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STATE OF THE ART IN VIDEO SYSTEM PERFORMANCE

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The closed circuit television (CCTV) system that is onboard the Space Shuttle has the following capabilities:

Camera

- based on a silicon intensified target (SIT) image tube
- has approximately 300 TV lines of horizontal resolution
- the full frame rate is 30/sec for monochrome images, 20 frames/sec for field sequential color format
- mates to a commandable pan and tilt unit
- has a commandable zoom lens assembly
- has operating settings for the iris, gamma, shading correction, etc.

Video signal switching and routing unit (VSU)

- accepts up to 14 input video signals, including up to 3 from cargo bay payloads and up to 4 from the crew compartment (which includes the middeck)
- routes video signals to 12 output ports, including two TV monitors, the Space Shuttle video tape recorder (VTR), and one KU or S band downlink channel
- allows two camera views to be multiplexed onto one composite signal which can then be recorded, displayed, or downlinked
- provides time tags to the video signals

Space Shuttle video tape recorder (VTR)

- records monochrome or color format video and audio from the VSU
- the playback video signal can be routed to the VSU or directly to the No. 2 TV monitor
- one 3/4 in. cassette can record for 30 min

Useful as it is, the Space Shuttle CCTV system is inadequate for use with many experiments that require video imaging. Some of these shortcomings are

(1) The CCTV camera cannot frame at more than 30 frames/sec.

(2) The camera does not have high resolution.

(3) The CCTV system lacks the ability to trade off resolution and frame rate in order to accommodate experiments with different imaging requirements.

(4) The camera lens has to be changed in order to switch from monochrome to color imaging.

(5) The CCTV camera captures color images in field sequential format which produces an image flicker effect on the Space Shuttle monitors. Only monochrome images can be displayed on Shuttle monitors because of this flickering. Also, the image data in field sequential format must be converted to NTSC format before it can be distributed on ground.

(6) The video tape recorder's 30-min maximum recording time is insufficient for experiments that require more than 30 min to run their course.

NASA does have a contract underway to build a 3-chip CCD color/monochrome camera using NTSC format to replace the existing SIT Shuttle cameras.

In order to assess the state of the art in video technology and data storage systems, NASA Lewis Research Center has been conducting a survey of manufacturers. The HHVT project engineers have searched the technical literature on state-of-the-art imaging components and data handling systems, as well as meeting with vendors and/or discussing their products via the telephone. The project engineers have investigated the state of the art in commercially available high frame rate video systems, image sensors and cameras, high speed data storage systems, and mass storage data systems. The database generated will be updated throughout the duration of the HHVT development project.

The performance of state-of-the-art solid state cameras and image sensors, video recording systems, data transmission devices, and data storage systems versus users' requirements are shown graphically on the attached charts (see Figs. 1 to 4). Figure 3 shows maximum data transfer rates versus users' requirements. In order to plot the transfer rate in terms of the highest possible frame rate versus resolution for a given data storage system, 1 byte/pixel was assumed to be sufficient. It is important to note that this graph assumes that the overall video system is not limited by the capabilities of the image sensor.

In comparing the various available data acquisition/transmission/storage systems, the dynamic random access memory (RAM) has numerous advantages. These advantages are

(1) Very high speed data acquisition
(2) Slower speed random access transfers
(3) Error correction
(4) Varying input data rates are acceptable
(5) Compatiblity with various control busses
(6) Compactness

One disadvantage of the dynamic RAM is that it has a relatively low storage capacity for extended high frame rate imaging.

The advantages of random file access systems such as PDT, NPDT, and optical disks are

(1) Large data capacity for extended imaging times
(2) Compatibility with various control busses
(3) Replaceable disks for greater storage capacity

Their disadvantages include

(1) Relatively slow data acquisition rates for high frame rate imaging
(2) Little or no error correction
(3) Questionable ruggedization of disks and disk drives
(4) Large volume requirements for most magnetic disk systems

Magnetic tape recorders have numerous advantages including

(1) Very large data capacity for extended imaging times
(2) Variable data acquisition/transmission rates for recording and playback
(3) Relatively high data transfer rates
(4) Error correction
(5) Replaceable tape cartridges for greater storage capacity
(6) Ruggedness
(7) Compactness

Their disadvantages are

(1) Relatively slow data transfer rates for direct recording of high frame rate images
(2) Incompatibility with various control busses
(3) Possible file access delay

Sixteen millimeter film has been used reliably in the past because there are numerous film cameras which allow very high frame rates with high resolution and the cameras have been ruggedized for flight. But their disadvantages are that images can only be acquired for very short durations at high frame rates because the film magazines run out so fast, and longer imaging times even at moderate frame rates require large amounts of film to be used. Also, astronauts are needed to replace the film magazines, adding extra work to their already busy schedules. On Space Station Freedom replenishment of film magazines will only occur every 3 months.

The conclusions that have been drawn from this survey of state-of-the-art video technology and memory systems are as follows:

(1) Current imaging systems and solid state sensors fall short of achieving a major portion of the users' requirements.

(2) Custom CID or CCD sensors could accommodate more of the users' requirements.

(3) Some data storage systems have the potential to satisfy a major portion of the users' requirements.

SOLID STATE IMAGE SENSORS AND CAMERA DATA

- TEKTRONICS TK128PR
  - RESOLUTION - 64 X 128 PIXELS
  - FRAME RATE - > 5000 FRAMES/SEC.
  - PIXEL RATE - 5 MHz (MAX.)/CHANNEL
  - VIDEO CHANNELS - 64

- RETICON RA2566N
  - RESOLUTION - 256 X 256 PIXELS
  - FRAME RATE - 500 FRAMES/SEC.
  - PIXEL RATE - 5 MHz/CHANNEL
  - VIDEO CHANNELS - 8

- GENERAL ELECTRIC CID512 CAMERA
  - RESOLUTION - 256 X 256 PIXELS
  - FRAME RATE - 500 FRAMES/SEC. (SKIP SCAN)
  - PIXEL RATE - 7.8 MHz
  - VIDEO CHANNELS - 1

- GENERAL ELECTRIC CID 256E SENSOR
  - RESOLUTION - 256 X 256
  - FRAME RATE - 150 FRAMES/SEC.
  - PIXEL RATE - 2.5 MHz/CHANNEL
  - VIDEO CHANNELS - 4

- KODAK VIDEK MEGA PLUS
  - RESOLUTION - 1320 X 1032
  - FRAME RATE - 10 FRAMES/SEC.
  - PIXEL RATE - 14 MHz (MAX)
  - VIDEO CHANNELS - 1

- TEKTRONICS TK2048M
  - RESOLUTION - 2048 X 2048
  - FRAME RATE - 4 FRAMES/SEC.
  - PIXEL RATE - 1 MHz (MAX)
  - VIDEO CHANNELS - 1

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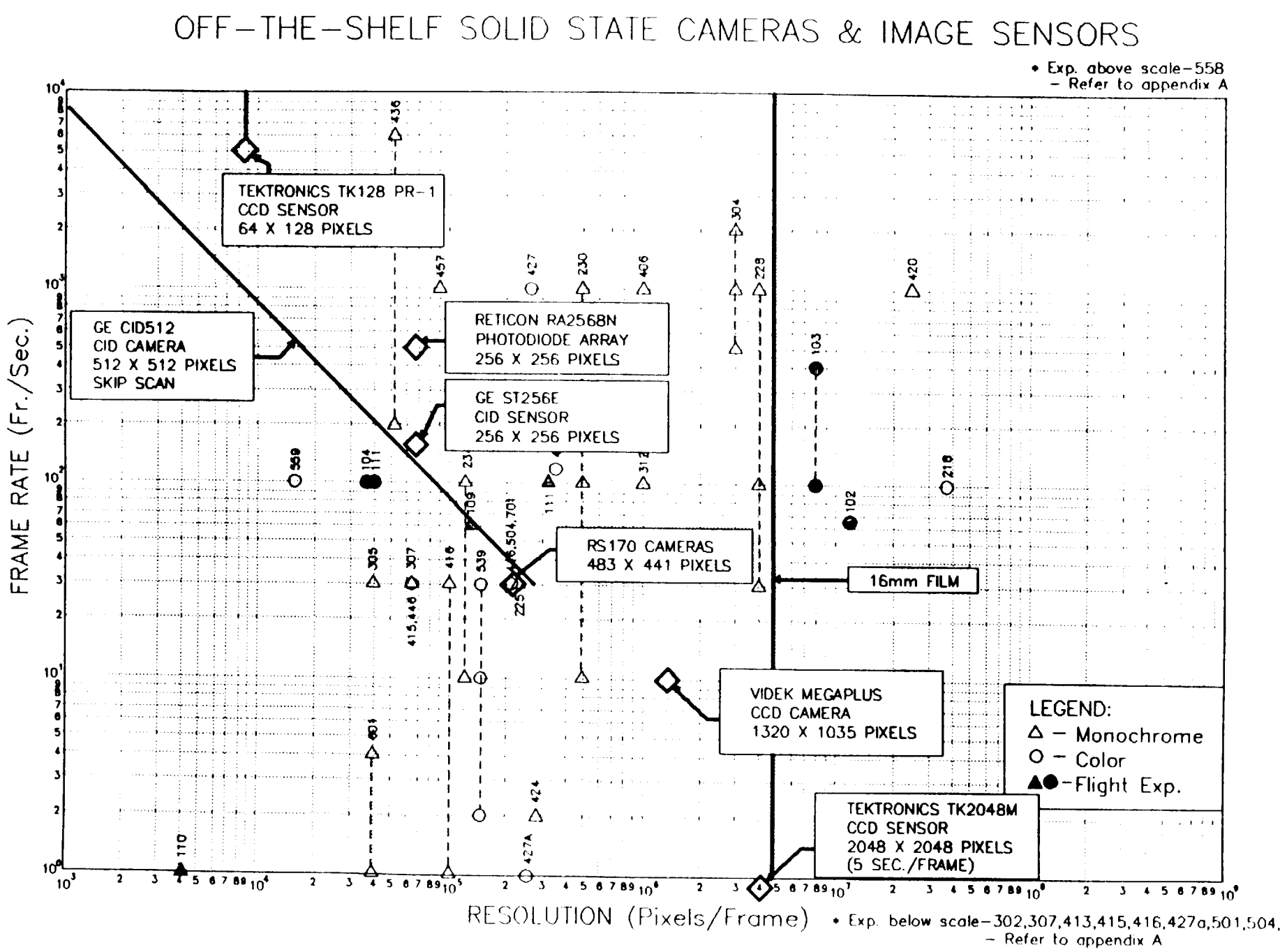

Figure 1

PRESENTLY AVAILABLE VIDEO SYSTEM DATA

- SPIN PHYSICS SP 2000
  - FULL FRAME RATE - 2000, 1000, 500, 200, 60
  - SENSOR
    - MOS ARRAY
    - RESOLUTION - 192 X 240 PIXELS
    - 32 PARALLEL CHANNELS
    - PIXEL RATE - 3.0 MHz
  - RECORDER
    - FULL RESOLUTION
    - 64 GRAY LEVELS
    - 34 TRACKS
    - 1/2" HIGH DENSITY CASSETTE

- NAC HVRB-200SS
  - FULL FRAME RATE - 200, 60
  - SENSOR
    - MOS CCD ARRAY
    - RESOLUTION - 244 X 280 PIXELS
  - RECORDER
    - 200 + HORZ. LINES
    - 1/2" VHS TAPE

- RS170 CAMERA & VHS VCR
  - FULL FRAME RATE - 30
  - SENSOR
    - CCD, CID, PHOTO-CAPACITOR, TUBE
    - RESOLUTION - 483 X 441 PIXELS
  - RECORDER
    - FULL FRAME RATE - 30
    - RESOLUTION - 483 X 320

- 16MM FILM
  - RAR 2498 FILM
  - ASA 125
  - FULL FRAME RATE - NO LIMIT
  - RESOLUTION - 1920 X 2400 PIXELS

OFF-THE-SHELF VIDEO RECORDING SYSTEM PERFORMANCE

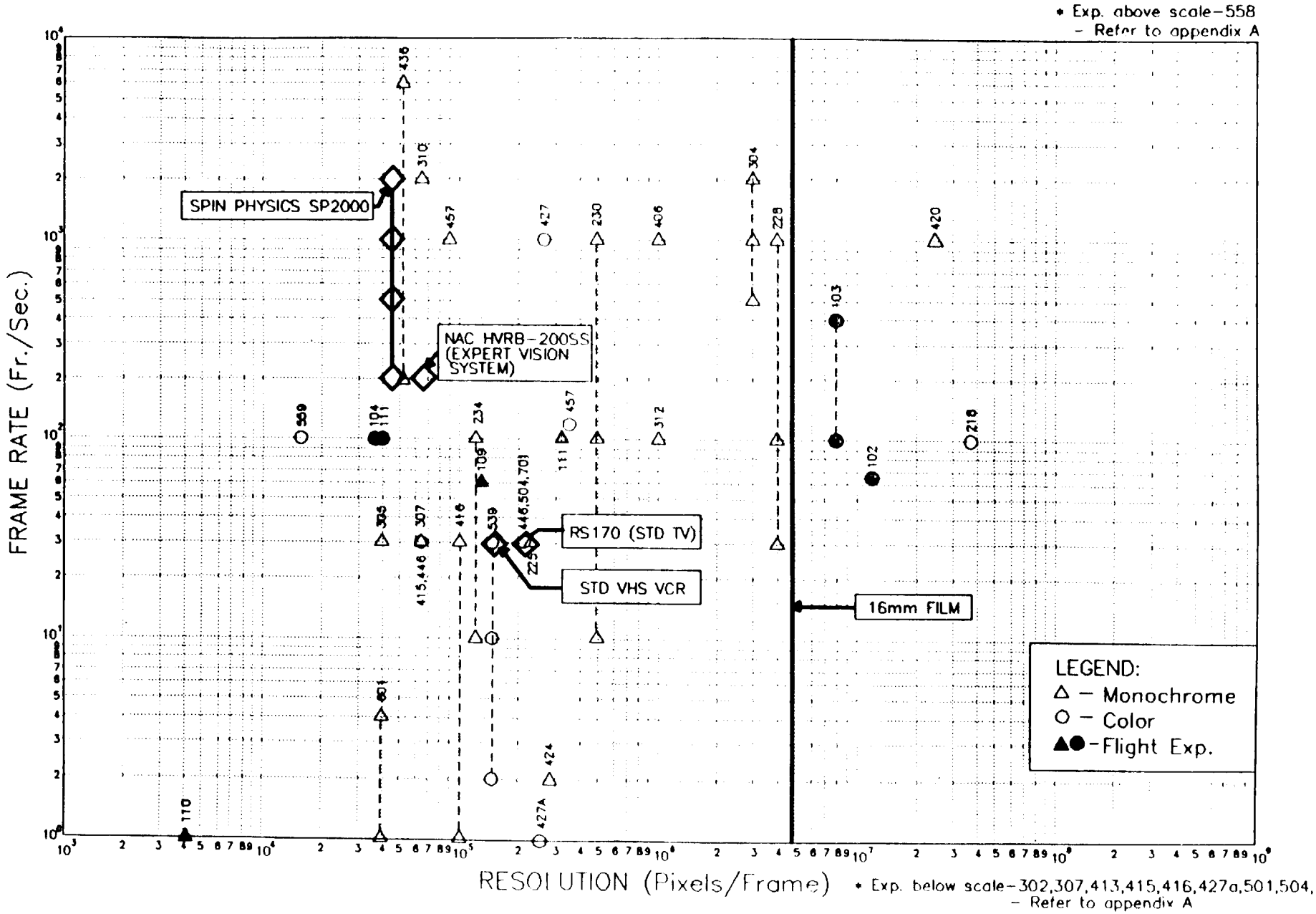

Figure 2

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GENERAL COMPONENT DATA FOR DATA TRANSFER RATE AND STORAGE

- O DYNAMIC RAM
  - ZITEL 93+ SPLIT
  - TRANSFER RATE - 640 MBYTES/SEC.
  - STORAGE CAPACITY - 512 MBYTES
  - DATA WORD SIZE - 256 PARALLEL CHANNELS
  - HIGH SPEED SEQUENTIAL BLOCK TRANSFER
  - SLOWER SPEED RANDOM WORD READ/WRITE
  - SIZE - 14" X 19" X 21.2"
  - AVAILABILITY - LATE '88

- O NON-PARALLEL MAG. DISK TRANSFER
  - RECOGNITION CONCEPTS INC. VISISTORE
  - TRANSFER RATE - 74 MBYTES/SEC. (SUSTAINTED)
  - STORAGE CAPACITY - 25 GBYTES
  - DATA WORD SIZE - 64 PARALLEL CHANNELS
  - RANDOM FILE READ/WRITE
  - SIZE - 60" X 19" X 27" (2)
  - AVAILABILITY - MID TO LATE '88

- O MAG. TAPE REC.
  - MIL. STANDARD 21-79AS
  - TRANSFER RATE - 30 MBYTES/SEC.
  - STORAGE CAPACITY - 99 GBYTES
  - DATA WORD SIZE - 8 PARALLEL CHANNELS
  - SEQUENTIAL DATA READ/WRITE
  - SIZE -170" X 16" X 16"
  - AVAILABILITY - MID '89

- O PARALLEL MAG. DISK TRANSFER
  - APPLIED MEMORY TECHNOLOGY MODEL 8300
  - TRANSFER RATE - 7.8 MBYTES/SEC. (SUSTAINED)
  - STORAGE CAPACITY - 1.0 GBYTES
  - DATA WORD SIZE - 16 PARALLEL CHANNELS
  - RANDOM FILE READ/WRITE
  - SIZE - 8.75" X 17" X 26"
  - AVAILABILITY - LATE '88

GENERAL COMPONENT DATA FOR DATA TRANSFER RATE AND STORAGE
(CONTINUED)

- OPTICAL DISK
  - KODAK
  - TRANSFER RATE - 1 MBYTES/SEC. *
  - STORAGE CAPACITY - 6.8 GBYTES
  - DATA WORD SIZE - 16 PARALLEL CHANNELS
  - RANDOM FILE READ/WRITE
  - SIZE -
  - AVAILABILITY -

- SHUTTLE KU BAND DOWNLINK
  - VIA TDRSS
  - TRANSFER RATE - 6.0 MBYTES/SEC. **
  - FULL USE OF SHUTTLE HIGH SPEED DIGITAL DATA CHANNEL

* INTERFACE LIMITED VIA SCSI

** DATA RATE FROM WHITE SANDS

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NEAR-TERM TECHNOLOGY DATA TRANSFER RATE vs. USER REQUIREMENTS

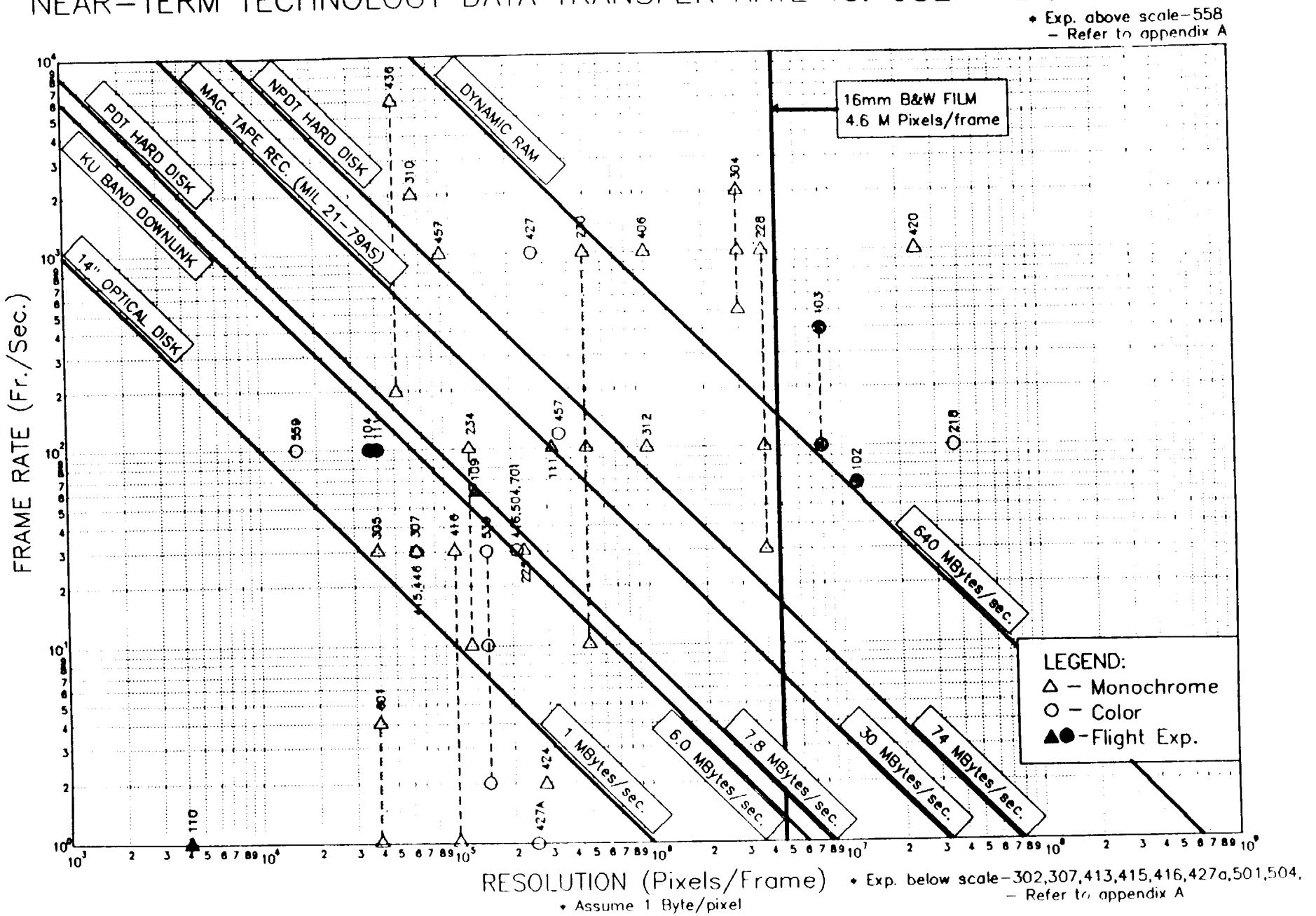

Figure 3

NEAR-TERM TECHNOLOGY STORAGE CAPACITY vs. USER REQUIREMENTS PER RUN

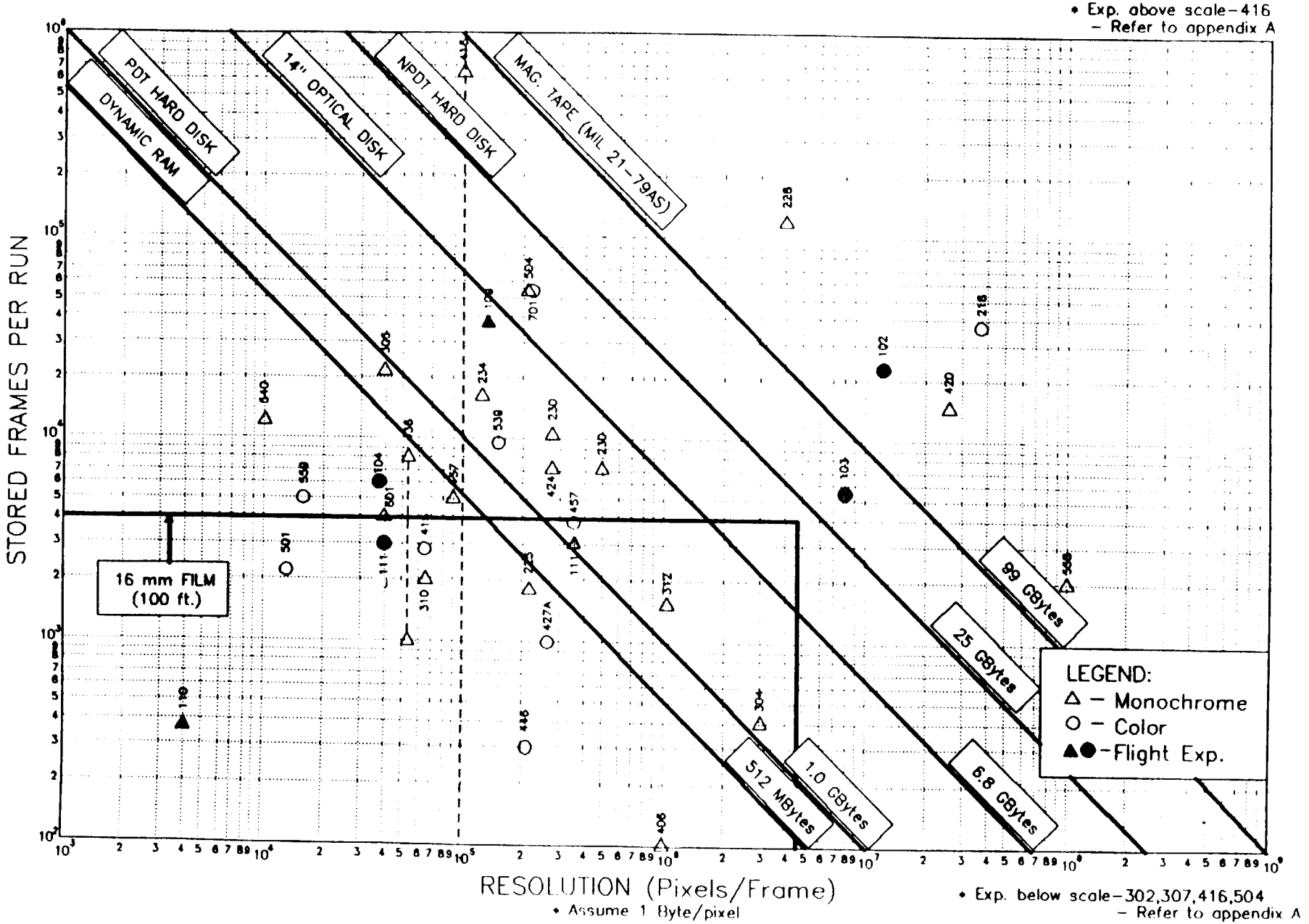

Figure 4

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