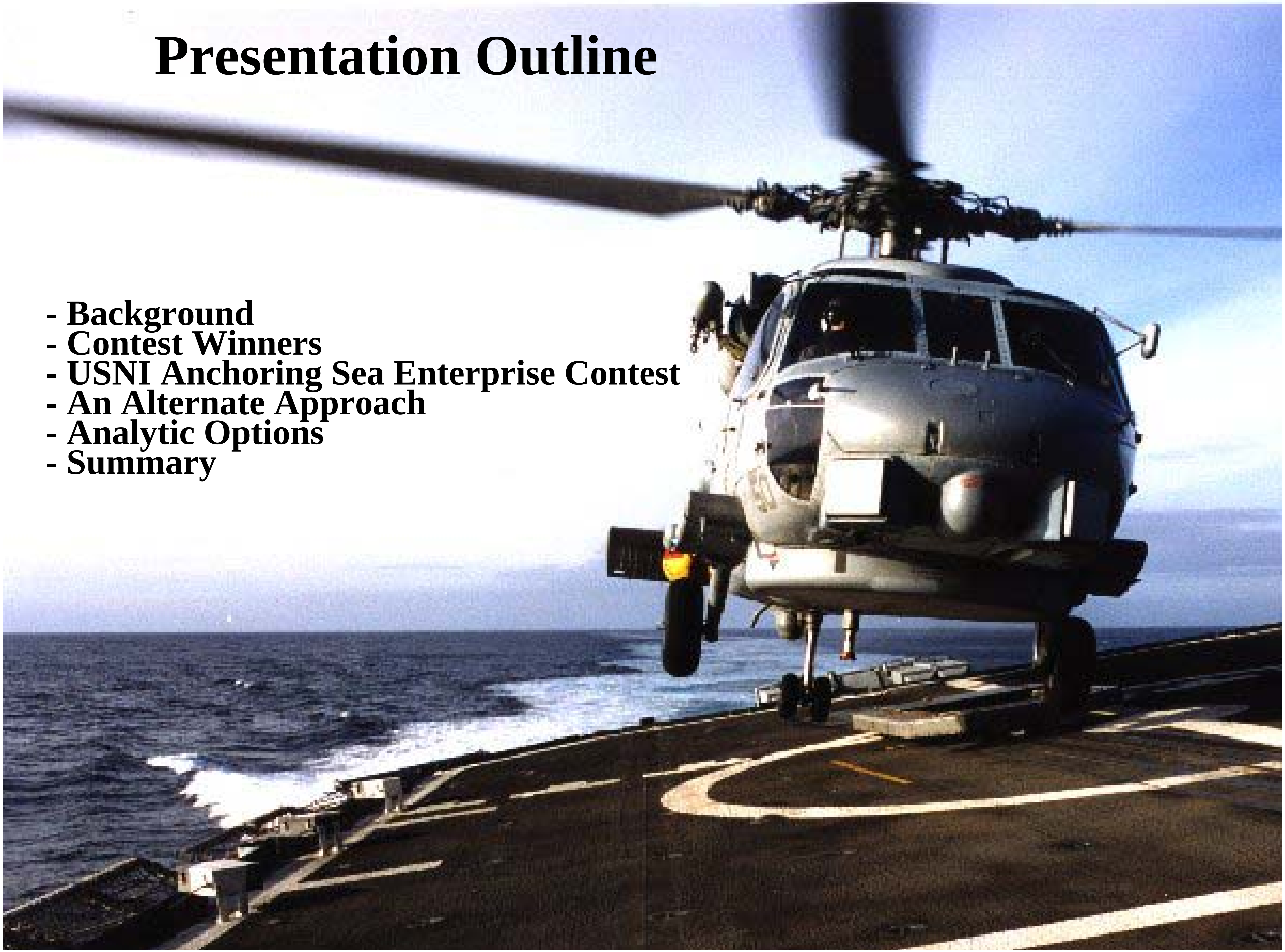
9th Annual Systems Symposium
San Diego, CA
23-26 October 2006

Dean Carico
Rotary Wing Ship Suitability Branch
AIR 5.1.6.11, Patuxent River, MD

Toward Flight Testing Less, Better

Presentation Outline

- Background
- Contest Winners
- USNI Anchoring Sea Enterprise Contest
- An Alternate Approach
- Analytic Options
- Summary



Background

- 1943 – First helicopter/shipboard landing
- 1945 – NATC established at Pax River MD
- 1949 – Rotary Wing Branch established in the Flight Test Division of the NATC at Pax River, MD
- 1982 – Dynamic Interface Section established
- 1980 – Deming – Total Quality Management
- 1990 – Reduce cost & cycle time of T&E
- 2000 + - Lean, Six Sigma, AIRspeed, Sea Enterprise (Doing less, better, etc)

US Naval Institute
Anchoring Sea Enterprise Essay Contest (1)

- Essay Contest announced in Jan 2006
  - 3,500 word essay; Several prizes (1^{st} = $15K)
- Areas of Emphasis
  - Increasing Efficiency and Effectiveness
  - Increasing Productivity (..doing less, better)
  - New Technology
  - Accelerating Innovation
  - Adaptive Organization Design
  - Outstanding Communication
  - Barriers, Incentives, and Mechanisms Necessary for Change
  - Leading Change
- Received 260 essays

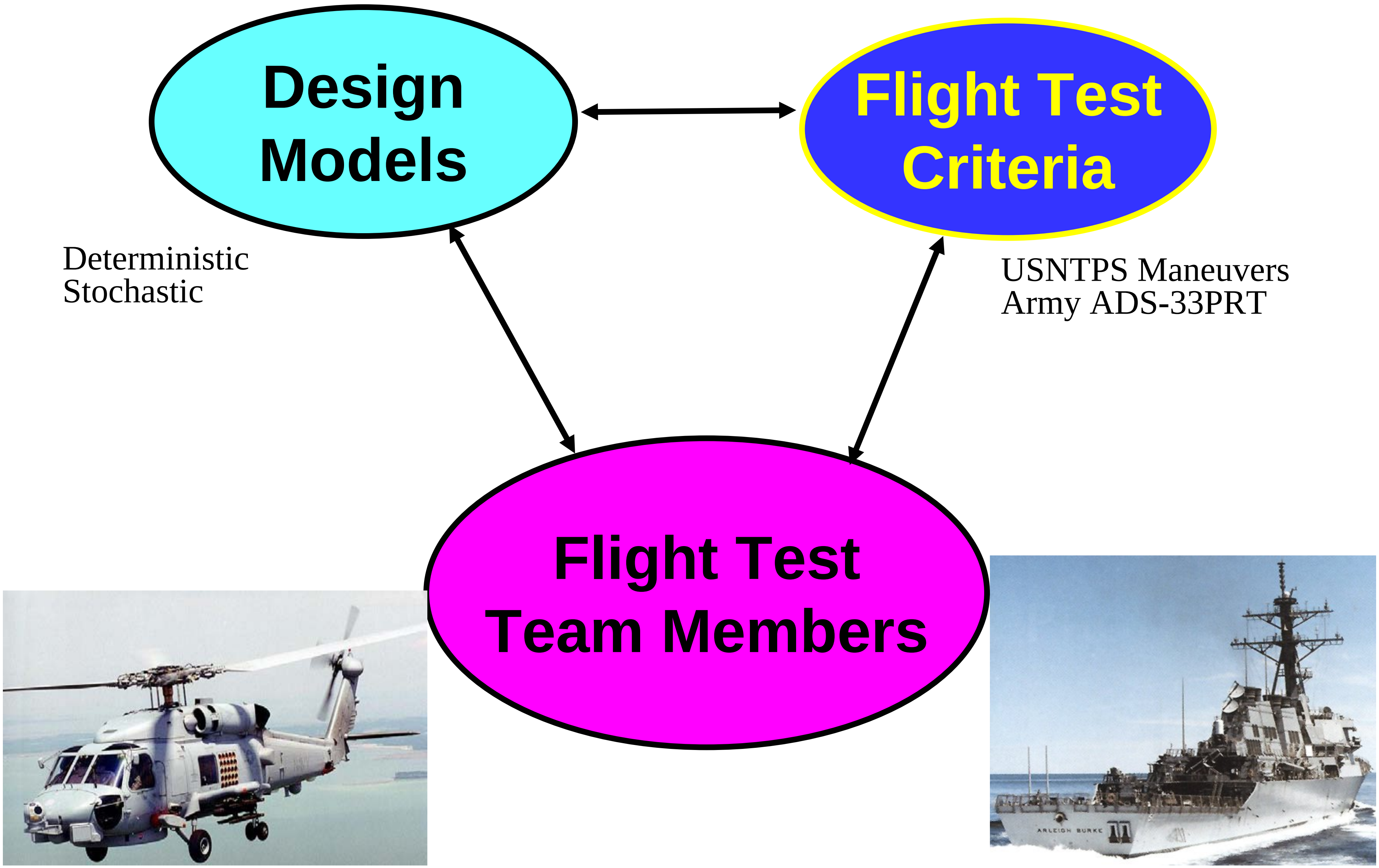
US Naval Institute
Anchoring Sea Enterprise Essay Contest (2)

- Winning essay: “Sea Wiki: How to Take the Navy’s Culture of Innovation to New Depths” LCDR Frederick Dini, Navy Supply Corp
  - A Wiki is a web page which contains all the information on a topic and anyone can add, delete, or edit its content.
- 2nd – “Retire the Twenty-Year System” Ben Atkins, GE Energy Financial Services
- 3rd – “Sea Enterprise: Get Under Way on Manpower” CAPT Ken Perry, Submarine Development Squadron 12
- Hon – “It’s the Network” ENS Tim Graczewski, USNR

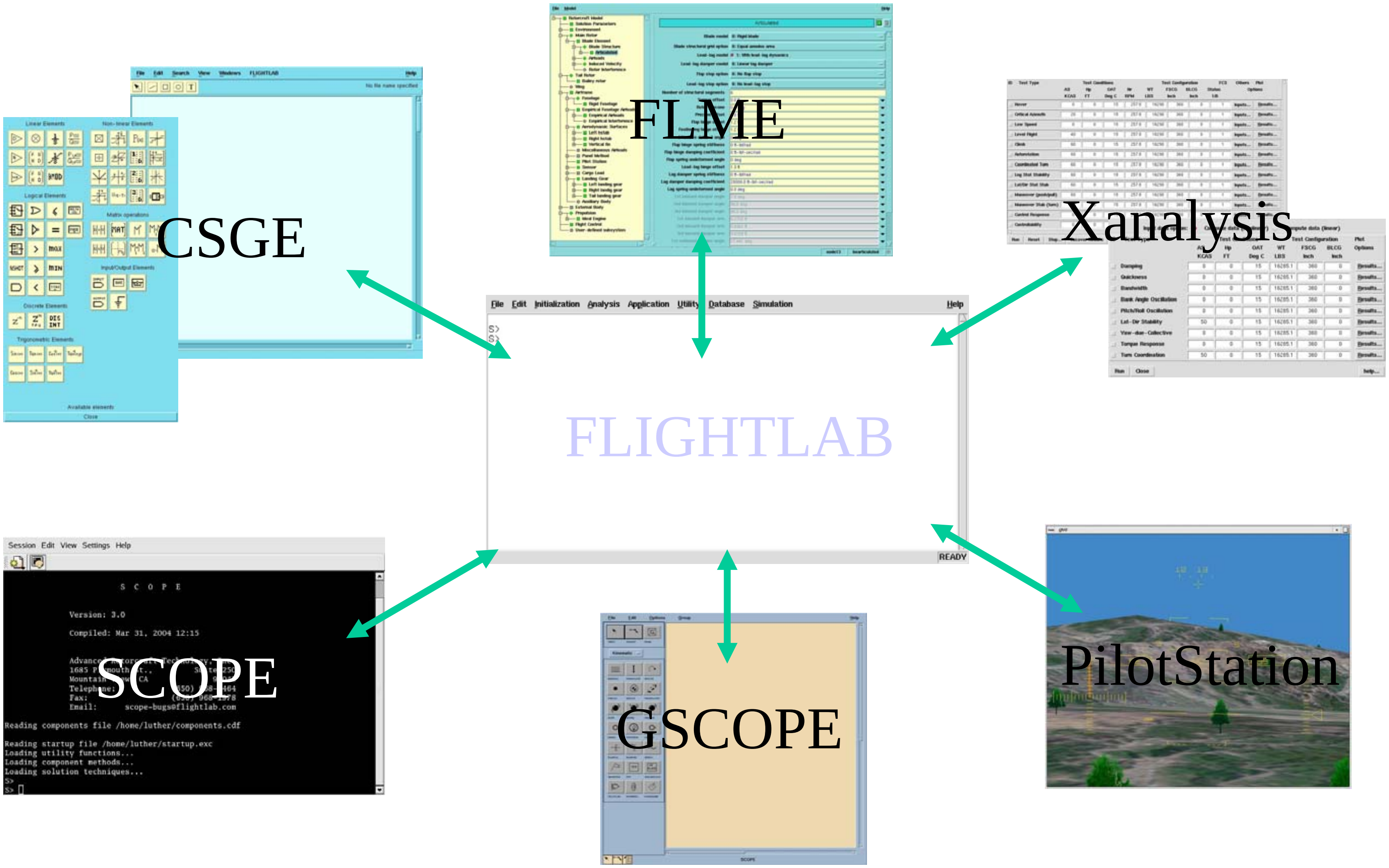
One of the 260 Essays: Technology Options to Enhance Rotorcraft/Ship Testing and Related Analysis

- Integrate design & flight test analytics
- Generic air vehicle model structure
- USNTPS & Army ADS-33PRT criteria
- High performance computing options
- Multimedia test planning & reporting
- Intelligent aircraft flight test database
- Advanced aircraft simulator MOE
- Aircraft/ship analytic options
- Advanced miniaturized data systems

Integrating Design &Flight Test Analytics



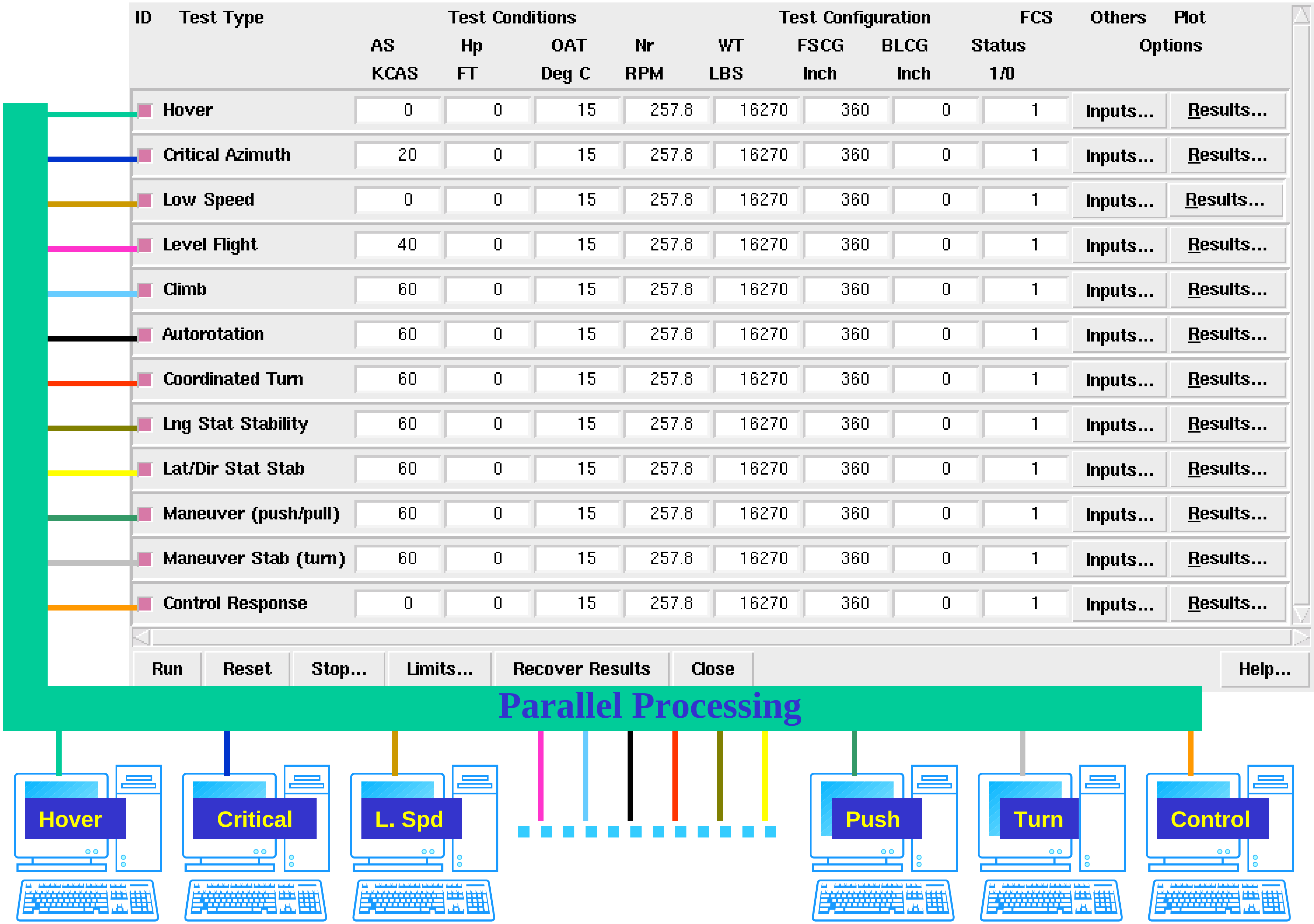
FLIGHTLAB Architecture



USNTPS FQ&P Tests Modeled in the FLIGHTLAB Environment

ID	Test Type	Test Conditions				Test Configuration			FCS	Others	Plot
		AS	Hp	OAT	Nr	WT	FSCG	BLCG	Status	Options	
		KCAS	FT	Deg C	RPM	LBS	Inch	Inch	1/0		
☐	Hover	0	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Critical Azimuth	20	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Low Speed	0	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Level Flight	40	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Climb	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Autorotation	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Coordinated Turn	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Lng Stat Stability	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Lat/Dir Stat Stab	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Maneuver (push/pull)	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Maneuver Stab (turn)	60	0	15	257.8	16290	360	0	1	Inputs...	Results...
☐	Control Response	0	0	15	257.8	16290	360	0	1	Inputs...	Results...

Run | Reset | Stop... | Limits... | Recover Results | Close | Help...



ID	Test Type	AS KCAS	Hp FT	OAT Deg C	Nr RPM	WT LBS	FSCG Inch	BLCG Inch	FCS Status 1/0	Others	Plot Options
	Hover	0	0	15	257.8	16270	360	0	1	Inputs...	Results...
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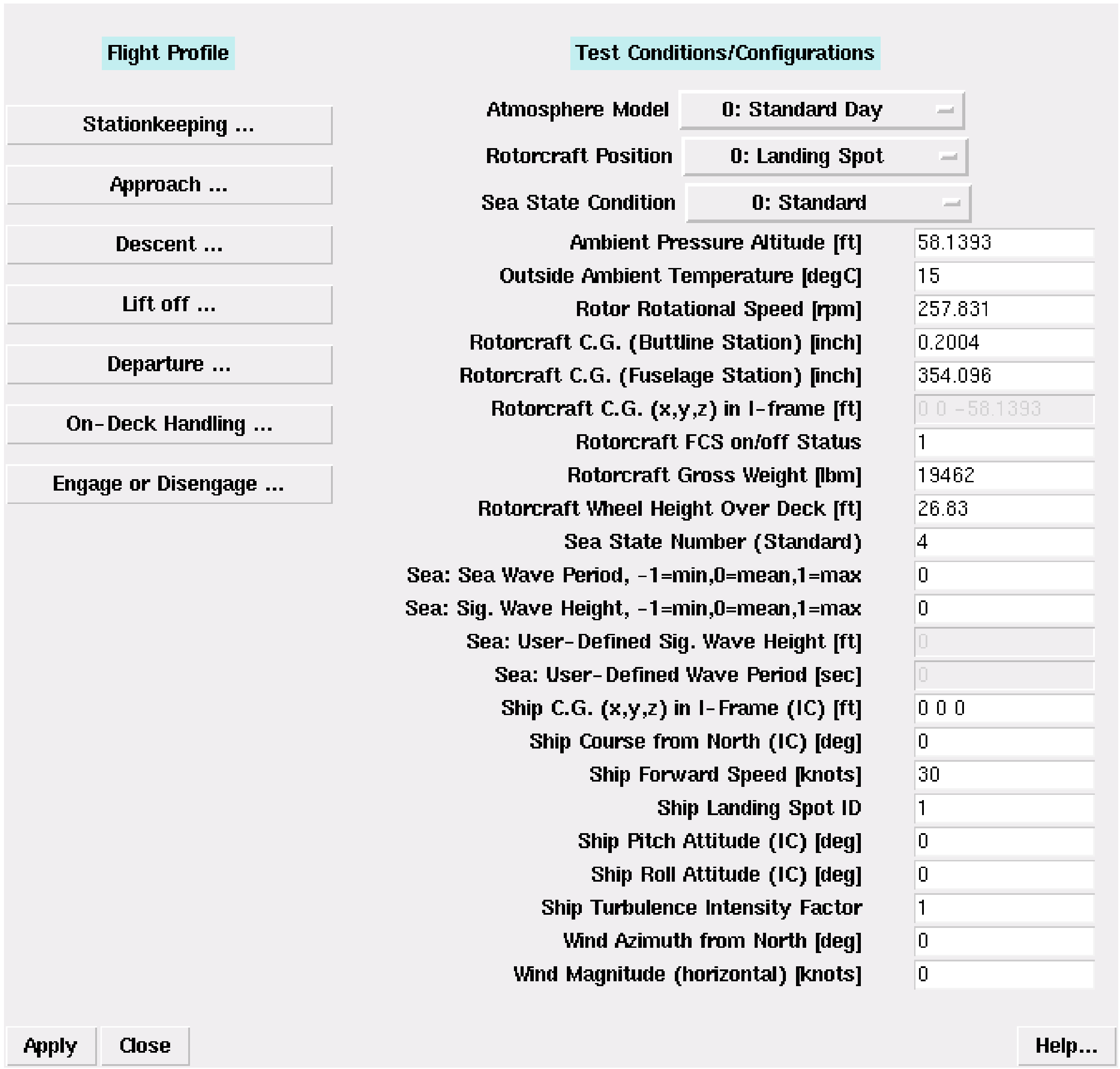
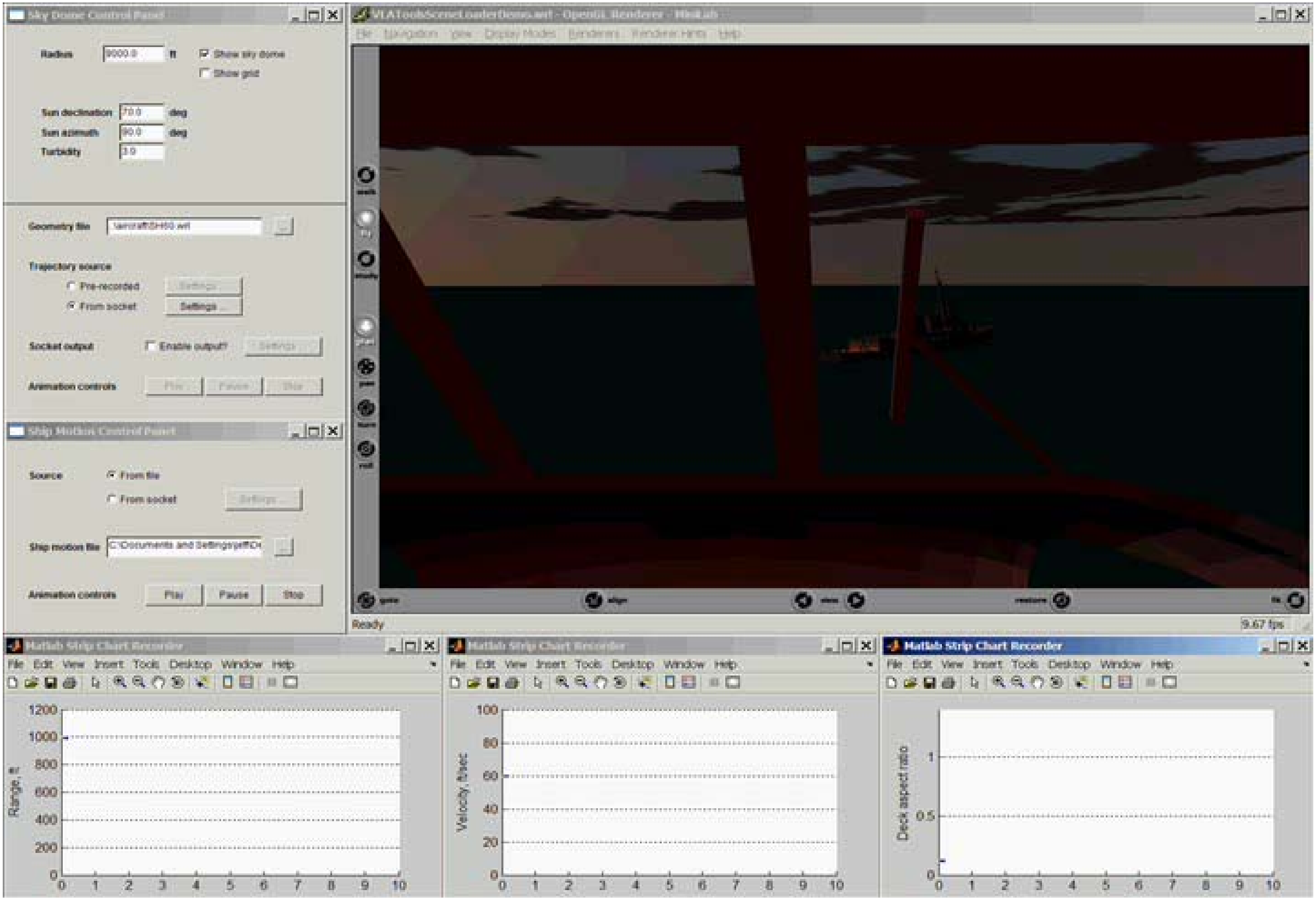
FLIGHTLAB Dynamic Interface GUI



PC-Based VLA Test Tool - CDI



PC-Based VLA Test Tool - SHAI

Rotorcraft Flight Test Analytic Options

- Aircraft/Ship Models
  - Helicopters & Rotorcraft (type DI flight)
    - Rotors, Fuselage, Engines, Flight control systems, landing gear arrangement, etc
- Aircraft/Ship Environment
  - Ship Airwake/Turbulence
  - Ship Motion
  - Visual Cues
- Component Integration
  - Rotor wake and ship airwake
  - Ship airwake and ship motion
  - Visual cues

Dynamic Interface Database History

Early (1960s-1970s)

- Limited computer facilities
- Prevented widespread data storage/search capability

1987, "Toward Automating the Helo/Ship DI Database"

- Called for automated, electronic databases
  - a) Program Management Information (correspondence, personnel info, project status, etc…)
  - b) Quantitative Test Data

1991, "The DI Database"

- Implemented 1987 "Quantitative Test Data" Database
- Centralized data storage + flexible search criteria
- Facilitated comparison with previous data

1997, "Summary of DI Database Files"

- Summarized all existing DI database files, formats
- NONE were linked together

2004, "Intelligent Aircraft/Ship Data Analysis Options"

- Attempt to link components, facilitate searching

RTO AGARDogragh 300 Helo/Ship Qualification Testing
The Netherlands, UK, & USA

RTO-AG-300 Vol. 22
AC/323(SCI-038)TP/53

RTO-AG-300 Vol. 22

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RTO AGARDograph 300

Flight Test Techniques Series – Volume 22

Helicopter/Ship Qualification Testing

(Les essais de qualification hélicoptère/navire)

Nielsen Engineering Intelligent Aircraft/Ship Database

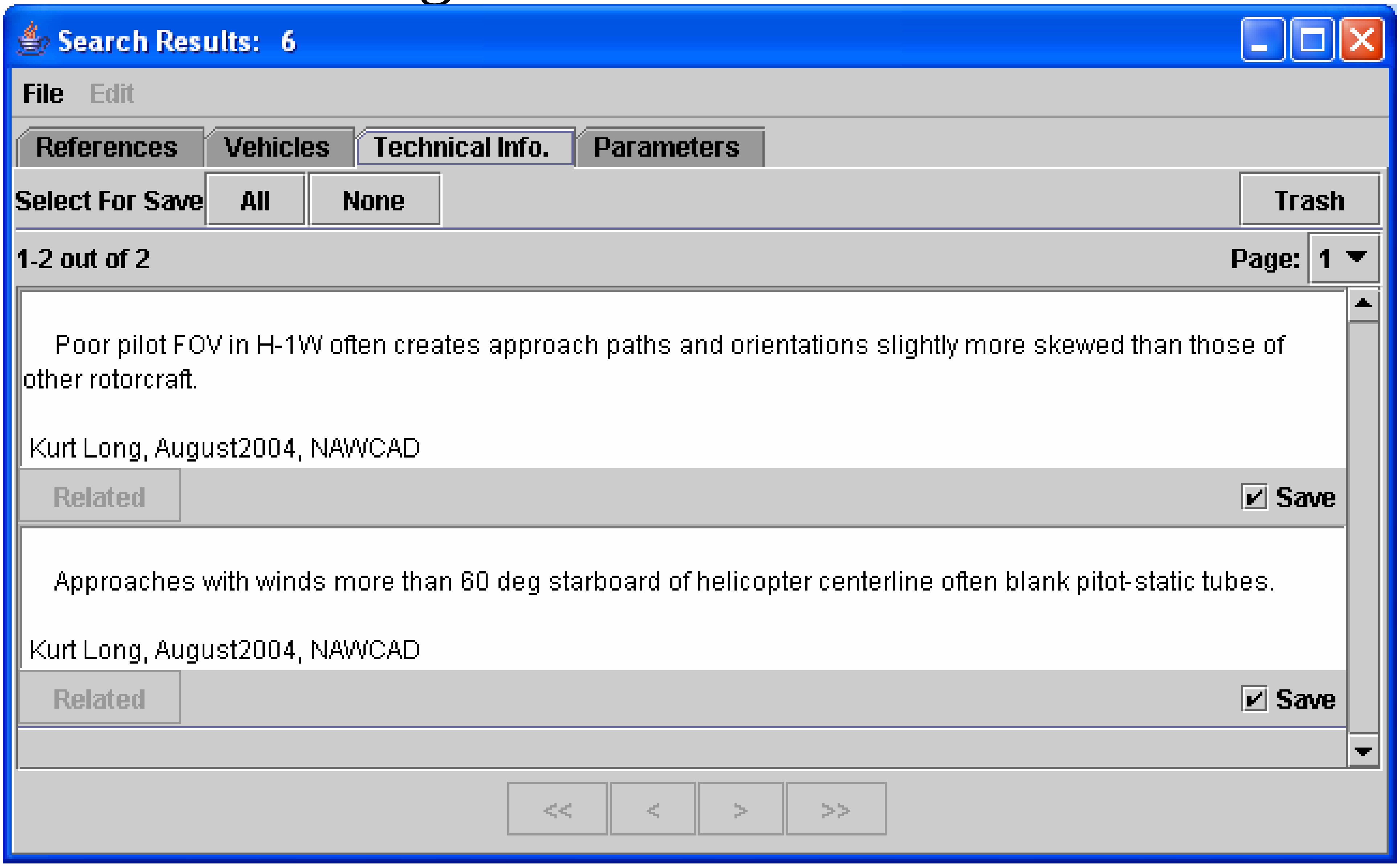
- Dynamic Interface eXpert Integration Environment

DIXIE

- Components
  - Data Databases
  - Knowledge Databases
  - Rule-Based Expert System
  - Administration Server
  - Remote Object Server
  - HTTP Server
  - FTP Server

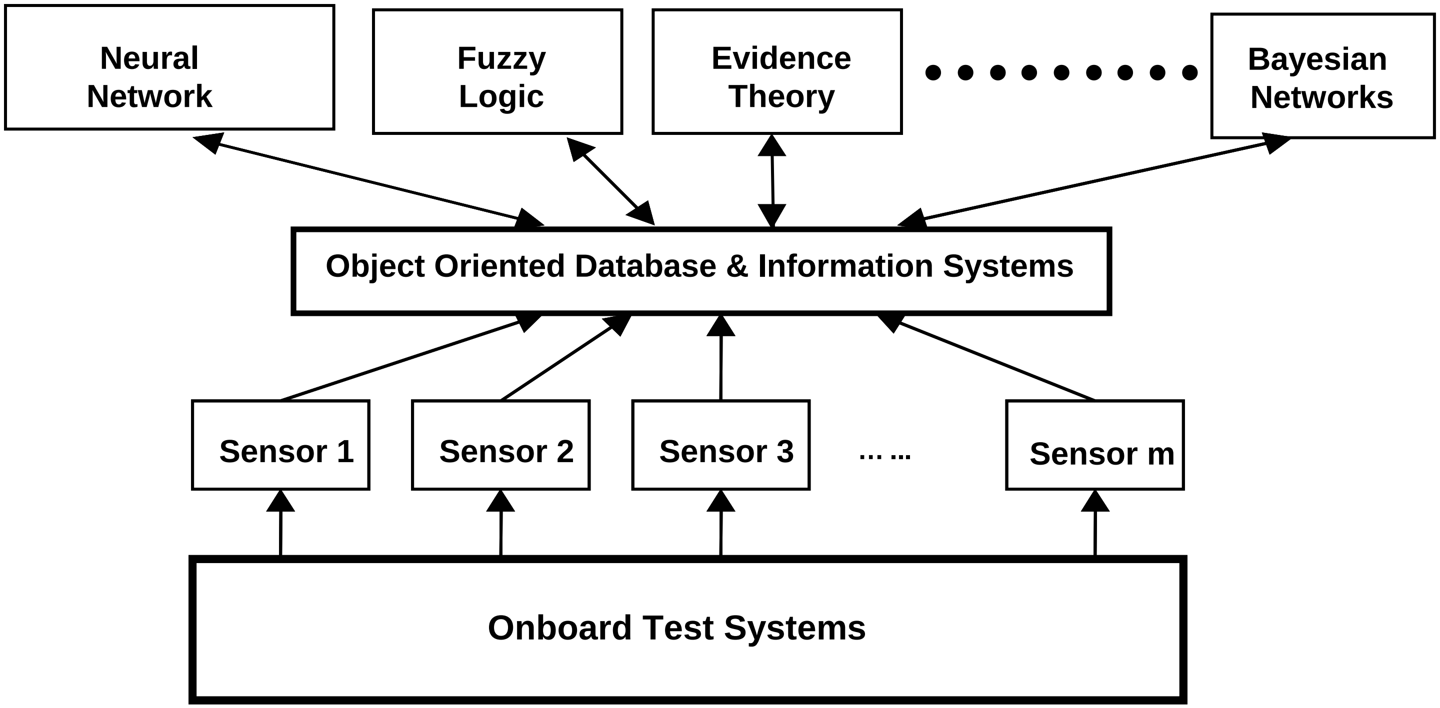
DIXIE Client

Knowledge Database Results Window



American GNC

An Adaptive Data Fusion and Analysis System



Components

- Neural Network
- Fuzzy Logic
- Theory of Evidence
- Bayesian Network
- Clustering
- Classification
- Data Consistency Checking

Kinematics based Data Consistency

The kinematics based consistency check of the data relies on the kinematics of the platform which describe the characteristics of motion.

Establishing the kinematics based consistency of the data includes three key steps:

(1) Formulating the kinematics model

(2) Defining the measurements error model

(3) Using a Kalman filter/smoother to verify the test results and isolate the invalid data

Flight Testing Less, Better
A Few Options

- **Develop the ability run the flight test matrix analytically while developing the test plan to check how close planned flights approach limits and to perform parameter sensitivity studies**

- **Flight test planning and reporting require a large portion of time allotted to a test program**
  - **Advanced multi-media test planning and reporting options could be used to generate flight test matrices and help reduce the test cycle time**
  - **Design of Experiment options could be used to help optimize (minimize) the flights listed in the flight test matrix**
  - **A Wiki engine could be used to consolidate all the information associated with the project**

Summary

- **The Concept of Flight Testing Less, Better can be achieved**
- **The Concept of Flight Testing Better, Faster, Cheaper, and Safer can also be achieved**
- **It will require improved flight test support analytics**
- **It will require improved flight test support databases**
- **It will also require integrating the design and flight test analytics and the related databases**
- **Considerable progress has been made, but more is needed**