NASA High-Speed 2D Photogrammetric Measurement System

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Abstract

The object of this Technical Memorandum is to provide users of the NASA high-speed 2D photogrammetric measurement system with procedures required to obtain drop-model trajectory and impact data for full-scale and sub-scale models. This guide focuses on use of the system for vertical drop testing at the NASA Langley Landing and Impact Research (LandIR) Facility.

Background

The Landing and Impact Research Facility (LandIR) is a 240 - by - 400 foot - A-frame structure with a 70 foot vertical drop tower. The facility, originally named the Lunar Landing Research Facility (LLRF), dates back to 1965 to train Apollo astronauts for lunar landings. In 1972 it was converted to crash-test full-scale aircraft, helicopters and fuselage subsections. It was re-named the Impact Dynamics Research Facility (IDRF) [1]. Most recently, the facility (now know as the LandIR Facility) has been used to support Orion Multi-Purpose Crew Vehicle (MPCV) impact tests and other aerospace related studies.

Overview

The NASA high-speed photogrammetric measurement system consists of various hardware for implementation of single-camera, two-dimensional photogrammetric measurement techniques. These techniques are applied to high-speed video sequences from which test article model trajectory and impact dynamics data are obtained during vertical drop tests. The basic instrumentation consists of high-speed cameras, camera control software and, custom MatLab-based software. The measurement technique has been used successfully for numerous test campaigns at the NASA Langley Landing and Impact Research (LandIR) Facility. Relevant tests using the system have included full-scale and half-scale Orion Multi-Purpose Crew Vehicle (MPCV) impact tests and other aerospace related studies. The focus of this Technical Memorandum mainly concerns, but is not limited to, use of the photogrammetry system for LandIR MPCV half-scale model soil characterization photogrammetric measurement studies conducted at the 70 ft. vertical drop tower.

Hardware Components:

The minimum hardware requirements for use of the photogrammetric measurement system are as follows:

Computer Requirements

● Pentium-based computer; performance video card; and wired network card.

Camera/Optics Requirements

●Minimum of one (1); Vision Research Phantom High Speed Camera (or equivalent), v7(800 x 600 resolution) or v9.1 (1632 x 1200 resolution) @ 1000fps; 14-bit CMOS sensor technology; Gigabit Ethernet interface; IRIG-B timing code; 2μsec shutter (See Fig.1).

Figure 1. Vision Research Phantom High Camera, Version 9.1

●Lenses: Various fixed focal lengths typically, 28mm, 35mm, 50mm, 60mm, 90mm, 105mm

Electronics

● IRIG Garman GPS 18 LVC, 5 meters, Time code generator model TCG with Internal GPS receiver, 1 to 9 VDC, 20mA ac adapter

Cables

●Cables: RG-58, various lengths up to 300 feet; Ethernet cable, 300 feet; camera cable bundle with IREG connector; camera power cable; camera Ethernet adapter cable; extension cords, 300 feet. BNC tee-connectors and BNC barrel connectors.

Misc. Hardware

●Tripods: Tall and heavy framed similar to Manfrotto tripod model 3258, Manfrotto tripod head model 3047

Software

●Phantom Camera Control Software, Phantom Control Version 8.4.630.0-C PhCon: 630

●NASA developed software using MatLab

System Hardware Configuration

Targets: Photogrammetry targets should be assembled as diffuse white-on-black or black-on-white printed arrangements. Typically, 6- to 8-inch square by one-half inch thick white form board plates are printed with centered black circles (See Fig. 2). Target size is dependent on distances from the camera and lens field-of-view. The form board plates are strategically positioned on the support beams of the model (See Fig. 3). Four (4) targets are nominally used on the half-scale MPCV model; two on the South-side (front view) and two on the West-side (side view) (See Fig. 4).

Figure 2. Target.
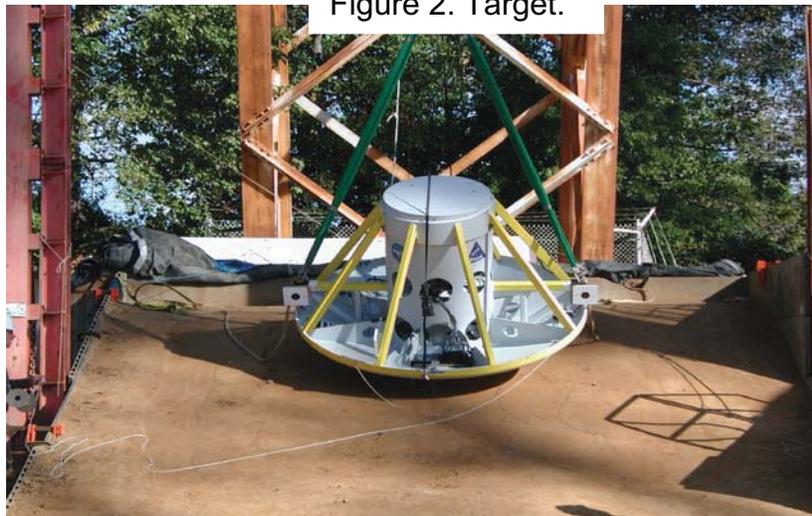
Figure 3. South-side targets on the support beams.

Figure 4. West-side targets on support beams.

Cameras: The LandIR Facility is oriented in an East-West direction with the entrance road to the facility, West Bush Road, on the south-side. (Refer to Fig. 5 for camera location orientation).


Figure 5. LandIR orientation.

 Three Phantom cameras are normally utilized to obtain video sequences for half-scale MPCV model drops. A camera on the south side captures target images on the front of the model. A camera on the west side captures target images to the left of the front-side of the model, and, a camera in the southwest corner of the facility captures images near the bottom of the model as it impacts the ground. Images from the southwest camera are used to help synchronize all of the other cameras at the precise moment of impact via use of the time code generator [2].

Typical lens assignments for the various cameras are:
● 50 mm lens for the south camera;
● 60 mm lens for the west camera;
● 28 mm lens for the southwest camera.

The choice lens is determined by the proximity of a particular camera to the model and the need to see specific targets at various aspects of the model during release and impact.

The south camera is placed about 70 feet from the edge of the vertical landing perimeter of the half-scale MPCV model (See Fig. 6). The west camera is also placed about 70 feet from the edge of the vertical landing perimeter (See Fig. 7). The southwest camera is placed at the corner edge of the vertical drop perimeter to obtain a good view of the bottom of the vehicle as it makes contact with the ground. For the south and west cameras, the tripod legs are fully extended to a height that positions the model in the center of the image plane. The tripods are leveled using the bubble level on the tripods. The cameras are leveled using the bubble levels, for tilt and rotation, on the tripod heads. The cameras are centered and squared normal to the horizontal and vertical planes of the model before the lenses are focused. The southwest camera and tripod do not need to be leveled since the images recorded are viewed for optimal angle perspective and no target information is acquired.

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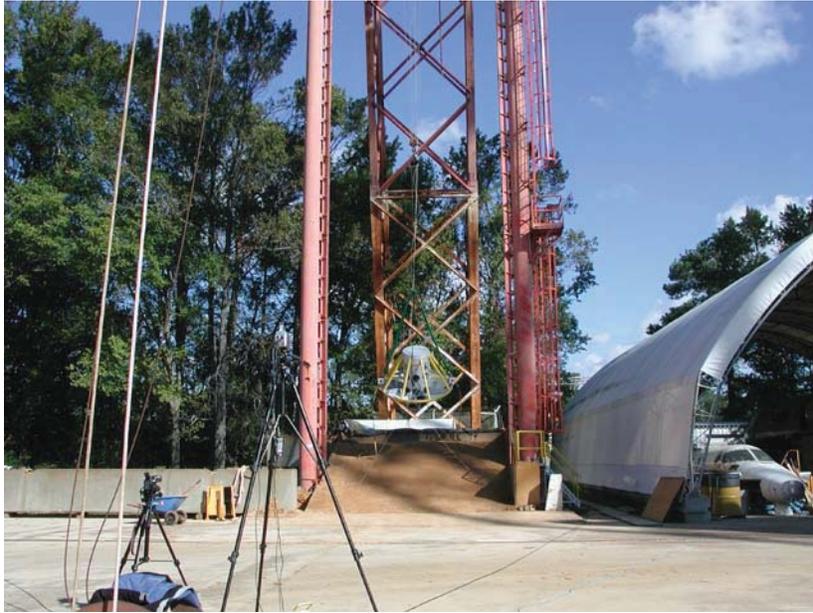
Figure 6. South camera view perspective.

Figure 7. West camera view perspective.

Relatively long focal length lenses are used to help minimize optical distortions when capturing image data for two-dimensional photogrammetric analysis. Perspective distortions are also minimized by carefully aligning the camera(s) perpendicular to the swing plane of the drop vehicle. Squaring the cameras' orthogonal to the vehicle's (swing/drop planes) coordinate system is important for obtaining good 2D photogrammetric reconstructions.

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Cabling:

Cable connections are made between the computer to power; computer to camera (via an Ethernet); camera to power; IRIG to power; camera to IRIG (See Fig. 8.)
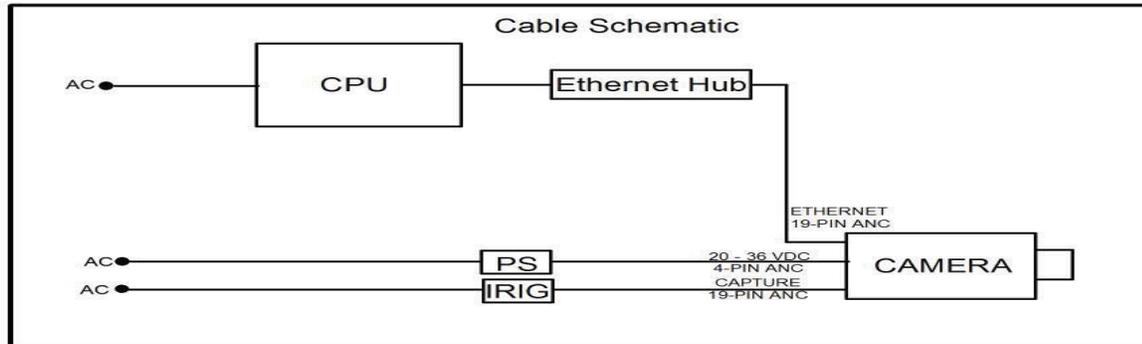
Figure 8. Cable schematic.

The following specific cable connections are required:

● Three of the four connections on the back of each Phantom V7 and V9 high speed cameras are used: Ethernet, Capture and 20 – 36 VDC (Power) (See fig. 9).

● Ethernet: A 19-pin ANC connector is attached to the Ethernet plug on the camera. The other end, a network connector, is attached to an Ethernet cable via an extender and plugged into the computer's network card.

● Capture: A 19-pin ANC connector is attached to the Capture plug on the camera. The other end, a BNC bundle, is attached to the IRIG BNC connector (white label). (A length of RG-58 cable and a BNC barrel connector is needed to make this connection).

● Power: A 4-pin ANC connector is attached to the 20 - 36 VDC plug on the camera. The other end is connected to the round prong of the power supply for the camera which is connected to a 120 VAC outlet.

Figure 9. Cable connections for the Phantom camera.

Note: There are at least seven (7) outdoor 120 VAC outlet panels around the perimeter of the LandIR facility than can be utilized when establishing power connections.

Viewfinder (not normally used): This allows for viewing of the camera set-up with use of a monitor at the camera. This camera feature is not used during set-up primarily because the image on the monitor has a smaller aspect ratio than what is viewed in the Phantom software image on the computer. Camera adjustments and leveling alignments are done using radio communication between the computer operator and the camera operator.

IRIG: The Garman GPS 18 LVC Timecode Generator, Model TCG, is a crystal controlled IRIG-B timecode source which will synchronize with 1 microsecond accuracy to GPS receiver outputs when available, otherwise reverting to coast or fail-safe mode. The IRIG is used to verify synchronization of the high speed video cameras.

The BNC connector on the IRIG is connected to the cameras IRIG (white connector) using a 5 VAC adapter into the IRIG. The other end of the adapter is plugged into a 120 VAC outlet.

System Software

Acquisition: Data is acquired using the Phantom camera control software (latest versions used are v 630 and v 654) (see Fig. 10). Recorded image data is stored within the camera's memory and uploaded to the controlling PC notebook at the conclusion of the test. The image data is volatile while in the camera memory and should be quickly uploaded to a PC before power is disconnected from

the camera. The Phantom software is also used to convert the proprietary Phantom formatted image (.cin) files to much smaller MatLab friendly (.avi) files with minimal file compression.

Figure 10. Image of model in the Vision Research Phantom software, ver. 630.

Analysis: Customized MatLab software is used to perform two-dimensional photogrammetric data analyses on images captured by the high-speed Phantom cameras used to capture drop model impact dynamics at the LandIR. Custom MatLab functions are used to identify and track each of the photogrammetric targets throughout the video sequence.

Data Acquisition and Analysis Procedures

Acquisition Using Phantom Software Package: Test video is acquired using Vision Research Phantom software, V.8.4.630. Two notebook computers are used to record the video from three or more cameras. Each camera view is given a unique filename.

For example, **2008-08-05_CEVHS_s_105mm**,
Where: *2008-08-05* is the date of the test;
                       CEVHS is Crew Exploration Vehicle Half Scale
                       s is South view
                       105mm is the lens size of a camera

Data is then transferred from the notebooks to two "work" external hard drives labeled "South and East" and "North and West". Copies of the raw data are also transferred to a backup external hard drive labeled **CEV Backup.** The gantry test engineer is provided with copies of the raw data. Raw data is in the Phantom software format, **cine, (*.cin).** The external hard drive directory structure may be set-up as follows:

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E:\CEV\South Camera\Centroid

● From the Phantom software menu choose **File** then **Open**.

● Select the appropriate *.cin* video file.

● Verify that the image has good contrast in the target area by playing the video file.

● From the menu, choose **File**, **Convert & Process cine**.

● In the **Open** window choose the *.cin* file to be converted. (See Fig. 11).

● A **Save Cine** window is opened.
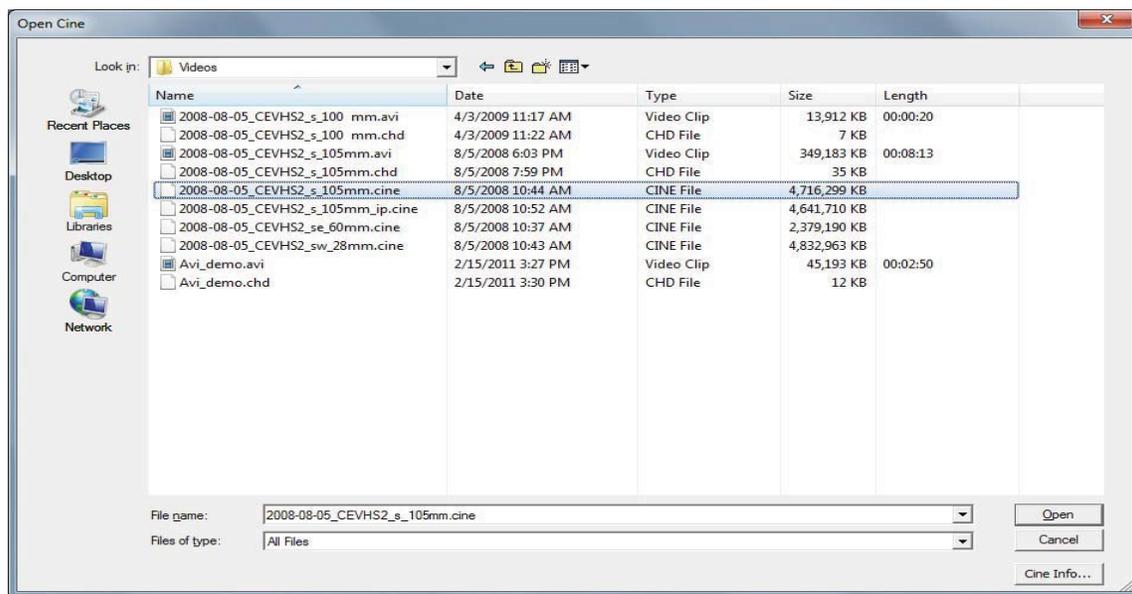
Fig. 11. Phantom Open Cine window.

● Give the file the same name as the *.cin* filename but choose *.avi* as the extension. Click **SAVE**. (See Fig. 12).

● An **AVI Options** window opens
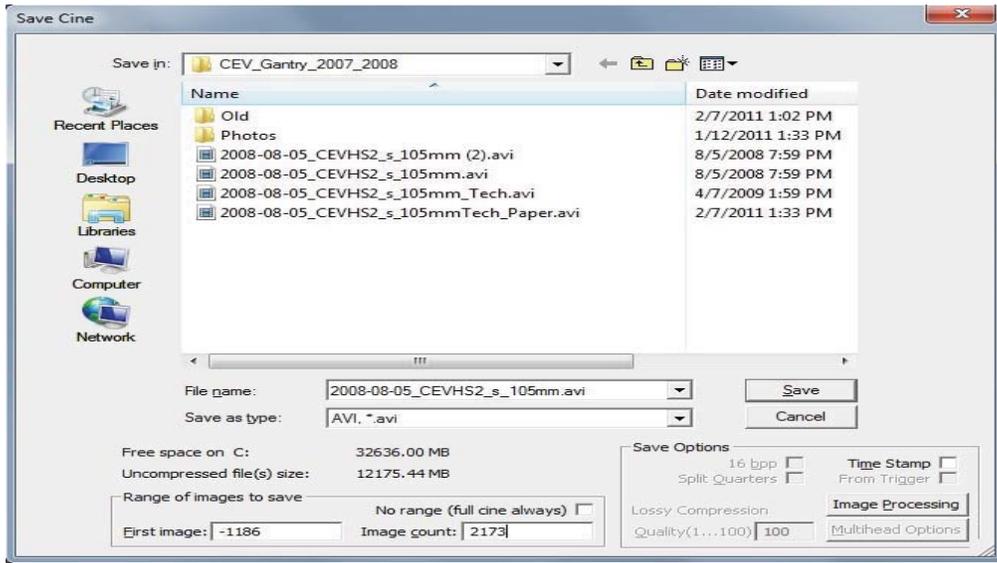
Fig. 12. Phantom Save Cine window.

- In the **Video Compression** drop-down window, choose **Intel Indeo Video 4.5**.

- Use the default **Frame Rate** (fps 5) and **Compression Quality** (65%).

- Click **OK**.

The conversion window opens and the video is converted. **Intel Indeo 4.5** is currently being used to convert and compress a *.cin* to a *.avi*. In the conversion process a *.chd file is also generated. This file format contains the time codes and must be retained.

The procedure above is repeated for each camera video file. The time it takes to convert a file may vary from 45 minutes to one hour for black and white video and from one and one-half hours to two hours for color video. File sizes vary from 2 GB to 7 GB in the .cin format. Converted .avi files are less than 1 GB.

Note: Video files converted to *.avi* may be longer than is needed for data information. In the **Save Cine** window, choose **Range of images to use** to shorten the file size.

To complete acquisition and formatting of images, within the CEV test directory, create a folder for the **Centroid** files.

Open one of the new *.avi* camera files.

A start frame and end frame for the new *.avi* file has to be determined. This is done by playing back the video of a camera's file in the Phantom software. The start frame is determined when the first targets are fully visible. Enter this frame number in Save Range. The end frame is determined by one of three conditions:

- when the model targets are fully off of the viewing screen, or,

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- sometime after the model has made impact with the ground, or,
- when targets are no longer visible due to interference from debris

Enter this number in Save Range as the end frame.

Camera frame rates determine the time values. When the camera is operating at 1000 fps (which is the typical frame rate) each frame is 0.001 seconds in time. The validity of these time values is confirmed through the IRIG.

Analysis using MatLab Software – Overview: Two-dimensional photogrammetric data analyses are derived from the high-speed video data images acquired by the Phantom cameras used to capture drop model impact dynamics at the LandIR. Custom MatLab functions are used to identify and track each of the photogrammetry targets throughout the video sequence. Grayscale contrasts between the targets and the background of the accompanying target mounting plates provide reliable frame-by-frame two-dimensional pixel tracking of the center of the targets on the image plane. These grayscale-weighted target centroid positions have approximate 0.1-pixel accuracy for each target within each video frame of the sequence. Occasionally target obstructions such as guy wires, tether ropes, or dust created during impact, are encountered during testing that interfere with target tracking. These encounters can cause errors or momentary loss of a target positions.

Centroid Processing of Image Data: Copy the camera folder containing converted *.avi* video into a sub-directory within the CEV folder. An example of the file structure can be:

C:\MatLAB\CEV\South Camera\2008-08-05_CEVS2_s_105mm.avi, and,
C:\MatLab\CEV\West Camera\2008-08-05_CEVW2_w_90mm.avi.

Open MatLab. In the **Current Folder** pull-down window, make sure the correct path is displayed (See Fig. 13).


Fig.13. MatLab Command Window in the work directory.

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There are two auxiliary NASA developed MatLab functions used to select the frame intervals:

avidisplay
aviStartEnd

avidisplay: A **Select File to Open** window opens (See Fig. 14). Choose the work *.avi* video. A **Figure 1** window opens and the *.avi* file advances the image frame-by-frame. The user can observe at what frame the targets appear in the view (start frame) and typically, at what frame the model impacts the ground (end frame).
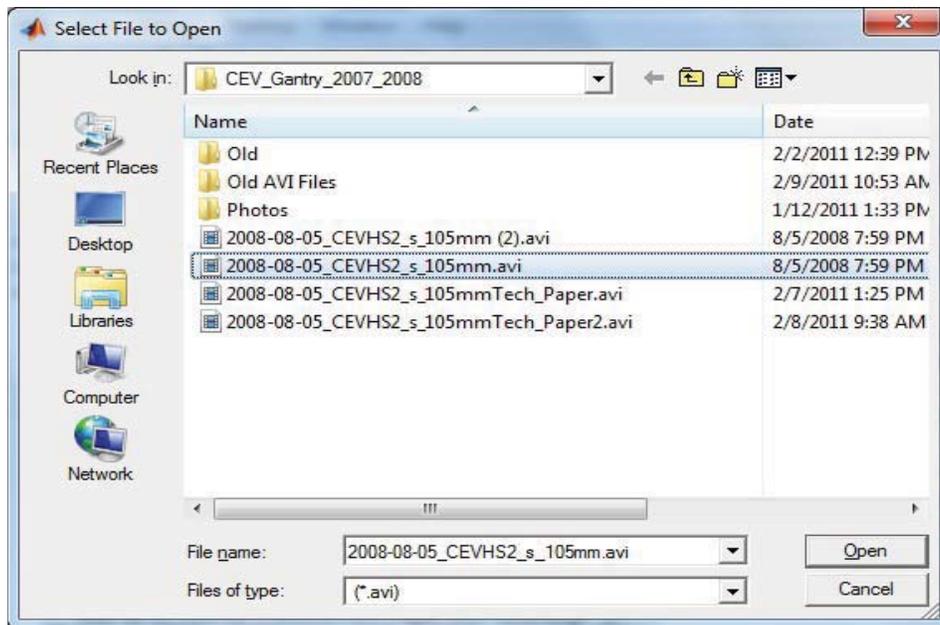
Fig. 14. MatLab Select File to Open window.

avidisplay can also be used with input arguments. For example,
avidisplay(frame start, frame increment, frame end).

aviStartEnd: A **Select File to Open** window opens. Choose the work *.avi* video. A **Figure 1** window opens with a scaled image. By clicking within the scaled area, the video can be advanced or reversed. Reading from left to right, the image can be reversed (-100 frames; -10 frames; -1 frame) or advanced (+1 frame; +10 frames; +100 frames). Select the start frame. Click outside of the **Figure 1** window. This will record the frame number. Click inside the window to advance to the end frame. Click outside the **Figure 1** window to record the end frame number.

Once this procedure is completed, the following information is displayed at the MatLab command line:

Filename:
FileSize:
FileModDate:
NumFrames:
FramesPerSecond:

12

Width:
Height:
ImageType:
VideoCompression:
Quality:
NumColormapEntries:

To continue the centroiding analysis, type **cev** at the MatLab prompt. Hit **Enter**.

The *CEV input* window opens**. (See Fig. 15).
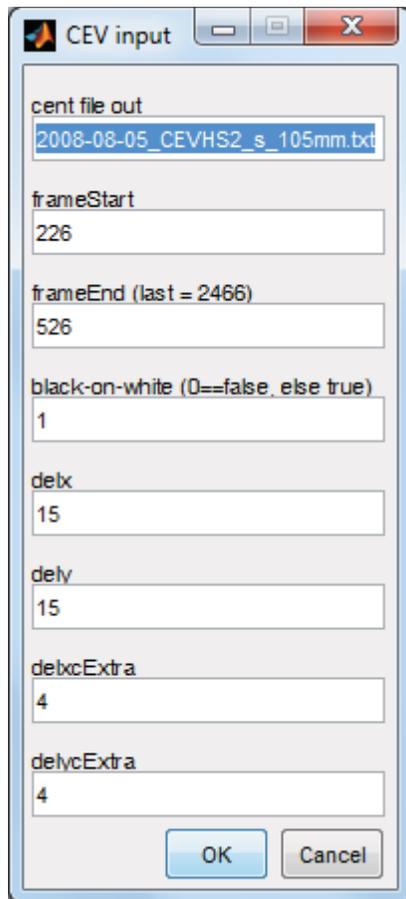
Fig.15. MatLab cev input window.

The CEV input window allows the user to edit the following data as required:

● **cent file out:** indicates the name of the centroid text output file

● **frameStart:** the initial video frame from which targets will be tracked

● **frameEnd:** the final video frame from which data will be tracked

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- **black-on-white (0==false, else true):** if tracking a black target on a white background, enter 1. If tracking a white target on a black (dark) background, enter 0.

- **delx, dely:** refers to the pixelated *region of interest* (ROI). The size of the ROI can be adjusted by entering a smaller or larger value, typically between 2 and 15.

- **delxcExtra and delycExtra:** refers to how many additional pixels the cev script will track beyond delx and dely. These values are typically between 0 and 4**.**

Once all the entries have been made, click OK, A **Figure 1 Select targets to track** window opens. Select, in order from left to right, the targets to be tracked. The targets are numbered in the order in which they are selected (See Fig. 16). Hit **Enter**. The CEV program will scan the targets within the video frames designated in the ***aviStartEnd*** function*.* MatLab will use backward tracking for lost targets and ask the user to re-select the lost targets. Hit ***Enter.***
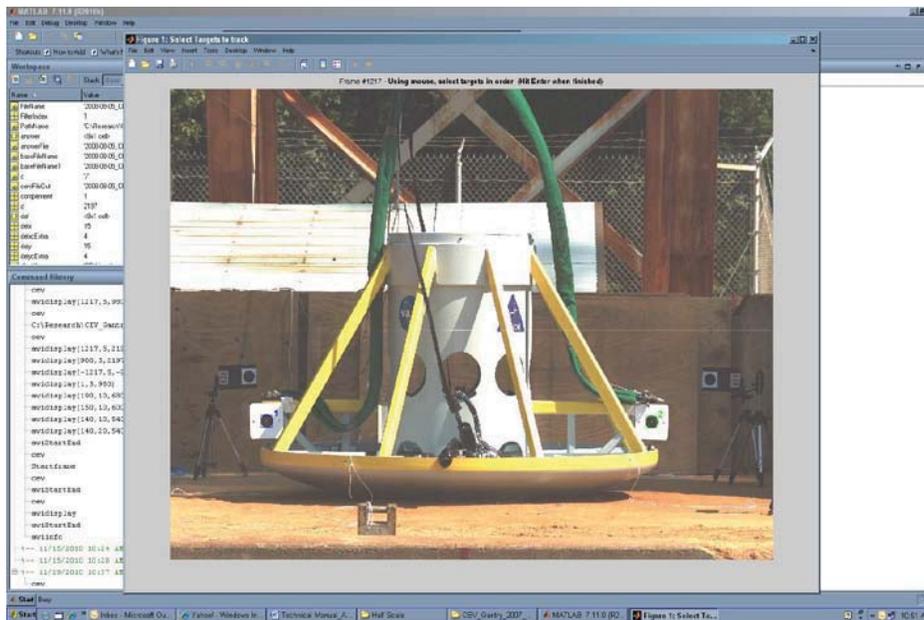
Figure 16. Targets 1 and 2 selected.

In the course of the scan, there may be targets that may have been compromised by debris, cables or shading. If one or more target(s) are compromised, a new target scan window, ***Re-Scanning for Lost Targets,*** will be displayed and the video will be re-tracked backwards. A ***Figure 3: Targets with suspect data = 1*** window is next displayed. This window allows the user to go to a specific target point and reject the data from the frame interval that is determined as having the invalid data.

Generated Plots: The initial plot depicts the difference in position between each of the target points with respect to the initial target points in an x- and y-coordinate (See Fig. 17). If there are no anomalies in the plot, the data is accepted by hitting ***Enter***.
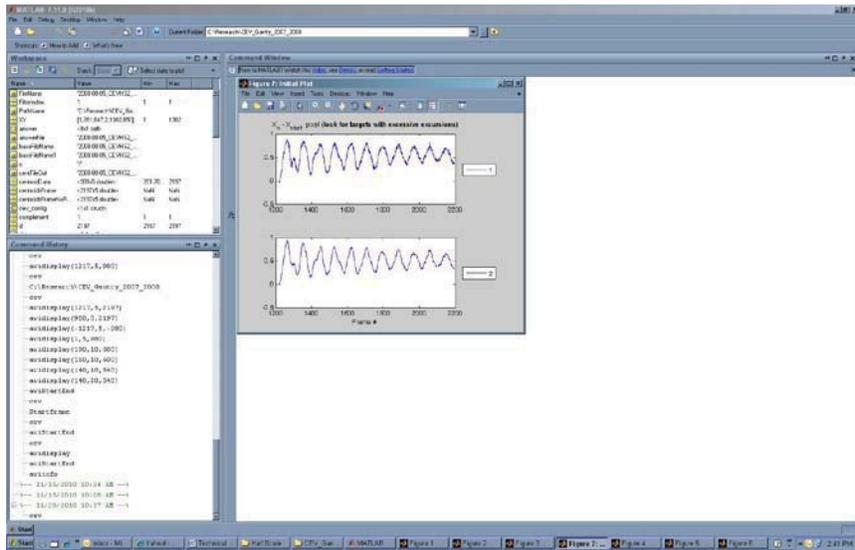
Figure 17. Initial CEV plot.

Once the initial plot is acceptable, a ***Figure 4*** plot is generated. This plot depicts the displacement of the test article (See Fig. 18). This plot should be saved with the name of the video and frame count with a ****.fig*** extension. An example filename is:

2008-08-05_CEVHS2_s_105mm_1217_2197.fig
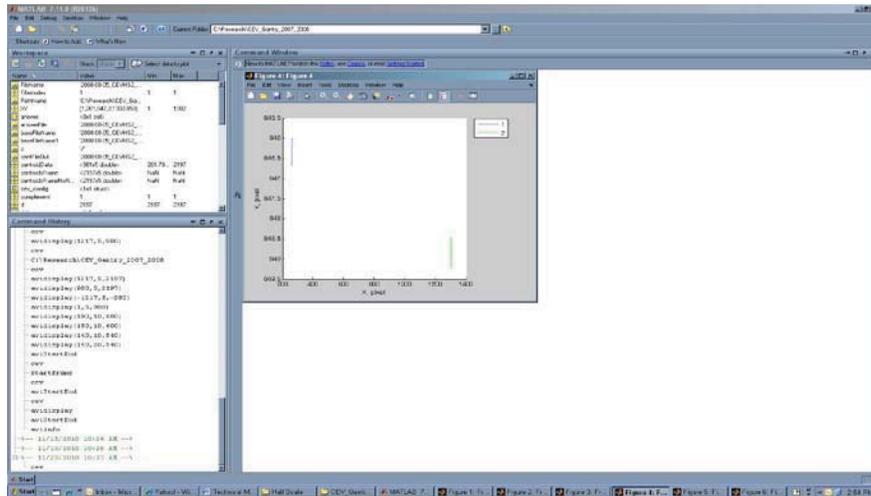
Figure 18. Test article plot.

Editing the Centroid File: A centroid file is generated within the work directory. For this example, the centroid filename is:

2008-08-05_CEVHS2_s_105mm_1217_2197.txt

Once the centroid file is generated, the user opens it in a text editor such as TexPad (See Fig. 19). The file is then saved and is ready for data reduction by the instrumentation research engineer. The reduced data is then forwarded to the test facility research engineer.
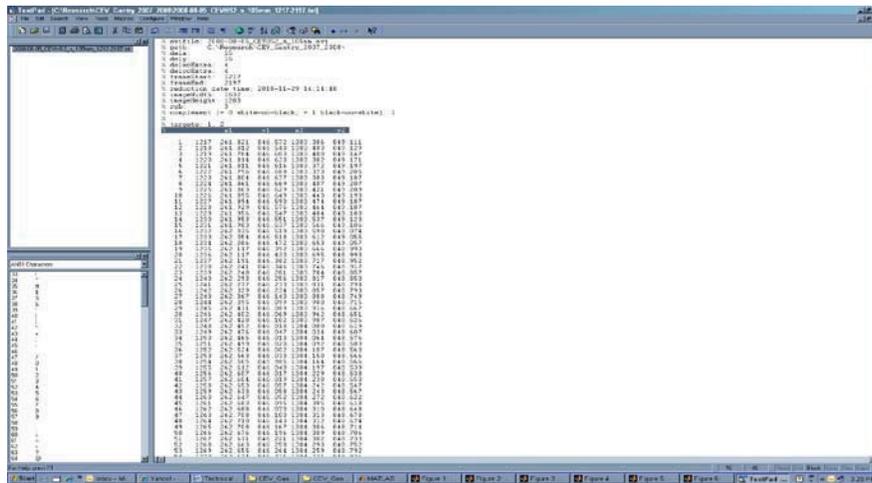
Figure 19. Centroid file in the TextPad Editor.

Additional Analysis of Data: Additional custom MatLab code is used to convert target centroid locations from image plane pixel units to object plane engineering units by multiplying an image-to-object plane scaling factor. Target position data is uniformly shifted in time, to set time T = 0 to within ± 2 milliseconds (± 2 video frames) of the point of impact when the vehicle makes first contact with the ground. Further analyses of the target position data are performed to determine the test article horizontal and vertical velocity and trajectory angles. Trajectory angles are computed using the relative positions of two targets that are far apart on the test article. Computed angles using targets with a large separation distance provided improved measurement accuracy compared to angle measurements using closely spaced targets.

The MatLab reduce d Function and Final Processing Steps: The MatLAB **Reduce_d** function can be used to process and analyze the CEV data. A CEV centroid data file (mentioned above) and setup (**.ini**) file are required when executing the **Reduce_d** function. The **.ini** file is used to setup the relevant information needed to properly identify specific test cases. For example, a standard *.ini* file is a fill-in-the-blank-type format that asks detailed questions about the test (See Fig. 20). These questions include but are not limited to:

● name of the centroid data file;
● date of the test;
● projected or anticipated data results for velocity and trajectory angles;
● type of camera(s) being used and the camera ID;
● gantry location;
● frame rate;
● selected lens and;
● resolution of the image sensor.

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```
2008-08-05_CEVHS2_s_105mm.ini - Notepad
File  Edit  Format  View  Help

; video:        2008-08-05_CEVHS2_s_105mm.cine

; Frame  Image  IRIG Time         Comment
; -----  -----  ------------      ----------------
;    1   -1514  10:34:07.689 806 S   Start of video
;  530    -985  10:34:08.218 805 S   Contact with ground
; 2466     951  10:34:10.154 805 S   End of video

[Reduce]
vid_file=      2008-08-05_CEVHS2_s_105mm.avi   ; Video showing contact with ground
vid_frame1=    1                               ; Frame number of first frame in this AVI
file_name=     2008-08-05_CEVHS2_s_105mm.txt   ; File to read centroid data from
first_frame=   1                               ; Matlab numbers video frames starting with 1
gnd_contact=   530                             ; Frame number for contact with ground
contact_Time=  10:34:08.218 805; IRIG time at contact with ground
contact_XY=    [783 1047]                      ; Reference point XY at ground contact
; mean(262,1304) = 783

test_date=     2008-08-05         ; Date of test as it will appear in plots, etc.
obj_make=      CEV
obj_model=     Half Scale
obj_type=      Boiler Plate
obj_abbr=      CEVHS
bag=
drop=          2                  ; Drop number

camera=        Phantom 9
camera_id=                        ; ID number of camera
camera_type=                      ; Used in creating unique output filenames
img_width=     1632               ; width of images in pixels
img_height=    1200               ; Height of images in pixels
lens=          105 mm             ; Camera lens focal length
fps=           1000
view=          South
camera_pos=    68.25              ; Camera's distance from drop vehicle in inches
gantry_station= 00.00             ; Gantry Station

drop_type=     Drop
pitch=         0.00               ; Pitch angle in degrees
yaw=           0.00               ; Yaw angle in degrees
v_vel=         12                 ; Expected vertical velocity (ft./sec.)
h_vel=         0                  ; Expected horizontal velocity (ft./sec.)

target_sep=    92.7432            ; Actual distance between first 2 targets for scaling in inches (North and South cameras)
SPP=           21                 ; Samples per Point for computing velocities

; TargetPairs=  3
; TgtLabels=    [1 2]             ; Target numbers in file may not be in 1,2,3,... order
Tgts1=         [1 2],[1 2]        ; 1st set is column numbers, 2nd is target labels
;Tgts2=        [3 4],[4 8]
;Tgts3=        [10 12],[10 12]

Range1=        [All]              ; Range of usable data in data file (frame numbers)
Range2=        [1 850]

; The following is used when creating the Documentation.
; the image and video files will be placed in Html\Images\...

targetCapt=    Photogrammetry Target Identification Numbers
TargetImage=   CEVHS2_South_View_targs.jpg
ImageCapt1=    CEV with Half Scale Boiler Plate
Image1=        CEVHS2_South_view.jpg
ImageCapt2=
Image2=
VidCapt1=      Video clip of CEV Drop
VidFile1=      2008-08-05_CEVHS2_S_105mm.mov
VidImg1=       CEVHS2_South_1st_view_mov.JPG
vidwidth1=     640
vidheight1=    360
```

Figure 20. Example of .ini file.

 An HTML folder is also required in the setup when processing the data. This folder contains still images of the test article which are used to help identify target locations on the vehicle. The **Reduce_d** code, when implemented, will produce an HTML data summary file (See Fig. 21). This file can then be easily converted into a PDF file format using Adobe Acrobat.

```
CEV Kennedy Sand Model - (KSM) Drop 10 (Drop, S) 2009-07-16

Optical Measurement Data Summary for KSM; Drop 10; South View;
Phantom 9 Camera (no. 7721)
(50 mm lens, 25 fps Vert, 0 fps Horz, 28.00 deg pitch, 0.00 deg
roll, 0.00 deg yaw)

Gantry Station (at impact):    0.00
Camera Position:                  83.50 feet to Center of Drop Vehicle
IRIG Time Stamp at Ground Contact: 08:48:15.423 506

For Reference Targets 1 & 2

Yaw Angle Change: -0.23 (deg) over 0.719 seconds to Ground Contact
     Rate of Angle Change:              -0.32 (deg/sec)
     Yaw Angle of Vehicle on Contact:    0.04 (deg)

     Image Scale Factor (inches/pixel): 0.18273

     Maximum Velocities (for Vertical) just after Ground Contact
     for Targets 1 & 2:
     Avg Vert Velocity: 299.41 (in/sec), 24.95 (ft/sec)
     Avg Horz Velocity: -0.36 (in/sec), -0.03 (ft/sec)
     Resultant Max Vel: 299.41 (in/sec), 24.95 (ft/sec)

Actual Displacement Measurement between Targets 1 & 2: 107.80 (in)
     Mean Target Displacement during Flight: 107.73 (in)
                         Standard Deviation: 0.05
     Mean Target Displacement for all of Test: 105.99 (in)
                         Standard Deviation: 1.83
```

Figure 21. Example of a summary file.

The typical **Reduction Folder** for *Reduce_d.m* (See Fig. 22) should contain, at a minimum, the CEV centroid data (***.txt***); *Reduce_d* setup file (***.ini***); and a HTML folder.
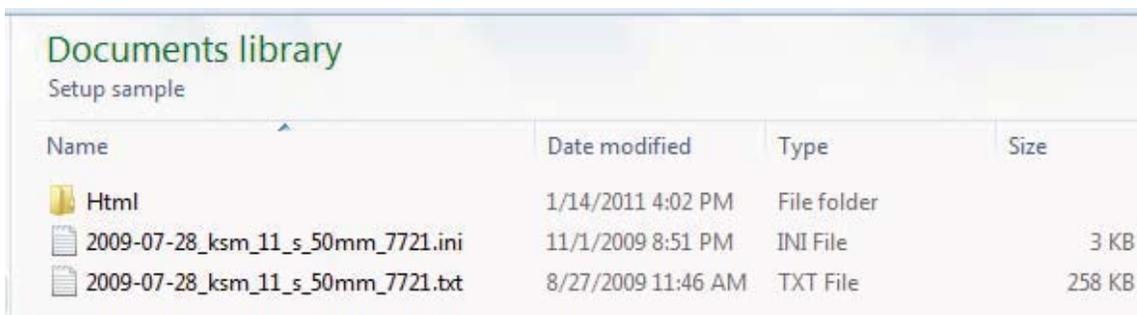

Fig. 22. Reduce_d content folder.

The HTML folder has an additional two required folders inside: a **Buttons** folder and an **Images** folder. The **Buttons** folder has supporting HTML *.jpg* images. These images support the HTML

output that is generated by MatLAB. The **Images** folder will contain descriptive images of the test article. When in MatLAB, set the **Current Folder** address path to the folder location, as seen in Fig. 19. Execute *Reduce_d* at the command prompt. The user is then prompted to choose an *.ini* file from the HTML folder. This process may take a couple minutes to complete.

The MatLAB code generates several figures (plots) which can be reviewed and edited, as needed. Type **return** at the command window prompt when the plots are acceptable and the user is ready to continue to the next step. (**Note:** MatLab figures are pre-set and should not be re-sized).

A **Reduce-d–Notice** pop-up window appears. This allows the user to save the plots to a new file within the current directory and/or create an **html** project file which will be placed in the HTML folder. The user also can elect to exit the program.

If the **Save Plots** button is selected, then a **Figures Folder** is created and MatLAB creates files in the *.fig* format. An option then becomes available to save the plots again, if desired. This feature will overwrite the existing saved figures (plots). If the **Create HTML** button in the **Reduce_d – Notice** window is selected, then an *.html* file is created and placed in the HTML folder. Backup copies of any previous *.html* files are placed in a folder labeled **Old**. Copies of the figures are created in a *.bmp* format (See Fig. 23). They are used in the *.html* file and placed in the **Images** folder.
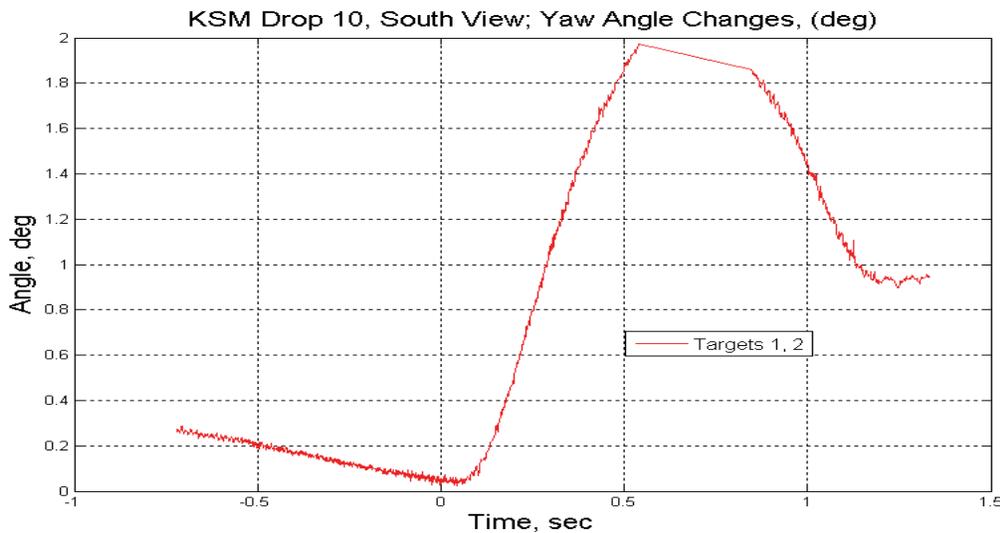

Figure 23. Data plot using *.html formatting.

Data files, in *.txt* and *.xls* formats, are used to create the data plots. These plots are copied and placed in the main Startup Directory. Backup, or old, data files are saved each time the *Reduce_d* code is executed. The backup files are then placed in an additional folder labeled **Old**.

Copies of *.html* files can be converted to the *.pdf* file format using Adobe Acrobat or equivalent software. Open the *.html* file in a browser utility such as, Windows Internet Explorer, and from the **File** pull down menu, select **Print.**. In the **Select Printer** option, choose **Adobe PDF** which will generate the *.pdf* file.
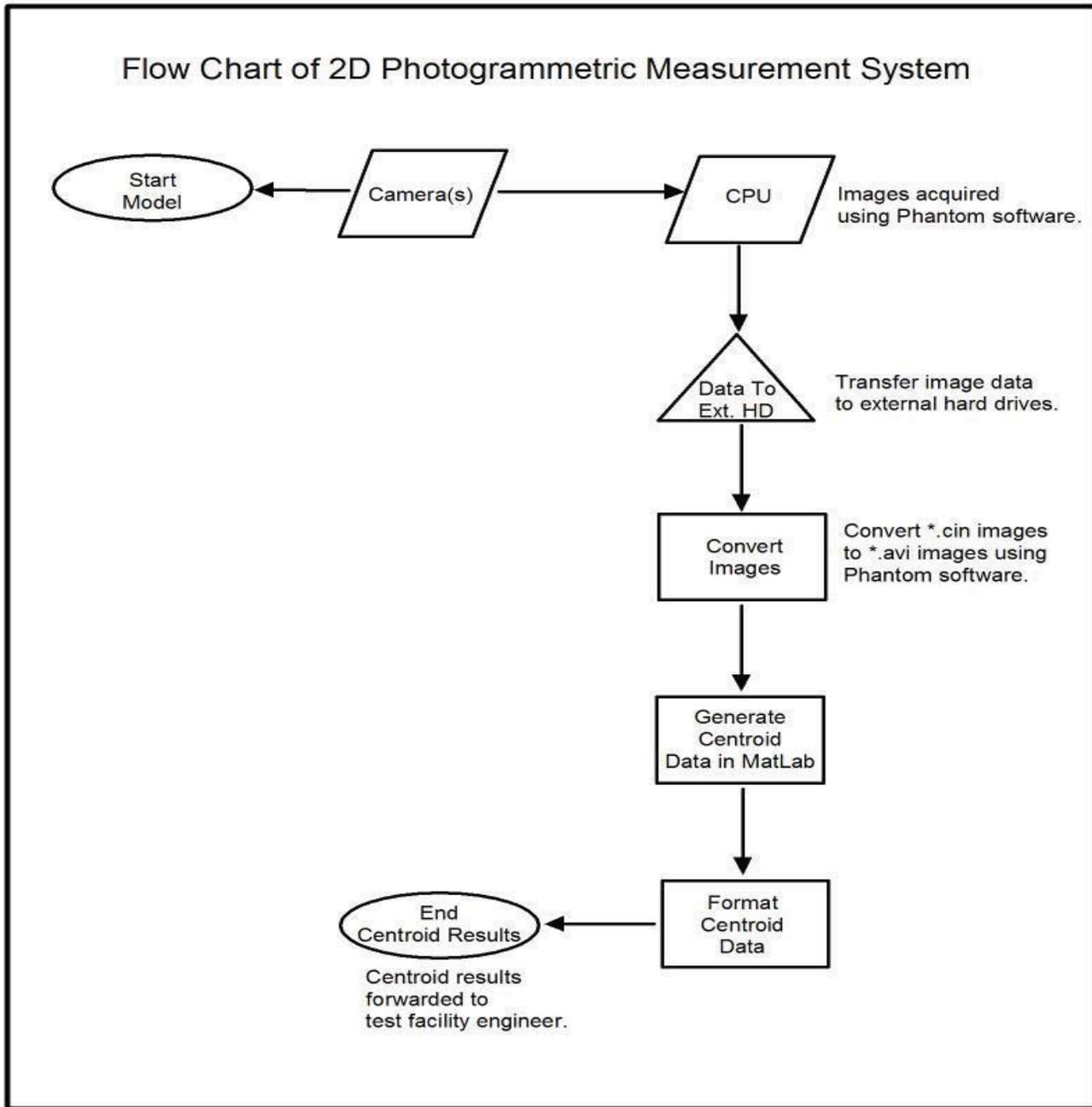
Figure24. Flow chart.

Summary

The NASA high-speed photogrammetric measurement system represents a versatile method for acquiring and processing drop-model trajectory and impact data for a variety of full-scale and sub-scale models tested at the NASA Langley LandIR Facility. The system is modular and consists of interconnected camera and computer technology and uses a composite of off-the-shelf and customized software for data acquisition and reduction. Figure 24 illustrates graphically the data flow

utilized in the system. The software has been designed to be as user-friendly as possible. This Technical Memorandum summarizes the detailed instructions necessary for use of the hardware and software systems. For more information regarding this system, please contact the NASA Langley Advanced Sensing and Optical Measurement Branch at the following address:

Advanced Sensing and Optical Measurement Branch (ASOMB)
NASA Langley Research Center
18 Langley Blvd., B-1200, Mail Stop 493
Hampton, Virginia 23681

http://asomb.larc.nasa.gov

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14. ABSTRACT

The object of this report is to provide users of the NASA high-speed 2D photogrammetric measurement system with procedures required to obtain drop-model trajectory and impact data for full-scale and sub-scale models. This guide focuses on use of the system for vertical drop testing at the NASA Langley Landing and Impact Research (LandIR) Facility.

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