MODELING CORRELATION WITH FLIGHT DATA

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SHUTTLE ENVIRONMENT WORKSHOP

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MOLECULAR (CONTAMINATION) FLOW MODELING
(SPACE 2 PROGRAM)

- PURPOSE OF THE MODEL

  - PREDICT THE INDUCED ENVIRONMENT OF THE SPACE SHUTTLE ORBITER/PAYLOAD ON-ORBIT

    - MODEL OUTPUT PARAMETERS

      - DENSITY

      - COLUMN DENSITY

      - RETURN FLUX

  - PREDICT THE INDUCED GAS FLOW BETWEEN ORBITER/PAYLOAD SURFACES

    - MODEL OUTPUT PARAMETERS

      - DIRECT SOURCE TO RECEIVER GAS FLOW

      - REFLECTED SOURCE TO RECEIVER GAS FLOW

MOLECULAR (CONTAMINATION) FLOW MODELING
(SPACE 2 PROGRAM)

● MODEL DESCRIPTION

THE MODEL IS A COMPUTER PROGRAM RELATING CERTAIN INPUT
PARAMETERS TO THE REQUIRED OUTPUT PARAMETERS. THE INPUT
PARAMETERS CHARACTERIZE THE TIME DEPENDENT STATUS OF THE
ORBITER/PAYLOAD

  ● INPUT PARAMETERS

    ● BODY GEOMETRY

    ● MATERIALS GAS EMISSION/REFLECTION/ABSORPTION
      CHARACTERISTICS

    ● ENGINE/VENT CHARACTERISTICS

    ● AMBIENT/EMITTED GAS INTERACTION

    ● TEMPERATURES
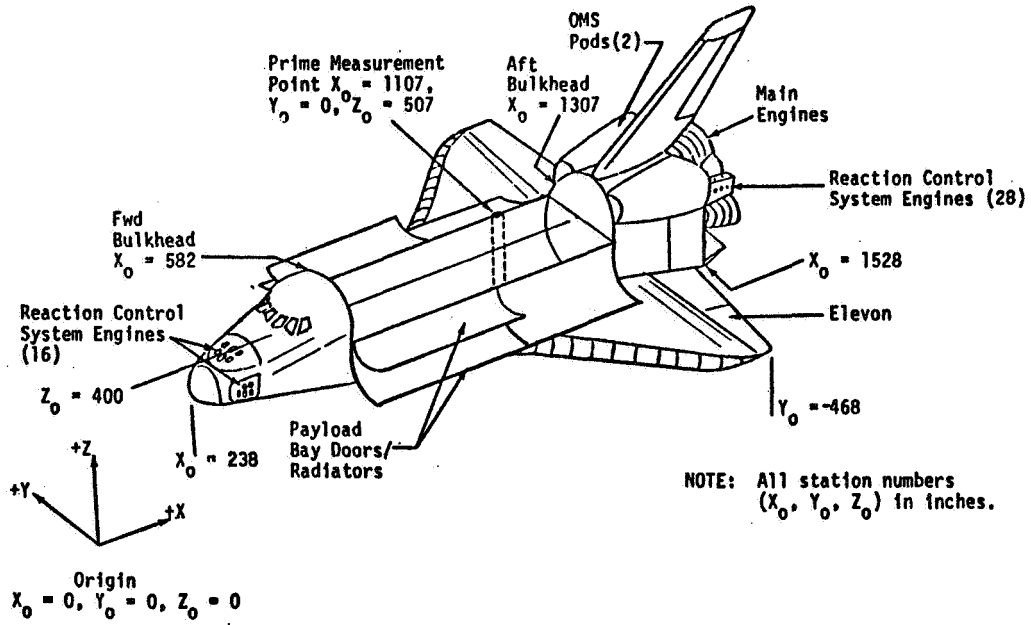
    ● TIME DEPENDENCE

  ● PROGRAM

    ● MOLECULAR TRANSPORT MECHANISMS

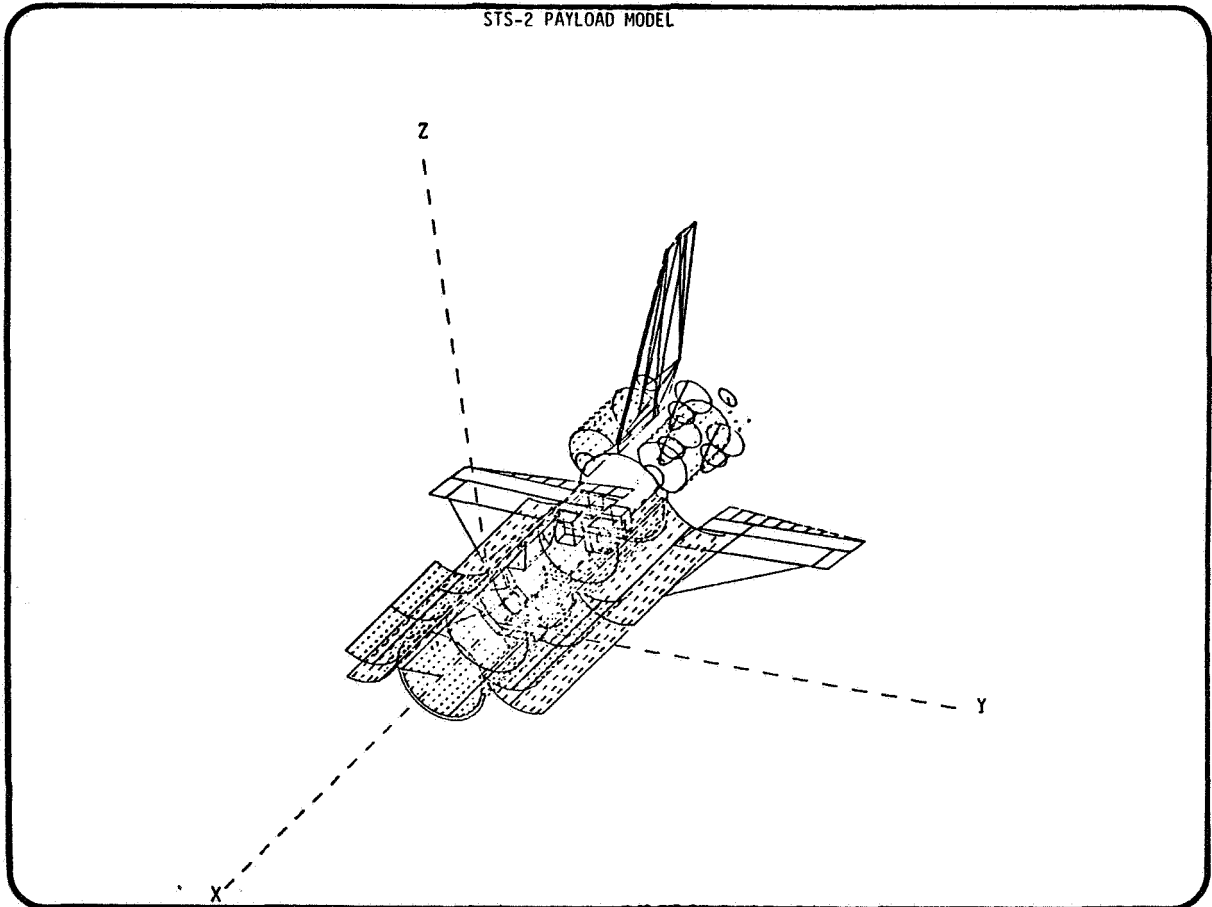---

MODEL APPLICATION: ORBITER FLIGHT TESTS

● INDUCED GAS ENVIRONMENT OF ORBITER/PAYLOAD SYSTEM

  ● STS-1

  ● STS-2

  ● STS-3

● INDUCED DIRECT GAS FLOW FROM ORBITER/PAYLOADS TO SENSITIVE
  AREAS (IN BAY)

  ● IECM INSTRUMENTS

● RETURN FLUX TO SENSITIVE AREAS

  ● IECM INSTRUMENTS

● INDUCED DIRECT GAS FLOW FROM ORBITER/PAYLOADS TO UNBERTHED
  PAYLOAD/SENSITIVE INSTRUMENTS

  ● IECM ON RMS

OMS Pods(2)

Prime Measurement
Point $X_0 = 1107$,
$Y_0 = 0$, $Z_0 = 507$

Aft
Bulkhead
$X_0 = 1307$

Main
Engines

Reaction Control
System Engines (28)

Fwd
Bulkhead
$X_0 = 582$

$X_0 = 1528$

Reaction Control
System Engines
(16)

Elevon

$Z_0 = 400$

$Y_0 = -468$

$X_0 = 238$

Payload
Bay Doors/
Radiators

+Z

+Y

+X

NOTE: All station numbers
(X_0, Y_0, Z_0) in inches.

Origin
$X_0 = 0$, $Y_0 = 0$, $Z_0 = 0$

STS-2 PAYLOAD MODEL

Z

Y

X
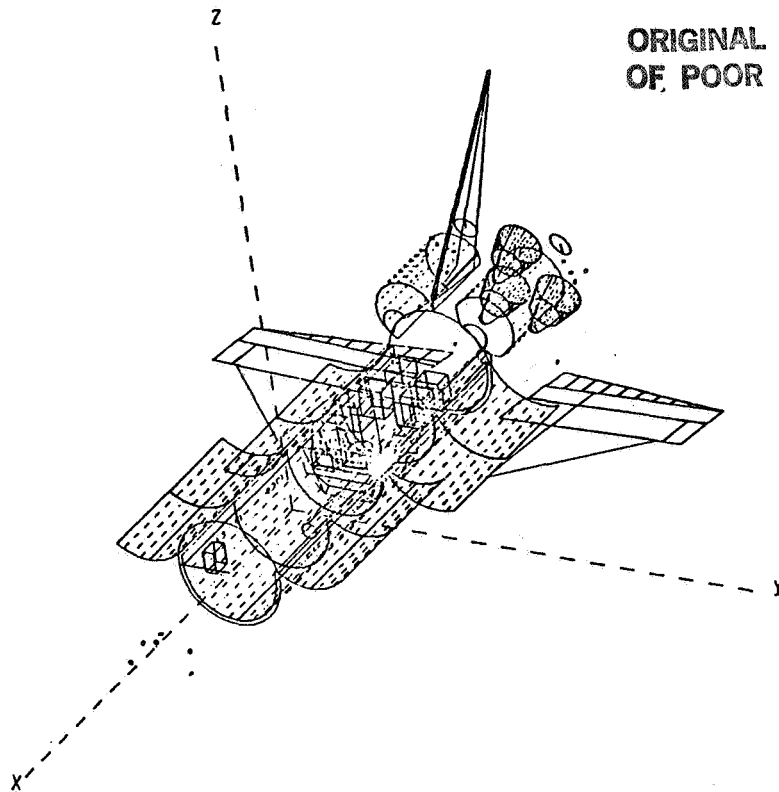
MODELING CORRELATION WITH FLIGHT DATA

● DIRECT FLOW OF OUTGASSING MOLECULES FROM BAY SURFACES
TO TQCM'S ON THE IECM

(IN 10^{-12} G/CM^2 SEC)   (STS-2/IECM IN ZLV ATTITUDE)

SPACE 2 PREDICTIONS	LOCATIONS	MEASUREMENTS
8.3	RIGHT	0...6.3
10.4	FWD	6.3...15.4
7.3	AFT	2...6.5
19.8	LEFT	0...4.0

MODELING CORRELATION WITH FLIGHT DATA

- DIRECT FLOW OF OUTGASSING MOLEDULES FROM BAY SURFACES
  TO TQCM'S ON THE IECM

  (IN 10^{-12} G/CM^2 SEC)   (STS-3/TAIL TO THE SUN ATTITUDE)

SPACE 2 PREDICTIONS	LOCATIONS	MEASUREMENTS
2.7	RIGHT	2...27
3.8	FWD	17...47
2.1	AFT	5...18
2.2	LEFT	7...25
0.07	TOP	5...15

MODELING CORRELATION WITH FLIGHT DATA

- RETURN FLUX OF WATER MOLECULES FROM THE FLASH
  EVAPORATORS TO THE MASS SPECTROMETER ON THE IECM
  (IN COUNTS PER SEC) (STS-2/IECM IN ZLV ATTITUDE)

SPACE 2 PREDICTIONS	LOCATION	MEASUREMENT
1000	TOP	250...750

MASS SPECTROMETER MEASUREMENT OF RETURN FLUX
(IN COUNTS/2 SEC, NEAR RAM ATTITUDE)

MISSION	AMU18	AMU 28	AMU 32	AMU 44
STS-2	4E+5...4E+3	(9...7)E+5	1E+4*	(7...1.5)E+4
STS-3		(1...5)E+6	1.5E+2...5E+4	≈500

*1E+4 = 1.10^4

SPACE 2 PREDICTIONS OF RETURN FLUX

(IN MASS SPECTROMETER COUNTS/2 SEC, RAM ATTITUDE)

MISSION	SOURCE	OUTG**	H_2O	N_2	CO_2	O_2
STS-2	OUTGASSING/ DESORPTION*	106	83	66	48	22
STS-2	CABIN LEAKAGE		136	14000	166	3800

*AT 20 HOURS MISSION ELAPSED TIME
**MODELED AMU:100

MODELING CORRELATION WITH FLIGHT DATA

RETURN FLUX

PREDICTED STS-2 CONTRIBUTIONS FROM MOLECULAR SOURCES TO MEASURED VALUES

MOLECULAR SOURCE* \ AMU	18	28	32	44
DESORPTION	NORMAL: MINOR TILES: MAJOR	MINOR	MINOR	MINOR
CABIN LEAKAGE	MINOR	MINOR	MODERATE	MINOR
AMBIENT N_2	-	MAJOR	-	-
AMBIENT O	-	-	MODERATE	-
OTHER	-	TO BE ANALYZED	MINOR	TO BE ANALYZED

*OUTGASSING - NO SIGNIFICANT AMOUNTS OF HEAVY MOLECULAR SPECIES HAVE BEEN
OBSERVED ABOVE PREDICTED LEVELS

RETURN FLUX MEASUREMENT ERROR ANALYSIS

MAJOR CONTRIBUTORS TO ERRORS IN THE DATA ANALYSIS ARE:

- MOLECULAR COLLISION PROCESS

- MASS SPECTROMETER CALIBRATION FACTOR, DEPENDING ON
  SYSTEM PUMPING SPEED

- MASS SPECTROMETER SYSTEM CHARACTERISTICS (H_2O, CH_4)

- AMBIENT CONTRIBUTIONS

SPACE 2 PREDICTIONS OF MOLECULAR COLUMN DENSITIES

(IN MOLECULES/CM^2 SEC)

MISSION	SOURCE	OUTG	H_2O	N_2	CO_2	O_2
STS-2	OUTGASSING/ DESORPTION***	0.6E+10**	0.2E+11	0.1E+11	0.7E+10	0.4E+10
STS-3	OUTGASSING/ DESORPTION****	0.4E+11	0.1E+12	0.6E+11	0.4E+11	0.2E+11
STS-2/3	CABIN LEAKAGE	-	0.1E+12	0.6E+13	0.7E+11	0.2E+13
STS-2	FLASH EVAPORATORS	—	1.4E+13	—	—	—
GOALS		1.0E+10*	1.0E+11	1.0E+13	1.0E+11	1.0E+13

* PER SPECIES
** 0.6E+10 = $0.6 \cdot 10^{10}$
*** AT 20 HOURS MISSION ELAPSED TIME, ZLV ATTITUDE
**** AT 20 HOURS MISSION ELAPSED TIME, TOP SUN ATTITUDE

MODELING CORRELATION WITH FLIGHT DATA

SUMMARY

- GOOD CORRELATION FOR DIRECT FLOW (TQCM)

- GOOD CORRELATION FOR RETURN FLUX, STS-2/H_2O

- CORRELATION FOR RETURN FLUX FROM OTHER MOLECULAR SOURCES/SPECIES APPEARS TO BE WITHIN EXPECTATIONS. MORE ANALYSIS IS REQUIRED

- SPACE 2 MODEL SEEMS TO BE AN ADEQUATE PREDICTIVE TOOL