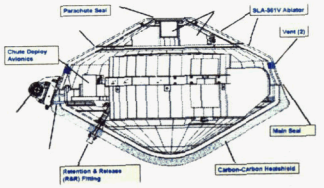
EV13 Genesis Reentry Observations and Data Analysis

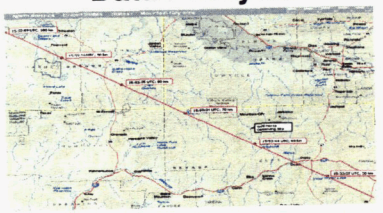
Wesley R. Swift (MSFC Group / Raytheon), Dr. Robert M. Suggs (EV13)

Abstract

The Genesis spacecraft reentry represented a unique opportunity to observe a "calibrated meteor" from northern Nevada. Knowing its speed, mass, composition, and precise trajectory made it a good subject to test some of the algorithms used to determine meteoroid mass from observed brightness. It was also a good test of an inexpensive set of cameras which could be deployed to observe future shuttle reentries. The utility of consumer grade video cameras was evident during the STS-107 accident investigation and the Genesis reentry gave us the opportunity to specify and test commercially available cameras which could be used during future reentries. This report describes the video observations and their analysis, compares the results with a simple photometric model, describes the forward scatter radar experiment, and lists lessons learned from the expedition and implications for the Stardust reentry in January 2006 as well as future shuttle reentries.



EV13 Genesis Reentry Observations and Data Analysis



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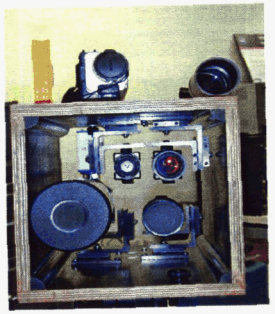
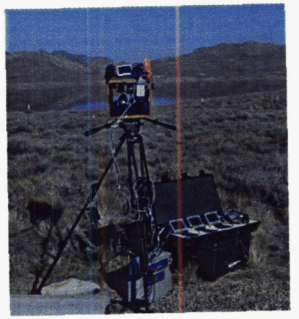
Pre-Reentry Assumptions

Acquisition:	15:55:28 UT Genesis predicted as bright as Venus at magnitude -4 This magnitude is marginally visible in daylight Altitude 59 miles
Mid Bright:	15:55:37 UT Assumed bright as a typical Iridium flare, magnitude – 6 This magnitude is easily seen if you know where to look Altitude 52.5 miles
Max Bright:	15:56:04 UT (predicted, 15:53:38 observed) Predicted maximum brightness magnitude -9 or as bright as the last quarter moon. Actual visual magnitude -5.4 This magnitude is easily found and visible in daylight Altitude 35 miles
Rapid fading:	15:56:08 UT

Instrumentation : Tracker

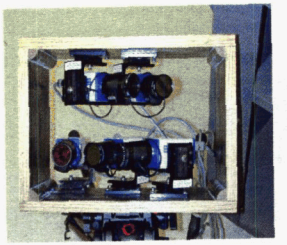


Tracker camera array fitted with lenses of various focal lengths and filters to reduce the daylight sky background and an objective grating for low resolution for spectra.



Tracker video array at Wild Horse NV. Note remote power and Digital 8 recorders by tripod. Tracking was never achieved due to low visibility of the Genesis capsule against daylight sky.

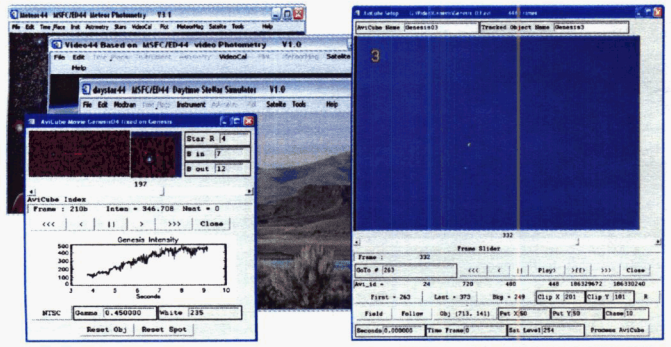
Instrumentation : Mosaic



Mosaic camera was an array of 5 Stellacam EX video cameras aligned to capture 110° FOV. Each camera was fitted with a 12mm f/0.8 lens, an R25 filter and a polarizer for contrast enhancement.

Mosaic Camera array in position at Wild Horse Reservoir, Nevada. Five digital 8 recorders and the remote power system are to the left of the tripod. The reentry path was from far right (West) to the left in this view. Photometric quality was obtained for *14* seconds of the trajectory.

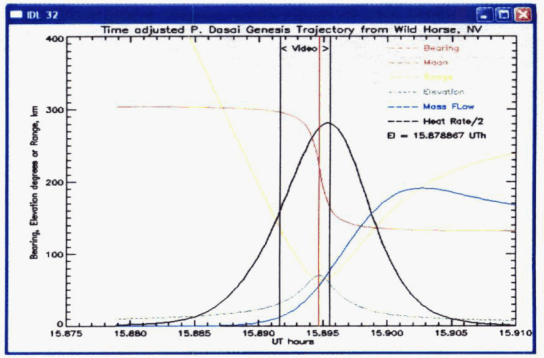
Video Analysis Software



The Genesis Video images were planned using **DayStar44** with ModTran, which is based on **Video44**, which in turn is based on **Meteor44** developed by NASA/MSFC.

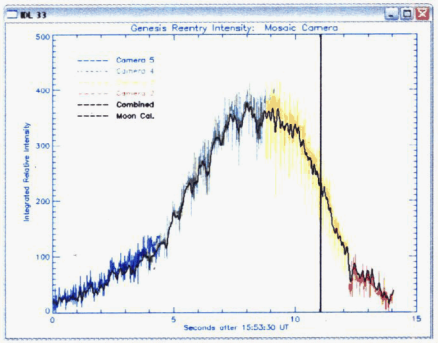
Video44 was used to analyze these images as well those from STS107 amateur video.

Genesis Post Flight Trajectory



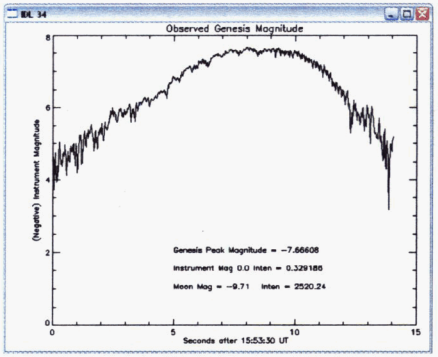
Genesis post reentry trajectory as determined by P. Dasai and viewed from Wild Horse, Nevada. The bearing and time of the lunar conjunction (vertical red) was used to find the time of was used to find the time of entry interface, EI, (15:52:43.9 UT) and to align with the video images.

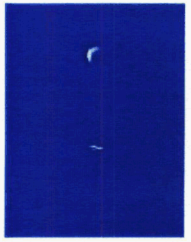
Mosaic Camera Photometry



Combined photometric intensity in instrument units. The overlap between cameras has been used to adjust the gain of cameras 2, 4 and 5 to that of camera 3. The Genesis intensity and timing at lunar conjunction (vertical line) as seen by camera 3 is used for time and intensity calibrations. Camera 2 included a significant sun glint which limited detectability.

Observed Genesis Magnitude

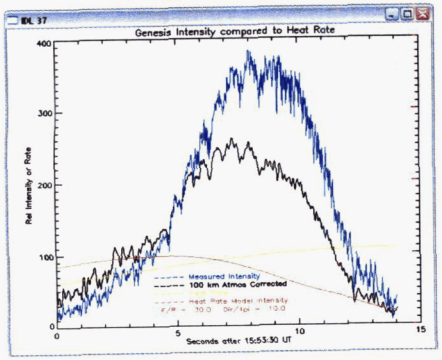




Genesis at conjunction is significantly dimmer than the moon.

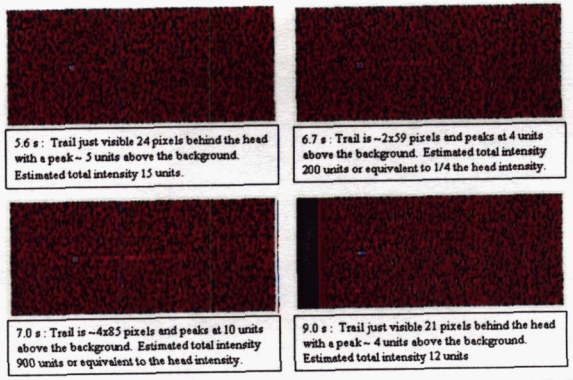
Observed **Instrument magnitude:** As a reference, the last quarter (23.6 day) moon is -9.10 visual magnitude with instrument color index (lunar) of -0.61. Visual magnitude is estimated as 2.29 magnitude dimmer (-5.4) than above observed instrument magnitudes.

Atmospheric and Range Corrected Observations



The P. Dasai post-reentry trajectory as viewed from Wild Horse, Nevada was used with the AFRL atmospheric model, ModTran, to correct the observed intensity to 100 km standard range and for atmospheric extinction over the slant path range.

Genesis Trail Observations



5.6 s : Trail just visible 24 pixels behind the head with a peak ~ 5 units above the background. Estimated total intensity 15 units.

6.7 s : Trail is ~2x59 pixels and peaks at 4 units above the background. Estimated total intensity 200 units or equivalent to 1/4 the head intensity.

7.0 s : Trail is ~4x85 pixels and peaks at 10 units above the background. Estimated total intensity 900 units or equivalent to the head intensity.

9.0 s : Trail just visible 21 pixels behind the head with a peak ~ 4 units above the background. Estimated total intensity 12 units

False color view of trail observed following the Genesis as captured by Matrix camera 4. Trail was first observed at peak of observations.

Mosaic Camera Summary

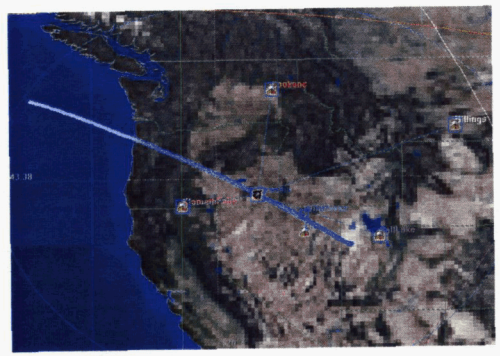
This experiment demonstrated that a simple array of commercial video cameras can photometrically record reentry emissions even under daylight conditions.

A stationary, staring array reliably captured data even though the reentry was never seen visually.

This data provides valuable constraints on meteor and reentry models.

Similar techniques are even more productive during nighttime reentries with their dark sky. A similar expedition is planned for the Stardust reentry.

Genesis Forward Scatter Radar



Geometry of the Genesis trajectory and TV transmitters at the video carrier frequency of 55.240 MHz, TV channel 2 with negative carrier offset.