Scientific Visualization in High Speed Network Environments

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Abstract

In several cases,new visualization techniques have vastly increased the researcher's ability to analyze and comprehend data.Similarly, the role of networks in providing an efficient supercomputing environment have become more critical and continue to grow at a faster rate than the increase in the processing capabilities of supercomputers.A close relationship between scientific visualization and high-speed networks in providing an important link to support efficient supercomputing is identified.

The two technologies are driven by the increasing complexities and volume of supercomputer data.

The interaction of scientific visualization and high-speed networks in a Computational Fluid Dynamics simulation/visualization environment are given. Current capabilities supported by high speed networks,supercomputers, and high-performance graphics workstations at the Numerical Aerodynamic Simulation Facility (NAS) at NASA Ames Research Center are described. Applied research in providing a supercomputer visualization environment to support future computational requirements are summarized.

HTML version

Graphics from this paper:

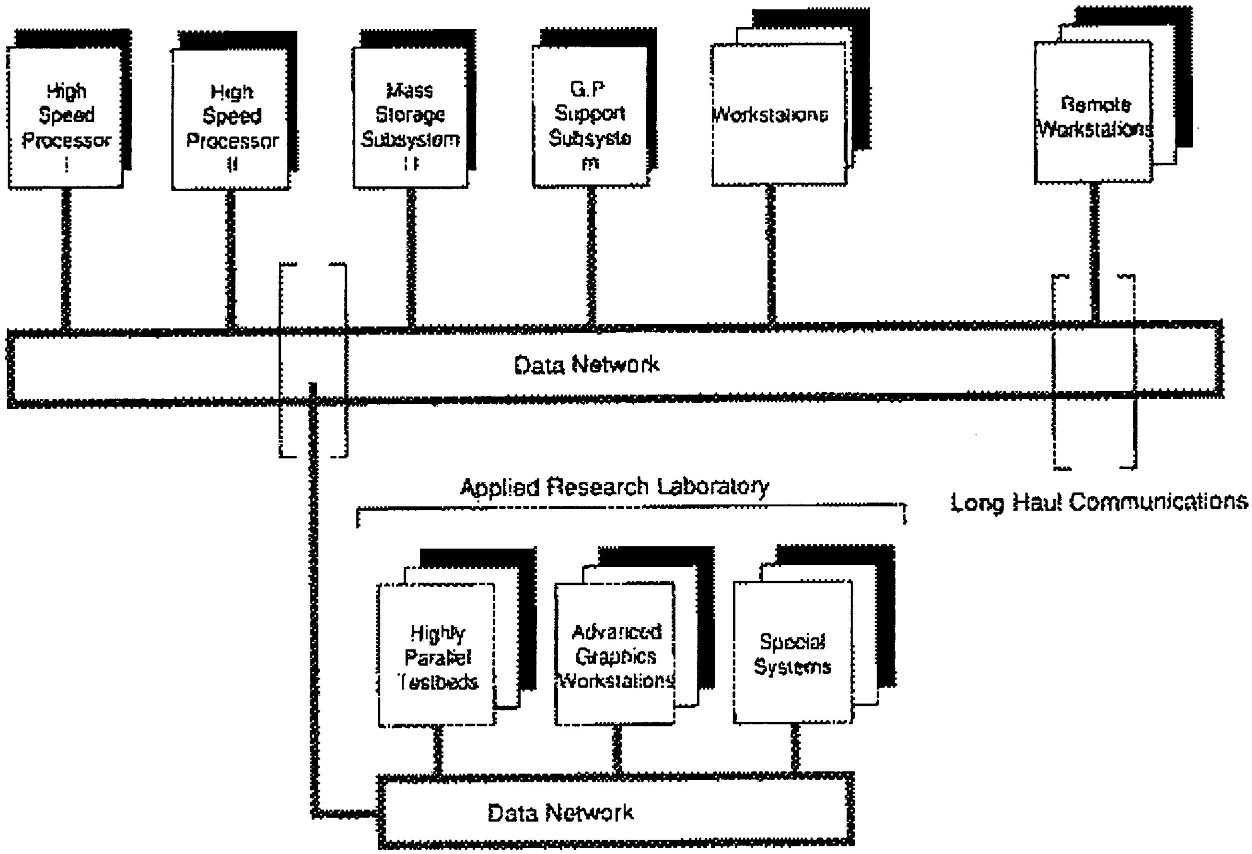

Fig. 1. The NAS Processing System Network (NPSN).

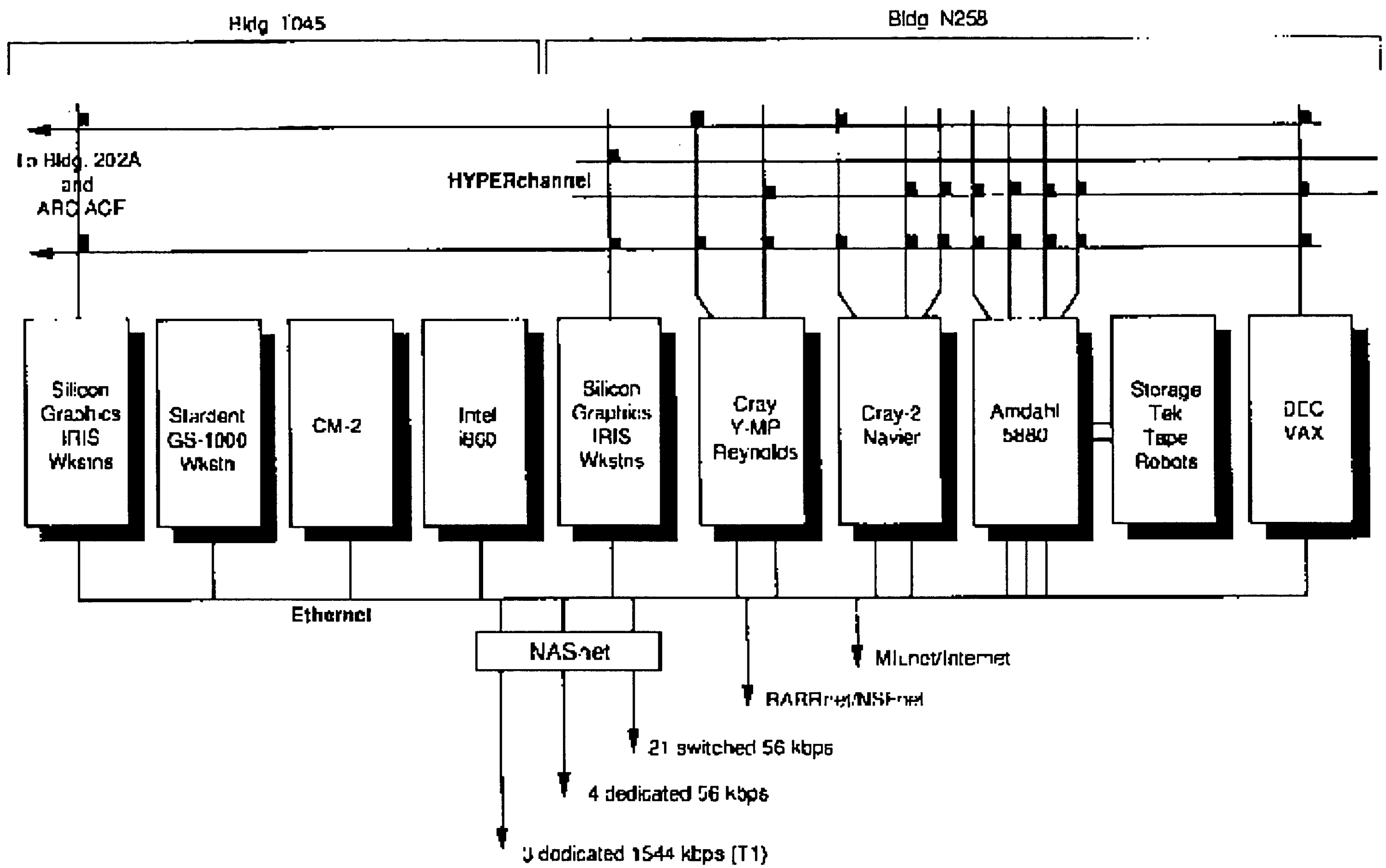

Fig. 2. The physical connectivity of NAS Processing System Network.

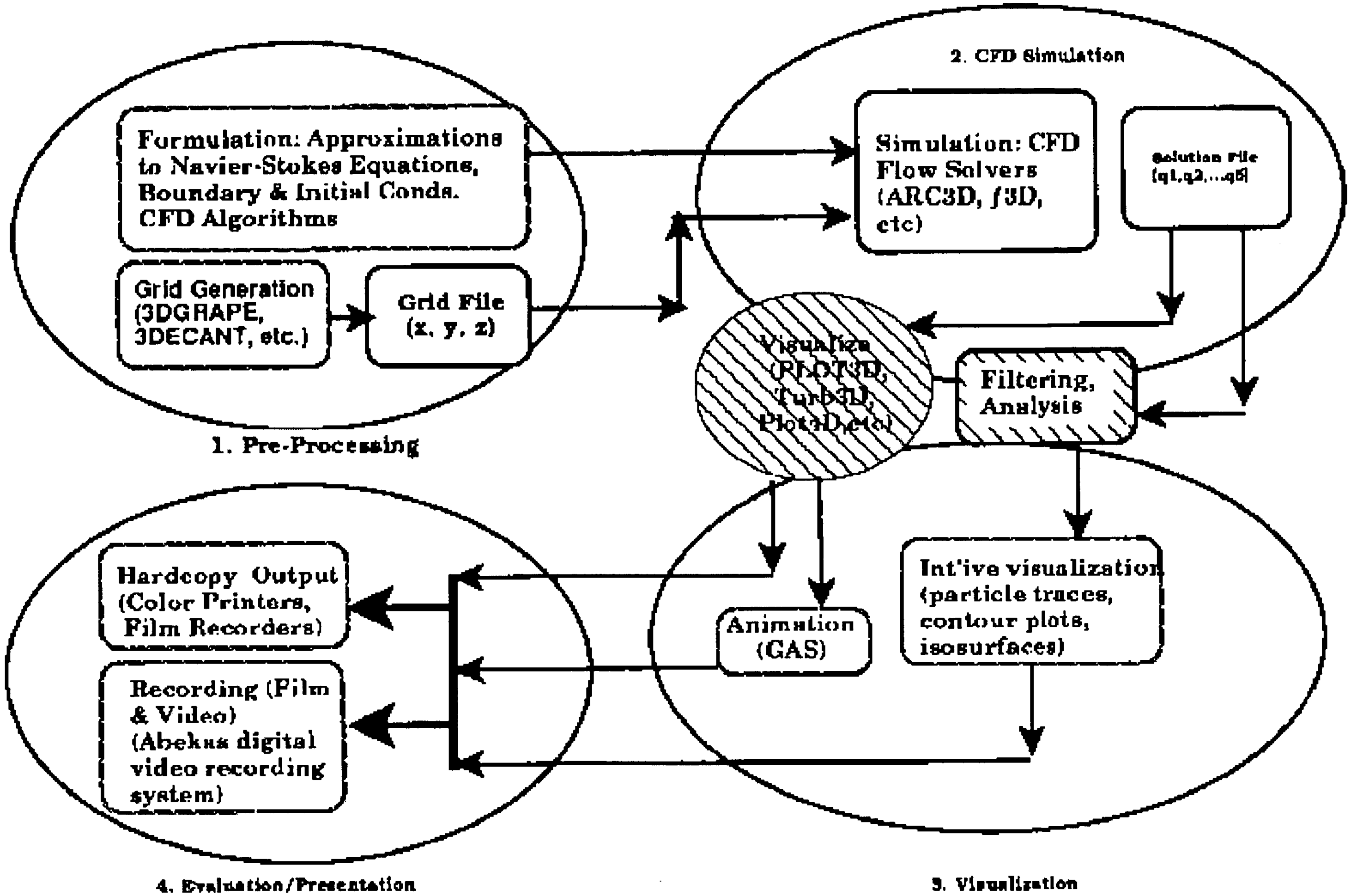

Fig. 3. CFD simulation and visualisation cycles.

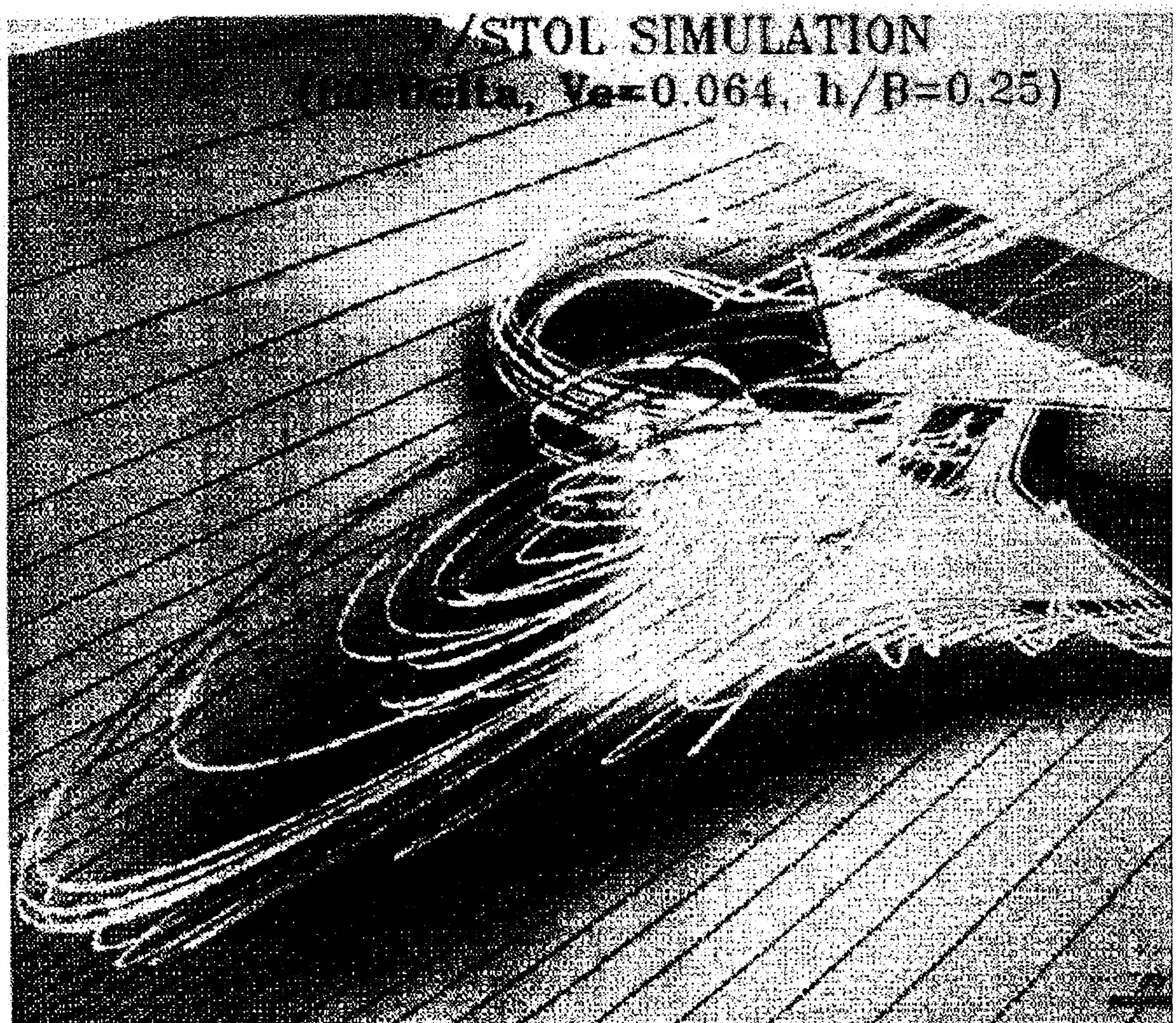

Fig. 4. Example of post-processing CFD graphic.

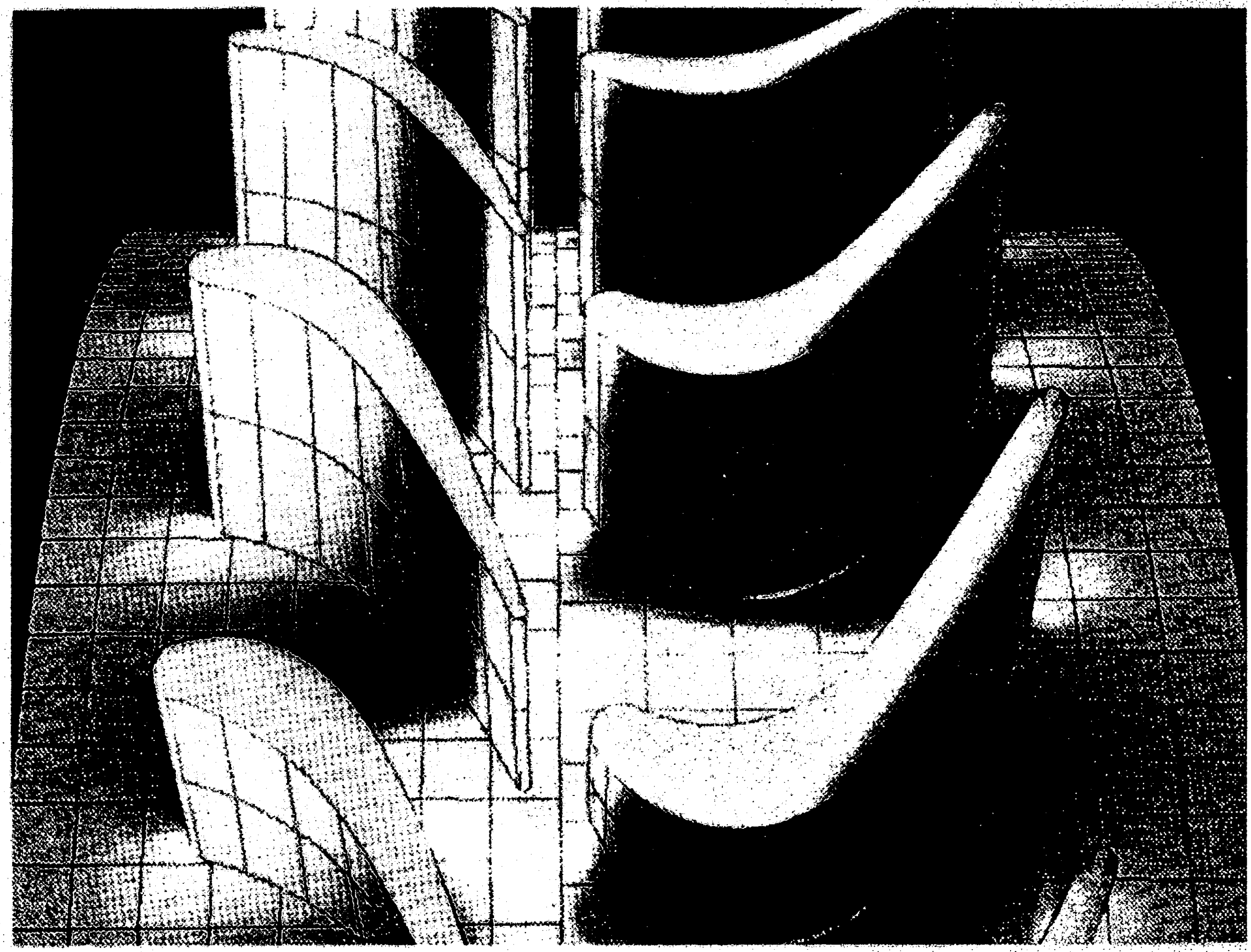

Fig. 5. Single frame of Ultra Image.

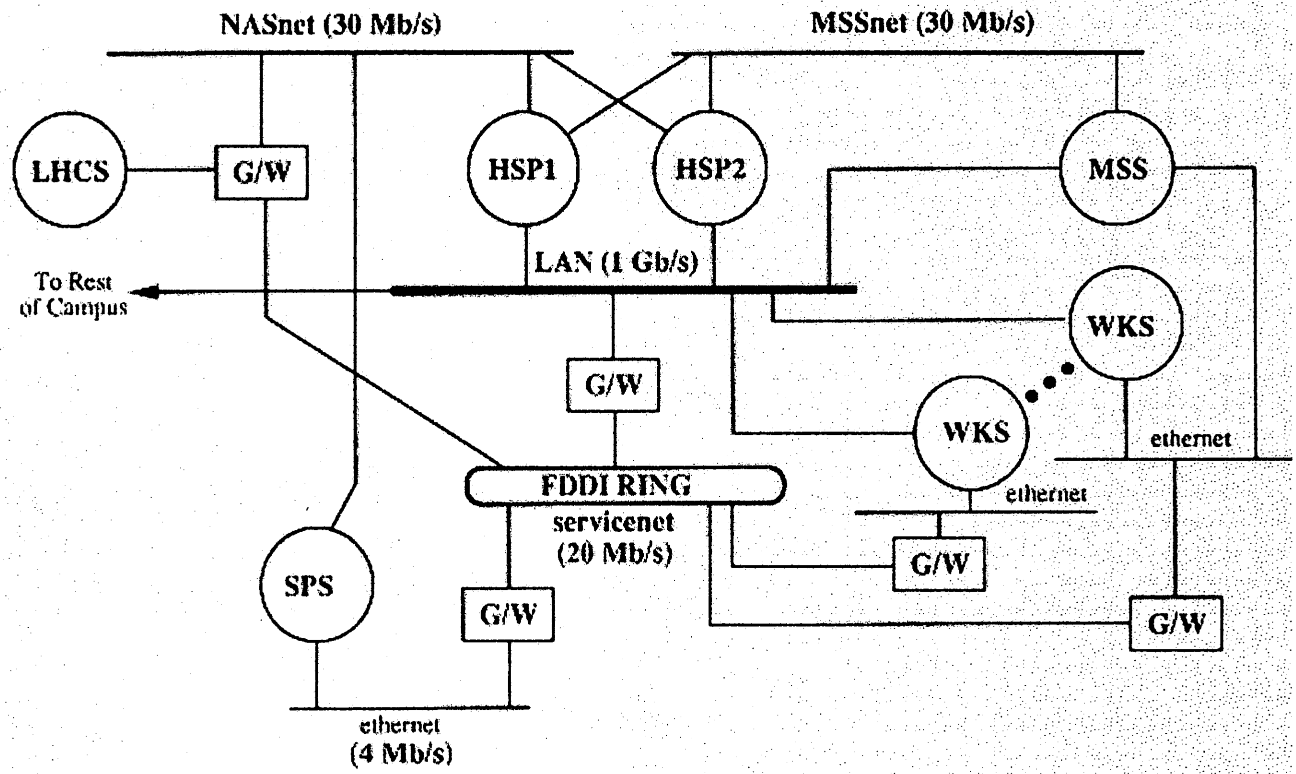

Fig. 6. NPSN network logical layout target configuration 1991.

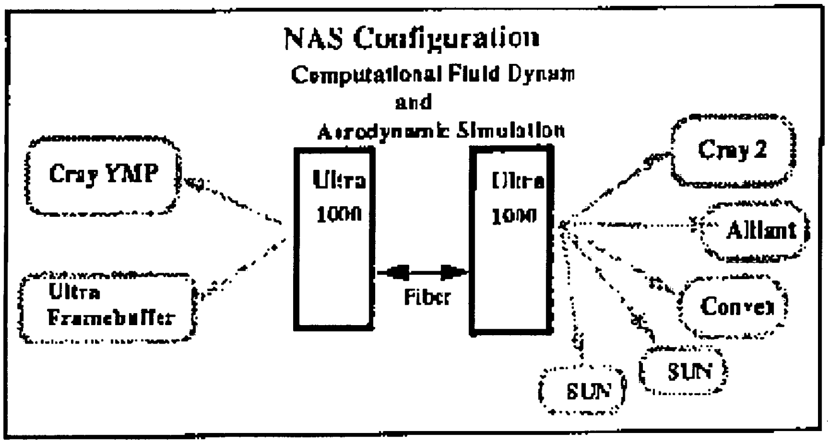

Fig. 7. The UltraNet test configuration.

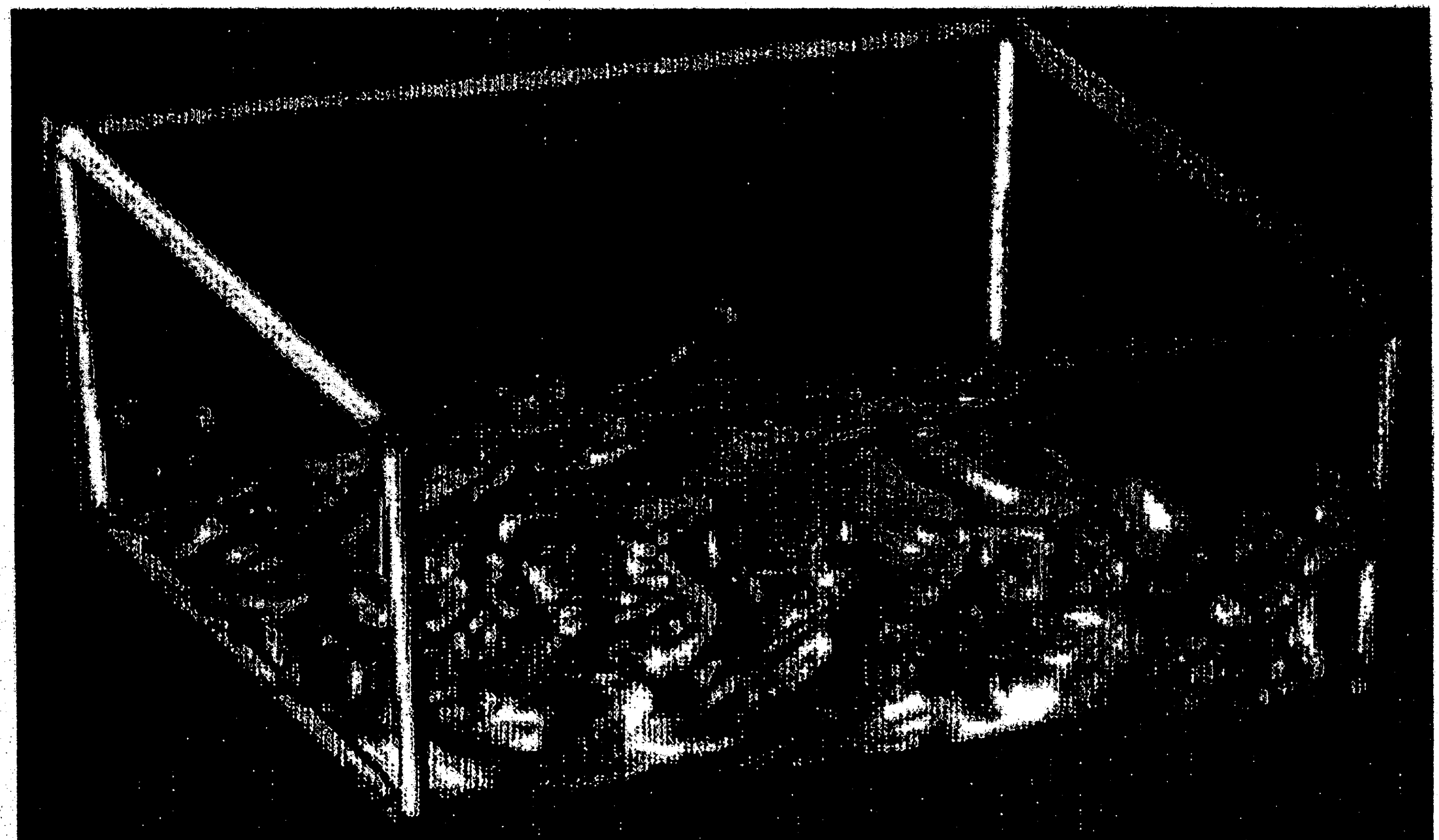

Fig. 8. Direct volume rendering of Spalarts's turbulent boundery layer flow. Flow is from left to right, with channel walls on top an bottom. Various vertical structures including the "hairpin" vortex is displayed.

Table 1
Specifications for Workstation 2

	WK1, 1984	WK2, min. spec.	WK2, actual
Make	SGI	? (SGI)	SGI
Model	2000, 3000 ser.	4D/25/Turbo	4D/320/VGX
CPU (ARC2D)	0.13 MFLOP	1.0 MFLOP	7.0 MFLOP
Graphics: shuttle	100 quads[1]/s	10K quads/s	30K quads/s
Memory	4 MB	32 MB	48 MB (128 max)
Disk	474 MB	760 MB	2 × 760 MB
Cost (non-discounted)	> $100K	$50K	$140K

[1] Shaded, 3-D non-coplanar quadrilaterals used in the NAS Shuttle Benchmark.

Table 2
CFD problems and applications on NPSN

CFD Area	Application Areas
High angle of attack - HARV	Fighters, missiles
Space Shuttle Launch Config.	Shuttle
Hypersonic	Aerospace plane
Turbulence	Design (all airborne vehicles)
Internal Flows	Turbomachinery, jet engines
Transonic Flows	Aircraft (F16)
Power Lift	V/STOL aircraft (harrier)

Table 3
Characteristic size of CFD data sets

Item/Size → ↓	Supercomputer (64 bit word)	Workstation (32 bit word)
Grid geometry (x, y, z)	$3 \times 10^6 = 3$ MegaWords	$3 \times 4 \times 10^6 = 12$ MBytes
Flow field solution $(q^1, q^2 \ldots q^5)$	5 MWords	$5 \times 4 \times 10^6 = 20$ MBytes
Solution file for one time step	8 MWords = 64 MBytes	32 MBytes
Unsteady flow (1000 time steps)	8 GigaWords = 64 GB	32 GigaBytes

Table 4
Characteristic size of visualization data sets

Single image visualization	Size of image data
Screen: 1024 × 1280 pixels/frame	1.3 Mega Pixels
Data: 4 bytes/pixel (RGB + alpha)	5.2 MB/frame
Animated visualization	**Size of animated data**
Flicker free 60 fps	300 MB/s
Video rate 30 fps	150 MB/s
Motion threshold ~ 12.5 fps	65 MB/s
Minimal dynamics 3–5 fps	15–25 MB/s
1 minute of animation @ 15 fps: (60 s × 15 fps × 5 MB/frame)	4.5 Gigabytes

Table 5

UltraNet transfer rates in kbps (memory to memory) double buffer. 1024 Kbytes user buffer

Source /host	Sun 3/260	Alliant	Convex	Cray-2	Cray Y/MP	Ultra frame buffer
Sun 3/260	4224	4186	4284	4334	–	
Alliant	3875	12039	5059	12188		
Convex	4083	8051	8471	8476		
Cray-2	3904	11253	8982	43640	29980	
Cray Y/MP	–	–	–	39586	24036	96500

Table 6
Projected technological evolution of simulation/visualization environments

Process	Current ('90)	Emerging ('95)
Supercomputing rates	1 GigaFLOPS (Cray Y-MP)	20-100 gigaFLOPS
Mass storage capacity	2 terabytes	10–1000 terabytes
Local area network	2 megabits/s	0.5–1 Gigabits/s
Transfer rates	(Ethernet)	(UltraNet/FDDI)
Workstation performance	10 MegaFLOPS	20 50 megaFLOPS
Computing method	Remote batch	Interactive, lagged time (tracking)
Visualization mode	Post-processing	Visual computing environment

[1] Projected.