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# Ground and Flight Testing of Non-Chrome Paint Systems; Part 1– Acceleration Factors

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Battelle-Columbus

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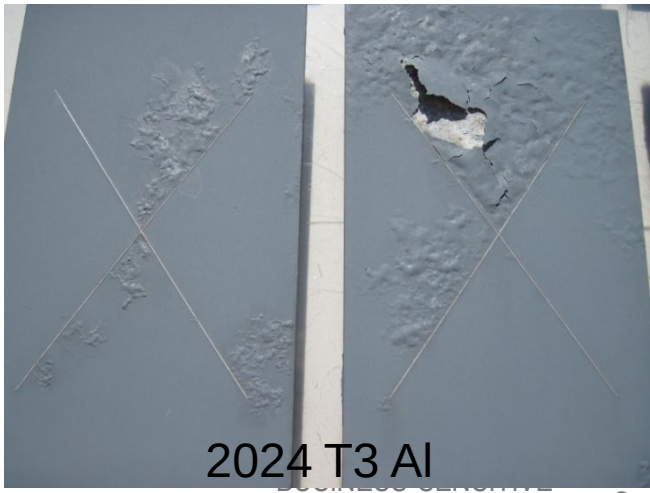
# Basis of Study

- Provide Supporting Data on Performance of Wide Range of Non-Chrome or Reduced Chrome Paint Stackups for Decisions Regarding Chrome Elimination
- Evaluate Wide Range of Chemical Stresses/Threats To Coatings
- Emphasis on Corrosion In Severe Ground and Flight Environments – **Field Data**
- Evaluate Significance of A Severe Ground Exposure to Flight; i.e. **Acceleration Factors (This Briefing)**
- Accelerated Laboratory Corrosion Tests Do Not Match Field and May Give Total Reversals of Performance
  - ASTM B117
  - GM9540
  - G2

Field, 1 Yr; Poor NC Primers

KC135 Wing Skin


2024 T3 Al

# Overview

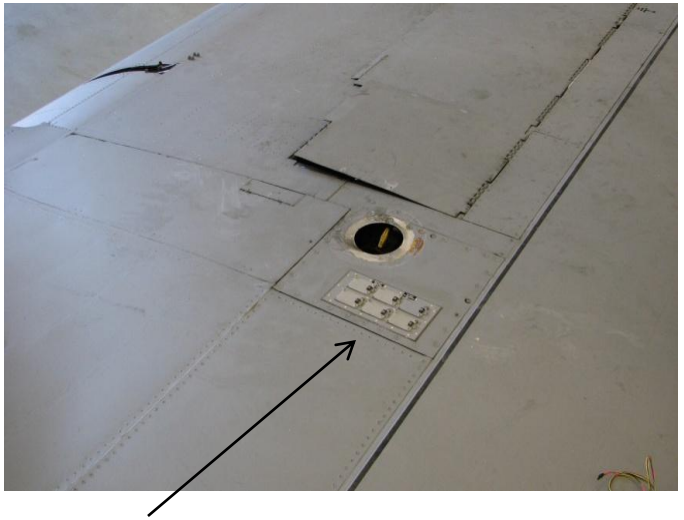
- A Large Flight and Ground Exposure Study Is Being Conducted To Evaluate Non-Chrome Paint Stackups In Comparison To Standard Chromated Systems
- The Emphasis is **Corrosion** as Produced By a Variety of Physical, Chemical, and Biological Stresses
  - Atmospheric/Coastal/Daytona Beach – This Briefing
  - Flight on OML of military aircraft – This Briefing
  - Fungal
  - Decon Solutions
  - Biocides
  - Urine
  - Wash Intervals
  - Wash Intervals + Biocides

# Scope and Approach In Study

- >60 Paint Systems Under Evaluation on Ground At Battelle's Daytona Beach Exposure Site
  - Mix and match pretreatments, primers, and topcoats
  - Painted and Scribed **Corrosion Sensors** (Electrical/Quantitative)
  - Painted and Scribed 2024 T3 **Aluminum Panels** (Visual/Subjective)
  - Painted and Scribed **Galvanic Couples** (Steel/Al) (Visual/Subjective)
- 9 Paint Systems Being Flown on Painted and Scribed Corrosion Sensors On Upper Fuselage of 42 Aircraft (Initiated by OSD)
  - C130
  - C5
  - HC144

# Examples of Ground and Flight

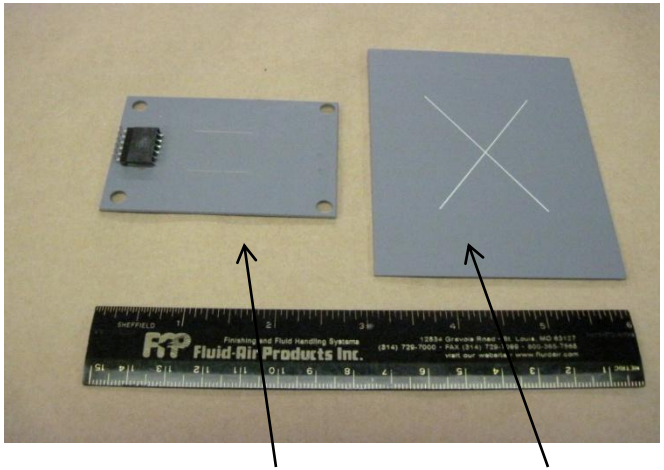
Daytona Test Rack @ 50 Meters (1 of 3 in use; ESI Steel = 165,000 microgm/cm2/yr.



Panel with 6 sensors on C130; Upper Fuselage


Galvanic Samples; 1 Year; Ground

Quantitative/ Objective

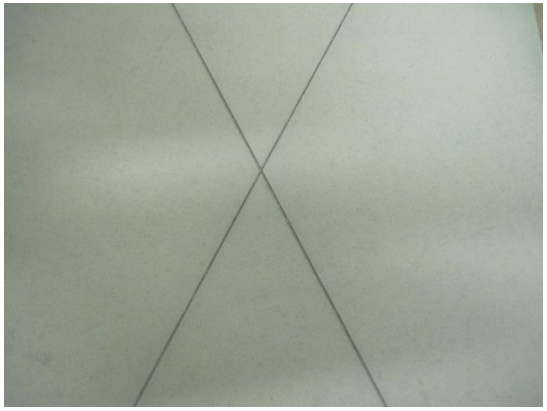



Visual/ Subjective

Typical sensor and Panel

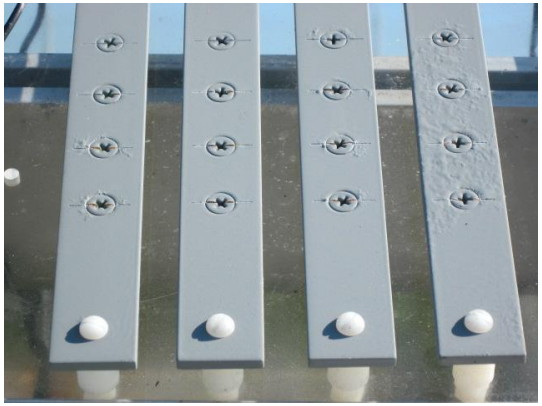
# Examples of Appearance of Field Samples

Best NC/NC Coating
4+ Years; 2024 Al

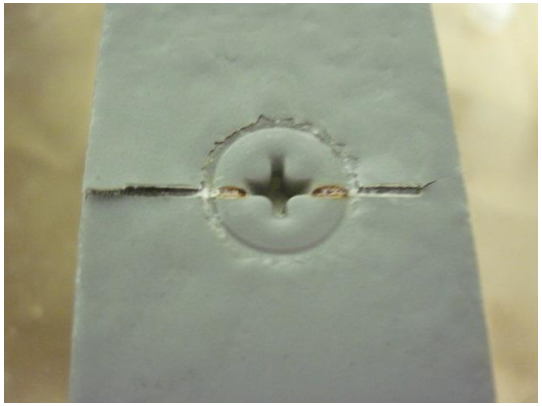


Typical Chromate Coating
4+ Years; 2024 Al

Poor NC Coating
<1 Year; 2024 Al



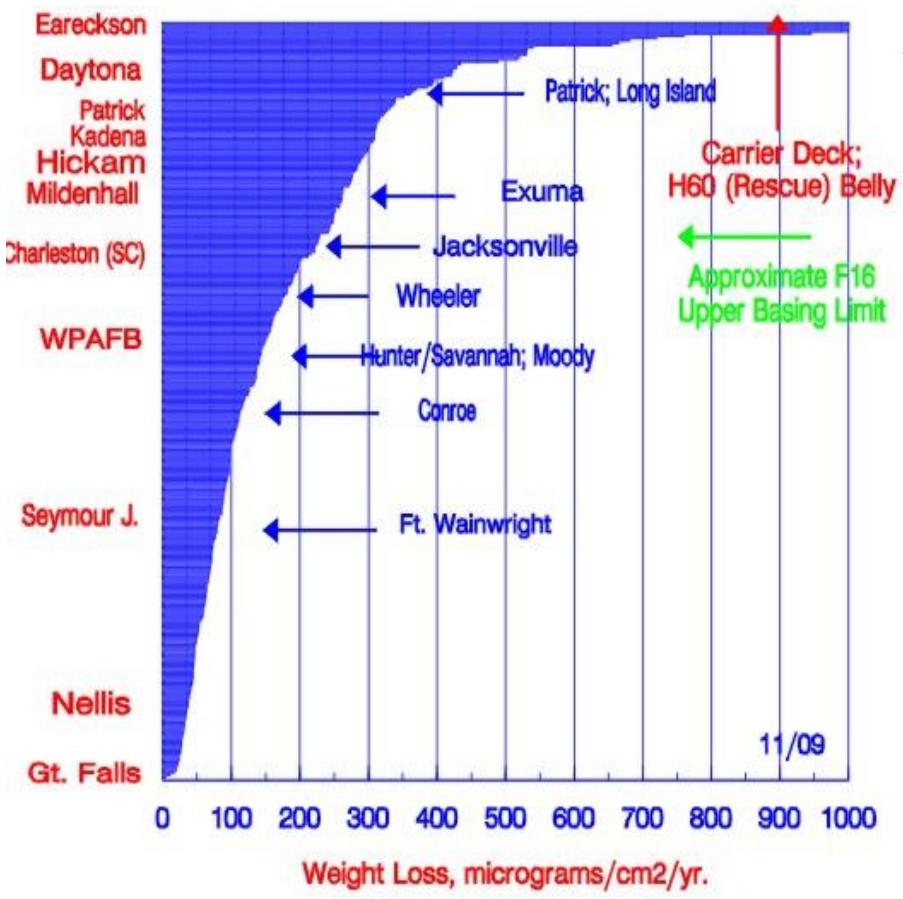
Galvanic Test Samples
< 1 Year; 2024 Al/Steel



Galvanic with Poor
NC Coating; < 1 Year

KC135 Wing Skin
2+ Years; C/C and NC Coatings

# Current Fleet Basing vs Worldwide Environmental Severity Index (ESI) Distribution




Ground ESI
This Study

| C130 Basing | C5 Basing |
|---|---|
| 90 -95% | 90-95% |
| 80-85% | 70-75% |
| 50-60% | 50-55% |

Current Basing of 3 Fleets In Relation to ESI Values

Ground Severity = Accelerated Exposure vs. Most of US Military Land Basing

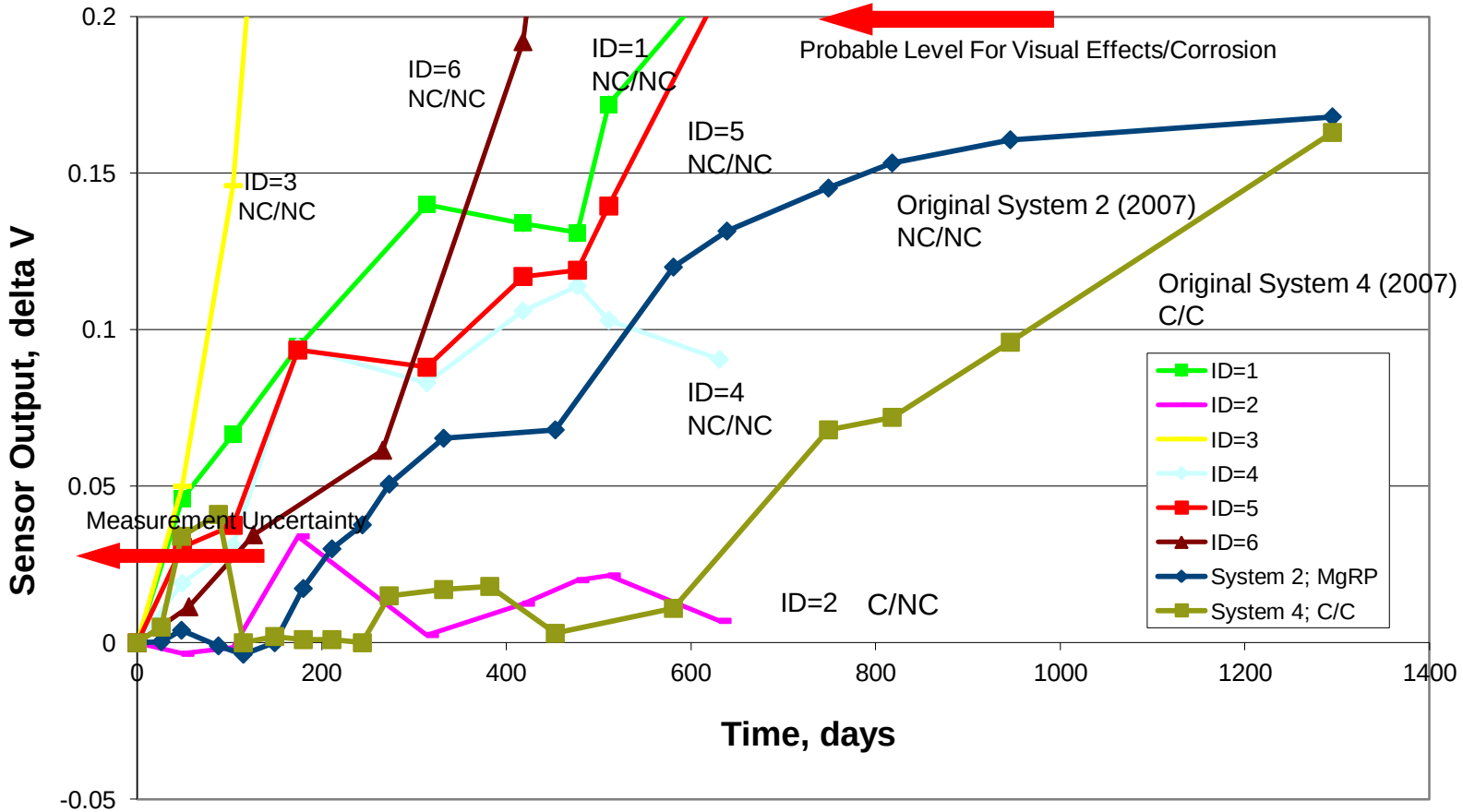
# Paint Stackups For Flight and Ground Evaluations – 2007 and 2009 Start

## 2009 Long Term Start; Ground and C130, C5, HC144

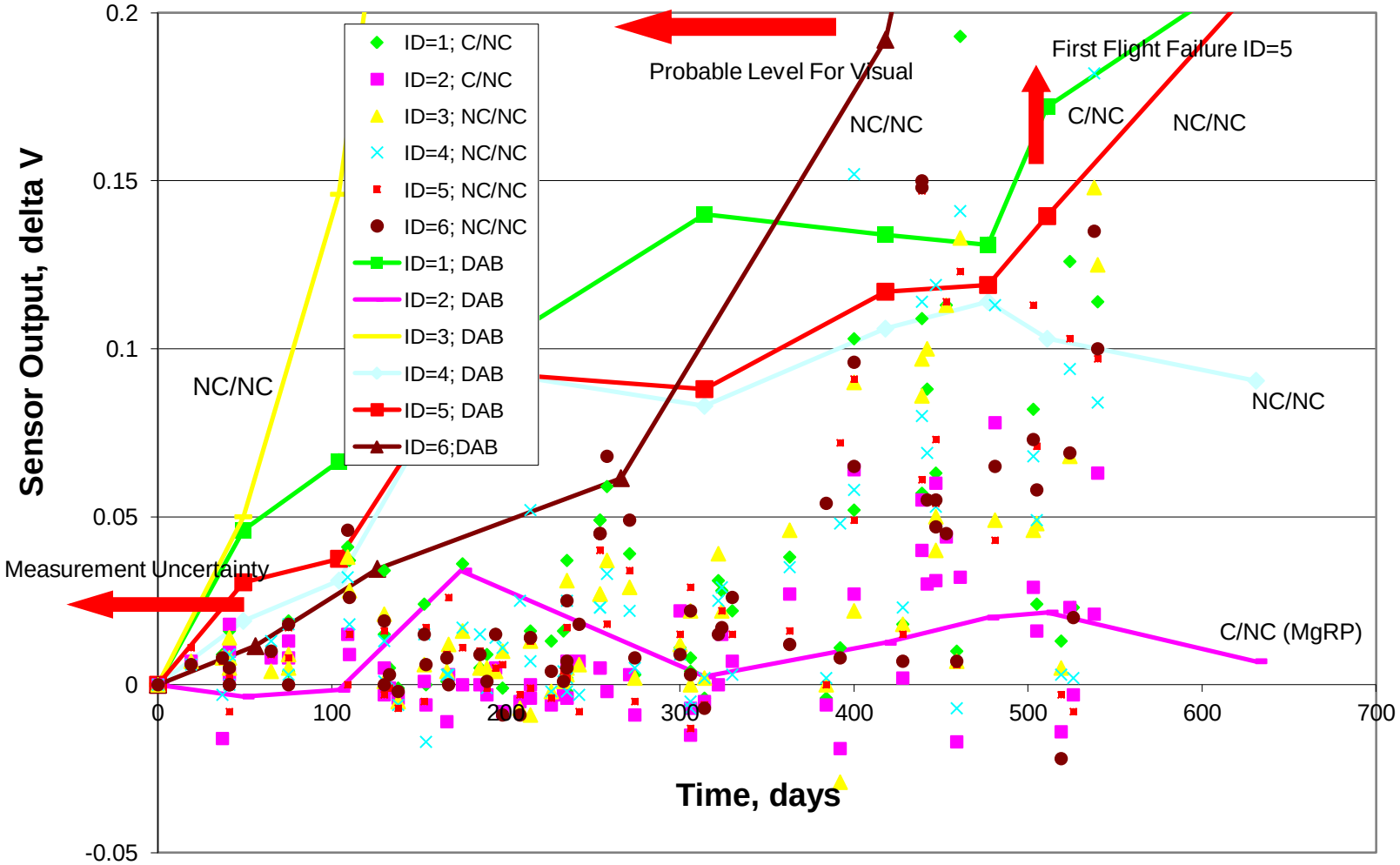
- ID=1 Alumigold / 44GN098 (DEFT) / 99GY001 (DEFT)
- ID=2 Alumigold / AE2100 (XP406-110) ANAC / 99GY001(DEFT)
- ID=3 Alodine 5700 / 02GN084 (DEFT) / 99GY001 (DEFT)
- ID=4 Alodine 5700 / 16708TEP (Hentzen) / 99GY001 (DEFT)
- ID=5 Prekote / Sicopoxy 577-630 (ANAC) / 99GY001 (DEFT) C130 only
- ID=5 Prekote / 02Y040B (DEFT) / 99GY001 (DEFT) C5 only
- ID=6 DEFT 1015/3021 / 02GN093 (DEFT) / 99GY001 (DEFT) C130 ,HC144 only
- ID= 6a Prekote / 02Y040B (DEFT) / PPG Desothane HS Half of C5s only
- ID = 6b Prekote / 02Y040B (DEFT) / AE5000 (ANAC) Half of C5s only
- **2007 Long Term Start – Ground and flight (H60/P3/AH64A)**
- ID=7 Alodine 1200S / 02GN083 (DEFT) / 99GY001 (DEFT)
- ID=8 Prekote / AE2100 (first generation) / AE5000 (ANAC) Old System 2
- ID=9 Prekote / 02Y-040 (DEFT) / 03GY310 (DEFT) Old System 3
- ID=10 MIL-C-5541 / 02Y040 (DEFT) / 03GY310 (DEFT) Old System 4
- ID=11 Alodine 5200 / Sicopoxy / 03GY310 (DEFT)
- ID=12 Prekote / Americoat 3351 / 03GY310 (DEFT)

MIL-PRF-85285 Ty IV
MIL-PRF-85285 Ty I
MIL-PRF-23377 Cl C2
MIL-PRF-23377 Cl N
MIL-PRF-85582 Cl N
MIL-DTL-81706

# Summary of Sensor Results – Ground @ Daytona For Same Paint Systems As C130 Flight



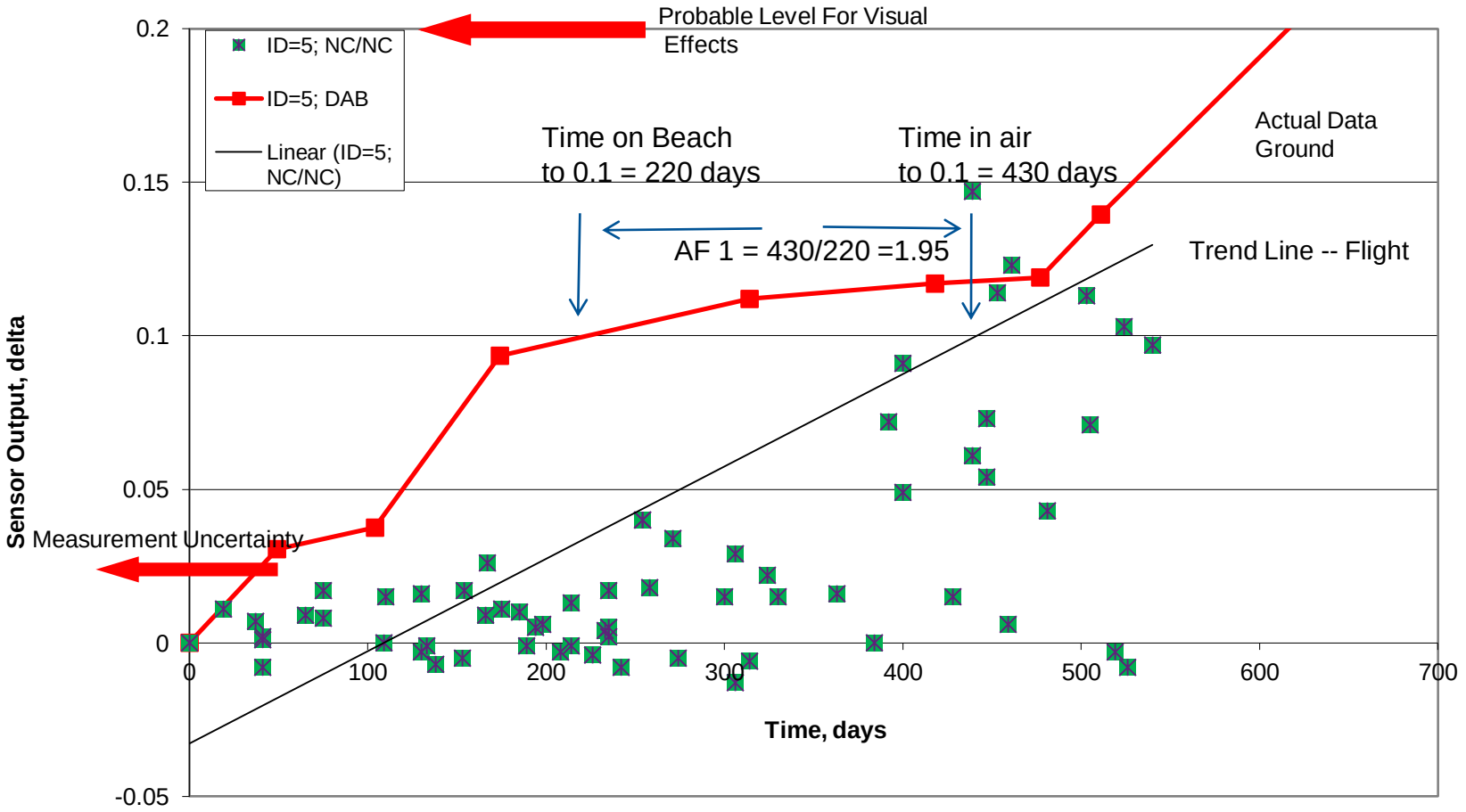
# Combined Data For Ground and On-Aircraft (Solid Lines = Ground; Points=Flight By T/N)



# Significance of Data

- Paint Systems Are Degrading Faster In Severe Environment of Daytona Than On OML of Aircraft
- This Provides Some Degree of Realistic Acceleration = AF 1
- Painted aluminum on ground will take much longer to visual degradation than response of sensor = AF 2

# Example of Acceleration Factor For Painted and Scribed Sensor In Flight vs. Daytona Beach Exposure -- One Paint System



# Analysis of Ground vs. Flight Data

- Ground is Accelerated vs Flight Per Sensor Data
  - ESI on OML is less than at Daytona for worst case basing of probably all USAF fleets
  - Analysis does not apply to sea basing
- 2024 Al Panels (Visual) React Much Slower Than Sensors = Additional Acceleration For Sensors Data
  - Acceleration Factor Even Greater
- Same Order of Performance of Paint Stackups For Both – Sensor vs.Al (Gnd) and Sensor Gnd vs Flight
- Enough Data to Define **Approximate** Acceleration Factors

# Acceleration Factors Gnd vs Flight and Gnd Sensor vs Gnd 2024 Al

- Sensors By Paint Stackup; Time (days) to Reach Same Electrical Change (Delta = 0.1 V)

| | Ground | Flight | Factor | Al (Visual) | Factor |
|---|---|---|---|---|---|
| » | | | | | |
| – ID=1 | 180 | 400 | 2.2 | 670 | 3.7 |
| – ID=2 | >600 | >700 | ---- | --- | |
| – ID=3 | 120 | 461 | 3.8 | >720 | >6 |
| – ID=4 | 170 | 420 | 2.3 | 710 | 4.1 |
| – ID=5 | 170 | 322 | 1.9 | 680 | 4 |
| – ID=6 | 310 | 461 | 1.1 | 560 | 1.8 |
| – MgRP (2007) | 670 | > 1500 | | >1500 | |
| – Cr/Cr (2007) | 980 | > 1500 | | >1500 | |
| | | » | Av= 2.3 | | |

# Acceleration Factor (Cont'd)

- Painted and Scribed 2024 Al Panels Require 2-4 Times Longer To Reach Visible Degradation Compared to Sensor Results
- Conservative Estimate = 4:1 Acceleration Factor For Severe Ground (Sensor) vs. Flight (2024 Al) For Worst Case Land Based Assets
- Significance of Sensor Results vs Painted 2024
  - Systems Deployed In 2007 Exposed to Equivalent of >10 Years On Wing of C130 and C5
  - Large Matrix Started 2009 Now Exposed to Equivalent of ~8 Years On Wing of C130 and C5

# Conclusions

- Procedures and Protocols Established For Flying Multiple Painted Corrosion Sensors on OML of Aircraft
- Approximate Acceleration Factors Now Established To Estimate The Meaning of Ground Based Exposures to Current ESI Levels of Fleet Basing
- Data Are Giving Optimistic Appraisals For Long Term Corrosion Protection For The Best Non-Chrome Systems For USAF Aircraft.
- Studies Are Continuing To Define Acceleration Factors More Precisely