Release Version 1.1

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Interconnection of Landmark Compliant Longwall Mining Equipment – Shearer Communication Specification for OEM-Accessible Inertial Sensor Data.

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

CSIRO, Exploration and Mining, May 2005
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Introduction

This purpose of this standard is to provide detailed specifications for accessing data from the Landmark Shearer Position Measurement System (SPMS). The SPMS incorporates a high-performance inertial navigation sensor which was developed as a key component of the Landmark automation project. Shearer pitch and roll information from the SPMS has been made available for direct access by the shearer OEM control system. This accurate and stable data can be used by the OEM control system as an alternative or in addition to independent shearer inclinometers.

The following is an alphabetical list of participants in the development of this standard

Peter Henderson *(Chairperson)*

David Hainsworth (CSIRO)
David Reid (CSIRO)

REVISION HISTORY			
Revision	Date	Changes	Initials
0.1	2 Dec 2003	Initial non-release version specifying only the object model so software construction can commence.	PIJ
0.2	23 Nov 2004	INS Raw Data class change	PIJ
1.0	Feb 2005	Finalise for release	DCR
1.1	April 2005	Tidy up Application Class Attr 8 Status definition	DCR

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Interconnection of Landmark Compliant Longwall Mining Equipment – Shearer Communication Specification for OEM-Accessible Inertial Sensor Data.

1. Overview

1.1 Landmark project overview

The Landmark project is an initiative of the Australian coal mining industry through the Australian Coal Association Research Program (ACARP). 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 in-seam horizon and manipulating roof supports without human intervention.

This document provides specifications for achieving communications and functional interconnectability between control elements of the Landmark longwall automation project. As part of the Landmark automation strategy, existing OEM longwall mining equipment form a necessary and integral part of the overall control system. Some additional components have been developed that are 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. Enhanced Horizon Control
3. Communications and Operator Interface
4. Information Systems
5. Collision Avoidance
6. Condition Monitoring

The project components are functionally separate but have commonality 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. At the communication and control level, the protocol for the interconnection of all Landmark compliant devices will be Ethernet/IP.

The technical detail in this document relates specifically to the shearer attitude (pitch and roll) information made available by the shearer-mounted Landmark Shearer Position Measurement System (SPMS) for direct access and use by the OEM shearer control system.

2. 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 combined with the *Control and Information Protocol (CIP)* component of DeviceNet. Ethernet/IP is managed by ODVA (Open DeviceNet Vendor Association) and CI (ControlNet International).

The basic network arrangement for the Landmark longwall automation control system in shown in Figure 1 with the block elements applicable to the Enhanced Horizon Control component indicated by drop-shadows.

The Ethernet/IP specification is described in the following subsections in terms of the well-known OSI Basic Reference Model as shown in Figure 2. The Ethernet/IP device model for the Landmark OEM-Accessible Inertial Sensor data is provide in Appendix A

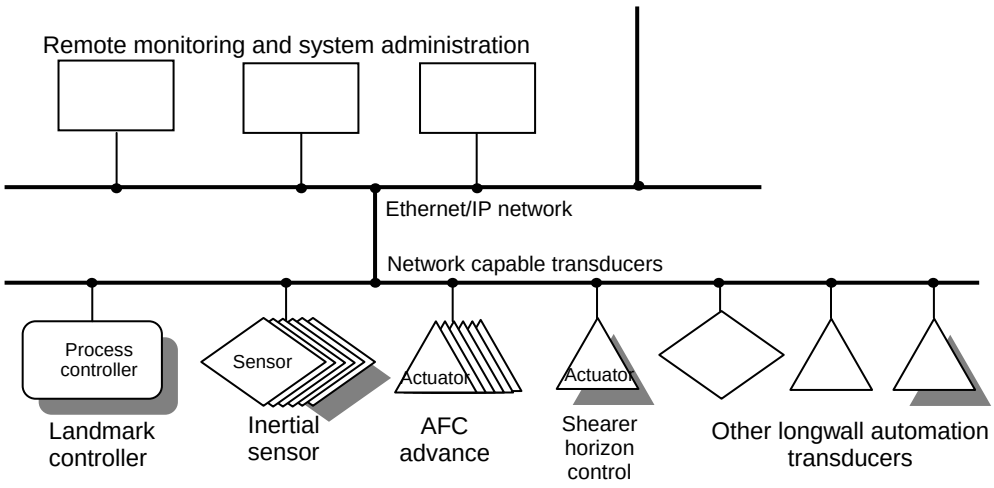

Figure 1: Basic configuration of networked control system.

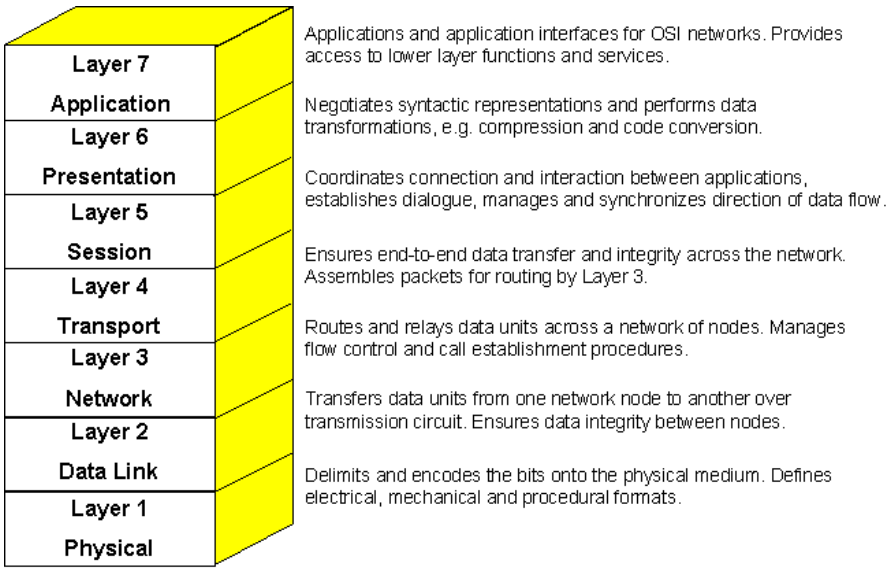

Figure 2: Seven layers of the well-known OSI Basic Reference Model

2.1 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 other Landmark compliant devices 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. Wireless Ethernet will be used for network segments where physical cable is undesirable or impractical – in particular for the segment portion between the fixed roof support structure and the moving shearer.

2.2 Layer 2 Data Link Layer

The data link between the Landmark Controller and other Landmark compliant devices will be at least 10Mbps Ethernet, (10BaseT) as described by the IEEE 802.3 specification.

2.3 Layer 3 and 4 Network and Transport Layers

The communications channel between the Landmark Controller and other Landmark compliant devices will support User Datagram Protocol (UDP) and Transport Control Protocol/Internet Protocol (TCP/IP).

2.4 Layer 7 Application layer

The communications channel between the Landmark Controller and other Landmark compliant devices 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.

Appendix A: OEM-Accessible Inertial Sensor Device Object Model.

A.1. Ethernet/IP Device Description

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
0x06	Connection Manager Object	No Attribute Data
0x67	Shearer Control System	1
0xF5	TCP/IP Interface Object	1
0xF6	Ethernet Link Object	1

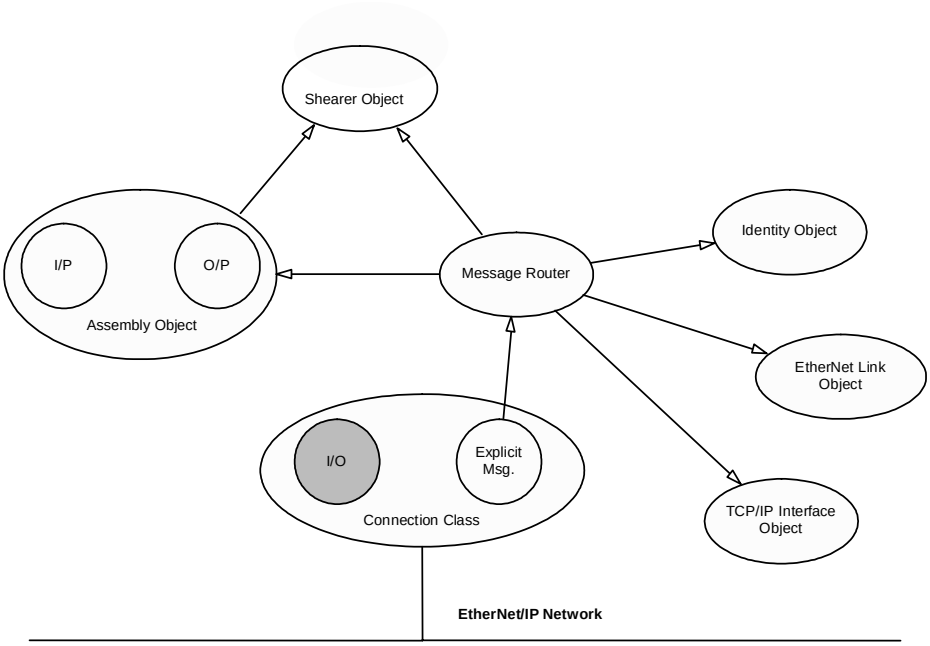

Figure A.1: Object model for the Longwall Shearer Enhanced Horizon Control system

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

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.7. Application Specific Class

A.7.1. Class 0x73 – Inertial Sensor

Class Attributes

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

Instance Attributes

There is only one instance of this class – instance 1.

The instantaneous shearer attitude (pitch and roll) information is supplied by the shearer-mounted inertial navigation sensor (INS). No external filtering is applied to this data as it is inherently stable and accurate and is practically unaffected by vibration or acceleration along any axis. The INS requires attitude calibration once per shearer installation and thereafter pitch and roll accuracy is of the order of $1/100^{th}$ of a degree.

The attitude information is only reliable when *Data Good* Bit 0 of Status Word (Attribute ID 8) is set. This corresponds to the INS achieving full gyrocompass alignment. A full gyrocompass alignment takes 15-20 minutes during which time the shearer needs to remain stationary. With the Landmark technology the gyrocompass time can be greatly reduced so that under most longwall operating conditions *Data Good* is achieved within 30 seconds of power-on.

Although each of the instance attributes can be accessed separately using *Get_Attribute_Single* requests, it is more efficient to access all three attributes with a single *Get_Attribute_All* request. The maximum data update rate via this Ethernet/IP interface is 5Hz.

Attr ID	Implementation	Access	Name	Data Type	Description of Attribute	Semantics of Value
8	Required	Get	Status	WORD	16 bit status word	Bit 0 : 1 = "Data Valid" 0 = "Data not valid" Bits 1-15: not defined
9	Required	Get	Pitch	REAL	Instantaneous pitch of the shearer as reported by the INS	-180.0 – 179.9 degrees Negative values are below the horizon and positive values are above when considered in the direction from main to tail gate.
10	Required	Get	Roll	REAL	Instantaneous roll of the shearer as reported by the INS	-180.0 – 179.9 degrees Positive values describe clockwise rotation of the shearer about the longitudinal axis when viewed from the main gate, zero represents horizontal and negative values otherwise

Common Services

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

