System for Slow Moving Aircraft

This system is based on the same concept previously described, but it also includes additional radial rigid elements, movable around a converging joint, connecting the inflatable frame to the canopy. Smaller inflatable tubes are used, such that less gas is needed for inflation, with considerable weight and volume, as well as cost, savings (Fig. 4).

A second new feature consists of attaching devices between the extremities of the rigid elements and the canopy which hold them together in a nonfixed relationship before and during the expansion of the frame, and permits them to disengage for unrestrained deployment (Fig. 5). This device permits considerable size and weight reduction at the expense of some deployment speed since the system is smaller than the canopy's projected area.

Design and Tests

Prototype for Stationary Supports

Prototypes with the following characteristics were built for free fall drops from buildings:

1) Inflatable frame: triangular shape; one chamber of elastomer coated fabric; 0.15 m diameter; 13.5 m perimeter
2) Canopy: 22 ft; conical circular; 1.1-oz, 50-ft^3/min nylon; 24 gores; modified for three master suspension lines and side panels
3) Gas for inflation: 1 kg CO_2
4) Weight: 12 kg (including container and bottle)

Testing

Altitude: 25 m (lowest from a building)
Load: 55 kg
Frame pressure: 0.9 kg/cm^2
Frame expansion time: 0.35 s
Deployment: 11 m
Landing speed: 4.6 m/s

Prototype for Slow Aircraft

Prototypes for slow aircraft were tested from a launching pad on the top of a car. The characteristics were as follows:

1) Inflatable frame: triangular shape; one chamber of elastomer coated fabric; 0.05 m diameter; 1.6 m perimeter
2) Radial rigid elements: three resin/glass cloth tubes, 0.98 m long
3) Attachment devices: two sliding rods tied on the canopy and sheathed in the rigid radial elements
4) Canopy: conventional 22 ft; conical circular; 1.1-oz, 50-CFM nylon; 24 gores and 24 suspension lines
5) Gas for inflation: 20 g CO_2
6) Weight: 4.1 kg (including container and CO_2 cylinder)

Testing

Speed (constant): 50 km/h
Frame pressure: 4.3 kg/cm^2
Deployment time: 2 s

Conclusions

The fast expansion and deployment of canopies, obtained with lightweight prototypes of the present concepts, appear to have use in emergency parachutes at the low altitudes and speeds encountered in such sports as hang gliding, or as emergency equipment for firemen on rescue operations from buildings.

Furthermore, the availability of more modern and adequate engineering materials than those used in the tested prototypes leaves room for considerable weight and size reduction, as well as faster deployment. Somewhat smaller, lighter, and less reinforced canopies made of zero porosity nylon and lighter suspension lines are already available in the market. The use of aramid fabric on the inflatable frame should also be of benefit, especially for the fire rescue equipment.

Acknowledgments

The author wishes to express sincere appreciation to G. Pangoni, head of the parachute section of the Centro Aeroespacial, São José dos Campos, SP, Brazil, for assisting in building the canopies used in the tests, and to H. Caldas, of São Paulo City Fire Department, for helping to carry out tests from buildings.

AIAA 81-2443R

Department of Defense Flight Testing: An Overview

James C. O'Connor*
USAAVRADCOM, St. Louis, Mo.

Introduction

THE present Department of Defense policy of dividing DoD test and evaluation into two distinct communities, developmental and operational, has evolved over the past 20 years. During the 1960s, Secretary of Defense Robert McNamara centralized the decision process for development and procurement of major weapon systems at the Secretary level. The emphasis in acquisition decision was on cost and not on the operational effectiveness of the system. To help the decision makers, "systems analysis" and "cost-effective analysis" tradeoff studies were created. Operational testing was usually done after the production decision.

This led to several DoD studies in the late 1960s. In July 1970, the Blue Ribbon Defense Panel Report, listed three significant test and evaluation deficiencies:

1) Operational testing and evaluation (OT&E) has been inadequate and too late.
2) Service organization for OT&E is generally inadequate.
3) The most glaring deficiency of OT&E is the lack of any higher-than-service organization responsible for overseeing defense OT&E.

The "fly-before-buy" philosophy evolved from the studies and placed more emphasis on the effectiveness of the weapon system in a simulated combat environment.

In December 1972, the Report of Commission on Government Procurement, provided specific recommendations for the correction of the previous deficiencies:

1) Withhold a production decision until tested in a realistic environment.
2) Establish an OT&E activity separate from the developer and user.

Today Federal Government testing is conducted in all services under the guidance of DoD Directive 5000.3. The directive states that developmental testing will be conducted by the material developer and operational testing by an independent agency reporting directly to the service Chief of Staff level.

Presented as Paper 81-2443 at the AIAA/SETP/SFTE/SAE/ITEA/IEEE 1st Flight Testing Conference, Las Vegas, Calif., Nov. 11-13, 1981; submitted Nov. 16, 1981; revision received Jan 11, 1982. This paper is declared a work of the U.S. Government and therefore is in the public domain.

*Major, U.S. Army and Aeronautical Engineer, Technical Management Division, CH-47 Modernization Program.

Table 1 System acquisition management

Milestone 0		Milestone I	Milestone II	Milestone III
Phase	Concept exploration	Demonstration validation	Full-scale engineering development	Production deployment
Effort	Conceptual study/exploration of alternatives	Preliminary design/ competitive demonstration	Detail design/ preferred system developed	Manufacturing/ product improvement
Development testing	Bench tests	DTI	PAE, DTII, icing, climatic mangar	Airworthiness and flight characteristics
Operational testing		OTI	OTII	OTIII

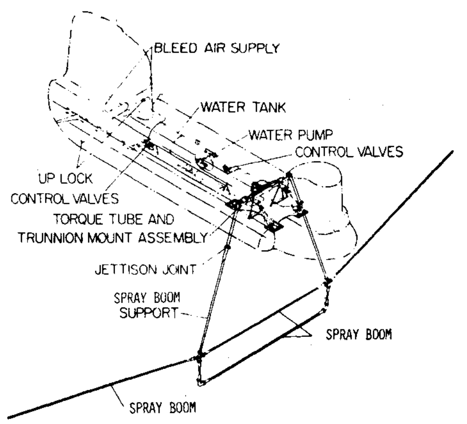

Fig. 1 Helicopter icing spray system.

Table 2 Test conditions

Temperature, °C	Liquid water content, g/m³ 0.25 (light)	0.50 (moderate)	0.75 (heavy)
−5	•	•	•
−10	•	•	
−15	•		

System Acquisition Management

The acquisition process consists of four distinct phases: concept exploration, demonstration and validation, full-scale engineering development, and production/deployment (see Table 1). Each phase requires a particular type and scope of testing. The data and results of these tests are used in the decision process at each milestone.

The remainder of this Note discusses the normal development and operational testing that would be required to field an Army aircraft. The type and scope of test would be tailored based on the aircraft mission, acquisition phase, DoD priority, and system complexity.

Developmental Testing

Developmental testing (DT) is done by the material developer to determine if the technical development objectives have been fulfilled. These tests are characterized by the use of engineering and scientific approaches under controlled conditions to provide quantitative and qualitative data. The PAE, icing, etc. shown in Table 1 are DT-related tests but have been individually listed for this Note.

Preliminary Airworthiness Evaluation

The preliminary airworthiness evaluation (PAE) is conducted on a fully instrumented prototype vehicle in the early stages of the development. The tests may be conducted during the validation phase or the full-scale engineering development phase or both. The purpose of the PAE is to: 1) conduct limited performance testing; 2) determine specification compliance; 3) conduct limited handling qualities, vibration, and noise level testing; and 4) verify the contractor recommended flight envelope.

The scope of the PAE will depend on the type of system being evaluated, the period of time alloted for the test, the stage of development of the material, and the helicopter itself (prototype or production model). Testing is normally performed at the contractor's facilities and requires approximately 10-40 hours of flight.

Development Tests I and II

Development test I (DTI) begins early in the validation phase to demonstrate fundamentally that technical risks have been identified and that solutions are in hand. Components, subsystems, brassboard configurations, or advanced development prototypes are examined to evaluate the potential application of technology and related design approaches prior to entry into full-scale development. This testing is done by the manufacturer and the government.

Development test II (DTII) measures the technical performance of a system and its associated support equipment and development training and maintenance support packages. Specifically, an evaluation is made of reliability, maintainability, availability, supportability, interoperability, and safety.

Icing

Artificial and natural icing tests are conducted during the full-scale engineering development phase and further tests may be done after the aircraft is fielded. The purpose of the tests is to determine the icing envelope of the aircraft with and without heated rotor blade deice protection. It is desired by the Army that the aircraft be capable of operating continuously in light (LWC = 0.25) icing conditions and for 30 min in moderate intensity (LWC = 0.5) icing conditions.

Artificial icing tests are conducted in forward flight by immersing the test aircraft in an icing environment produced by a spray boom attached to a CH-47C helicopter (see Fig. 1). Liquid water content (g/m^3), which relates to the icing intensity, is controlled by varying the flow rate of water from the spray boom. A constant ambient air temperature is maintained by varying aircraft altitude. Desired test conditions are shown in Table 2.

Natural icing tests are flown in the natural environment at an altitude which produces the greatest liquid water content within the cloud mass.

Climatic Laboratory Tests

Our defense weapon systems must be capable of effectively operating in a wide range of temperature and moisture conditions. Testing of this nature in a natural environment is cost prohibited. To conduct these tests, the military services use the U.S. Air Force Climatic Laboratory at Eglin AFB in Florida. In the climatic hangar, aircraft systems, subsystems, and components can be functionally operated at temperatures from −65 to +125°F. Tests are conducted on fully instrumented, operational aircraft. Provisions are provided in the hangar to run the engines and rotor systems through their full operating range. Approximately two months of testing is required to cover the entire temperature range.

Airworthiness and Flight Characteristic (A&FC)

The A&FC is conducted on a production prototype or production aircraft delivered from either an initial or a pilot production run after the milestone III decision has been made. The test determines whether or not the transition from an engineering development prototype to a production item has been made successfully and whether the system meets contract and military specifications. Specifically the tests determine:

1) Detailed information on performance, stability and control, powerplant operation, and integrated system characteristics.
2) Data for technical manuals.
3) Verification of the recommended flight envelope for operational use.

The scope of test varies from 80-150 flight hours. Performance tests include six-to-eight level flight speed power polars, forward flight climb, autorotational descent, hover, takeoff and landing, vertical climb, and height-velocity. Flying qualities tests include control positions, static longitudinal stability, static lateral-directional stability, maneuvering stability, control response, dynamic stability, and degraded modes. Operational-type tests such as slope landings, mission maneuvers, and instrument/night flight may also be included. All these tests are conducted at several center of gravity positions and density altitudes.

The A&FC is the last formal development test in the acquisition cycle. Engineering change proposals may require development testing during the production/deployment phase.

Operational Testing

Operational testing (OT) is done by an organization that is independent of the developing, procuring, and using commands. The tests are accomplished with typical user operators, crews, or units in as realistic an operational environment as possible. The purpose of OT is to determine the effectiveness and suitability of the system in a simulated combat situation. The adequacy of doctrine, organization, operating techniques, tactics, and training are also evaluated.

Operational Test I

OTI is conducted during the validation phase and should provide an indication of military utility and worth to the user.

Operational Test II

OTII is done prior to the milestone III production decision. The purpose is the same as previously discussed. The scope of tests may involve several prototype aircraft which may be flown against a type or model aircraft for comparison. Unlike the developmental testing, trained testers and sterile test environments are not used. As pointed out in the introduction, considerable emphasis has been placed on the results of these tests. A technically superior weapon system which has been successfully evaluated in developmental testing may be shown to be unsuitable in the real world.

Conclusion

The information gained from successful accomplishment of the developmental, operational, and environmental tests is a key requirement for decisions to commit additional resources to a program or to advance it from one acquisition phase to another. It is the objective of the government tests to field a defense weapon system that is technically proved, operationally effective, and meets the threat.

AIAA 82-4154

Incompressible Symmetric Flow Characteristics of Sharp-Edged Rectangular Wings

Erik S. Larson*
The Aeronautical Research Institute of Sweden, FFA Stockholm, Sweden

Nomenclature

A	= aspect ratio
c	= wing chord
c.g.	= center of gravity, reference point, 0.25 chord
c.p.	= center of pressure
ΔC_D	$= C_D - C_{D_0}$ = lift-dependent drag/qS, lift-dependent drag coefficient
C_L	= lift/qS, lift coefficient
C_m	= pitching-moment/qSc, pitching moment coefficient
C_N	= normal force/qS, normal force coefficient
F_1, F_2, F_3	= empirical correction factors
K_p	$= \partial (C_{N,p}) / \partial (\sin\alpha\cos\alpha)$
$K_{v,\mathrm{le}}$	$= \partial$(2 leading-edge suction force from one side/qS) $/\partial \sin^2\alpha$
$K_{v,\mathrm{se}}$	$= \partial$(2 tip suction force from one side edge/qS) $/\partial \sin^2\alpha$
$\hat{K}_{v,\mathrm{se}}$	$= \partial$(2 tip suction force from one side edge/qS) $/\partial \sin^{5/3}\alpha$
M	= Mach number
q	= freestream dynamic pressure
S	= wing area
x	= streamwise coordinate, origin at the leading edge
α	= angle of attack, deg
β	$= \sqrt{1-M^2}$
ξ	$= (x_{\mathrm{ref}} - x_i)/c$, dimensionless distance between reference point and c.p. of the aerodynamic item in question

Subscripts

p	= potential or attached flow
v, le	= vortex effect at the leading edge
v, se	= vortex effect at the side edge

Introduction

In a previous Note,[1] the symmetric, aerodynamic characteristics—lift, lift-dependent drag, and pitching moment coefficients—on sharp-edged rectangular wings were obtained by a set of semiempirical, analytical formulas that

Received Nov. 17, 1981; revision received Jan. 15, 1982.

*Senior Research Engineer, Department of Aerodynamics. Member AIAA.