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Image-Data Transmission Demonstration over the Tracking and Data Relay Satellite System

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EXECUTIVE SUMMARY

OBJECTIVE

The objective of this demonstration was to investigate relevant parameters and show the feasibility of transmitting image data over the Tracking and Data Relay Satellite System (TDRSS).

RESULTS

This demonstration has shown that an image can be compressed, transmitted, received, processed, sent to a remote location over the Internet, and displayed in under 1 minute. Although the image was downloaded only at one site, many sites can receive this information at the same time. This is a significant benchmark in determining the usefulness of such a system to disburse near-real-time image data.

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PURPOSE

This demonstration investigated relevant parameters and showed the feasibility of transmitting image data over the Tracking and Data Relay Satellite System (TDRSS). Measurements of transmission time and data-compression quality at various baud rates were conducted. This test also provided the opportunity to evaluate Stanford Telecom's (S-Tel's) portable TDRSS transmitter (PORTCOM) in operation.

DEMONSTRATION SETUP

Figure 1 shows the equipment configuration for this demonstration. The original image data were stored on the hard drive of a personal computer (PC). A Titan Company compression algorithm named Increased Compression Engine (ICE) was used to reduce the image size with minimal image-quality degradation. The compressed image was sent from the PC to the PORTCOM via an RS-232 serial communication link. The PORTCOM framed the data and added error-correction information to ensure validity and proper recognition by the receiver. Then the data were sent through the transmitter (which had a 1-watt output power specification) to a 6.8-dBi circularly polarized patch antenna. With the antenna directed toward the geostationary location of the TDRSS satellite, the data were relayed to the ground station. Beamforming processing of the received channels was done at the ground station. The processed data were sent from the ground station over a National Aeronautics and Space Administration (NASA) Communication Network (NASCOM) to the Network Control Center (NCC) at Goddard Space Flight Center (GSFC) in Greenbelt, MD. A workstation or network server at NCC was then able to perform a variety of operations with the data. The data could be stored in a specific directory or posted on a web page for access to anyone with the correct password who is connected to the Internet via file transfer porotocol (FTP) or net browser. The data could also be sent automatically via e-mail to designated recipients. For this demonstration, the image data were downloaded from the NCC server to a PC and then displayed.

PORTCOM EQUIPMENT SPECIFICATIONS

The following table lists parameters of the PORTCOM equipment.

Table 1. PORTCOM equipment specifications.

Parameter	Specification
Center frequency	2287.5 MHz
RF power	1.0 watt (+30 dBm)
3-in-diameter patch antenna	6.8-dBi gain, 80-deg beamwidth
User interface	RS-232 for PC
Prime power (battery option)	10 to 20 VDC, < 0.9 A @ 12 VDC
Integrated GPS receiver	8 channels
Data transfer rates	600 bps to 19.2 kbps
Data modulation	BPSK/PN
Data frame format	TDRSS standard—User formats definable
Selectable PN code	2047-chip gold code
Communications	Spread spectrum and error correction coding

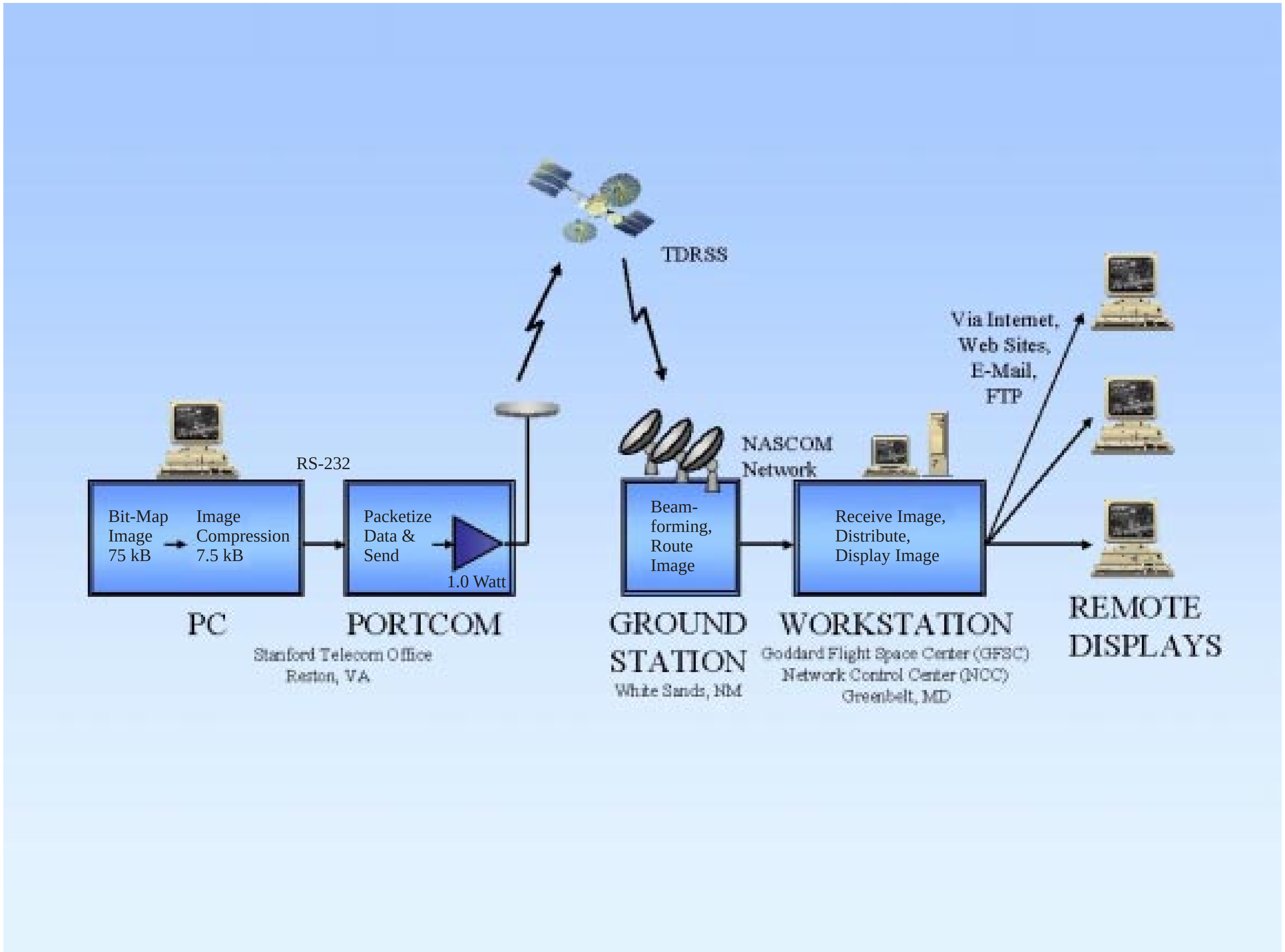

Figure 1. Demonstration setup.

IMAGE DATA

The image in figure 2 was used in the demonstration and stored in bitmap format that consisted of 315 by 240 pixels in an 8-bit gray scale. Disk storage space was 75 kB.

Figure 2. Demonstration image.

IMAGE COMPRESSION

Table 2 lists the effects of compression on image size and the resulting image quality. A compression ratio of 1:10 yielded a 90-percent reduction in size, and a compression ratio of 1:100 yielded a 99-percent reduction in size. The additional size reduction from 90 to 99 percent was small, while the image quality greatly deteriorated. The observation was that the additional processing to obtain 9-percent additional reduction in size was not worth the effort. The compression algorithm was executed on a PC in a Windows environment. The process involved loading the data, selecting the compression ratio, and executing the routine. The compression time was less than 2 seconds for all compression ratios. The PC used for compression processing had a Pentium 200-MHz processor with 32 MB of random access memory (RAM).

Table 2. Image-compression comparison.

Compression Ratio	File Size (k)	Reduction (%)	Image Quality
1:1	75	0	Original
5:1	15	80	Excellent
10:1	7.5	90	Good
20:1	3.75	95	Good
50:1	1.5	98	Poor
100:1	0.75	99	Blurred

The following figures show a comparison of image quality for different compression ratios. The original image and compressed images of 5:1, 10:1, 20:1, 50:1, and 100:1 are shown in figures 3a to 3f, respectively. The amount of useful compression is a function of the original image. Claims of compression ratios of 100:1 are usually based on a high-resolution image that is compressed (i.e., degraded) to some level that is acceptable to the human viewer. If the original image is of lower resolution or quality, then less degradation, and hence, compression is tolerable to the viewer. This image was of a lower quality and resolution. Compression of this image greater than 20:1 producs an image that is blurred, and much detail is out of focus. Each image is also shown inverted to aid in identifying feature degradation as the compression ratio increases.

Figure 3a. Original image.

Figure 3b. Compression ratio 5:1.

Figure 3c. Compression ratio 10:1.

Figure 3d. Compression ratio 20:1.

Figure 3e. Compression ratio 50:1.

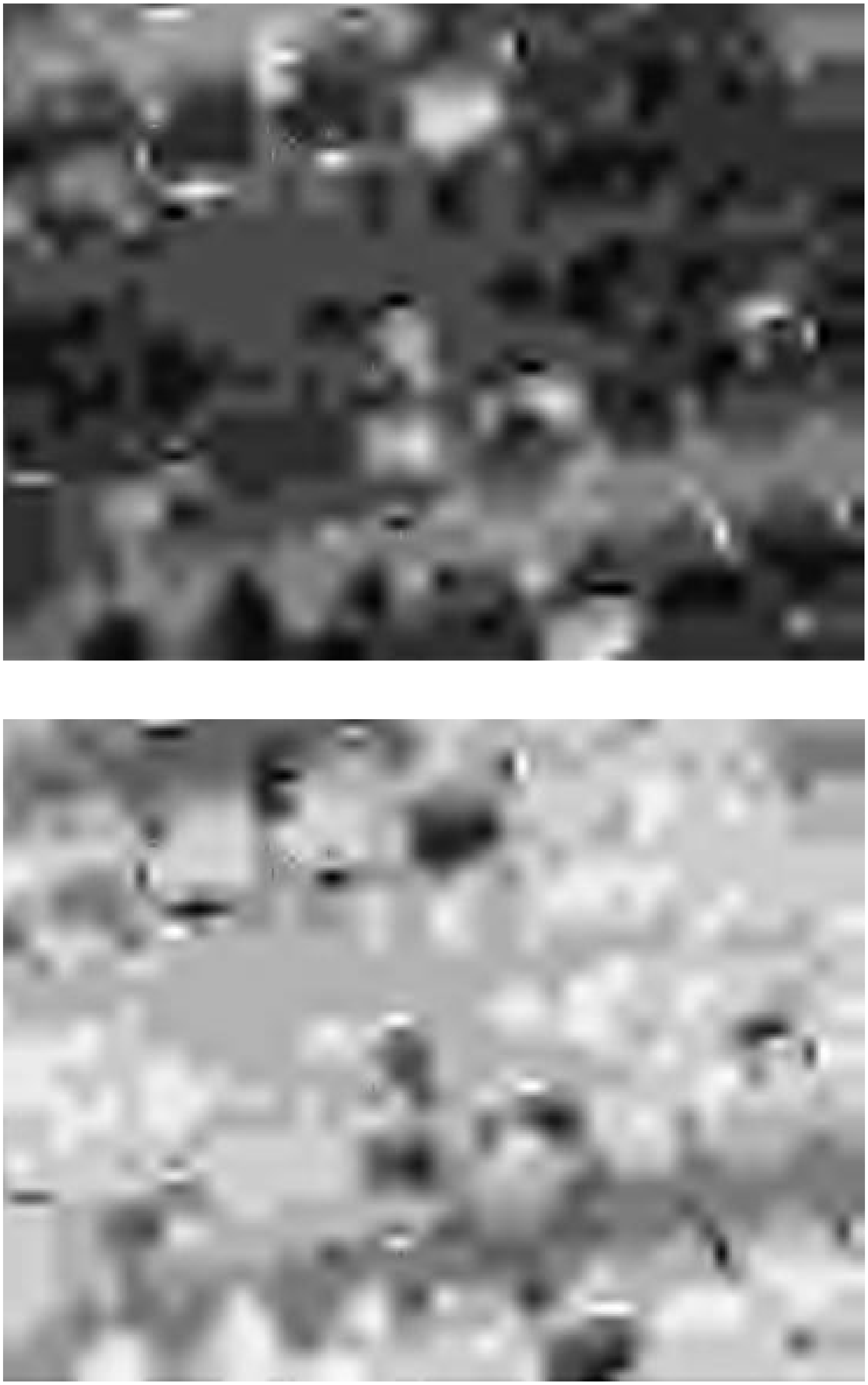

Figure 3f. Compression ratio 100:1.

TRANSMISSION TIME RESULTS

Table 3 shows the elapsed transmission time for sending compressed and uncompressed images at 2400 and 4800 bps. The transmission times for the uncompressed images at 4800 and 2400 bps scale by size. The transmission times for the compressed images were similar because the PORTCOM framed the data before transmission, and the image size was less than a full frame. During the demonstration, after the image was transmitted at 4800 bps, a hardware problem occurred with the network at GSFC thereby halting the transmission of images. Later that day, after the network was repaired, the images were transmitted at 2400 bps.

Table 3. Transmission time comparison.

Image Compression	Data Rate (bps)	Time
Uncompressed	4800	3 minutes
Compressed (20:1)	4800	30 seconds
Uncompressed	2400	5.5 minutes
Compressed (20:1)	2400	35 seconds

CONCLUSION

The demonstration was successfully conducted. The components are available to transmit image data from a remote location and receive the image at any site connected to the Internet. The hardware problem with the NASCOM network, which halted the demonstration, would be solved by using another path to send the image data. The ICE compression algorithm worked very well and was simple to install and use. It is fairly inexpensive and could be licensed for multiple users. Stanford Telecom's PORTCOM system is a viable solution to communicating with TDRSS. The system is small in size and worked as advertised during the demonstration. The transmission time for the compressed images was approximately 30 seconds. A portion of the elapsed time was attributed to the operator manually loading the image, running the compression algorithm, and saving the files. These manual functions could be automated in an operational system, which would further reduce the overall transmission time by 5 to 10 seconds. This demonstration has shown that an image can be compressed, transmitted, received, processed, sent to a remote location over the Internet, and displayed in under 1 minute. Although the image was downloaded only at one site, any number of sites could have received this information at the same time. This is a significant benchmark in determining the usefulness of such a system to disburse near-real-time image data.

FUTURE CONSIDERATIONS AND TESTING

Stanford Telecom is developing a VME-based beamformer that would remove the dependency on NASA ground-station beamforming equipment. This development would yield an on-demand capability to image data distribution without the need to schedule TDRSS time directly.

The next step would be to test this capability from a mobile transmitting platform.

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13. ABSTRACT *(Maximum 200 words)*

This report details the feasibility of transmitting image data over the Tracking and Data Relay Satellite System (TDRSS). Measurements of transmission time and data-compression quality at various baud rates were conducted. Stanford Telecom's portable TDRSS (PORTCOM) was evaluated.

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