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MULTISHAKER MODAL ANALYSIS TESTING AND SPACECRAFT STRUCTURES

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MULTISHAKER MODAL ANALYSIS TESTING AND SPACECRAFT STRUCTURES

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ABSTRACT

MULTISHAKER MODAL ANALYSIS TESTING

AND

SPACECRAFT STRUCTURES

S. Draisey

The information reported on the results of a literature survey of multishaker modal analysis testing, applicable to spacecraft structures was presented at CRC on September 27, 1983.

This report consists of copies of the vu-graphs which were shown in the presentation.

PREFACE

The contents of this report were presented at the Communications Research Centre in Ottawa on September 27, 1983.

The presentation was part of the work done under DSS Contract No. 01ST.36001-2-1794 on Modal Analysis.

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MULTISHAKER MODEL ANALYSIS TESTING AND SPACECRAFT STRUCTURES

1. TO DOCUMENT AND DESCRIBE THE VARIOUS APPROACHES TO MULTISHAKER TESTING.

2. TO DETERMINE WHAT INDUSTRIAL GROUPS ARE USING THE VARIOUS MULTISHAKER TESTING METHODS AS WELL AS THE TYPES OF STRUCTURES BEING TESTED.

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OBJECTIVES OF MULTISHAKER TESTING
W.R.T. SINGLE SHAKER TESTING

SINGLE SHAKER TESTING

- EXCITE STRUCTURE AT ONE POINT
- USUALLY RANDOM OR IMPACT EXCITATION
- THOUGH THE STRUCTURE MAY BE EXCITED AT MORE THAN ONE POINT, IT IS DONE SO ONE POINT AT A TIME

ADVANTAGES TO MULTISHAKER TESTING

- SEPARATION OF GROUPED MODES
- ELIMINATE STATIONARITY PROBLEMS
- SOME TYPES OF MULTISHAKER TECHNIQUES REDUCE TEST TIME

DISADVANTAGES TO MULTISHAKER TESTING

- MORE EXOTIC COMPUTER AND CONTROL SYSTEMS REQUIRED

TYPES OF MULTISHAKER EXCITATION

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FORCE APPROPRIATION (CLASSICAL SINE SWEEP OR DWELL, PHASE RESONANCE METHOD)

- POSITION SHAKERS SUCH THAT ONLY ONE MODE IS EXCITED
- SPECTRAL ANALYSIS IS NOT REQUIRED, THOUGH IT CAN BE USED
- PRESENTS SIGNIFICANT EXCITER POSITIONING, CONTROL AND TUNING PROBLEMS
- CONFIDENCE IN RESULTS APPEAR HIGH THROUGHOUT THE INDUSTRY
- TIME CONSUMING

NON APPROPRIATED FORCE

- EXCITE STRUCTURE AT, AT LEAST TWO POINTS, SIMULTANEOUSLY
- EACH EXCITATION SHOULD BE UNCORRELATED WITH RESPECT TO EVERY OTHER EXCITATION
- MAKES USE OF SPECTRAL ANALYSIS TECHNIQUE KNOWN AS MULTIPLE COHERENCE FUNCTION
- EXCITATION CAN BE RANDOM, SINUSOIDAL OR TRANSIENT
- FOR STRUCTURES WHICH REQUIRE EXCITATION AT SEVERAL POINTS, FOR ADEQUATE CHARACTERIZATION, TEST TIME IS SIGNIFICANTLY REDUCED AND THE ASSUMPTION OF STATIONARITY IS REALIZED
- CLOSELY SPACED MODES CAN BE IDENTIFIED

BASE ACCELERATION

- COMMONLY APPLIED VIBRATION TESTING TECHNIQUE FOR SPACE STRUCTURES
- ALTHOUGH MOTION IS APPLIED AT ONLY ONE POINT, THE EFFECTIVE FORCES CORRESPOND TO MULTIPLE INPUTS
- FOR THE SAKE OF ANALYSIS, MUST BE TREATED AS A SPECIAL FORM OF MULTIPLE INPUT PROBLEM

FORCE APPROPRIATION	BASE ACCLERATION	NON APPROPRIATED FORCES
- ESTIMATION OF FORCE DISTRIBUTION - TUNING TECHNIQUES - INDICATOR FUNCTION	- NOT AVAILABLE	- MULTIPLE COHERENCE FUNCTION

INDICATOR FUNCTION (FROM ESA WORK)

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PHASE PURITY CRITERION

$$\Delta = 1.0 - \frac{\sum_i |Re(u_i)| \, m_i \, |u_i|}{\sum_i m_i \, |u_i|^2} \qquad i = 1, 2, \ldots\ldots$$

WHERE m_i ARE THE LOCAL MASSES

u_i COMPLEX DISPLACEMENT RESPONSE AT DOF i

$\Delta \rightarrow 1$ AT $w = w_r$

ASHER'S CRITERIA
FOR FORCE APPROPRIATION

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$B' F = 0$ WHERE F - FORCE MATRIX

B' - REAL COMPONENT OF COMPLEX ADMITTANCE MATRIX

- THE MULTIPLE COHERENCE FUNCTION IS USED TO MEASURE THE DATA QUALITY BETWEEN ONE OF SEVERAL INPUTS TO THE PORTION OF THE OUTPUT IT CAUSES

- THE FRF's FOR TWO INPUTS ACTING SIMULTANEOUSLY ARE:

$$H_{Y1} = \frac{G_{Y1}}{G_{11}} \qquad H_{Y2} = \frac{G_{Y2}}{G_{22}}$$

WHERE: INPUT 1 AND INPUT 2 ARE NOT FULLY CORRELATED

H_{Y1} IS THE FRF OF THE OUTPUT DUE TO INPUT AT POINT 1

G_{Y1} IS THE CROSS SPECTRA BETWEEN THE OUTPUT AND INPUT 1

G_{11} IS THE AUTO SPECTRA OF INPUT 1

- POLYREFERENCE
- LEAST SQUARES ESTIMATE

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APPLICATIONS OF MULTISHAKER TESTING
(SPACECRAFT)

FORCE APPROPRIATION

- SPACE TELESCOPE (HAMMA, SMITH, STROUD - 1976)
- DSC-III S/C IN STOWED CONFIGURATION
  (FERRANTE, STAHLE, BRESTMAN - 1980)
- MARINER JUPITER/SATURN SPACECRAFT
  (LEPPERT, LEE, DAV, CHAPMAN, WADA - 1976)
- VOYAGER JUPITER/SATURN PAYLOAD
  (HANKS, MISERENTINO, IBRAHIM, LEE, WADA - 1978)
- DEFENSE METEOROLIGAL SATELLITE - RCA
  (CHU, VOORHEES, METZGER, WILDING - 1981)

NON APPROPRIATED FORCES

CONCLUDING REMARKS

- MULTISHAKER SINE (APPROPRIATED FORCE) HAS BEEN ACCEPTED FOR S/C WORK
- MULTIPLE RANDOM (NON APPROPRIATED FORCE) IS RECEIVING ACCEPTANCE IN OTHER INDUSTRIES AND WILL PROBABLY BE ACCEPTED FOR S/C WORK VERY SOON

MULTISHAKER PAPERS

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	APPROPRIATED FORCES	BASE EXCITATION	NON-APPROPRIATED FORCES	PARAMETER ESTIMATION
THEORY	(1) ASHER (6) MOROSOW & AYRE (8) HALLAUER & STAFFORD (13) IBANEZ (14) CHU ET AL (18) NIEDBAL (20) NIEDBAL (15) CRAIG ET AL	(19) LINK & VOLAN	(15) CRAIG ET AL (17) VOLD ET AL	(5) PAPPA & IBRAHIM (7) RICHARDSON & KNISKERN (17) VOLD ET AL (19) LINK & VOLAN
EXPERIMENTAL	(2) HAMMA ET AL (3) SMITH ET AL (4) FERRANTE ET AL (9) LEPPERT ET AL (10) HANKS ET AL		(2) HAMMA ET AL (3) SMITH ET AL (11) CARBON ET AL (12) ALLEMARG ET AL	

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DRAISEY, SHERRY

-- Multishaker modal analysis testing and spacecraft structures.

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