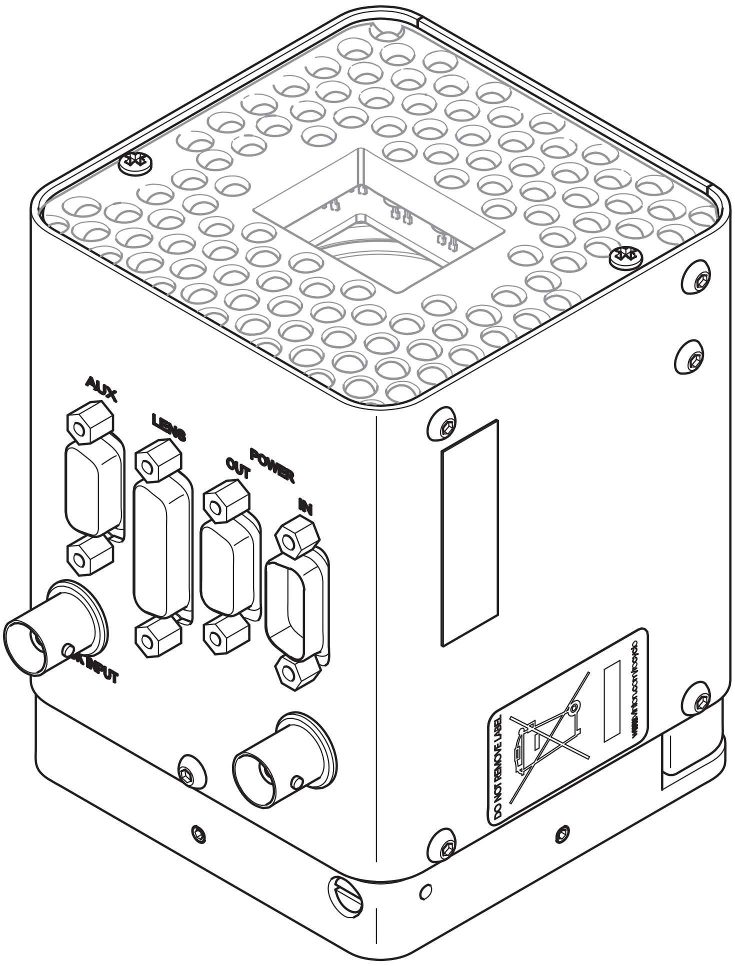
Free-D Virtual Studio System

Operators Guide

V3975-4980



Vinten
RADAMEC
BROADCAST ROBOTICS

Robotic Camera Control Systems

free-d Virtual Studio System

Operators Guide

Publication Part No. V3975-4980 Issue 1

Trademarks

Vinten Radamec® and Vinten® are registered trademarks of the Vitec Group plc.

Free-d™ is a registered trademark of the BBC.

Windows® is a registered trademark of the Microsoft Corporation.

Important information about this document

Information contained in this document is subject to change. Camera Dynamics Limited reserves the right, without notice, to make changes in equipment design or performance as progress in engineering, manufacturing or technology may warrant.

Published by:

Technical Publications Department
William Vinten Building
Western Way
Bury St Edmunds
Suffolk IP33 3TB
UK
Tel: +44 1284 752 121
Fax: +44 1284 750 560
Email: technical.publications@vitecgroup.com

Safety - Read This First

Understanding these instructions

English

EN The original instructions presented in this operators guide were written in English, and subsequently translated into other languages. If you are unable to understand these instructions, contact Vinten Radamec or your distributor to obtain a translation of the original instructions (EU Countries).

БЪЛГАРСКИ

BG Оригиналните инструкции, представени в настоящото ръководство на производителя, бяха написани на английски език, а след това - преведени на други езици. Ако не разбирате тези езици, свържете се с Vinten Radamec или с Вашия дистрибутор, за да получите оригиналните инструкции (за страните от Европейския съюз).

Česky

CS Pokyny uvedené v této operátorské příručce byly původně napsány anglicky a následně byly přelo_eny do ostatních jazyků. Nerozumíte-li těmto pokynům, kontaktujte společnost Vinten Radamec nebo svého distributora, abyste získali překlad originálních pokynů (členské státy EU).

Danish

DA De originale instruktioner, der præsenteres i denne betjeningsvejledning, er skrevet på engelsk og derefter oversat til andre sprog. Hvis du ikke forstår disse instruktioner bedes du kontakte Vinten Radamec eller vor forhandler for at få en oversættelse af de originale instruktioner (EU-lande).

Deutsch

DE Die Originalanleitung in diesem Bedienungshandbuch wurde auf Englisch verfasst und anschließend in andere Sprachen übersetzt. Bei Verständnisproblemen in einer der übersetzten Sprachen kontaktieren Sie bitte Vinten Radamec oder Ihren Fachhändler; dort erhalten Sie eine Übersetzung der ursprünglichen Anleitung (EU-Staaten).

Eesti

ET Käesoleva kasutajajuhendi algtekst on koostatud inglise keeles ning seejärel tõlgitud teistesse keeltesse. Kui juhend osutub teie jaoks arusaamatuks, võtke juhendi emakeelse tõlke hankimiseks ühendust Vinten Radameci või kohaliku esindajaga (Euroopa Liidu riigid).

Ελληνικά

EL Οι αρχικές οδηγίες αυτού του οδηγού για το χειριστή συντάχθηκαν στα Αγγλικά και μεταφράστηκαν στη συνέχεια σε άλλες γλώσσες. Εάν δυσκολεύεστε να καταλάβετε αυτές τις οδηγίες, επικοινωνήστε με τη Vinten Radamec ή το διανομέα σας για να λάβετε μια μετάφραση των αρχικών οδηγιών (Χώρες ΕΕ).

Español

ES Las instrucciones originales que se indican en esta guía del operador se han redactado en inglés y posteriormente se han traducido a otros idiomas. Si no entiende estas instrucciones, póngase en contacto con Vinten Radamec o con su distribuidor para obtener una traducción de las instrucciones originales (para países de la UE).

Français

FR Les instructions originales présentées dans ce guide d'utilisation ont été écrites en anglais puis traduites dans d'autres langues. Si vous ne comprenez pas ces instructions, contactez Vinten Radamec ou votre revendeur pour obtenir une traduction des instructions originales (pour les pays de l'UE).

Gaeilge

GA Scríobhadh na treoracha bunaidh don treoirleabhar oibritheora seo as Béarla, agus aistríodh iad go teangacha eile ina dhiaidh sin. Mura bhfuil tú in ann na treoracha seo a thuiscint, téigh i dteagmháil le Vinten Radamec nó le do dháileoir, chun aistriúchán de na treoracha bunaidh a fháil (Tíortha an AE).

Italiano

IT Le istruzioni originali presentate in questa guida per l'operatore sono in lingua inglese e successivamente tradotte nelle altre lingue. Qualora le istruzioni non fossero disponibili nella lingua desiderata, potete contattare Vinten Radamec o il vostro distributore per ricevere la traduzione delle istruzioni originali (Paesi UE).

Latviešu

LV Šajā operatora rokasgrāmatā iekļautie norādījumi sākotnēji tika sarakstīti angļu valodā un pēc tam pārtulkoti citās valodās. Ja nesaprotat šos norādījumus svešvalodā, sazinieties ar Vinten Radamec vai tirgotāju, lai saņemtu norādījumu tulkojumu (kādā no ES dalībvalstu valodām).

Lietuvių

LT Šiame operatoriaus vadove pristatomos pirminės instrukcijos parašytos anglų kalba ir vėliau išverstos į kitas kalbas. Jei šių instrukcijų nesuprantate, susisiekite su „Vinten Radamec“ arba savo platintoju ir gaukite pirminių instrukcijų vertimą (ES šalies kalba).

Magyar

HU A kezeloi útmutatóban található utasítások angol nyelven íródtak, és utólag fordították azokat más nyelvekre. Ha nem érti ezen utasításokat, kérjük, vegye fel a kapcsolatot a Vinten Radamecnel vagy a helyi képviselettel, és igényelje az eredeti utasítások fordítását (EU országok).

Malti

MT L-istruzzjonijiet originali ippreżentati f'din il-gwida ta' operaturi kienu miktuba bl-Ingliż, u sussegwentement maqluba fl-lingwi ohra. Jekk ma tistax tifhem dawn l-istruzzjonijiet, ikkuntattja lil Vinten Radamec jew id-distributur tieghek biex tikseb traduzzjoni ta' l-istruzzjonijiet originali (Pajjiżi ta' UE).

Nederlands

NL De oorspronkelijke instructies in deze bedieningshandleiding zijn geschreven in het Engels en vervolgens in andere talen vertaald. Als het onmogelijk is deze instructies te begrijpen, neemt u contact op met Vinten Radamec of met uw distributeur om een vertaling te bemachtigen van de oorspronkelijke instructies (EG-landen).

Polski

PL Oryginalne instrukcje zamieszczone w niniejszym podręczniku operatora zostały napisane w języku angielskim, a następnie przetłumaczone na inne języki. Jeśli nie rozumieją Państwo tych instrukcji, prosimy skontaktować się z siedzibą lub dystrybutorem Vinten Radamec, aby uzyskać tłumaczenie oryginalnych instrukcji (kraje UE).

Português

PT As instruções originais apresentadas no guia do operador foram escritas em Inglês e traduzidas para outros idiomas. Se não conseguir compreender estas instruções contacte a Vinten Radamec ou o seu distribuidor para obter a tradução das instruções originais (Países da UE).

Română

RO Instrucțiunile originale prezentate în acest ghid pentru operatori au fost scrise în limba engleză, şi traduse ulterior în alte limbi. În cazul în care nu înțelegeți aceste instrucțiuni, contactați Vinten Radamec sau distribuitorul dumneavoastră pentru a obține o traducere a instrucțiunilor originale (Țările UE).

Slovensky

SK Pôvodné pokyny, uvedené v tomto návode na obsluhu, boli napísané v anglictine a následne preložené do iných jazykov. Ak nerozumiete týmto pokynom, obrátte sa na spolocnost Vinten Radamec alebo vášho distribútora, aby vám zaslal preklad originálnych pokynov (krajiny EU).

Slovenščina

SL Originalno besedilo teh navodil za uporabo je bilo napisano v angleščini in prevedeno v ostale jezike. Če ne razumete teh navodil, se obrnite na podjetje Vinten Radamec ali lokalnega zastopnika, ki vam bo posredoval originalna navodila (velja za dr_ave EU).

Suomi

FI Tähän käyttäjän oppaaseen sisältyvät ohjeet on kirjoitettu alun perin englanniksi ja käännetty sitten muille kielille. Ellet ymmärrä näitä ohjeita, ota yhteyttä Vinten Radameciin tai jälleenmyyjään ja pyydä alkuperäisten ohjeiden käännöstä (EU-maat).

Svenska

SV Instruktionerna i denna handbok skrevs ursprungligen på engelska och har sedan översatts till flera språk. Om du inte förstår dessa instruktioner, kontakta Vinten Radamec eller din återförsäljare för en ny översättning av originalinstruktionerna (EU-länder).

Important safety instructions

1. Take heed of warnings and instructions
You should read all of the safety instructions before operating the equipment. Retain this operators guide for future reference and adhere to all warnings in the guide or on the equipment. Do not attempt to operate this equipment if you do not understand how to operate it.

2. Usage Statement
Do not use this product for any other purpose other than that specified in this usage statement. The *free-d*™ virtual studio system is designed specifically for use within television broadcasting studios where the precise positioning and orientation of each studio camera is required to obtain a virtual scene from the appropriate viewpoint. The *free-d* system allows unrestricted movement while panning and tilting through 360 degrees and works with a variety of camera mountings including manual pedestals, cranes and hand-held cameras. The *free-d* system is intended to be used by television camera operators, trained to use Vinten Radamec robotic equipment.

3. Water, moisture and dust
Protect the product from water, moisture and dust. The presence of electricity near water can be dangerous. Do not use the product near water and take care that liquids are not spilled onto the equipment. For outdoor applications, only use products that are specifically designed for outdoor usage.

4. Climate
The equipment should not be used outside the operating limits. Refer to the Technical Specifications for the operating range of the equipment.

5. Cleaning
We encourage regular cleaning of the product.

- Do not use oil or grease on any exposed part of the equipment. This is unnecessary and traps dirt which acts as an abrasive.
- Do not use solvent or oil based cleaners, abrasives or wire brushes to remove accumulations of dirt as these damage the protective surfaces. To clean mechanical surfaces, use only detergent based cleaners.
- External electrical connection ports should only be cleaned with a semi-stiff brush or a clean, dry air supply.

6. Servicing
You should not attempt to service the equipment. Contact Camera Dynamics Ltd or your local distributor to arrange servicing. Maintenance beyond that detailed in this guide must be performed by competent personnel in accordance with the procedures in the Technical or Maintenance Manual for the equipment.

7. Notes about Robotic equipment
Display prominent warning signs in studios, alerting personnel that robotic equipment is present and may move without warning.Ensure personnel remain a minimum of 1 m (40 inches) clear of robotic equipment in use.
Operators must familiarise themselves with the resulting working envelope of robotic products including all ancillary equipment (lens, zoom and focus controls, viewfinder, prompter etc.), to prevent inadvertent collisions.
Only operate robotic products remotely when you can see them to avoid harm to personnel and collisions with obstacles and other hazards.

8. Power sources
Only connect the equipment to a power supply of the type described in the Technical Specifications or as marked on the equipment.

9. Cables
Always ensure that all power and auxiliary communications cables are routed so that they do not present any danger to personnel. Take care when routing cables in areas where robotic equipment is in use.

Certificates and compliances

Manufactured under license on behalf of the BBC© in compliance with the following European Directives:

2006/95/EC Low Voltage Directive

89/336/EEC EMC Directive

By application of the following Harmonised Standards:

BS EN 60065: 2002+A1 2006: Audio, video and similar electronic apparatus-Safety requirements

BS EN 55103-1:1996 Electromagnetic Compatibility-Product Family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use - Part 1: Emissions: Environments E4 and E5

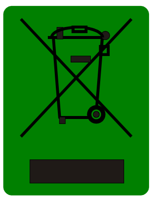
BS EN 55103-2: 1997 Electromagnetic compatibility - Product Family standard for audio, video, audio-visual and entertainment lighting control apparatus for professional use - Part 2: Immunity. Environments E1, E2, E3, and E4

Other Certification

CFR 47:2006 Code of Federal Regulations: Pt 15 Subpart B-Radio frequency devices - Class A - unintentional radiators.

Caring for the environment by recycling

Recycling old electrical and electronic equipment



This symbol on the product or on its packaging indicates that this product must not be treated as household waste (applicable in the European Union and European countries with separate collection systems). It shall be handed over to the applicable collection point for the recycling of electrical and electronic equipment. Please visit **www.vintenradamec.com/recycle** for details.

By ensuring this product is disposed of correctly, you will help prevent potentially negative consequences for the environment and human health, and help conserve natural resources.

Technical specification

Lens Encoder

Weight	1 k g (2.2 lbs)
Length	4.5 cm (1.7 in.)
Width	7.0 cm (2.7 in.)
Height	13.6 cm (5.4 in.)
Output signals	1024 pulses / rev of encoder
Electrical Connection	1m flying lead to 26 way HD type

Target Seeking Camera

Weight	1.5 k g (3.3 lbs)
Length	8.2 cm (3.2 in.)
Width	8.2 cm (3.2 in.)
Height	10.0 cm (3.9 in.)
Output signals	Serial digital video (NTSC)
Input power	24 V DC, 20W
PSU input	100-240 V AC, 1.5A, 50-60Hz
Electrical Connection	
Video output	BNC
Genlock input	BNC
Lens encoder input	26w HD-type
Power input	2 x 9w D-type
RBU input	15w HD-type

Free-d Processor Unit

Weight	8.5 k g (18.7 lbs)
Length	50.0 cm (19.7 in.)
Width	48.3 cm (19.0 in.)
Height	4.3cm (3.9 in.)

Output signals:

Analogue video

Camera data . . . . System normal relay

Power input . . . . .90 - 264 V AC, 47-63 Hz, 5A

Contents

Contents (continued) **Page**

Illustrations

Tables

Introduction

A key component of any virtual studio system is a means of measuring the precise position and orientation of each studio camera. This data is used to render the virtual scene from the appropriate viewpoint. Developed by the BBC R&D, the *free-d* virtual studio system allows unrestricted movement of studio cameras while panning and tilting through 360 degrees, accurately measuring the position and orientation of the camera to ensure the precise matching of the real and virtual worlds.

The main features of the *free-d* system are:

- 8 axes of motion tracking (x, y, z, pan, tilt, roll, zoom, focus).
- Unlimited number of cameras.
- Multiple studios.
- No single point of failure for more than one camera.
- Minimal daily set-up; returns absolute position and orientation at switch-on.
- Passive target infrastructure.
- Places no significant constraint on scene content or studio environment.
- High speed operation.
- Suitable for studio heights from 3 to at least 10 metres.
- Supports studio sizes up to 3000 square metres.
- Position resolution < 1 millimetre.
- Orientation resolution < 0.01 degrees.
- Delay one video frame.

The *free-d* system uses a number of passive coded targets permanently installed out-of-shot in the studio lighting grid. The targets are mounted at one of two or more different heights (differing by 0.5-1 m) at an optimum distance between each target to suit the height of the studio, The targets are installed in an optimum pattern of high and low targets to ensure that the maximum number of targets are identified, with the minimum number of low targets obscuring high targets. Each target consists of concentric black and white retroreflective rings that form a circular bar code, providing each target with a unique identification and ensuring a sufficient number remain visible under normal studio lighting conditions. The diameter of the target depends on the height the target is from the floor, but is typically 20 cm.

Each studio camera is fitted with zoom and focus sensors for the camera's lens and an auxiliary upward-looking target-seeking camera mounted perpendicularly to the optical axis. The *free-d* target-seeking camera incorporates a cluster of bright LEDs which constantly illuminate the retroreflective targets; ensuring a uniform high-contrast image. For correct operation at least four targets, and preferably more, must be visible at all times. Allowing for about half being obscured by lights, hoists etc. a medium-sized studio may need around 300 targets installed. The image data and lens settings are encoded into a serial-digital-video signal for onward transmission to the *free-d* processing unit.

The *free-d* processing unit, one of which is required for each camera, receives the serial-digital-video signal from the target-seeking camera and computes the studio camera's position and orientation in real-time. The processing unit identifies the targets in the image, measures their positions to sub-pixel accuracy and reads their barcodes. Knowing the exact positions of all the targets in the studio, which are stored in a non-volatile database, the position and orientation of the camera is computed. The *free-d* processing unit generates a serial data stream which conveys the position, orientation, zoom and focus data to the virtual set system. The complete data package is transmitted via a high speed serial data link to the 3D VR system. The protocol for this link is based on the Vinten Radamec Serial Position Interface protocol.

Calibrating the *free-d* system

To calculate the studio camera's position and orientation to the required precision the *free-d* system must know the exact position of every target to an accuracy of about one millimetre. To measure every target to this accuracy, whilst not impossible, would be difficult and time consuming. Therefore a calibration process is carried out which, assuming the approximate positions of the targets are known, is able to refine their positions to the necessary accuracy. To provide an absolute frame of reference the accurate positions of two targets, and the height of a third, must be known. So long as the targets are mounted rigidly and are not disturbed this process need only be performed once.

The studio calibration process consists of moving the *free-d* target-seeking camera around the studio whilst the positions of the targets in the images it sees are automatically recorded. The requirement is that every target should be seen from a number of different directions, so that its true position can be accurately determined, and the calibration software displays a map showing the status of each target in this respect.

As well as the target positions, the system needs to know some intrinsic parameters of the *free-d* target-seeking camera and how it is mounted on the studio camera. This information is also stored in the non-volatile database in the *free-d* processing unit, and each camera encodes a unique ID number in its data output allowing the processing unit to select the appropriate parameters. Each *free-d* processing unit can store the parameters for multiple studio cameras, allowing cameras to be swapped (for example in the event of a failure) without any need to reconfigure the *free-d* system.

Each *free-d* processing unit has the capacity to store the target position database for two or more studios (up to a limit of about 4000 targets in total), the particular studio in use being selected using switches provided on the *free-d* processing unit. In this way all *free-d* processing units within a studio centre can contain identical data, making it much easier to redeploy the *free-d* system from one studio to another and to provide a common spare unit suitable for use in any studio.

Configuring the *free-d* system

Once the studio has been calibrated and the database of studio and camera information has been programmed into each of the *free-d* processing units, the *free-d* system is entirely autonomous. It will generate absolute position and orientation data for each studio camera within a few seconds of being switched on (depending on the nature of the lens sensors it may be necessary to manually initialise the zoom and focus). All cameras are independent and there is no single point of failure which could affect more than one camera.

On initial installation, and if it is necessary to reconfigure the *free-d* system (for example a recalibration is required, or a new camera is added), a general purpose (Windows™) computer is used. This is connected to the *free-d* processing unit instead of the virtual set system and is used to download information from the *free-d* processing unit, for example during studio calibration, to store a 'master copy' of the camera and studio databases (e.g. on a network file server) and to upload the databases to the *free-d* processing units. If multiple serial ports are fitted, it is possible for the computer to communicate with several *free-d* processing units. Alternatively, they may be connected and configured sequentially.

Software

Calibration and configuration operations are carried out using the FREEDWIN utility software running on a computer running Microsoft Windows™ (95, 98, Me, NT4, 2000 or XP). Note that FREEDWIN utility stores its configuration file FREED.CFG in the current directory. The software can be launched from the computer desktop or using the Start menu (Programs > BBC Free-D > Free-D for Windows).

The LOMWIN utility software communicates with the *free-d* processor unit and can be called as a sub-program by FREEDWIN to download or upload data to the unit or it can be run as a stand-alone utility for diagnostic or demonstration purposes.

An online help file is available from the BBC Free-D menu, by selecting the Free-D help option.

FREEDWIN

The FREEDWIN utility is used to configure the *free-d* system, allowing you to configure a number of cameras within the studio and nominate your computer outputs for interfaces. The FREEDWIN utility can display three lists; a camera list that displays automatically on startup that lists all the cameras and their calibration offsets, a studio list that displays the fixed targets within the studio and the interface list that displays a list of the different serial ports on your computer that may be used for communication with the *free-d* processing unit.

FREEDWIN provides Wizards, available from the Utilities menu, to assist with the calibrating and configuration of the *free-d* system, and studio levelling where the target positions are adjusted to ensure that the camera's height is reported accurately. Each wizard provides a step-by-step guide to the process.

CAUTION!	**The FREEDWIN Utility is used primarily to configure and test the *free-d* system. The only function that should be used by Operators is the LOMWIN utility. This utility can be run to obtain information about the *free-d* system setup.**

Getting started with FREEDWIN

To launch FREEDWIN, you can either:

- double-click on the desktop shortcut icon; or
- from the Start menu, choose Programs > BBC Free-D > Free-D for Windows.

FREEDWIN (Fig. 1) is a Windows-based program that uses a conventional application window, consisting of a title bar, a set of menus, an editing pane and a status bar. The FREEDWIN window works similar to other application windows, allowing you to reposition the window on your computer desktop by dragging it with your mouse (left button), minimise it (so that it appears only as an item on your task bar) and close the application; but you cannot resize or maximise the window.

Title bar: Displays the name of the application (FREEDWIN) and the current version number of the application software. The title bar also contains a Minimise button, a (disabled) Maximise button and a Close button. If you close the window using the Close button or using the keyboard shortcut Alt-F4, you will be prompted to save the current *free-d* configuration (if any changes have been made).

Menu bar: Contains five menus, File, Edit, View, Utilities and Help. Each menu can be activated by clicking on the appropriate menu name or by using a keyboard shortcut (hold down Alt and press the key corresponding to the initial character). If any of the menu items are unavailable, they will appear dimmed.

View: Can view three pages within FREEDWIN; Camera view, Studio view and Interfaces view. See **About the View lists**.

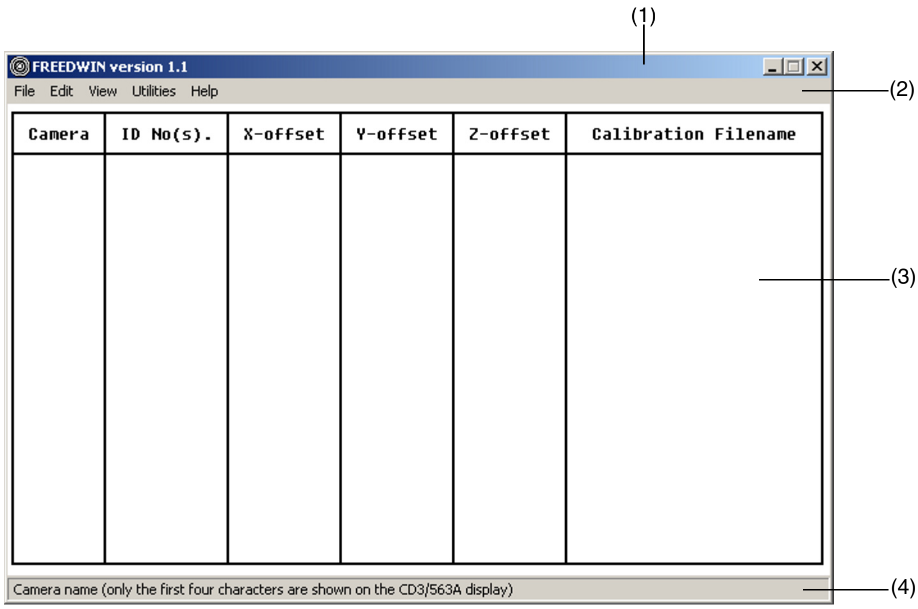


Fig. 1 FREEDWIN

(1) Title bar (2) Menu bar (3) View (4) Status bar

Status bar: When a menu item is selected, the status bar displays a brief description of the function of that command. If an item in the Utilities menu is dimmed (unavailable) the status bar contains a message explaining why that option is unavailable. This can be very useful in determining how to proceed. Otherwise, when the program is waiting for input from the user the status bar describes the required content of the current field (containing the cursor). If the program is busy, the status bar indicates what operation is taking place.

About the View lists

The View menu lets you select one of three possible pages of the current *free-d* system configuration: the Camera List, the Studio List or the Interfaces list.

CAUTION! **It is recommended that Operators do not edit the system configuration (Camera List, Studio List and Interface List) or run any of the configuration wizards using the FREEDWIN utility, as any changes to the data will affect the system setup.**

Camera list

The Camera list (Fig. 2) displays a list of the different cameras (a maximum of 19) known about in the current *free-d* system configuration. For each camera the following information is listed:

Camera: The *free-d* camera name. Only the first four characters of the camera name are transferred into the binary database, and therefore only those characters are displayed on the *free-d* processor unit's display when selected to show the current camera.

ID No(s).: The hexadecimal ID number or numbers of the camera, optionally as a range (xx-yy) or a list (aa,bb...). Each *free-d* camera has a unique 8-bit ID which is encoded in its data output; this ID is determined partly by switches internal to the camera (affecting the most-significant four bits) and partly by inputs to the camera via its auxiliary connector (affecting the least-significant four bits). When the auxiliary connector is not in use it is safest to specify a range of 16 addresses (e.g. 30-3F) so that the same calibration file is selected irrespective of the four LSBs.

X-offset: The X-offset, in metres, between the optical axis of the *free-d* camera and the reference point whose position you wish the system to return. This is measured in the direction of the X axis when the camera's pan and tilt are zero. If the reference point is to the right of the *free-d* camera, when viewed from behind the studio camera, then the offset should be positive. If the reference point is to the left of the *free-d* camera, then the offset should be negative. Commonly the reference point corresponds to the intersection of the pan axis and the optical axis of the studio camera. With most mounting arrangements this offset is small or zero.

Y-offset: The Y-offset, in metres, between the optical axis of the *free-d* camera and the reference point whose position you wish the system to return. This is measured in the direction of the Y axis when the camera's pan and tilt are zero, i.e. along the studio camera's optical axis. If the reference point is in front of the *free-d* camera, then the offset should be positive. If the reference point is behind the *free-d* camera, then the offset should be negative. Commonly the reference point corresponds to the intersection of the pan axis and the optical axis of the studio camera.

Z-offset: The Z-offset, in metres, between the nodal plane of the *free-d* camera and the reference point whose position you wish the system to return. This is measured in the vertical direction when the camera's tilt is zero. If the reference point is above the *free-d* camera, then the offset should be positive. If the reference point is below the *free-d* camera, then the offset should be negative. Commonly the reference point is the intersection of the pan axis and the optical axis of the studio camera. The nodal plane of the *free-d* camera corresponds to the bottom edge of the B B C logo.

Calibration Filename: The name of the calibration file for the particular *free-d* camera. It is important that the correct calibration file is specified for the given range of ID numbers, otherwise the system performance may be seriously degraded. Note that the filename cannot contain spaces.

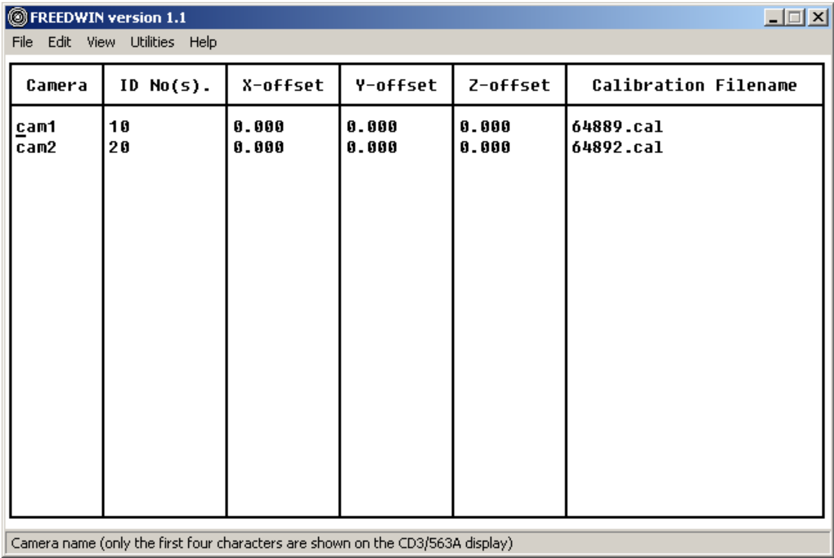


Fig. 2 Camera List

Studio list

The Studio list (Fig. 3) displays a list of the different studios (a maximum of 19) known about in the current *free-d* configuration. For each studio the following information is listed:

Studio: The studio name. Note that only the first four characters are actually transferred into the binary database, and therefore only those characters are displayed on the *free-d* processor's display when selected to show the current studio.

ID No(s).: The hexadecimal ID number or numbers of the studio, optionally as a range (xx-yy) or a list (aa,bb...). The current studio is selected by means of switches on the *free-d* processor unit, from a theoretical maximum of 256 different 8-bit IDs. When the system is configured for use in only one studio, it is safest to specify the full range of addresses (i.e. 00-FF) so that the ID number is ‘don't care’.

Fixed #1: The barcode number of the first ‘fixed’ target. When calibrating a studio the system needs to establish an absolute 3D frame of reference with respect to the fixed infrastructure (floor, walls etc.). This is achieved by specifying the X, Y and Z coordinates of two of the targets, thus defining a straight line passing through these two points, and constraining rotation about this line by specifying the Z coordinate (height) of a third target.

Fixed #2: The barcode number of the second ‘fixed’ target. The first two fixed targets should be selected such that there is a reasonably large distance between them (therefore improving the accuracy of the straight line thus defined) without either target being so near to the edge, or being obstructed, that the calibration process cannot accurately establish its position relative to the others.

Fixed #3: The barcode number of the third ‘fixed’ target. Only the Z coordinate (height) of this target needs to be measured accurately. This target should be selected as being a reasonable distance from the straight line joining the first two fixed targets (therefore accurately constraining rotation about this line) but not so near to the edge, or obstructed, that the calibration process cannot accurately establish its position relative to the others.

Target Data Filename: The name of the target data file for the particular studio. This file contains the X, Y and Z coordinates of all the targets, initially only approximately (except for the three fixed targets) but after calibration to an accuracy of about ±1 millimetre. Note that the filename cannot contain spaces.

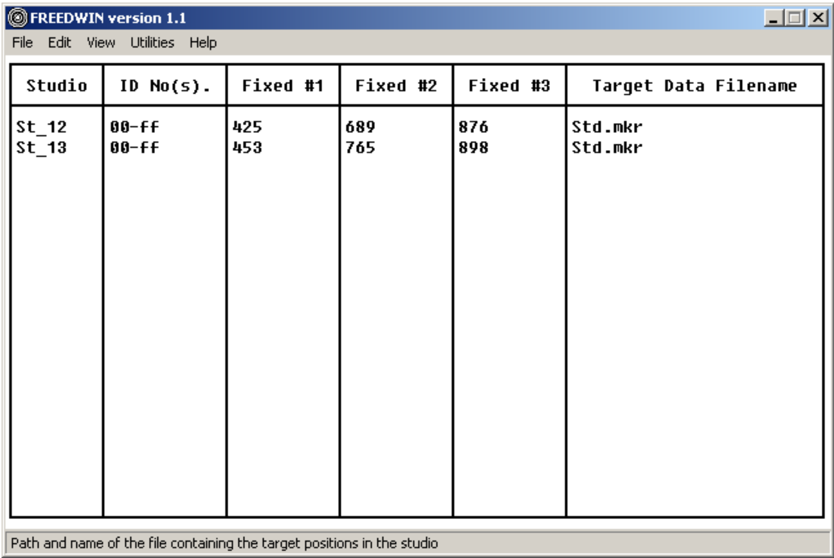


Fig. 3 Studio List

Interfaces list

The Interfaces list (Fig. 4) displays a list of the different serial ports (a maximum of 19) fitted to the PC, and which might be used for communication with a *free-d* processing unit. For each serial interface the following information is listed:

Interface: The name by which the serial interface is known to Windows™. Typically the serial ports are called COM1, COM2, COM3, COM4 and so on.

I/O Port: Optionally the I/O port address at which this port may be accessed from MS-DOS™. This is not used by FREEDWIN or LOMWIN, but may be entered if required for compatibility with the DOS utilities FREED and LOM.

IRQ number: This is not used by FREEDWIN or LOMWIN, but may be entered if required for compatibility with the DOS utilities FREED and LOM.

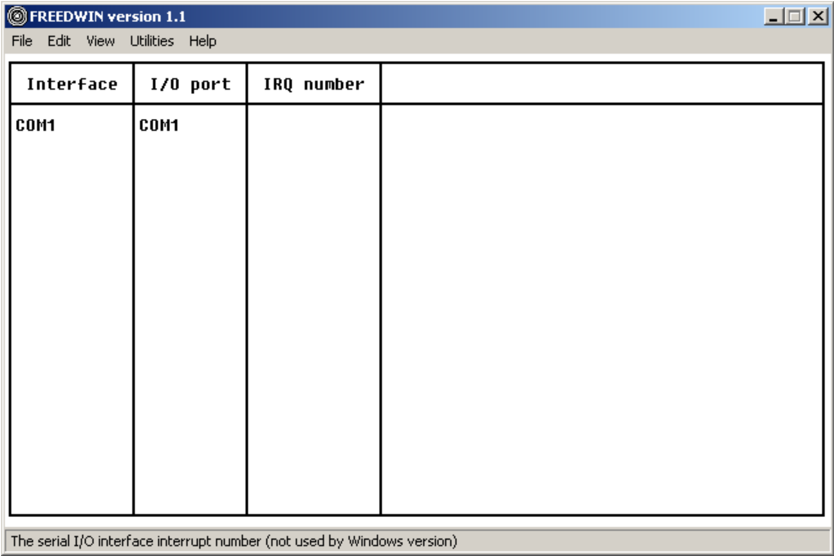


Fig. 4 Interface List

LOMWIN

LOMWIN is a Windows based program that communicates with the *free-d* processor unit via a serial link and is called as a sub-program by FREEDWIN when it needs to download data from or upload data to the *free-d* processor unit. LOMWIN can also be run as a stand-alone utility for diagnostic or demonstration purposes.

LOMWIN can be used in two modes:

- with a bidirectional serial data connection to the *free-d* processor unit. In this mode LOMWIN both controls and monitors the processor, as is required for studio calibration and configuration operations.

- with a receive-only serial data connection to the *free-d* processor unit. In this mode LOMWIN monitors and displays the data output from the processor, typically when it is driving a virtual set system in real time.

LOMWIN can be run either from within FREEDWIN, using the Run LOMWIN utility command from the Utility menu or on its own from a desktop shortcut. It is usually more convenient to run it from FREEDWIN because the serial port used for communication with the *free-d* processor unit is automatically selected. When run from a desktop shortcut the default port COM1 is used. To change the default port, a command line option must be added to the Target field within the Properties dialog box (Fig. 5).

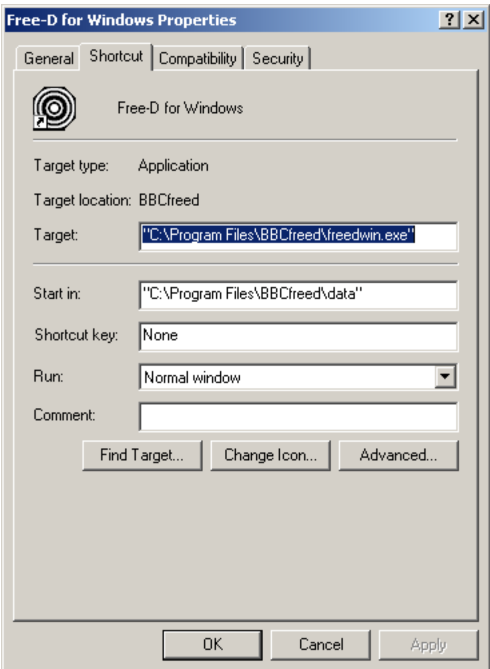


Fig. 5 FREEDWIN Properties dialog box

To change the port, you:

1. Right-click on the *free-d* for Windows icon on your computer desktop.
2. From the menu, choose Properties to launch the Properties dialog box (Fig. 5).
3. On the Shortcut tab, enter the details of the communications port in the Target field, for example:

   `C:\path\lomwin.exe -c COM2.`

How to use LOMWIN

Like FREEDWIN, LOMWIN uses a conventional window consisting of a title bar, header and six data panels and a footer listing the available commands (Fig. 6). The window works similar to other application windows, allowing you to reposition the window on your computer Windows™ desktop by dragging with your mouse, minimise it (so that it appears only as an item on your task bar) and close the application, but you cannot resize or maximise the LOMWIN utility window.

NOTE: LOMWIN is controlled entirely from the keyboard.

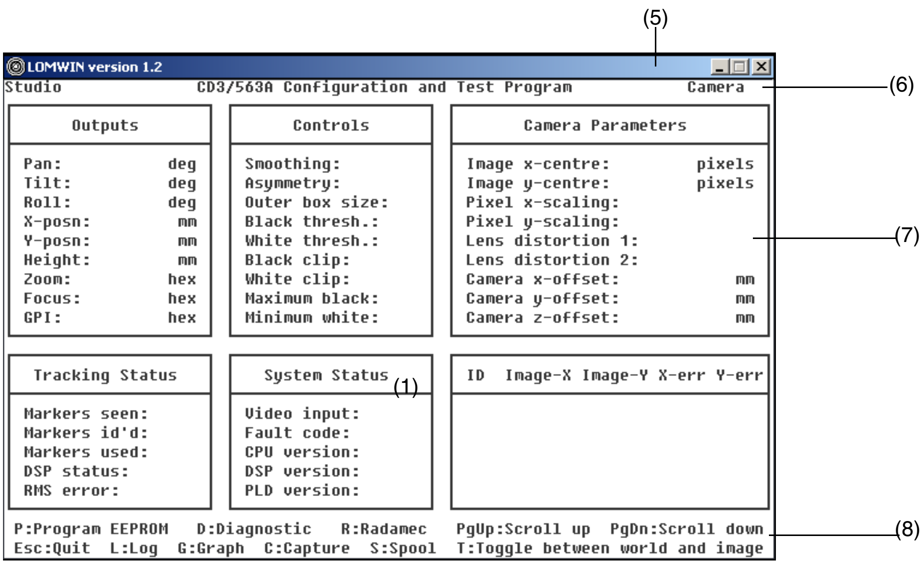


Fig. 6 LOMWIN

(5) title bar (6) header (7) data panels (8) footer

The header contains the hexadecimal studio ID on the left-hand side and the hexadecimal camera ID on the right-hand side. Note that if communication with the *free-d* processor unit has not been established the camera and studio IDs will be blank. The corresponding studio and camera names can be discovered by comparing the IDs with the ranges given in the Studio List and Camera List respectively within FREEDWIN.

Outputs panel

Outputs	
Pan:	**32.17 deg**
Tilt:	**0.61 deg**
Roll:	**30.04 deg**
X-posn:	**1089.1 mm**
Y-posn:	**1898.5 mm**
Height	**952.5 mm**
Zoom:	**80000 hex**
Focus:	**80000 hex**
GPI:	**00F0 hex**

The Outputs panel displays the current studio camera orientation, position, zoom and focus as returned from the *free-d* processor unit. Note that when LOMWIN is running with a receive-only data connection to the Free-d processor unit, only the Outputs panel will display data.

Pan: The angle in degrees between the Y-axis and the projection of the studio camera's optical axis onto the horizontal (XY) plane. A positive value indicates a pan to the right (i.e. the camera rotates clockwise when viewed from above).

Tilt: The angle in degrees between the studio camera's optical axis and the horizontal (XY) plane. A positive value indicates an upwards tilt. If both pan and tilt are zero the camera is looking in the direction of the positive Y axis.

Roll: The angle of rotation in degrees of the studio camera about its optical axis. A positive value indicates a clockwise roll, when viewed from behind the camera.

X-position: The horizontal displacement in millimetres of the camera from its reference position in the direction of the X-axis.

Y-position: The horizontal displacement in millimetres of the camera from its reference position in the direction of the Y-axis.

Height: The vertical displacement in millimetres of the camera from its reference position. A positive value indicates an upwards displacement.

Zoom: A hexadecimal value related to the rotation of the zoom ring. It is the responsibility of the virtual set system to convert this value to that required to control the rendering of the virtual background, knowing the type of lens in use.

Focus: A hexadecimal value related to the rotation of the focus ring. It is the responsibility of the virtual set system to convert this value to that required to control the rendering of the virtual background, knowing the type of lens in use.

GPI: 16-bit hexadecimal value sent from the *free-d* camera. The first two digits are a general purpose 8-bit value corresponding to inputs fed to the camera's auxiliary connector; these are ignored by the *free-d* system and can be used to carry any (slowly changing) data from the camera to the virtual set system. The last two digits correspond to switch settings within the *free-d* camera (the fourth digit indicates the approximate shutter speed as follows: 0 = 1/10000 sec, 1 = 1/4000 sec, 2 = 1/2000 sec).

Controls panel

Controls	
Smoothing:	**0.9**
Asymmetry:	**0.5**
Outer box size:	**58**
Black Thresh:	**32**
White Thresh:	**128**
Black clip:	**32**
White clip:	**96**
Maximum black:	**1**
Minimum white:	**50**

The Controls panel displays the current configuration parameters for the *free-d* processor unit. These are changed using switches on the unit, but it will normally be satisfactory to leave them set to their default values.

Smoothing: This determines the degree to which targets entering or leaving the field of view of the *free-d* camera (or appearing and disappearing for any other reason) cause a disturbance to the measured position and orientation. The default value is 0.95.

Asymmetry: This determines at what point to reject a target because it appears to be asymmetrical. Increasing the value can prevent the rejection of 'marginal' targets, but since their measured positions are suspect their inclusion may impair system accuracy. The default value is 0.5.

Outer box size: This determines the maximum size of target which will be recognised. By default the box size is set to 'automatic', and the value displayed is that which the system is currently using. Only in exceptional circumstances, or for testing, should the box size need to be forced to a fixed value.

Black threshold: This determines the maximum acceptable video level in the dark region around a target. It should be set so that flare and shiny objects in the vicinity of a target are ignored. The default value is 32.

White threshold: This determines the minimum acceptable video level of the bright regions of a target. It should be set to allow for a reduction in video level as the distance from the targets increases. The default value is 128.

Black clip: This determines the minimum level to which the incoming video is limited before the 'centre of gravity' of a target is measured. The default value is 32.</TD

White clip: This determines the maximum level to which the incoming video is limited before the 'centre of gravity' of a target is measured. It should be set sufficiently below the White threshold to allow for some variation of intensity across a target. The default value is 96.

Maximum black: This determines the maximum acceptable number of pixels in the dark region around a target having levels exceeding the Black threshold. The default value is 1.

Minimum white: This determines the minimum acceptable number of pixels in the bright region of a target having levels exceeding the White threshold. The default value is 50.

Camera Parameters panel

Camera Parameters	
Image x-centre:	**459.15 pixels**
Image y-centre:	**256.84 pixels**
Pixel x-scaling:	**0.59497**
Pixel y-scaling:	**-0.58497**
Lens distortion 1:	**0.20933**
Lens distortion 2:	**-0.16784**
Camera x-offset:	**0.0 mm**
Camera y-offset:	**370.0 mm**
Camera z-offset:	**-40.0 mm**

The Camera Parameters panel displays the calibration parameters of the *free-d* camera, derived from the contents of the appropriate calibration (.CAL) file, and the offsets between the *free-d* camera and the reference point whose position is returned.

Camera x-offset: The displacement in millimetres between the optical axis of the *free-d* camera and the reference point, measured in the direction of the X axis when the camera's pan and tilt are zero. A positive value indicates that the reference point is to the right of the *free-d* camera, when viewed from behind the studio camera.

Camera y-offset: The displacement in millimetres between the optical axis of the *free-d* camera and the reference point, measured in the direction of the Y axis when the camera's pan and tilt are zero. A positive value indicates that the reference point is in front of the *free-d* camera.

Camera z-offset: The displacement in millimetres between the nodal plane of the *free-d* camera and the reference point, measured in the vertical direction when the camera's tilt is zero. A positive value indicates that the reference point is above the *free-d* camera. The nodal plane of the Free-d camera corresponds to the bottom edge of the BBC logo.

Tracking Status panel

Tracking Status	
Markers seen:	**19**
Marker's id'd:	**11**
Markers used:	**9**
DSP status:	**0**
RMS error:	**0.06**

The Tracking Status panel displays information related to the current performance of the Free-d camera tracking.

Markers seen: The number of targets which are recognised based on the acceptance criteria in the Controls panel, i.e. Box size, Black threshold, White threshold, Maximum black and Minimum white.

Markers identified: The number of targets whose bar-codes have been read (this may include other bright objects misinterpreted as targets with an ID of 4095).

Markers used: The number of targets whose bar-codes exist in the target position database for the current studio, and which are therefore used in the position and orientation calculation.

DSP status: The status of the most recent calculation. A zero or positive value indicates the number of iterations required to compute the camera's position and orientation. A negative value indicates a failure:

- 255 = too few targets
- 254 = failed to converge
- 253 = DSP reset
- 252 = internal error.

RMS error: The residual error, in pixels. This is a measure of how close the target images are to their theoretical positions. A value in excess of 0.1 should lead to a suspicion that a studio calibration is required, or that the wrong camera calibration file is being used.

System Status panel

System Status	
Video input:	**OK**
Fault code:	**0**
CPU version:	**2.5**
DESP version:	**2.7**
PLD version	**2.1**

The System Status panel displays information on the overall status of the *free-d* system. The status indicators are defined as:

Video input: The status of the video input from the *free-d* camera:

- OK
- FAIL (the video input is absent)
- FAULT (the video input is present but unlocked or otherwise faulty)
- FREEZE (the video image is 'frozen' e.g. during data acquisition.

Fault code: Either zero, signifying no fault, or a value signifying a fault condition. See the **Free-d communication protocols** for more information.

CPU version: The version number of the firmware running in the single-chip CPU controlling the *free-d* processor unit.

DSP version: The version number of the software running on the Digital Signal Processor which performs the camera position and orientation calculation.

PLD version: The version number of the programmable logic configuration.

Target Data

ID	Image-X	Image-Y	X-err	Y-err
454	290.96	62.42	-0.01	0.13
98	475.23	268.81	-0.01	0.04
370	583.88	313.32	-0.05	-0.10
351	536.03	418.01	0.04	0.06

The Target Data panel displays one of two alternative views, either image data (shown above) or world data (shown below). You can toggle between these views by pressing the T key. In both views you can scroll the list up and down using the Page Up and Page Down keys.

In the image data view the X and Y coordinates (in pixels) of each visible target are shown, along with the differences between the observed coordinates and where they should theoretically be seen from the calculated camera position and orientation. If any of the difference values are unusually large, it may suggest that the relevant target has moved since the studio was calibrated. However, because of the smoothing process these values are only meaningful when the camera is stationary and the target is steadily in view.

ID	World-X	World-Y	World-Z
81	994.9	606.0	2454.4
87	995.0	803.0	2455.3
93	797.3	607.0	2454.9
98	797.4	802.8	2454.9
104	1201.3	198.5	2450.7

In the world data view the X, Y and Z coordinates of all the targets are shown. This is simply a copy of the target position database stored in the *free-d* processing unit. It takes some time to upload the data via the serial link, so you may find that not all the targets are listed for the first few minutes.

Commands

The available keyboard commands are listed in the footer (8) and are activated with a single press of the appropriate key. The commands are:

P:Program EEPROM: This command prompts you for the name of a data file, the contents of which are uploaded to the *free-d* processor and programmed into its non-volatile EEPROM memory. This should normally be accessed via the Upload database option of FREEDWIN.

D:Diagnostic: This command cycles through the three diagnostic modes of the *free-d* processor and back to normal operation. The diagnostic modes set the monitoring video output to dark grey, light grey and a test pattern respectively.

R:Radamec: This command alternates between normal polling and Radamec-style polling. In the latter mode the *free-d* processor is requested to send Vinten Radamec-compatible A2 messages. Since these messages have no provision for a roll value the camera must be mounted on a tripod or pedestal.

PgUp:Scroll up: This command scrolls the contents of the Target Data panel down one line, so that earlier lines may be seen.

PgDn:Scroll down: This command scrolls the contents of the Target Data panel up one line, so that later lines may be seen.

Esc:Quit: This command exits LOMWIN. It is equivalent to clicking on the close button in the title bar.

L:Log: This command toggles the logging mode on and off. When logging, the current position and orientation of the camera are written to the file LOM.LOG (in the current directory) once per second.

G:Graph: This command displays a graphical representation of how the measured camera position changes with time. It can be used to assess the residual noise when the camera is stationary. Pressing any key returns to the normal display.

C:Capture: This command prompts for the name of a file to which image data will be written. Subsequently each press of the spacebar causes the image coordinates of all the visible targets to be written to the file. This facility is primarily used in the *free-d* camera calibration process.

S:Spool: This command initiates the image data acquisition process used for studio recalibration. This should normally be accessed via the Acquire image data option of the FREEDWIN utility.

T:Toggle between world and image: This command alternates between the Image Data display and the World Data display in the Target Data panel

F:Save to file: This command saves the world target data to a .MKR file. It is particularly useful if the original data has been lost and must be recovered from that stored in the processing unit.

Free-d communication protocols

General

Communications with the *free-d* processing unit is by RS422/RS485 serial data:

Baud rate	38.4 kbaud
Data bits	8 (LSB first)
Parity	Odd
Stop bits	1
Total bits	11

Data is transferred in messages. Each message consists of:

Message type

Camera ID number

Data (depending on message type)

Checksum

Multi-byte data values are sent most-significant-byte first.

The checksum is calculated by subtracting (modulo 256) each byte of the message, including the message type, from 40 (hex).

The Camera ID number identifies the camera concerned. If the Camera ID of a message received by the *free-d* processor unit does not match that of the camera to which the unit is connected, the message is ignored. However, if the Camera ID is set to FF (hex) no comparison is made and the message is always recognised. Messages transmitted by the *free-d* processor unit carry the ID number of the camera to which it is connected.

Protocols

There are two modes of operation, stream mode and polled mode. In stream mode, the *free-d* processor unit will send position updates at the field rate of the reference video (genlock) input, or at approximately 60 Hz if no genlock source is connected. In polled mode, the *free-d* processor unit will send a message only when specifically requested - a maximum rate of 100 polls per second is allowed. Switching between the two modes is possible using a command message. The *free-d* processor unit initialises itself to stream mode using message D1.

The *free-d* processor unit can be configured to a 'Radamec-compatible' mode, in which it transmits messages with the same format as would be returned by an RP2 robotic pedestal. Since Radamec-format messages have no provision for a camera 'roll' value, in this mode the camera must be mounted on a tripod or other suitable platform. Both stream and polled Radamec-compatible modes are available.

Message structures

Type D0 - poll / command

The D0 message is used to poll the *free-d* processor unit for data or to send a command to the unit.

The message contains 4 bytes: :

<D0>	Message type
<CA>	Camera ID
<CD>	Command
<CK>	Checksum

Commands presently defined are:

00	Stop stream mode
01	Start stream mode
02	Stop freeze mode
03	Start freeze mode
D1	Poll for position update (and stop stream mode)
D2	Request system status
D3	Request system parameters
D4	Request first marker data
D5	Request next target data
D6	Request first image point
D7	Request next image point
D8	Request next EEPROM data
DA	Request camera calibration values
DB	Request diagnostic mode

Type D1 - camera position/orientation data

The D1 message is used for transferring the camera position and orientation data from the *free-d* processor unit.

The message contains 29 bytes:

<D1>	Message Type
<CA>	Camera IDs
<PH><PM><PL>	Camera Pan Angle
<TH><TM><TL>	Camera Tilt Angle
<RH><RM><RL>	Camera Roll Angle
<XH><XM><XL>	Camera X-Position
<YH><YM><YL>	Camera Y-Position
<HH><HM><HL>	Camera Height (Z-Position)
<ZH><ZM><ZL>	Camera Zoom
<FH><FM><FL>	Camera Focus
<SH><SL>	Spare / User Defined (16 bits)
<CK>	Checksum

See **Parameter definitions** for details of the content of this message.

Type D2 - system status

The D2 message is used for transferring the system status from the *free-d* processing unit.

The message contains 16 bytes:

<D2>	Message type
<CA>	Camera ID
<SW>	Switch settings
<LD>	LED indications
<FS>	System status
<CV>	CPU firmware version number
<PV>	PLD firmware version number
<DV>	DSP software version number
<DS>	DSP status
<MR>	Number of markers seen (i.e. detected by hardware)
<MC>	Number of markers identified (i.e. bar-codes read)
<NP>	Number of markers used (identified and in database)
<EH><EM><EL>	RMS error
<CK>	Checksum

Bits in the 'switch settings' byte are:

Bits 0-3	Setting of the hex switch S5 (inverted)
Bit 4	0 = S2 left (decrease value / scroll left)
Bit 5	0 = S2 right (increase value / scroll right)
Bit 6	0 = S4 closed (save settings)
Bit 7	0 = S3 left (results mode), 1 = S3 right (entry mode)

Bits in the 'LED indications' byte are:

Bit 0	1 = video input present
Bit 1	1 = video input OK
Bit 2	1 = serial data input present
Bit 3	1 = data 'freeze' mode 0 = normal
Bit 4	1 = too few markers
Bit 5	1 = RMS error high
Bit 6	1 = DSP alert (see DSP status)
Bit 7	1 = fault (see system status)

Note that only one 'video input' LED (D3) is present in the hardware, which lights when both Bit 0 and Bit 1 of the 'LED indications' byte are set.

The version numbers should be interpreted as BCD, with an implied decimal point between the two digits, e.g. 12 (hexadecimal) refers to version 1.2.

The RMS error is expressed in pixels as a 24-bit positive number, where the most-significant bit (bit 23) is always zero, the next 8 bits (bits 22 to 15) are the integer part and the remaining bits (bits 14 to 0) are the fractional part; alternatively, this may be thought of as an unsigned integer value in units of 1/32768 pixels. The range of values is from zero to nearly 256.0 pixels (7FFFFF hex).

The 'DSP alert' bit is set whenever the DSP status is negative (bit 7 set).

The 'fault' bit is set whenever the system status byte is non-zero.

The system status is an 8-bit number which can take one of the following values:

0	System normal (no detected errors).
1	A processor reset occurred. This code is only present transitory.
2	Serial communications error. This is most likely to be caused by a message being sent to the Free-d processing unit before the reply to the previous message has been received.
3	Vertical blanking failure. This may indicate a hardware fault, or a problem with the digital video input.
4	Xilinx failure. The programmable logic devices have not initialised correctly; if persistent, this indicates a hardware fault.
5	I2C bus failure. Communication between the CPU and peripheral devices has failed, indicating a probable hardware fault.

6	EEPROM failure. An attempt to save the parameters to non-volatile memory U3 has failed, indicating a probable hardware fault.
7	DSP failure (1). The DSP failed to acknowledge a command; if persistent, this indicates a hardware fault.
8	DSP failure (2). The DSP failed to accept data; if persistent, this indicates a hardware fault.
9	DSP failure (3). The DSP failed to provide data; if persistent, this indicates a hardware fault.
10	DSP failure (4). The DSP is flagging an exception error; if persistent, this indicates a hardware or software fault.
91	I2C communication failure: No Reply.
93	I2C communication failure: Bus Error.
94	I2C communication failure: ACK Error.
95	I2C communication failure: Undefined State.
96	I2C communication failure: Overflow.

The 'I2C communication failure' codes result from a problem with communication between the *free-d* processor unit and the I2C peripherals U3 and U17, most likely indicating a hardware fault.

The DSP status is a signed 8-bit number which when negative indicates an error condition as follows:

-1 = Too few valid markers visible to compute camera position

-2 = Iteration failed to converge

-3 = A DSP reset occurred

-4 = Internal DSP error

A zero or positive value of DSP status indicates the number of iterations which were required to compute the camera's position.

Type D3 - control parameters

The D3 message is used for transferring the control parameters. It may be sent to the *free-d* processing unit in order to set their values, or requested from the *free-d* processing unit in order to interrogate the current values. Operation of switch S4 saves the current values to EEPROM which become the default values following a subsequent processor reset.

The message contains 13 bytes:

<D3>	Message type
<CA>	Camera ID
<SN>	Studio ID
<SM>	Smoothing value
<HI>	Maximum asymmetry
<HO>	Half box width
<BT>	Black video threshold

<WT>	White video threshold
<BC>	Black video clip level
<WC>	White video clip level
<MB>	Maximum number of >black pixels between boxes
<MW>	Minimum number of >white pixels in inner box
<CK>	Checksum

The 'studio ID' is in the range 0 to 255 and determines which database of marker positions (stored in the on-board EEPROM) is used.

The 'smoothing value' is in the range 0 to 255, corresponding to settings of smoothing between 0.000 and 0.996.

The 'maximum asymmetry' is in the range 0 to 255, in units of 1/128 pixels. This sets a limit on the difference between the centre position of a marker as measured by the hardware and its position as estimated as the mid-point between opposite edges. If set to zero, a test mode is entered in which the returned pan value increments continuously at a rate of 30° per second (25° per second when genlocked at 50 Hz).

The 'half box width' determines the size of the outer box used in marker detection. The maximum value is 41 pixels: if a larger value is set the unit will not operate correctly; the box height is calculated to ensure the box is square. A value of zero signifies 'automatic': the *free-d* processor unit sets the box size according to the apparent size of the markers in the image.

The 'black video clip level' and 'white video clip level' determine the clipping which is applied before the marker's position is measured. Too little clipping can make the position measurement over-sensitive to level variation, such as might be caused by uneven illumination. Too much clipping, however, can cause excessive aliasing which can impair the measurement accuracy.

The 'maximum number of black pixels' and 'minimum number of white pixels' values are used in conjunction with the 'black video threshold' and 'white video threshold' to control the marker detection process. A marker is recognised if there are at least the specified minimum number of pixels above the 'white' threshold within the inner box, and at most the specified maximum number of pixels above the 'black' threshold between the inner and outer boxes.

The *free-d* processor unit acknowledges receipt of a D3 message by replying with a D3 message containing the new data (if the 'half box width' was set to zero, signifying automatic, the actual value in use is returned).

Type D4 & D5 - marker data

The D4 and D5 messages are used for transferring marker data from the *free-d* processing unit. Each message contains data about a single marker: requesting message D4 causes data for marker zero to be transmitted and requesting message D5 causes data for the next marker in sequence to be transmitted. After data for the last marker has been sent, the next message will contain data for the first marker, with a message type of D4 (whether the request was for D4 or D5).

The messages contain 18 bytes:

<D4> or <D5>	Message type
<CA>	Camera ID
<SN>	Studio ID
<MH><ML>	Marker Number
<XH><XM><XL>	Marker X-Position
<YH><YM><YL>	Marker Y-Position
<HH><HM><HL>	Marker Height (Z-Position)
<FH><FM><FL>	Marker Flags
<CK>	Checksum

The X-Position, Y-Position and Height are sent in the same format as the camera position in message D1 (see Parameter definitions).

The MSB of Marker Flags (bit 7 of FH) is set for a valid marker and cleared for an invalid marker. If the marker is flagged as invalid its position data should be ignored.

Type D6 & D7 - image data

The D6 and D7 messages are used for transferring image data from the *free-d* processing unit. Each message contains data about a single marker: requesting message D6 causes data for the first marker in the image to be transmitted and requesting message D7 causes data for the next marker in the image to be transmitted. After data for the last marker has been sent, the next message will contain data for the first marker, with a message type of D6 (whether the request was for D6 or D7).

The messages contain 18 bytes:

<D6> or <D7>	Message type
<CA>	Camera ID
<MI>	Marker Index (zero for message D6)
<MH><ML>	Marker Number
<XH><XM><XL>	X-Position in image
<YH><YM><YL>	Y-Position in image
<AH><AM><AL>	Error in X-Position
<BH><BM><BL>	Error in Y-Position
<CK>	Checksum

The X-Position and Y-Position are positive values in units of 1/256 pixels (i.e. XH,XM is the integer part of the X-Position in pixels and XL is the fractional part).

The Error values are signed and in units which depend on the lens calibration. To obtain values in pixels the X-Error must be divided by X-Scale (see message DA) and multiplied by 512. Similarly the Y-Error must be divided by Y-Scale and multiplied by 512.

Type D8 - EEPROM data

The D8 message is used for transferring EEPROM data from or to the *free-d* processing unit. If a D8 message is sent to the *free-d* processing unit the EEPROM is programmed with the data supplied, and the *free-d* processing unit replies with a D8 message containing the new data.

The message contains 21 bytes:

<D8>	Message type
<CA>	Camera ID
<EH><EL>	EEPROM Address
<D0>......<DF>	16 bytes of EEPROM data
<CK>	Checksum

The EEPROM can only be programmed or read 16-bytes at a time. The EEPROM address within the message corresponds to the address of the first byte of data transferred.

See **Data structures** for details of the format of the EEPROM database.

Type D9 - request EEPROM data

The D9 message is used to request the transfer of EEPROM data from the *free-d* processing unit. The unit replies with a D8 message containing 16 bytes of EEPROM data.

The message contains 5 bytes:

<D9>	Message type
<CA>	Camera ID
<EH><EL>	EEPROM Address
<CK>	Checksum

The EEPROM address determines the address of the first data byte to be transferred.

Type DA - camera calibration data

The DA message is used for transferring camera calibration data from the *free-d* processing unit. The data corresponds to the camera currently in use. If a valid camera is not connected to the *free-d* processing unit, or if the camera has only recently been connected, the data is invalid.

The message contains 30 bytes:

<D9>	Message type
<CA>	Camera ID
<CH><CM><CL>	Lens X-Centre
<DH><DM><DL>	Lens Y-Centre
<SH><SM><SL>	Lens X-Scale
<TH><TM><TL>	Lens Y-Scale
<AH><AM><AL>	Lens Distortion A (radial, square term)

<BH><BM><BL>	Lens Distortion B (radial, fourth power)
<XH><XM><XL>	X-Offset from auxiliary camera to studio camera
<YH><YM><YL>	Y-Offset from auxiliary camera to studio camera
<ZH><ZM><ZL>	Z-Offset from auxiliary camera to studio camera
<CK>	Checksum

See **Data structures** for details.

Type DB - diagnostic mode

The DB message is used to switch the *free-d* processing unit into a diagnostic mode or to return the diagnostic mode currently set.

The message contains 4 bytes:

<D9>	Message type
<CA>	Camera ID
<DM>	Diagnostic mode
<CK>	Checksum

Only the two most-significant bits of diagnostic mode are defined. The possible modes are:

00	Normal operation
40	Set video data to 0x55
80	Set video data to 0xAA
C0	Set video data to test pattern

The *free-d* processing unit acknowledges receipt of a DB message by replying with a DB message containing the new mode.

Type A4 - poll / command (Radamec compatibility mode)

The A4 message is used to poll the *free-d* processing unit for data or to send a command to the unit in a way compatible with Radamec robotic pedestals.

The message contains 4 bytes:

<A4>	Message type
<CA>	Camera ID
<CD>	Command
<CK>	Checksum

Commands presently defined are:

00	Stop Radamec-compatible stream mode
01	Start Radamec-compatible stream mode
02	Request camera ID
FF	Poll for Radamec-compatible position update

In the case of commands 00 and 01 the *free-d* processing unit acts on the message but does not reply.

In the case of command 02 (request camera ID) the <CA> byte in the message should be set to FF. The CD3/563A processing unit replies with an A4 message having the <CA> byte set to the current camera ID and the <CD> byte set to 02.

In the case of command FF (poll) the *free-d* processing unit replies with an A2 message.

Type A2 - camera position/orientation data (Radamec compatibility mode)

The A2 message is used for transferring the camera position and orientation data from the *free-d* processing unit in a form compatible with Vinten Radamec robotic pedestals. Note that there is no provision to send a 'roll' value, so the camera must be mounted on a tripod or pedestal.

The message contains 30 bytes:

<A2>	Message type
<CA>	Camera ID
<PH><PM><PL>	Camera Pan Angle
<TH><TM><TL>	Camera Tilt Angle
<ZH><ZM><ZL>	Camera Zoom
<FH><FM><FL>	Camera Focus
<HH><HM><HL>	Camera Height (Z-Position)
<XFH><XFL>	Camera X-Position (fraction)
<XIH><XIL>	Camera X-Position (integer)
<YFH><YFL>	Camera Y-Position (fraction)
<YIH><YIL>	Camera Y-Position (integer)
<00><00>	Pedestal Orientation (set to zero)
<SH><SL>	Spare / User Defined (16 bits)
<CK>	Checksum

The Pan Angle is expressed as a 24-bit integer in units of 1/900 degrees, where zero is represented by 080000 hex. The range of values is from -180.0 degrees (058730 hex) to +180.0 degrees (0A78D0 hex).

The Tilt Angle is expressed as a 24-bit integer in units of 1/900 degrees, where zero is represented by 080000 hex. The range of values is from -90.0 degrees (06C398 hex) to +90.0 degrees (093C68 hex). The Camera Zoom is expressed as a 24-bit positive unsigned number in arbitrary units related to the rotation of the 'zoom ring' on the camera lens. It will be necessary for the host system to convert this to a true zoom value based on the type and particular sample of lens and camera in use.

The Camera Focus is expressed as a 24-bit positive unsigned number in arbitrary units related to the rotation of the 'focus ring' on the camera lens. It will be necessary for the host system to convert this to a true focus value based on the type and particular sample of lens and camera in use.

The Height is expressed as a 24-bit integer in units of 1/82.2 mm. The range of values is from -102,051.2 mm (800000 hex) to +102,051.2 mm (7FFFFF hex).

The X-Position and Y-Position are expressed in units of millimetres as a 16-bit integer part and a 16-bit fractional part. The range of values is from -32,768 mm (integer part 8000 hex, fractional part 0000 hex) to almost +32,768 mm (integer part 7FFF hex, fractional part FC00 hex).

NOTE: Unlike a Radamec robotic pedestal and camera head, it is not possible to pre-load the encoder positions by transmitting an A2 message to the *free-d* processing unit.

Parameter definitions

The following sections describe the parameters used to convey the position, orientation etc. of the studio camera.

Definition of axes

A set of orthogonal right-handed axes (X, Y and Z) is used, fixed with respect to the reference frame of the studio. The X and Y axes lie in the horizontal plane, and the Z axis is vertical. The positive direction of the Z-axis is upwards.

Camera pan angle

The camera pan angle is defined as the angle between the Y-axis and the projection of the optical axis of the camera onto the horizontal (XY) plane. A zero value corresponds to the camera looking in the positive Y direction and a positive value indicates a pan to the right (i.e. the camera rotates clockwise when viewed from above).

The value is expressed in degrees as a 24-bit twos-complement signed number, where the most-significant bit (bit 23) is the sign bit, the next 8 bits (bits 22 to 15) are the integer part and the remaining bits (bits 14 to 0) are the fractional part; alternatively, this may be thought of as a signed integer value in units of 1/32768 degree. The range of values is from -180.0 degrees (A60000 hex) to +180.0 degrees (5A0000 hex).

Camera tilt angle

The camera tilt angle is defined as the angle between the optical axis of the camera and the horizontal (XY) plane. A positive value indicates an upwards tilt. If the pan and tilt angles are both zero, the camera is looking in the direction of the positive Y axis.

The value is expressed in degrees as a 24-bit twos-complement signed number, where the most-significant bit (bit 23) is the sign bit, the next 8 bits (bits 22 to 15) are the integer part and the remaining bits (bits 14 to 0) are the fractional part; alternatively, this may be thought of as a signed integer value in units of 1/32768 degree. The range of values is from -90.0 degrees (D30000 hex) to +90.0 degrees (2D0000 hex).

Camera roll angle

The camera roll angle is defined as the angle of rotation of the camera about its optical axis. A roll angle of zero corresponds to a 'scan line' of the camera sensor (i.e. a horizontal in the image) being parallel to the horizontal (XY) plane. A positive value indicates a clockwise roll, when viewed from behind the camera.

The value is expressed in degrees as a 24-bit twos-complement signed number, where the most-significant bit (bit 23) is the sign bit, the next 8 bits (bits 22 to 15) are the integer part and the remaining bits (bits 14 to 0) are the fractional part; alternatively, this may be thought of as a signed integer value in units of 1/32768 degree. The range of values is from -180.0 degrees (A60000 hex) to +180.0 degrees (5A0000 hex).

Camera X-position

The Camera X-position is defined as the horizontal displacement of the camera from its reference position in the direction of the X-axis.

The value is expressed in millimetres as a 24-bit twos-complement signed number, where the most-significant bit (bit 23) is the sign bit, the next 17 bits (bits 22 to 6) are the integer part and the remaining bits (bits 5 to 0) are the fractional part; alternatively, this may be thought of as a signed integer value in units of 1/64 mm. The range of values is from -131,072.0 mm (800000 hex) to nearly +131,072.0 mm (7FFFFF hex).

Camera Y-position

The Camera Y-position is defined as the horizontal displacement of the camera from its reference position in the direction of the Y-axis.

The value is expressed in millimetres as a 24-bit twos-complement signed number, where the most-significant bit (bit 23) is the sign bit, the next 17 bits (bits 22 to 6) are the integer part and the remaining bits (bits 5 to 0) are the fractional part; alternatively, this may be thought of as a signed integer value in units of 1/64 mm. The range of values is from -131,072.0 mm (800000 hex) to nearly +131,072.0 mm (7FFFFF hex).

Camera height (Z-Position)

The camera height is defined as the vertical displacement of the camera from its reference position. A positive value indicates an upwards displacement.

The value is expressed in millimetres as a 24-bit twos-complement signed number, where the most-significant bit (bit 23) is the sign bit, the next 17 bits (bits 22 to 6) are the integer part and the remaining bits (bits 5 to 0) are the fractional part; alternatively, this may be thought of as a signed integer value in units of 1/64 mm. The range of values is from -131,072.0 mm (800000 hex) to nearly +131,072.0 mm (7FFFFF hex).

Camera zoom

The camera zoom is defined as the vertical angle of view of the camera, i.e. the vertical angle subtended at the camera lens by the top and bottom edges of the active picture.

The value is expressed as a 24-bit positive unsigned number in arbitrary units related to the rotation of the 'zoom ring' on the camera lens. It will be necessary for the host system to convert this to a true zoom value based on the type and particular sample of lens and camera in use.

Camera focus

The camera focus is defined as the distance between the camera lens and an object at which the object will be in sharp focus.

The value is expressed as a 24-bit positive unsigned number in arbitrary units related to the rotation of the 'focus ring' on the camera lens. It will be necessary for the host system to convert this to a true focus value based on the type and particular sample of lens and camera in use.

Data structures

The following sections describe the data structures within the non-volatile storage of the *free-d* processor unit. The storage consists of a Flash EEPROM holding up to 64 Kbytes of data, comprising a database of marker positions for one or more studios and a database of camera and lens calibration values for one or more cameras. Since the space available must be shared between these databases, the maximum size of each is dependent on the size of the other. The data capacity of the EEPROM is sufficient for approximately 4000 markers (corresponding to perhaps five medium-sized studios); the maximum number of cameras for which data may be stored is 256.

Data tables

There are five types of data table presently defined:

- Camera data pointers
- Studio data pointers
- Camera and lens data
- Studio data
- Marker data

Camera data pointers

This table consists of 256 16-bit values (512 bytes) starting at EEPROM address 0x0000. Each 16-bit value represents a pointer to an area of EEPROM at which data for a particular camera is stored; the pointers are stored most-significant-byte first. The index into the table is the 8-bit 'Camera ID' which is received from the camera encoded in its serial digital video signal.

If camera data is present for a particular Camera ID, then the appropriate entry in the table (at address 0x0000 + 2 * Camera_ID) contains the address within the EEPROM at which the **Camera and lens data table** is stored. If no data is present for that camera then the table entry contains the value 0xFFFF. Two or more entries in the table may point to the same camera and lens data.

Studio data pointers

This table consists of 256 16-bit values (512 bytes) starting at EEPROM address 0x0200. Each 16-bit value represents a pointer to an area of EEPROM at which data for a particular studio is stored; the pointers are stored most-significant-byte first. The index into the table is the 8-bit 'Studio ID' which is selected by the user either from the front-panel switches on the *free-d* processor unit or via the serial data interface.

If studio data is present for a particular Studio ID, then the appropriate entry in the table (at address 0x0200 + 2 * Studio_ID) contains the address within the EEPROM at which the Studio Data table is stored. If no data is present for that studio then the table entry contains the value 0xFFFF. Two or more entries in the table may point to the same Studio Data.

Camera and lens data table

This table consists of 32 bytes of data relevant to a particular studio camera. The contents of the table are:

Camera Name (4 bytes)

Lens X-Centre (3 bytes)

Lens Y-Centre (3 bytes)

Lens X-Scale (3 bytes)

Lens Y-scale (3 bytes)

Lens Distortion A (3 bytes)

Lens Distortion B (3 bytes)

X-Offset from auxiliary camera to studio camera (3 bytes)

Y-Offset from auxiliary camera to studio camera (3 bytes)

Z-Offset from auxiliary camera to studio camera (3 bytes)

Unused (1 byte)

The Camera Name should be left-justified and consist of 7-bit ASCII characters (MSB=0).

The Centre, Scale and Distortion values characterise the lens in the upwards-looking auxiliary camera and are generated from images of a precision calibration object. They are stored most-significant-byte first.

The Offset values represent the displacement between the 'centre' of the lens in the upwards-looking camera and the reference point on the studio camera whose position should be returned by the camera-tracking system. The X, Y and Z-Offsets are defined such that they are aligned with the real-world X, Y and Z axes when the camera's pan, tilt and roll angles are all zero (see **Parameter definitions**). In other words, the Z-Offset is vertical (positive if the studio camera is above the auxiliary camera), the Y-Offset is in the direction of the optical axis (positive if the studio camera is in front of the auxiliary camera) and the X-Offset is from side to side (positive if the studio camera is to the right of the auxiliary camera).

The Offset values are represented in the same units as the camera's position, i.e. as 24-bit twos-complement signed integers in units of 1/64 mm (see **Parameter definitions**). They are stored in the table most-significant-byte first.

Studio data table

This table consists of 16 bytes of data relevant to a particular studio. The contents of the table are as follows:

Studio Name (4 bytes)

Number of Markers (2 bytes)

Pointer to First Marker (2 bytes)

Spare (8 bytes)

The Studio Name should be left-justified and consist of 7-bit ASCII characters (MSB=0).

The Number of Markers consists of a 16-bit integer, stored most-significant-byte first.

The Pointer to First Marker is the EEPROM address of the **Marker data table** for the lowest-numbered marker. It is stored most-significant-byte first.

Marker data table

This table consists of 16 bytes of data relevant to a particular marker. The contents of the table are as follows:

Marker Number (3 bytes)

Marker X-Position (3 bytes)

Marker Y-Position (3 bytes)

Marker Height (Z-Position, 3 bytes)

Pointer to Next Marker (2 bytes)

Unused (2 bytes)

The Marker Number is an unsigned integer representation of the marker's 'bar-code' value. It is stored most-significant-byte first (the first byte is always zero).

The Marker X, Y and Z-Positions are the coordinates of the marker, with respect to the frame of reference of the studio as defined in **Parameter definitions**. The values are expressed in millimetres as 24-bit twos-complement signed numbers, where the most-significant bit (bit 23) is the sign bit, the next 17 bits (bits 22 to 6) are the integer part and the remaining bits (bits 5 to 0) are the fractional part; alternatively, this may be thought of as a signed integer value in units of 1/64 mm. The range of values is from -131,072.0 mm (800000 hex) to +131,072.0 mm (7FFFFF hex). They are stored most-significant-byte first.

The Pointer to Next Marker is the EEPROM address at which the **Marker data table** for the next marker (in ascending sequence of marker numbers) is stored. If this is the last (highest-numbered) marker, the value is set to 0xFFFF. It is stored most-significant-byte first.

Miscellaneous

Since the tables are all an exact multiple of 16 bytes in length, they will normally be stored in the EEPROM at addresses which are themselves exact multiples of 16.

For correct operation it is essential that the Number of Markers contained in the **Studio data table** corresponds to the number of **Marker data tables** in the linked-list pointed to by the Pointer to First Marker. It is also essential that the **Marker data tables** be linked in ascending sequence of marker number.

It is possible to insert or delete a marker, without having to re-write the entire studio data, by changing the relevant Pointer (link) values, and adjusting the Number of Markers value to suit.

Two or more **Studio data tables** may point to the same **Marker data table**, should there be a requirement to have one or more aliases of the studio name.

free-d processor unit

Processor card settings and warnings

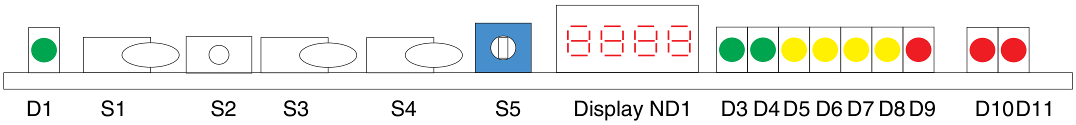


Fig. 7 Free-d processor unit panel

The front panel of the *free-d* processor unit consists of 5 toggle switches, a number of LEDs and a alphanumeric display that are used to indicator errors and/or warnings.

Toggle switch settings

The RESET switch (S1) resets the *free-d* processor unit and restarts the Xilinx devices and DSP.

The change value or scroll display switch (S2) takes effect once per momentary operation or continuously (at an accelerating rate) if held closed. The range of adjustment depends on the parameter selected.

The mode switch (S3) determines whether switch (S2) and the alphanumeric display (ND1) are used to display or change the control parameters such as the of smoothing or to display the outputs from the system including the calculated camera position.

The STORE switch (S4) saves the current values of the control parameters in EEPROM. If the STORE switch (S4) is held while a RESET is performed, the default settings are loaded. To avoid storing the old settings the switches should be operated in the following sequence:

- hold RESET, hold STORE, release RESET, wait until self-tests are complete, release STORE.

The default settings may be saved by a subsequent operation of the STORE switch (S4)

The settings of the toggle switches are detailed in table 1.

Table 1 free-d processor unit toggle switch settings

Switch number	Function
S1	Reset (biased)
S2	**Left position:** reduce value or scroll display left **Right position:** increase value or scroll display right
S3	**Left position:** display/change control parameters **Right position:** display calculated results
S4	STORE settings

Rotary switch (S5)

The rotary switch (S5) determines which control parameter is to be displayed/changed or which output value is to be displayed on the alphanumeric display (ND1) depending on the setting of the mode toggle switch (S3), detailed in Table 2.

Table 2 free-d processor unit rotary switch S5 settings

Switch S5 setting	S3 Left	S3 Right
0	studio name	camera name
1	smoothing value	number of targets used. See note 1.
2	maximum asymmetry	overall RMS error
3	box size	camera x-position (mm)
4	black threshold	camera y-position (mm)
5	white threshold	camera height (mm)
6	black clip value	camera pan angle (degrees)
7	white clip value	camera tilt angle (degrees)
8	maximum non-black	camera roll angle (degrees)
9	minimum white	camera data (zoom etc.) See note 2.
A	marker to interrogate. See note 3.	image x-centre
B	image x-position (pixels)	Image y-centre
C	image y-position (pixels)	pixel x-scaling
D	world x-position (mm)	pixel y-scaling
E	world y-position (mm)	lens distortion A
F	world height (mm)	lens distortion B

Notes:

1. This normally shows the number of markers used in the camera position calculation, but by using toggle switch S2 the display can be switched, in sequence, to the number of markers identified (i.e. which target bar-codes have been read), the number of markers detected by the hardware and the DSP status value. If the DSP status is positive it indicates the number of iterations required in the camera position calculation; if negative it indicates an error code as follows:

    - -1 = too few valid markers
    - -2 = iteration failed to converge
    - -3 = A DSP reset occurred
    - -4 = Internal DSP error

2. This can be scrolled to show the nine bytes of camera data (hexadecimal) as ZH ZM ZL FH FM FL AU ID GP, where:

    - ZH ZM ZL is the current zoom value (24 bits)
    - FH FM FL is the current focus value (24 bits)
    - AU is the auxiliary data (for example, diagnostic)
    - ID is the camera’s identification number
    - GP is 8-bits of general-purpose user input

3. This selects and indicates which marker's information is displayed in positions B to F.

LED indications

The LED indications are detailed in table 3.

Table 3 free-d processor unit LED indications

LED Number	ON	OFF	Flashing
D1	CPU working	No power	CPU resttting (fault)
D3	Video input present and locked		
D4	serial data input present		
D5	data freeze mode		
D6	too few targets		
D7	RMS error high		
D8	DSP alert		
D9	fault (code shown on alphanumeric display (ND1)		
D10	Xilinx booting error or failed		
D11	DSP booting error or failed		

Alphanumeric display ND1

In normal circumstances, the four-character alphanumeric display (ND1) shows the parameter or result value selected with the toggle switch S3 and rotary switch S5. However, in the event of an error condition the display shows "E n" and in the event of a self-test failure the display shows "Fnnnn" as detailed in table 4.

Table 4 free-d processor unit alphanumeric display ND1 error/warnings

ND1 code	Error/warning
E1	A processor reset has occurred. This code is only present transitory.
E2	Serial communications error. This is most likely to be caused by a message being sent to the CD3/563A before the reply to the previous message has been received.
E3	Vertical blanking failure. This maybe a hardware fault or a problem with the digital video input.
E4	Xilinx failure. The programmable logic devices have not initialised correctly. If persistent this indicates a hardware fault.
E5	I2C bus failure. Communication between the CPU and peripheral devices has failed, indicating a probable hardware fault.

Table 4 free-d processor unit alphanumeric display ND1 error/warnings

ND1 code	Error/warning
E6	EPROM failure. An attempt to save the parameters to non-volatile memory U3 has failed, indicating a probable hardware fault.
E7	DSP failure (1). The DSP failed to acknowledge a command. If persistent this indicates a hardware fault.
E8	DSP failure (2). The DSP failed to accept data. If persistent this indicates a hardware fault.
E9	DSP failure (3). The DSP failed to provide data. If persistent this indicates a hardware fault.
E10	DSP failure (4). The DSP is flagging an exception error. If persistent this indicates a hardware or software fault.
E91	I2C communication failure. No reply.
E93	I2C communication failure. Bus error.
E94	I2C communication failure. ACK error.
E95	I2C communication failure. Undefined state.
E96	I2C communication failure. Overflow.
F000	The Xilinx FPGAs have not configured correctly. Suspect a hardware fault or an incorrectly programmed U33.
F1xx	The DSP is not operating correctly. The value of xx may indicate the nature of the problem: F100: Failed to boot. F110: Memory self test failed. F118: Software error occurred. These codes and any value of xx other than those listed may also be caused by a failure of communication between the control processor and the DSP. The code F110 can result if no video input is present.
F2xx	Video bus VO failed. Data should be 55 (hex) or AA (hex), but was xx (hex).
F3xx	Video bus V4 failed. Data should be 55 (hex) or AA (hex), but was xx (hex).
F4xx	Filter bus RAF1 failed. Data should be 2C (hex) or 3C (hex), but was xx (hex).
F5xx	Filter bus RAF2 failed. Data should be 28 (hex) or 38 (hex), but was xx (hex).
F6xx	Filter bus RAF3 failed. Data should be 28(hex) or 38 (hex), but was xx (hex).
F7xx	Filter bus SYM1 failed. Data should be 35 (hex) or 94 (hex), but was xx (hex).
F8xx	Filter bus SYM2 failed. Data should be 00 but was xx (hex).
F9xx	An attempt to select page 2 of video RAM resulted in error code xx (hex).
FAxx	Even video RAM failed. Data should be D5 (hex) or 2A (hex), but was xx (hex).
FBxx	Odd video RAM failed. Data should be D5 (hex) or 2A (hex), but was xx (hex).
FCxx	Dual-port RAM (U10) failed. Data should be 42 (hex) but was xx (hex).

Table 4 free-d processor unit alphanumeric display ND1 error/warnings

ND1 code	Error/warning
FDxx	Dual-port RAM (U4) failed. Data should be 07 (hex) but was xx (hex).
FExx	Dual-port RAM (U10) failed. Data should be 25 (hex) or DA (hex), but was xx (hex).
FFxx	Dual-port RAM (U4) failed. Data should be F6 (hex) or 0A (hex), but was xx (hex).

A transitory error code which does not reappear on a subsequent reset should not be considered to indicate a fault condition.

Note that the possible cause of the fault is given as a guide only. It is quite probable that the true location is elsewhere; for example a fault listed as 'dual-port RAM failed' may be caused by many failures other than the dual-port RAMs themselves.

Parts list

The following list includes the main assemblies and optional accessories. For further information regarding repair or spare parts, please contact Camera Dynamics Limited or your local Vinten Radamec distributor.

For information on-line, visit our website at

www.vintenradamec.com

Item	Part No.
Main Assemblies:	
Free-D MKIII camera Unit	V3975-0001
Free-D Processing Unit	177-072-0001
Free-D camera PSU	V3975-1004
Accessories:	
Ferrite EMC Filters (2 off)	E710-018
Cables:	

All cables must be shielded.

Vinten RADAMEC BROADCAST ROBOTICS

CHINA

The Vitec Group plc China
Room 706, Tower B
Derun Building
YongAn Dongli A No. 8
Jianwai Ave
Chaoyang District
Beijing, P.R.China 100022
Tel: +86 10 8528 8748
Fax: +86 10 8528 8749

FRANCE

Camera Dynamics sarl
171, Avenue des Grésillons
92635 GENNEVILLIERS Cedex
France
Tel: +33 820 821 336
Fax: +33 825 826 181

GERMANY

Camera Dynamics GmbH
Gebäude 16
Planiger Straße 34
55543 Bad Kreuznach
Germany
Tel: +49 671 / 483 43 30
Fax: +49 671 / 483 43 50

Camera Dynamics GmbH
Erfurter Straße 16
85386 Eching
Germany
Tel: +49 89 / 321 58 200
Fax: +49 89 / 321 58 227

JAPAN

Vinten Japan KK
P.A. Bldg. 5F
3-12-6 Aobadai
Meguro-ku Tokyo 153-0042
Japan
Tel: +81 3 5456 4155
Fax: +81 3 5456 4156

SINGAPORE

Camera Dynamics Pte Ltd
6 New Industrial Road
#02-02 Hoe Huat Industrial Building
Singapore 536199
Tel: +65 6297 5776
Fax: +65 6297 5778

USA

Camera Dynamics Inc.
709 Executive Blvd
Valley Cottage
NY 10989
USA
Tel: +1 845 268 0100
Fax: +1 845 268 0113
Toll Free Sales: 1 888 2 Vinten

UK

Camera Dynamics Limited
William Vinten Building
Western Way
Bury St. Edmunds
Suffolk IP33 3TB
UK
Tel: +44 1284 752121
Fax: +44 1284 750560
Sales Fax: +44 1284 757929

info@vintenradamec.com
www.vintenradamec.com

Publication Part No: V3975-4980