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A Study on the Store Compliance Verification for KT-1P Aircraft

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Abstract : KT-1P for the Peru Air Force will be used as a utility aircraft with upgraded avionics equipment and arming capability based on KT-1 and KA-1. KT-1P should be shown for compatibility of new store loading configurations loaded with dispenser, bomb, and rocket based on aircraft-store compatibility test and evaluation procedures before KT-1P is operated as a light attack aircraft. The weapon system ground test for installation and flight test for envelope expansion including store separation are described in this paper, which was performed referring 'seek eagle program' under MIL-HDBK-1763 and MIL-HDBK-244A.

Key Words : KT-1P, Utility Aircraft, Store Compatibility, Test & Evaluation (T&E)

1. Introduction

Fighter aircraft need to be tested for aircraft/store compatibility in strict flight envelope restrictions to operate new store configuration. Developers have used Computational Fluid Dynamics (CFD) method and wind tunnel testing for alleviating expanse and risk by simulating store compatibility because flight tests are very expensive and high risk [1, 2]. Although CFD and wind tunnel testing is used to demonstrate the integration of stores with aircraft inexpensively and safely, the final operating envelope should be verified by flight test on reference to MIL-HDBK-1763 and 244A relating aircraft/store compatibility [3, 4].

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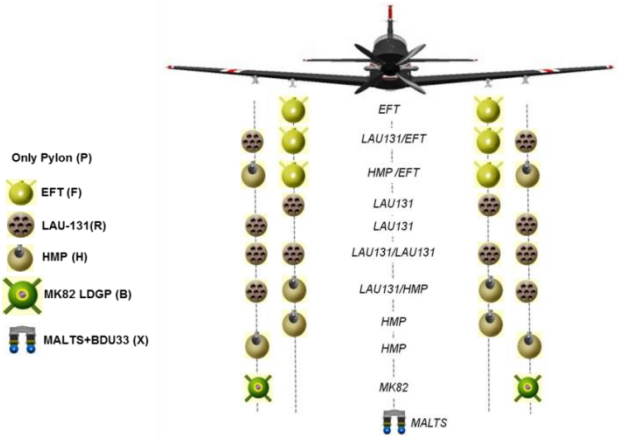


Fig. 1 KT-1P Store Loading Configurations

This paper addresses weapon system ground test in terms of integration compatibility and safe store separation to confirm the clearance and safety with regard to new store configuration. We also verified acceptable store separation characteristics with respect to individual stores through flight test. The store separation test conditions were defined from analysis results based on CFD, wind tunnel test and simulation. Moreover, weapon system`s functional capabilities and performance associated with general

purpose bomb and rocket were evaluated through flight testing involving specific store configurations in various flight test conditions. After carriage and employment envelope expansion flight test, bias effect test required for completion of air to ground bombing algorithm and weapon accuracy test for MK-82, BDU-33 and rocket were evaluated. Total 11 store configurations were tested for KT-1P as shown in Fig. 1.

2. Weapon System Ground Test

One of the first analyses to be made in defining the compatibility of a store with the aircraft is that of ensuring physically fit and interference with any part of the aircraft and other stores specified for KT-1P to comply with MIL-STD-1289D [5]. Clearance test was conducted to confirm the external store installation condition, store-to-aircraft and store-to-store clearances on the ground as shown in Fig. 2.

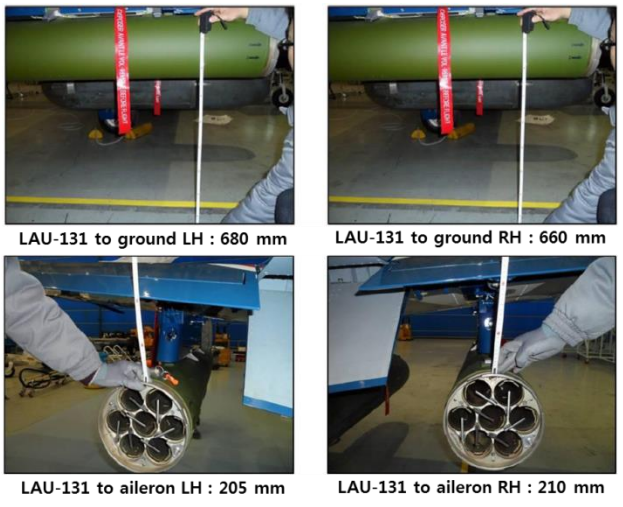


Fig. 2 Rocket Launcher Clearance (Ground)

There were some different left / right clearances from stores to ground because of the difference between hydraulic fluid and nitrogen gas in left / right main landing gear structure. External stores were normally installed and removed in accordance with the installation & removal procedure and all clearances were enough to compare with the minimum clearance standards.

The picture on the right side in Fig. 2 shows LAU-131 rocket launcher separation from aircraft to the ground. During store separation ground test, weapon and arming control system were evaluated such as drop sequence, release and jettison mode. Also Fig. 3 shows that stores were able to separate safely from pylon and aircraft without bomb rack or jamming on the ground.

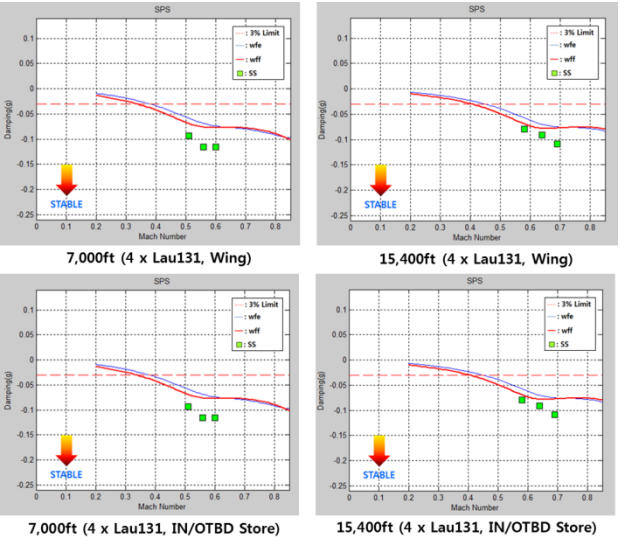
Fig. 3 Ground Store Separation Test

3. Envelope Expansion Flight Test

Envelope expansion flight tests such as flutter, loads and stability and control (S&C) test were performed to expand carriage flight operational envelope for required each store loading configurations.

The purpose of flutter test was to verify that KT-1P is free from flutter, other adverse aeroelastic problems, undesirable vibration phenomena such as Limit Cycle Oscillations (LCO), and the absence of divergence.

Flutter flight test for all store configurations was conducted at speed up to V_D (design diving speed) and frequencies and damping values were measured to confirm an aeroelastic trend according to planned test conditions.



※wfe: wing fuel empty/ wff: wing fuel full(Prediction)
ss: sine sweep(test results)

Fig. 4 Flutter Flight Test Results for 4 x LAU-3 Loaded Configuration (Wing, IN/OTBD Store)

Flutter test results showed that the damping values for wing and In-board/Out-board store have slightly decrease trend as speed increased in accordance with frequency of the flutter prediction line for aircraft wing fuel empty (wfe) and wing full fuel (wff) conditions. Also damping values satisfied 3% damping requirements (Mill-A-8870C) for any critical flutter mode for all store configurations shown like Fig. 4 [6, 7].

Flutter, buzz, divergence and aeroservoelastic instability tendency were not identified in the operational flight envelope for all store configurations.

Loads survey test was conducted to obtain flight loads survey data up to 80% of design limit load (DLL). After completion of loads survey test, loads demonstration test was performed up to 100% design limit load (DLL) to confirm validate loads at key envelope conditions and provide data for KT-1P flight manual development.

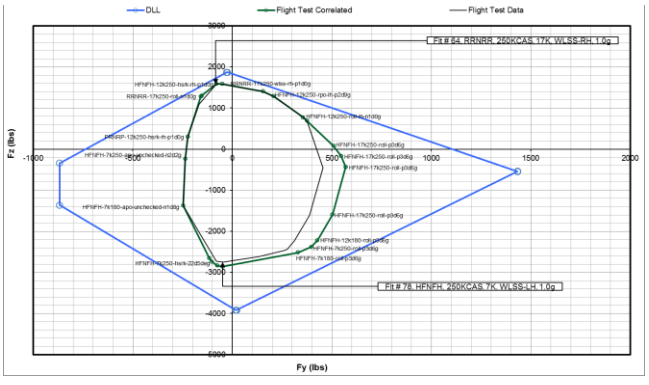


Fig. 5 Loads flight test results (Inboard Pylon)

Fig. 5 shows the measured and extrapolated loads of inboard pylon Fz and Fy forces. As shown in the figure, the design limit loads are confirmed as conservative to the actual loading conditions.

As a result of loads flight test, the loads on all of major structural components were within the DLL envelope.

S&C test was performed to verify stability & controllability such as static & dynamic stability and so on for all axes of KT-1P.

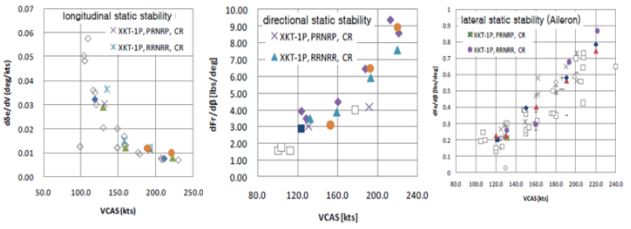


Fig. 6 Static Stability Results for 4xLAU-3 Loaded Configuration

Under S&C test, all stability and controllability characteristics including static and dynamic stability requirements for longitudinal, lateral and directional axis are satisfied for all test conditions considered within operational flight envelope as shown in Fig. 6 [7].

4. Store Separation Flight Test

Store separation flight test is one of the high risk and expensive tests that requires test crews to focus highly on the test because it is the first time to separate store loaded from the aircraft. It was conducted for new store loading configuration and envelope expansion in terms of BDU-33, MK-82LDGP and LAU-131(Inboard & all pylons) rocket launcher in comparison to KO-1 and KO-1 gun installation program.

The purpose of this test was the verification of employment and selective / emergency jettison capability. Required store assets could be reduced through operating asymmetry configuration instead of symmetry configuration to increase the cost effectiveness of the program. Based on the CFD simulation analyses, test conditions were defined for each store test configuration and performed in build-up fashioned with photo chaser and camera installed to test aircraft to verify stores separation from the aircraft in a safe manner and do not interfere with the airframe or other stores after separation .

The LAU-131 jettison was performed at 160/200/227 KCAS and 1G level flight condition from an inboard pylon & all pylon.

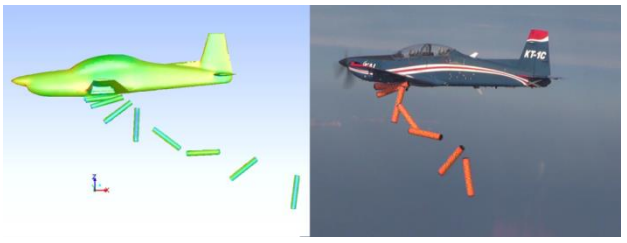


Fig. 7 Comparison of CFD and Flight Test for LAU-131 Jettison (227KCAS)

The qualitative comparison of photographs shows the difference between CFD analysis and chaser view as shown in the Fig. 7. Separation clearance between separated LAU 131 launcher and pylon was closer than expected due to high and fast pitch down angle occurring from launcher compared to downside of induced displacement from the aircraft. Test speed was reduced from 227KCAS to 200KCAS in order to get the sufficient clearance for armament/store integration (Ch.17) [8]. Fig. 8 presents photographic data from on board video camera at 200 and 227 KCAS respectively. As a result of store separation test at 200KCAS, the clearance was increased. Fig. 9 presents the comparison of the LAU-131 rocket launcher trajectories between CFD and flight test at 200KCAS. Compared with CFD analysis, displacement and orientation angle of launcher was rapidly changed because the difference between analysis and test result was increased in accordance with increased pitch angle occurring launcher in which could be caused by analysis including the turbulence model and mesh generation.

Fig. 8 Flight Test Results of Empty LAU-131 at Inboard (200KCAS (Left) vs 227KCAS (Right))

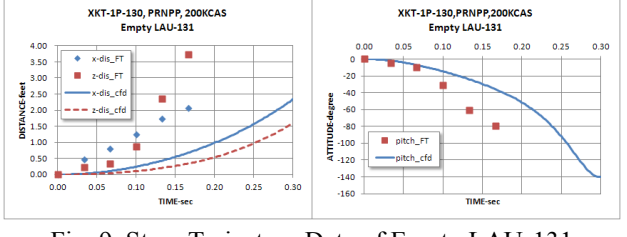


Fig. 9 Store Trajectory Data of Empty LAU-131 at Inboard (200KCAS)

There weren`t any interference with the airframe or other store after separation for other configurations as a result of store trajectory data analysis.

5. Conclusions

KAI performed compatibility test & evaluation for KT-1P aircraft of the Peru Air Force with respect to some store loading configurations by applying loaded general bomb, LAU-131 with rocket and so on referring 'Seek Eagle Program' under MIL-HDBK-1763 and 244A [9]. Ground test such as MOI measurement, fit / function test and ground store separation test was conducted. Flight test was categorized as carriage test like envelope expansion tests, performance verification tests, employment test like store separation test, and weapon accuracy test including ballistic separation effect (BSE) test. Firstly structural integrity from flutter and loads test and flying quality from stability and control test which is envelope expansion test items was verified for requested operational flight envelope. And with confirmation for safety release from wind tunnel test, CFD analysis and ground store separation test, in-flight store separation test was performed safely for the objected external store including dispenser like LAU-131. Currently we are on the final stage for accuracy test and ROKG will be certificate for KT-1P army capability based on these all analysis and test results.

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