Current Health of the F-16 Fleet

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Overview

- Introduction
- Background
- Health of the Fleet Analysis
  - Data Collection and Sources
  - Analysis Process
- Conclusions

Introduction

- The F-16 is a compact, multi-role fighter aircraft.
  - Flown by the United States and many additional countries.
  - First version flown in December 1976.
- Various models (10/15, 25/30/32, 40/42, 50/52) introduced in subsequent years.
  - Many of the oldest aircraft have been retired.
  - Exact retirement dates for remaining aircraft are unknown.
- Aircraft structural integrity must be maintained throughout the remaining life.

http://www.hill.af.mil/388fw/ViperWestLink/new2004photos/demo2004/pages/climbing.htm

Introduction

- The Health of the Fleet (HOTF) analysis is an aircraft structural integrity program (ASIP) support tool designed to summarize and analyze fatigue cracking data obtained from various sources.
- Fatigue cracking trends are identified.
- Predictions for problematic areas of future cracking can be made.
- Maintenance cost and downtime for repairs and inspections are calculated for future planning.
- HOTF is important due to the extended service life requirements of the F-16.

Background: Design Paradigms

- Safe Life
  - Assumes no damage tolerance
  - Minimum inspections
  - Parts replaced when design service life reached
- Damage Tolerance
  - Assumed initial crack size
  - Estimates crack growth
  - Protects by inspections based on crack growth evaluation
  - Failure criteria defined for parts

Background: Design Paradigms

- **Holistic Structural Integrity**
  - **Accounts for evolution of damage throughout the aircraft's service life**
  - **Identifies critical structure for various types of damage**
  - **Probabilistic determinations on presence of damage and subsequent life**
  - **Defines damage effects**

Background: Health of the Fleet and Holistic Structural Integrity

- The Health of the Fleet analysis falls within the holistic framework.
- With HOTF, we can gain deeper understanding of aircraft sustainment requirements through:
  - Current fleet state,
  - Cracking problem areas,
  - Underlying causes of fatigue cracking,
  - Required maintenance actions,
  - Prediction of future issues, including cracking, and
  - Potential aircraft modification needs.
- HOTF assists in knowing what to expect, thereby minimizing “surprises.”

Background: F-16 Structural Inspections

- Individual Aircraft Tracking (IAT) Program
  - Tracks potential structural damage growth
  - Adjusts average maintenance schedule based on individual aircraft usage
  - Projects flight hours and dates of maintenance requirements
  - Predicted from Durability and Damage Tolerance Analysis (DADTA)
- Phase Inspections
  - Based on crack findings
- Analytical Condition Inspection (ACI)
  - Sampling of critical structural components during depot modification or repair

Why perform a health of the fleet study?

- **The F-16's mission mix has changed from the original design.**
- **Significant cracking has occurred.**
- **Many problem areas have been repaired and/or have had structure replaced.**
- **Future areas of fatigue related cracking need to be identified.**

Health of the Fleet Analysis Purpose

- Determine cost of:
  - Current inspections
  - Future modifications
- Data collection to support:
  - Aircraft attrition
  - Risk analysis

Prior F-16 Modification Programs

- Most modification programs identify and replace well known problem areas. These mod programs include:
  - SLIP/SLEP
  - Falcon UP
  - Falcon STAR
- Health of the Fleet analysis will assist in prediction and identification of problem areas to prevent reactive type program development.

Health of the Fleet Study Process

- Collect fatigue cracking data
- Analyze findings
- Identify trends
- Predict areas of future cracking
- Quantify maintenance costs and downtime for inspections of interest (example: IAT)

Health of the Fleet Analysis

- **Sources of data:**
  - **Requests for engineering disposition, ~1600 entries related to fatigue cracking (web-based)**
  - **Lockheed Martin F-16 Fleet Cracking Database, ~4500 entries**
  - **Individual Aircraft Tracking (IAT) reports and control points/Data Processing System (DPS)**
  - **Fleet Structural Maintenance Plan (FSMP)**

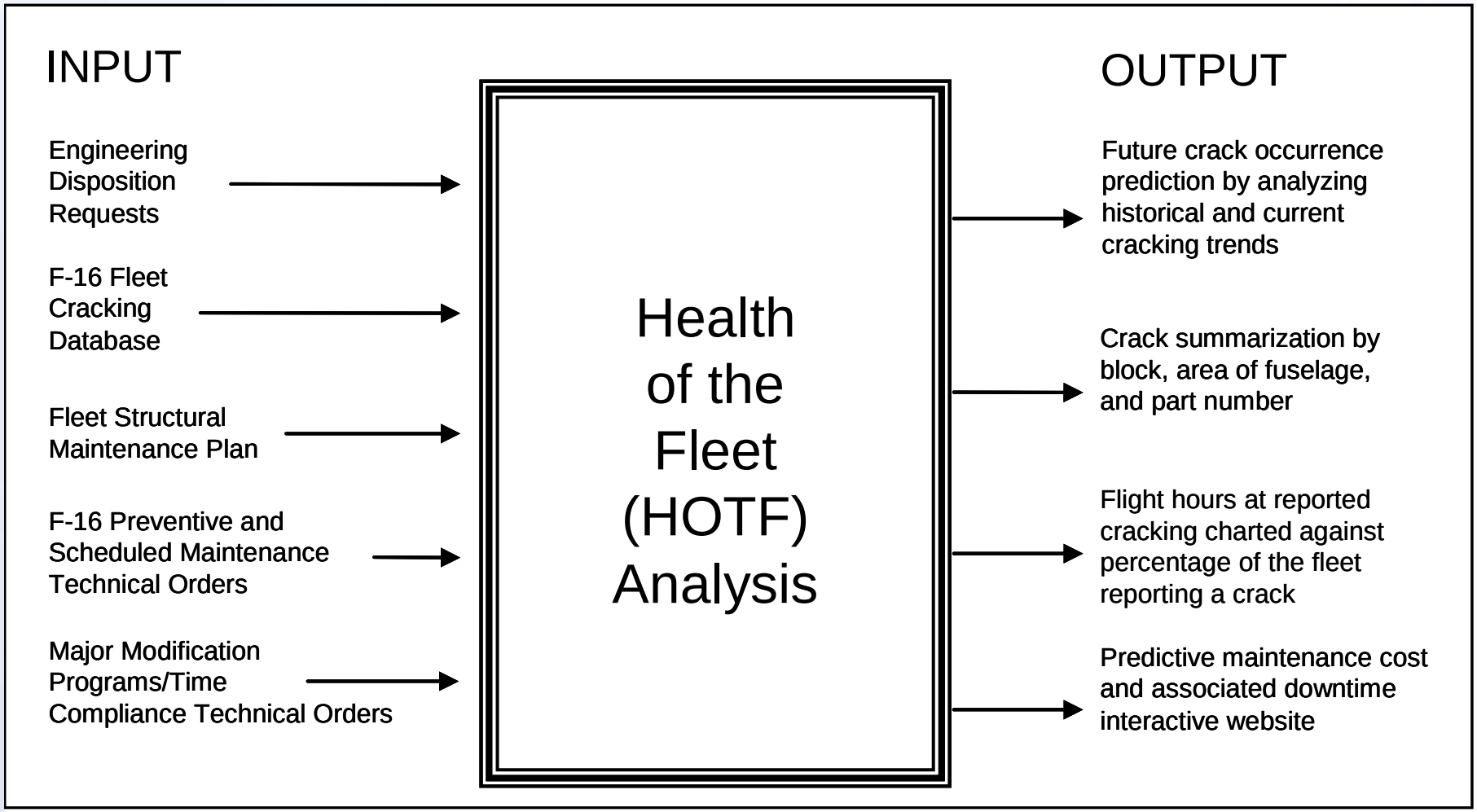
Analysis Details

- Requests for engineering disposition (107T/202, web-based)
  - Only fatigue related cracking used from database
  - Duplicates from 107T/202 and Lockheed databases eliminated
  - Cracking occurrences charted by flight hours, part number, etc.
- Lockheed Martin F-16 Fleet Cracking Database
  - Database fed from various sources
  - Incidents of fatigue related cracking reported

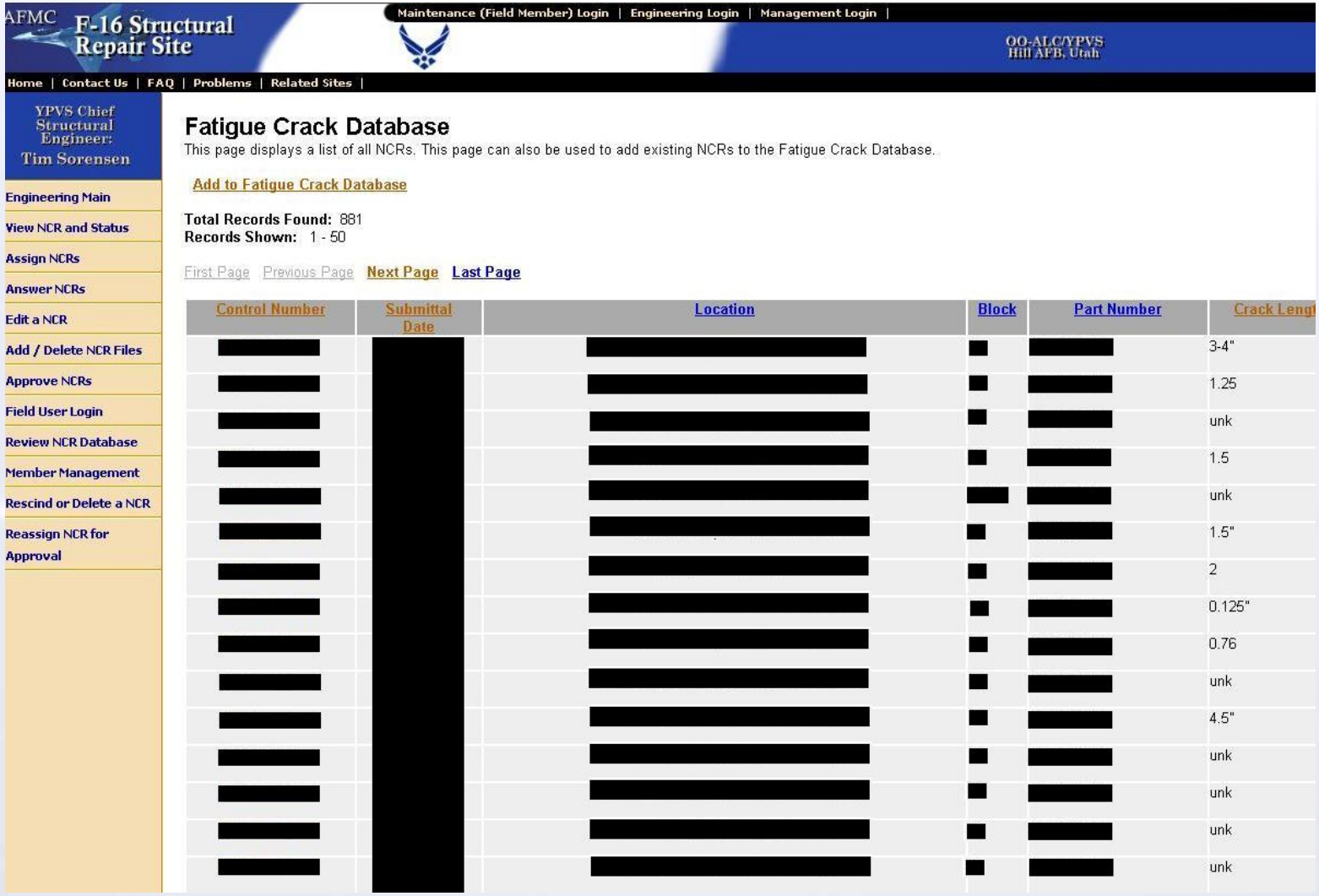
Analysis Details (continued)

- Individual Aircraft Tracking (IAT)/Data Processing System (DPS)
  - Information on control points, planned maintenance actions, and baseline crack growth are among the data used
- Fleet Structural Maintenance Plan (FSMP)
  - Information on inspections, control points, and predicted life are examples of data used

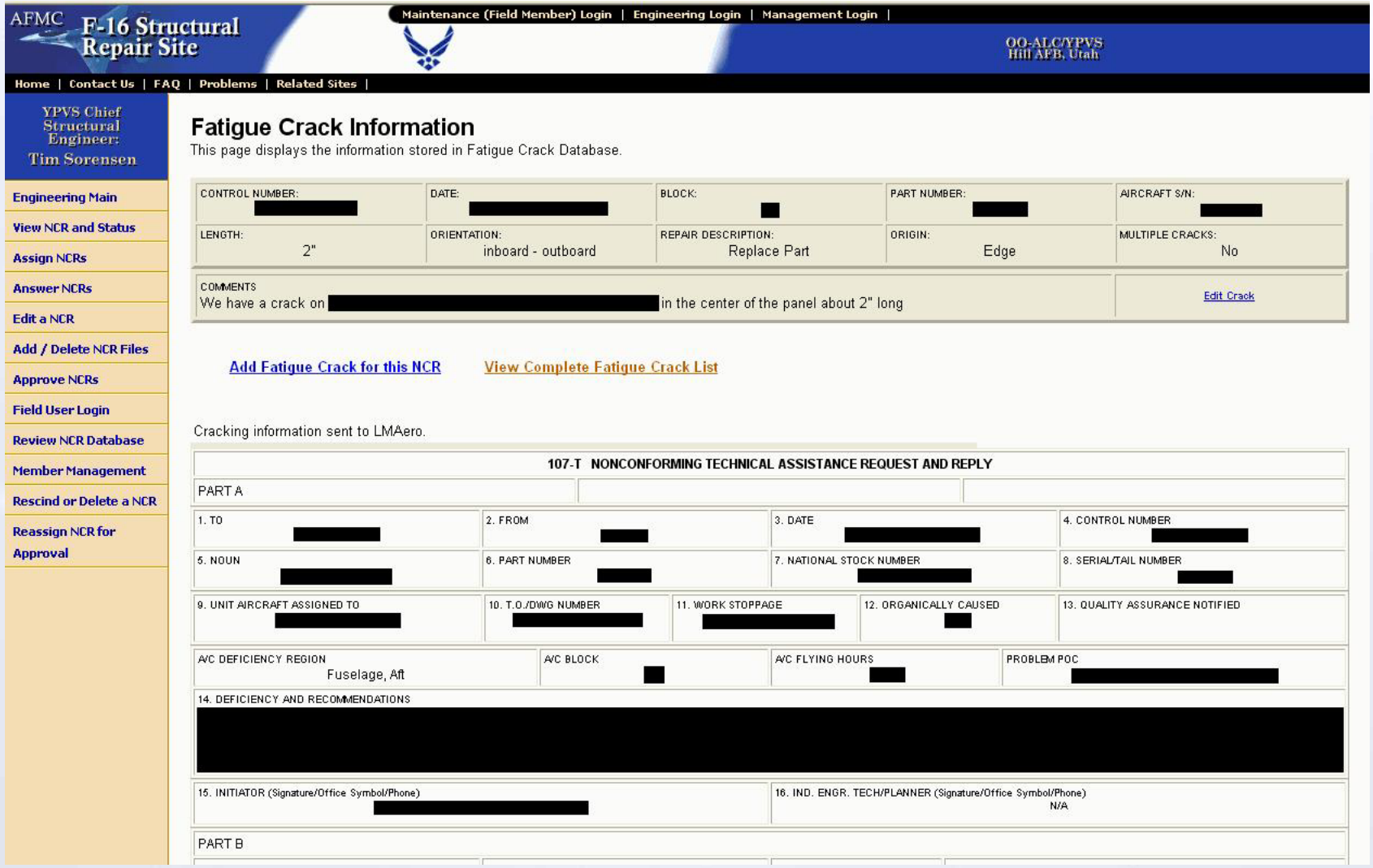
Health of the Fleet Overview



Engineering Disposition Request
Fatigue Crack Database



Engineering Disposition Request Fatigue Crack Data



AFMC F-16 Structural Repair Site

Maintenance (Field Member) Login | Engineering Login | Management Login |

OO-ALC/YPVS Hill AFB, Utah

Home | Contact Us | FAQ | Problems | Related Sites |

YPVS Chief Structural Engineer: Tim Sorensen

- Engineering Main
- View NCR and Status
- Assign NCRs
- Answer NCRs
- Edit a NCR
- Add / Delete NCR Files
- Approve NCRs
- Field User Login
- Review NCR Database
- Member Management
- Rescind or Delete a NCR
- Reassign NCR for Approval

Fatigue Crack Information

This page displays the information stored in Fatigue Crack Database.

CONTROL NUMBER:	DATE:	BLOCK:	PART NUMBER:	AIRCRAFT S/N:
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
LENGTH:	**ORIENTATION:**	**REPAIR DESCRIPTION:**	**ORIGIN:**	**MULTIPLE CRACKS:**
2"	inboard - outboard	Replace Part	Edge	No

COMMENTS: We have a crack on [redacted] in the center of the panel about 2" long — Edit Crack

Add Fatigue Crack for this NCR View Complete Fatigue Crack List

Cracking information sent to LMAero.

107-T NONCONFORMING TECHNICAL ASSISTANCE REQUEST AND REPLY

PART A

1. TO	2. FROM	3. DATE	4. CONTROL NUMBER
[redacted]	[redacted]	[redacted]	[redacted]
5. NOUN	**6. PART NUMBER**	**7. NATIONAL STOCK NUMBER**	**8. SERIAL/TAIL NUMBER**
[redacted]	[redacted]	[redacted]	[redacted]

9. UNIT AIRCRAFT ASSIGNED TO	10. T.O./DWG NUMBER	11. WORK STOPPAGE	12. ORGANICALLY CAUSED	13. QUALITY ASSURANCE NOTIFIED
[redacted]	[redacted]	[redacted]	[redacted]	

A/C DEFICIENCY REGION	A/C BLOCK	A/C FLYING HOURS	PROBLEM POC
Fuselage, Aft	[redacted]	[redacted]	[redacted]

14. DEFICIENCY AND RECOMMENDATIONS: [redacted]

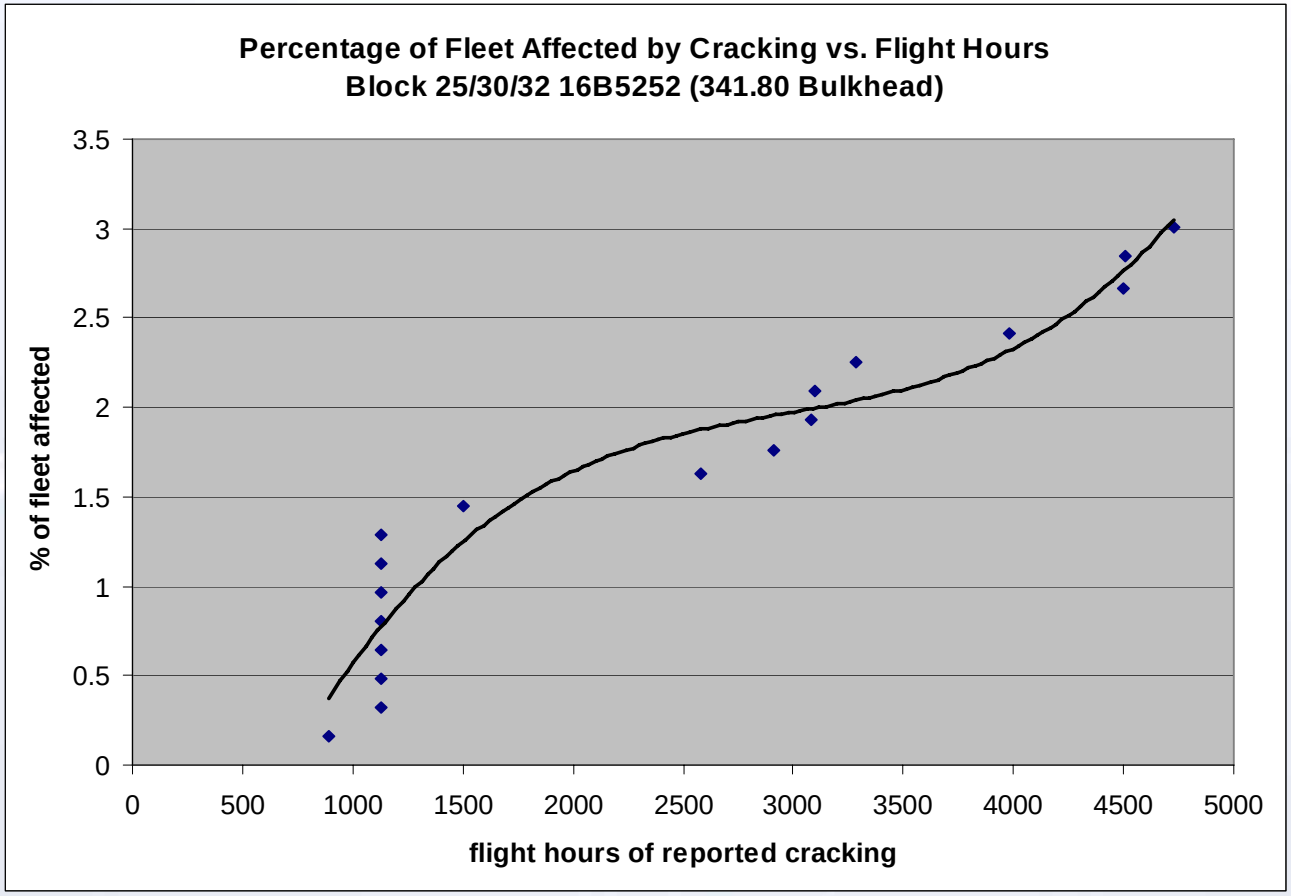
15. INITIATOR (Signature/Office Symbol/Phone)	16. IND. ENGR. TECH/PLANNER (Signature/Office Symbol/Phone)
[redacted]	N/A

PART B

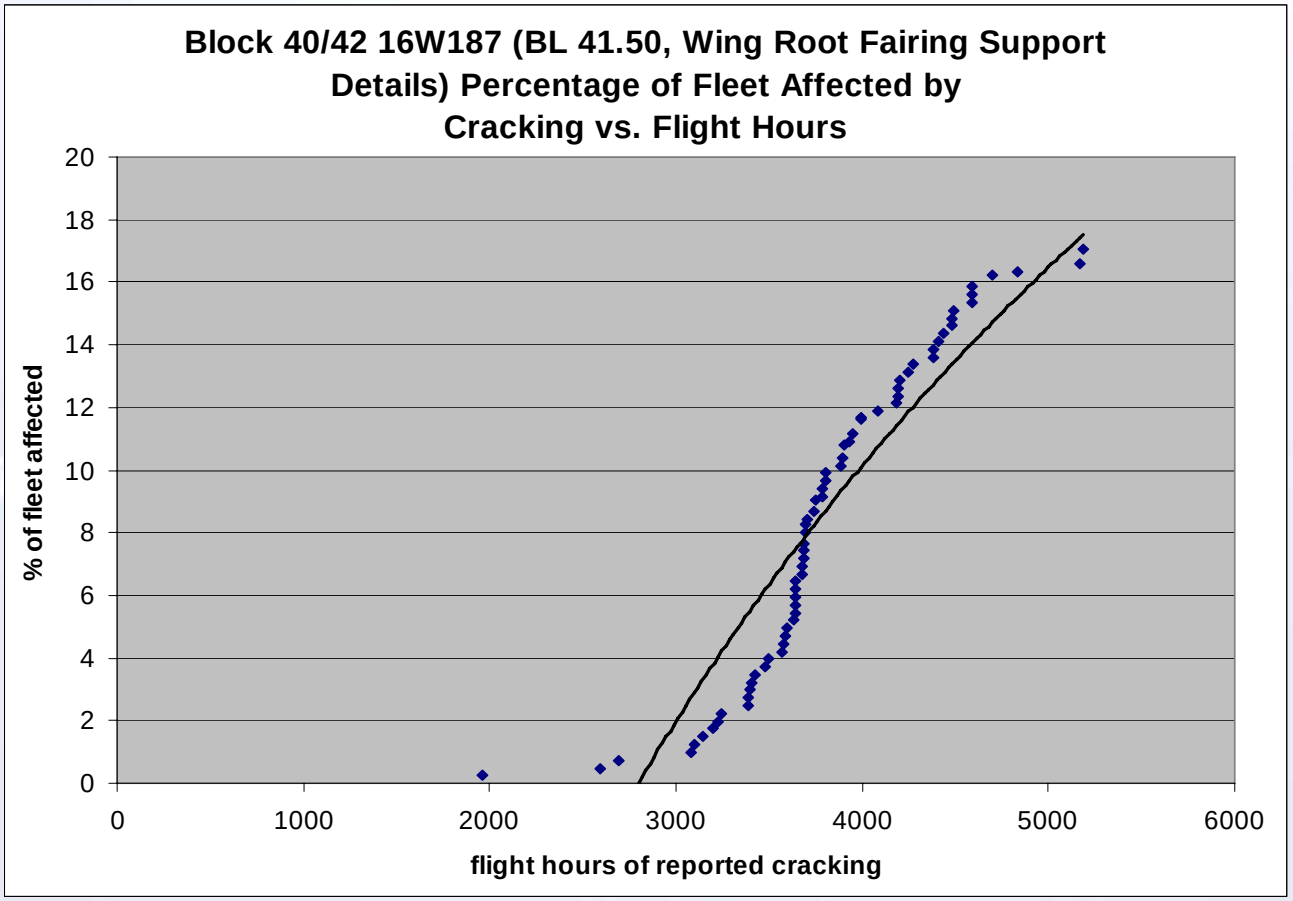
Major Tasks

- Summarized fatigue cracking data
  - Engineering disposition requests
  - Fleet cracking data from Lockheed Martin FIN
  - Periodically updated
- Identification of potentially life limiting structural locations
- Development of Selected Inspection Cost Estimator (SLICE) website

Block 25/30/32 341.80 Bulkhead Percentage of Fleet Affected by Cracking vs. Flight Hours



Block 40/42 16W187 (BL 41.50, Wing Root Fairing Support Details) Percentage of Fleet Affected by Cracking vs. Flight Hours



Analysis Assumptions

- Number of cracks is cumulative.
  - Part repair or replacement are not accounted for in crack counts.
- Charts exclude reported cracks without date or flight hour information.
- Multiple cracks may exist on the same part on the same aircraft.
  - example: bulkhead with cracks in several fastener holes.

Analysis Assumptions (continued)

- The same crack may be reported repeatedly due to crack growth reports.
- Percentage of aircraft affected is calculated using fleet size in the crack report year.
  - Some historical records may be inaccurate as the date may reflect input into the system instead of the report date.
  - Flight hours, when available, are assumed to be correct.

Web Based Selected Inspection Cost Estimator (SLICE)

- Input data obtained from FSMP and equipment specialists
  - IAT control point number and description
  - Hours to first inspection and subsequent inspection interval
  - Hours required for inspection procedures
- Calculated values
  - Projected years for inspections
    - Successive inspections are predicted
    - Years for inspections adjusted for individual aircraft flight hours
  - Required hours for inspections and cost per man-hour used to estimate overall inspection costs

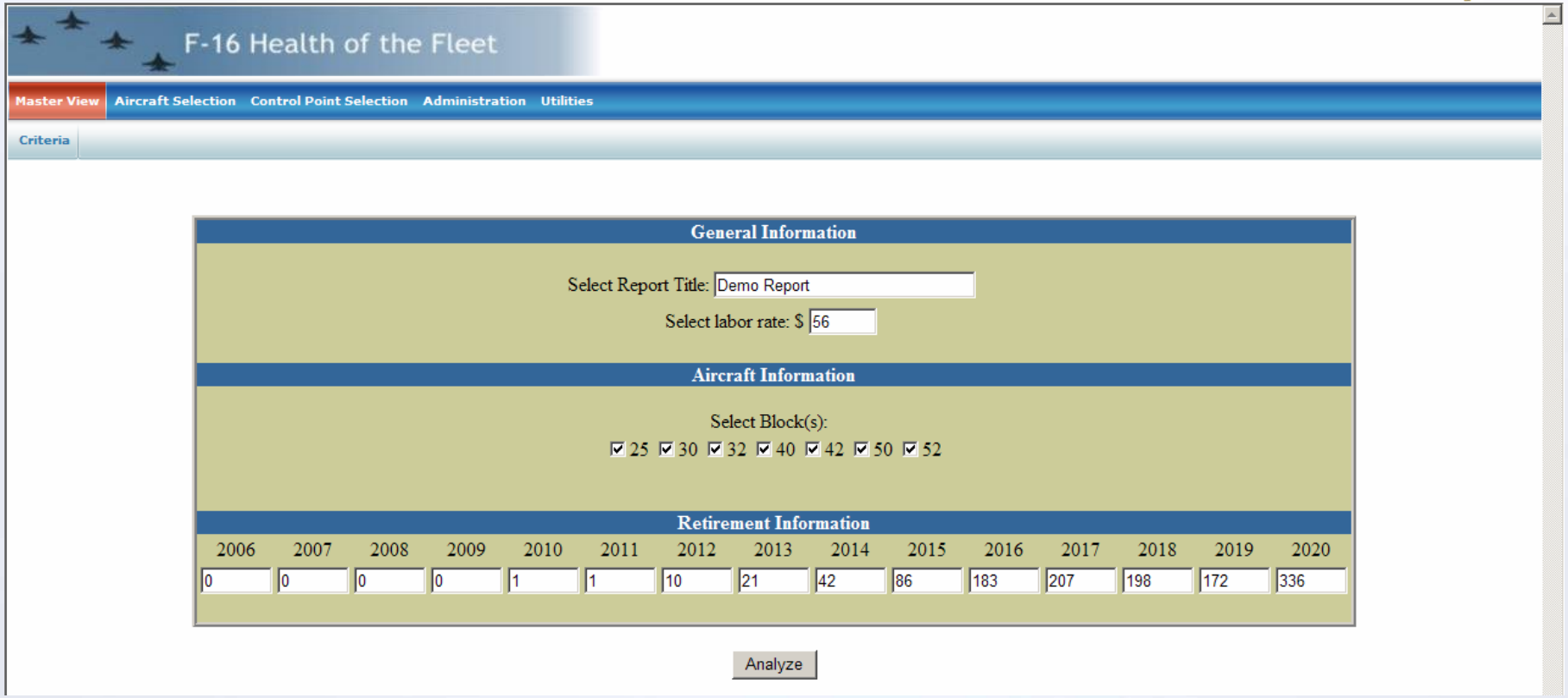
Web Based SLICE (continued)

- Output (current and projected)
  - Chart of projected labor hours and associated cost by year
  - List of the projected top ten control points by cost per year
  - Anticipated aircraft downtime for IAT and/or selected inspections per year

Web Based SLICE (continued)

- Features of estimator program
  - Interactive capability to change:
    - flight hours per year
    - labor cost
    - hours required for unique access and inspection of a control point
    - inspection intervals
    - aircraft attrition per year

Web Based Selected Inspection Cost Estimator (SLICE) Overview



FICTITIOUS DATA

Web Based SLICE Overview

Master View | Aircraft Selection | Control Point Selection | Administration | Utilities

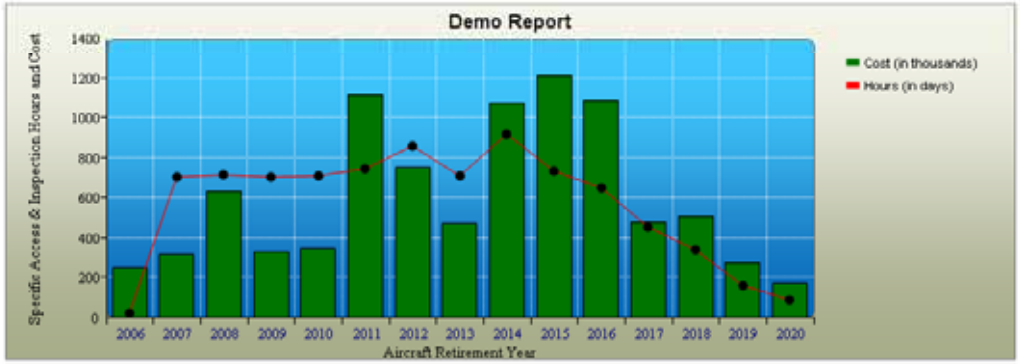
Criteria | Demo Report

Revise Report Criteria | Remove Report

Demo Report

Cost and Downtime

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Retirement by Year	0	0	0	0	1	1	10	21	42	86	183	207	198	172	336
Resulting Inventory	1257	1257	1257	1257	1256	1255	1245	1224	1182	1096	913	706	508	336	0
Resulting Cost (Thousands)	$254.8	$320.6	$637.4	$331.7	$348.7	$1124	$753.9	$476.4	$1080	$1216	$1090.6	$480.6	$510.1	$280.3	$177.8
Resulting Down Time (Days)	21.9	702.3	714.9	704.7	707.3	745.6	861.2	709.3	918.1	730.1	646.8	449.6	336.2	157.7	87.2



Top 10 Control Points

C.P. IAT Number	Description	Cost (Thousands)

FICTITIOUS DATA

Future Plans

- Investigate individual control points of interest based on risk assessment scenarios, risk-based maintenance action schedules, and aging aircraft projection
- Incorporate maintenance induced damage (dents, tears, etc.) for determination of major cost and downtime drivers
- Continue to update analysis with reported fatigue cracks
- Improve data reporting procedures and databases
- Create a corrosion specific database to facilitate easier tracking

Conclusions

- The Health of the Fleet analysis is an important part of sustaining the F-16 until retirement.
- The analysis is constantly evolving to address various problems and additional requirements that may arise.
- The Health of the Fleet analysis is designed so that new data may be introduced easily, and analysis options can be expanded.
- New databases continue to be introduced for useful ASIP data capture.
- The concepts used for the F-16 Health of the Fleet analysis can be applied to other airframes.

Acknowledgments

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- Special thanks to Phil Allen (SAIC)

Questions?

http://www.hill.af.mil/388fw/ViperWestLink/new2004photos/demo2004/pages/F-16%20TwoShip%20Viper%20West.htm