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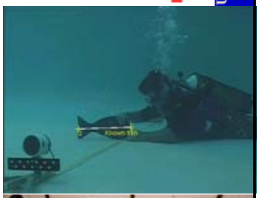


Day 2 - Session 2

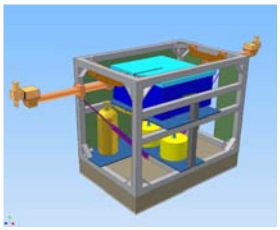
Parachute Tracking Example

New Parachute Concepts

- Parachute design has changed little since the mid 20^{th} century
- Increased payloads required for the modern soldier require new designs
- Air flow models for new designs must be validated
- US Army using ground based and air drop tests of scalable parachute models to provide validation

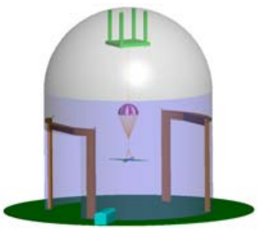
Aim and Configuration

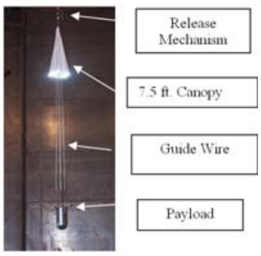
- Long term aim of establishing a database of parachute aerodynamics, correlating shape information with acceleration, velocity, load and canopy configurations
- Tracking the parachute from an independent external platform is beyond the project scope
- Accordingly the design effort is concentrating on image and data capture from the parachute payload



Experiment Design

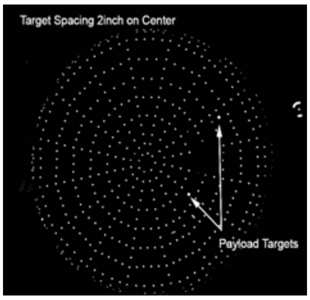
- Drogue (2m) and generic scale model (2.3m) parachutes used for indoor drop tests at LaRC and Plum Brook facilities
- Drogue chute drops at LaRC (25m) to validate the camera setup, image capture, calibration and sequence processing
- Scale model parachute drops at Plum Brook (40m) within a controlled environment

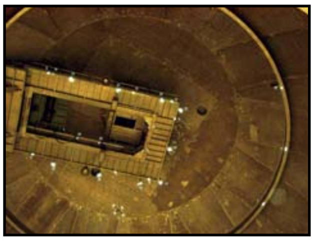




Parachute Targeting

- Retro reflective targets placed on the canopy and leading edges
- Initial schemes at LaRC delineated the gores and proved to be too dense for tracking, especially during canopy inflation
- Schemes at Plum Brook used less dense targeting or leading edge only
- Reference targets placed on ceiling



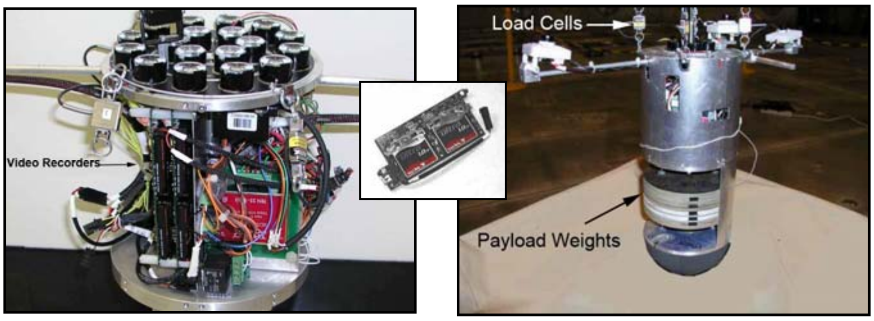


Camera Setup

- 5 or 6 fixed Dalsa 1600x1200 progressive scan cameras with ring lights on the floor around the drop point
- 30fps recording to a multi-camera recorder
- 2 “circuit board” 720x480 cameras with LEDs on the payload
- 30fps recording to flash cards via DVRs with time burnt on images
- Overall synchronisation from visual events (eg lights on, external flash)

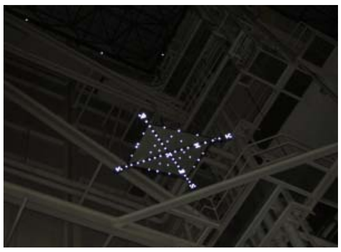
Payload Canister

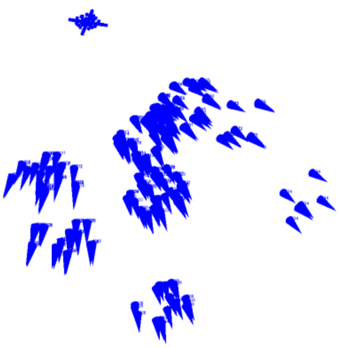
- Purpose built system to provide variable weight, a close range stereo-view of the canopy and a platform for other instruments
- 4 minutes of JPEG video recorded to two 1Gb flash cards
- Also records air velocity (hot wire anemometer), triaxial acceleration and suspension line loads
- Radio controller used to command all functions



Camera and RO Calibration

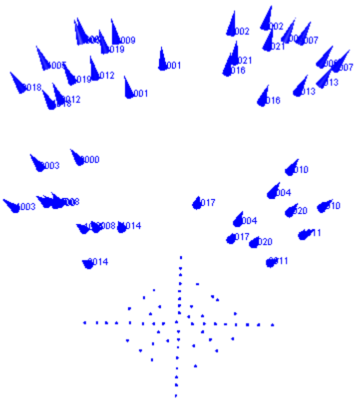
- Dalsa cameras and payload cameras calibrated independently
- Self-calibration and RO of Dalsa cameras determined by lowering a calibration fixture down the guide wire
- Rotation and tilts induced using extra wires to provide a strong network
- Resection on ceiling targets used in preference to a relative orientation based on the network adjustment



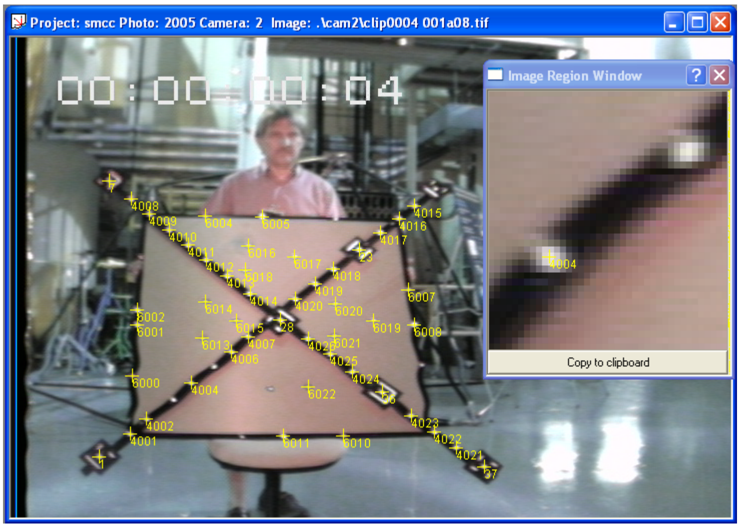


Payload Camera Calibration

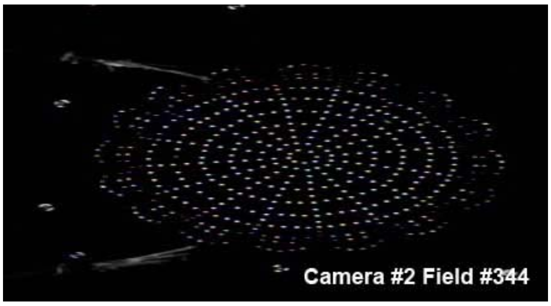
- Self-calibration and RO of payload cameras determined using the calibration fixture at the same range as the canopy
- The fixture was tilted and moved around within the field of view to optimise the network and coverage within the image format
- For both the Dalsa and payload cameras the self-calibrations used known lengths on the arms of the calibration fixture as scale constraints

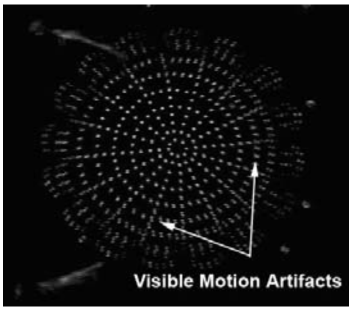


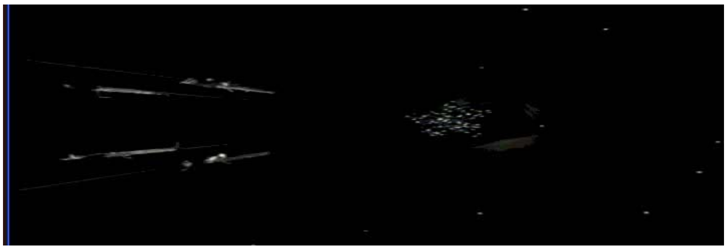
Payload Camera Image Quality



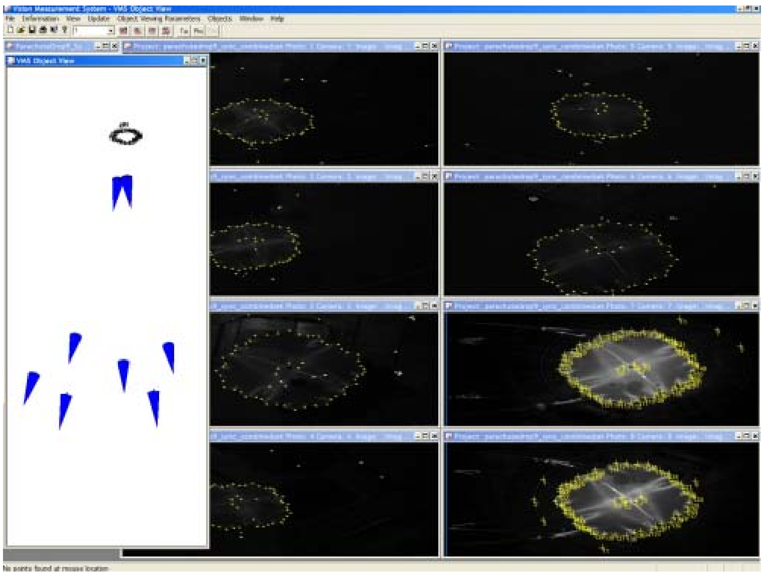
Payload Camera Field Images

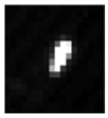




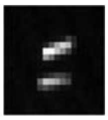


Sequence Processing





Typical target images



Payload camera images (taken at flash sync)

Conventional Sequence Processing

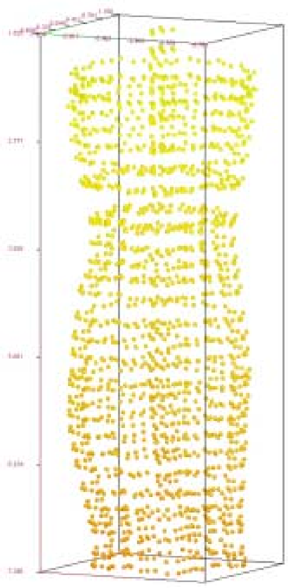
Operator controlled sequence initialisation, then for each new epoch:

- Image measurements of known control points are made by back-driving to their computed locations
- The camera locations and orientations are re-computed by least squares resection
- Image measurements of tracked targets are made by back-driving to their computed locations
- Computation, by intersection and then network solution, of the locations of all targets
- Estimates of the next location of each tracked target are then computed by trajectory prediction

Search Based Sequence Processing

- Conventional approach is prone to error if the target path is not curvilinear or targets are obscured, especially skirt targets
- An automated search based approach for combined target image correspondence and tracking is currently undergoing refinement.
- The method determines the minimum crossing point in 3D space for each possible target image group.
- Candidate targets are established from an optimal set of correspondences with the aid of an efficient search tree.
- This is a work in progress - further refinement will include a multi-pass search to include target images not included in the first pass.

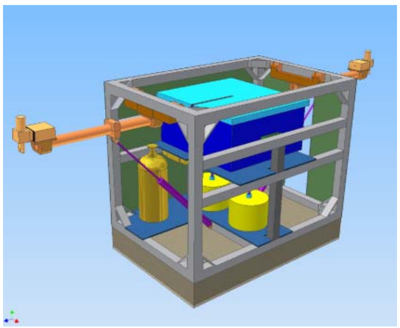
Visualisation



- Pulsations of leading edge clearly visible in images and graphic
- Sinusoidal twisting motion not evident from image sequence

Air Drop Payload System

- Much larger payload for full size parachutes and improved camera system
- T-slotted aluminium frame and honeycomb 100mm cardboard base resists a 6m/s impact
- 710 H 610 W 920 L
- Option of ballast
- Radio controlled

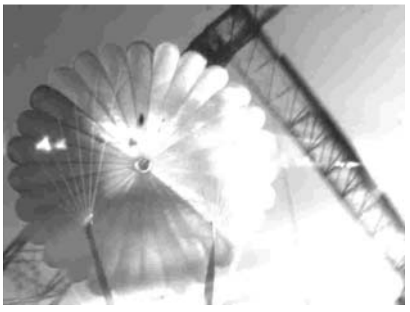


Air Drop Image Capture

- Two pneumatically controlled arms for camera extension
- Frame transfer cameras with 1/3” CCD 1024 by 768 sensors, 20Hz frame rate
- Digital interfaces to Matrox capture boards
- Maximum of 1 min recording time to solid state storage
- 0.1 pixel calibration precision

Gantry Drop Tests

260 foot high Apollo moon lander test gantry at LaRC



Three early morning drops

Guide wires for safety

Poor image quality

Helicopter Drop Tests

- Three 200m drops from a UH-1 Huey at U.S. Army National Guard Training Center at Quonset Point, Rhode Island
- To improve target definition, backing material was applied to the outside of the canopy behind each target, combined with a lens filter and red light LEDs