

Version 0.30

CSIRO Exploration & Mining Report **P2008/1280**

Interconnection of Landmark Compliant Longwall Mining Equipment – Landmark System Information Data Communication.

This standard has been developed as part of the Landmark longwall automation project. This document is subject to change.

Introduction

This purpose of this standard is to provide detailed specifications for achieving interoperability between control and sensing elements in the Landmark Information System Data Server of the Landmark Longwall Automation project. As part of the Landmark automation strategy, existing longwall mining equipment will form an important and integral part of the overall control system. The objective of this standard is to ensure that all interconnected components, both existing and yet to be developed, interact and operate in a predictable and consistent manner.

The following is a list of participants in the development of this standard

Dr Andrew Strange (CSIRO)

Jeremy Thompson (CSIRO)

Christopher Wesner (CSIRO)

Peter Ingram-Johnson (CSIRO)

Table 1 Revision History

Revision	Date	Changes	Initials
0.1	21 June 2004	Initial non-release version specifying only the object model so software construction can commence.	PIJ
0.11	1 July 2004	Some class level clarity, added APR data to INS record	PIJ
0.2	30 August 2004	Changed model to separate classes based on instantaneous/historical rather than vector/discrete. Added Chock pressure, AFC and Ram extension requirements	PIJ
0.21	2 September 2004	Changed Horizontal Adjustment inputs. Made just roof and floor adjustments, and change multiple adjustment to be RLs not offsets. The indexing of offsets and RLs is now implicit.	PIJ
0.22	14 September 2004	Slight change to Chock Pressure Cycle data structure in object model to simplify (has no impact on client data unpacking)	PIJ
0.23	4 October 2004	Moved sequence number attribute in object model and introduced "which attributes ready" flag	PIJ
0.24	13 October 2004	Merged face profile and cut model in class 0x72, using values on an 0.5m basis	PIJ
0.25	12 November 2004	Changed easting, northing, altitude to LREALs	PIJ
0.26	1 March 2006	Modified for Broadmeadow ASM. Changed fixed Attributes in Network Status Class to a variable array. Added <i>Get Profile Data</i> Service to Historical Profile Data Class (0x72). Added Timestamp element to Historical Profile Data Class (0x72). Added haulage current attributes to Instantaneous Shearer Data (0x71). General formatting to match standard EIP documentation style.	JPT
	23 March 2006	Changed easting, northing and altitude back to REAL in Historical Profile Data Class (0x72) attribute 0x9	JPT
0.27	10 August, 2007	Updated Class 0x71 to reflect Class 0x64 and 0x67. Removed attributes that were only available from Beltana and not from 0x64 and 0x67. Attributes removed are <i>Operational Status</i> , <i>Current Shield</i> , <i>Left/Right Drum Operational</i> , <i>Pump Motor Current</i> , <i>Current Data</i> , <i>AFC</i> . Attributes modified are: <i>Left/Right Haulage Current</i> merged to <i>Haulage Current</i> ; changed roof support pressure units to kPa; <i>Ram Extension Vector</i> to same attribute in 0x64; <i>Leg Pressure Vector</i> to same attribute in 0x64 which includes instantaneous and set pressures. Added the odometer offset to class 0x72.	ADS

0.28	6 September, 2007	<p>Updated Class 0x71 to include an operational status attribute that represents data freshness. Modified attribute numbers of the other attributes so they are grouped to enhance the readability of the operational status attribute.</p> <p>Updated this document to remove redundant sections.</p>	ADS
0.29	26 September, 2007	<p>Updated Class 0x71 to include the AFC data that was removed in version 0.27.</p>	ADS
0.30	4 October, 2007	<p>Updated Class 0x71 to re-include current shield parameter. The attribute IDs for left/right/haulage motor currents were changed to accommodate the inclusion of current shield.</p> <p>Modified the units of leg pressures to bar, speed of shearer to m/min, left/right/haulage motor currents to be a percentage of a full load current.</p> <p>Added status parameter to Historical Profile Data object to indicate the direction of a profile (i.e. either maingate to tailgate or tailgate to maingate) and if that profile is complete.</p>	ADS

Contents

Introduction	2
Contents.....	5
List of Figures	6
1 Overview	7
1.1 Landmark project overview.....	7
1.2 Scope and purpose.....	7
Appendix A: Landmark System Information Data Server Device Object Model.....	8
A.1 Ethernet/IP Device Description	8
A.2 Object Model	8
A.3 How Objects Affect Behaviour.....	8
A.4 Defining Object Interfaces.....	8
A.5 Device Operation.....	8
A.6 Core Object Classes.....	8
A.7 Application Specific Class.....	9
A.7.1 Class 0x70 – Network Status	9
A.7.1.1 Class Attributes (Instance 0)	9
A.7.1.2 Instance Attributes.....	9
A.7.1.3 Common Services.....	9
A.7.1.3.1 Get_Attribute_All response	9
A.7.2 Class 0x71 – Instantaneous Shearer Data.....	10
A.7.2.1 Class Attributes (Instance 0)	10
A.7.2.2 Instance Attributes.....	10
A.7.2.3 Common Services.....	12
A.7.2.3.1 Get_Attribute_All response	12
A.7.2.4 Object Specific Services.....	12
A.7.2.5 Semantics	12
A.7.2.5.1 Current Sequence (Attribute 0x0B)	12
A.7.3 Class 0x72 – Historical Profile Data	12
A.7.3.1 Class Attributes (Instance 0)	12
A.7.3.2 Instance Attributes.....	13
A.7.3.3 Common Services.....	15
A.7.3.3.1 Get_Attribute_All response	15
A.7.3.4 Object-specific Services	15
A.7.3.4.1 Get Profile Data (Service Code 0x4B).....	15

List of Figures

Table 1 Revision History.....	3
Figure A.1 Object model for Landmark System Information Data Server.....	8
Figure A.2 Supported Core Classes.....	8
Figure A.3 Network Status - Class Attributes	9
Figure A.4 Network Status - Instance Attributes.....	9
Figure A.5 Network Status - Common Services.....	9
Figure A.6 Instantaneous Shearer Data - Class Attributes	10
Figure A.7 Instantaneous Shearer Data - Instance Attributes.....	10
Figure A.8 Instantaneous Shearer Data - Common Services.....	12
Figure A.9 Historical Profile Data - Class Attributes.....	12
Figure A.10 Historical Profile Data - Instance Attributes	13
Figure A.11 Historical Profile Data - Common Services	15
Figure A.12 Historical Profile Data - Object Specific Services	15
Figure A.13 Historical Profile Data - Get Profile Data Service Request.....	15
Figure A.14 Historical Profile Data - Get Profile Data Service Response	16
Figure A.15 Historical Profile Data - Get Profile Data Service Error Codes	16

Interconnection of Landmark Compliant Longwall Mining Equipment – Landmark System Information Communication

1 Overview

1.1 Landmark project overview

The Landmark project is an initiative of the Australian coal mining industry. The aim of the project is to develop an integrated longwall automation system, comprising existing longwall equipment and advanced sensor technology, that will reliably carry out the routine functions of cutting and loading coal, maintaining face geometry and manipulating roof supports without human intervention

This document provides specifications for achieving communications interconnectability between control elements of the Landmark longwall automation project. As part of the Landmark automation strategy, existing longwall mining equipment form a necessary and integral part of the overall control system. Some additional components have been developed specific to the Landmark automation system. A key objective of this project is to achieve interoperability: not only between the control system components developed as part of this project but to ensure that the system will operate with a broad mix of commonly used longwall mining equipment.

1.2 Scope and purpose

The Landmark automation control system comprises six major components and will be implemented over a three year period. The six major components are:

1. Face Alignment
2. Horizon Control
3. Communications and Operator Interface
4. Information Systems
5. Collision Avoidance
6. Condition Monitoring

The project components are functionally separate but are common at the device and control system level. To achieve the goal of system openness and component interoperability it is necessary to define a control and communication specification for Landmark compliant equipment that is generally applicable across the six components

The technical detail in this document relates specifically to the Landmark System Information Data Server.

The Landmark System Information Data Server is an Ethernet/IP server supplying saved data from the Landmark System Database and live data from an INS and a PLC5 on the Shearer equipment.

Appendix A: Landmark System Information Data Server Device Object Model.

A.1 Ethernet/IP Device Description

Landmark System Information (Generic Device). Ethernet/IP Device Type 0x00

A.2 Object Model

Figure A.1 Object model for Landmark System Information Data Server

Object Class ID	Object Class Name	Number of Instances
0x01	Identity Object	1
0x02	Message Router Object	No Attribute Data
0x06	Connection Manager Object	No Attribute Data
0x70	Network Status Object	1
0x71	Instantaneous Shearer Object	1
0x72	Historical Profile Object	1
0xF5	TCP/IP Interface Object	1
0xF6	Ethernet Link Object	1

A.3 How Objects Affect Behaviour

As described for Generic Device in Volume 1: CIP Common Specifications, Chapter 6, Section 6-8.2.

A.4 Defining Object Interfaces

As described for Generic Device in Volume 1: CIP Common Specifications, Chapter 6, Section 6-8.3

A.5 Device Operation

A.6 Core Object Classes

The following Core Object Classes will support all required instance, attributes and services as defined by the CIP and EIP Standards.

Figure A.2 Supported Core Classes

Class Name	Class Code	Specification Reference
Identity Object	0x01	See Common Industrial Protocol (Ed 2.1) Vol 1, Chap 5, Part 1, Section 5-2
TCP/IP Interface Object	0xF5	See EtherNet/IP Adaption of CIP (Ed 1.1) Vol 2, Chap 5, Section 5-3
Ethernet Link Object	0xF6	See EtherNet/IP Adaption of CIP (Ed 1.1) Vol 2, Chap 5, Section 5-4

A.7 Application Specific Class

A.7.1 Class 0x70 – Network Status

A.7.1.1 Class Attributes (Instance 0)

Figure A.3 Network Status - Class Attributes

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
1	Required	Get	Revision	UINT		Current value = 01

A.7.1.2 Instance Attributes

There is only one instance of this class – instance 1. The single attribute returns an array of device name and device status pairs.

Figure A.4 Network Status - Instance Attributes

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
8	Required	Get	Network Status Array	ARRAY of	An array of names and status	
			Device Name	SHORT_STRING	The name of the device eg “Main Gate Access Point”	
			Device Status	UINT		1 = online 0 = offline

A.7.1.3 Common Services

Figure A.5 Network Status - Common Services

Service Code	Implementation		Name	Description
	Class	Instance		
0x01	Required	Required	Get_Attribute_All	Returns contents of all attributes
0x0E	Required	Required	Get_Attribute_Single	Returns contents of specified attribute

A.7.1.3.1 Get_Attribute_All response

For class attributes, since there is only one possible attribute, the Get_Attribute_all response is the same the Get_Attribute_Single response.

For instance attributes, attributes shall be returned in numerical order, up to the last implemented attribute.

A.7.2 Class 0x71 – Instantaneous Shearer Data

A.7.2.1 Class Attributes (Instance 0)

Figure A.6 Instantaneous Shearer Data - Class Attributes

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
1	Required	Get	Revision	UINT		Current value = 01

A.7.2.2 Instance Attributes

There is only one instance of this class – instance 1. These attributes relate to real time metrics of the shearer.

Figure A.7 Instantaneous Shearer Data - Instance Attributes

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
8	Required	Get	Operational Status	UINT	Status of the instantaneous shearer data at time of request.	Bit 0 = all data is fresh Bit 1 = all data is stale Bit 2 = landmark database data is fresh (attributes 9-11) Bit 3 = shearer data from class 67 is fresh (attributes 14-20) Bit 4 = drum data from class 67 is fresh (attributes 22-23) Bit 5 = ram extension data from class 64 is fresh (attribute 26) Bit 6 = leg pressure data from class 64 is fresh (attribute 27) Bits 7-13 = unused Bits 14-15 = reserved for LIS server
9	Required	Get	Pitch	REAL	Pitch of shearer	degrees
10	Required	Get	Roll	REAL	Roll of shearer	degrees
11	Required	Get	Current Sequence	INT	Current Sequence number of complete historical profiles	See Semantics section A.7.2.5.1
14	Required	Get	Speed	REAL	Speed of shearer	m/min
15	Required	Get	Direction	SINT	Direction of shearer	-1 = toward main gate, 0 = stopped, 1 = away from main gate
16	Required	Get	Position	REAL	Position of shearer (odometry)	metres
17	Required	Get	Current Shield	INT	Shield the shearer is currently on	Range from 1 to number of shields
18	Required	Get	Left Cutter Motor Current	REAL		% of Full Load Current (FLC)
19	Required	Get	Right Cutter Motor Current	REAL		% of Full Load Current (FLC)
20	Required	Get	Haulage Current	REAL		% of Full Load Current (FLC)

22	Required	Get	Left Drum Height	REAL		mm
23	Required	Get	Right Drum Height	REAL		mm
26	Required	Get	Ram Extension Vector	ARRAY of		Array of Ram extension STRUCTs. One for each roof support. Array ordering from maingate support (first value) to tailgate support (last value).
			Ram Extension	STRUCT of		STRUCT includes elements from Status to Ram extension value inclusive.
			Roof Support Status	INT	Describes the status and cycle state of roof support. Cycle completion is defined as occurring when the push is complete. The next cycle starts when the support lowers in preparation for advance.	Bit 0 = data valid Bit 1 = support set Bit 2 = support advancing Bit 3 = support pushing Bit 4 = cycle complete Bit 5 = unknown state Bit 6 = advance fault
			Ram Extension value	INT	The instantaneous extension of the roof support D/A Ram	mm
			AFC	INT	Offset representing the distance of the AFC from the last profile	mm
27	Required	Get	Leg Pressure Vector (formerly Chock Pressure)	ARRAY of		Array of Leg Pressure STRUCTs. One for each roof support. Array ordering from maingate support (first value) to tailgate support (last value).
			Leg Pressure	STRUCT of		STRUCT includes elements from Status to Set Pressure transducer, 4 values inclusive.
			Roof Support Status	INT	Describes the status and cycle state of roof support. Cycle completion is defined as occurring when the push is complete. The next cycle starts when the support lowers in preparation for advance.	Bit 0 = data valid Bit 1 = support set Bit 2 = support advancing Bit 3 = support pushing Bit 4 = cycle complete Bit 5 = unknown state Bit 6 = advance fault
			Leg Pressure Transducer 1	REAL	The instantaneous leg pressure for rear right leg	bar
			Set Pressure Transducer 1	REAL	The set pressure for rear right leg	bar
			Leg Pressure Transducer 2	REAL	The instantaneous leg pressure for rear right leg	bar
			Set Pressure Transducer 2	REAL	The set pressure for rear right leg	bar
			Leg Pressure Transducer 3	REAL	The instantaneous leg pressure for rear right leg	bar
			Set Pressure Transducer 3	REAL	The set pressure for rear right leg	bar

			Leg Pressure Transducer 4	REAL	The instantaneous leg pressure for rear right leg	bar
			Set Pressure Transducer 4	REAL	The set pressure for rear right leg	bar

A.7.2.3 Common Services

Figure A.8 Instantaneous Shearer Data - Common Services

Service Code	Implementation		Name	Description
	Class	Instance		
0x01	Required	Required	Get_Attribute_All	Returns contents of all attributes
0x0E	Required	Required	Get_Attribute_Single	Returns contents of specified attribute

A.7.2.3.1 Get_Attribute_All response

For class attributes, since there is only one possible attribute, the Get_Attribute_all response is the same the Get_Attribute_Single response.

For instance attributes, attributes shall be returned in numerical order, up to the last implemented attribute.

A.7.2.4 Object Specific Services

The Instantaneous Shearer Data class provides no object specific services.

A.7.2.5 Semantics

A.7.2.5.1 Current Sequence (Attribute 0x0B)

This is the sequence number of the latest complete profile as generated by the control system.

A.7.3 Class 0x72 – Historical Profile Data

A.7.3.1 Class Attributes (Instance 0)

These attributes relate to the panel parameters that are fixed over the life of the panel.

Figure A.9 Historical Profile Data - Class Attributes

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
1	Required	Get	Revision	UINT		Current value = 01
3	Required	Get	Number of Instances	UINT	Number of instances of profile data	Size of the profile data queue
8	Required	Get	Number of Roof Supports	UINT		Gives array sizes for roof support oriented data
9	Required	Get	Panel Width	UINT		m
11	Required	Get	Panel Coordinates	STRUCT of	ENA coordinates of the start of the panel	
			Panel Easting	LREAL		
			Panel Northing	LREAL		
			Panel Altitude	LREAL		

			Panel Heading	LREAL		
12	Required	Get	Panel Name	SHORT_STRING	Name of the current panel	Empty string (length 0) means no valid panel
13	Required	Get	Odometry Offset	REAL	Distance between shearer odometer and centre of shearer.	m

A.7.3.2 Instance Attributes

There are up to 255 instances (maximum allowable). Each instance represents a queue element. The instance number describes the position of the element in the queue, with instance 1 being the most recent element added. The number of instances represents the size of the queue. For example, if there are 10 instances, then there are 10 of each type of profile available from the database, the latest profile being instance 1 and the oldest profile being instance 10.

When requesting a block of profiles, care should be taken to check the sequence number of each profile returned, as the queue may have increased in size (or moved if the size is 255) while the profiles were being retrieved.

For example, if you wanted the last 10 Cut Model profiles, you would request Class 0x72, Instance 1, Attribute 9, then request Class 0x72, Instance 2, Attribute 9 then ... finally Class 0x72, Instance 10, Attribute 9. Then check all the sequence numbers of the returned attributes for any duplicates (which would happen if the queue moved) and if any are found, adjust the indexing accordingly and get either Instance 1 or Instance 11 depending on your needs.

Horizon adjustments for the next pass only are placed in the Landmark System by a Set_Attribute_Single request on attribute 11. Attribute 11 is a single adjustment for the next shear cycle. Attribute 12 is used to place multiple cycles of desired reduced levels in advance (for example to deal with a seam break). Note: attribute 11 contains offsets, attribute 12 contains RLs. The way to place multiple advance horizon adjustments is to repeatedly call Set_Attribute_Single for attribute 12, using the sequence number of the last known shear, incrementing the Shear Offset for each horizon adjustment vector.

Figure A.10 Historical Profile Data - Instance Attributes

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
9	Required	Get	Sequence Number	INT	Unique sequence number attached to each face traversal	Positive values are valid
			Status	INT	Bitmask indicating if the profile is complete and the direction of travel across the face.	Bit 0 is 0: Profile is complete. Bit 0 is 1: Profile is incomplete. Bit 1 is 0: Tailgate to maingate run Bit 1 is 1: Maingate to tailgate run (Note: Bit 0 is the "least significant bit")
			Cut Vector Size	UINT	Number of Cut Data elements in the Cut Vector	

			Cut Vector	ARRAY of	Array of cut model data.	Approx One element for each approx 0.5m increment of shearer travel across the face (i.e. 2 x panel width)
			Cut Data	STRUCT of		
			Extracted Floor	STRUCT of	Consists of absolute easting, northing, altitude values which are spaced at roughly 0.5m intervals. The actual spacing can be determined from the easting, northing values	ACTUAL x,y,z of the floor at roughly 0.5m intervals
			Easting	REAL		
			Northing	REAL		
			Altitude	REAL		
			Extracted Roof	INT		z offset in mm from Extracted Floor
			Upper Seam Boundary	INT		z offset in mm from Extracted Floor
			Lower Seam Boundary	INT		z offset in mm from Extracted Floor
			Timestamp	DT	Timestamp when the last data point was log for this profile	Time is EST (GMT +10)
10	Required	Get	Chock Pressure Cycle	STRUCT of		
			Sequence Number	INT		Positive values are valid
			Chock Pressure Array	ARRAY of		One element for each shield
			Chock Pressure Summary	STRUCT of		
			Start Cycle	TIME		
			End Cycle	TIME		
			Leg1 Pressure at set	REAL		
			Leg1 Max Pressure	REAL		
			Leg1 Max Rate of Increase	REAL		
			Leg1 Average Pressure	REAL		
			Leg2 Pressure at set	REAL		
			Leg2 Max Pressure	REAL		
			Leg2 Max Rate of Increase	REAL		
			Leg2 Average Pressure	REAL		
			11	Required	Set	Horizon Adjustment Single
Sequence Number	INT	Unique sequence number attached to each face traversal				Positive values are valid
Horizon Adjustment Vector	ARRAY of					One element for each 0.5m increment of shearer travel across the face

			Horizon Adjustment	STRUCT of		
			Floor horizon offset	INT		In mm
			Roof horizon offset	INT		In mm
12	Required	Set	Desired Reduced Levels	STRUCT of		
			Shear offset	UINT	Number of shears after the sequence number	The desired reduced levels for the nth shear after the one indicated by the sequence number below. 0 is not valid.
			Sequence Number	INT	Unique sequence number attached to each face traversal	Positive values are valid
			Desired RL Vector	ARRAY of		One element for each 0.5m increment of shearer travel across the face
			Desired RL	STRUCT of		
			Floor RL	REAL	New floor reduced level required	In mm from 0 datum
			Roof RL	REAL	New roof reduced level required	In mm from 0 datum

A.7.3.3 Common Services

Figure A.11 Historical Profile Data - Common Services

Service Code	Implementation		Name	Description
	Class	Instance		
0x01	Required	NA	Get_Attribute_All	Returns contents of all attributes
0x0E	Required	Required	Get_Attribute_Single	Returns contents of specified attribute
0x10	NA	Required	Set_Attribute_Single	Sets contents of specified attribute
0x4B	Required	NA	Get_Profile_Data	Returns the profile data for a specified Sequence Number

A.7.3.3.1 Get_Attribute_All response

For class attributes, attributes shall be returned in numerical order, up to the last implemented attribute. Get_Attribute_All is not available for instance attributes

A.7.3.4 Object-specific Services

Figure A.12 Historical Profile Data - Object Specific Services

Service Code	Implementation		Name	Description
	Class	Instance		
0x4B	Required	NA	Get Profile Data	Returns the profile data for a specified Sequence Number

A.7.3.4.1 Get Profile Data (Service Code 0x4B)

This service is used to retrieve data for a specific profile sequence number.

Figure A.13 Historical Profile Data - Get Profile Data Service Request

Parameter	Data Type	Description	Semantics
-----------	-----------	-------------	-----------

Sequence Number	INT	The Profile Sequence Number to retrieve data for.	Positive values are valid
-----------------	-----	---	---------------------------

Figure A.14 Historical Profile Data - Get Profile Data Service Response

Name	Data Type	Description of Attribute	Semantics of Value
Sequence Number	INT	Unique sequence number attached to each face traversal	Positive values are valid
Status	INT	Bitmask indicating if the profile is complete and the direction of travel across the face.	Bit 0 is 0: Profile is complete. Bit 0 is 1: Profile is incomplete. Bit 1 is 0 : Tailgate to maingate run Bit 1 is 1: Maingate to tailgate run (Note: Bit 0 is the "least significant bit")
Cut Vector Size	UINT	Number of Cut Data elements in the Cut Vector	
Cut Vector	ARRAY of	Array of cut model data.	Approx One element for each approx 0.5m increment of shearer travel across the face (i.e. 2 x panel width)
Cut Data	STRUCT of		
Extracted Floor	STRUCT of	Consists of absolute easting, northing, altitude values which are spaced at roughly 0.5m intervals. The actual spacing can be determined from the easting, northing values	ACTUAL x,y,z of the floor at roughly 0.5m intervals
Easting	LREAL		
Northing	LREAL		
Altitude	LREAL		
Extracted Roof	INT		z offset in mm from Extracted Floor
Upper Seam Boundary	INT		z offset in mm from Extracted Floor
Lower Seam Boundary	INT		z offset in mm from Extracted Floor
Timestamp	DATE_AND_TIME	Timestamp when this Cut Data was logged	

This service shall support the following error codes.

Figure A.15 Historical Profile Data - Get Profile Data Service Error Codes

EIP Error Name	General Status	Extended Status	Description
Invalid Parameter Value	0x03	None	The supplied Profile Sequence Number parameter was invalid ie negative.
Object Does Not Exist	0x16	0x01	Profile Sequence Number is valid but no data is available due to bad profile data. This will occur for 0 < Seq <= Max Seq.
		0x02	Profile Sequence Number is valid but no data is available because the profile is yet to be created. This will occur for 0 < Max Seq <= Seq.