Center for Aircraft Structural Life Extension

KC-135 Teardown Program Development

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U.S. AIR FORCE

Integrity - Service - Excellence

Acknowledgements

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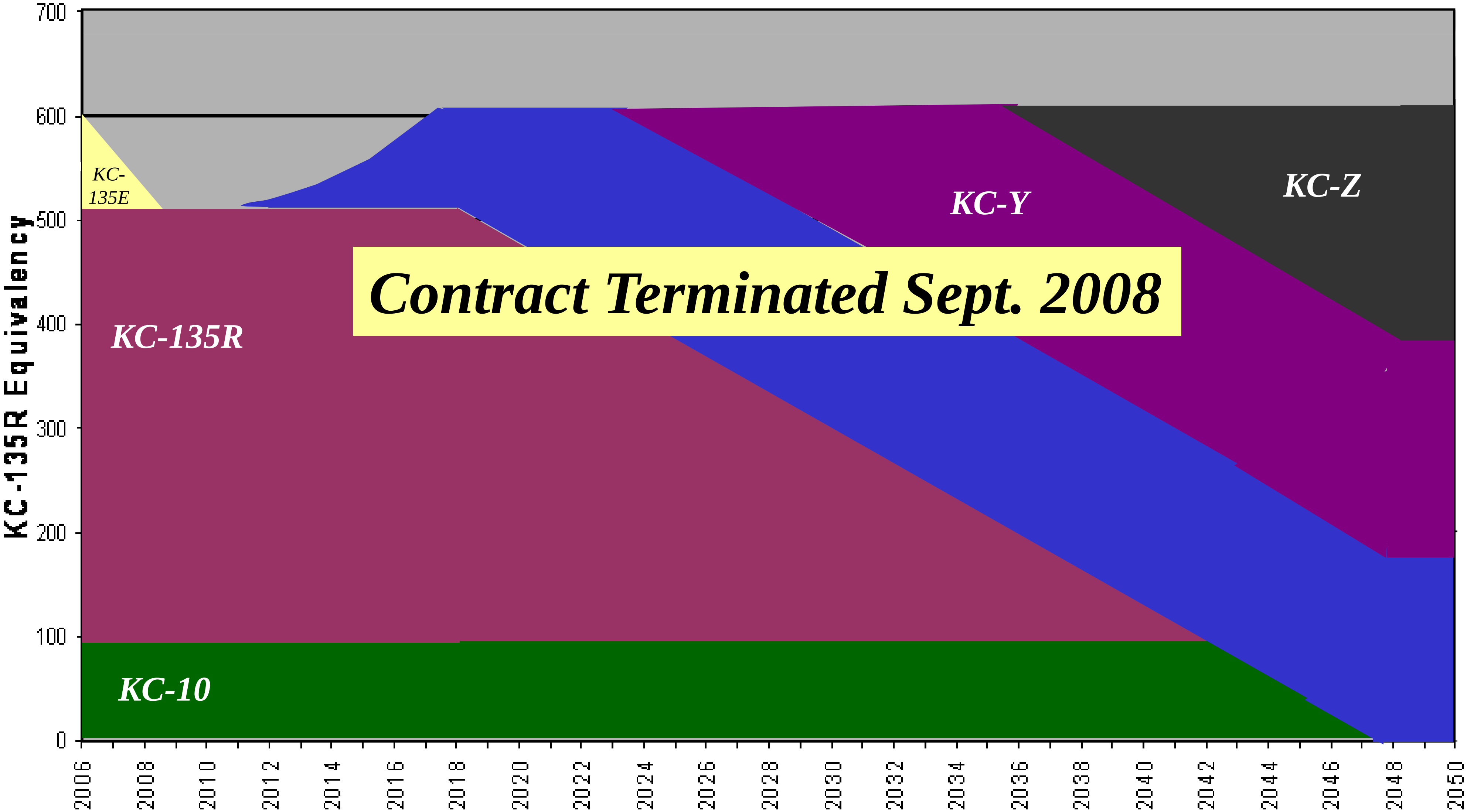
- Requirements
- Teardown Objectives
- Organization and Integration
- Teardown Aircraft Selection
- Teardown Process
- Program Exit Criteria
- Conclusion

Notional Recapitalization Approach

Background



Fleet Usage

Background

MDS	Usage Statistics	GAG Cycles	Operating Time (Hrs)	Average Age (Years)
KCE	μ	4,707	18,159	48.7
	$\tilde{x}$	4,705	17,984	49.1
	σ	405	1,553	1.0
	min	3,768	15,254	45.1
	max	5,727	23,909	50.2
KCR	μ	4,234	18,627	46.3
	$\tilde{x}$	4,193	18,367	45.8
	σ	396	2,560	2.0
	min	3,124	13,769	43.1
	max	6,402	32,708	49.6
KCT	μ	4,355	19,462	48.0
	$\tilde{x}$	4,336	19,406	48.2
	σ	226	1,311	0.7
	min	3,863	16,161	43.1
	max	4,982	22,938	48.8
Special Purpose	μ	4,768	33,233	45.0
	$\tilde{x}$	4,995	32,930	45.6
	σ	1,301	9,128	1.6
	min	2,752	11,058	43.0
	max	8,016	49,517	50.5

1972 Full Scale Fatigue Test

- Catastrophic wing failure at
  - 10,300 flights
  - 55,505 flight hours

MIL-STD-1530C

Requirements

- Meet the requirements in section 5.4.3.3.2
  - "A Structural Teardown Program may be required if an aircraft is ***expected to operate beyond its design service life*** or if there is ***evidence of extensive damage*** that may jeopardize the aircraft's structural integrity. The need for and timing of a Structural Teardown Program shall be based on force management updates described in 5.5.6."
  - Section 5.5.6 states, "Mission and usage changes, major modifications, as well as ***aircraft inspection findings*** shall be evaluated by analysis and/or testing (to include a possible additional full-scale static and/or durability test) to determine the need for and timing of periodic updates to the force management strategy. It is envisioned that updates will be required every 5 years or as dictated by the requirements defined in the subparagraphs below. Information which results from the updates described below shall be documented in the FSMP."

Teardown Objectives

- Determine the current condition of the C/KC-135 fleet. Destructive teardown inspection is required to assess the following:
  - The level of corrosion damage
  - The condition of spot-welds
  - The presence of stress corrosion cracking (SCC) with a special emphasis placed on cracks ≥ 0.25 inch
  - The presence of fatigue cracking, especially in locations that cracked during the 1962 and 1972 fatigue tests
    - Special emphasis will be placed on cracks ≥ 0.05 inch unless additional data is required to establish a well-characterized equivalent initial flaw size distribution

Teardown Objectives (cont.)

- Determine effectiveness of corrosion mitigation efforts following the 1990s hidden corrosion teardown program of SN 61-0291 Mitigation efforts included:
  - Widespread application of corrosion preventive compounds (CPC)
  - Addition of drain holes where water and other contaminates tend to collect

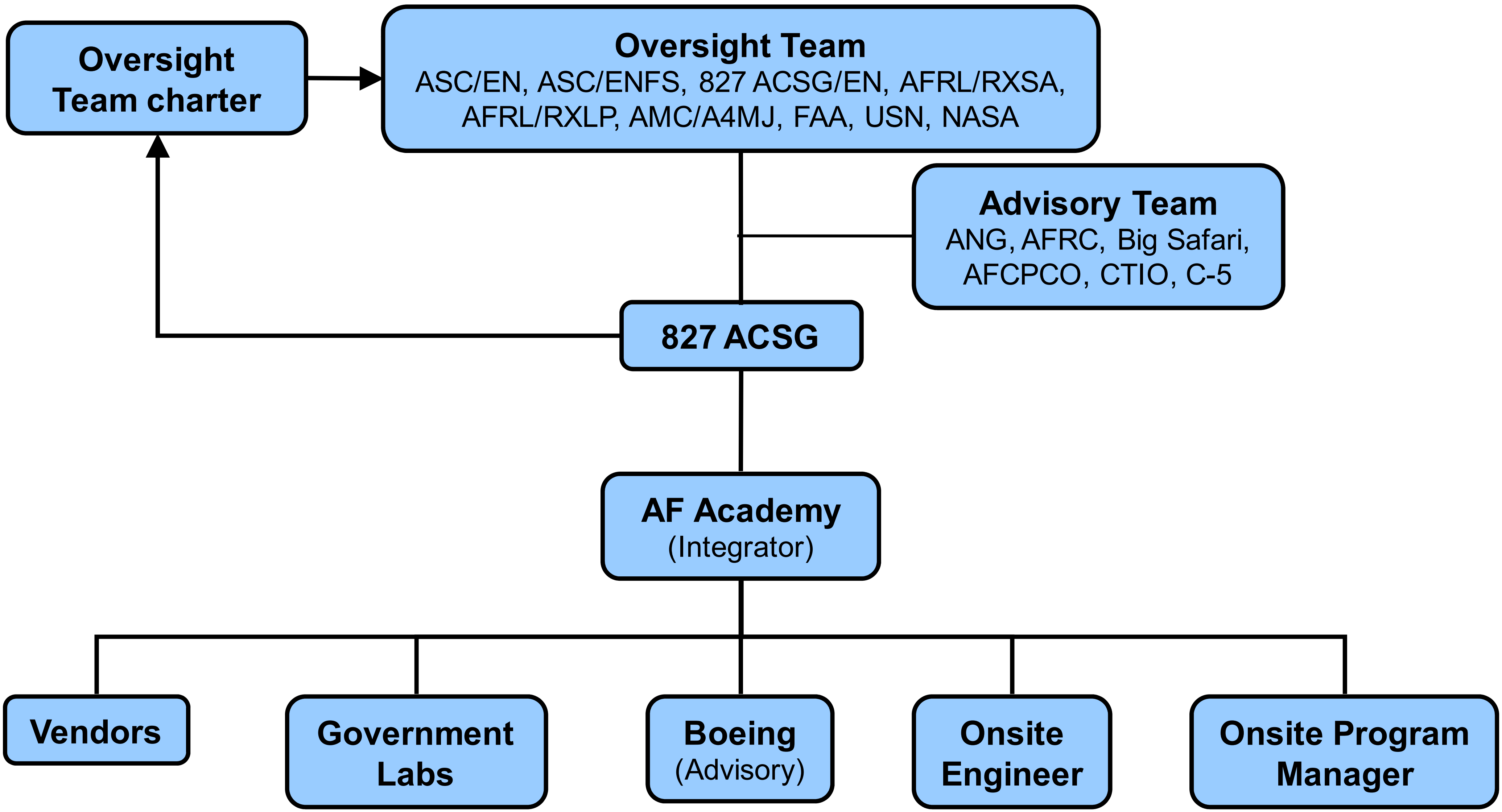
Teardown Objectives (cont.)

- Confirm ASIP inspection adequacy
  - For each teardown aircraft, compare the results of the T.O. 1C-135-36 NDI inspections completed during the teardown activity with the results of the part level NDI accomplished at the same locations
- Perform analysis to anticipate future damage (corrosion, SCC, fatigue, etc.) as a function of time (hours, years) by combining results of
  - Teardown inspection of these 3 aircraft
  - 1990s teardown inspection of SN 61-0291
  - Boeing 707 commercial and military derivative aircraft experiences

Teardown Objectives (cont.)

- Establish recommendations to maintain structural integrity:
  - Determine need for fatigue testing
  - Maintenance actions (inspections, repairs, replacements, modifications) to preserve structural integrity and aircraft viability out to 2040+ and beyond
  - Determine need for future C/KC-135 teardown inspection and analysis efforts

Organization and Integration



Teardown Aircraft Selection

- Three aircraft selected for teardown
- KC-135R, 63-8886 – Sep 06 Mishap

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- Three aircraft selected for teardown
- KC-135R, 63-8886 – Sep 06 Mishap
- Several special purpose and entire KC-135E being retired
  - Due to structural similarity of KC-135E to remaining fleet – select two KC-135E's for teardown
- Selection based on weighting of input parameters

Input

Teardown Aircraft Selection

- **Contributing to Fatigue**
  - **Flight Hours** ✓
  - **Ground-Air-Ground (GAG) Cycles** ✓
  - **Wing EFH** ✓**, Fuselage EFH** ✓**, Empennage EFH** ✗
- **Contributing to Corrosion**
  - **Aircraft Age** ✗
  - **Environmental Damage – "*Basing Severity*"** ✓
- **Aircraft History**
  - **Interview MX personnel** ✓
  - **Number of Major Structural Repairs, MX History** ✓
  - **Depot "Over & Above"** ✗
  - **Time Since Last Programmed Depot Maintenance** ✗

Environmental Severity Index (ESI)

- ESI is questionable as a primary aircraft selection criteria based on the following concerns:
  - At least three sets of ESI data are in circulation
    - Structural Damage Management Tool (SDMT)
    - University of Virginia
    - Battelle
  - Two known methods for calculating ESI
    - ESI = ACR / ACR_{min};   ACR = Average Corrosion Rate
    - ESI = 12 Month Mass Loss / 14 μm/cm^2 *

      * 14 μm/cm^2 = second lowest 12 month mass loss value

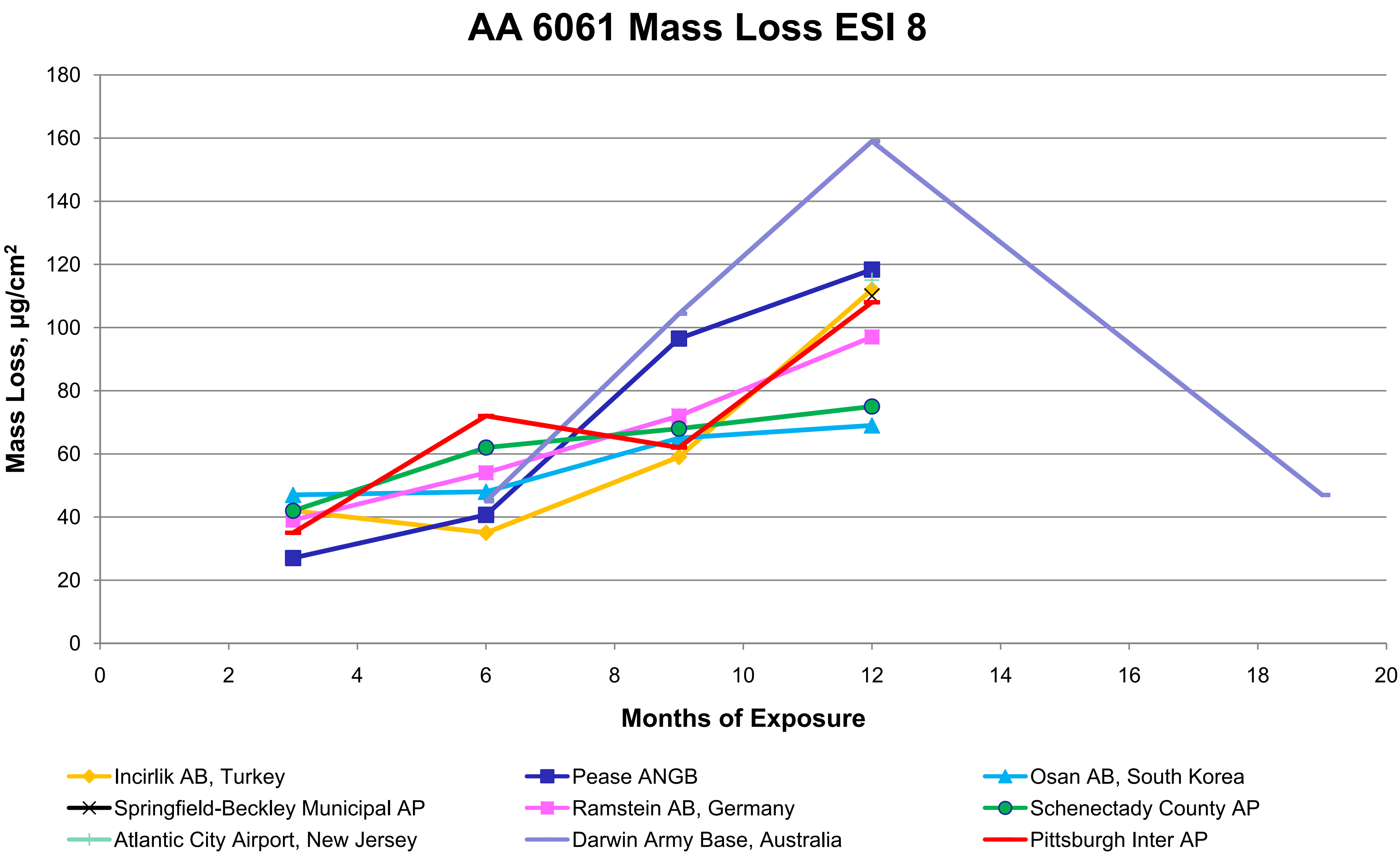
ESI Concerns

- Variation in mass loss data used to calculate ESI suggests seasonal effects
  - ESI value might be different based on when data was collected
  - Unusually high or low amount of precipitation may move a base into a different ESI range
- Large variation in mass loss data shows there may not be a statistical difference between an ESI of 5, 6 or even 8
  - Statistical difference do exist between larger ESI spreads, such as between 5 and 20
- The longer the exposure time the larger the spread in the data suggesting that over time there is even less of a difference between ESIs
- No direct correlation between ESI and corrosion
  - No way to account for the health of the aircraft coatings

Data Analysis

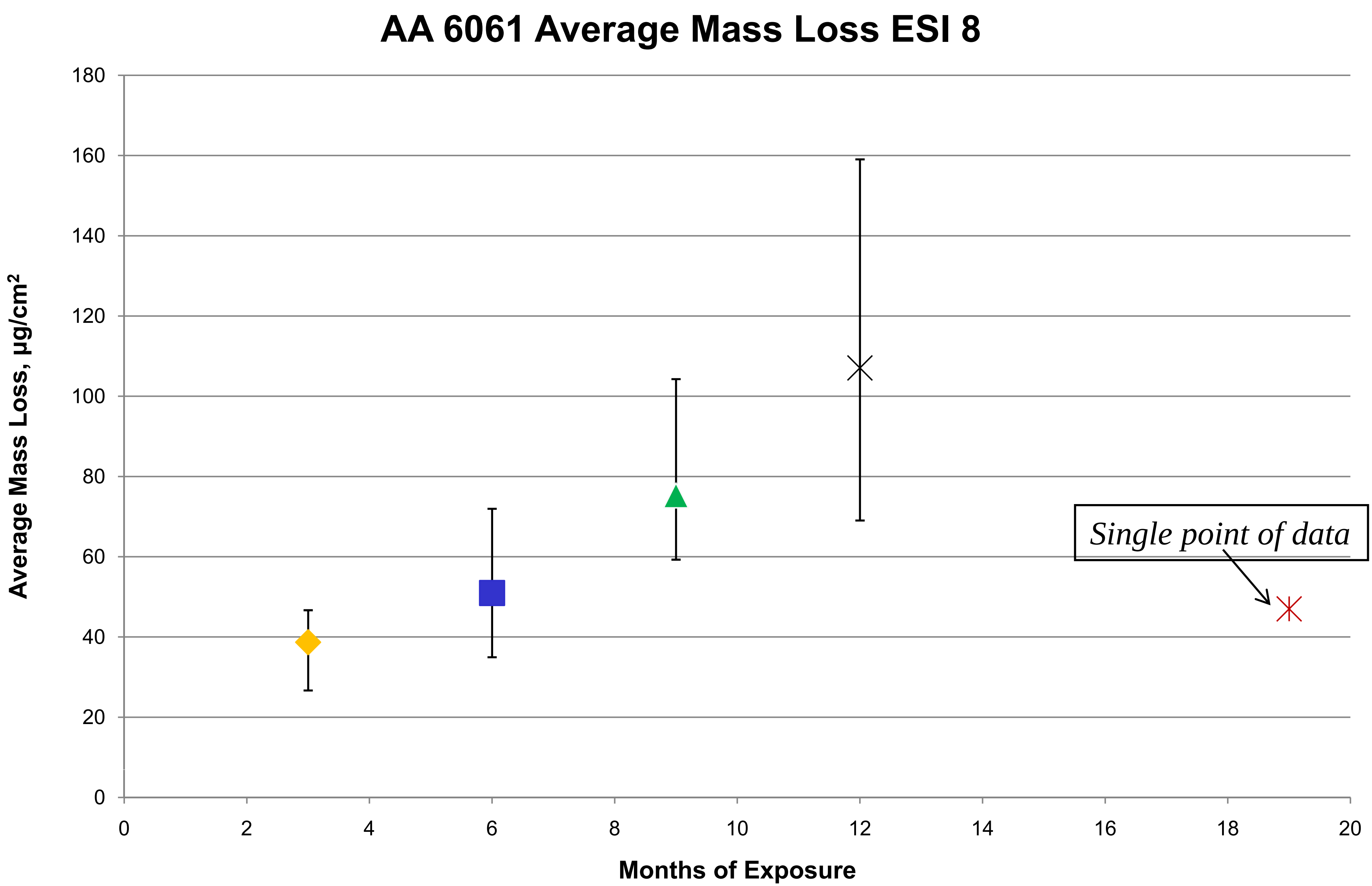
Variation in SDMT Data

- SDMT data was analyzed by different plotting methods.



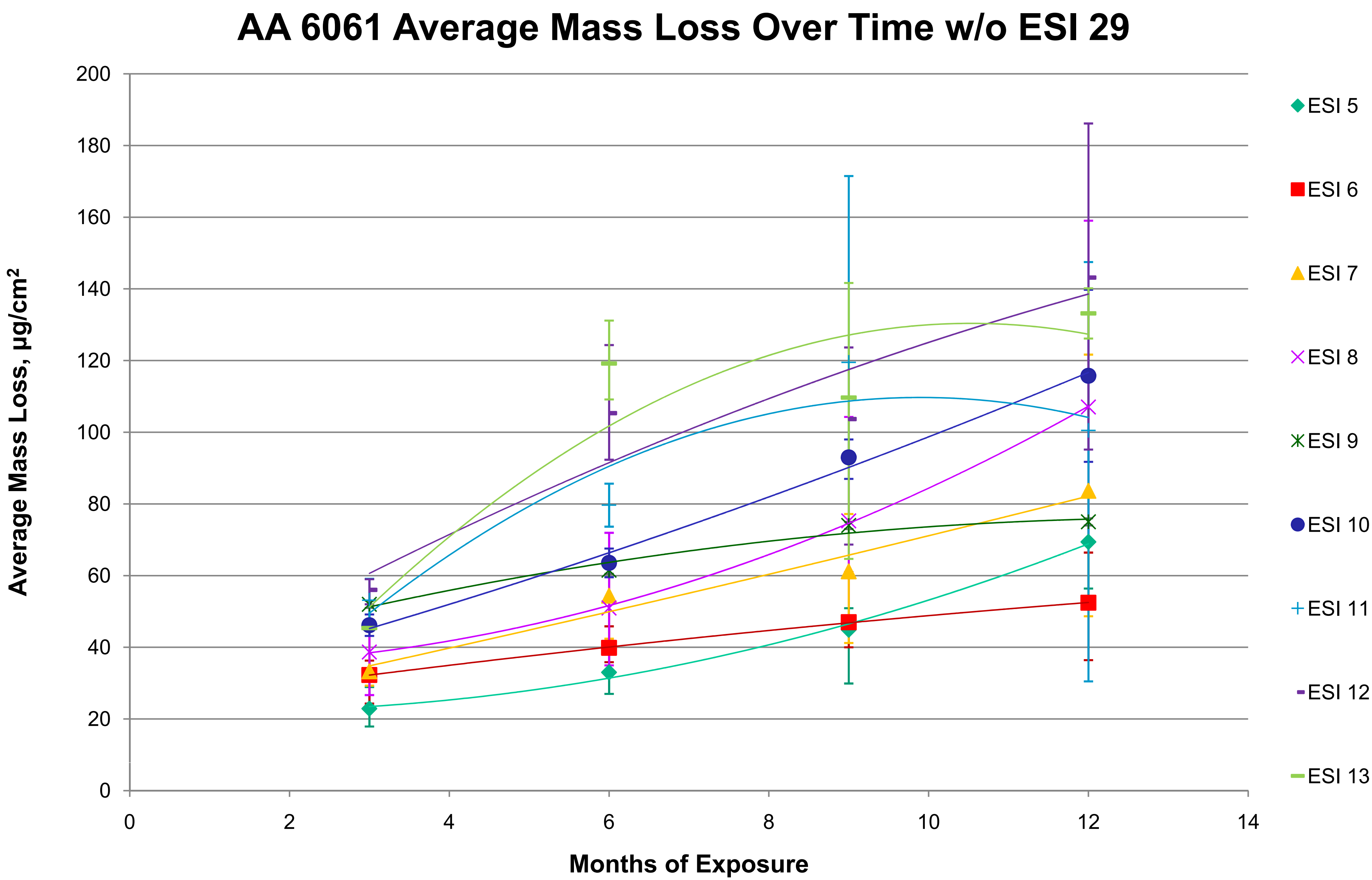
Data Analysis

Variation Over Exposure Time SDMT Data



Data Analysis

SDMT AA6061 Data Without ESI 29



ESI & Teardown Aircraft Selection

- Despite variation in ESI data, ESI is being used as a selection criteria
- ESI values were assigned to all KC-135 bases listed in the (by tail number) basing history
- Published Battelle ESI values were used
  - If an ESI value was not available for a base listed then the ESI of the closest environmentally equivalent base with an ESI available was used
  - Engineering judgment was used with regard to distance from the ocean and other factors when selecting an ESI for a base without ESI data available

Weighting Schemes - Initial

Teardown Aircraft Selection

- Single Parameter
- Multi-parameter
  - 10+ variations

Weight Factor	Opt 1	Opt 2	Opt 3	Opt 4	Opt 5	Opt 6	Opt 7	Opt 8	Opt 9	Opt 10
GAG	1	0	0	0	0	0	0	1	0	0
Wing-EFH	1	1	1	1	0	0.5	1	1	0.5	0
Fuselage-EFH	1	1	1	0	1	0.5	1	1	0.5	0
Years	1	1	0	0	0	0	0	0	0	0
Hours	1	0	0	0	0	0	1	1	0	0
Basing Severity	1	1	1	1	1	1	1	1	0	1

- Opt 1: *Equal Weight*
- Opt 2: *EFH & All Corrosion*
- Opt 3: *EFH & Base Severity*
- Opt 4: *W-EFH & Basing Severity*
- Opt 5: *F-EFH & Basing Severity*
- Opt 6: *Fractional EFH & Base Severity*
- Opt 7: *EFH & Base Severity, Hours Bias*
- Opt 8: *Equal w/o Years*
- Opt 9: *Fatigue*
- Opt 10: *Corrosion*

Weighting Schemes – Final

Teardown Aircraft Selection

Fatigue & Corrosion → Opt 3
Corrosion → Opt 2
Fatigue → Opt 1

Weight Factor	Opt 1	Opt 2	Opt 3
GAG	0	0	0
Wing-EFH	0.5	0	0.25
Fuselage-EFH	0.5	0	0.25
Years	0	0	0
Hours	0	0	0
Basing Severity	0	1	0.5

Ranking

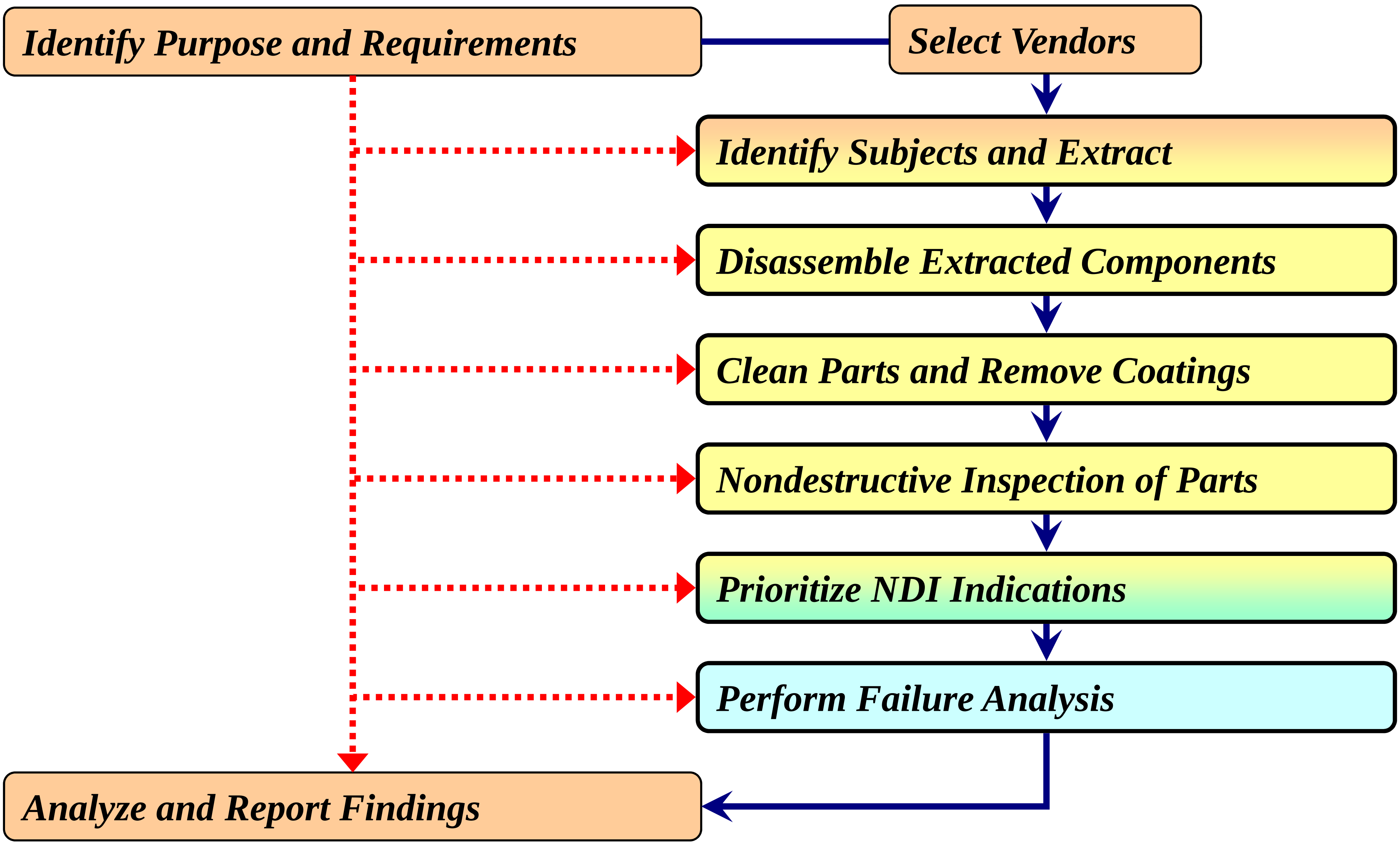
Teardown Aircraft Selection

Weight Factor	Opt 1	Opt 2	Opt 3
GAG	0	0	0
Wing-EFH	0.5	0	0.25
Fuselage-EFH	0.5	0	0.25
Years	0	0	0
Hours	0	0	0
Basing Severity	0	1	0.5

- Observations
  - Special purpose and KC-135R consistently rank highest
  - Corrosion metric has significant impact on overall ranking
  - KC-135E do not rank high by any weighting scheme
  - Weighting scheme insufficient – must include aircraft history

MDS	Opt 1	Opt 2	Opt 3
SP	14	1	1
KCR	25	7	2
KCR	31	4	3
KCR	27	13	4
SP	29	14	5
SP	13	35	6
SP	24	40	7
SP	37	25	8
SP	17	54	9
SP	7	71	10

Teardown Process



Program Exit Criteria

- Complete accountability of all sections, parts, and failure analysis specimens
- Using Oversight Committee approved and validated teardown protocols, complete all inspections and required analyses of all teardown subjects
- Root cause determined for all prioritized NDI indications and section-level Close Visual Inspection indications
- All failure analyses accepted by review authority, AFRL/RXSA
- All non-teardown items of teardown aircraft disposed. All parts with NDI indications and all failure analysis specimens are archived at Aircraft Maintenance and Regeneration Group
- Teardown Data Management System archived – one copy at 827th ACSG with a backup copy at CAStLE
- Final report approved by 827th ACSG

Conclusion

- Tanker recapitalization schedule unknown
- Some aircraft will exceed full scale fatigue test simulated flight hours before planned retirement
- Corrosion damage has been extensive on some aircraft
- Teardown goals/objectives and exit criteria promotes meeting cost, schedule and performance goals
- Large teardown programs require dedicated team
- Aircraft MX history must be included in teardown article selection