

DIAGNOSTICS AND ACTIVE CONTROL OF AIRCRAFT INTERIOR NOISE

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INTRODUCTION

This project deals with developing advanced methods for investigating and controlling interior noise in aircraft. The work concentrates on developing and applying the techniques of Near Field Acoustic Holography (NAH) and Principal Component Analysis (PCA) to the aircraft interior noise dynamic problem. This involves investigating the current state of the art, developing new techniques and then applying them to the particular problem being studied. The knowledge gained under the first part of the project was then used to develop and apply new, advanced noise control techniques for reducing interior noise. A new fully active control approach based on the PCA was developed and implemented on a test cylinder. Finally an active-passive approach based on tunable vibration absorbers was to be developed and analytically applied to a range of test structures from simple plates to aircraft fuselages.

SIGNIFIGANT PROJECT ACHIEVEMENTS

The significant achievements of each of the project section are summarized in bullet fashion below.

- A. *Application of Near Field Acoustic Holography(NAH) to studying interior noise in aircraft.***
- Developed and implemented a new, efficient NAH Green function which removes the interior acoustic singularity problem.
 - Developed and implemented a new, efficient NAH formulation which reduced the required number of measurement planes.
 - Designed and constructed a test box with acoustic and structural sources as well as a microphone array for testing NAH formulations.
 - Experimentally tested and verified new NAH formulations in the test box. Compared results to classical analytical models. The results verified that the new NAH technique is accurate.
 - Experimentally implemented and processed results from applying new NAH formulation to a Cessna aircraft fuselage. The results showed that the new NAH will successfully work in identifying acoustic and structural sources in real structures.
 - Compared new NAH performance to previous NAH codes. The new NAH formulation was shown to be more efficient and accurate than the conventional NAH technique.
 - Communicated new information and codes to NRL and NASA personnel.
- B. *Principal Component Analysis(PCA) of aircraft interior noise and its use in ASAC design.***
- Developed new PCA approaches for analyzing and determining important fuselage vibration patterns in aircraft fuselages.

- Applied the new PCA analysis to various test noise patterns. The results demonstrated the ability of the PCA to break down complex vibration and sound fields into more readily interpretable results. These results gave good insight into the major dynamics of the problem.
- Developed a feedforward LMS controller based on the PCA approach.
- Implemented the PCA controller on DSP board.
- Successfully demonstrated use of the PCA controller on simple plate systems. The results showed that the PCA controller is an efficient and stable way of controlling multi-mode response in dynamic systems with a limited number of control channels.
- Successfully demonstrated PCA controller on composite fuselage test rig at NASA LaRC. The results demonstrated that the PCA controller can achieve good global control in real fuselage systems with a limited number of control channels.
- Studied the sensitivity of the PCA's to systems change and its influence on control performance. The results demonstrated that in some cases control performance is very sensitive to PC changes and thus on-line system ID is needed for a robust system.
- Developed new system ID methods for PCA controller.
- Communicated results with NASA personnel.

C. Globally de-tuned vibration absorbers (TVA's) for reducing interior noise.

- Modified aircraft interior noise/TVA analytical model to include effect of multiple TVA's.
- Use modified analytical model to study optimal locations of multiple tuned and de-tuned TVA's under various operating conditions. The results showed that as more TVA's were used, the needed tuning range is decreased and that the best locations are near the propeller closest point of sweep.
- Studied the use of "virtual microphones" obtained by processing base acceleration of TVA's through a single transfer function to obtain radiated the sound field at microphone points. The results show that this is feasible when single TVA's or multiple lightly coupled TVA's are implemented. When the TVA's are strongly coupled (through the base structure dynamics) then more complex, coupled filtering techniques will be needed.

CONCLUSION

Much progress was made in this period of work. New system identification techniques for aircraft interior noise were developed and successfully applied to test structures and real aircraft fuselages. New active and active-passive control approaches were studied and analytically and experimentally demonstrated on laboratory test systems and real aircraft fuselages. The work represents a significant contribution to solving the aircraft interior noise problem.