MIT Rocket Team Payload

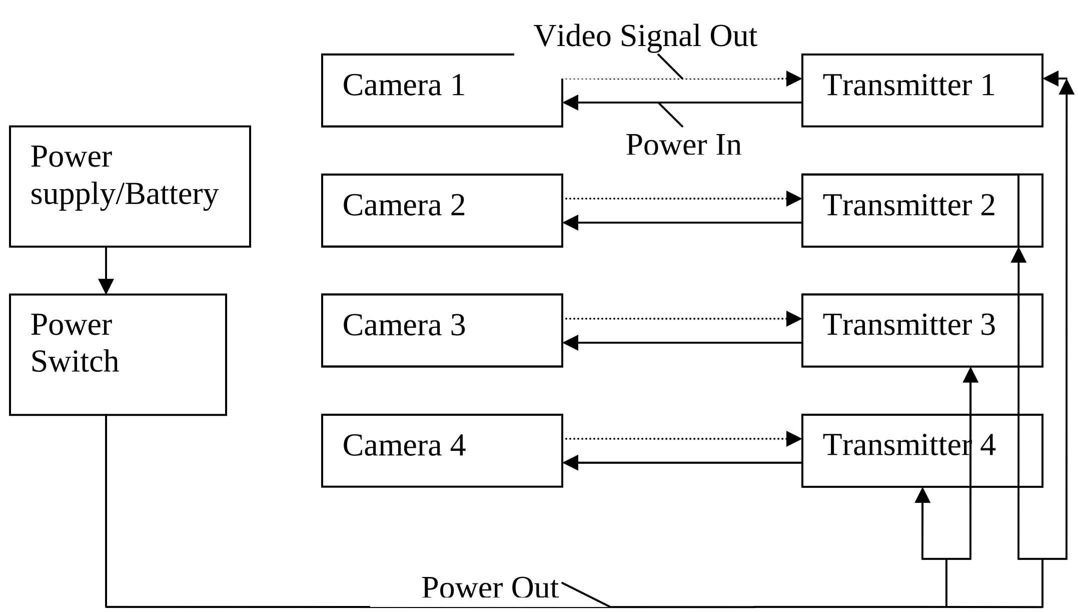
Overview of Previous System:

The previous payload system consisted of 4 major components: the power supply/battery, power switch, the video transmitter, and the video cameras themselves.

Two of the cameras used were manufactured by Sony and use a SONY CXD2163BR Signal Processor. These are NTSC 403, Hi resolution cameras. This means they have 403 Horizontal Line Resolution x 480 Vertical Line Resolution. The other two cameras used could not be identified. According to work previously done on this project, all four cameras were purchased from Visual Zoom (www.visualzoom.com).

Although I have attempted to contact Visual Zoom to find out more information on the non – Sony cameras, they were unable to provide detailed specifications on these cameras. All I know is that the other two cameras record at lower image quality and at a lower resolution.

In the previous setup, a 9.6 volt, 6000 mAH battery was used. Connected to the battery terminals was a specially modified on/off switch, and a series of power adapter cables that distributed power to the each of the video transmitters. The transmitters then relayed the power to each of the cameras. Once the power was distributed to each of the cameras, the cameras then delivered video signals back to each of the individual transmitters. The transmitters performed transmission of the signal from each of the four cameras, using four separate antennas.



Condition of Payload after Previous Rocket Flight Test

Each camera was tested before any further work proceeded. The cameras were labeled, 1 through 4, and the condition of the cameras was noted and recorded.

According to my observations, all four cameras were fully operational. During the previous launch however, only two cameras transmitted a reliable signal, implying that one of camera transmitters is not functional.

Using a multimeter, we were able to properly assess the condition of the wiring for the each of the cameras. Two of the cables that provided power and two of the cables that carried a video signal to two of the cameras, had a severed connector. A note of this has been made and I am currently searching a place I can purchase some extra camera connectors from.

Proposed Design

The new system will also have four cameras, but instead of sending four separate signals to four separate antennas, four full resolution images from each of the four cameras would be combined and delivered into a single video stream that would eventually be delivered from a single antenna. Before perfecting the details of broadcasting, we decided to make a four camera system that would be fully operational first.

In order to facilitate testing, it was proposed that we use onboard camera recording to have a sense of the sort of image quality that we should hope to expect from our four camera system. To that end we purchased two items: MTI DCQ-2000 quad processor from MTI Multiplexers (to combine the four images into a single video stream) and the "Mini VCR" purchased from Marbil Enterprises @ www.surveillance-spy-cameras.com (for onboard digital recording).

A 12 volt power supply will be used. All power supply connections will be routed through a printed circuit board, and the voltage will be divided to provide the necessary voltage for each component.

Jason Lapenta's Work/Multiplexing the image

Jason Lapenta had formerly created a special sequencer that would record and multiplex the video signal such that four full resolution images would be transmitted.

Unfortunately although this method would prove to be useful when broadcasting the signal, a significant amount of time would need to be consumed in post processing. Each frame would have to be picked out and sorted with the remaining camera frames. A lapse time would also be present in the resulting video stream, as imagery from one camera is being recorded before switched to another. Although Jason Lapenta has done a notable amount of work on this, some work still needs to be done to perfect the system.

Using Jason's programmed multiplexing FPGA board would require us to invest a large amount into post processing the broadcasted signal stream. To ease the amount of post processing we would have to do I instead decided to purchase an off the shelf, high resolution digital quad processor in an effort to combine all four pictures into a single high – resolution video stream. Each of the corresponding images would still have only half of the pixel resolution of the full quad image, but, since the full quad image has a total resolution of 858* 512 pixels, that shouldn't present too much of a problem.

A Note on Video Resolutions

Since the camera will be converted into a digital output, in order to split the video into a four camera quad image, we will be dealing primarily in terms of pixel resolution. Pixel Resolution is different from analog TV Line Resolution.

Since we will be dealing with pixel resolution it is important to note that NTSC definition of video resolution of 525 vertical scan line resolution would correspond to a maximum potential TV pixel resolution of 448 horizontal pixel resolution by 480 vertical pixel resolution.

A typical VCR recording will capture the full 480 vertical resolution but will only capture **220 - 240 lines** of horizontal resolution. It will still capture the NTSC standard of **480 lines** of vertical resolution however.

The MTI DCQ-2000 Quad-Processor has the following specifications:

Pixel Resolution of 858 x 512 pixels
Display rate of 60 frames per second
Quad Update rate of 60 frames per second.

Although it has this "high resolution" this resolution is only true for the full quad image display. Using Adobe Premiere Elements, I was able to divide the quad image display into four separate corresponding videos for each camera.

As a result each camera image will have a total resolution of 429 horizontal pixel resolution x 256 vertical pixel resolution, when broadcast from the rocket.

The frame rate of the images will be at 60 frames per second.

This is true only if the image is digitally transmitted and the video signal is broadcasted from the rocket.

Mini Video Recorder:

To facilitate image capture onboard the rocket and to test the reliability of the video connections, we would need to find a high quality mini DVR recorder. To get an appreciably high resolution, however, we would have had to invest approximately $1,995 for Fast Forward Video's Mini DVR Pro (a mini DVR recorder capable of recording video imagery at DVD quality: 720 x 480 pixel resolution.)

Since we were under a tight budget and since we were planning to use Jason Lapenta's original multiplexing concept, a lower resolution mini dvr recorder would have initially suited the task. As a result, we purchased a $399 mini dvr recorder, which is the lowest price for a device that suited our needs. This recorder records at a video resolution of 352 x 240 pixel resolution, at only 25 frames/second, and compresses the resulting video imagery into ASF imagery.

<u>Images with Quad Processor and Mini - DVR</u>

If we were to use Jason Lapenta's multiplexing concept, we would have been able to use this mini-dvr without too much of a problem. The mini dvr would have recorded images from each of the four cameras at full resolution with the frames from each camera interleaved with one another. This method would require us to resort each individual frame ourselves. We would still have to contend with a low frame rate as well, as in we would have camera images that would updated at only 7.4925 frames per second.

The final resolution of a single camera image using Jason Lapenta's multiplexing method would be 352 x 240 pixel resolution at 7.4925 frames per second.

Using the Quad processor with the mini dvr would yield a better frame rate but would obtain single camera image with a picture resolution that was only half of the maximum capable resolution of the mini-dvr.

The final resolution when using the multiplexer of a single camera image would be 352/2 x 240/2 = 176 x 120 pixel resolution at 25 frames per second.

This leads to the conclusion that we should NOT use the mini-DVR as a visual example of the final image we can achieve. The mini-DVR should only be used to test the ability of the video system setup to provide a recordable composite video signal. It could also be used to test the reliability of video connections.

Top image is Image recorded with Mini Dvr without quad (25 fps@ 352x240 pixel resolution)
Bottom image is a single Image recorded by Mini-DVR with quad (25 fps@ 176 x 140 pixel resolution)

Signal Reception of Quad-Processor Broadcast:

Eventually, the signal will need to be broadcasted from the rocket, so the failure of the Mini-DVR to capture video at our desired resolution is not too much of a setback.

Using the quad processor purchased here is what we can expect:
One full-screen quad image at 858 x 512 resolution at 60 frames/second
- Four individual images at 429 x 256 pixel resolution at 60 frames/second

This is assuming no signal loss.

VCR Recording of Broadcast Signal:
Once the signal is recorded onto the VCR, however the quad image will be recorded at 240 by 480 pixel resolution, regardless of the high resolution output of the quad processor.

Once all imagery has been processed from the video cassette recording using video editing software, and the quad image is digitally split into 4 individual screen shots each screen shot will have only a 180 x 240 pixel resolution. This pixel resolution is only slightly higher than the imagery delivered to us by the mini DVR recorder. Now that we have a visual idea of what to expect when using the mini DVR in conjunction with the quad processor, we have a general idea of the resolution that the final imagery will provide us when using the quad processor in conjunction with VCR recording.

Necessity for Highest Image Quality:
Preservation of the resolution received from the cameras is essential. The quad processor reduces the resolution received by the cameras but not by much. In order to obtain the highest image quality possible, it is imperative that all components of the system be able to carry the pixel resolution of the capture device. For that reason, we cannot use a simple VCR to record the quad signal. We should use a high quality digital video recorder, or a computer based digital video recorder, to capture the broadcasted video signal. Once captured digitally, then the image can be split into four separate video streams.

Final Recommendations:
Use of a Mini DVR to capture the images retrieved by the cameras on the payload is not recommended. I would only use the Mini DVR to make sure that the cameras will work with a given video setup.

Use of a video cassette recorder to record the final imagery is not recommended, as we will have substantial loss of pixel resolution. The results would be similar to the results that the Mini DVR provides.

Multiplexing presents problems.

Using Jason Lapenta's method would cause us to have a reduced frame rate for our each of our camera images, but full resolution is maintained. Since the rocket will be rotating at some angular velocity, a low frame rate would lead us to have rather choppy video, and will provide consecutive image frames that will appear very different from one another. Additionally, the post processing involved to use this method will be rather tedious, as we would have to sort and match 1792.8 frames for a one minute video of sequence.

The use of a quad processor I feel would be better suited for this application. Since a high pixel resolution processor is used, once this image is divided individually, the original horizontal video resolution of each of the four cameras is maintained, while some of the vertical resolution is sacrificed.

If you want the best resolution:

If the maintaining the ultimate highest resolution is desired, I recommend using a single hi-resolution camera, broadcasting the analog signal, and then recording the broadcasted analog signal using a standard Digital Video Recorder, or computer equipped with a high-end digital video capture card. Using any other type of recording device would result, in substantially poor quality low-resolution image.

If you choose to go this route future uropers should attempt to find a way to transmit all four signals and deliver them through a single antenna. Bear in mind, that you will need four separate DVR Recorders, to capture the final signal. (If you record using VHS you are again reducing the resolution captured, and it would be no different than using the quad processor anyway)

Recommended Next Steps

Determine whether it's both time and cost effective to broadcast digitally, as opposed to broadcasting analog. If analog transmission offers more benefits, figure out what will be required to transmit an image from a single camera 100 kilometers high. Once we've worked out the details of broadcasting the imagery of a single camera, then we can attempt to find a way to capture imagery from 4 cameras. After this, work should be done on creating a despin mechanism for the camera payload.

Top image is an Saturday Night Live Clip (Recorded @ 30 fps, 640 x 480 pixel resolution), Divx 5.2.1

Bottom image is the same image fed through the multiplexer: Note the diminished resolution but bear in mind, that this image was fed through an S-Video out connection at slightly reduced quality, input into the multiplexer, then captured by a Canopus ADVC-50 Analog to Digital video converter, capture card. It was then compressed using Cinepak compression, and cut in Adobe Premiere Elements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