Horizon Sensing (Proposal #51)
Quarterly Report (6th)
41050R06

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Report Period End Date:	**June 2002**
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Project Period:	**36 months**
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DOE Award No.:	**DE-FC26-01NT41050**
Name of Submitting Organization:	**Stolar Research Corporation**
Address:	**848 Clayton Highway** **Raton, NM 87740**
NETL Project Manager:	**David M. Hyman**
Total Project Cost:	**$1,740,039.00**
DOE Share:	$779,750.00
Participant Share:	$960,289.00

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Abstract

Real-time horizon sensing (HS) on continuous mining (CM) machines is becoming an industry tool. Installation and testing of production-grade HS systems has been ongoing this quarter at Oxbow Mining Company, Monterey Coal Company (EXXON), FMC Trona, Twentymile Coal Company (RAG America), and SASOL Coal. Detailed monitoring of system function, user experience, and mining benefits is ongoing. All horizon sensor components have finished MSHA (United States) and IEC (International) certification.

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Project Objectives

The objective of this project is to demonstrate the feasibility of real-time stress measurement, bit loading, and horizon sensing on a longwall shearer, boring machine, continuous miner, and loading bucket.

Project Cost Summary

	First Year		Second Year		Third Year		Total	
	Plan+	**Actual***	**Plan+**	**Actual***	**Plan+**	**Actual***	**Plan**	**Actual**
Participant	320	1,960	320	3,600	320	3,600	960	
DOE	263		258		259		780	
Total	583		578		579		1,740	

Amount in thousands of dollars

Key:

+   Planned costs for the full year

*   Actual costs through the reporting period. Based on full Stolar Research Corporation staff deployment of the Horizon Sensor Project at $280K/month

Experimental

Installation of HS-CM systems on Joy 12CM12-10A mining machines occurred during this quarter at Twentymile Coal Company and Oxbow Mining Company (both in Colorado). Both installations contained several unique upgrades to the system's mechanical and software functionality. These upgrades have improved survivability and performance. The installed systems at Site 1 (Monterey), Site 2 (Twentymile), and Site 3 (Oxbow) have proved rugged, dependable, and maintenance free for the duration of use.

Site 2 System Operational Testing

Site 2 is the Twentymile Coal Company near Steamboat Springs, Colorado. A discussion of experimental work at Twentymile Coal follows.
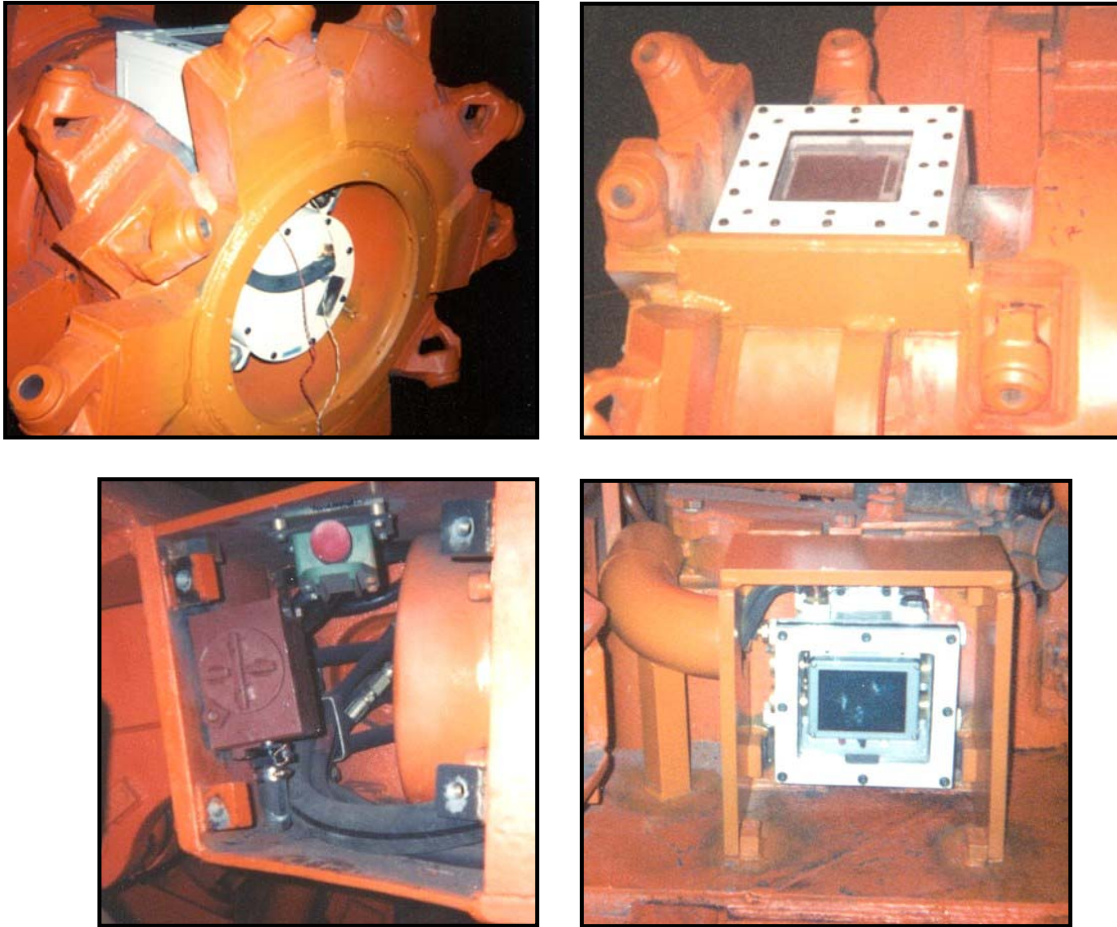
Figure 1. HS-CM installed on Joy 12CM12 at Twentymile Coal

Site 2 Timeline

- HS System Install (at surface shop): April 9–10

- CM moved underground: April 18

- CM taken underground and moved to face

- Mine Visit: May 4

    - Performed system testing and crew training only

    - CM moved to rock section, no calibration work done

- Mine Visit: May 15

    - Stolar crew returned to install flash-chip upgrade. Demonstrated the zero reference procedure. Could not get time on maintenance shift to calibrate the system.

- The physical assemblies themselves are holding up very well to mining condition, impact/abrasion, and use from personnel. No parts have needed to be replaced to date due to damage or wear.

- The total tonnage, shifts, and operational hours have not yet been documented but the unit has been running underground for 2 weeks and the cutter head has 24 hours of rotational/cutting time on it.

- Mine Visit: May 17–22

  - Returned to perform more calibration work and operator training. First good opportunity to do underground calibration work.

  - When rotating system, found resonant frequencies the drum-center was at 32 inches above ground level (AGL), with no water spray. Frequencies were: roof 508.25 MHz; floor 508.25 MHz.

  - With water sprays off, the IF measurements were recorded as follows: At 1 foot 0 inches above horizontal, roof measurements were: I= -1870 (± 10),Q= -732 (± 50). At 1 foot 7 inches below horizontal, floor measurements were: I= -2080 (± 20), Q= -450 (± 50)

  - When water sprays were turned on, the IF measurements changed to the following: At 1 foot 0 inches above horizontal, roof measurements were: I= -1700 (± 40),Q= -1020 (± 60). At 1 foot 7 inches below horizontal, floor measurements were: I= -1550 (± 90),Q= -790 (± 80)

  - When drum-center was at 32 inches AGL, the water spray was turned on and the frequencies changed to: roof 507.75 MHz; floor 507.75 MHz. With this new frequency and the water sprays on, the IF measurements changed to the following: At 1 foot 0 inches above horizontal, roof measurements were: I= -1320 (± 30), Q= -1080 (± 40)

Prediction Response @ 507.75 MHz			
Roof Predictions		Floor Predictions	
Accurate	Error	Accurate	Error
0	10	0	11
2		1	12
3		2	
5		3	
7		4	
9		8	
12		9	

Calibration Table #1 Cutter in coal; w/ water Entry #4; Cross-cut mining; Operator- Chris Winey					**Calibration Table #3** Cutter in coal; w/o water Entry #5; Straights mining; Operator- Phil Yarner				
	Roof Res= 507.75		Floor Res= 507.75			Roof Res= 507.75		Floor Res= 507.75	
Depth	Roof_I	Roof_Q	Floor_I	Floor_Q	Depth	Roof_I	Roof_Q	Floor_I	Floor_Q
0	-300	-500	-880	1680	0	-327	-571		
1	80	-200	-50	1100	1	-464	-561		
2	100	-400	-80	1200	2	-441	-595		
3	0	-400	200	1700	3	-71	-602		
4			900	1900	4	-180	-563	660	4205
5	125	-550	1490	2780	5	-239	-420	1318	3266
6	20	-50	1100	2780	6	-356	-385	1702	2890
7			1700	2900	7	-328	-635	742	1383
8	-1700	1700	300	2800	8	-214	-694	185	370
9	-2100	2300	1160	2900	9	-274	-723	521	345
10	-1900	2350	1480	2300	10	-310	-483	300	266
11	-2150	2350	900	1900	11	-456	-588	1124	2004
12	-1800	2280	550	1550	12	-412	-764	2730	3088

- Mine Visit: June 4

- Calibrated to satisfactory standards

- HS-CM Operational Specifics

- Final Configuration

  - Center Freq: 509.50 MHz (Range= 3 MHz)

  - Attenuation = 14 dB

  - Average = 5 points (10 degrees)

- System Performance and Calibration

  - The system is calibrated on the floor from 0 to 12 inches, but I set the "max depth" to 8 inches so only 0 to 8 are predicted. I thought 9 through 12 were too close in IQ space to be stable. Calibrated the roof from 0 to 7 inches, but 5 and 6 are unstable.

  - Verified the floor calibration over the course of several cuts, and predictions from 0 to 6 inches seam realistic (they never cut anything thicker than 6 inches). Could not physically verify the predictions, but you can see correspondence between thickness prediction and the current height numbers.

- General System Comments

  - Calibration was done specifically for the wet conditions in the down-slope entries. The system will need to be recalibrated once the water level goes down or pooling is not a factor due to entry slope.

  - The response of the predictions is fairly quick. When sumping in 2 to 5 feet there will usually be 1 to 4 predictions that flash to the screen (800-mV sensitivity). These predictions do not stay on the screen after they are made but rather clear themselves after the coal is swept back into the pan. This is because the measurements from the resulting air gap are not related to the calibration table and a prediction cannot be made. We may be able to stabilize this with software, but we need more operator feedback.

  - The system needs a body inclinometer to accurately input calibration bins and correct height measurements. It also needs boom inclinometer filtering to smooth the angle noise from the cutting vibration/impacts. These two tasks are under way and should be implemented on our next visit.

  - The physical assemblies themselves are holding up very well to mining condition, impact/abrasion, and use from personnel. No parts have needed to be replaced to date due to damage or wear.

  - The total tonnage, shifts, and operational hours have not yet been documented, but the unit has been running underground for 4 weeks and the cutter head has 66 hours of rotational/cutting time on it.

- Mine Visit: June 17

- System inspection during idle shift; no calibration or cutting done

- System Performance and Calibration

  - The system still contained calibration data on the floor and roof from 0 to 8 inches

  - Could not verify the calibration; could not cut coal on idle shift

- General System Comments

  - The system still needs a body inclinometer and hardware is ready, but RAMP is pending and could not install.

  - The physical assemblies themselves are holding up very well to mining condition, impact/abrasion, and use from personnel. No parts have needed to be replaced to date due to damage or wear.

- The total tonnage, shifts, and operational hours have not yet been documented but the unit has been running underground for 6 weeks and the cutter head has 114 hours of rotational/cutting time on it.

- Site 3 System Operational Testing

    - Site 3 is the Oxbow Mining Company near Paonia, Colorado. A discussion of experimental work at Oxbow follows.

Figure 2. HS-CM installed on Joy 12CM12 at Oxbow Mining Company

Site 3 Timeline

- HS System Install (at surface shop and mine site): June 13–20

- CM moved UG: June 21

- CM taken underground and moved to face. After first shift of use, the cutter head hours were listed at 2158. Testing schedule is pending RAMP approval.

- Mine Visit: July 13

    - Finished installation (power hookups, etc.)

    - Performed preliminary system testing and crew training only

    - No calibration work done

- Mine Visit: July 18

    − Performed initial geological calibration with satisfactory results

    − The physical assemblies themselves are holding up very well to mining condition, impact/abrasion, and use from personnel. No parts have needed to be replaced to date due to damage or wear.

    − The total tonnage, shifts, and operational hours have not yet been documented, but the unit has been running underground for 4 weeks and the cutter head has 92 hours of rotational/cutting time on it.

    − HS performance while mining still undergoing evaluation and will be discussed in next quarterly report.

Conclusions

Horizon Sensor testing at Twentymile Coal Company and Oxbow Mining is ongoing.

RAMP approval for underground HS-CM installation and testing has been fast-tracked for most applications.

In-mine prediction testing at Monterey indicates HS system capabilities are within advertised sensitivity and detection parameters. Monitoring of the system at this site is ongoing.

Additional installation and testing programs have begun at other mines and will be reported during the next quarter.

The major program milestones to date are on-schedule and include:

Complete	Date	Percent Completed
Completed U.S. MSHA Certification	September 15	100
Completed Australian IEC Certification	March 31	100
U.S. In-mine CM Test (EXXON)	January 31	100
U.S. Production CM (EXXON)	March 31	100
U.S. Production Borer Miner (FMC Trona)	March 25	100
U.S. Production CM (Twentymile Coal)	March 31	100
U.S. Longwall Shearer Test (EXXON)	June 30	80
U.S. Production Shearer (Blue Mountain Energy)	July 31	50
U.S. Production Shearer (Ohio Valley Coal)	July 31	50

Other Key Program Accomplishments

- Field Installation Approval (RAMP) complete for Joy 12CM-12 at EXXON, Twentymile, Oxbow, and Blue Mountain Energy

- Field Installation Approval (RAMP) complete for Joy 4 LS Shearers at EXXON and Blue Mountain Energy

- Horizon Sensor Longwall (HS-LW) system developed

- Horizon Sensor Bore Miner (HS-BM) system developed and installed

- Field Installation Approval (RAMP) under way for Marietta Miners, Joy Shearers, and DBT Shearers

- HS-LW installations under way with Monterey (EXXON)

Project Recognition

- Trade show booth featuring HS-2 at the 2002 Annual Meeting of the Society for Mining, Metallurgy, and Exploration, Inc. (SME)

- *World Coal* Magazine feature article May 2002, "Breakthrough Technology"

Project Assessment

(internal DOE use only)

- Open issues and/or problems

  - None noted

- Overall assessment

  - Off to a good start

References

None