THE ISOSAT SMALL SATELLITE A DESIGN IN ISOGRID TECHNOLOGY

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ABSTRACT

ISOSAT, a small hexagonal shaped satellite structure, was designed and constructed in the Industrial Technology Department at Utah State University as a senior research project using automated manufacturing techniques and incorporating the "Isogrid" structure concept. Isogrid applications can be found in projects such as Skylab, most cylindrical structural elements of the Delta rocket and in the engine shrouds of Boeing's new 777 commercial airliners.

The basis of the Isogrid is the repeating pattern of equilateral triangles which make up the structure. This pattern, machined into solid aluminum plates, results in a substantial weight savings with an acceptable reduction in structural strength. The intersections of adjacent triangles are referred to as nodes. These nodes serve as uniformly distributed attachment points for the mounting of instrumentation and other hardware.

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BACKGROUND

Isogrid technology began as early as 1964 when Dr. Robert R. Meyer along with Oliver P. Harwood, working under a NASA-MSFC contract, set out to find a stable, lightweight structure for compressively loaded domes. The most promising was a pattern of repeating triangular stiffening members. This pattern had the advantages of: being more stable than a cubic arrangement, efficient in both compression and bending and providing uniform attachment points at triangle intersections, referred to as nodes. The pattern is isotropic in nature, hence the name: "Isogrid". Key points of the Isogrid concept are listed in Table 1 taken from the *Isogrid Design Handbook.*

* A lattice of intersecting ribs forming an array of equilateral triangles

* Characteristics:

  - Isotropic (no directions of instability or weakness)
  - Poisson's Ratio = 1/3
  - Efficient in compression and bending

* Advantages:

  - Easily Analyzed
  - Can be optimized for wide range of loading intensities
  - Standard pattern for attachment (nodes accommodate equipment mounting without change)
  - Readily reinforced for concentrated loads and cutouts
  - Redundant load paths

Table 1 ISOGRID

Dr. Meyer's work showed significant promise and was extended to cylinders as an Independent Research and Development program. Aside from ISOSAT, the Isogrid concept has been used for workshop interiors aboard Skylab and is currently used in the engine shrouds of Boeing's new 777 commercial airliners as well as most cylindrical structural elements of the Delta rocket.

Another advantage of the Isogrid pattern is the ease with which it lends itself to CNC (Computer Numerical Controlled) machining. It allows the designer to scale the grid pattern and the numbers of nodes to fit an individual project's needs just by changing a few parameters on a computer terminal. The overall symmetry of the pattern also allows for precise indexing of larger parts using simple tooling fixtures.

ISOSAT

Based on the principles discussed above, Utah State University in cooperation with Ecliptic Astronautic Company of Pasadena, California, has designed a small ISOSAT spacecraft structure, to be carried aloft in a GAS (Get Away Special) canister in the cargo bay of the Space Shuttle and then ejected into independent orbit. A prototype has been manufactured and sent to various organizations for comment before proceeding with the flight article.

This prototype, know as ISOSAT 1, is a hexagonal cylinder, 18.25 inches in height and 19 inches at its widest point. Its 6 side panels are connected by Tungsten Inert Gas (TIG) welding and it features interchangeable endplates as well as a moveable center shelf to further increase the number of possible attachment points. This prototype is shown in Figure 1.

ISOSAT 1 is currently being examined and evaluated for future design refinements by numerous organizations for possible incorporation into their microspacecraft projects. Pending further design modifications, including removable side panels and multiple shelves, ISOSAT 2 will be completed by late summer 1992 and will be test flown, during this conference, on a high-altitude research balloon. Expected weight reduction will be 80-90% over solid aluminum plate.

Example plates of numerous variations have been produced which show the versatility of the pattern as well as the extremely thin webs and skins that can repeatedly be machined under CNC control. These plates are shown in Figure 2.

ISOSAT 1 shows that the Isogrid design concept yields an extremely versatile system for component attachment as well as a very desirable strength to weight ratio. It has also proven that Utah State University's ITE department in conjunction with Space Dynamics Laboratory, is capable of producing low-cost innovative space structures using highly accurate CNC machine tools.

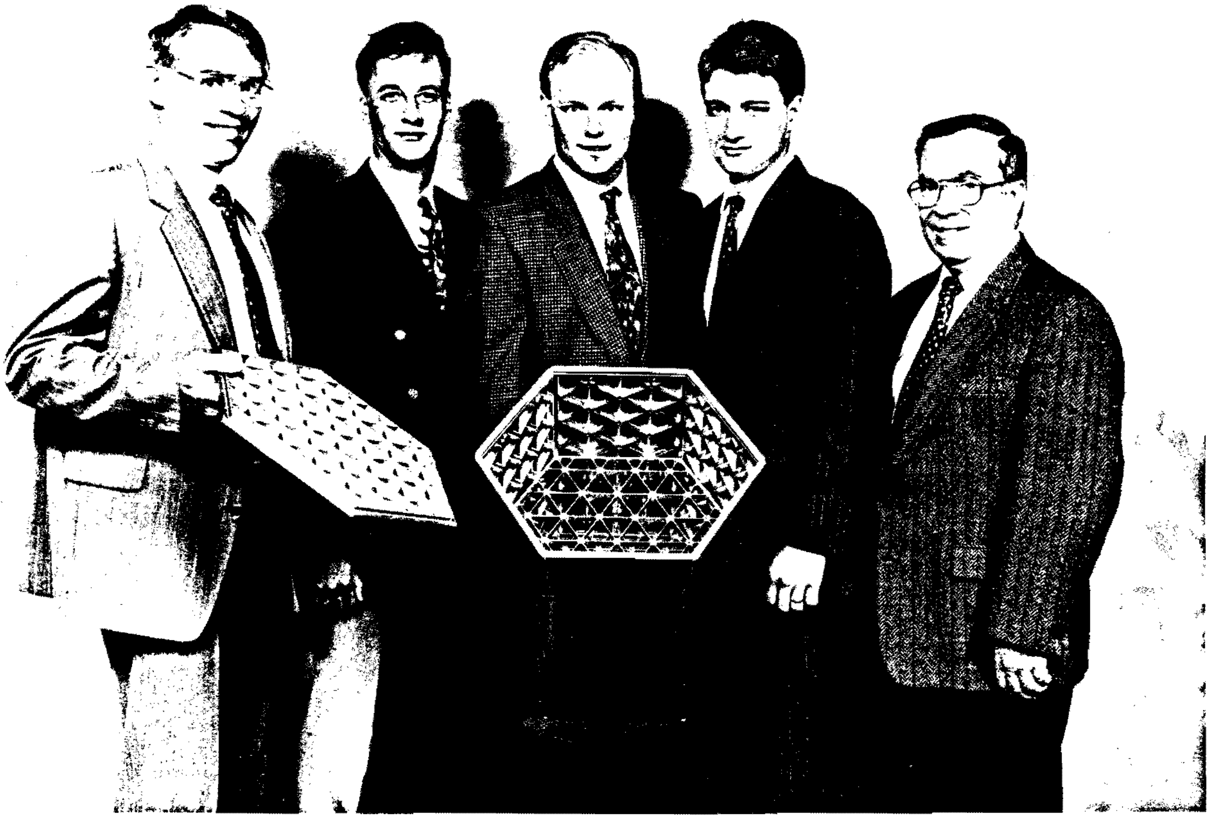

Figure 1 ISOSAT Design Team and Advisors. Shown Left to Right: Prof. Reed M. Nielsen, Kevin K. Jezak, Mark V. Hines, Joseph P. Greathouse, Dr. G. William Watt.

Figure 2

Typical Isogrid Shelves