

AFFTC-PA-11252



# STATISTICALLY DEFENSIBLE TEST & EVALUATION

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UNITED STATES AIR FORCE



# Air Force Flight Test Center

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*War-Winning Capabilities ... On Time, On Cost*



**U.S. AIR FORCE**

## Statistically Defensible Test & Evaluation

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*Integrity - Service - Excellence*

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# Overview



- **Organizing and Training for SDT&E**
- **Test Approaches**
- **AFFTC Application Examples**
- **Way Forward**



# Organizing and Training for SDT&E



- **AFFTC approach is to employ a shop of statistical experts (a stable of PhDs) to provide assistance to engineers during test planning and data analysis**
  - **Difficult to turn discipline engineers into statistics experts (nor do we want to)**
  - **Many tests are unique, so “cookbook” planning techniques are usually not possible**
- **Engineers and managers receive several courses on statistics and DOE so they can communicate with the experts**
- **Use a variety of tools: R, JMP, Matlab, etc**
- **Monthly information exchange meeting where technical experts describe use of statistics in their discipline:**

Flight controls  
Collision avoidance  
Performance  
Human Systems Integration  
Radar Systems  
Electronic Attack

Modeling & Simulation  
Guidance, Nav, ID  
Communications  
C4ISR  
Weapons Systems  
Anechoic Facility

R&M  
Avionics  
Threat Signals  
Propulsion  
Structures  
Subsystems



# Test Approaches



- **Statistical**
  - **Designed Experiments**
  - **Observational Studies (may have limited scope of inference based on test design)**
- **Demonstrations**
- **SME/Opinion-Based**
  
- **Primary difference is in the outcome of each approach:**
  - **Validity of the result, and**
  - **Scope of inference that can be made for that test**



# AFFTC Application: Target Detection and Recognition



## Test Objective:

- Demonstrate the ranges at which a pilot can recognize and identify certain ground targets using imaging sensors in a targeting pod

## Test Approach:

- DOE with four factors and four response variables
- Augmented flight tests with post-flight video review

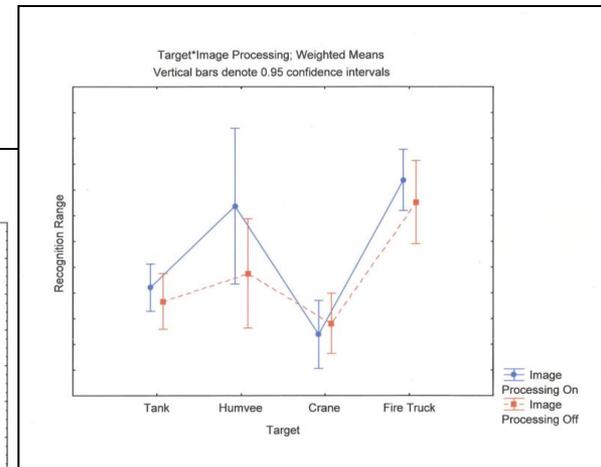
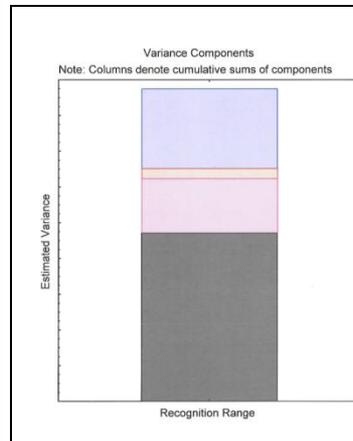
## Analysis Approach:

- Paired t-test to compare in-flight data to post-flight data
- ANOVA to determine significant factors, recognition ranges, and identification ranges

	Recognition	Identification
p-value	0.46	0.078

No statistical difference, but close!

## Results:





# AFFTC Application: Endurance Verification



## Test Objective:

- Determine if an aircraft, in mission capable configuration, has a minimum total endurance of **X** hours plus appropriate fuel reserves IAW AF instructions

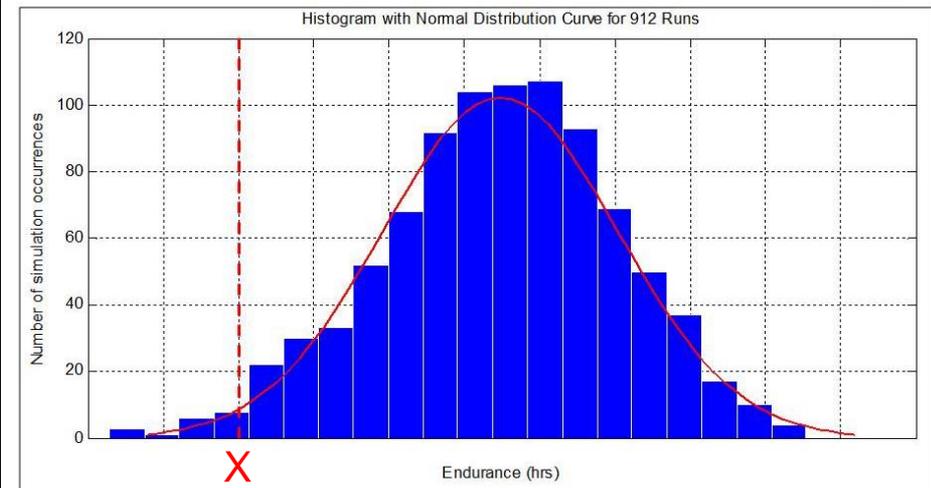
## Test Approach:

- Collect flight data regarding drag and lift coefficients, fuel flow, and static pressure error

## Analysis Approach:

- Estimate uncertainties associated with weight, outside air temperature, thrust, fuel, flow, drag coefficient, and calibrated airspeed
- Use Monte-Carlo analysis to generate expected range and endurance

## Results:





# Way Ahead



- **Developing handbook to include overview of statistics and AFFTC best practices**
- **Adding statistics input and review to our test planning and reporting processes**
- **Planning pathfinder projects in each technical discipline**
- **Potential research topics:**
  - **New flight test techniques**
  - **Analysis of time series data**
  - **Quantifying measurement uncertainty**
  - **Bayesian techniques**