VIDEO REQUIREMENTS FOR MATERIALS PROCESSING EXPERIMENTS IN THE SPACE STATION U.S. LABORATORY

Charles R. Baugher
Space Science Division
Marshall Space Flight Center

ABSTRACT

Full utilization of the potential of the materials research on the Space Station can be achieved only if adequate means are available for interactive experimentation between the science facilities and ground-based investigators. Extensive video interfaces linking these three elements are the only alternative for establishing a viable relation. Because of the limit in the downlink capability, a comprehensive complement of on-board video processing, and video compression. The application of video compression will be an absolute necessity since it's effectiveness will directly impact the quantity of data which will be available to ground investigator teams, and therefore their ability to review the effects of process changes and the experiment progress.

Traditional methodology in materials research investigations has evolved amid close investigator interaction with samples and processes in ground-based laboratories. Effective transition of the research discipline to the space-based laboratories being designed for the Space Station will require a means of continuing this orthodox approach and expanding it to encompass relatively large teams of collaborating scientists at diverse locations. Clearly, the only means of implementing the requirement will be through an efficient and imaginative use of video communications between the Space Station experiments and investigator laboratories. The requirement for comprehensive video presentations of experiment processes and status is further accentuated by the need for on-board crew interaction with

experiments which are otherwise extensively contained to avoid the possibility of accidental exposure to noxious processes.

Although it is seemingly a modest requirement, the actual implementation of adequate video monitoring of the Space Station materials processing experiments is complicated by the number of video sources in the planned facility (of the order of ten), their variety, and the several cases in which experiment scientific return will be directly commensurate with the available resolution and/or frame rate. The aggregate bandwidth necessary to freely transfer the raw video information to the ground far exceeds the science allocation form the total 300 Megabits per second being planned for the Station communication link through the Tracking and Data Relay Satellite (TDRS).

To bring the requirement into compliance with the reality of the restrictions, it is apparent that special measures must be implemented within the Station internal video and data management system. An analysis of the science video in terms of a realistic operation model provides guidance on the subsystems necessary to effectively manage the science requirements.

The video from the experiments will range from single frame, high resolution images of the status of crystal growth processes; through requirements involving manipulation which can be readily serviced by the NTSC "media standard"; to a requirement for state-of-the-art in frame rate and resolution to capture the details of certain combustion, fluid flow, and very rapid crystallization phenomena. In general, rapid transmission to the ground is desirable for analysis purposes; however, only the manipulation type of operations will require a near "real-time" type of link. Since the experiment-to-ground delay is not generally of direct importance to the science return, it is possible to make effective use of on-board data buffering and subsequent transmission during periods of opportunity. Indeed, a portion of the video data will be of interest only when

analyzed in conjunction with the returned samples and can, therefore, be archived at the Station for return with the regular supply missions.

Since the Station will also serve as an active research facility on it own, manned by a scientific crew able to render judgments and synthesize observation, there will be a requirement for on-board interaction with the video data. This interaction will require a set of general purpose video utility tools such as freeze frame, data overlays, and appropriate frame conversion capability. Inclusion of these tools will also alleviate the downlink congestion since scientific crew members can interdict or pre-sort observational data which does not satisfy the experiment requirements. Collectively, the requirements dictate that an experiment dedicated video processing facility will be mandatory as an integral part of the Space Station Laboratory.

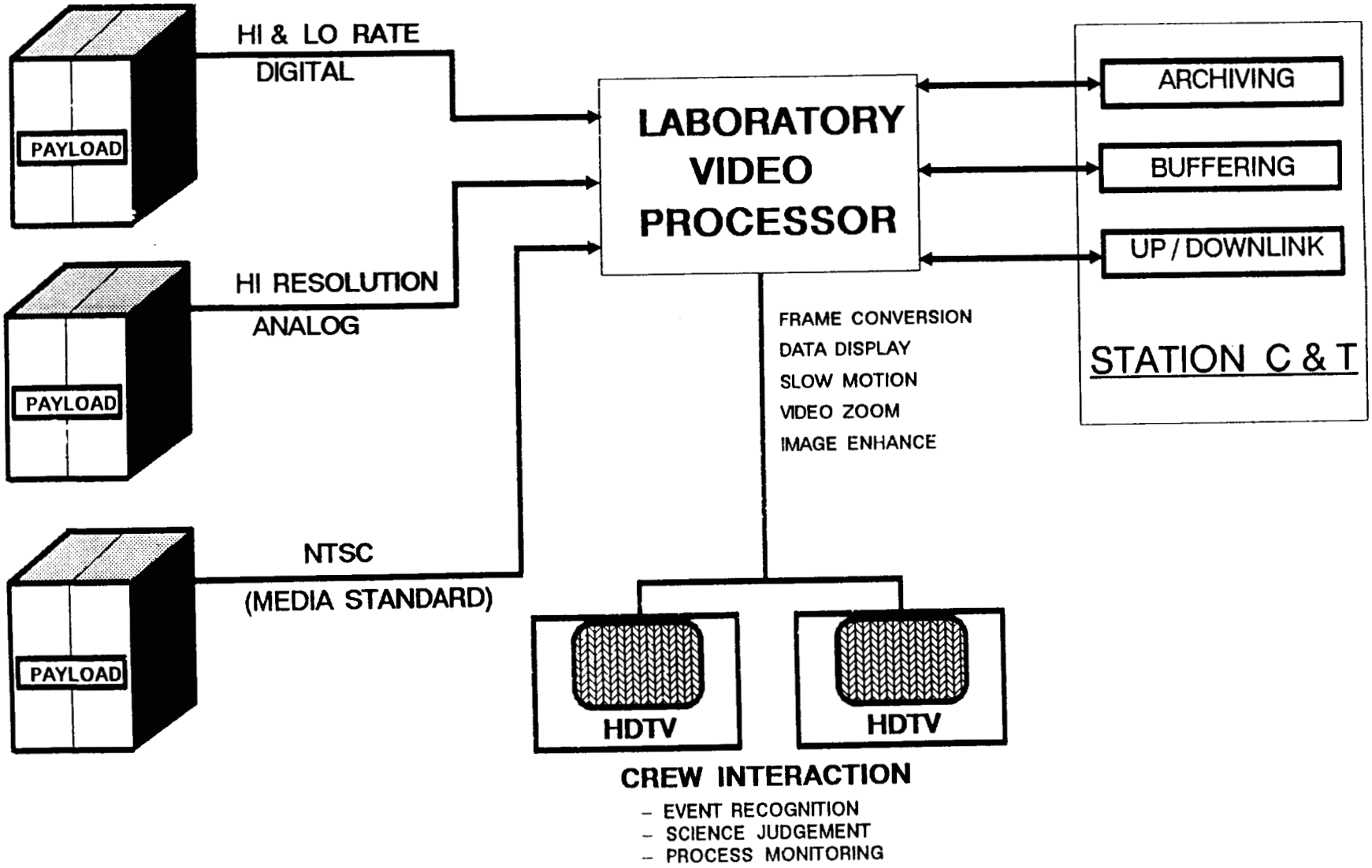
However, even with the inclusion of an extensive video processing, recording, and data management capability, adequate operation of the materials processing facilities will likely be limited by the data downlink capability. In some cases this limit will be incurred because adequate buffer requirements are beyond the current state-of-the-art and data will be generated faster than can be reasonably transmitted to storage. In other cases, the limit will occur because experiment reiteration rates will be fixed by the overall available through-put rate to the ground. With regular supply missions between the station and the ground scheduled for 90 day centers, modest generation rates can overwhelm archival storage capability and one or two continuous video sources would saturate the available downlink transmission bandwidth.

Clearly, an aggressive utilization of video compression is indicated for essentially all of the video data from materials experiments, and it is likely that the data will prove responsive to the application of the art. In many of the cases the application will be trivial since

the video images will be of interest only where there are changes in slowly varying processes in a small portion of a large field. Manipulative operations occupy the middle ground in the hierarchy of difficulty. In others, such as the details of rapid motion in very low contrast fields, the application will be challenging if it is to prove useful.

In addition to the link between the Station complex will also influence the capability of the overall system to service the video requirements of the science experiments. At the conclusion of the Space Station definition phase these internal rates appeared to be unduly restrictive and tended to establish further restrictions on experiment operations. Should cost considerations preclude a substantial increase in internal data rates, the application of video compression will become an even more critical factor in community. In this case, the burden of compression will fall on individual experiments and will likely be accomplished in a much more severe environment. Compression will be implemented within the restricted space of experiment facilities and will be pushed to the limit of its capability to reduce bandwidth requirements. In this case, it is likely that its full application will only be realized after an evolutionary period involving cooperative research between the two communities of investigators.

OPERATIONS MODEL

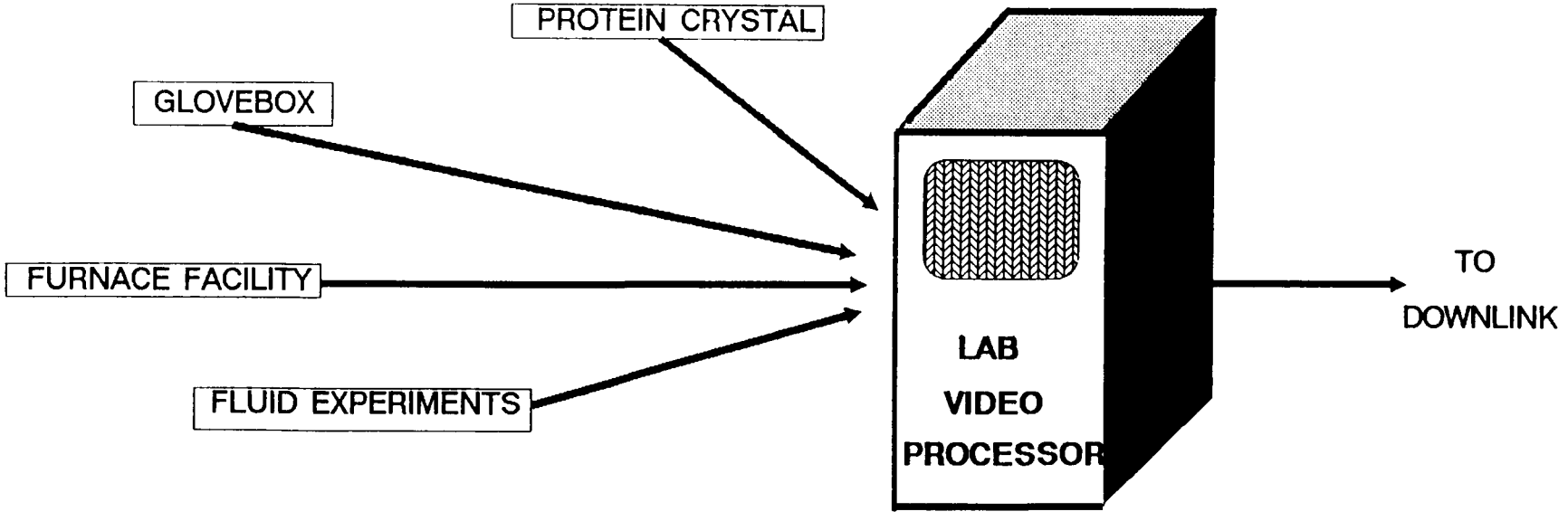


U.S. LABORATORY VIDEO PROCESSOR SUBSYSTEM

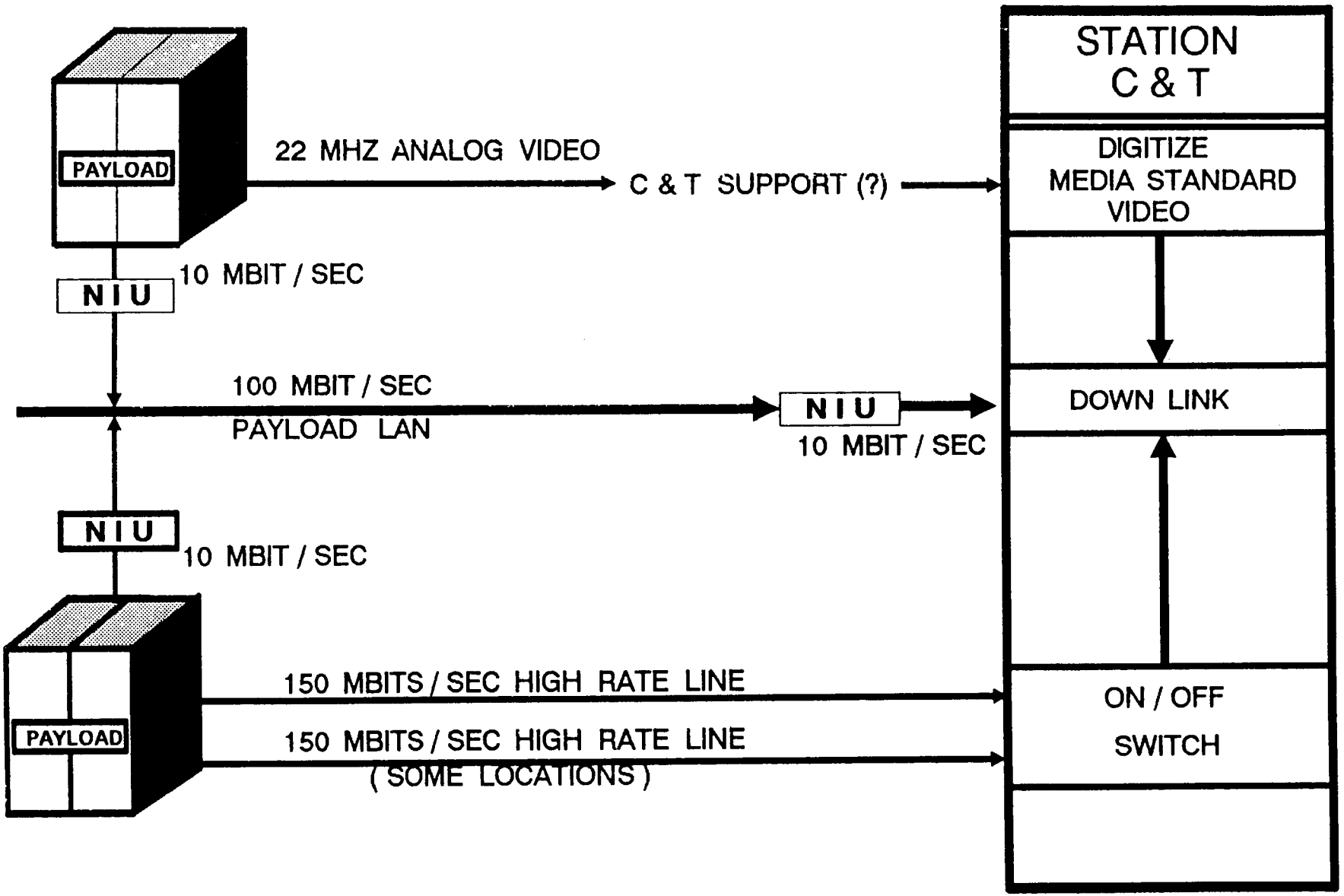
SUBSYSTEM DEFINITION

A LABORATORY DEDICATED SUBSYSTEM PROVIDING THE NECESSARY PROCESSING OF VIDEO IMAGES FROM MULTIPLE PAYLOAD FACILITIES IN THE U.S. LABORATORY MODULE TO SUPPORT ON-BOARD SCIENCE OPERATIONS AND EXPERIMENTS AND TO MANAGE AND COORDINATE THE UTILIZATION OF DOWNLINK RESOURCES.

DISPLAY OPERATIONS	TRANSMISSION OPERATIONS
FRAME CONVERSION IMAGE ENHANCEMENT UTILITY MANIPULATIONS	COMPRESSION MERGING FORMATTING



CURRENT DMS AND VIDEO ARCHITECTURE



PROPOSED ARCHITECTURE
(OR EQUIVALENT)