DIGITAL VIDEO SYSTEM PERFORMANCES ON MASER 11

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ABSTRACT

The Digital Video System (DVS) developed by Techno System Developments (TSD) has been successfully employed in several Sounding Rockets campaigns. The system has evolved from the very first pioneer models since 1996 to the current configuration that in conjunction with the advanced features of the Maser Service Module (MASM) provides a complete and advanced solution for both the flight and ground segments.
The DVS offers to the users a virtual unlimited range of possibilities in terms of interfacing the last generation digital cameras and real-time processing/compression of images for the better exploitation of the, often limited, on board storage and communication resources.

1. DVS CONCEPT IN SOUNDING ROCKETS

Fig.1 illustrates the concept of the DVS as applied for Sounding Rockets missions:

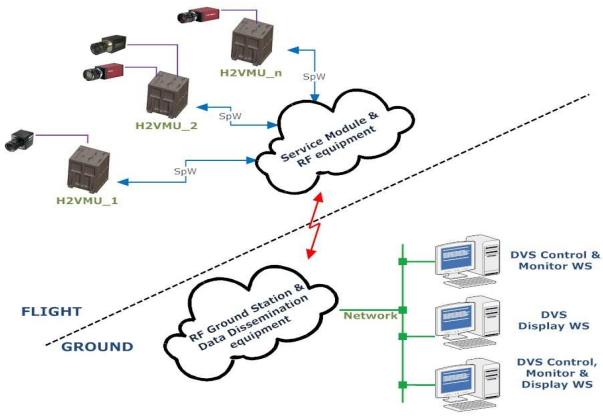
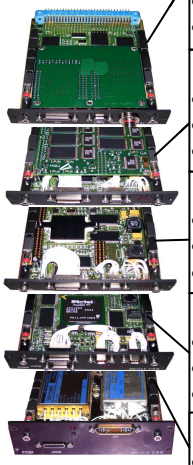


Figure 1: DVS Concept in Sounding Rockets

The DVS consists of a flight and a ground segment.
The flight segment comprises a number of small electronic units named H²VMU (High Resolution/High Frame Rate Video Management Unit) that are in charge of interfacing almost any type of the currently employed cameras (both digital and analogue), performing the desired image process and storage and transferring the output to the Service Module for transmission to Ground.
The ground segment comprises any number of standard workstations connected to the network where the rocket TM data is distributed to the users. The software of the workstations works in real-time and performs the extraction of image and hk data from the network data stream, the image decompression, visualization and local storage.

1.1. Typical H²VMU Arrangement

The H²VMUs are modular units that can be variously assembled according to the user's requirements. Each module carries out a well defined task and communicate with the other modules through several point-to-point high speed links named ChannelLinks working at 1.2Gbits/s. By putting together more modules it is possible to perform more tasks in parallel thus achieving very high performances.
A typical H²VMU configuration is depicted in Fig.2 with a short description of the different module features:



Camera I/F & Video Acquisition Module
- CameraLink, Analogue, Firewire, HD-SDI I/Fs available
- Up to 60Mpixels/s @ 10bits/pixel
- Image Size from 64x64 to 2048x2048

Wavelet Compression & Storage Module
- Lossless or low compression (CF: 1÷10)
- Non volatile storage memory up to 64GB
- Data storage rate up to 30MB/s

Wavelet Compression Module
- Medium/High compression (CF: 10÷100)
- Real-time compression up to 20Mpixels/s
- Constant bit rate output

Central Computer Module
- TM/TC packetization according to CCSDS
- 2 SpaceWire I/Fs up to 50Mbits/s
- Synchronous Serial I/F for direct connection

Power Cond. & Distribution Module
- 18÷40V Input Power
- Input Filtering
- HK data acquisition

Figure 2: Typical H²VMU Arrangement

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2. MASER11 DVS CONFIGURATION

The DVS employed for the MASER11 flight campaign provided support to three out of four experiment modules and to the Recovery System. The flight part was composed of four H^{2}VMUs interfacing nine cameras with different characteristics in terms of video requirements, for a total processing rate of up to 470Mbits/s. The ground part comprised several DVS workstations; some of them dislocated into the Esrange Block House for the real-time monitoring and control during the flight and a few others in the Esrange Scientific Center for the display of the images only.
Fig.3 show a schematic arrangement of the main elements involved in the DVS set-up:

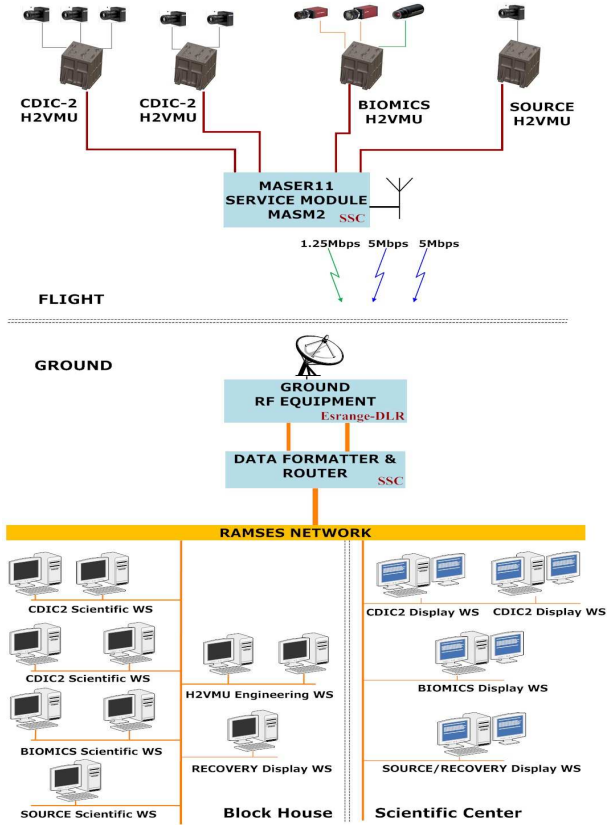

Figure 3: Maser11 DVS Configuration

2.1. H^{2}VMUs for CDIC-2 Module

The CDIC-2 Module was provided with 2 H^{2}VMUs, serving two different experiments.
The first unit interfaced 3 digital cameras with CameraLink interface; it performed lossless compression and storage at full frame rate (30fps) and lossy compression and download at reduced frame rate (6fps)
Fig.4 shows the layout of the H^{2}VMU and samples of images with size in pixels and indication of the compression factors (CF) utilized during the image data download

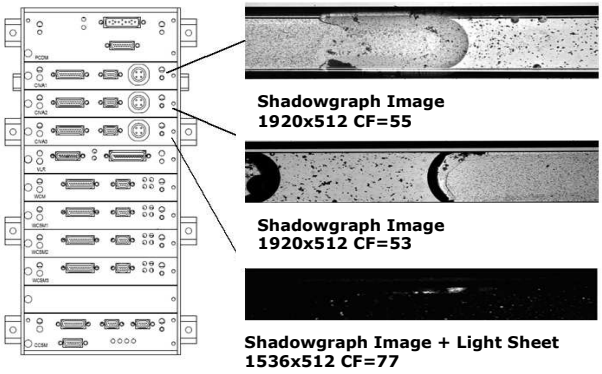

Figure 4: CDIC-2 H^{2}VMU – Capillary Cells

The second unit interfaced 2 digital cameras with CameraLink interface; it also performed lossless compression and storage at full frame rate (30fps) and lossy compression and download at reduced frame rate (6fps)
Fig.5 shows the layout of the H^{2}VMU and samples of images with size in pixels and indication of the compression factors (CF)

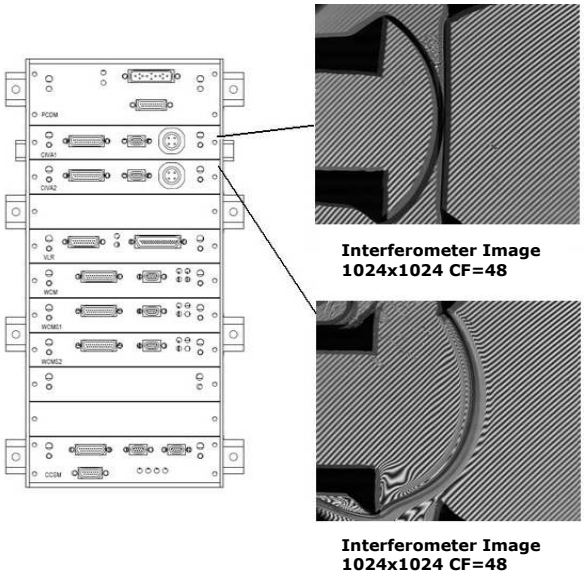

Figure 5: CDIC-2 H^{2}VMU – Hele-Shaw Cells

2.2. H^{2}VMU for SOURCE Module

The SOURCE Module was provided with one H^{2}VMU interfacing one digital camera with CameraLink interface; it performed lossless compression and storage at 16fps and lossy compression and download at reduced frame rate (8fps)
Fig.6 shows the layout of the H^{2}VMU and samples of images with size in pixels and indication of the compression factor (CF).

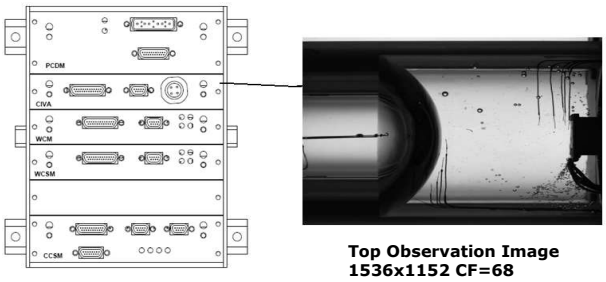

Figure 6: SOURCE H²VMU

2.3. H²VMU for BIOMICS and Recovery Modules

The BIOMICS Module was provided with one H²VMU interfacing two digital cameras with FireWire interface and one analogue camera belonging to the rocket's Recovery System. The unit performed lossy compression and download at 2fps of the BIOMICS images and lossless compression and storage and lossy compression and download at full frame rate (25fps) of the Recovery System images.
Fig.7 shows the layout of the H²VMU and samples of images with size in pixels and indication of the compression factors (CF).

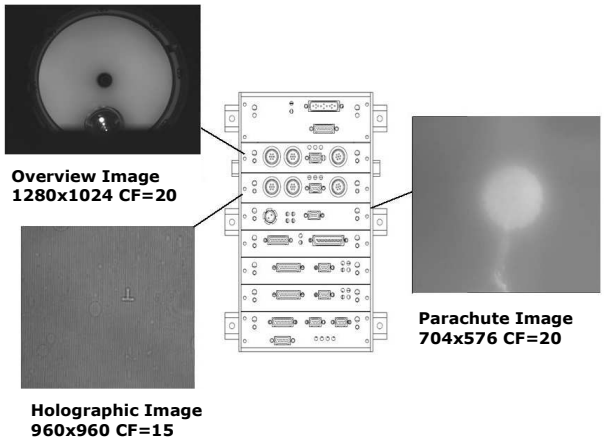

Figure 7: BIOMICS & Recovery H²VMU

3. DVS FLIGHT ON BOARD MASER11

The DVS performed flawlessly during the whole countdown and flight of the Maser11 rocket. Two downlink channels at 5Mbits/s were available for the compressed video download to ground. A third channel at 1.25Mbits/s was also available for the transmission of scientific and housekeeping data. The downlink bandwidth was fairly distributed among the nine flight cameras.
Tab. 1 summarizes the main characteristics of the video downlink in terms of image parameters and bandwidth allocation:

Experiment Module	Camera	Image Size	fps	CF	Data Rate (kbit/s)	SpaceWire Allocation
CDIC2	SHALS Cam1	1920x512	6	55	857	22.3%
	SHALS Cam2	1536x512	6	77	490	
	SHA	1920x512	6	53	890	
	INT1	1024x1024	6	48	1048	20.9%
	INT2	1024x1024	6	48	1048	
SOURCE		1536x1152	8	68	1665	16.6%
BIOMICS & RECOVERY	Camera1	960x960	2	15	983	20.3% or 40.5%
	Camera2	1280x1024	2	20	1048	
	Recovery	704x576	25	20	4055	

Table 1: DVS Downlink Parameters

Tab. 2 shows the results of the DVS flight in terms of lost images. Here the term "lost" means an image that was not possible to reconstruct on ground, regardless of the reason that can reside either in a telemetry bit error or in any other communication path from the on-board camera to the ground workstation. The negligible image error rate indicated in the table gives evidence of the excellent performance of the DVS. The higher rate of lost images related to the Recovery System camera is easily explainable by bearing in mind that the camera was operated during the re-entry phase of the rocket, i.e. when telemetry drops or errors are much more frequent.

Video Channel	Received Images	Lost Images	Image Loss Percentage
CDIC-2 Module			
SHALS Camera1	2817	1	0.035%
SHALS Camera2	2795	1	0.036%
SHA	2857	1	0.035%
INT1	2809	2	0.071%
INT2	2778	1	0.036%
	14056	6	0.042%
SOURCE Module			
Source Camera	3886	2	0.051%
BIOMICS & RECOVERY Module			
Biomics Camera1	916	0	0%
Biomics Camera2	953	0	0%
Recovery Camera	8584	77	NA

Table 2: DVS Downlink Results

Fig. 8 shows the result of the retrieval of the images from the on-board storage memory after the rocket payload recovery. During the 6-minute Maser flight almost 100000 images were recorded for a total amount of about 90GB of data.

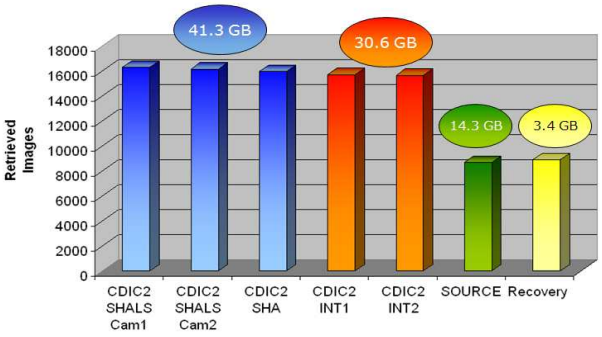

Figure 8: Image Storage Results

4. CONCLUSION

The Maser11 flight represents the first sounding rocket mission where the Digital Video System was massively employed. The success of the mission has demonstrated the level of performances, reliability and maturity reached by the DVS that can be considered today the only complete solution for digital video management readily employable on board sounding rockets and several other space platforms.