Mechanics

Tilt/Tip/Piston Manipulator With Base-Mounted Actuators

The geometry and kinematics of this manipulator would afford advantages for some applications.

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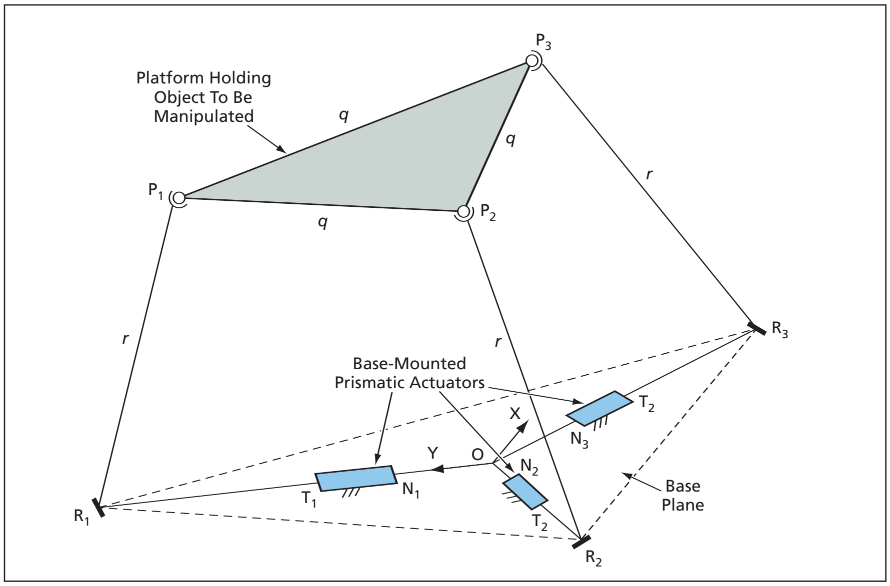
A proposed three-degree-of-freedom (tilt/tip/piston) manipulator, suitable for aligning an optical or mechanical component, would offer several advantages over prior such manipulators:

- Unlike in some other manipulators, no actuator would support the weight of another actuator: All of the actuators would be mounted on a base. Hence, there would be less manipulated weight.
- The basic geometry of the manipulator would afford mechanical advantage: that is, actuator motions would be larger than the motions they produce in the manipulated object. Mechanical advantage inherently increases the accuracy and resolution of manipulation.
- Unlike in some other manipulators, it would not be necessary to route power and/or data lines through manipulator joints.



Lengths of Links R_1T_1, R_2T_2, and R_3T_3 are varied to adjust the piston, tilt, and tip coordinates of the platform.

The proposed manipulator (see figure) would include three prismatic actuators (T_1N_1, T_2N_2, and T_3N_3) mounted on the base and operating in the same plane. Examples of suitable prismatic actuators include lead-screw mechanisms, linear hydraulic motors, piezoelectric linear drives, inchworm-movement linear stepping motors, and linear flexure drives. The actuators would control the lengths of links R_1T_1, R_2T_2, and R_3T_3.

Three spherical joints (P_1, P_2, and P_3) would be located at the corners of an equilateral triangle of side length *q* on the platform holding the object to be manipulated. Three inextensible limbs (R_1P_1, R_2P_2, and R_3P_3) having length *r* would connect the spherical joints on the platform to revolute joints (R_1, R_2, and R_3) at the ends of the actuator-controlled links R_1T_1, R_2T_2, and R_3T_3. By varying the lengths of these links, one could control the tilt, tip, and piston coordinates of the platform. Closed-form equations for direct or forward kinematics of the manipulator (given the lengths of the variable links, find the tilt, tip, and piston coordinates) have been derived. The equations of inverse kinematics (find the variable link lengths needed to obtain the desired tilt, tip, and piston coordinates) have also been derived.

This work was done by Farhad Tahmasebi of **Goddard Space Flight Center**. *Further information is contained in a TSP (see page 1).* *GSC-14874-1*

Measurement of Model Noise in a Hard-Wall Wind Tunnel

Spurious noise is suppressed in processing of digitized microphone outputs.

Ames Research Center, Moffett Field, California

Identification, analysis, and control of fluid-mechanically-generated sound from models of aircraft and automobiles in special low-noise, semi-anechoic wind tunnels are an important research endeavor. Such studies can also be done in aerodynamic wind tunnels that have hard walls if phased microphone arrays are used to focus on the noise-source regions and reject unwanted reflections or background noise. Although it may be difficult to simulate the total fly-over or drive-by noise in a closed wind tunnel, individual noise sources can be isolated and analyzed.

An acoustic and aerodynamic study was made of a 7-percent-scale aircraft model in a NASA Ames 7-by-10-ft (about 2-by-3-m) wind tunnel for the purpose of identifying and attenuating airframe noise sources. Simulated landing, takeoff, and approach configurations were evaluated at Mach 0.26. Using a phased microphone array mounted in the ceiling over the inverted model, various

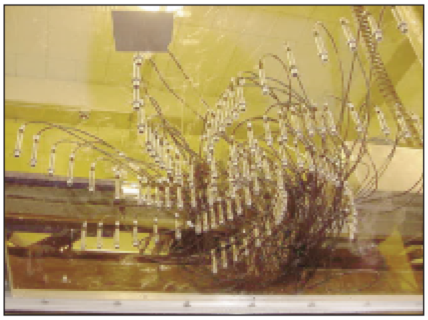


Figure 1. The **Array of Microphones** was mounted above the aircraft model in the test section of the wind tunnel. A cloth cover has been removed from under the microphones to make the model visible in this view.

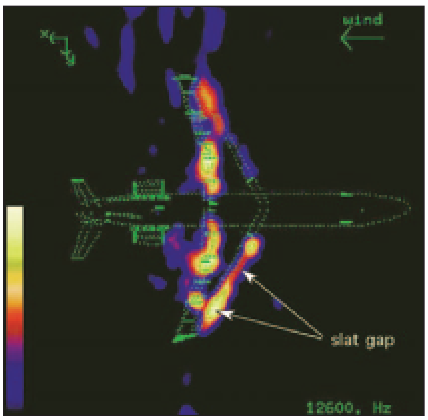


Figure 2. A **Contour Map of Wing-Slat Noise** at a frequency of 12.6 kHz was computed from measurements made by the microphone array. The color-contour range is 8 dB.

noise sources in the high-lift system, landing gear, fins, and miscellaneous other components were located and compared for sound level and frequency at one flyover location. Numerous noise-alleviation devices and modifications of the model were evaluated. Simultaneously with acoustic measurements, aerodynamic forces were recorded to document aircraft conditions and any performance changes caused by geometric modifications.

Most modern microphone-array systems function in the frequency domain in the sense that spectra of the microphone outputs are computed, then operations are performed on the matrices of microphone-signal cross-spectra. The entire acoustic field at one station in such a system is acquired quickly and interrogated during postprocessing. Beam-forming algorithms are employed to scan a plane near the model surface and locate noise sources while rejecting most background noise and spurious reflections. In the case of the system used in this study, previous studies in the wind tunnel have identified noise sources up to 19 dB below the normal background noise of the wind tunnel. Theoretical predictions of array performance are used to minimize the width and the side lobes of the beam pattern of the microphone array for a given test arrangement.

To capture flyover noise of the inverted model, a 104-element microphone array in a 622-mm-diameter cluster was installed in a 19-mm-thick poly(methyl methacrylate) plate in the ceiling of the test section of the wind tunnel above the aircraft model (see Figure 1). The microphones were of the condenser type, and their diaphragms were mounted flush in the array plate, which was recessed 12.7 mm into the ceiling and covered by a porous aromatic polyamide cloth (not shown in the figure) to minimize boundary-layer noise. This design caused the level of flow noise to be much less than that of flush-mount designs. The drawback of this design was that the cloth attenuated sound somewhat and created acoustic resonances that could grow to several dB at a frequency of 10 kHz.

A correction methodology has been developed to account for the signal interference. The first side lobe of the beam pattern was 13.4 dB down from the peak response at 8 kHz and at an angle of 23° from the normal vector: these characteristics made it possible to obtain good acoustic signals from the model when the model was located at a distance of 1.11 m from the array. Data were acquired at 12,321 scan points in a plane encompassing the model. From these data, aerodynamic noise from sources as small as 6 mm on the model surface could be identified easily.

The microphone signals were digitized at a rate of 153,600 samples per second on 104 channels simultaneously by use of analog-to-digital converter circuits and a computer. The resulting maximum acoustic frequency was 60 kHz with a bandwidth of 300 Hz. The data for frequencies <2 kHz were found to be of marginal utility because the microphone beam pattern at those frequencies was too wide. The data for frequencies >32 kHz were found to be of marginal utility because at those frequencies, the sources were too weak and the side lobes too strong. The frequency limits of 2 and 32 kHz correspond to limits of 140 and 2,240 Hz, respectively, on the full-scale aircraft.

A sound-convection correction was included in the processing of the data so that sources appeared to come from the model rather than being swept downstream. The acoustic sources were depicted, one frequency at a time, as color contours on the scan plane with the model outline superimposed, as shown in Figure 2. Various integration schemes have been developed to compute the combined effects on a listener and to generate narrowband and third-octave acoustic spectra.

Ten airframe noise sources that might be important to approach and landing noise of the full-scale aircraft were identified in the study. The relative strengths of these sources and their dependences on the configuration of the aircraft were documented. Although the data were scaled to the frequencies for the full-scale aircraft, no extrapolation to full-scale flyover was performed.

This work was done by Paul T. Soderman of **Ames Research Center**. *For further information, contact the Ames Technology Partnerships Division at (650) 604-2954.*
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Loci-STREAM Version 0.9

Marshall Space Flight Center, Alabama

Loci-STREAM is an evolving computational fluid dynamics (CFD) software tool for simulating possibly chemically reacting, possibly unsteady flows in diverse settings, including rocket engines, turbomachines, oil refineries, etc. Loci-STREAM implements a pressure-based flow-solving algorithm that utilizes unstructured grids. (The benefit of low memory usage by pressure-based algorithms is well recognized by experts in the field.) The algorithm is robust for flows at all speeds from zero to hypersonic. The flexibility of arbitrary polyhedral grids enables accurate, efficient simulation of flows in complex geometries, including those of plume-impingement problems. The present