Functional Digital Aircraft in Landing Gears

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Mechanical Dynamics

Orlando, June 21st, 2000

Commercial and military aircraft design and analysis has historically been conducted by several separate groups, each with different specialties. Typically, as a preliminary aircraft design evolves into actual hardware, numerous re-designs and accompanying analyses occur for the aircraft system and its subsystems. Each level of analysis becomes increasingly complex and more detailed. However, since the design and analysis groups typically conduct their own separate analyses using their own analytical representations of the aircraft system and subsystems, a completely functional analytical representation of the actual air vehicle, with merged-in, accurate subsystems from the different groups (or subcontractors), is never realized.

Aircraft companies have continually been attempting to gain a better understanding of the behavior of the complete air vehicle at all expected operating points. Several methods to accomplish this are listed below:

(a) Perform actual tests with complete actual aircraft
(b) Perform representative tests with actual sections, or subsystems of the actual air vehicle
(c) Perform representative tests with actual individual components

(d) Perform hybrid tests with hybrid aircraft (hardware/software in the loop)

(e) Perform virtual tests/simulations with complete functional digital aircraft
(f) Perform virtual representative tests/simulations with functional digital subsystems
(g) Perform virtual representative tests/simulations with functional digital individual components

(h) Perform virtual tests/simulations with simplified digital aircraft
(i) Perform virtual representative tests/simulations with simplified digital subsystems
(j) Perform simplified virtual tests/simulations with simplified digital aircraft
(k) Perform simplified virtual representative tests/simulations with simplified digital subsystems

Items (a)-(c) generally yield the best insight into the aircraft's behavior; however, they are frequently the most expensive. Items (e)-(g) are intended to be accurate, virtual representations of the tests conducted in (a)-(c). Most analyses conducted today are of the type associated with Items (h)-(k). This presentation will focus on Items (e)-(g), with the concentration on the landing gear subsystem of an aircraft. Advantages and disadvantages if these items relative to one another will be discussed.

ADAMS/Aircraft will enable aircraft companies to build, test, and analyze complete, functional digital aircraft from models and data obtained from several different groups (or subcontractors). Moreover, the same digital aircraft can be shared and used by different groups for their individual needs. Virtual tests for the complete functional digital aircraft, and for the subsystems and components, will be included.

Current development focuses on the template-based integration of the landing gear subsystem with the air vehicle. The following automated virtual tests can currently be performed for the following fully-functional assemblies: (1) wheel assembly: tire tests; (2) landing gear structure assembly: static axle loading test with locked and unlocked strut; (3) landing gear assembly: drop test, retract-extend test; (4) full-aircraft assembly: ground attitude, carrier launch ground attitude, tip-back, landing, dynamic taxi, turning, braking.

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2000 International ADAMS User Conference

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Mechanical Dynamics

Agenda

- Functional Digital Aircraft Background
- ADAMS/LGT
- Discussion

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Strategic Partners

DASSAULT SYSTEMES

MSC

SDRC

The MATH WORKS Inc

ANSYS

integrated systems

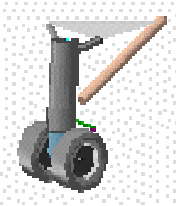
BOEING

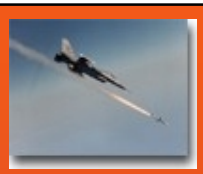
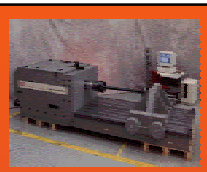
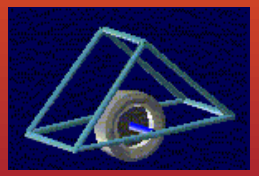
LOCKHEED MARTIN

ABAQUS

Mechanical Dynamics

Test & Analysis



	Actual Event Tests (Full Aircraft)	Representative Tests (Section/Subsystem)	Representative Tests (Components)
Actual Hardware & Software			
Hybrid Hardware & Software			
Complete Digital Hardware & Software			
Simplified Digital Hardware & Software			

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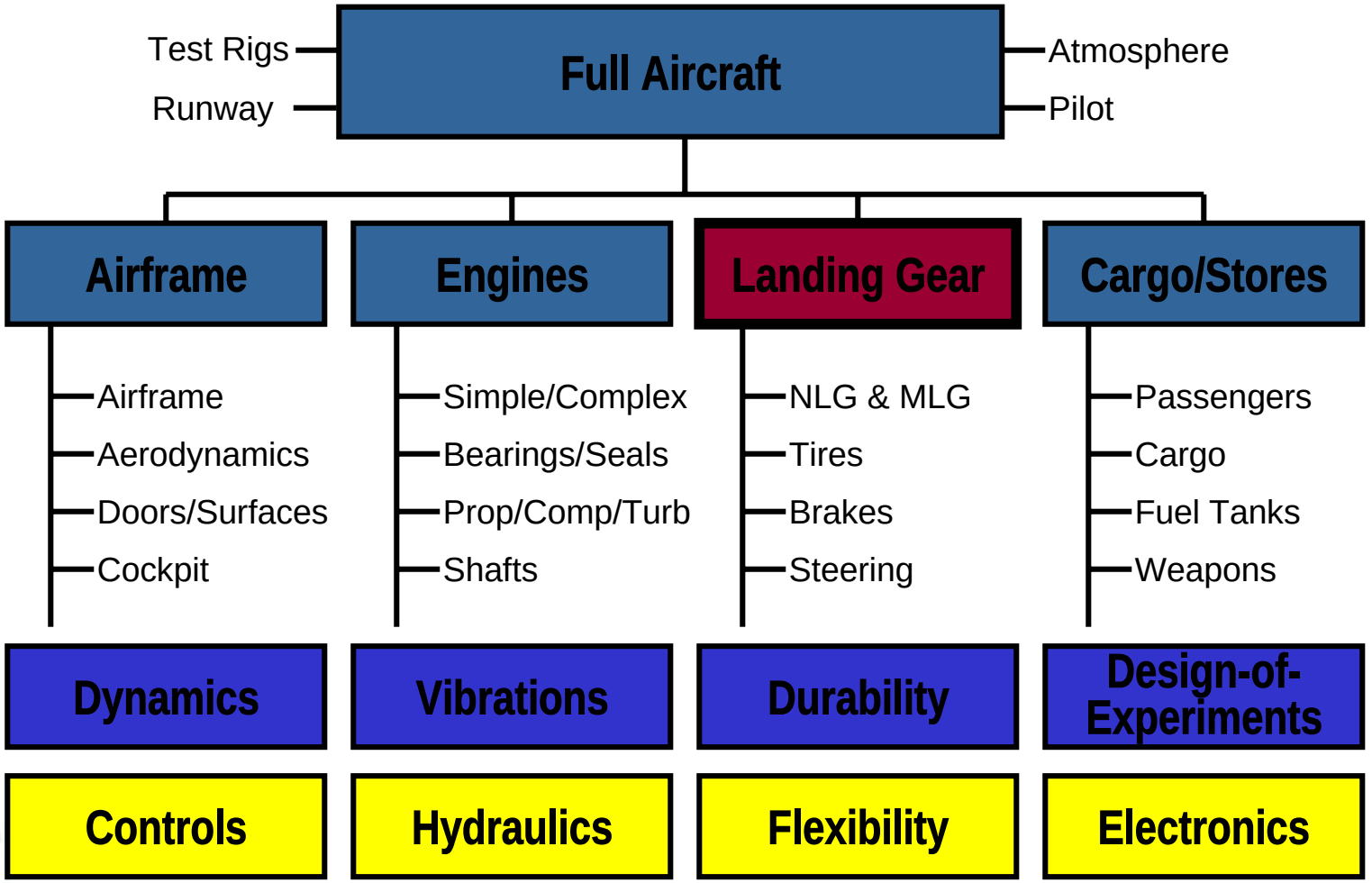
Functional Digital Plane®



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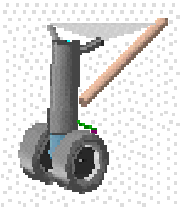
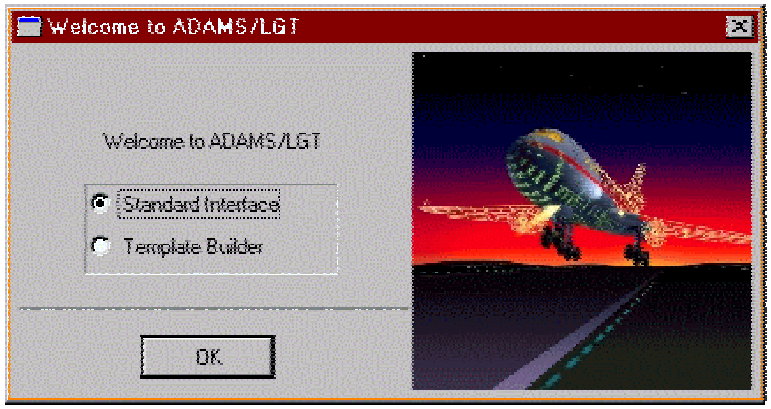
ADAMS/LGT





- Automates time-consuming landing gear DESIGN and ANALYSIS tasks
- Customized interface to ADAMS, allowing user to assemble virtual prototypes and run them through standard tests
- Template (parametric subsystem) approach to assembling full aircraft model
- CATIA (CAT/ADAMS) for exact template updates

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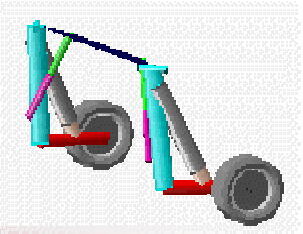
ADAMS/LGT User Modes



- Standard Interface (standard user mode)
  - assemble various subsystems together
  - minor adjustments (hardpoint locations, property files, etc.)
  - perform standard tests, and generate automatic output
- Template Builder (expert user mode)
  - use existing (or customized) capabilities of LGT
  - create subsystem templates for various types/classes of subsystems
  - add joints, springs, forces, geometry
- Customizer (MDI staff, with Customer)
  - add customized functionality to ADAMS; specific to landing gear design at Customer Site

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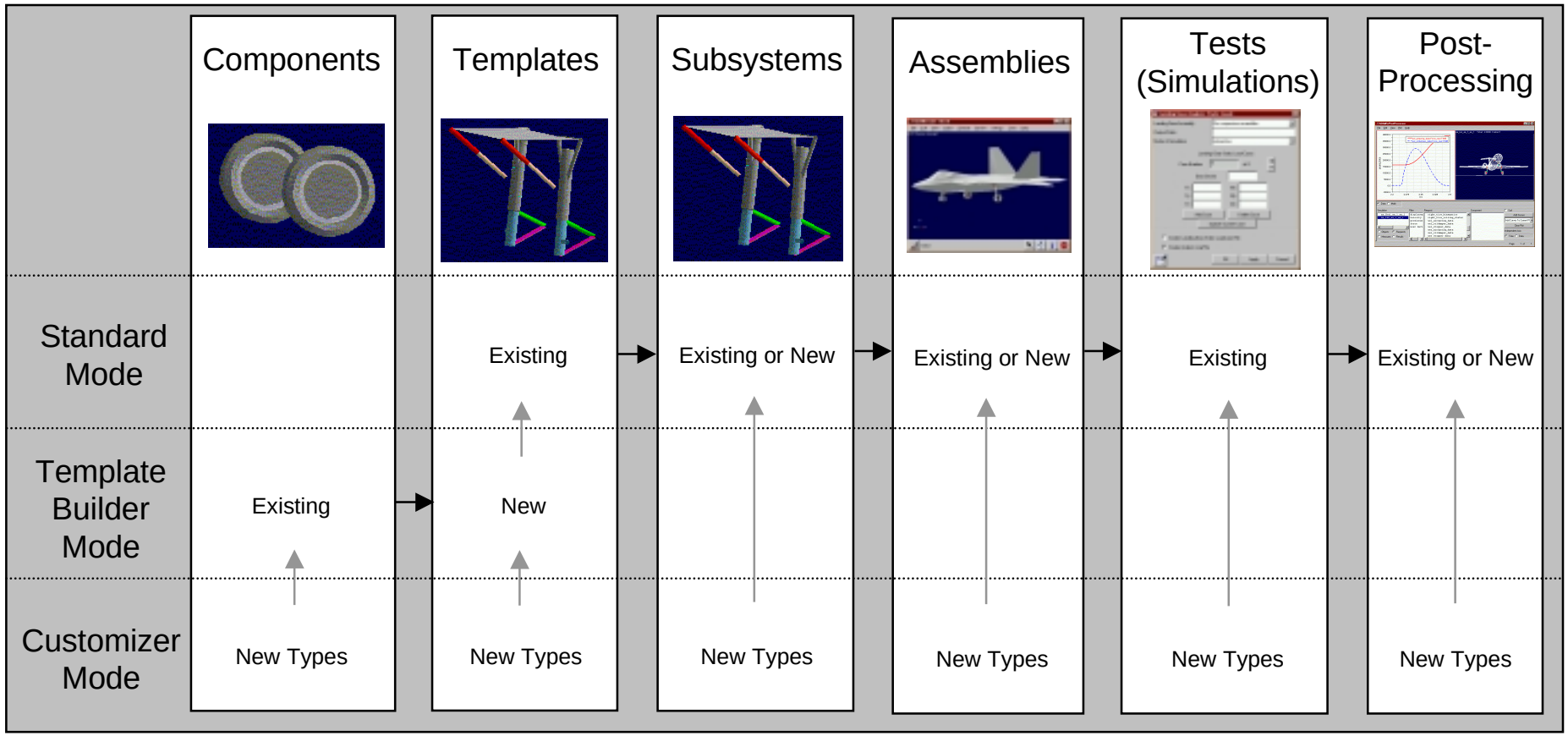
ADAMS/LGT Workflow



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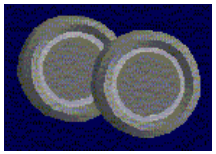

Components	Templates	Subsystems	Assemblies	Tests (Simulations)	Post-Processing

- Oleo - air spring, metered oil damper, stoppers, bearing forces
- Retract-extend - single/double hydraulic actuator, constant force actuator, smooth-motion actuator
- Steering - force-based actuator, smooth-motion actuator
- Wheel spin-up elements
- Aero - aircraft aero forces, landing gear aero forces, door aero forces
- User-defined forces
- Tire element - general-purpose aircraft tire mode
- Engine/thrusters
- Standard ADAMS/Car components

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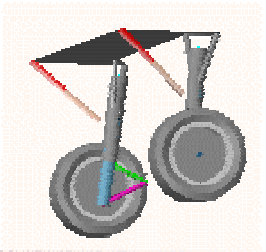
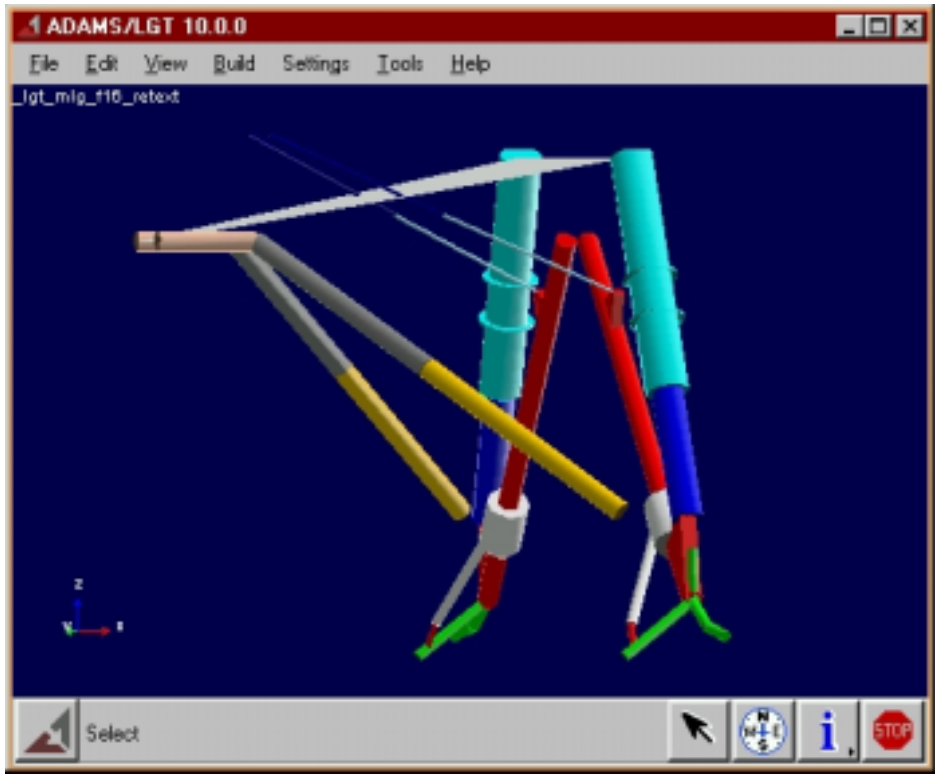
ADAMS/LGT



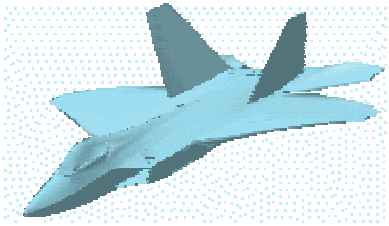
Components	Templates	Subsystems	Assemblies	Tests (Simulations)	Post-Processing

- Nose & Main Landing Gear
- Nose & Main Wheel
- Brake
- Airframe
- Engine
- Controls
- Hydraulics
- (Testrigs)



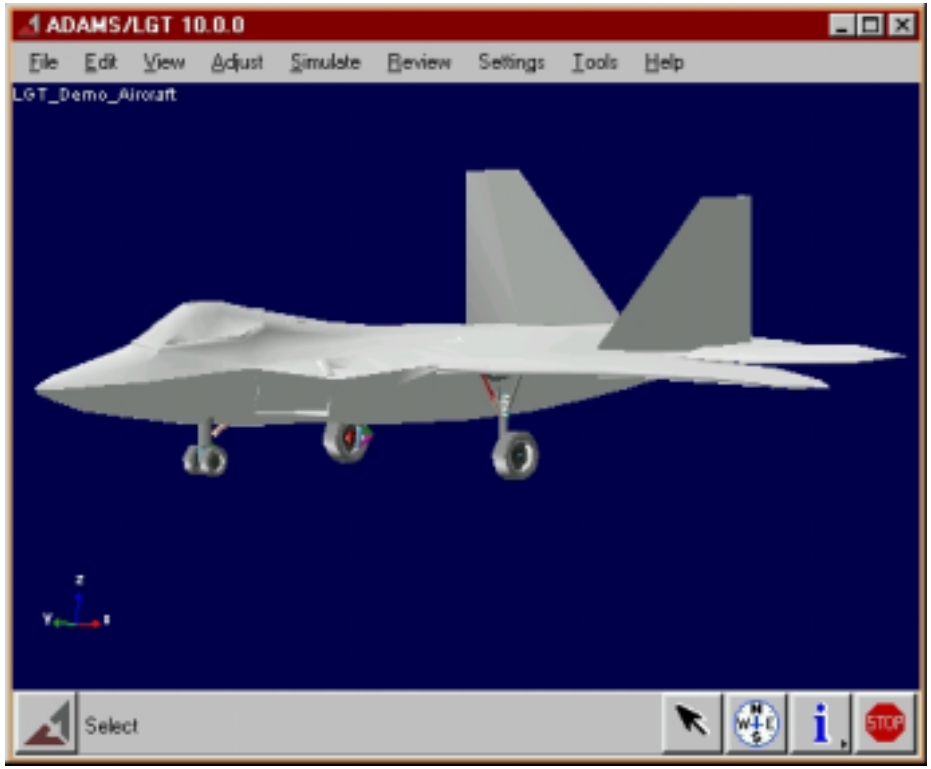
Mechanical Dynamics

ADAMS/LGT



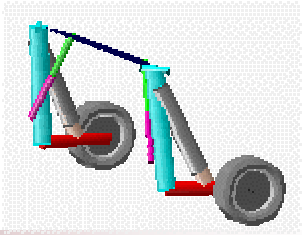
Components	Templates	Subsystems	Assemblies	Tests (Simulations)	Post-Processing

- Article (for component test)
- Single Wheel
- Landing Gear Structure (without wheels)
- Landing Gear Dynamics (with wheels)
- Full-Aircraft



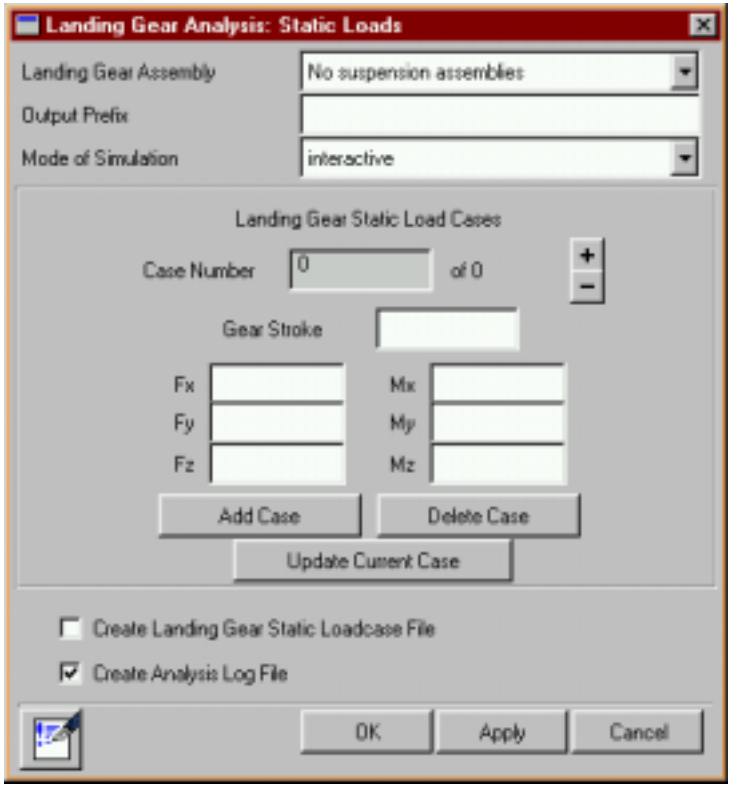
Mechanical Dynamics

ADAMS/LGT



Components	Templates	Subsystems	Assemblies	Tests (Simulations)	Post-Processing

- Article (for component test)
  - Article test (dyno)
- Single Wheel
  - Tire tests
- Landing Gear Structure (without wheels)
  - Steady Axle Loads
- Landing Gear Dynamics (with wheels)
  - Retract/Extend, Drop



Mechanical Dynamics

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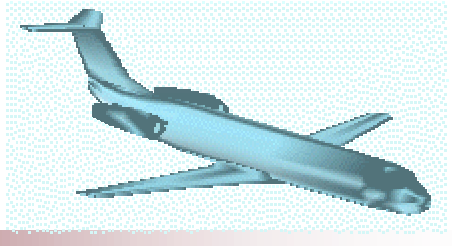
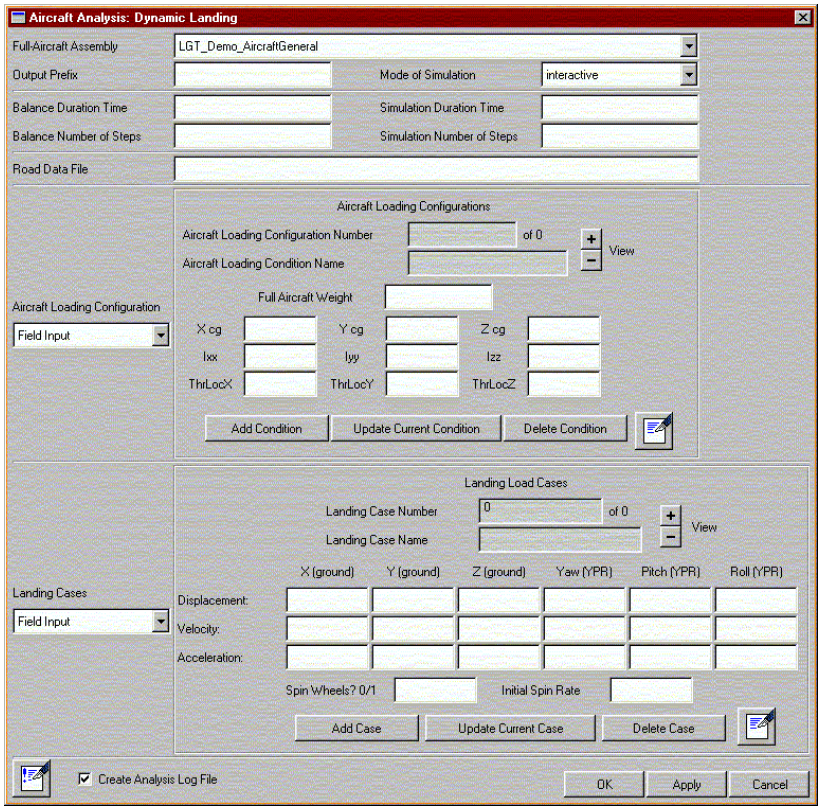


Components	Templates	Subsystems	Assemblies	Tests (Simulations)	Post-Processing

- Full-Aircraft
  - Ground
    - Ground Attitude, Carrier Launch Sims, Dynamic Tipback, Tiedown, Towing
  - Taxi
    - Dynamic Taxi, Turning, Braking, General Pilot Maneuvering
  - Landing
    - General Landing, General Pilot Maneuvering
  - In-Flight



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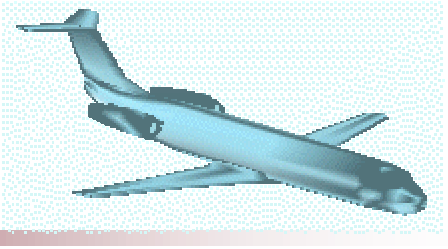

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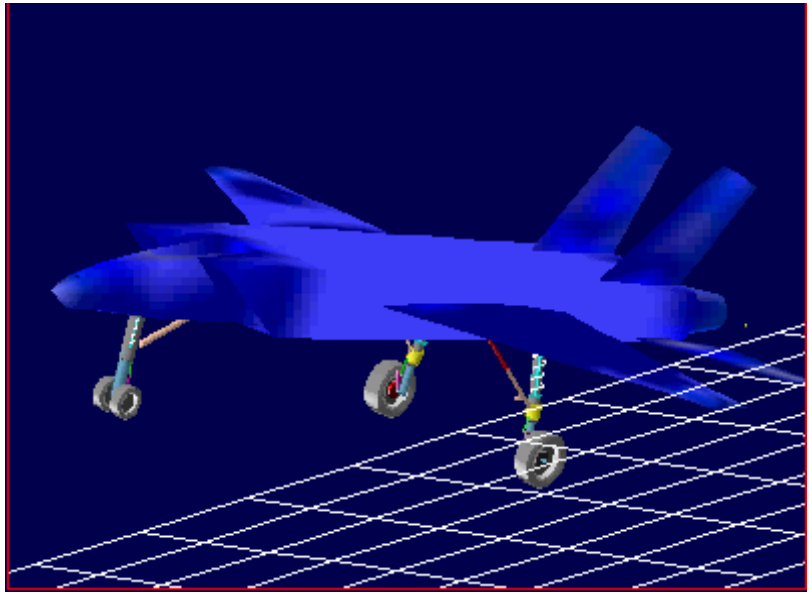

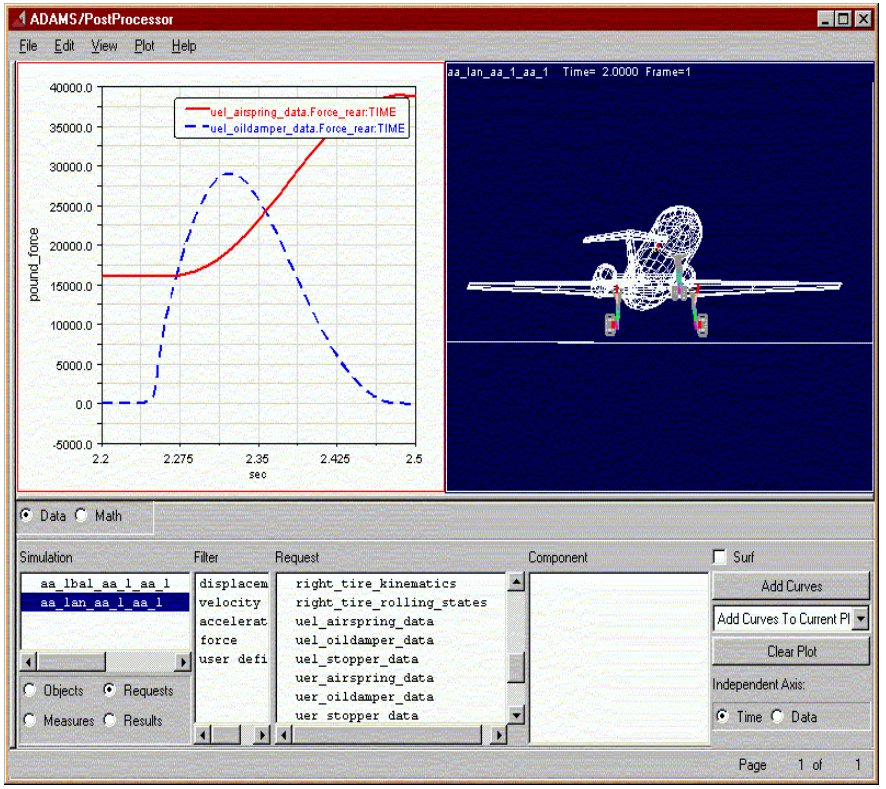

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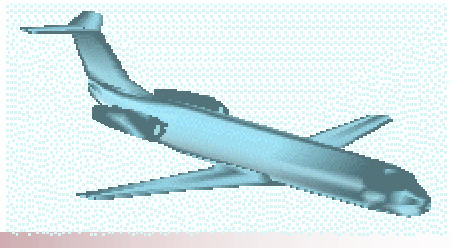

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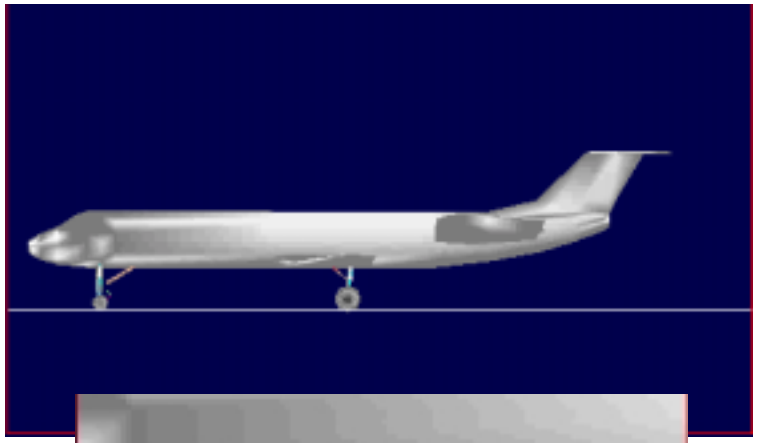

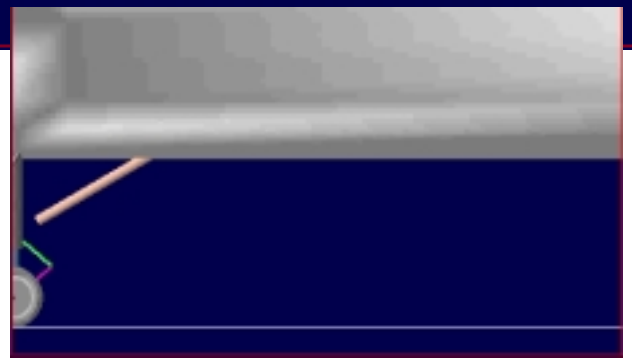

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ADAMS/Aircraft Flight Plan

Stage 1: Interface & General LGR Modeling

User Environment
Basic Event Tests
Basic Components

Stage 2: Higher-Fidelity Modeling

More Detailed Components
Flex Bodies
More Full Aircraft Tests
Gen-Purpos Tire Model

Stage 3: Advanced Modeling & Maneuvers

General Pilot Maneuvers
FCS (ADAMS/Controls)
ADAMS/Hydraulics
Mil-Spec & FAR/JAR
Enveloping/Post Proc.
Modal Aerodynamics

Stage 4: Advanced Modeling & Maneuvers

Shimmy
Advanced Tire Models
Fatigue
Vibrations
High-fidelity Brakes
Helicopters
Embedding in Catia

Multiple Releases

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Discussion

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