

COMBUSTOR-DIFFUSER INTERACTION PROGRAM*

R. Srinivasan and C. White
Garrett Turbine Engine Company

INTRODUCTION

Modern gas turbine engines for both unmanned and man-rated applications operate at high pressure and temperature levels. Advanced compressor systems for such applications produce high exit Mach numbers in excess of 0.5. With current combustor-diffuser systems, the cycle penalties and engine size negate some of the benefits from improved compressor and combustor technology. Advanced, low-pressure-loss, stable diffuser configurations are required to obtain the complete benefits of advanced compression and combustion systems.

Empirical design techniques, as used in the past, cannot be extended with accuracy to advanced technology designs. A generalized analytical model does not exist that accurately models the combustor-diffuser flowfield and is applicable to a wide variety of diffuser designs with different inlet flow conditions.

OBJECTIVES

The objectives of the Combustor-Diffuser Interaction (CDI) Program are to:

- o Identify the mechanisms and the magnitude of aerodynamic losses in the prediffuser, dome, and shroud regions of an annular combustor-diffuser system
- o Determine the effects of geometric changes in the prediffuser, dome, and shroud wall on aerodynamic losses and loss mechanisms
- o Obtain a data base that can be used to assess advanced numerical aerodynamic computer models for predicting flowfield conditions in an annular combustor-diffuser system
- o Assess the ability of current analytical models to predict flowfield characteristics in annular combustor-diffuser systems, including pressure distributions
- o Upgrade the analytical models based on the experimental data for flowfield characteristics
- o Determine the effects of modifications to the aerodynamic models based on the combustor-diffuser system performance
- o Design and test-evaluate advanced diffuser systems to verify the accuracy of the upgraded analytical model

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DESCRIPTION

The CDI Program consists of the following phases:

- o I - Literature Search
- o II - Baseline Configuration
- o III - Parametric Benchmark Configuration
- o IV - Performance Configuration

Phase I of the program involves a literature search of the state-of-the-art in aerodynamic models applicable to predicting the performance of a wide variety of combustor-diffuser designs. Based on this effort, an advanced analytical model will be selected.

Phase II of the program involves the design and fabrication of the baseline configuration and the acquisition of benchmark-quality data. Accurate three-dimensional (3-D) laser Doppler velocimeter (LDV) measurements will be made at several locations in the combustor-diffuser flowfield and the analytical model will be evaluated and upgraded in accordance with this experimental data.

Phase III will evaluate the effects of geometric changes to the system on the performance. In this phase, a minimum of eight geometric changes will be investigated, with benchmark-quality data obtained for each geometry. This data will be used to further refine the analytical models.

Phase IV will assess the ability of the analytical models to predict flowfields and pressure recovery characteristics for full-annular advanced combustor-diffuser configurations.

RESULTS

Phase I efforts have been completed, resulting in collection of analytical and empirical design methodology on combustor-diffuser systems. A fully elliptic code has been selected for analyzing the combustor-diffuser interaction.

Phase II of the program is in progress. Preliminary experimental studies were made to determine the minimum sector angle needed without encountering errors due to end-wall boundary layer. Based on these tasks, a 2X sector rig was designed with a 60-degree sector angle. This design employs a straight-wall prediffuser with a dump region and combustor orientation, as shown in Figure 1. The entire rig is fabricated of Plexiglas, with provisions for installing optical-quality windows to facilitate LDV measurements. The test rig is currently in fabrication.

The 3-D LDV system to be used for benchmark testing is shown in Figure 2. This is a 3-color, 3-component system that will operate in an off-axis backscatter mode. The effective measurement volume will have a diameter of 0.06mm and a length of 0.22mm. Measurements will be made for 15 different flow rates through the inner and outer annuli. The LDV surveys will be made at several axial stations, with the near-wall measurements as close as 0.5mm from the walls. During these tests, the prediffuser inlet Mach number will be maintained at 0.35. Prior to the detailed measurements, flow visualization tests will be conducted to guide test rig modifications.

Analytical model predictions have been obtained for all of the flow conditions at which Phase II tests will be conducted. These results will be compared with the LDV data. Furthermore, a generalized nonorthogonal grid system is being developed to accurately simulate complex wall shapes.

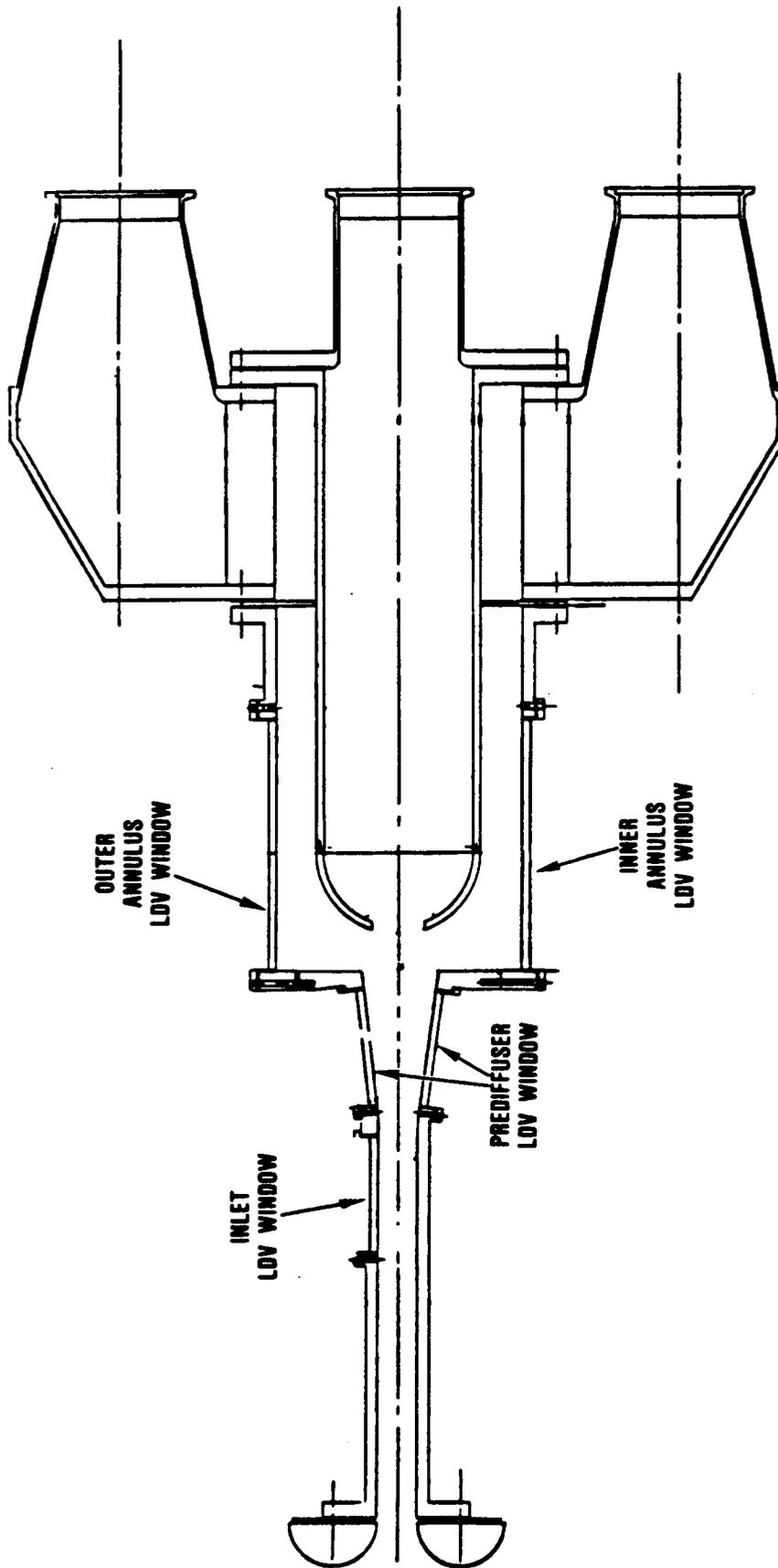


Figure 1. Schematic of CDI Test Rig.

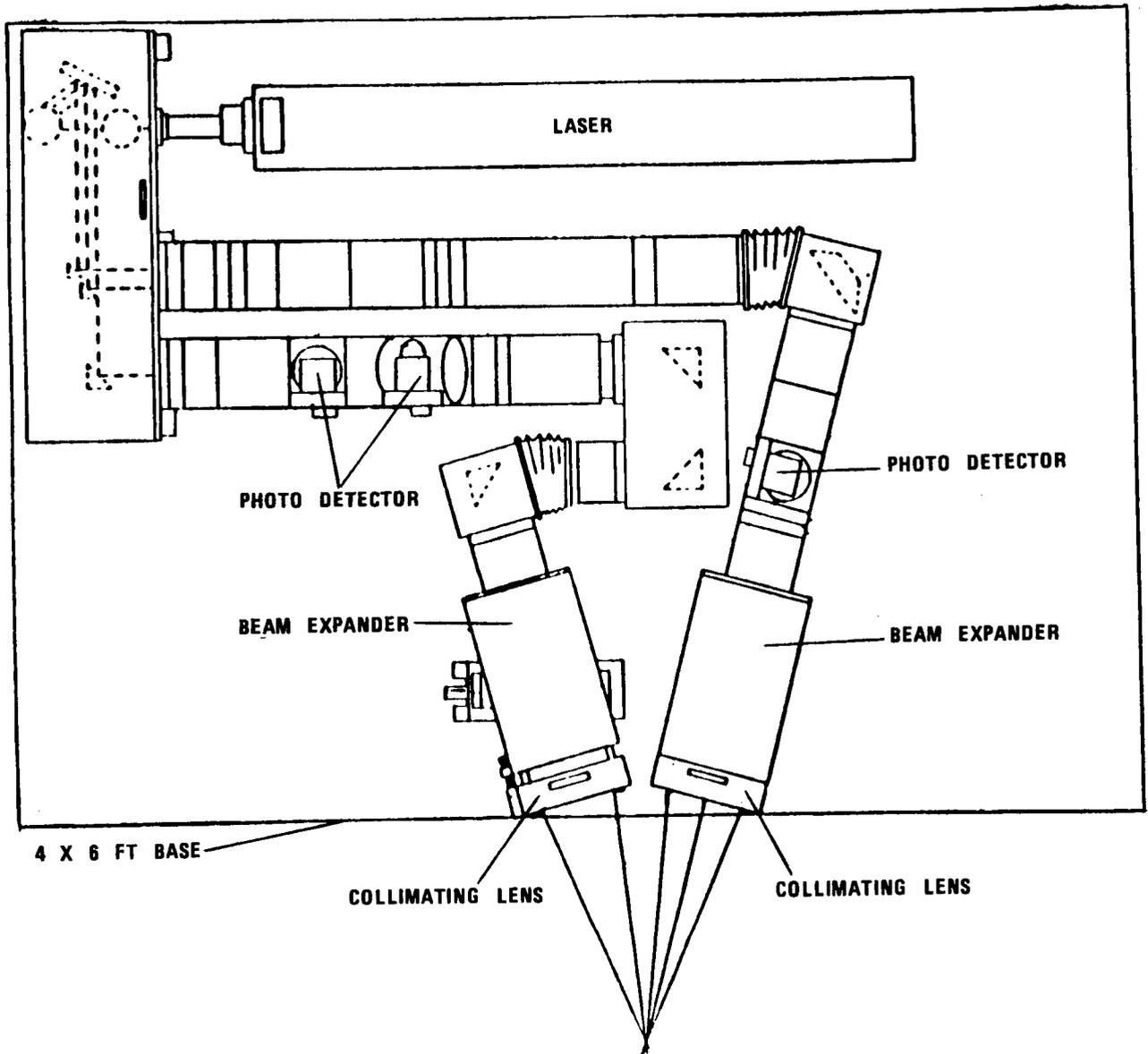


Figure 2. Layout of 3-D LDV System.