Five P's of Progress at NASA

This application of the Five P's of Progress underscores the need to apply purposeful methods to Math and Science education to be effective in the industry. Preparation for virtual reality programming solutions should begin early in education and should be strategically phased. Appropriately designed coursework can save both time and resources that are typically wasted by trial-and-error fabrication and testing of new and existing products.

1. Purpose

In 1999, NASA's 70 Meter antenna had a servo drive system that was worn out and no longer commercially available. The servo drive system used computers, electrical/electronic, and hydraulic

equipment track spacecraft in deep space. The drive system was comprised of a bull gear, pinions, gear reducers (Figures 35 &36), hydraulic motors, hydraulic lines (Figure 2 below), servo-pump, and servo-valve, etc. New vendors had to be selected to fabricate parts due to commercial obsolescence of the original parts. Prior to the manufacture of new parts, vendors needed details on how to design the parts to meet the original design intent of moving and pointing 9 million pounds of antenna structure while accounting for expected wind loads.

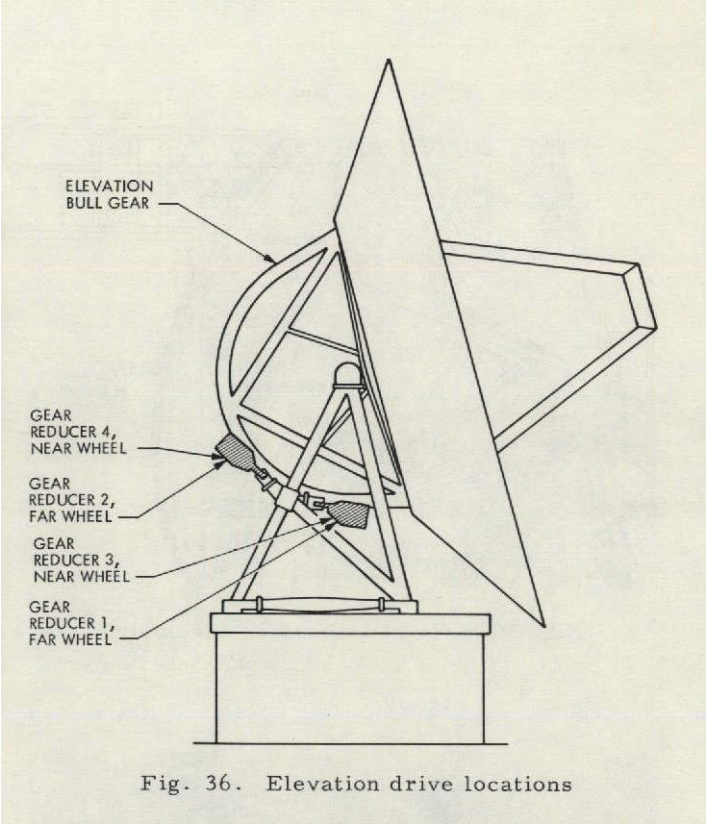

Fig. 36. Elevation drive locations

2. Plan

Previous test reports (Dalmo Victor), from many years back, showed anomalies in the antenna's performance that were not explained. This is the configuration of the of DSN's 70 meter antenna hydraulic circuit (See pages 6-7 of PDF) prior to the 70 Meter Antenna retrofit showing the long hydraulic lines between the hydraulic motors and the servo-valve.

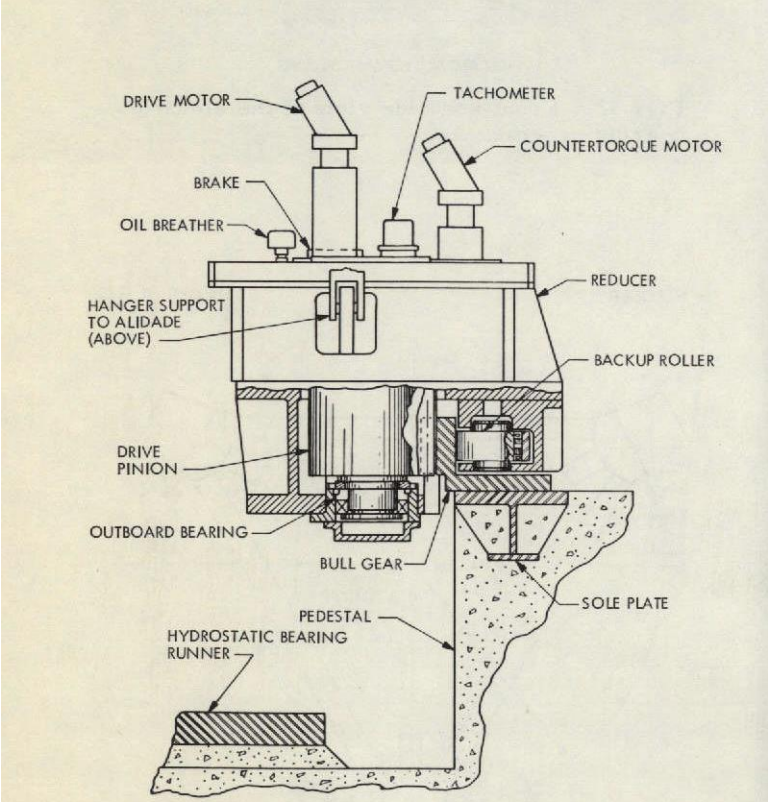

Fig. 35. Cross section of azimuth gear drive reducer

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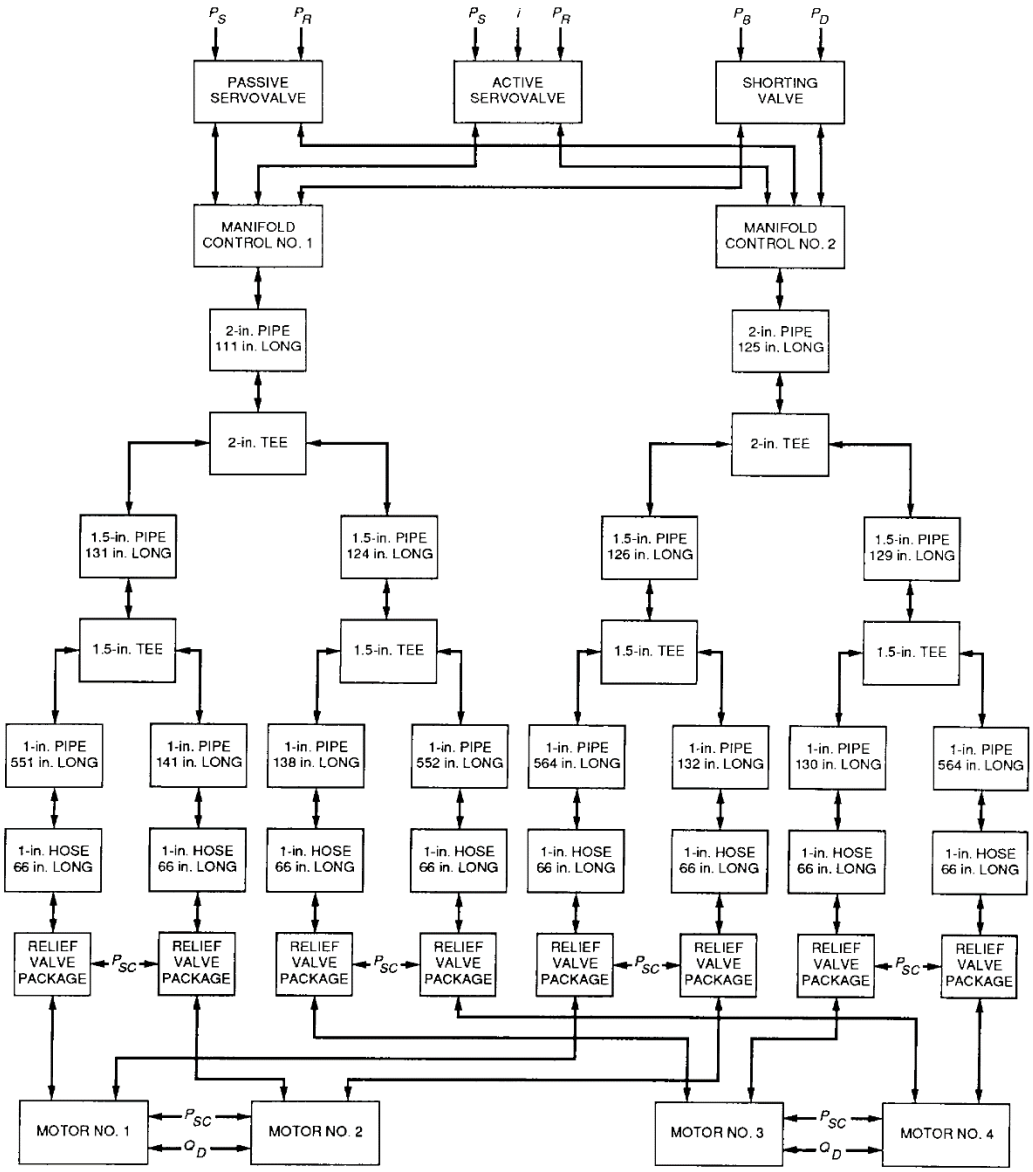

Fig. 2. DSN 70-meter antenna servo hydraulic system azimuth component layout.

3. Preparation

A white paper was developed to understand the antenna's functional operations and design margins. The paper determines the antenna's rotational motion parameters, using signatures or clues offered by the hydraulic system. Judging from anomalies in previous mechanical test reports from many years back, a 3-dimensional transient hydraulic model was also developed to guide in the redesign of the drive system and retrofitting effort. A computer model of the servo drive system was developed to evaluate pointing and slewing performance margins.

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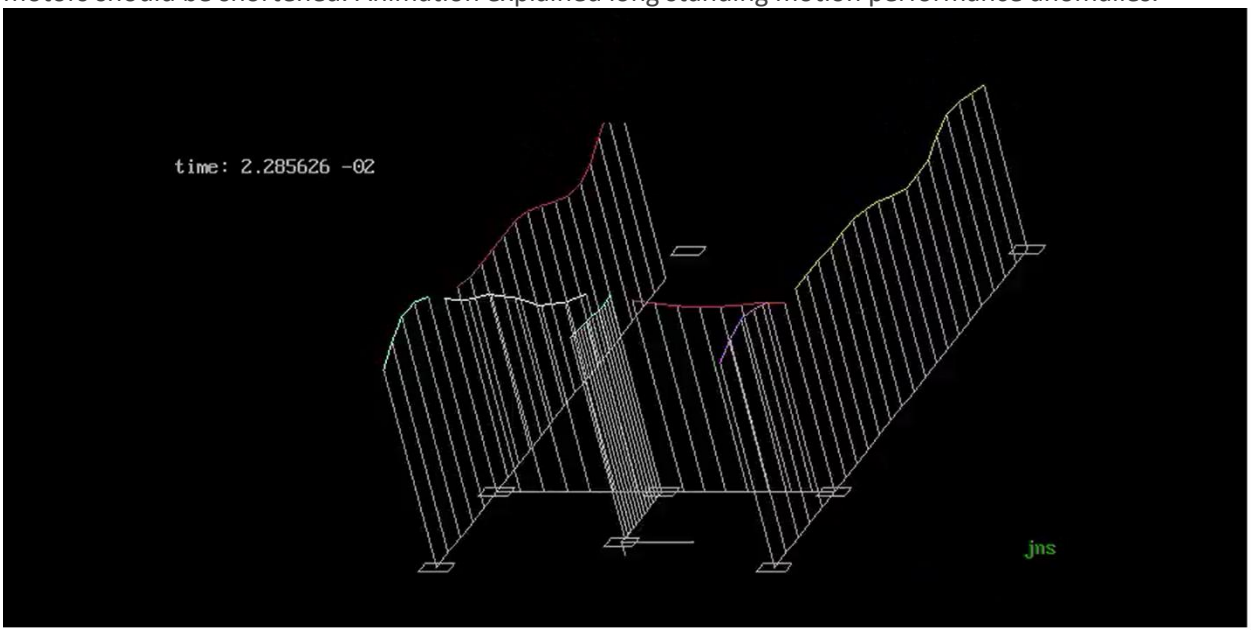
4. Practice

Animation software from ICBM liquid propulsion systems and from aerial refueling systems design and development was used to explain why long hydraulic lines between the servo-valve and hydraulic motors should be shortened. Animation explained long standing motion performance anomalies.



The four rectangles at the extreme ends of the pipe network animation image above represent the four hydraulic motor ports. The forwardmost rectangle in middle of pipe network, where the pressure disturbance starts, represents the active servo-valve (See Figure 2 above).
Animation of hydraulic pressures showed why the hydraulic motors chattered causing excessive, premature wear between pinions and the bull gear of the 70 Meter antenna. Animation is a cheaper, more versatile alternative to purchasing and installing instrumentation on the servo drive system components and conducting data acquisition for various modes of operation.

5. Progress

The 70 Meter antenna hydraulic system was redesigned with shorter hydraulic lines between the servo-valve and the hydraulic motors. A servo-system prototype was built by a company in Texas to validate the predictions of the computer animation and servo system analysis.

Undergraduate coursework aimed at performing virtual reality programming should be developed further. Twenty years have elapsed since this project was completed. Over the course of twenty years, opportunity to expand these tools and skills into the classroom has been frequently met with considerable resistance due to politics, traditions of tenure, lack of awareness, and status quo.

Check your if your school curriculum offers something similar. MSCsoftware products are a commercial version of what students should be doing in the classroom starting with the application of math education using goals similar to "coding CANVAS", then moving to virtual reality programming in physics classes, similar to this example. The traditional siloed approach to education where software is absent

from the coursework leads to professional isolation, and incapacity due to "tunnel vision" that siloed education methods foster. This is the typical work of a **simulation/integration engineer**. There is an increasing industry demand for these type skills. Check your favorite job boards to verify this statement.