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MATHEMATICA

ECONOMIC ANALYSIS OF THE SPACE SHUTTLE SYSTEM

See page 0-19: 0-33 on Space Tug being

Prepared for

National Aeronautics and Space Administration

Washington, D.C. 20546

Jan. 31, 1972

EXECUTIVE SUMMARY

0.1 CONCLUSIONS

The major conclusions of the Economic Analysis of the Space Shuttle System are:

- o THE DEVELOPMENT OF A SPACE SHUTTLE SYSTEM IS ECONOMICALLY FEASIBLE ASSUMING A LEVEL OF SPACE ACTIVITY EQUAL TO THE AVERAGE OF THE UNITED STATES UNMANNED PROGRAM OF THE LAST EIGHT YEARS.
- o A THRUST ASSISTED ORBITER SHUTTLE (TAOS) WITH EXTERNAL HYDROGEN/OXYGEN TANKS IS THE ECONOMICALLY PREFERRED CHOICE AMONG THE MANY SPACE SHUTTLE CONFIGURATIONS SO FAR INVESTIGATED. EARLY EXAMPLES OF SUCH CONCEPTS ARE RATO OF MCDONNELL DOUGLAS, TAHO OF GRUMMAN-BOEING, AND SIMILAR CONCEPTS STUDIED BY NORTH AMERICAN ROCKWELL AND LMSC - LOCKHEED; THESE CONCEPTS ARE NOW COMMONLY KNOWN AS ROCKET ASSISTED ORBITERS (RAO).
- o THE CHOICE OF THRUST ASSIST FOR THE ORBITER SHUTTLE IS STILL OPEN. THE MAIN ECONOMIC ALTERNATIVES ARE PRESSURE FED BOOSTERS AND SOLID ROCKET MOTORS, EITHER USING PARALLEL BURN. A THIRD ECONOMIC ALTERNATIVE TO THESE VERSIONS IS TO USE SERIES BURN BOOSTERS.

These conclusions are based on the following results of the economic analysis:

Union) -- was confined to between 500 and 900 Space Shuttle flights in the 1978 to 1990 period, the present analysis was confined to look at the range of Space Shuttle flights between 400 and 650 Space Shuttle flights, with major variations in the analysis at 514 and 624 flights.

Two separate benefit lines were arrived at and are shown in Figure 0.3: first, the analysis concentrating around 514 Space Shuttle flights shows the economic results with the exclusion of some DoD missions that are particularly suited for Space Shuttle operations; second, the analysis concentrating at around 624 Space Shuttle flights takes the same NASA mission model, now, however, including on the DoD side the missions omitted in the first analysis.

With regard to the lower benefit line, we conclude that at 514 flights in the 1979-1990 period, the estimated benefits of a Space Shuttle System are $10.2 billion in 1970 dollars with a variance of $940 million -- expressed in allowable non-recurring costs. The economic "break even" point is reached at an annual space activity level of about 30 Space Shuttle flights, carrying satellite payloads. This annual level of NASA and DoD space activity in the 1980's and beyond will justify the development of the TAOS Space Shuttle at a social rate of discount of 10 percent.

When, on the other side, Space Shuttle related DoD missions are included, the economic analysis shows, at 624 Space Shuttle flights in the 1979 to 1990 period, an estimated benefit of $13.9 billion of allowable non-recurring costs, with a standard deviation of $\pm$ $1.45 billion. As activity levels are increased or decreased around these space programs, the expected benefits of a Space Shuttle System increase or decrease as shown by the two benefit lines in Figure 0.3. The TAOS Space Shuttle System will "break even" at an annual activity level of about 25 Space Shuttle flights, carrying satellite payloads, when the "624" mission model is taken as representative of U. S. space activities in DoD and NASA for the 1980's.

Again, we want to emphasize that these results reflect the benefits of a Space Shuttle System when applying a 10 percent real social rate of discount to the complete economic analysis.

Document II-15

Document title: James C. Fletcher, Administrator, NASA, to Senator Walter F. Mondale, April 25, 1972.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

Democratic Senator Walter Mondale of Minnesota was a skeptic with respect to the wisdom of developing the Space Shuttle from the time the program was first proposed in 1970. In this letter to Mondale, NASA Administrator Fletcher provides a top-level overview of the expectations for the Shuttle program shortly after it was approved by President Nixon, as well as a final configuration selected. The March 15 Appendix to the Space Shuttle Fact Sheet to which Fletcher refers as an enclosure does not appear here.

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[1] NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Washington, D.C. 20546

April 25, 1972

OFFICE OF THE ADMINISTRATOR

Honorable Walter F. Mondale
United States Senate
Washington, D.C. 20510

Dear Senator Mondale:

This is in further response to your letter of February 23, 1972, on the space shuttle. The answers to your 22 questions are numbered as in your letter; to save space I have given a brief indication of the subject of each question in lieu of repeating the question in its entirety. All cost estimates are stated in current dollars.

1. Projected Costs of the Space Shuttle

The estimated costs of the space shuttle program are as given below. These estimates correspond to those in the Appendix to the Space Shuttle Fact Sheet, as revised March 15, 1972 (copy enclosed).

a. Development and initial investment costs:
   (1) Development cost, based on the use of the recoverable parallel-burn solid rocket motor booster configuration now selected, and with prudent provision for potential cost increases as development proceeds . . . $5.15 billion
   (2) Facilities costs for development and initial operations, including launch and landing facilities to be provided at the Kennedy Space Center . . . $.3 billion
[2] (3) Investment for initial operating inventory. This is subject to future decisions based on requirements in the late 1970's and early 1980's. On the reasonable assumption that 3 production and 2 refurbished orbiters will be needed, we have allowed in our projections a total of . . . $1.0 billion
   Total development and initial investment $6.45 billion
b. The later additional investment costs required at and after the end of this decade to fly a reasonable mission model all through the 1980's are estimated at $1.6 billion. This amount includes the $500 million estimated to be required for the sec-

10. Space Station

NASA's space station studies have been completed and there are no present plans for development, production, or specific missions. The mission model study referred to above assumes that a 6-man space station might be operational in the mid-1980's. The non-recurring costs of development and investment for a space station of this type has been estimated at about $3 billion. An amount of this magnitude is compatible with my earlier statement [6] that all costs of the space shuttle program and the other elements of a balanced total space program can be accommodated in an overall space budget at about the present annual levels. The decision to proceed with the space shuttle does not commit the Nation to proceed with a space station.

11. Mathematica Study

The Mathematica, Inc. study concludes that the space shuttle can be justified on economic grounds for a wide range of possible mission models. Mathematica studied in detail a range of discrete mission models calling for from 681 to 403 shuttle flights over a 12-year period (1979–1990). When these results were extended to even lower numbers of flights, Mathematica found that even with a 10% discount rate the break-even point occurred at 360 flights over the 12-year period. Thus the shuttle would represent a good investment even if the total number of flights did not exceed an average of 30 per year, or even less if a period longer than 12 years had been assumed for the useful life of the shuttle. (It should be noted that both Atlas and Thor boosters have been in use for over 13 years.) The Mathematica conclusions do not depend on the weight of the payloads associated with the program. A copy of the final Mathematica, Inc. report and related reports by Aerospace Corporation and Lockheed were sent to you some time ago.

12. Assessment of Mathematica Study

The Mathematica, Inc. study has been subjected to review by NASA management and within the Office of Management and Budget, and has been presented by Dr. Oskar Morgenstern of Mathematica to a number of other professional economists and to the Senate Committee on Aeronautical and Space Sciences. I am not aware of any professionally competent adverse criticisms of either the methodology or the findings. On the other hand, many of us, including myself, believe that the constraints placed by Dr. Morgenstern and his people on the scope of the study, whereby they excluded the benefits of any missions which would be beyond today's state-of-the-art, or which would not be possible of performance using expendable vehicles, represented an extremely conservative approach which has resulted in an understatement of the real advantages that will result from the introduction of the space shuttle.

[7] 13. Military Use of the Shuttle

The space shuttle can be used for both civil and military missions; in both cases the number and nature of the missions to be flown are matters for future decision. In the mission model referred to in the enclosed Fast Sheet Appendix, military missions represent substantially less than one-half of the total.

14 and 15. Cost per Pound of Payloads

The cost per pound of scientific and technical payloads is not particularly useful as a general measure. First, it can vary greatly depending on the design and use of the