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Video for flight test

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ABSTRACT
The NLR is using video systems for flight test since 1984. The systems used formerly consisted of black and white tube camera's and U-matic video recorders with 2 hour tapes. Nowadays miniature colour remote head camera's are used in combination with time/text annotation and mixing capability, HI-8 video recorders with up to 3 hours endurance and high resolution monitors. The systems consists of max 4 video channels. All the functions can be controlled remotely by a serial RS422 link. Because it was decided that the ultilisation of airborne video equipment was not essential, the choice in devices was broad, and the hardware costs could be kept low. Nevertheless final tests proved that the system withstands the DO-160 environmental conditions. The NLR has recently introduced a second generation Image Processing System, which is capable to digitise and store real time sequences of half an hour. Subsequently it is possible to submit these images to automatic measurements, which for instance enables the accurate calculation of trajectories of aircraft or other objects. The image processing will be introduced and an example of the data processing will be given. This system has been developped under a contract awarded by the Netherlands Agency for Aerospace Programs (NIVR) for use in Fokker flight programs.

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VIDEO FOR FLIGHT TEST

ABSTRACT

The NLR is using video systems for flight test since 1984. The systems used formerly consisted of black and white tube camera's, and U-Matic video recorders with 1/2 hour tapes.

Nowadays miniature colour remote head camera's are used in combination with time/text annotation and mixing capability, HI-8 video recorders with up to 3 hours endurance and high resolution monitors. The systems consist of max 4 video channels. All the functions can be controlled remotely by a serial RS422 link.

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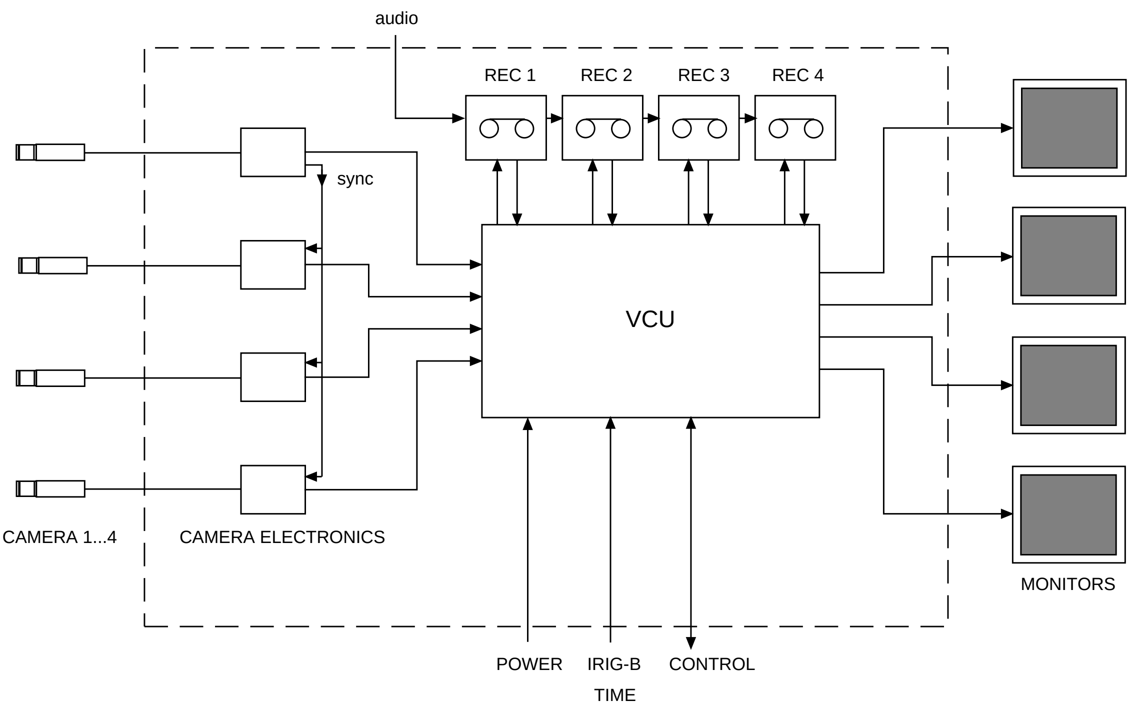
The NLR has recently introduced a second generation Image Processing System, which is capable to digitise and store real time sequences of half an hour. Subsequently it is possible to submit these images to automatic measurements, which for instance enables the accurate calculation of trajectories of aircraft or other objects. The image processing system will be introduced and an example of the data processing will be given.

This system has been developped under a contract awarded by the Netherlands Agency for Aerospace Programs (NIVR) for use in Fokker flight test programs.

NOMENCLATURE

ASCII	International standard for text.
EMI	Electro Magnetic Interference.
EEPROM	Electrical Erasable Programmable Read Only Memory
IRIG-B	Inter Range Instrumentation Group timecode standard
JPEG	Joint Photographers Expert Group=Standard for image compression.
NLR	National Aerospace Laboratory
RS422/RS232	Standards for serial Datatransmission.
VCU	Video Control Unit.
Y/C	Video signal connection consisting of separate luminance and chrominance signals

BLOCKDIAGRAM VIDEO SYSTEM



1. Introduction and applications.

The applications for video for flight test are emerging. Recent test aircraft carry up to 15 possible camera positions where 4 are used at the same time, with 4 recorders and 4 monitors.
All pictures are annotated with time of day, and some parameters in engineering units.
The images are frequently used for measurements, both for aircraft positioning and object movements. For this application a digital image storage and processing system is used.

Examples of video applications are:

<u>Inside the aeroplane:</u>

- crew: ergonomics, cockpit workload.
- instruments: reading.

<u>Outside the aeroplane:</u>

- icing.
- flow investigation: tufts, smoke.
- water ingestion.
- landing gear.
- separations.
- lowering of static bomb or cone.
- engine: inlet and exhaust; ice- and smoke.
- control surfaces.
- wings.
- propellers.
- tail.
- positioning.

2. Overview of the system.

The system consist of up to 4 complete video systems, uses miniature remote head camera's, Hi-8 video recorders, central switching and annotation unit of own development, and 9" or 14" video

monitors. Remote Control is accomplished via an RS422 link from an Instrument Control Computer or a PC. Remote control is also possible via simple Recording on/off switches in the cockpit. The cameras feature shutters for short exposure times to image moving objects sharply and to automatically correct varying lighting. By mixing it is possible to compose one picture out of two cameras.
Time lapse recording is available for long duration recordings of up to 1 week.
The data processing equipment consist of a frame grabber, a real time hardware JPEG ompressing system and 2 fast hard disk for storage. The storage capacity is 30 minutes of life video in total. The quality is of high level, exceeding HI-8 standard. Inputs are available for composite video, Y/C and Component. The Image Processing software is able to perform corrections on the recorded images and to measure objects in the images with sub pixel accuracy.

3. The camera.

The camera is a commercially available remote head camera with the following features:

- Remote head of 16 mm diameter, 100 mm long.
- Head/Electronics Cables up to 30 meters.
- Shutter from 1/50 to 1/10.000 sec.
- Auto shutter option for automatic lighting correction.
- High resolution of 752 x 582 pixels.
- Y/C output for sharp pictures.
- relatively low cost.
- Objectives of 4, 7.5, 15 and 24 mm.

The shutter has an option to adapt for variable lighting. This is a very useful function in the varying lighting conditions in flight. The camera is modified to allow for remote control of the shutter functions to be able to correct remotely for backlight situations if necessary. The camera is tested for Temperature, Altitude, Vibration and EMI. The results are very good, only for EMI some additional filtering was applied. The camera head functions good up to -75 deg C (limit of test equipment!).
The automatic shutter option proved to be very useful in flight conditions because the light varies constantly depending on flight direction and sunlight. A dripwatertight housing is developed for outside applications of the camera, with a simple heater to prevent condensing of the lens when the aircraft is descending.
The camera cable is a special 12 wire cable with dedicated connectors. These cables are fabricated in house. In dry weather the camera is used outside without housing.
Power requirement is 12 VDC at 0.7 A.
Special tray's are designed to mount the camera electronics unit in the instrumentation racks.

4. The recorder.

The recorders used are the V80AB-F, Milspec airborne HI-8 recorders from TEAC.
The HI-8 system has an endurance of 90 minutes per tape, 3 hours in long play mode. The HI-8 system is commercially and professionally widely used, so there is a broad choice in replay equipment.
The recorders are compact and rugged and completely remote controllable with RS 422 serial signals. Remote control via discrete on/off signals is also possible.
The recorder is tested for Temperature, Altitude, Vibration and EMI with good results. For low temperatures internal heaters are used. The recorder is modified by adding a counter for running hours, to be able to plan the periodic maintenance, and a remote/local switch.
In other applications these recorders are used for data recording in combination with Merlin encoders.
The Time Lapse option permits the recording of 0.5 sec video every 10, 20 or 60 seconds, resulting in recording time of 30, 60 or 180 hours (1 week). This is a very useful function for the recording of intermittent troubles with icing or troublesome mechanisms.

5. The VCU.

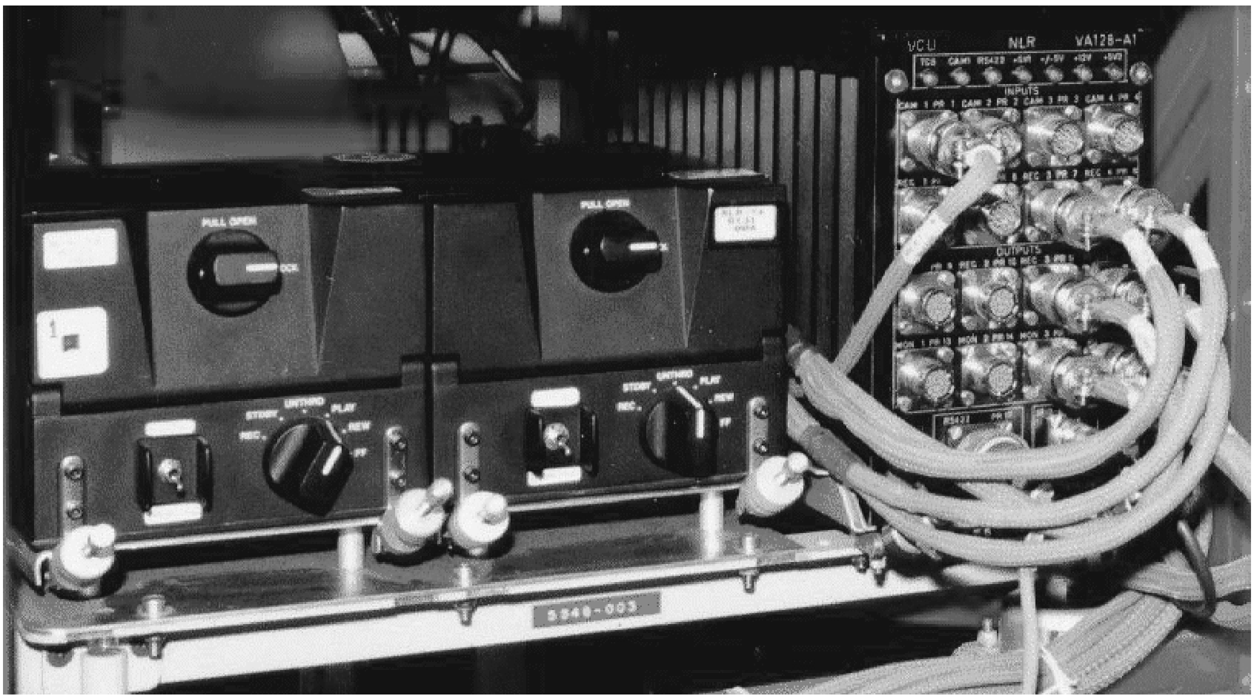
The Video Control Unit is the central device in the video system. The functions of the VCU are:

1. 12 VDC Power supply of the cameras

2. 4 discrete signals for shuttercontrol of the cameras

3. Mixer for the camera video signals. The VCU is able to combine two video signals into one over an arbitrary cut-out. This function is controlled by a command like:
   @ (rec no)(cam no)(x,y position start of cut)(x,y position end of cut) (CR)

4. Input selector for the recorders. Each camera can be hooked up to each of the recorders.



5. Receiver and decoder of the Time Code. The IRIG -B timecode signal is decoded and annotated as one line of text to the four recorder signals as:
123 10:55:59:999
Format: Record number hours:minutes:seconds:millseconds.
If the IRIG-B fails, the VCU will continue on its own clock while displaying ??? for the record number.

6. Receiver for RS422/RS232 control signals and Annotator text. This is the connection which is used for remote control of the entire video system.

7. Annotator for the 4 video recorders. The ASCII text that is coming in via RS422 is coded with recorder 1 to 4; and annotated as a 38 character line of text in the image of the selected recorder. The text can be selected big or small, at the top or bottom of the image, transparent or with background. Text without recorder number is routed to all four annotators.

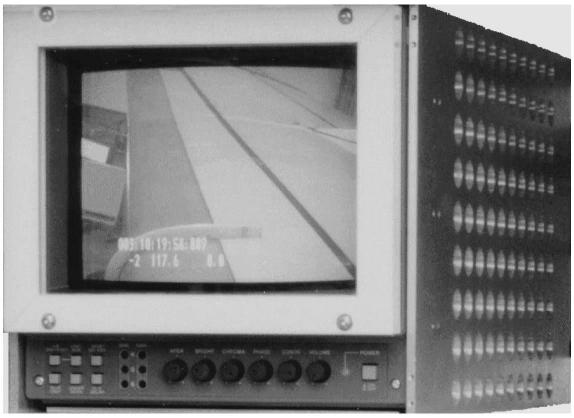
8. Distributor of RS422 control signals to the recorders. The control signals coded for recorder 1 to 4 are sent to the appropriate recorder. The status signals of the recorders (inclusive tape counters) are sent back on request.

9. Input selector for the 4 monitors. Every monitor can be switched directly to each camera- or recorder output.

10. Distributor of audio record and replay signals. The communication system in the aeroplane is connected to the recorder inputs, the recorder outputs being connected to the monitor loudspeakers.

The VCU is developed by the NLR electronics department, and tested for Temperature, Altitude, Vibration and EMI. It uses 115 VAC 400 Hz 80 W, and for the videorecorders 28 VDC. The VCU status is stored in EEPROM to make it robust against short and long power interrupts. The VCU works with Y/C (separated Luminance and Chrominance) circuits througout the whole device to give sharp images, and preventing cross colour effects.

6. The monitor



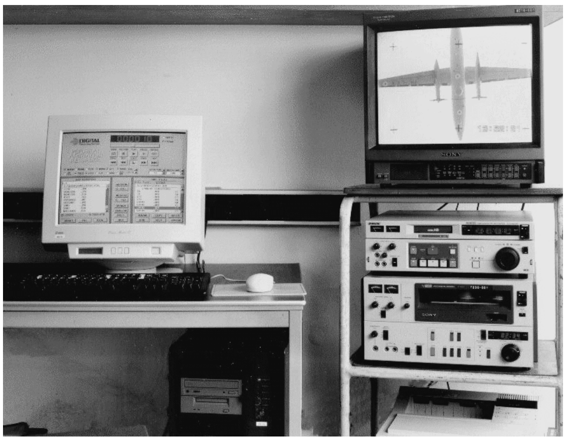
The monitors are professional high resolution Sony 9” and 14” monitors. They are modified to withstand EMI and vibration tests. Special windows are placed in front of the picturetubes to protect the viewer from implosion of the tube and to reduce EMI penetrating through the screen. The Power supplies are modified for 115 VAC 400Hz. Special racks are designed for stable mounting. For power and video ruggedised connectors are applied.

7. The Image Processing system.

For the processing and measuring of video images an Image Capture and Processing system is available. The capture system consists of a real time colour frame grabber with built in timebase corrector, real time colour JPEG video compressor and fast hard disks. The complete system is housed in a Pentium PC. The resolution is 752 x 576 pixels, there is room for half an hour full quality video on the harddisks. After the capture each frame is digital accessible, and there is a very convenient search capability. In this way you can select the pictures you want to process easily.

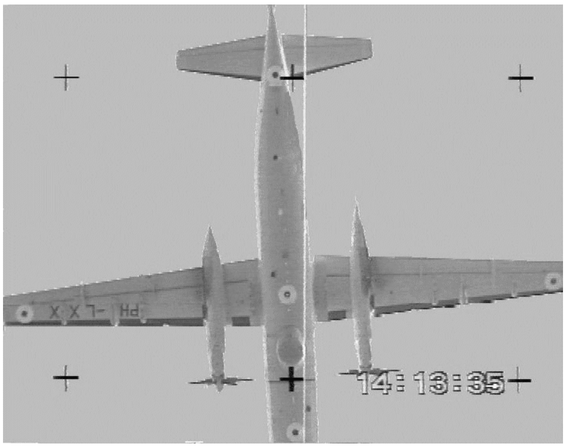
Besides this the image processing system offers the following features.

1. Picture enhancement when the lighting is not optimal. This process will remove shading effects
2. Automatic selection of objects on the base of a predefined shape.
3. Automatic measurement of the position, area, perimeter, etc. of the object in sub pixel accuracy.
4. Export of the measured data in any form.



8. Examples of applications:

<u>Checking of the accuracy of a radio altimeter.</u>



The aeroplane is marked with circles at the wingtips at known distance. Flying over a vertical upwards looking video camera, pictures are taken with short exposure times. No instrumentation in the aeroplane is needed.
The circles in the pictures are measured, and from this the altitude of the aircraft can be calculated. Accuracy can be better than 0.2 %.

Wingtorsion measurement.

The videocamera is installed behind a window over the wing. The wingtip is marked with black and white stripes.

During flight tests the images are recorded. Using the Image Processing system the deflection and torsion of the wingtip is measured to an accuracy of 1 mm and 0.05 deg.

Aircraft Positioning.

This method is used for navigation system reference measurements. The aircraft is flying over a runway with a downlooking camera viewing the runwaylights.
Short exposure times are used to avoid smearing. The position of the lights is accurately measured in respect to the runway.

From the position of the lights in the images the position of the aircraft can be calculated. Accuracy up to cm level.

9. Conclusions.

In relatively short time a state of the art video system was developed.

Using commercial equipment whenever possible kept costs low, nevertheless environmental demands have been met.

The system has been used up to now in flight test practice for two years without malfunction.

The image processing equipment opens the possibility for accurate and fast measurements with video in short time.