Release Version 2.04

CSIRO Exploration & Mining Report **1068F**

Interconnection of Landmark Compliant Longwall Mining Equipment – Roof Support System Communication and Functional Specification for Face Alignment.

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

Introduction

The purpose of this standard is to provide detailed specifications for achieving interoperability between control and sensing elements in Component 1 (Face Alignment) 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 an alphabetical list of participants in the development of this standard

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REVISION HISTORY			
Revision	Date	Changes	Initials
1.0	7 May 2002	Initial release based on *Communication and Functional Standards for the Interconnection of Landmark Compliant Longwall Mining Equipment – Discussion Paper*	DCR
1.1		Modified title page name and bottom note	DCR
	20 August 2002	Added *RPC Sequence Number, AAD Sequence Number* and *Default Advance Distance* attributes. Added detail of Assembly Object format Removed *Required Position Correction Fresh* and *Actual Advance Distance Fresh* flags from Device Model	PIJ
	20 August 2002	Updated flow diagrams to include *RPC Sequence Number, AAD Sequence Number* and *Default Advance Distance*	DCR
1.2	25 September 2002	Added comments to Instance Attribute table Attribute 6 Corrected a couple of typos	DCR
	8 October 2002	Added attribute ID 10 - Shearer Position and attribute ID 11- Shearer Direction to Class Attributes table	DCR
	17 October 2002	Added text to clarify the definition of the normalised error correction vector. Based on comments provided by Chris Flynn (Joy US)	DCR
	13 November 2002	Corrected ID 11 - Shearer Direction semantics	DCR
	28 March 2003	Added Sequence Number, Gate Width and Panel Width	PIJ
	2 April 2003	Updated Roof Support System and Landmark Process Controller operational flow charts	DCR
1.3	22 May 2003	Added AFC data from RSS as an Assembly object (instance 3)	PIJ
1.31	26 May 2003	Changed sequence number in Roof Support Module class to INT.	PIJ
1.32	30 May 2003	Changed AFC attribute module number to UINT.	PIJ
2.0	10 October, 2003	Modifications in accordance with CSIRO/Joy meeting Moss Vale 16 September, 2003 Removed requirement for AAD values. Described valid region in shearer travel for requesting new RPC values. Added description of RSS status bit 0 *RPC Request* flag in lieu of RSS Sequence number update.	DCR
2.0	10 October, 2003	Minor grammatical changes to text Replaced inconsistent references to Nominal Advance Distance with Default Advance Distance	DCR
2.01	03 November, 2003	Corrected inconsistencies regarding which component changes the sequence numbers	PIJ
2.02	Jan 2005	Added Face Profile definition to device model Added Ram Extension definition to device model	DCR

2.03	March 2005	Changed Face Profile data type from INT to DINT to allow for larger range Added leg pressure definitions	DCR
2.04	June 2006	Expanded *Invalid Sequence Number* definitions for RPCs and Face Profiles Replaced inconsistent references to Required Advance Distance with Recommended Advance Distance	DCR

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Interconnection of Landmark Compliant Longwall Mining Equipment – Roof Support System Communication and Functional Specification for Face Alignment

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 Longwall Roof Support system which is a key element of Face Alignment (component 1).

2. Overview of the Face Alignment control system

The objective of Component 1 is to achieve automated face alignment. From a control perspective this is achieved using the lateral information from a shearer-mounted inertial sensor to survey the three-dimensional position of the armoured face conveyor (AFC) during each pass of the shearer across the longwall face. This position information is used to generate a correction signal for the movement of the AFC via the roof support advance mechanism. This general arrangement for a typical longwall operating mode is shown in Figure 1. The basic control system block diagram for automated face alignment is shown in Figure 2 using the nomenclature indicated in Figure 1.

The communication and control protocol for all Landmark compliant devices will be Ethernet/IP. Figure 3 shows the basic network arrangement for the Landmark control system with the block elements applicable to Face Alignment indicated by drop-shadow boxes.

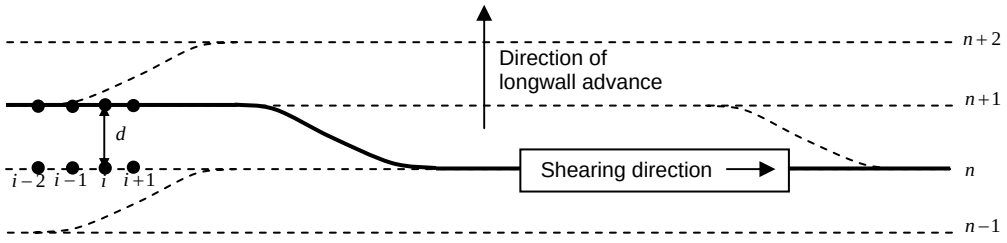

Figure 1: Schematic of shearer path and AFC profile in plan view. A typical shearer path shown as a dashed line and AFC profile at a particular time shown as a solid line.

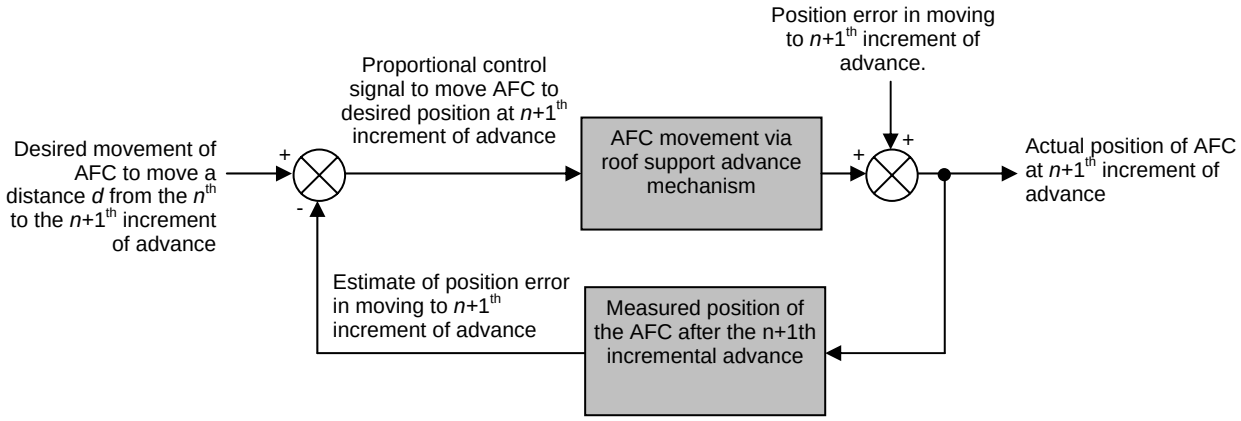

Figure 2: Face alignment basic control system block diagram. The diagram describes the closed loop process of moving the AFC from the n^{th} to the n+1th incremental advance at the i^{th} roof support position as shown in Figure 1.

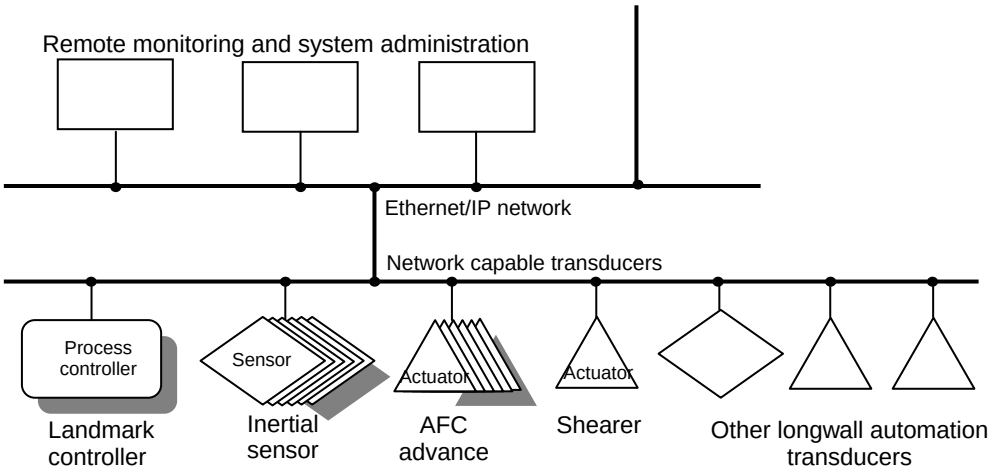

Figure 3: Basic configuration of the networked control system. The elements applicable to Automated Face Alignment are shown with drop-shadow boxes.

3. Ethernet/IP overview

The requirement for complete interoperability between all modules in the Landmark automation system dictates a common communication protocol (and physical link where possible). The communication and control protocol for Landmark compliant devices will be Ethernet/IP (IP stands for Industrial Protocol not Internet Protocol). Ethernet/IP is an open-system industrial protocol which builds on standard Ethernet technology and the *Control and Information Protocol (CIP)* component of DeviceNet. Ethernet/IP is managed by ODVA (Open DeviceNet Vendor Association) and CI (ControlNet International).

The Ethernet/IP specification for the Face Alignment component of the Landmark control system is described in the following subsections in terms of the OSI Basic Reference Model as shown in Figure 4.

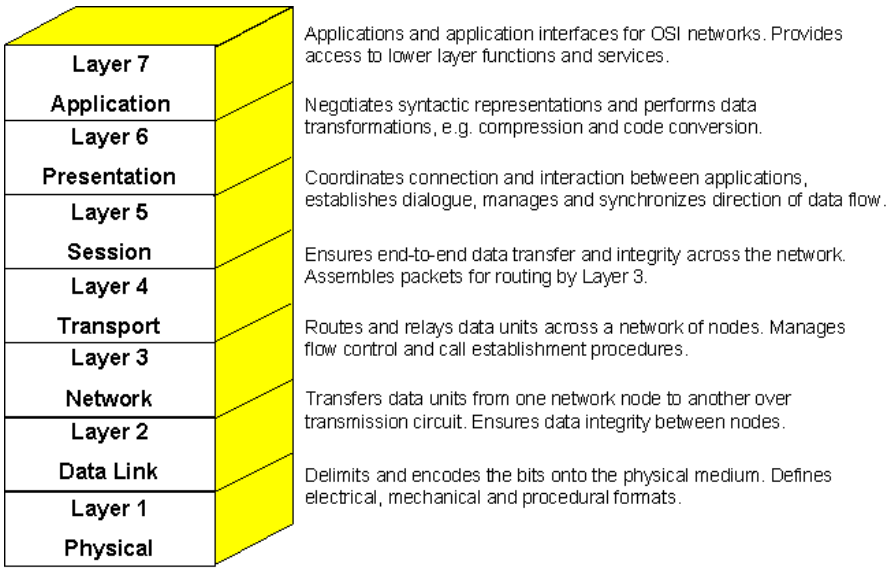

Figure 4: Seven layers of the OSI Basic Reference Model

3.1 Layer 1 Physical Layer

The Ethernet/IP specification makes provision for the use of copper shielded and unshielded twisted pair (Cat 5) cable and fibre optic cable at data rates up to 100Mbps. The specification does not preclude the use of other Ethernet compliant link media such as wireless Ethernet.

The physical link between the Landmark Controller and Longwall Roof Support device will be Category 5 shielded twisted pair (STP) copper cable and sealed RJ45 variant connectors all meeting the requirements described in Volume 2: Ethernet/IP Adaptation of CIP Chapter 8.

3.2 Layer 2 Data Link Layer

The data link between the Landmark Controller and the Longwall Roof Support device will be 10Mbps Ethernet, (10BaseT) as described by the IEEE 802.3 specification.

3.3 Layer 3 and 4 Network and Transport Layers

The communications channel between the Landmark Controller and the Longwall Roof Support device will support User Datagram Protocol (UDP) and Transport Control Protocol/Internet Protocol (TCP/IP).

3.4 Layer 7 Application layer

The communications channel between the Landmark Controller and the Longwall Roof Support device will support the Control and Information Protocol (CIP) application layer as described by Volume 1: CIP Common Specifications and Volume 2: Ethernet/IP Adaptation of CIP Specifications.

4. Specification for Longwall Roof Support system

The Longwall Roof Support system controls the advance of the armoured face conveyor (AFC) and is therefore the primary actuator in achieving controlled face alignment. From a control system perspective, the Roof Support system can be treated as a multi-channel position actuator with each channel corresponding to a roof support module and therefore a fixed point along the AFC. The shearer-mounted inertial navigation equipment is the primary position sensor and can be treated as a multi-channel position sensor with each channel corresponding to a fixed point along the AFC. The Landmark Controller processes information from the Shearer Position sensor and provides position correction information to the Roof Support system.

At the network and control level the Roof Support system, Shearer Position sensor and Landmark Controller all appear as Ethernet/IP devices. The network architecture is Client/Server with the Landmark Controller as client and all other control system devices as servers.

The basic control system block diagram for the Face Alignment component of the project is shown in Figure 5.

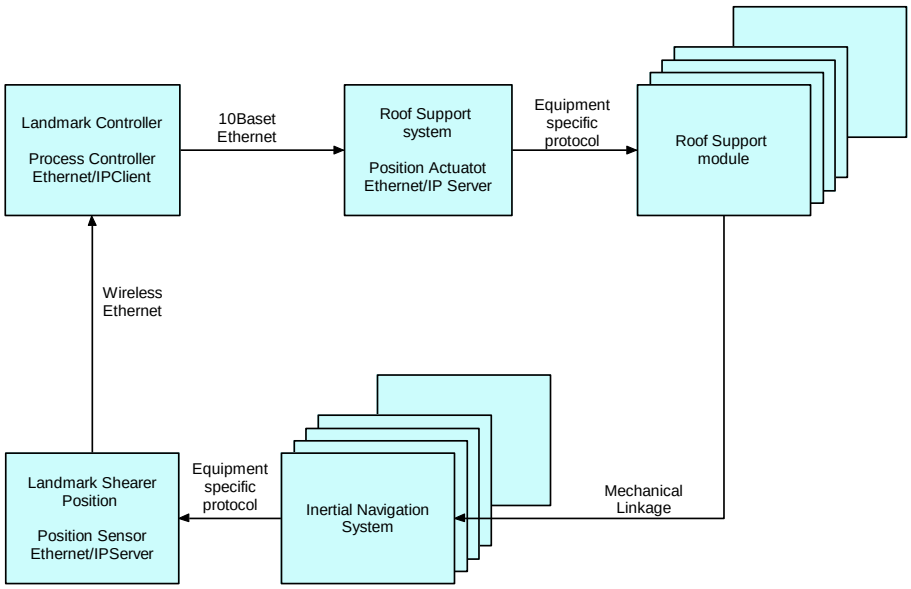

Figure 5: Block diagram of Face Alignment control system

The general functional requirements of the Roof Support system actuator are as follows

1. To advance the AFC at each Roof Support module a linear distance determined by summing the Roof Support Default Advance Distance (nominal web thickness) with the position correction information provided by the Landmark process controller as described in Section 4.1.

2. In addition to item 1, the Roof Support system is responsible for ensuring that the position correction information provided by the Landmark Controller cannot cause the Roof Support system to operate outside the designed control envelope.

3. In the absence of valid position correction information, the Roof Support system is to assume a value of zero.

4. All existing internal roof support control systems, including safety systems and timing and sequencing remain the responsibility of the Roof Support system.

5. The Roof Support system is responsible for incorporating the position correction value into any automated manoeuvre algorithms (eg AFC snaking, gate-end turn-around) in such a way that the AFC position correction is achieved.

6. To provide status information as requested by the Landmark Controller.

4.1 Concept of Recommended Position Correction (RPC) values

The Recommended Position Correction value describes the adjustment from the constant Default Advance Distance which must be applied by a given roof support module to ensure that the AFC is moved to a position so as to achieve a Desired Face Profile. A vector of RPC values is computed with each element corresponding to a single roof support module. The vector of RPC values is normalized to ensure that all elements have a value less than or equal to zero.

The concept of normalised Recommended Position Correction values can be demonstrated with reference to Figure 6. Conceptually the process involves moving the Desired Face Profile (dotted line A or C) toward the actual face profile (solid line B), in the direction of coal face movement, until one or more tangents exist (point d). Note that the Desired Face Profile describes the desired "shape" of the face (as a function of shearer across-face position) and geodetic orientation (eg., degrees of rotation from true or grid north) but not the location in the direction of coal face movement.

The Recommended Position Correction values (solid arrows) are zero at the tangential points (point d) and negative elsewhere. The RPC value is most negative (ie having the greatest magnitude) where there is the greatest distance between the Desired Face Profile and actual face profiles (at point e).

For a given Default Advance Distance, the required advance distance (dashed arrows) for each support to achieve an actual face profile equaling the Desired Face Profile is given by:

required advance distance = Default Advance Distance + Recommended Position Correction

which yields the actual face profile indicated by the solid line F. Where the magnitude of the Recommended Position Correction value is greater than the Default Advance Distance, the Recommended advance distance should be set to zero. In this case the Desired Face Profile will not be completely achieved.

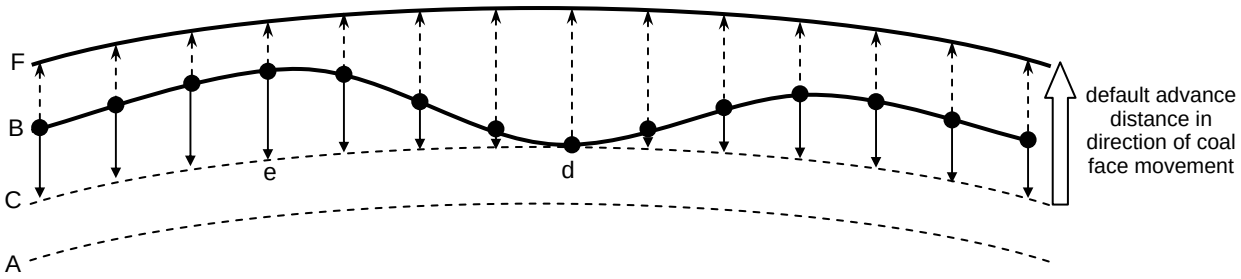

Figure 6: Diagrammatic representation of the relationship between the Desired Face Profile (dashed line A or C), actual face profile (solid line B), normalised Recommended Position Correction values (solid arrows), required advance distance (dashed arrows) and the resulting face profile (solid line F).

4.2 Computation of Recommended Position Correction (RPC) values

Computation of Recommended Position Correction values is described using the following terminology.

RPC_n	Recommended Position Correction vector computed and issued at the end of the *n*th shear.
DFP_n	Normalised Desired Face Profile vector determined at the end of the *n*th shear.
AFP_n	Actual Face Profile vector determined at the end of the *n*th shear.

As described in Section 4.1 the Recommended Position Correction is the difference between the normalized Desired Face Profile and Actual Face Profile at the end of a given shear so that

$$RPC_n = DFP_n - AFP_n \quad \ldots 1$$

From a control perspective Equation 1 will not work well as it does not take into account the movement of the AFC that has occurred during shear *n* in response to previously issued correction information ie RPC_{n-1}. Equation 1 can be expanded to this additional information yielding

$$RPC_n = DFP_n - AFP_n - RPC_{n-1} \quad \ldots 2$$

In Equation 2 the addition of the RPC_{n-1} term accounts for the inherent half cycle lag in the control loop and produces a more stable control system.

4.3 Availability of Recommended Position Correction values

Due to data availability and processing requirements, the computation of Recommended Position Correction values for shear *n* can only occur after the completion of that shear. For this reason the Landmark Controller can only provide the Roof Support system with Recommended Position Correction values for the *n*+1th shear once the *n* shear is complete. If the Roof Support system requests Recommended Position Correction values at any point during and prior to the completion of the *n*th shear the Landmark Controller will supply RPC_{n-1} values.

The Roof Support systems requests Recommended Position Correction values by setting an *RPC Required* flag (RSS Class Attribute 9 – Status bit 0). This attribute is polled by the Landmark Controller and when this flag is set the Landmark Controller will supply the Roof Support system with an assembly of current RPC values and current Sequence Number. The Roof Support system should clear the *RPC Required* flag as soon as the requested RPC assembly is received. The Roof Support system can determine the freshness of the RPC assembly by means of the sequence number.

This sequence and data exchange process through one shear half-cycle is described by flow diagram in Figures A.2 & A.3 in Appendix A.

4.4 Roof Support Device Model and Operation

The Ethernet/IP device object model for the Roof Support system is detailed in Appendix A.

Appendix A: Longwall Roof Support System Device Object Model.

A.1. Ethernet/IP Device Description

Longwall Roof Support System (Generic Device). Ethernet/IP Device Type 0x00

A.2. Object Model

Object Class ID	Object Class Name	Number of Instances
0x01	Identity Object	1
0x02	Message Router Object	No Attribute Data
0x04	Assembly Object	3 (Instance 1 & 2 Output, Instance 3 Input)
0x06	Connection Manager Object	No Attribute Data
0x64	Roof Support Module	< 250 (As many channels as required) Instance # denotes the channel number Class (Instance 0) contains global RSS data
0xF5	TCP/IP Interface Object	1
0xF6	Ethernet Link Object	1

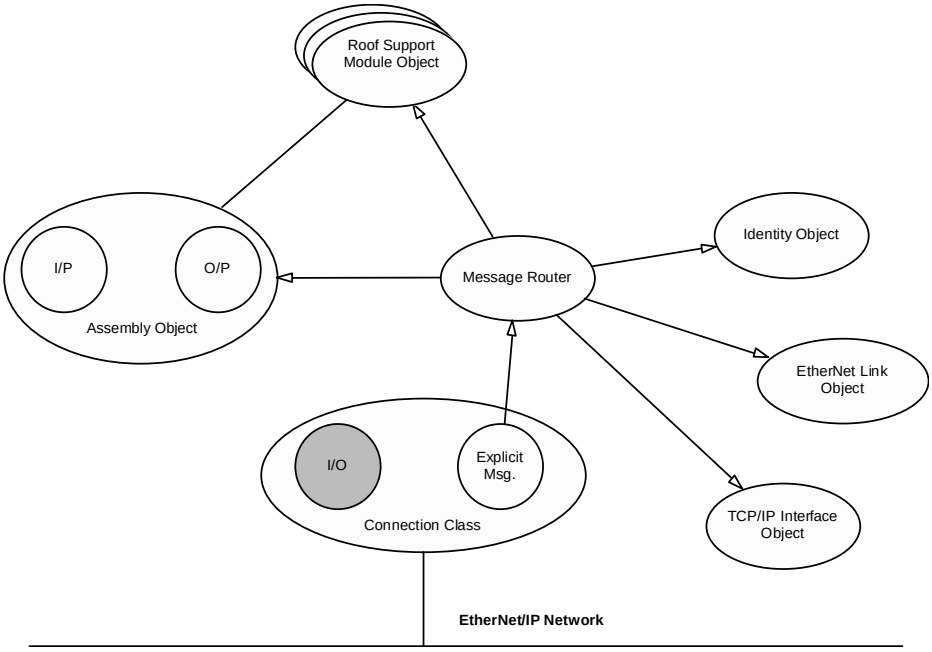

Figure A.1: Object model for Longwall Roof Support system

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

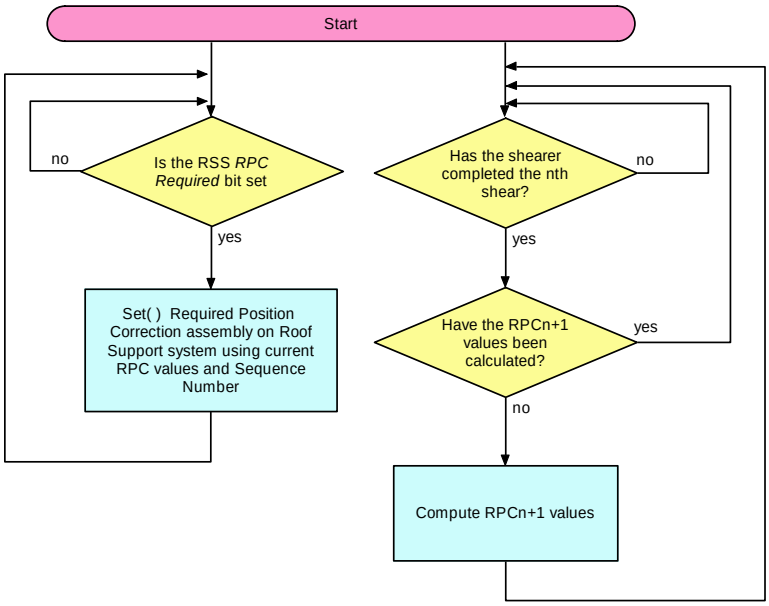

Figure A.2: Flow chart of Landmark Controller interaction with Longwall Roof Support system through one half shear cycle.

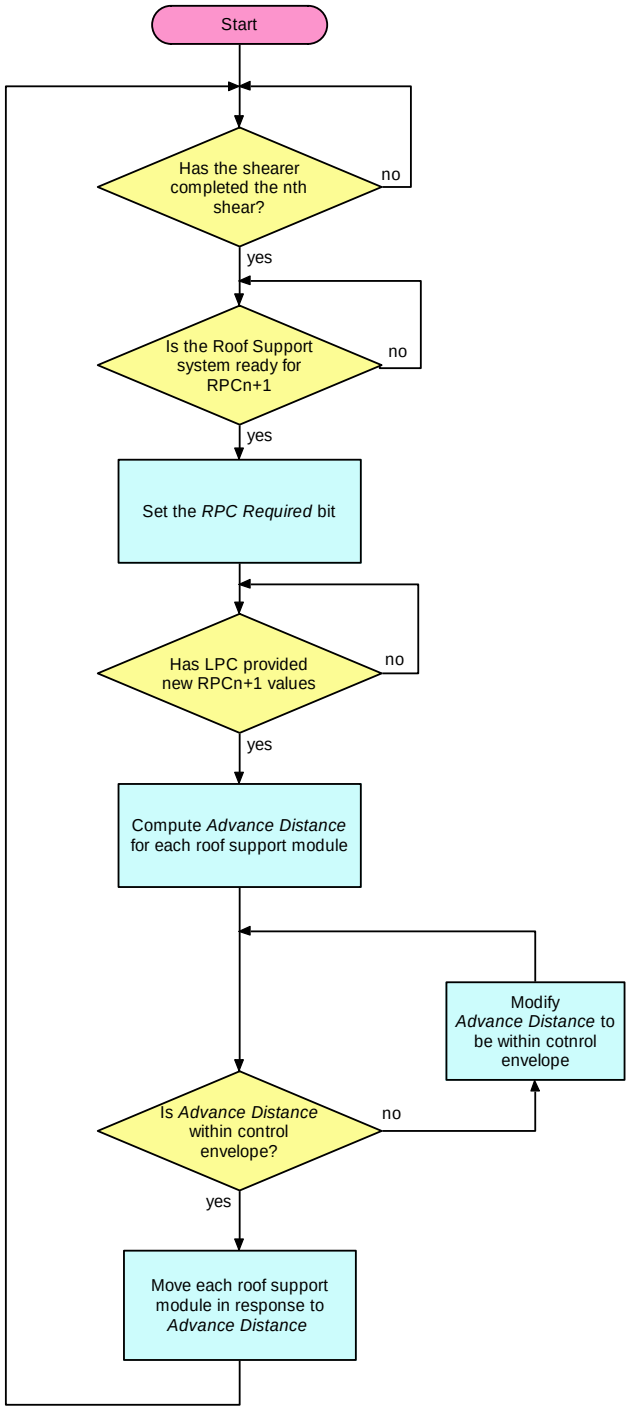

Figure A.3: Flow chart of Roof Support system interaction with Landmark Controller through one half shear cycle

A.6. Core Object Classes

The following Core Object Classes will have supported attributes and services.

A.6.1. Class 0x01 – Identity Object

Class Attributes

Class Attribute ID 1 (Revision) will be implemented

Instance Attributes

All required Instance Attributes (ID 1 – ID 7 inclusive) will be implemented.

A.6.2. Class 0xF5 – TCP/IP Interface Object

Class Attributes

Class Attribute ID 1 (Revision) will be implemented

Instance Attributes

All required Instance Attributes (ID 1 – ID 6 inclusive) will be implemented.

A.6.3. Class 0xF6 – Ethernet Link Object

Class Attributes

Class Attribute ID 1 (Revision) will be implemented

Instance Attributes

All required Instance Attributes (ID 1 – ID 3 inclusive) will be implemented.

A.6.4. Class 0x04 – Assembly Object

Class Attributes

No class attributes are required.

Instance Attributes

Three instances of the assembly object will be implemented. Instance 1 and 2 are Output Assembly Objects which means they are to be set by the client, not by the server. Instance 3 is an Input Assembly object which means they are provided by the server.

The client will supply arrays of *Recommended Position Correction* (RPC) and *Face Profile* data via the Output assembly objects. The client may also get the RPC and Face Profile data from the server as a means of delivery verification.

The client will get an array of *Ram Extension* data via the Input assembly object

A.6.4.1 Instance 1: Face Adjustment

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
3	Required	Set/Get	Face Adjustment vector	STRUCT of		Struct includes elements from Sequence Number through to Recommended Position Correction value..
			Sequence Number	INT	Each Face Adjustment vector has a unique sequence number	Negative sequence numbers indicate invalid data. Usually starts at 0 and increments for each face traversal. Invalid Sequence numbers are further defined as -1 = Landmark system un-initialised/not ready -2 = No valid data available -3 = Face Alignment has not been enabled by operator
			Face Adjustment	ARRAY of		Array of RPCs, one for each roof support. Array ordering from maingate support (first value) to tailgate support (last value)
			Recommended Position Correction value	INT	The recommended adjustment to roof support advance	In mm

Sequence Numbering

In order to accommodate sequence numbering, the first INT in the assembly will be the sequence number. A unique (nominally sequential) sequence number will be assigned by the Landmark Controller at each point in the shear cycle when new *Recommended Position Correction* (RPC) values are available. A sequential number will be assigned to each shear half cycle. A shear half cycle is defined as a single complete traverse of the shearer across the longwall face.

Sequence numbers will start at 0 and typically increment by 1 for each new set of RPC data supplied. When the sequence number reaches the maximum positive value allowable in an INT (32767), it will be reset to 0. A negative sequence number will indicate invalid data, an uninitialised state or an erroneous state. Certain negative sequence numbers have specific meaning

A sequence number of –1 indicates that the Landmark system in un-initialised or in an unknown state. This is typically a Landmark startup state and will occur when either the first

shear half cycle has not yet been completed or when the Landmark Controller has power cycled and will remain until the Landmark Controller has all the navigation data required to compute valid RPC values. A sequence number of -2 indicates that that there is no valid data available. This is typically due to the unavailability of data from the shearer-mounted navigation system. A sequence number of -3 indicates that the longwall operator has not enabled (or temporarily disabled) the face alignment system and therefore no RPCs can be issued.

Recommended Position Correction

Following the sequence number is an array of INTs, one for each *roof support module* present. Each member of the array is a *Recommended Position Correction* (RPC) in mm. Each member is an integer, so no fraction of mm is possible. RPCs are negative valued with a maximum value of 0 and describe how much less than full stroke each support should advance. For example an RPC value of zero will result in the support advancing full stroke.

A.6.4.2 Instance 2: Face Profile

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
3	Required	Set/Get	Face Profile vector	STRUCT of		Struct includes elements from Sequence Number through to Recommended Position Correction value..
			Sequence Number	INT	Each Face Profile vector has a unique sequence number	Negative sequence numbers indicate invalid data. Usually starts at 0 and increments for each face traversal Invalid Sequence numbers are further defined as -1 = Landmark system un-initialised/not ready -2 = No valid data available
			Face Profile	ARRAY of		Array of Face Profile values, corresponding to each roof support. Array ordering from maingate support (first value) to tailgate support (last value)
			Face Profile value	DINT	Face alignment relative to maingate end	In mm

Sequence Numbering

As described in Instance 1: Face Adjustment vector. Note that the longwall operator cannot disable the issuing of Face Profile data and so a sequence number of -3 is not specifically defined for Face Profiles

Face Profile value

Following the sequence number is an array of INTs, one corresponding to each *roof support module* present. Each member of the array is a Face Profile value in mm. Each member is an integer, so no fraction of mm is possible. These values describe the horizontal profile of the face at points corresponding to support. These values are normalized so the first (maingate end) value is always zero.

A.6.4.3 Instance 3: Roof Support Ram Extension

This assembly object provide instantaneous D/A ram extension information to the client. The internal update rate of this data is controlled by the Roof Support server and no explicit strategy for determining data freshness has been included. The internal data update period should not exceed 30 seconds.

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
3	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	In mm

A.6.4.4 Instance 4: Roof Support Leg Pressure

This assembly object provides leg pressure information to the client. Provision is made for up to four pressure transducers per roof support. Transducers 1 & 2 are used for two legged supports. Values corresponding to unused or uninstalled transducers should be set to zero. The internal update rate of this data is controlled by the Roof Support server and no explicit strategy for determining data freshness has been included. The internal data update period should not exceed 30 seconds.

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
3	Required	Get	Leg Pressure 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).
			Leg Pressure	STRUCT of		STRUCT includes elements from Status to Set Pressure transducer 4 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
			Leg Pressure transducer 1	UINT	The instantaneous leg pressure for front left leg	In kPa
			Set Pressure transducer 1	UINT	The set pressure for front left leg	In kPa
			Leg Pressure transducer 2	UINT	The instantaneous leg pressure for front right leg	In kPa
			Set Pressure transducer 2	UINT	The set pressure for front right leg	In kPa
			Leg Pressure transducer 3	UINT	The instantaneous leg pressure for rear left leg	In kPa
			Set Pressure transducer 3	UINT	The set pressure for rear left leg	In kPa
			Leg Pressure transducer 4	UINT	The instantaneous leg pressure for rear right leg	In kPa
			Set Pressure transducer 4	UINT	The set pressure for rear right leg	In kPa

Common Services

Service Code	Implementation	Name	Description

	Class	Instance		
0x0E	n/a	Required	Get_Attribute_Single	Returns contents of specified attribute
0x10	n/a	Required	Set_Attribute_Single	Sets specified attribute value

Note: “Single” means a single array of data, not a single element of the array.

A.7. Application Specific Class

A.7.1. Class 0x64 – Roof Support Module

Class Attributes

The status attribute consists of 16 flags. Bit 0 is used to indicate that the RSS is ready for a new set of RPCs. When RPCs are required this bit will become 1 and when RPCs are subsequently received this bit will become 0. Bit 1 is used to indicate that the RSS is ready for a new Face Profile vector with similar meaning to Bit 0.

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		
8	Required	Get	Default Advance Distance	UINT		
9	Required	Get	Status	UINT	RSS Status flags..	Bit 0 = RPCs required. Bit 1 = Face Profile vector required
10	Optional - for test purposes only	Set	Shearer Position	DINT	Millimeters of shearer travel across face	
11	Optional – for test purposes only	Set	Shearer Direction	INT	Indicates direction of shearer motion	+1 = movement away from support 1 0 = shearer stationary -1 = movement towards support 1
12	Optional – for test purposes only	Get	RPC Sequence Number	INT	Sequence Number that was sent in the last RPC assembly packet.	
13	Required	Get	Panel Width	UINT	Width of the face of the panel.	In m.
14	Required	Get	Gate Width	UINT	Width of the panel gate.	In m.

Instance Attributes

At this stage, these attributes will be set and read internally by the server and not used externally by the network. Setting RPCs and Face Profile values and getting Ram Extension and Leg Pressure information will be performed via *Assembly* objects.

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
1	Required	Get	Instance Number	UINT		Channel Number
2	Not Used					
4	Not Used					
5	Required	Set	RPC sequence number	INT	Sequence number of RPC for this module	
6	Required	Set	Recommended Position Correction	INT	Millimeters of recommended position correction	RPC values are normalised to be negative valued (ie having a maximum value of zero)
7	Required	Set	Face Profile	DINT	Horizontal alignment of face relative to maingate	In mm
8	Required	Get	Roof Support Status	INT	Describes data validity and the status and cycle state of roof support.	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
9	Required	Get	Ram Extension value	INT	The instantaneous extension of the roof support D/A Ram	In mm
10	Required	Get	Leg Pressure transducer 1	UINT	The instantaneous leg pressure for front left leg	In kPa
11	Required	Get	Set Pressure transducer 1	UINT	The set pressure for front left leg	In kPa
12	Required	Get	Leg Pressure transducer 2	UINT	The instantaneous leg pressure for front right leg	In kPa
13	Required	Get	Set Pressure transducer 2	UINT	The set pressure for front right leg	In kPa
14	Required	Get	Leg Pressure transducer 3	UINT	The instantaneous leg pressure for rear left leg	In kPa

15	Required	Get	Set Pressure transducer 3	UINT	The set pressure for rear left leg	In kPa
16	Required	Get	Leg Pressure transducer 4	UINT	The instantaneous leg pressure for rear right leg	In kPa
17	Required	Get	Set Pressure transducer 4	UINT	The set pressure for rear right leg	In kPa

Common Services

Service Code	Implementation		Name	Description
	Class	Instance		
0x0E	Required	Required	Get_Attribute_Single	Returns contents of specified attribute
0x10	Required	Required	Set_Attribute_Single	Sets specified attribute value