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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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SKYLAB RTCC MASS PROPERTIES SYSTEM REQUIREMENTS

Mission Planning Support Office

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
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SKYLAB PROGRAM

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By E. Ray Hischke
Data Management Group

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MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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HOUSTON, TEXAS

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SKYLAB RTCC MASS PROPERTIES SYSTEM REQUIREMENTS

By E. Ray Hischke

INTRODUCTION

The Skylab Real-Time Computer Complex (RTCC) Mass Properties System should be a carryover of the present Apollo RTCC Mass Properties System with a few minor modifications and several deletions. The system should compute and maintain weight and centers of gravity for the CSM and the orbital assembly as well as SPS engine trim angles.

COMPUTATION UNITS

The miscellaneous summation unit may be used to compute various items for display or for input to other units. After all required inputs have been made to the miscellaneous unit, any number of lines may be summed. This sum should be displayed in the CSM (A), the orbital assembly (V), and the entry (ENT) coordinate systems. The CSM/OWS docking angle and docking port must be input to this unit.

The CSM input unit should be used to compute total CSM mass properties for display or for input to other units. After all required inputs have been made to the CSM input unit, all modules should be summed. This sum should be displayed in the CSM (A) coordinate system.

The digital autopilot unit may be used to compute SPS engine trim angles for an input CSM weight. The required centers of mass may be obtained from either temporary or permanent propellant depletion tables.

EQUATIONS FOR COMPUTATION

1. To compute composite center of mass (cg)

$$\vec{r}_{cm} = \Sigma \vec{r}_i m_i / \Sigma m_i$$

where $\vec{r}_{cm}$ = location of composite center of mass,

m_i = mass of each module, and

$\vec{r}_i$ = location of each module.

2. a. To transform VEH to CSM at port 5 coordinates,

$$X_{A5} = 1215.5 - X_V$$

$$Y_{A5} = Y_V \cos DKANG + Z_V \sin DKANG$$

$$Z_{A5} = -Y_V \sin DKANG + Z_V \cos DKANG$$

where DKANG = 35° - input delta docking angle

b. To transform CSM at port 5 to VEH coordinates,

$$X_V = 1215.5 - X_{A5}$$

$$Y_V = Y_{A5} \cos DKANG - Z_{A5} \sin DKANG$$

$$Z_V = -Y_{A5} \sin DKANG - Z_{A5} \cos DKANG$$

where DKANG = 35° - input delta docking angle

c. To transform VEH to CSM at port 3 coordinates,

$$X_{A3} = Z_V + 1187.3$$

$$Y_{A3} = Y_V \cos DKANG + X_V \sin DKANG$$

$$Z_{A3} = Y_V \sin DKANG - X_V \cos DKANG$$

where DKANG = 45° - input delta docking angle

d. To transform CSM at port 3 to VEH coordinates,

$$X_v = Y_{A3} \sin DKANG - Z_{A3} \cos DKANG$$

$$Y_v = Y_{A3} \cos DKANG + Z_{A3} \sin DKANG$$

$$Z_v = X_{A3} - 1187.3$$

where DKANG = 45° - input delta docking angle

3. To compute SPS engine trim angles,

$$\text{pitch} = \tan^{-1}\left(\frac{-Z}{X - 833.2}\right) + 2.15$$

$$\text{yaw} = \tan^{-1}\left(\frac{Y}{X - 833.2}\right) - .95$$

4. To compute SPS fuel and oxidizer weights for depletion table,

$$\text{Fuel} = \frac{\text{output weight - dry weight}}{1 + \text{input mixture ratio}}$$

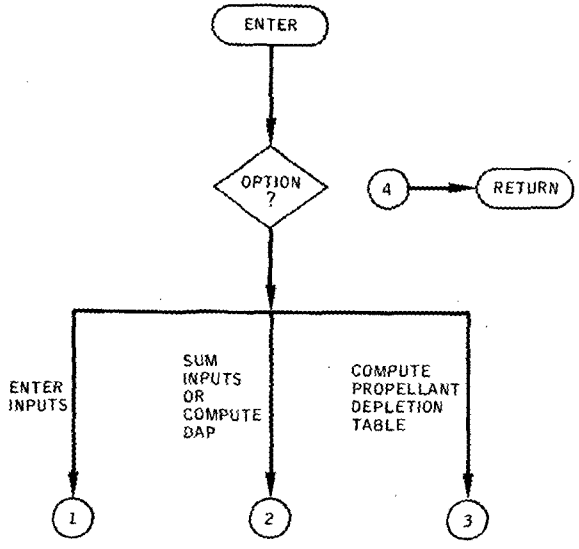
Oxidizer = fuel * input mixture ratio

5. To transform CSM to ENT coordinates,

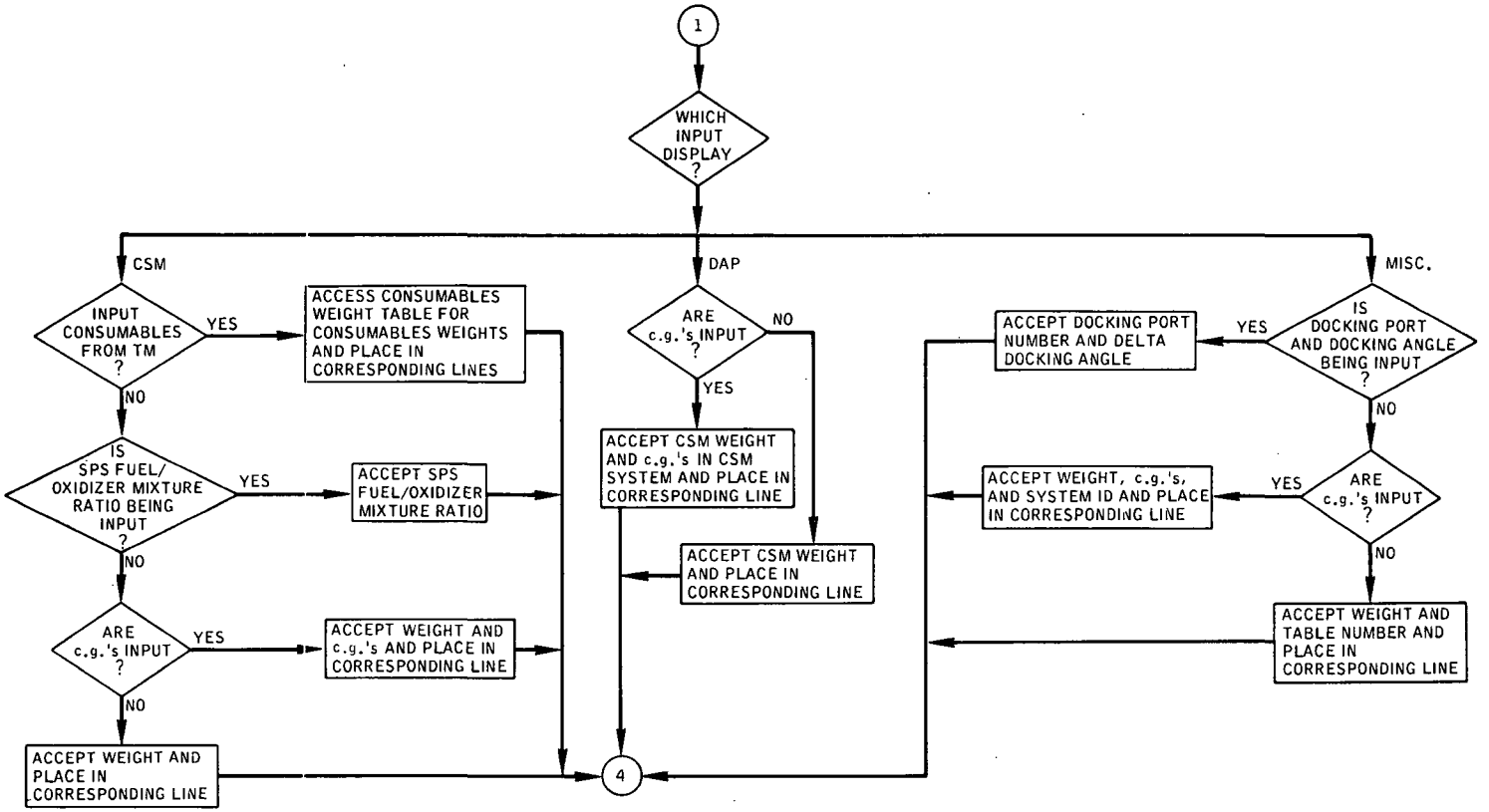
$$\Delta X = X_A - 1141.25$$

$$\Delta Y = Y_A$$

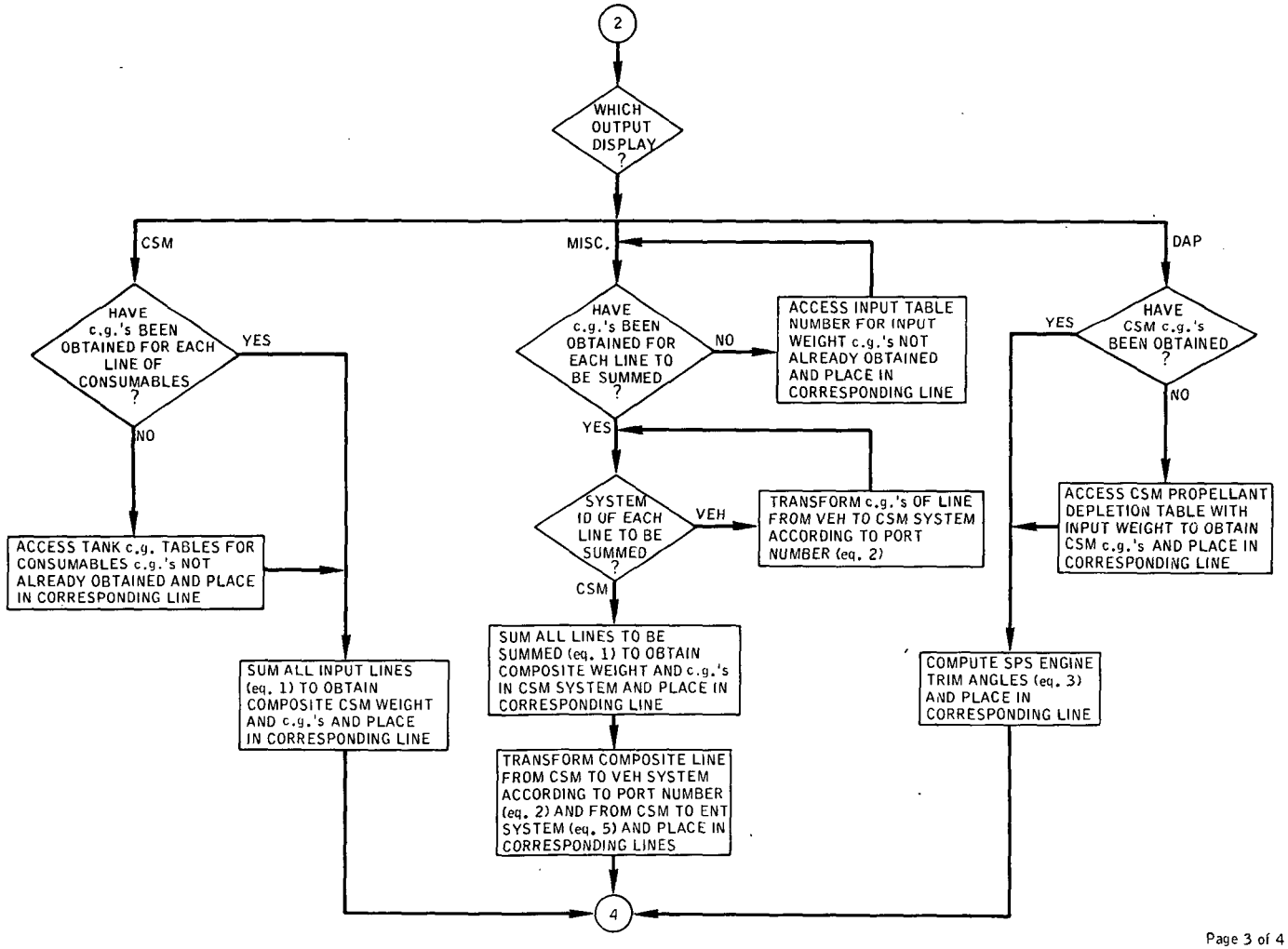
$$\Delta Z = Z_A$$



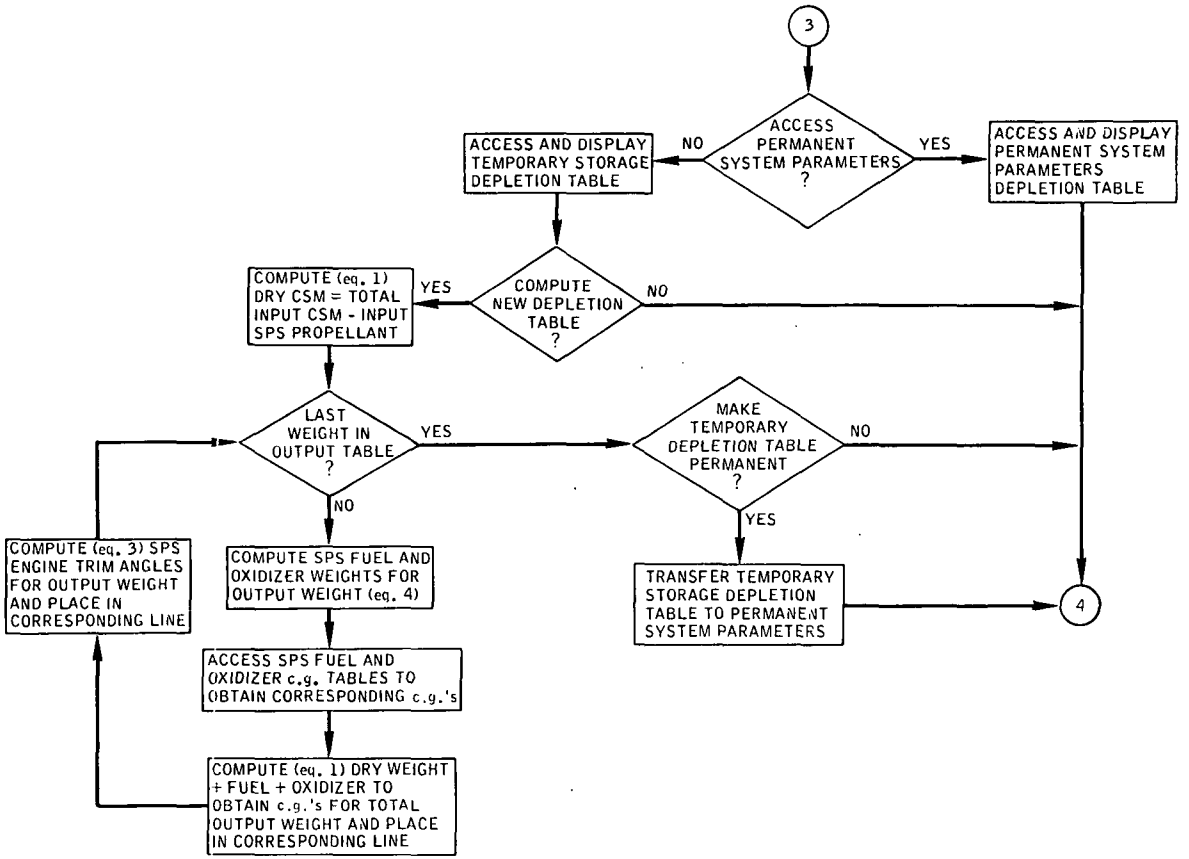
Functional flow chart.



Functional flow chart - Continued.



Functional flow chart - Continued.



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Functional flow chart - Concluded.