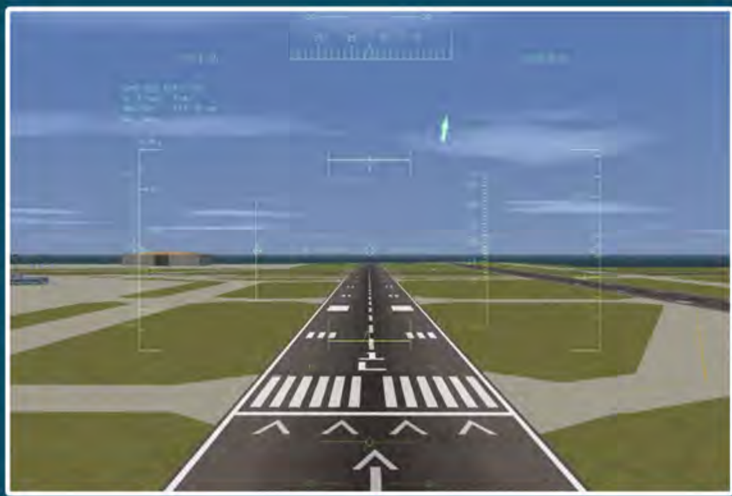
FLIGHTLAB® Run-time System

A Turnkey Host Computer and Software Infrastructure for FLIGHTLAB® Flight Dynamics Models

The FLIGHTLAB® Run-time System was produced to facilitate the integration of FLIGHTLAB® Run-time Models into customer simulator applications, ranging from hardware-in-the-loop laboratories to Full-Flight Simulators. With the FLIGHTLAB® Run-time System, a customer can integrate the FLIGHTLAB® Run-time Model into their host environment. The FLIGHTLAB® Run-time System consists of libraries for execution of the model, an operator console, and the FCM driver for real-time operation and local area network communication.



FCM Driver

The FCM driver provides a set of simulation control operations for the Run-time Model, handles the input/output and data transfer, and can interface with external processes within the customer's network. The operations provided by the FCM driver include loading, starting, stopping, and pausing of the model. The FCM driver is also used to set the initial conditions and aircraft configuration. Data communication protocols supported by the FCM driver include local/distributed shared memory and uni-/multicast UDP via the local area network. The FCM driver comes with a user console for ease of use during integration. The FCM driver can also interface directly with external processes such as the image generator (using CIGI protocol), control loaders, and instrument panels.

FLIGHTLAB® Component Library

The FLIGHTLAB® component library provides the component interfaces and methods needed to execute a Run-time Model within the run-time environment.

Operator GUI for Run-time System

The FLIGHTLAB® Run-time System includes the FCM Console, a Graphical User Interface (GUI) supporting operations, monitoring, and debugging of the FLIGHTLAB® Run-time Model. This GUI also allows the user to load the model, set initial conditions and configurations, trim, and fly the model. The FCM console allows the operator to modify, monitor, and plot model interface data in real-time. The FCM console is extremely useful during the integration of FLIGHTLAB® models into the simulator host environment. All functionalities of the FCM Console, excluding visualization of interface data, are available through a remote API to support direct integration of a customer's IOS with the Run-time Model

Recommended Hardware

The FLIGHTLAB® Run-time system requires a Linux operating system. Contact Advanced Rotorcraft Technology Inc. for reccomended computer hardware and configurations.

Malfunctions

Various aircraft system malfunctions can be included to support pilot emergency operations training. Malfunctions may include, but are not limited to, engine malfunctions (e.g., compressor stall, stuck fuel control, broken power turbine shaft, etc.), tail rotor malfunctions (e.g., loss of blades, loss of control, stuck controls, etc.), control system malfunctions (stuck movable stabilators, sensor failures, loss of SAS/FPS, etc.), and battle damage.

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ADVANCED ROTORCRAFT TECHNOLOGY

A LEADER IN ROTORCRAFT SIMULATION

FLIGHTLAB® Run-time Models for Real-time Applications

FLIGHTLAB® rotorcraft models run in real-time and are ideal for integration with new and existing simulation facilities. These self-contained rotorcraft dynamics models, including multiple rotor eVTOL and FVL configurations; are physics based, have proven fidelity, and are capable of real-time operation on current generation PCs.

ART

FLIGHTLAB® Run-time Models for Real-time Applications

Advanced Rotorcraft Technology, Inc. (ART) has produced detailed flight dynamics models of various aircraft configurations in support of real-time applications. The flight dynamics models run in the FLIGHTLAB® Run-time System and are well suited for integration with new simulation facilities and for upgrading existing facilities in a cost-effective manner. The models were developed and tested using the FLIGHTLAB® Development System. The FLIGHTLAB® Run-time system and the flight dynamics models can be run on a single modern, low-cost computer that interfaces with the host simulation environment over a network connection. Custom data interfaces can be tailored to support the specific needs of user applications. The flight dynamics models are in binary form and therefore protect any company proprietary information.

FLIGHTLAB® Run-time Models are physics based and are available with selected levels of fidelity and validation as required for specific applications. Advanced models have been validated through extensive pilot evaluation and comparisons with flight test data to meet the highest FAA certification standard (e.g., FAA Level 7 Flight Training Devices (FTDs) and Level B/C/D Simulators). Intermediate models have been evaluated by experienced pilots and, when available, with flight test data. Intermediate models exceed FAA Level 6 FTD requirements. Baseline models have been tested for reasonability across the full flight envelope based on performance data in the pilot manual and exceed FAA Level 5 FTD requirements. Intermediate and advanced models may include features such as engine start-up/shut-down, sling load operations, ship airwake interactions, system malfunctions, expendable stores, and more. Advanced FLIGHTLAB® Run-time Models are used internationally, including in Full Flight Simulators at Ft. Campbell, in the U.S. Army's Aviation Combined Arms Tactical Training (AVCATT) simulators, and in the Army's Flight School XXI programs.

Rotor Blade Element Models

FLIGHTLAB® Run-time Models utilize a blade element modeling approach for rotors, fans, and propellers. The blade element model represents the physical blade by discretizing it into several spanwise segments that capture the local aerodynamic and dynamic phenomena along the span of each blade. By combining the local aerodynamic and dynamic segments, the overall blade response can be solved. Variable aerodynamic and structural grid sizes for each blade allow each model to be customized to the best accuracy obtainable for the available computational power.

Fuselage, Wing, and Empennage Aerodynamics

The total fuselage aerodynamic forces and moments are modeled using table lookup body airloads as a function of sideslip and angle of attack. For the highest available accuracy, the body airloads table may be generated through use of 3D CFD on the isolated fuselage geometry. The wing and empennage airloads are modeled as aerodynamic surfaces where lift, drag, and pitching moment coefficients are obtained from table lookups as a function of Mach number and angle of attack. The effects of control surfaces and high-lift devices such as ailerons, spoilers, trailing edge flaps, and leading edge slats can also be included via a 3D table lookup based on test data or CFD. The mutual aerodynamic interference between the fuselage, wing, and empennage is also represented.

Engine and Drivetrain Dynamics

Detailed and dynamically accurate representations of the aircraft engines and drivetrain components are available in FLIGHTLAB®. The engine inlet, compressor, combustor, and turbine, as well as the fuel flow dynamics can be modeled in detail to reflect the physical characteristics of each engine. Electric motors can also be modeled, including rotational speed control. The drivetrain model supports modeling of gear-box, clutch, shaft inertia, stiffness, and friction losses. In addition, ART can customize the engine and drivetrain model to support user specified malfunctions.

Engine and Flight Control Systems

FLIGHTLAB® Run-time Models support arbitrarily complex aircraft flight control systems, including the primary flight control system, the stability augmentation system, the flight path stabilization system, and the outer loop autopilot modes. Similarly, engine Full Authority Digital Engine Control (FADEC) and fuel control and management systems can be modeled. If available, engine and flight control systems are developed based on manufacturer block-diagram control schematics. Control system models may also include system failure and malfunction modeling.

Aerodynamic Interference

FLIGHTLAB® supports various options for modeling the mutual aerodynamic interactions between rotors, wings, fuselage, empennage, external objects, ground surface, buildings, and ships at the desired fidelity level. The interference models can be calibrated by test data or Viscous Vortex Particle Method/CFD analysis to provide industry leading accuracy while running in a real-time environment.

Landing Gear and Ground Interaction

The dynamic interaction between the aircraft and the landing surface is physically modeled with a combination of elements such as struts, springs, dampers, hinges, tires, and wheels. The ground surface models include sloped surfaces, moving surfaces (such as ship deck), as well as terrain conditions ranging from dry/wet concrete to sand, grass, mud, and even water.

Atmospheric Environment

Atmospheric models are provided for standard day, hot day, etc. and calculate the variation of temperature, density, and pressure with altitude. Wind speed, direction, and turbulence levels may also be specified. For maritime operations, an available ship airwake model reproduces the turbulence from the ship deck superstructures for a range of wind over deck angles and sea-states.

Simulation Qualification Tool

The Simulation Qualification Tool (SIMQT) provides the capability to execute simulated flight tests utilizing the Run-time Model. Utilities are also provided to plot the simulation results with available test data to support production of the Qualification Test Guide for simulator certification. The generated plots include information on the test conditions, as well as tolerance bands in accordance with the certification requirements.

Level D

MH-60M	Lynx
UH-60M	Bell 412
UH-60L	OH-58D/Bell 407A

Level 6

AH-64A	UH-1
AH-64D	TH-67
AH-64E	AS350/550
UH-60A	KMAX
CH-47D	Super Puma
CH-47F	AH-1W

Basic Engineering Models

OH-6	EC145
XV-15 Tiltrotor	EC155
SH-60B	A129
MH-60R	R-22
CH-53	Boeing 737
S-76	A320
S-92	A340
MD 500	F-16
Bell 206	T-45
EC135	V-22

Generic Models

Single Main Rotor	Tiltrotor
Co-axial	Compound
Tandem	eVTOL

Generic Weight Classes

- Heavy
- Medium
- Light

External Bodies and Sling Loads

Optional single and multiple attachment-point sling loads are available. The dynamic interaction between the rotorcraft and the slung load is modeled using an elastic cable model. The slung load model can include 6-degree-of-freedom (DOF) body dynamics, body aerodynamics, ground contact points, and aerodynamic interference from the rotorcraft. In addition, adjustable length hoist and towing operations can be modeled in FLIGHTLAB®. External bodies are also available, including ship models, external fuel storage, radar domes, jettisonable stores, and more.

eVTOL and Future Vertical Lift Modeling and Simulation

New rotorcraft configurations to support the Military Future Vertical Lift (FVL) program and to support commercial electric Vertical Takeoff and Landing (eVTOL) aircraft for air mobility and agriculture, delivery, surveillance, photography, etc.applications, require the ability to model multiple distributed rotors, ducted fans, wings and their aerodynamic interactions with each other and with the fuselage. The FLIGHTLAB® Run-time System supports parrellelization of these multi-rotor models to provide real time operation for any number of rotors. Real-time simulation of these multi-rotor configurations has been implemented and tested for piloted evaluation, for hardware in the loop testing, and for embedded systems as well.