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MCDONNELL DOUGLAS TECHNICAL SERVICES CO.
HOUSTON ASTRONAUTICS DIVISION

SPACE SHUTTLE ENGINEERING AND OPERATIONS SUPPORT

DESIGN NOTE NO. 1.4-4-21

AN ONBOARD DEORBIT TARGET LINE COMPUTATION TECHNIQUE

MISSION PLANNING, MISSION ANALYSIS AND SOFTWARE FORMULATION

AUGUST 1976

This Design Note is Submitted to NASA under Task Order No. D0506, Subtask B1, Task Assignment C in Fulfillment of Contract NAS 9-14960.

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1.0 Summary

Prior to the decision restricting deorbit targeting to the ground for Orbital Flight Tests (OFT), a single, constant entry interface (EI) range, target line generator was being developed to provide the onboard EI target constants. This target line generator, which eventually was reduced to one linear equation, was developed to the point that it provided autonomous landing site relocation capability, negligible core storage, and acceptable performance for the cases tested. The purpose of this design note is to document the design concept and results for future reference.

2.0 Introduction

The onboard deorbit target line generator was envisioned as being a concise and time expedient software design. The objective was to design a target line generator that required only a small amount of core storage and provided landing site relocation capability. A fast, simple, reliable, and autonomous deorbit target line generator was designed and tested.

C_1 and C_2 are guidance target constants which define the entry interface V_V versus V_H target line. The C_1 value is the ordinate intercept of the V_V vs V_H target line. The C_2 value is the slope of the V_V vs V_H target line. For a given landing site,vehicle configuration, and orbit inclination, the target line varies primarily as a function of EI latitude as shown in references 1, 2, and 3.. This study was initiated to determine if a simple onboard algorithm could be designed to produce the target line as a function of EI latitude for any landing site within a given latitude band of the primary site.

3.0 Discussion

A single, constant EI range, linear C_1 vs ϕ equation was developed from several landing sites and various cross ranges. The landing sites used in this study were Cape Kennedy, Edwards, and Guam. A mission 2 orbit defined by a 230 n.m. circular orbit of 55° inclination was chosen with a south approach trajectory toward each landing site.

The nominal fourth order polynomial targeting equations for Cape Kennedy, Guam, and Edwards from earlier studies (reference 1, 2, and 3) were used to develop the linear C_1 vs ϕ equation. Referring to Figure 1, the fourth order C_1 vs ϕ targeting polynomials for Guam and Edwards are translated using the Cape Kennedy C_2 value. The Cape Kennedy C_2 value is used as a reference constant because it is the primary design landing site for mission 2 and its landing site latitude lies between Guam and Edwards. By interpolating a line through the fourth order curves, the linear C_1 vs ϕ equation will assume the Cape Kennedy C_2 value. The linear line can be interpolated differently than as shown in Figure 1 such as to minimize the C_1 margin. Minimizing the C_1 margin between the linear line and the translated curves will reduce the flight path angle error and heating penalty.

Identical ϕ_{EI} Different C_1

Referring to Figure 1, the Cape Kennedy, Edwards, and Guam fourth order C_1 vs ϕ polynomials have regions of identical latitude but different values of C_1. This dissimilarity occurs

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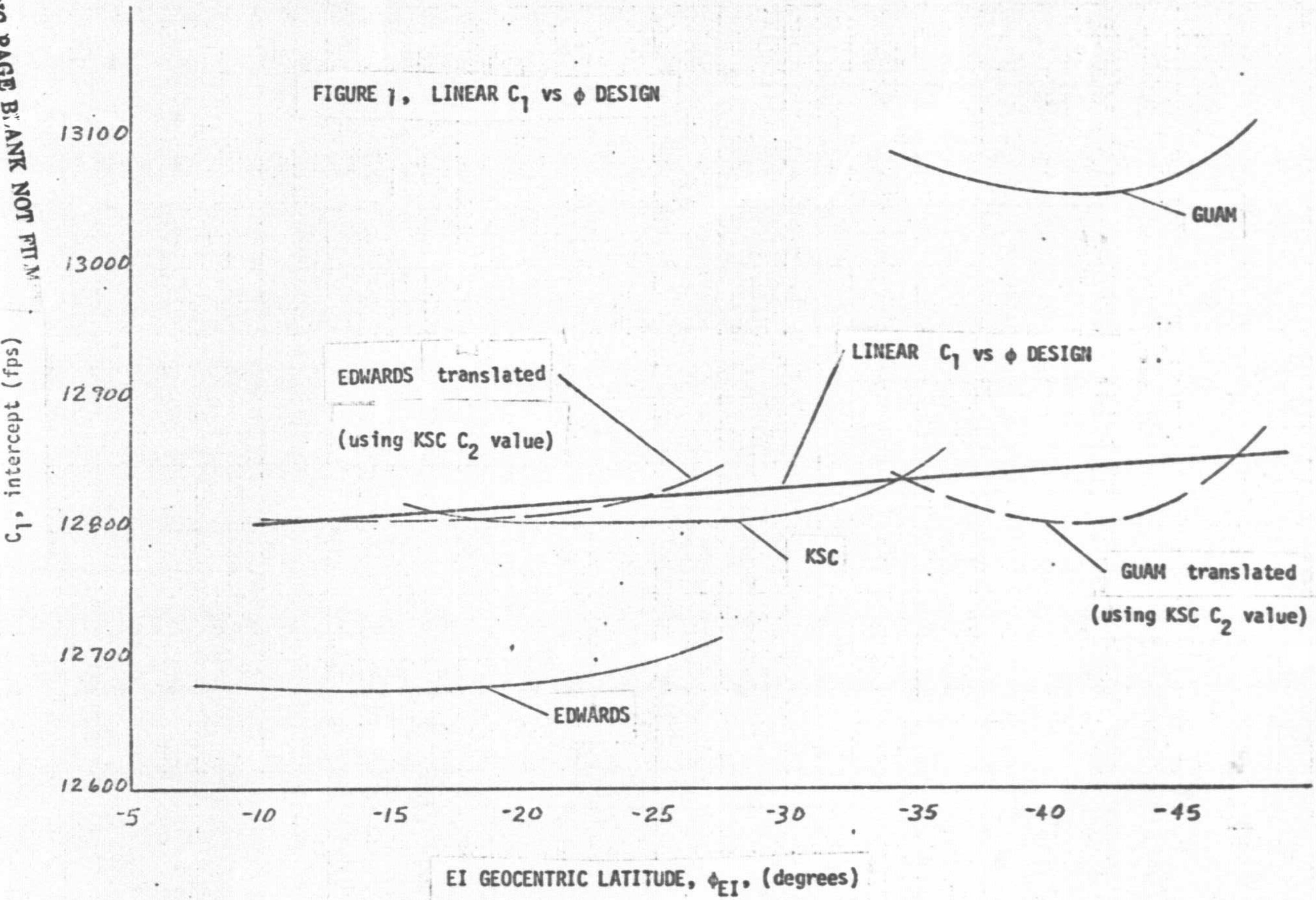

FIGURE 1, LINEAR C_1 vs φ DESIGN

from cross range differences and not from any contribution of earth oblateness. The earth oblateness effects acting on the entry approach paths having the same ϕ_{EI} will be the same. However, the cross range influence on range will affect the C_1 value.

A larger cross range trajectory will produce a larger actual distance flown compared to a smaller cross range. Since the EI range is held constant, the larger range effect due to cross range must be compensated by a shift in the V_V- V_H target line. As a result of the V_V- V_H target line shift, the value of C_1 will change. For different landing sites with the same ϕ_{EI} (as in Figure 1), the cross ranges for those ϕ_{EI} entry trajectories are different and different C_1 values result.

4.0 Results

The entry heating performance results are compared between the linear C_1 vs ϕ equation and the nominal fourth order equations in Figure 1. The entry heating data was performed for cross ranges in the region of 800 ± 100 n. m. The difference in the maximum backface over-temperatures for the Cape Kennedy trajectory was 1.63,° 1.20° for the Edwards trajectory, and 0.38° for Guam. In all cases, the maximum surface temperatures decreased slightly with the linear line. In the same respect, the largest flight path angle error at entry interface for the performance data collected was 0.0266 degrees which did not adversely affect the heating results. However, the worst possible performance case which occurs at ϕ_{EI} = - 42.5° (see Figure 1) and would result in a flight path angle error of about 0.094 degrees was not evaluated since onboard deorbit had been abandoned at the time and no further consideration was given to thorough performance evaluations.

5.0 Conclusion

The results of this study indicate that a single, constant EI range, linear C_1 vs ϕ equation shows promise of determining the C_1 and C_2 target line constants for multiple landing sites with reliable performance results. Even though an extensive performance evaluation was not conducted, this initial design concept warrants consideration if at a later date onboard deorbit targeting is reinstated.

6.0 REFERENCES

1. TM 1.4-4-C-28: "Onboard Deorbit Targeting Module Entry Interface Target Line Storage and Retrieval," 18 February 1976.

2. TM 1.4-4-C-30: "Simplified Entry Targeting Generator (SETG) Applied to a Guam Landing Site," 18 February 1976.

3. TM 1.4-4-C-34: "Onboard Deorbit Targeting Module (SETG) Entry Interface Target Line Storage and Retrieval," 18 March 1976.