BIG DUMB BOOSTER STUDIES

Although several corporations and the Government have conducted analytical studies and tests of the Big Dumb Booster concept, the results of one study often contradict the findings of another. This section briefly summarizes the results of these analyses.

Favorable Studies

The first stage engine of the original Aerospace Corporation Big Dumb Booster was to have 1.5 million pounds of thrust, the same as the Saturn V. Because of the Big Dumb Booster's greater weight, its payload capacity was only 43,000 pounds, compared to the Saturn V's 250,000 pounds. Yet the study concluded that this rocket would cost 25 times less than the Saturn V, yielding a cost per pound to low earth orbit five times lower than the Saturn V.

In the late 1960s, several aerospace companies performed system studies on minimum-cost launch vehicles. One study done for NASA proposed a family of three rockets. The largest would have employed two 3 million pound thrust engines in the first stage, giving it a payload capacity of 120,000 pounds, half that of the Saturn V.[26] This booster would have been the same height as the Saturn V and weighed twice as much, but would have been able to place a pound in orbit for one-quarter the cost of the Saturn V.[27]

McDonnell Douglas proposed building a 22-foot diameter solid booster coupled with a Saturn IVB second stage to deliver 100,000 pounds to low-earth orbit for a cost of $270 per pound (in 1967 dollars), less than half the cost of a Saturn V.[28]

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26 National Aeronautics and Space Administration, Transportation Systems Division, "Low Cost Launch Vehicle Study," contractor report NASW-1792, June 23, 1969, p. 1.8; see also G.W. Elverum, Jr., "Scale Up to Keep Mission Costs Down," 24th International Astronautical Congress, October 1973.

27 However, in order to launch the Saturn V payload, such an approach would require a total thrust of 8.7 million pounds.

28 National Aeronautics and Space Administration, Marshall Space Flight Center, "Use of Large Solid Motors in Booster Applications," contractor report NAS-8-21051, Aug. 30, 1967.

The Government conducted some demonstration projects on Big Dumb Booster engines. In the late 1960s the Air Force supported 120 ground tests of pressure-fed engines scaled up to 250,000 pounds of thrust. Also in the 1960s, NASA Lewis Research Center managed the 260-inch diameter solid rocket program, which utilized a motor designed by Aerojet. Three successful firings were completed for thrust levels from 3.0 to 7.5 million pounds.

These hardware developments and systems studies prompted the Air Force to start an R&D program for a minimum-cost launch vehicle in 1968. However, the program was cancelled before a thorough analysis of the overall life-cycle costs of such a booster could be established. Most of the Big Dumb Booster research was officially abandoned in 1972 when President Nixon chose to pursue the piloted, reusable Space Shuttle instead of continuing development of ELVs. Reusability of the expensive Shuttle orbiter appeared to provide substantial cost reductions over expendable systems.

A 1982 study for NASA reintroduced the concept as a proposed “Low Cost Shuttle Surrogate Booster” that could be used to carry cargo in place of the Shuttle.[29] This study reached many of the same conclusions as earlier studies. It envisioned a booster having roughly the same height and take-off weight as the Saturn V, but carrying a Shuttle-sized payload of 65,000 pounds, or one-fourth that of the Saturn V. The additional weight of this design resulted primarily from its heavier half-inch thick steel tanks.

Unfavorable Studies

Although favorable studies have reported up to five-fold cost reductions with Big Dumb Boosters, other studies have concluded that these designs would not reduce costs at all. One workshop participant, whose company examined the idea in the late 1960s, said, “We were one of the earliest supporters of the ‘low-cost’ approach, but the more we studied it the more it cost."

29 “Study of a Cost-Optimized Pressure-Fed Liquid Rocket Launch Vehicle,” D.E. Fritz and R.L. Sackheim, paper No. AIAA-82-1108, AIAA 18th Joint Propulsion Conference, June 1982.

A 1969 McDonnell Douglas study for NASA compared 32 low-cost launch vehicle designs.[30] configurations with pressure-fed engines were judged to be more costly than conventional boosters with pump-fed engines.

In 1985 Martin Marietta and General Dynamics were asked by the Air Force to analyze Big Dumb Boosters because of the "intuitive attractiveness" of the design.[31] The studies concluded that total launch system costs per flight would be 40 to 50 percent more for a pressure-fed Big Dumb Booster than for a comparable pump-fed booster. They found that cost savings achieved by simpler engines were offset by the greatly increased weight of the vehicle.[32]

Critique

None of these studies is definitive, as each was pursued only at the conceptual design level. Big Dumb Booster proponents argue that the unfavorable studies fall into the trap of analyzing the concept according to models that assume costs are proportional to weight.[33] This unfairly penalizes Big Dumb Booster approaches, and "woefully underestimates the development, fabrication, and testing costs resulting from the complexity of today's minimum weight launch

30 "Integral Launch and Reentry Vehicle Study--Parametric Vehicle Comparison," NASA contract 9-9204, March 1969.

31 Dr. Richard Weiss, Chief Scientist, Air Force Astronautics Laboratory, personal communication, Dec. 1, 1987.

32 However, one reviewer noted that, "The flaw in these studies was to overemphasize the cost of propellant and materials and underestimate the increase in personnel resulting from using more complex hardware with complicated interfaces."

33 One reviewer noted that any good cost estimation considers truly analogous data and appropriate adjustments for complexity, rather than merely comparing weights. At the current state of the art, it is easier to compare the materials and manufacturing costs of proposed vehicles than it is to compare operations costs.

vehicle design." Indeed, it may be futile to draw inferences about "what can be" based on "what has been." As one workshop member noted, historical data may be innocently biased by company experience. In some cases, the data are two decades old.[34]

Part of the disagreement on Big Dumb Booster costs may be the result of different accounting assumptions. Big Dumb Booster opponents maintain that technology choices that reduce cost in one area, such as engines and tanks, may drive up costs elsewhere, for example by requiring larger launch pads and facilities. A number of panel members criticized the early, optimistic studies for not adequately considering ground operations costs.

Reducing operations costs is critical to reduced life-cycle costs.[35] Operations costs may account for more than half of the total life cycle costs of a launch system.[36] Big Dumb Booster supporters on the workshop agreed that a credible study of the Big Dumb Booster would have to include detailed estimates of operations costs.

Variations in study assumptions or ground rules will profoundly affect the outcome of cost comparisons. For example, flight rates assumed in one study are often very different from the flight rates assumed in other studies. Most studies assume major increases in demand. Because assumed future launch rate is a major driver of estimated life-cycle cost, a study that based its cost projections on an expectation of many future launches would be biased because that system would have a high number of flights over which to amortize its development costs.

Another significant factor that can perturb straightforward cost-reduction concepts, such as the Big Dumb Booster, is the application of principles of recovery and reuse. Proponents of reusable systems point out that the use of costly, high-performance components is justified if they can be reused often enough. However, the potential cost savings of reusable or

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34 See *Reducing Launch Operations Costs: New Technologies and Practices,* op. cit., Appendix A for a discussion of the uncertainties and subjectivity in current space transportation cost-estimating models.

35 *Reducing Launch Operations Costs: New Technologies and Practices,* op. cit.

36 For the Shuttle, one analysis estimated that costs for launch and mission operations will account for 86 percent of the total life cycle costs. National Aeronautics and Space Administration, "Shuttle Ground Operations Efficiencies/Technologies Study," Kennedy Space Center, NAS10-11344, May 4, 1987.

partially reusable systems are not well understood, nor sufficiently demonstrated. The Naval Research Laboratory (NRL) has just started a small program to develop a pressure-fed, recoverable, launch vehicle that could be launched from the ocean.[37] This sea-launch concept could apply to a wide variety of launcher sizes. If recovery and reuse prove successful, the concept could provide a basis for providing reduced-cost launches. Although NRL's initial analysis appears promising for small launchers, several years of development and testing would be required to prove the concept, especially for large launchers.

The NASA LRB study has analyzed the costs for system design, development, testing and evaluation (DDT&E), unit manufacture, and operations for both pressure-fed and pump-fed Shuttle LRBs. The study indicates essentially equal DDT&E costs for both, but lower unit costs for the pump-fed concept.[38] The pump-fed concept therefore appears the technology ‘f choice for Shuttle liquid rocket boosters. Assumed flight rates varied between nine and 14 per year.

37 Naval Research Laboratory briefing to OTA, Dec. 27, 1988.

38 NASA briefing to OTA, September 1988.