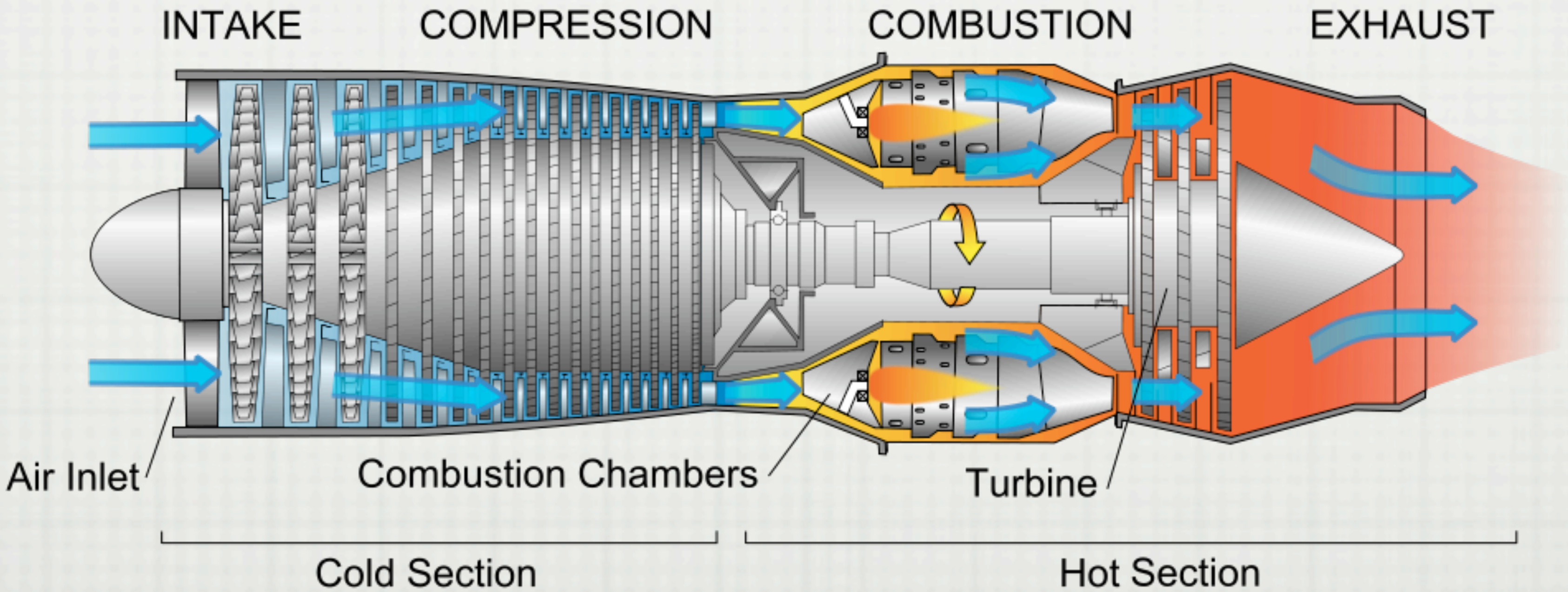
COMBUSTOR INSTABILITY SUPPRESSION IN AIRCRAFT GAS TURBINE ENGINES

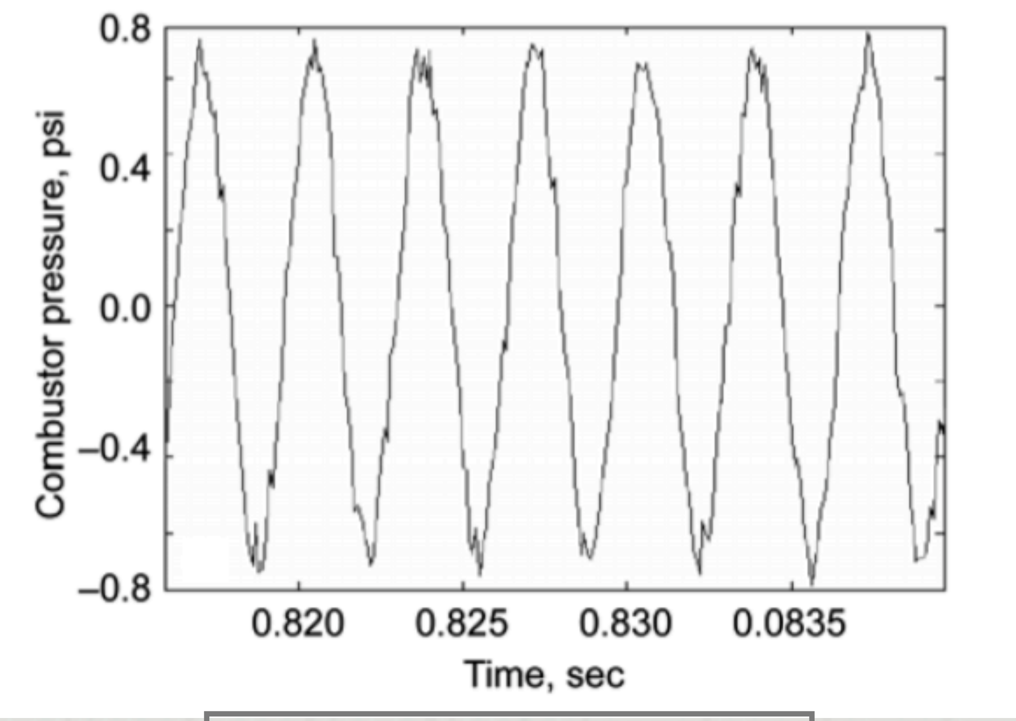
DOUG CARDER
AME 50531
DECEMBER 8, 2010



CHANG, C.T., DELAAT, J.C., KOPASAKIS, G. "ADAPTIVE INSTABILITY SUPPRESSION CONTROLS METHOD FOR AIRCRAFT GAS TURBINE ENGINE COMBUSTORS," *JOURNAL OF PROPULSION AND POWER*, VOL. 25, NO. 3, PP. 618-627, MAY-JUNE 2009.

COMBUSTOR INSTABILITY

- LEAN COMBUSTION IS BETTER FOR LOW NO_X EMISSIONS BUT IS SHOWN TO HAVE MORE INSTABILITY
- INSTABILITY LIMITS OPERATING RANGE
- INSTABILITY CAN CAUSE FLAME TO EXTINGUISH



PRESSURE INSTABILITY

SOLUTION: FUEL MODULATION

- **CHOSEN METHOD: ADAPTIVE SLIDING PHASOR AVERAGED CONTROL (ASPAC)**
- **MONITOR THE PRESSURE INSTABILITY IN THE COMBUSTOR USING DYNAMIC PRESSURE SENSORS**
- **ALTER THE FUEL FLOW INTO THE COMBUSTOR TO ALTER THE PRESSURE INSTABILITY**

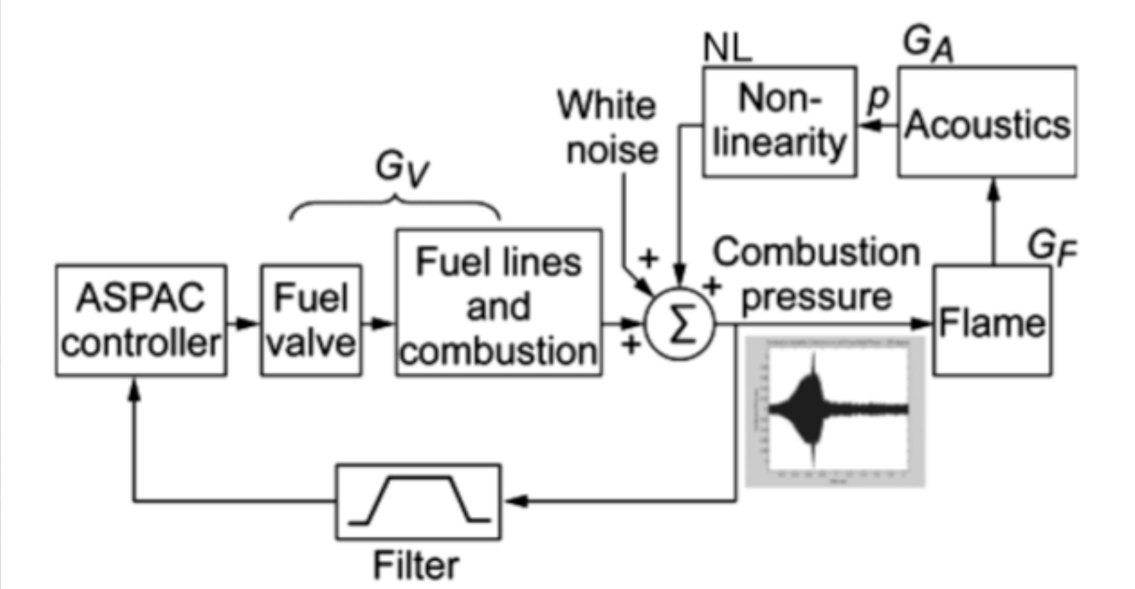
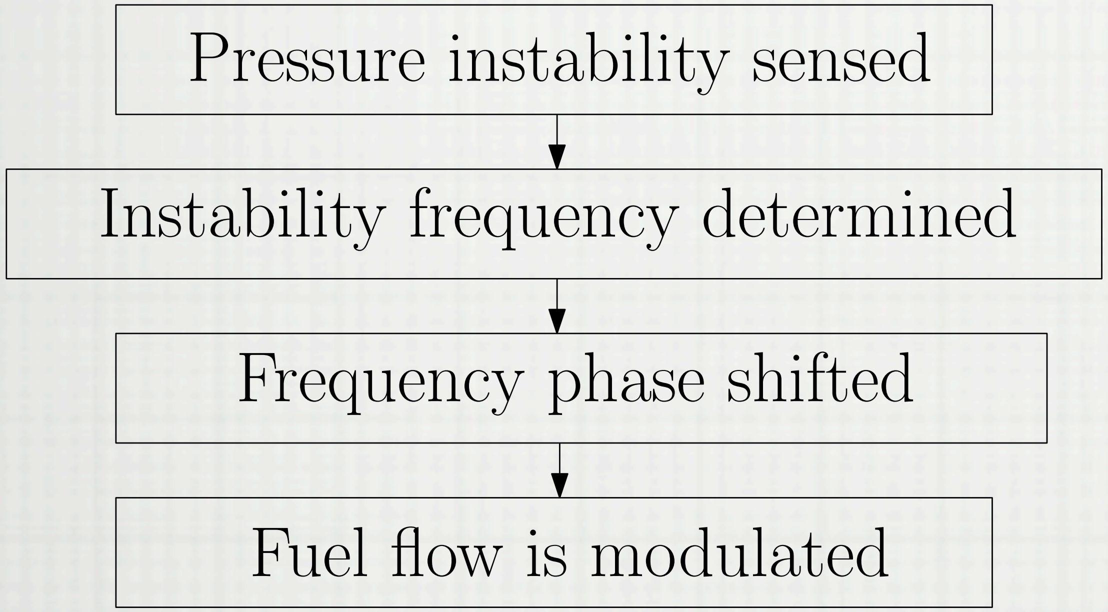
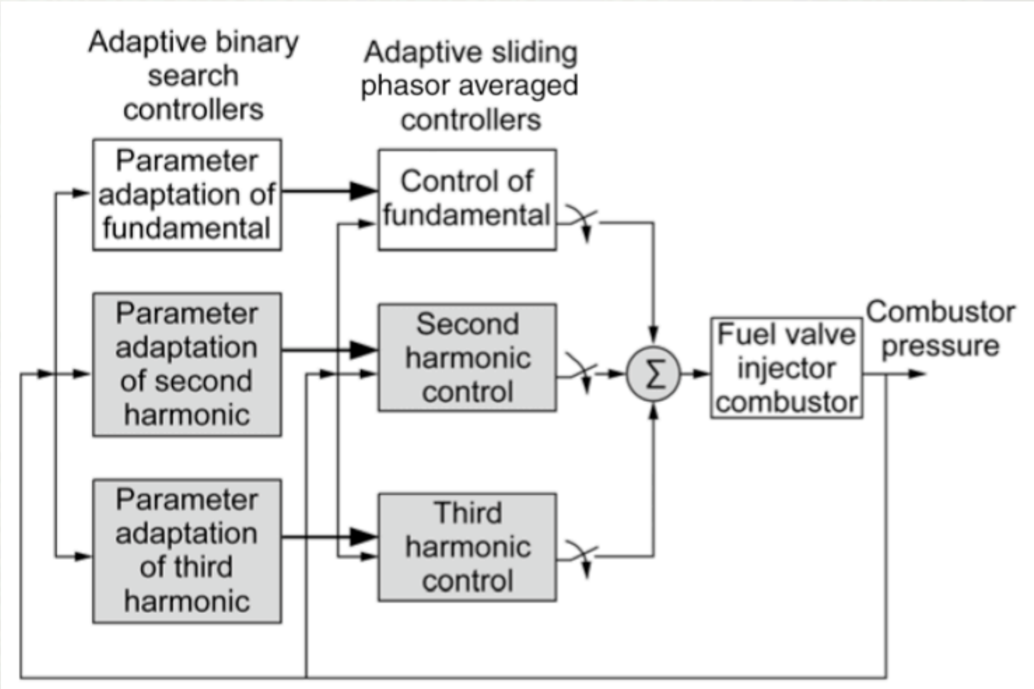


DIAGRAM OF SYSTEM

$$G_V = \frac{K_V \omega_V^2}{s^2 + 2\zeta_V \omega_V s + \omega_V^2}$$

ASPAC METHOD

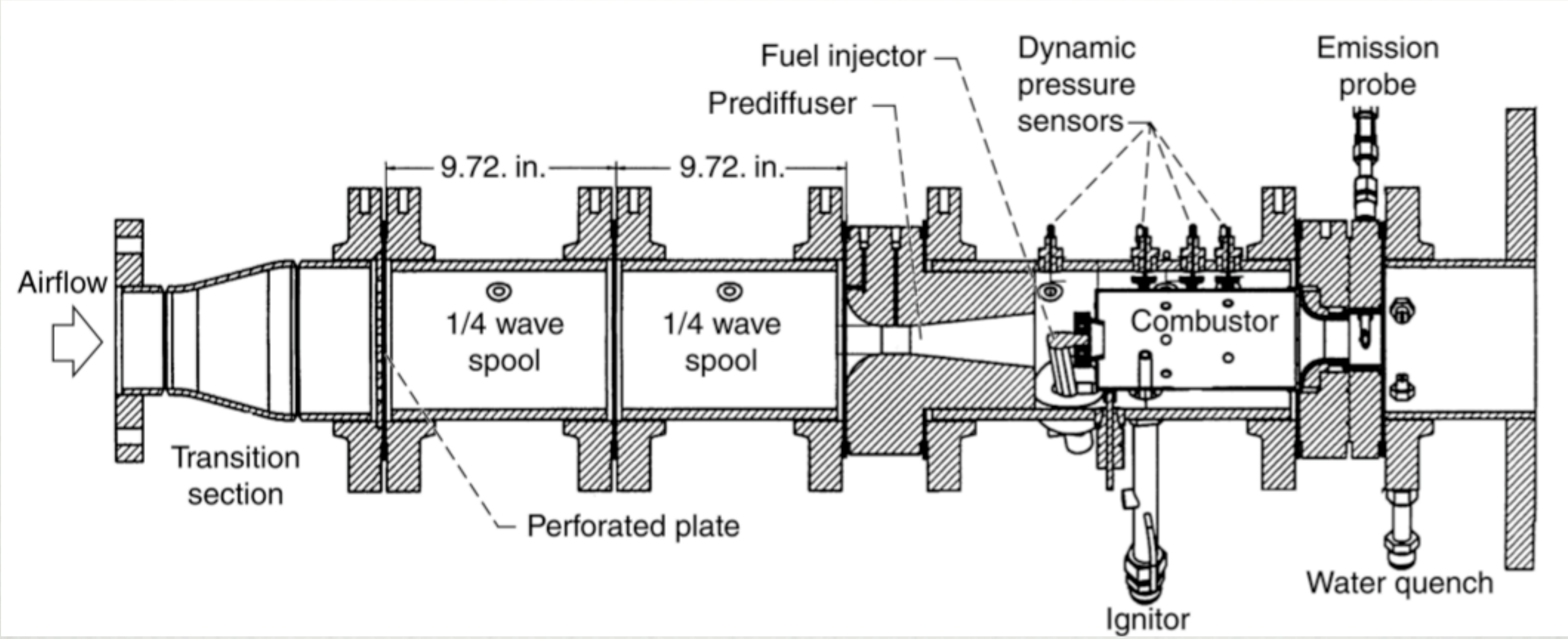




ASPAC CONTROL DIAGRAM

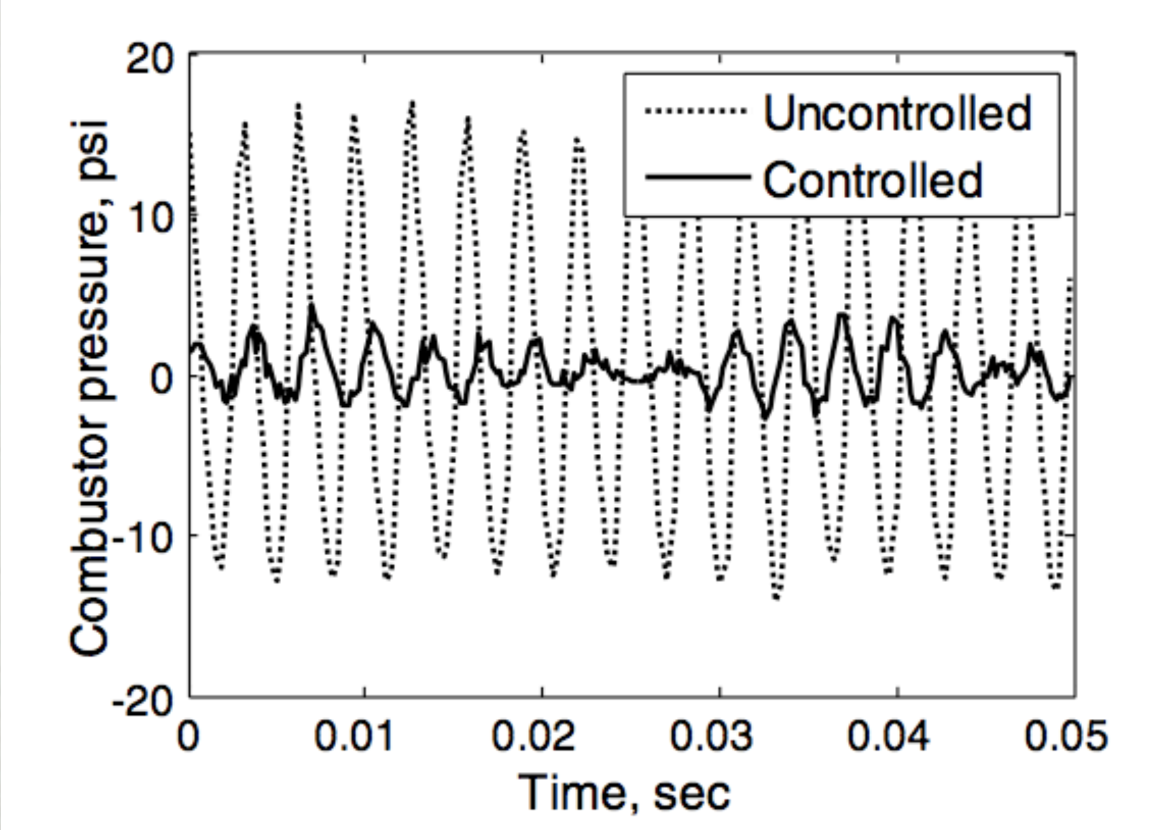
$$f_{HFRC} = 533 \text{ Hz}, f_{LFRC} = 315 \text{ Hz}$$

EXPERIMENTAL APPARATUS



TEST RIG CONFIGURATION

RESULTS

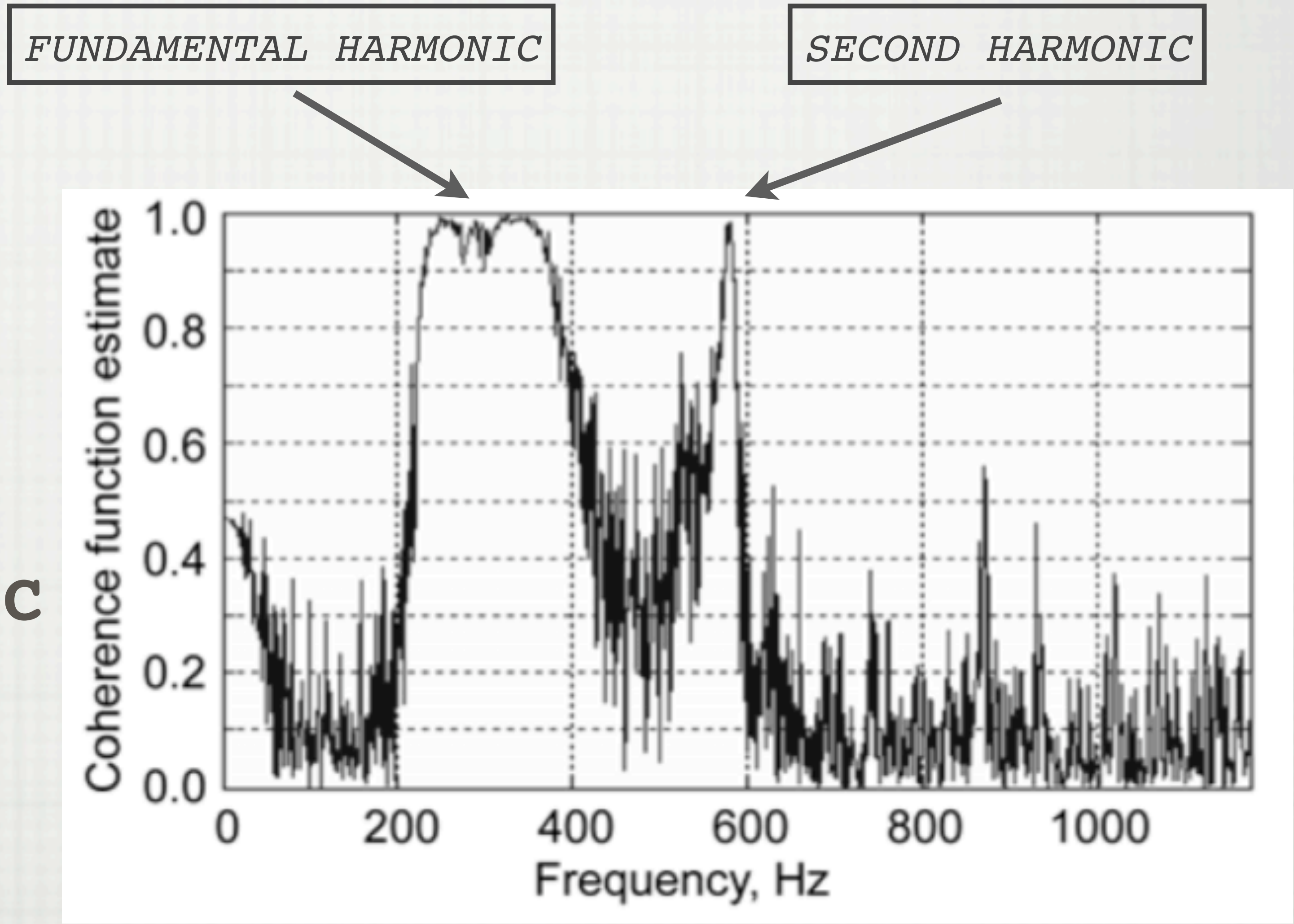


LFRC PRESSURE INSTABILITY PLOT

- **ASPAC METHOD SUPPRESSED AMPLITUDE 90% IN LFRC AND 80% REDUCTION IN RMS PRESSURE**
- **CLOSED-LOOP CONTROL EXHIBITED PRESSURE SPIKES AT AND NEAR INSTABILITY FREQUENCY**

COUPLING

- COUPLING OBSERVED BETWEEN FIRST AND SECOND HARMONIC
- FUNDAMENTAL HARMONIC RESPONDS TO SECONDARY HARMONIC SUPRESSION



CONCLUSIONS

- COMBUSTOR HIGHLY CONDUCIVE TO DYNAMIC COUPLING
- COUPLING BETWEEN THE FUNDAMENTAL MODE AND ITS HARMONICS WAS EXPLOITED TO REACH GREATER SUPPRESSION LEVELS
- SECOND HARMONIC OF THE INSTABILITY WAS PARTICULARLY EFFECTIVE AT SUPPRESSION
- OPEN-LOOP SYSTEM MORE EFFECTIVE AT SUPPRESSION THAN CLOSED-LOOP SYSTEM