate level of required fleet-wide maintenance actions (readiness, availability and costs)
  - Develop trends that correlate with maintenance costs and aircraft downtime (readiness and costs)
  - Correlate with anticipated damage to validate the IAT and structural models (increase confidence in engineering estimates of life ending events)

MIL-STD-1530C Requires Mx Data – Why?

Rapidly delivering war-winning capability

- Conduct risk assessments
  - Focus management attention on most important reliability issues/consequences of a failure
- Validate effectiveness of existing processes
  - Correlate NDI capabilities with crack and corrosion findings
  - Determine likelihood of missing damage that could result in class A mishaps
- Establish the extent of aging damage in each aircraft
  - Identify aircraft that should be acted upon first (safety)
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Maintenance Data Collection (MDC) STIC

Rapidly delivering war-winning capability

- Concept: Change the concept of logistics data collection systems for decision making
- Objective: Collect the aging damage information required to anticipate future reliability problems
- Functions:
  - Define best processes/practices for capturing engineering data that support reliability and risk analyses without impacting production cycle-time
    - Initially concentrate on capturing:
      - ACI and 107/202 form data
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  - Demonstrate/Build interfaces between existing USAF databases and ASIP analysis tools used for predicting structural reliability and anticipating structural failures
  - Establish procedures for determining the level of aging damage in each aircraft

USAF ASIP Task V Process

The Feedback Loop for Maintaining Integrity and Safety

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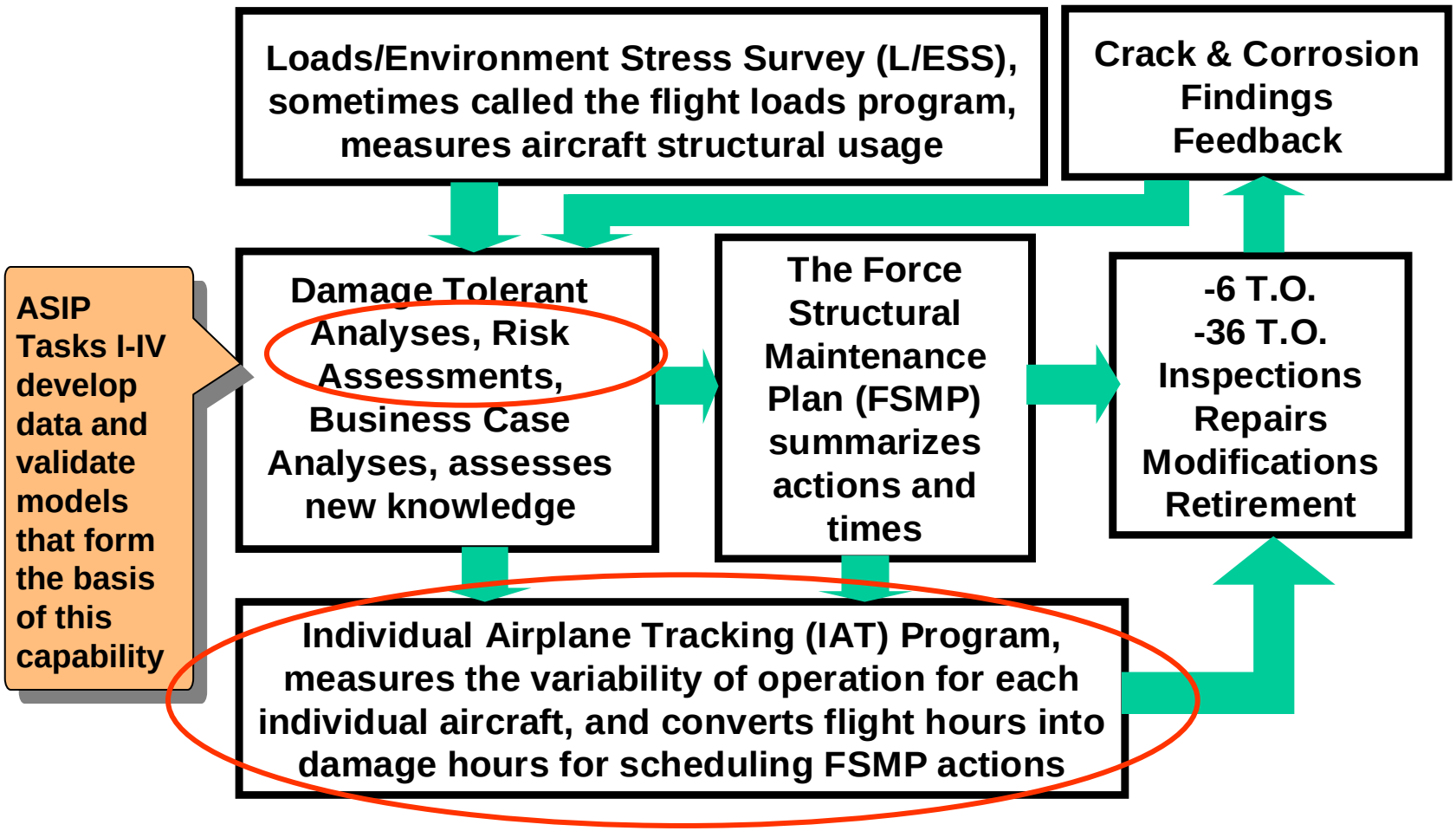

- Process tracks the causes/effects of aging on airframe
- Trend analysis supports updating FSMP to account for new findings

ASIP Systems Management

Decision-Making Feedback Loop – Strategic Planning

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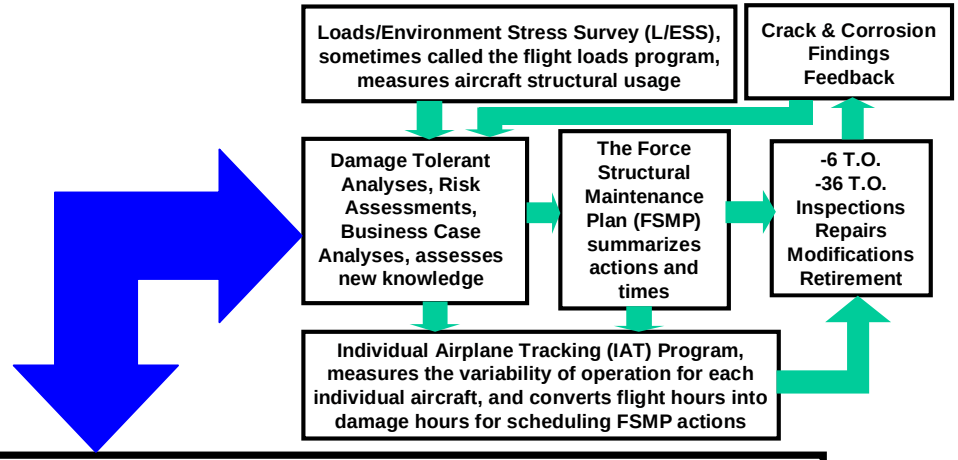
MAJCOM/XP/DR/LG

Defines:

- Service life capability requirements
- Expected/ planned usage
- Readiness levels
- Budgets



SPO Management

- Translates MAJCOM requirements into aircraft specific plans
- Provides feedback on changes in:
  - Life expectations
  - Maintenance options including upgrades
  - Costs
  - Risks

ASIP Management

- Defines structural maintenance requirements & operational limits
- Assesses impact of planned usage scenarios (mission mixes, stores, …) on expected service life capability
- Develops estimates of remaining structural life for fleet based on planned usage
- Evaluates maintenance options, including upgrades, based on meeting requirements, while balancing costs and risks
- Prepares summary reports that compares expectations with actual

Example of Ideal "To Be State"

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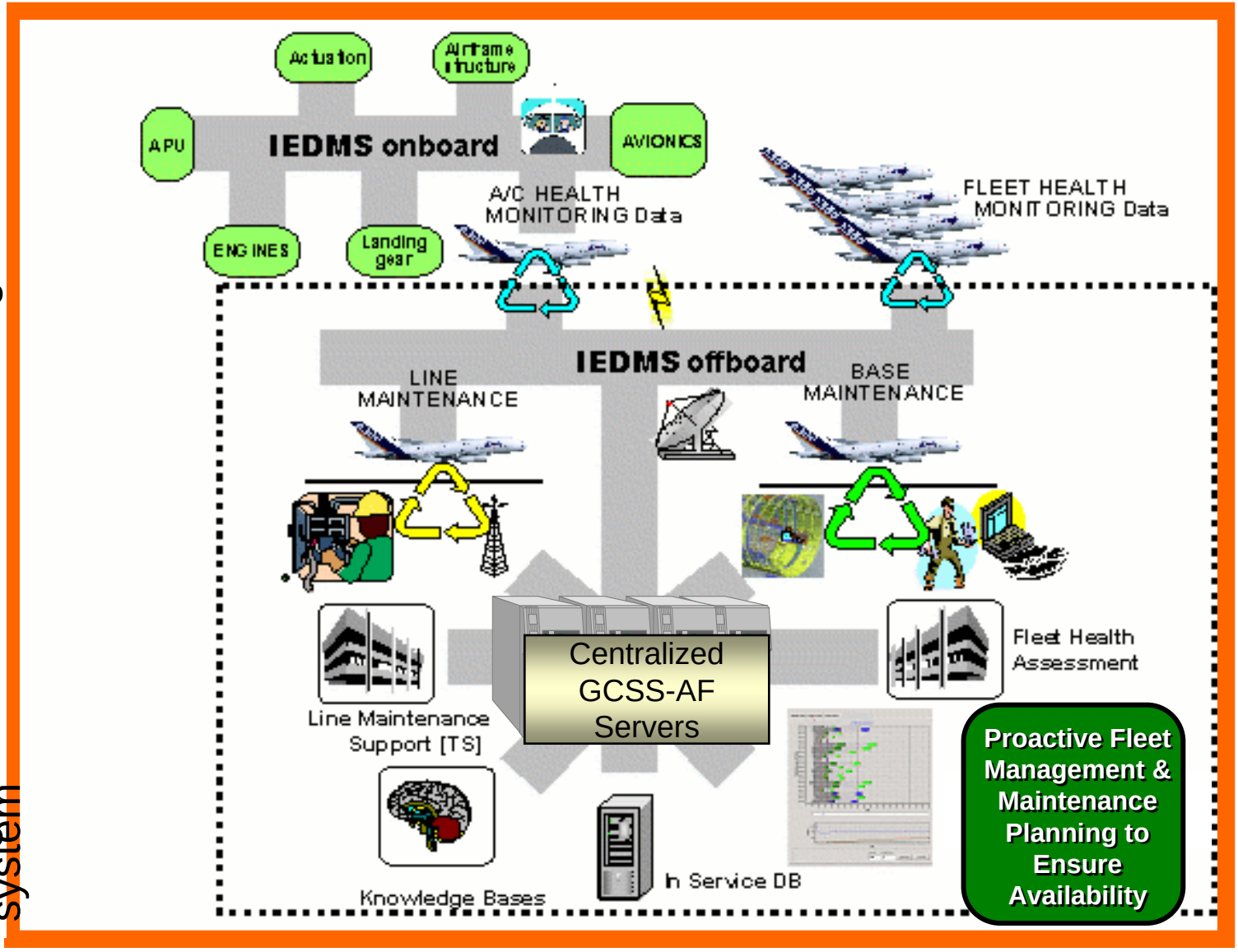
Integrated electronic data management system



General Concern Expressed
Depot and S&T Agree

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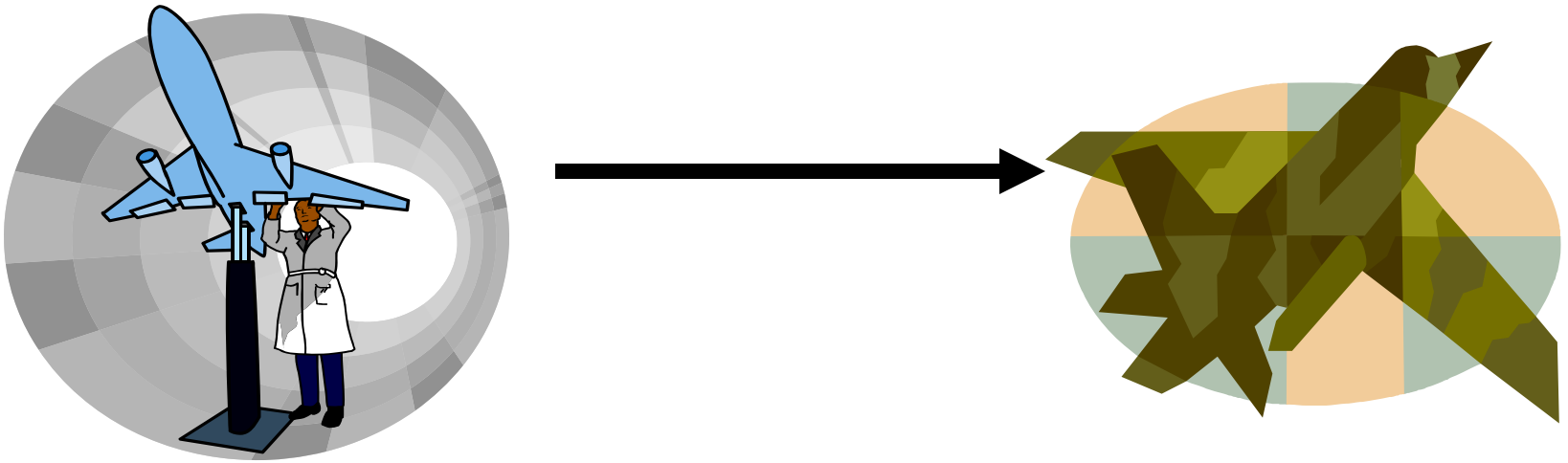
Issue: Sustainment of Aging Aircraft

– Bridging the gap between technology readiness and weapon system application



Developing the Plan

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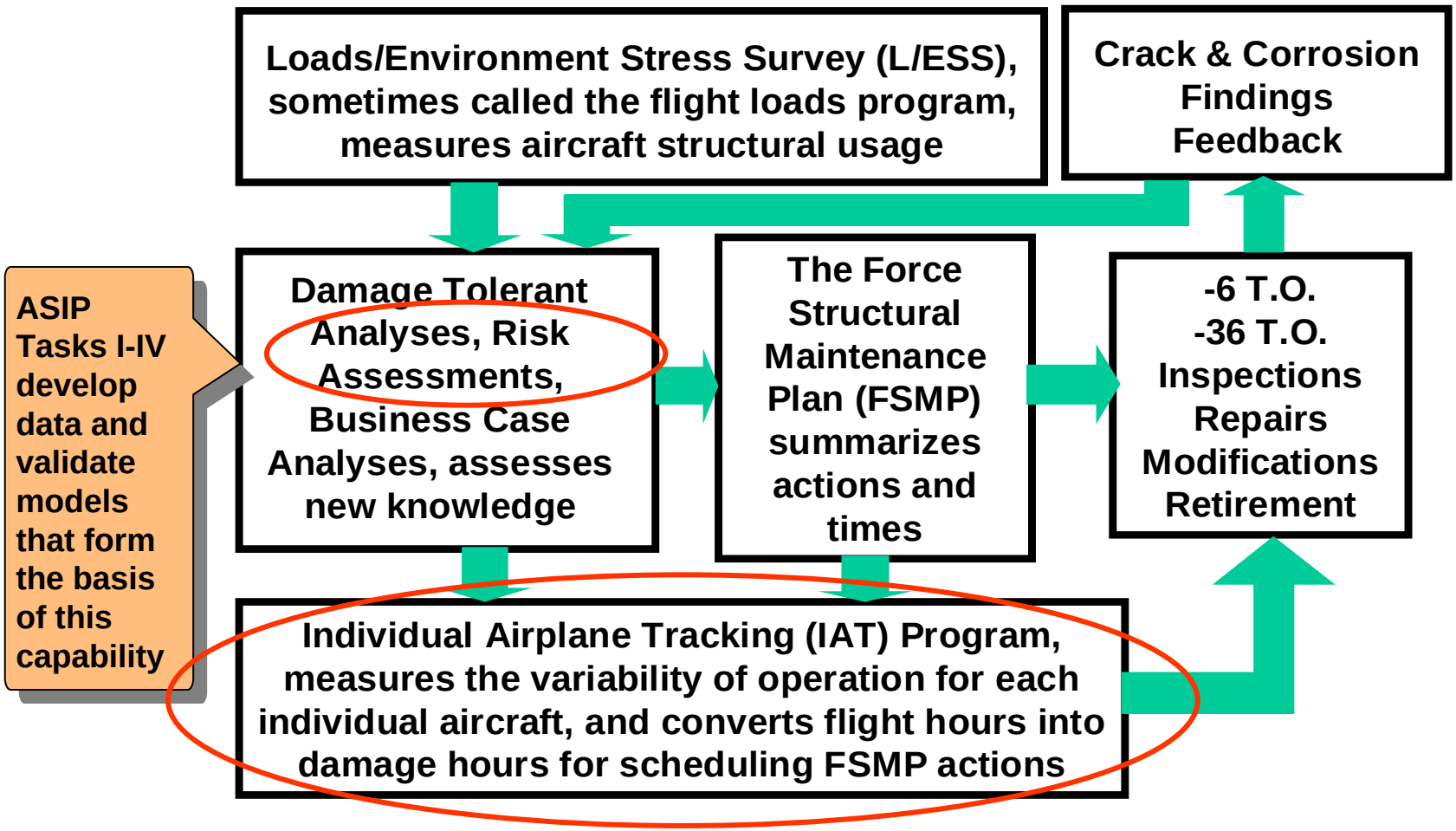

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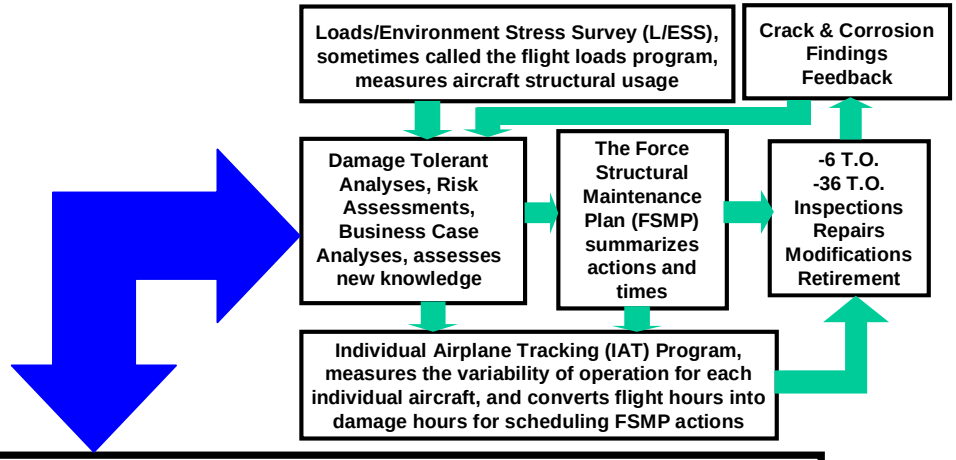

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Charts to Illustrate IAT Suggested Outputs

Simple Ways of Defining Usage

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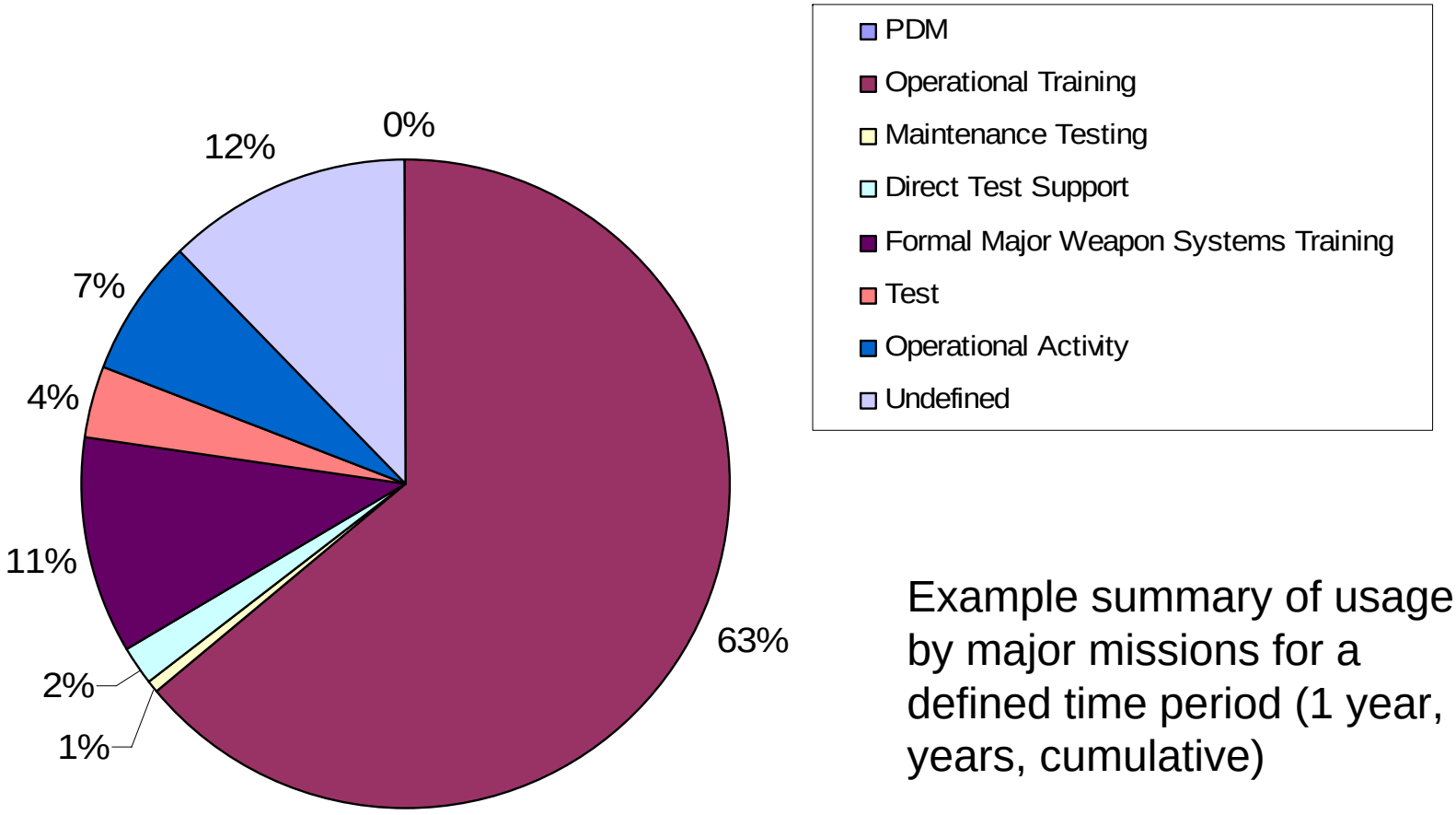

Example summary of usage by major missions for a defined time period (1 year, 5 years, cumulative)

Next Step: Develop simple way to assess the relative effects of mission types

Risk Assessment Workshop
Objectives

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- To enhance the deterministically-based ASIP process with risk assessment/risk management tools that will provide system program management and Air Force leadership with a clear understanding of the risks of potential airframe structural failures
- To establishing acceptable methods for conducting & reporting aircraft structural integrity risks.
- To be held in Dayton on 30 Jun-1 Jul
- http://www.usasymposium.com/riskman/

Hazard Assessment

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Mishap Risk Assessment

High	1-5
Serious	6-9
Medium	10-17
Low	18-20

SEVERITY PROBABILITY	Catastrophic 	Critical	Marginal	Negligible
Frequent	1	3	7	13
Probable	2	5	9	16
Occasional	4	6	11	18
Remote	8	10	14	19
Improvable	12	15	17	20

Concept based on steady state conditions – structural risks grow exponentially once cracks are present; need to define exposure period for hazard

Risks With and Without ASIP Damage Tolerant Design

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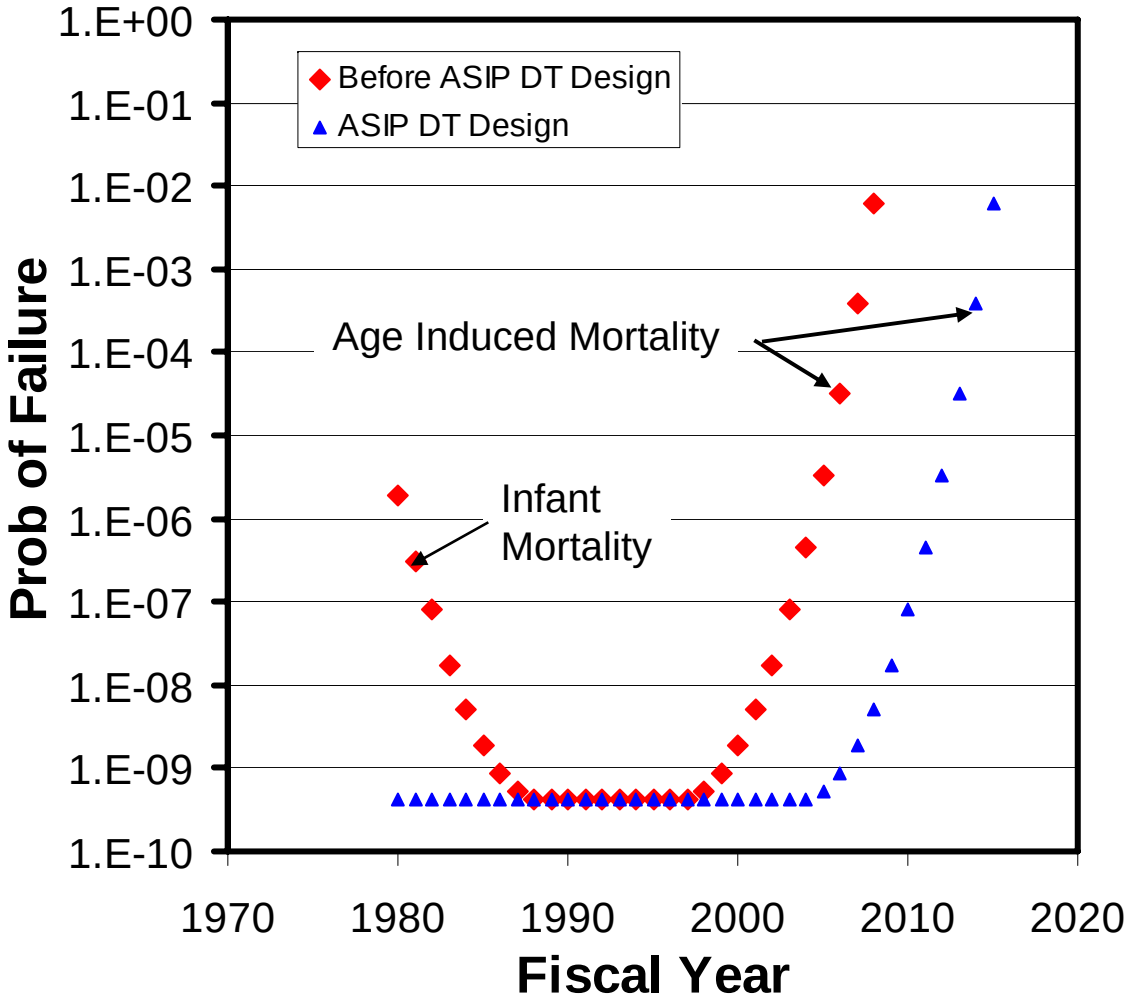

Reliability Bathtub Curve

Risk for a Specific Detail
Without a Mitigation Plan

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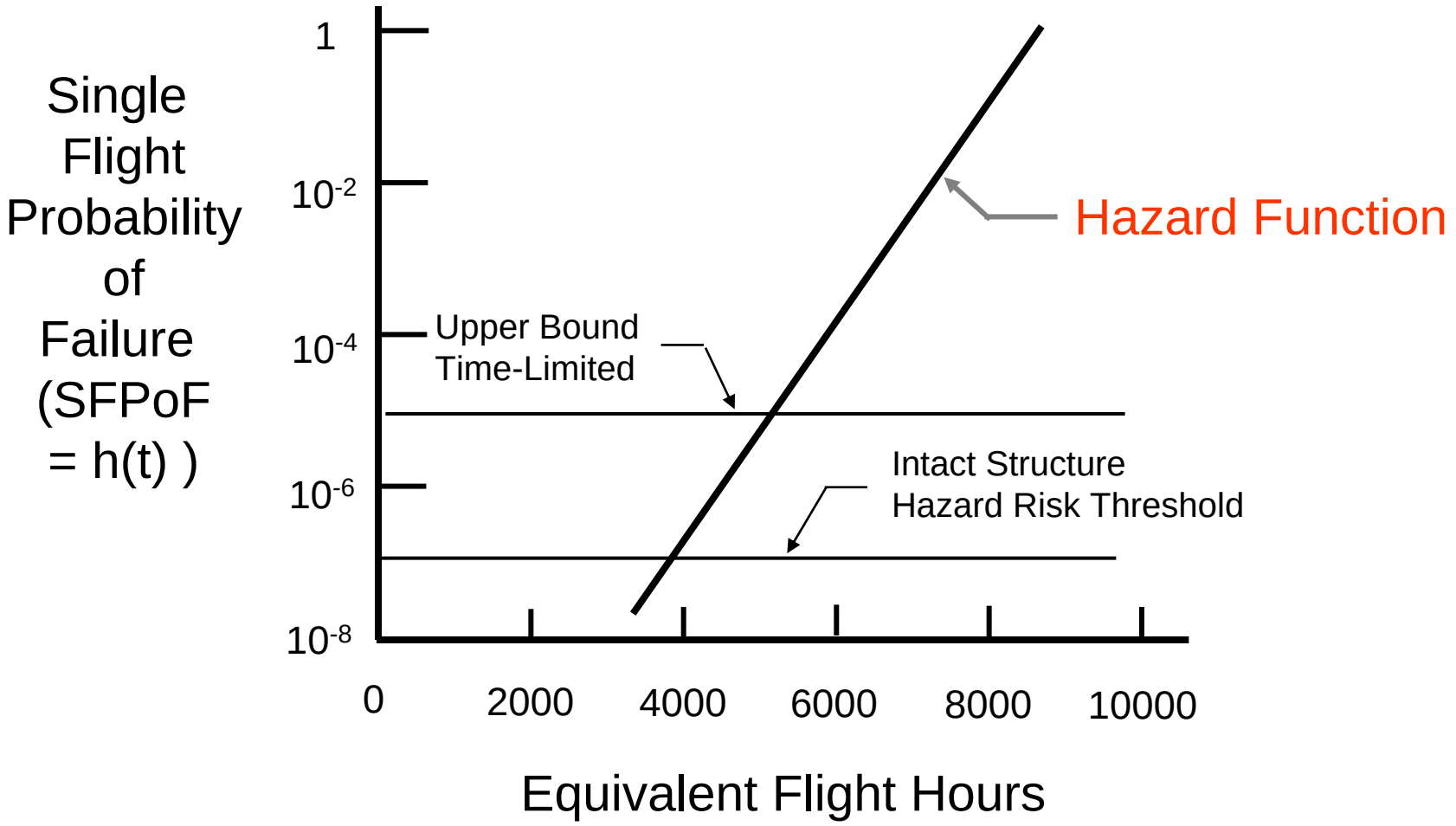
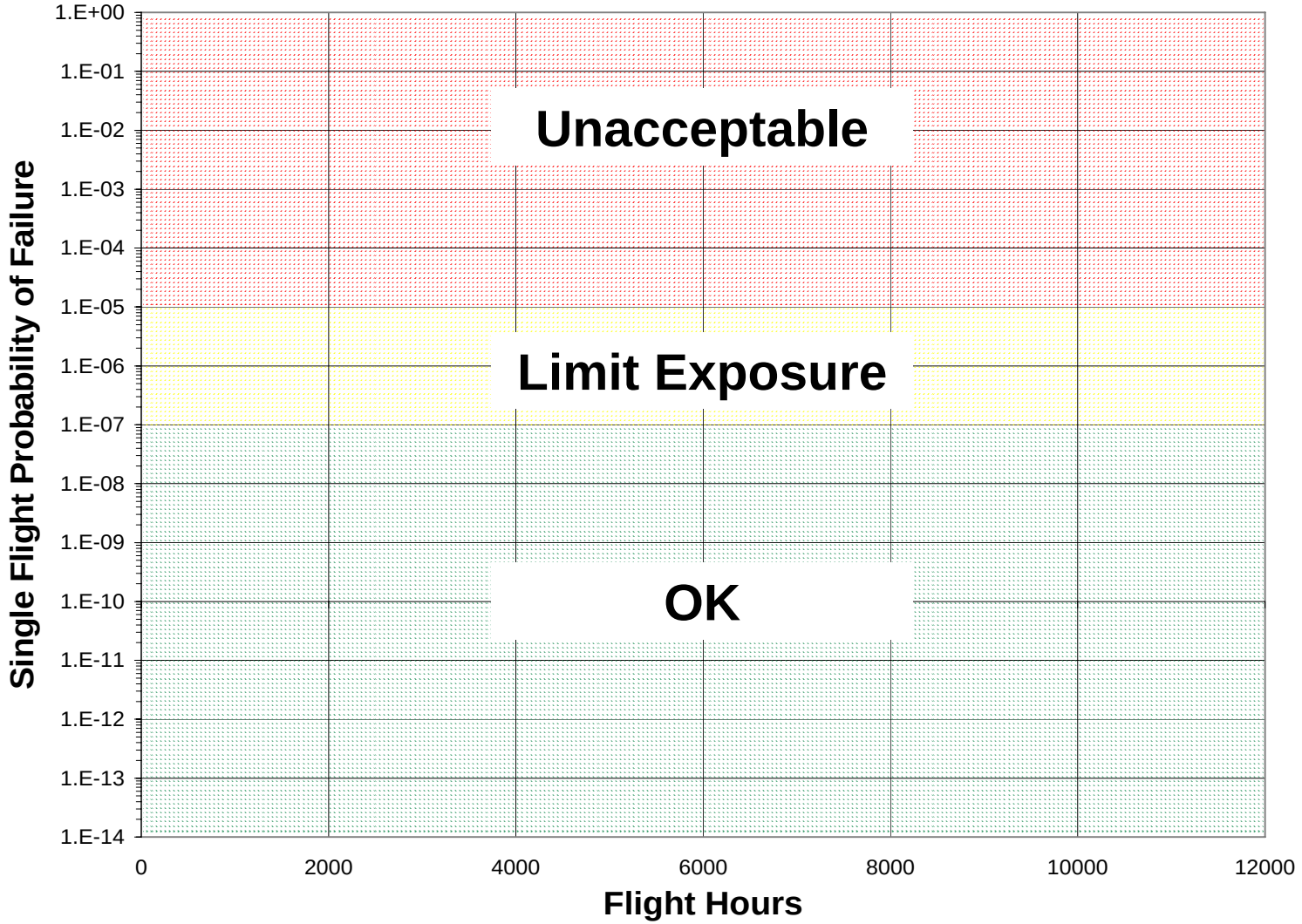


(enhance existing deterministic damage tolerance approaches with crack and corrosion findings data to add new dimension to communicate structural risk to management)

SFPoF Thresholds
JSSG-2006 Guidance

Rapidly delivering war-winning capability



Choices Based on Risk

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- Assessment tools (like PROF) allow ASIP and NDI engineers to collaborate and evaluate the interactions between
  - The likely crack population
  - The expected NDI equipment sensitivity for detecting cracks as measured by the Probability of Detection (POD) capability, i.e., estimates a_{NDE}
  - Time intervals

  on choices that minimize the potential risk of structural failure
- Future decisions might be based on managing RISK

AFI and AFPD

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- Once MAJCOM Supplemental AFIs are completed, ASC/EN and SAF/AQ will start rewriting AFI and AFPD
- Updated AFI will cover responsibilities associated with:
  - USAF ASIP Manager
  - SPO Single Manager
  - SPO Chief Engineer
  - SPO ASIP Manager
  - MAJCOM POC

Example of Ideal "To Be State"

Rapidly delivering war-winning capability

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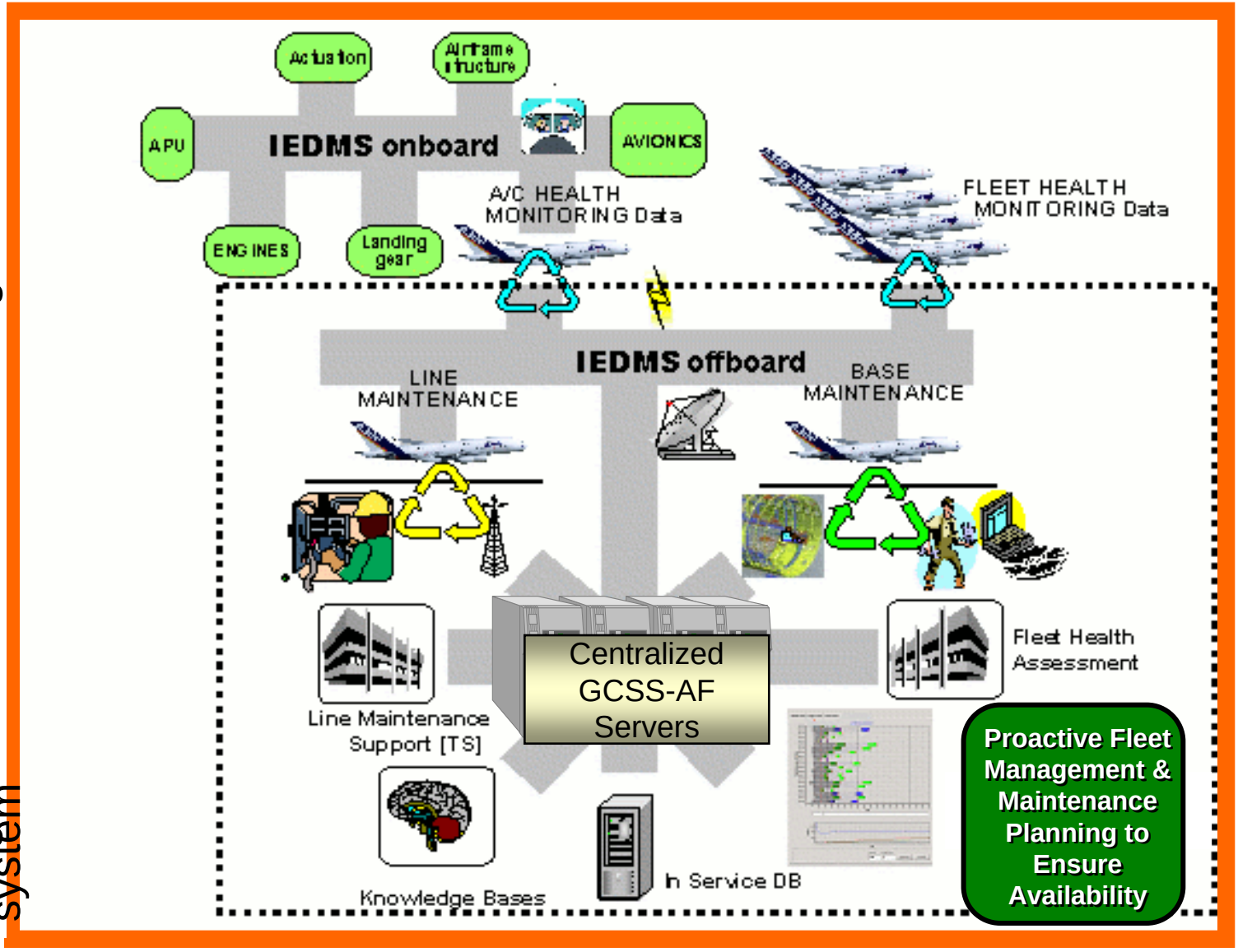

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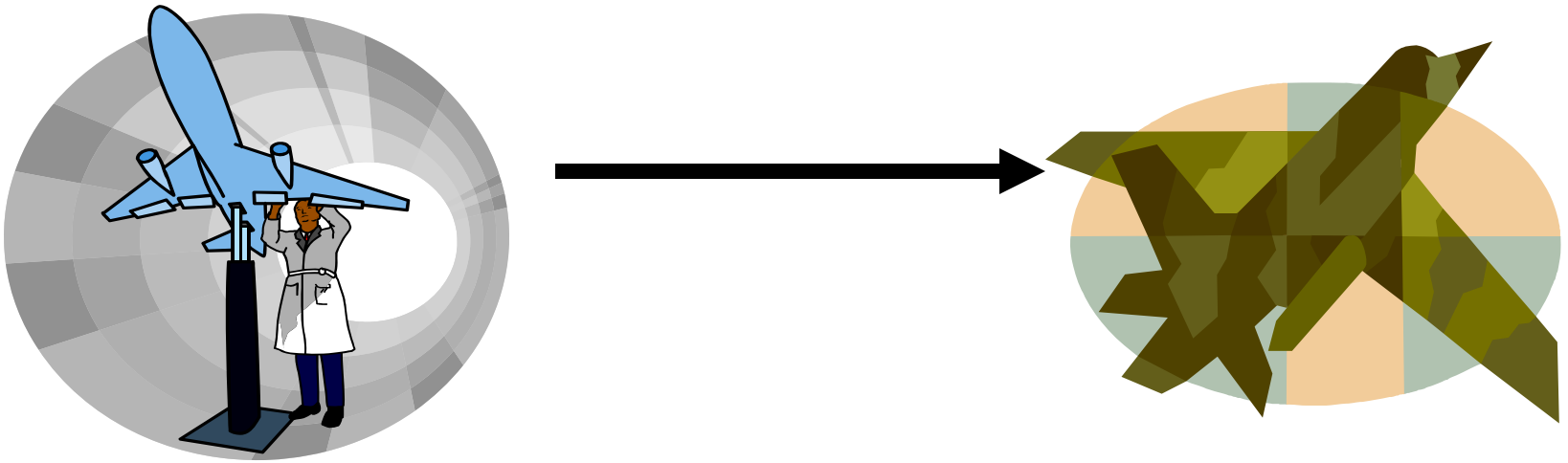

Addressing AFIA Recommendations (1 of 2)

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No	Finding on	Recommendations (OPR)
1	Overall Implementation	Ensure that an effective ASIP is established for each aircraft operated by USAF (SAF/AQ) – ASC/EN will work with SAF/AQ to establish a reporting process to ensure that ASIPs exist for all aircraft; Ensure each aircraft has an up-to-date ASIP – Use the ASIT review to document extent of problem, inform SAF/AQ of results (ASC/EN)
2	Policy & Guidance & Oversight & Accountability	Correct inconsistencies and clarify responsibilities, authority and accountability in AFPD & AFI – ASC/EN will work with SAF/AQ, AF/IL and MAJCOMs to update; Develop clear guidance on tailoring ASIP for UAVs – Rewrite instruction to clarify application to rotorcraft and UAVs; Establish Mil-HDBK-1530 as a directive document – in process by ASC/EN; Formally designate an Air Force ASIP Manager to promote and ensure effectiveness of ASIP AF-wide – **requires AF leadership decision to appoint this position**; Develop/implement metrics to ensure ASIP effectiveness at the SPO and MAJCOM levels, develop proactive metrics – expand on suggestions in finding; (OPR for all No. 2 recommendations is SAF/AQ)
3	Implement Policy & Guidance	Publish MAJCOM documentation specifying command responsibilities/tasks – Work with AMC and AFSOC to determine level of current documentation – work with other MAJCOMs to support their documentation efforts; Appoint MAJCOM OPRs – Support MAJCOMs in their selection of a technical individual to support program; Establish, document and implement procedures to notify SPO of contemplated usage changes – Work with ASIP Managers/SPO single managers to start process of requesting information annually (OPR for all No. 3 recommendations is MAJCOM/CCs)

Black = recommendation
Blue = response
Red = Key to successful transformation

Addressing AFIA Recommendations (2 of 2)

Rapidly delivering war-winning capability

No	Finding on	Recommendations (OPR)
4	ASIP Reviews	Document procedures for periodic reviews – Prepare documentation that describes purpose of review, tie into need for annual SPO ASIP review ; Develop/implement procedures for ASIP managers to notify SAF/AQ et al. when the weapon system ASIP changes – ASC/EN will work with ASIP managers and leadership on this communication issue; Include rotorcraft in future reviews – ASC/EN already planned to do this
5	Risk Analysis	Determine/document an acceptable method for conducting & reporting aircraft structural integrity risks (SAF/AQ) – ASC/EN is working with ASIP Managers to address this using the AFRL/VA developed/validated PROF system; Identify/collect data that will support accurate risk assessments using accepted structural tools (ASC/EN, ALC/EN) – ASC/EN is working with ASIP Managers to identify fatigue and corrosion findings data that can be collected and interfaced with ASIP tool set; Train ASIP Managers (ASC/EN) – ASC/EN plans a structures risk assessment/risk management workshop in the May/June 04 timeframe that will support this recommendation
6	Discrepancy Reporting	Incorporate SPO ASIP Managers' data requirements into existing maintenance data collection systems (AF/IL) – ASC/EN will work with AF/IL and ALC/ENs to define the data and appropriate collection systems; Develop an interface between these existing data collection systems and ASIP analysis tools (AFMC/CC) – to be accomplished collectively by ASC/EN and the ALC/ENs based on ASIP Managers recommendations
7	Corrosion Management	Update guidance to clarify what portions of the aircraft structure should be included in FSMPs (ASC/EN) – Rewrite MIL-HDBK-1530 guidance to clarify; Update guidance to integrate elements of the weapon system's corrosion prevention and control plan with its FSMP (ASC/EN) – ASC/EN will work with SPOs' ASIP Managers and corrosion specialists to develop the systems engineering process that will address this recommendation for structures corrosion management