expensive hardware mockups. The elimination of hardware mockups (difficult to maintain in the latest configuration) saved 150,000 man-hours on the V-22 EMD program. Parts are then digitally pre-assembled to catch design errors early, when changes are least expensive, prior to fabrication.

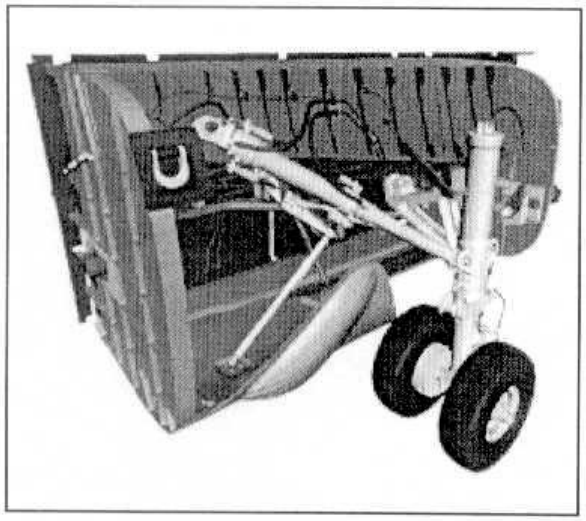

Figure 8. Landing Gear Solid Model

VERICUT™, a tool for providing Numerical Control programming concurrent with product design, uses the same CATIA™ data base. The NC programmers "fabricate" their part electronically (using VERICUT™) to determine cutter feeds and speeds. Once the part has been "electronically fabricated" the original design model is over-laid on the fabricated part and any areas of divergence are immediately apparent to the NC programmer who can then take appropriate corrective action.

VALISYS™, a valuable quality control software tool also tightly integrated with the CATIA™ system, provides a necessary link between engineering and manufacturing. It provides the capability to check the engineering design to verify and ensure that the geometric dimensioning and tolerances are correct to the standard, and it allows part tolerances to be represented in the three-dimensional models. Where these tolerances are critical for the assembly of detailed parts, they are labeled as key characteristics.

Since variations can occur during manufacturing, VALISYS™ performs quality checks to ensure that part integrity is maintained throughout the fabrication process. VALISYS™ helps design quality into not only the product, but also the manufacturing process.

Using CPD, IPTs, DPA, VERICUT™, and VALISYS™ lowers cost and increases product quality. These benefits were validated early in the product development process and disseminated to the IPTs if corrective action was required. The result has been increased quality because individual parts are designed with producibility and ease of assembly considered from the beginning; this, in turn, permits proper manufacturing tolerances and decreased variation so parts fit correctly the first and every time. As an example, the three sections that comprise the V-22 airframe were successfully mated in one-half hour (excluding fastening). In FSD this process took several days.

Manufacturing Technologies and Systems

To develop the V-22, Bell-Boeing is incorporating some of the most technically advanced manufacturing systems available today. These systems are integral parts of the CPD process, and Bell-Boeing is investing in them to take full advantage of the cost and economic benefits they generate for military and commercial applications.

When comparing the traditional manufacturing technologies employed on the FSD V-22, to the advanced systems being used to manufacture the EMD configuration, the evolution is profound. Now, advanced machines, utilizing the CATIA™ database, robotically manufacture large, one-piece composite sections and high-speed-machine single-piece aluminum frames from billets for the V-22. These systems allow engineers to eliminate hundreds of parts and dedicated tooling. Four important systems being used are optical lay-up template, trim and drill cell, advanced technology assembly, and fiber placement.

Optical Lay-up Template

For flat or simple contour parts, hand lay-up using composite broad-goods is often the manufacturing process of choice. To improve the efficiency of hand lay-up, new technologies and manufacturing concepts are being used to build the V-22. Bell-Boeing has implemented a new, laser-based ply locating system called Optical Layup Template (OLT) in the composite manufacturing facility. The system combines laser technology and various optical components with data supplied by CATIA™ to project a three-dimensional image of a detail onto a contoured lay-up tool, Figure 9. This three-dimensional capability means the laser line will conform to ply lay-up surfaces, thus eliminating the need for labor-intensive locating templates previously needed to fabricate composite parts. Coupling OLT with CATIA™ allows changes to engineering designs to be made instantaneously with no need to fabricate new templates. Reduced template fabrication results in major savings in the cost of producing storing and maintaining expensive templates.