Cooperative Mining Robots

ISSUE RECORD				
Engineer	**Issue No.**	**Reason for Reissue**	**Page/Pages**	**Date**
Brooks Barrett Joe Galyean Tom Gauntner Shaun Heilmann Rob Lane Salman Mujahid John Nawrocki Kristen Radecsky Jason Salisbury Manon Skrzypecki Jeff Stofanak Andrew Thomas	1.01	Changed Format	ALL	February 11 2004

Description:
This document provides the functional block state requirements for all subsystems of the Cooperative Mining Robots. Defined within this document, one will notice that each subsystem defines its individual states as well as a brief explanation of what the subsystem will be accomplishing. This document serves as the preliminary for the detailed design.

Table of Contents

Wired Communication 5

Communication: 5

Wireless Communication 6

Navigation 7

Motor Control 8

Central Control 9

Sanity 11

Power 12

System Requirements 13

Chassis Specifications 14

Functional Block Requirements 15

Functional Block Diagram 17

System Requirements vs. Functional Block Requirements 18

Supervisory Station

Engineer:

Manon Skrzypecki
Shaun Heilmann
Brooks Barrett

Description:

This section provides state requirements for the Supervisory Station portion of the Cooperative Mining Robots.

Architecture:

The Supervisory Station is broken up into non-user, user and high-level states with the given inputs and outputs for the system

Non-user states:

- Accept status from all robots
- Handshake with robots about map
    - If version number out of date, send new map
- Accept position reports
- Handshake with robots about mine assignment
- Respond to robots about shift status requests
- Send new mine assignments
- Send map change command
- Request and accept debug information from specific robot
- Receive error flags

User states:

- Create map in text
- Send text file
- Create mine assignments
- Display current map (include robot position on map)
- Display previous, current and future mine assignments (talk to Gum on Monday)
- Display robot status
- Display error flags

High Level

- Power on/off
- Menu Options based on HyperTerminal input
    - Create map
    - Create shift
        - Display current robots on system with current mine assignment status
        - Create/Edit mine assignments
        - Update option to update robot mine assignments

Inputs

- *User*
  - Map configuration
  - Mine assignments
  - Update option to transmit info to robots
  - Begin and end shift
- *Non-user*
  - Robot location
  - Robot status
  - Robot error flags

Outputs

- *User*
  - Display map with current robot locations
  - Display robot status
  - Display robot error flags
  - Display mine assignments
- *Non-user*
  - Send map to robots
  - Send mine assignments to robots
  - Send execution command to robots
  - Send shift status to robots

Wired Communication

Engineer:

Shaun Heilmann
Joe Galyean
Tom Gauntner

Description:

This section provides state requirements for the wired communication portion of the Cooperative Mining Robots.

Architecture:

Communication:

The Wired Communication function block provides a communication link between the Wireless Communication and the Supervisory Station functional blocks. The Wired Communication shall provide the following states:

- Transmit to the Supervisory Station
- Receive from the Supervisory Station
- Notify Supervisory Station if received message was corrupt for retransmission
- Retransmit message to Supervisory Station if message was corrupt
- Transmit to all nodes of the Wireless Communication
- Receive from Wireless Communication
- Notify Wireless Communication if received message was corrupt for retransmission
- Retransmit message to Wireless Communication is message was corrupt

System shall be based on Ethernet protocol in which a maximum of 32 nodes shall be used for Wireless Communication link. In addition a single node shall deal directly with the supervisory terminal.

Wireless Communication

Engineer:

Joseph Galyean
Rob Lane
Andrew Thomas

Description:

This section provides state requirements for the wireless communication portion of the Cooperative Mining Robots.

Architecture:

The Wireless Communication functional block provides a communication link between the Cooperative Mining Robot and the Wired Communication functional block. The Wireless Communication shall provide the following states:

- Process and transmit message to Central Control
- Receive data for message from Central Control
- Transmit location to Navigation
- Receive location information from Navigation
- Transmit message to Wired Communication
- Receive message from Wired Communication

Transmit to and receive from Wired Communication states shall contain a handshaking routine to ensure the message is correctly transmitted or received.

Navigation

Engineer:

Salman Mujahid
John Nawrocki
Jason Salisbury

Description:

This section provides state requirements for the navigation portion of the Cooperative Mining Robots.

Architecture:

Navigation shall provide five [5] functions:

- Communicate with Central Control
  - This state will communicate with central control by receiving both map information and mine work orders. It will also send Error and debugging information back to central control.
  - Inputs – Map information or mine work orders
  - Outputs – Error and debugging information including that from Motor Control
- Communicate with Wireless
  - This state will communicate with wireless by receiving movement commands. It will also send the movement commands from its own robot to wireless.
  - Inputs – Movement commands from other robots
  - Outputs – Movement commands from this robot
- Communicate with Motor Control
  - This state will communicate with motor control by receiving completed tasks. It will also send the new tasks to motor control.
  - Inputs – Completed task information as well as error and debugging information
  - Outputs – Commands to perform new tasks
- Decide the path to take
  - This state will take the movement commands that were received from wireless and the mine work orders received from central control and will make a decision about the path to take. It will then issue the orders that will go to motor control, including the direction commands.
  - Inputs – Movement commands from other robots and mine work orders.
  - Outputs – The path the robot must take to reach it's destination including direction commands
- Idle (Wait for receive)

Motor Control

Engineer:

Rob Lane
John Nawrocki
Jason Salisbury
Jeff Stofanak

Description:

This section provides state requirements for the motor control portion of the Cooperative Mining Robots.

Architecture:

Motors:

The robot motor control shall track a tape, placed on the floor, with negligible error. The motor control shall provide five [5] functions:

- Straight
- Reverse
- 180° turn
- Right turn
- Left turn

There shall be a panic state in which power to each motor will be interrupted until which time the Navigation sees fit to apply power again.

Communication:

Input - Motor control shall receive commands from Navigation to perform a function.
Output - Motor control shall inform Navigation each time it has completed a specific function

Central Control

Engineer:

Brooks Barrett
Kristen Radecsky
Andrew Thomas

Description:

This section provides state requirements for the Central Control portion of the Cooperative Mining Robots.

Architecture:

High Level

1. Power on / reset
2. Check previous status
   Finds out if it were reset, and if so why. (Check EEPROM)
3. Check for coherent response from all subsystems indication the system is operational.
4. Broadcast status
   Send its state to other bots and supervisory station.
5. Ask for Map
6. Broadcast a request for everyone to send a position report and wait a little to receive.
7. Feed map with current positions to navigation.
8. Broadcast confirmation map is loaded.
9. Ask for Mine Assignment from supervisory station.
10. Send Navagation specific mine to work from
11. Perform Tasks (defined below)

SPECIAL STATES
ERRORS – random and interrupting (defined below)
Sanity Check – automatic and periodic

11. Perform Tasks

Check shift status.

If shift has not yet started, wait.

If shift started, tell navigation to proceed.

If shift over, tell navigation go to maintenance shaft.

Check each subsystem's states for normal operation

Poll each subsystem for error flag – Triggers ERROR state with flag

Receive Supervisor command

Accept new mine designation

Send Navigation specific mine to work

If command is a map change, store condition in eeprom, trigger reset.

Debugging information requested

Dump debug info to supervisor.

Deal with request for position report

Halt report sending until confirmation of map loaded from requesting bot.

ERRORS

Duplicate error flag(s) to supervisor.

If error flag is Low Power, tell navigation to go to maintenance shaft.

Sanity

Engineer:

Manon Skrzypecki
Kristen Radecsky
Jeff Stofanak

Description:

This section provides state requirements for the Sanity portion of the Cooperative Mining Robots.

Architecture:

1. Power on
2. Handshake with Central Control
   This includes sending and receiving a specified pattern of bits. Shall occur continuously as long as there is no problem.
3. Error exchange in handshaking once.
4. Error exchange in handshaking twice.
5. Error exchange in handshaking three times.
6. Sanity declares a reset.

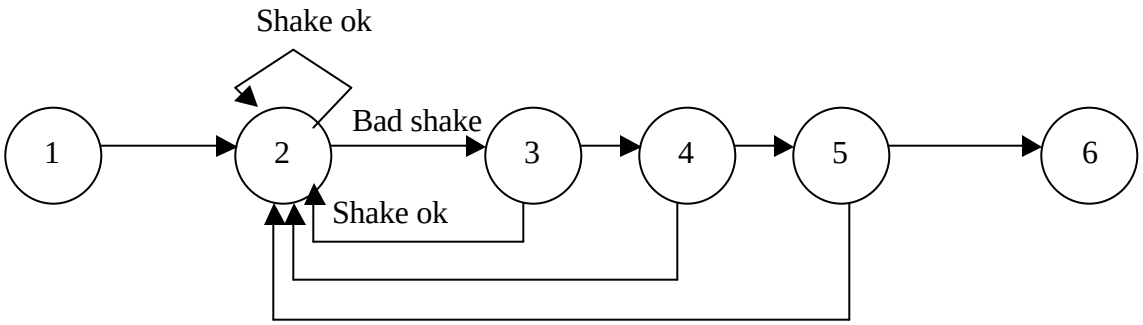


Figure 1.1

Power

Engineer:

Salman Mujahid
Tom Gauntner
Jeff Stofanak

Description:

This section provides state requirements for the power portion of the Cooperative Mining Robots.

Architecture:

Power Monitoring:

The Power Monitoring module shall be responsible for monitoring the battery level triggering an alarm when the low battery threshold is reached. The low battery threshold shall be determined when the system current is better understood. Thus this unit shall have two states.

1. Functioning with adequate power from the battery and the battery level indicator is off.
2. The battery level indicator is on and the appropriate signal is sent to central control regarding emergency power being activated.

Power Distribution:

The Power Distribution module shall be responsible for allocating power to the five modules on the robot, namely

1. Wireless Communication
2. Navigation
3. Motor Control
4. Central Control
5. Sanity.

Power Distribution shall be responsible for controlling current overdraw to Motor Control. This unit will have three states.

1. Normal operation, the system is functioning normally with all power requirements met and no current overdraw.
2. Motor Control Alarm, the system is functioning with overdraw to Motor Control and appropriate signal sent to central control.

System Requirements
Version 1.01

R000 A maximum of four [4] robots shall *cooperatively* mine ping-pong balls from a multiple chamber mine.

R001 A supervisory station console shall monitor all robot activity, receive all robot failure alarms, and provide robot work assignments.

R002 A sensor path beneath the robots shall provide primary navigation throughout the mine.

R003 Bidirectional overhead infrared communication links shall support access to each robot at a minimum of two [2] times per second.

R004 Communications shall be supported robot-robot and robot-console from all locations in the mine.

R005 A maximum of thirty-two [32] of maximum ten [10] foot radius infrared networked communication zones shall support all communications.

R006 One or more robots may exist in each communication zone.

R007 The infrared communication zones shall provide secondary navigation.

R008 Robots shall be implemented on a customer-provided robotic chassis comprised of a drive train and mining implements.

R009 A mining mission shift shall be four [4] hours.

R010 A single voltage rechargeable source shall be provided for each robot.

R011 Given the mission criticality and environment, maintenance activities on robots shall be deferred to the end of the shift.

R012 Robots shall safely interact with other robots, non-robots and their environment.

R013 The design of the system shall be manufacturable.

Chassis Specifications
Version 1.00

S000 The chassis is a circle of diameter sixteen [16] inches comprised of 1/8" aluminum.

S001 A drive train assembly is mounted on a line bisecting the circular chassis.

S002 Useful payload for the chassis is twenty [20] pounds.

S003 The drive train is comprised of two [2] wheel assemblies [wheels six [6] inches diameter, one [1] inch wide] separated on the bisecting line by twelve [12] inches to the center of each drive wheel.

S004 Drive wheels are uncoupled. A reversible geared DC permanent magnet motor assembly drives each.

S005 An unloaded drive assembly rotates a wheel at fifty-five [55] RPMs when a twelve [12] volt DC source is applied. Under these conditions the motor draws 1.6 amps.

S006 The platform is not expected to balance on the drive wheels. Two [2] swivel castors mounted fore and aft of the driveline are utilized to keep the platform level.

S007 Drive assemblies utilize approximately twenty-five [25] percent of the available chassis real estate.

S008 Clearance from chassis bottom to the ground is approximately one and one half [1.5] inches.

S009 Duty cycle for the motors TBD.

Functional Block Requirements
Version 1.02

F000 Internal states of subsystems shall be externally available.

F001 Supervisory Station
- F001.00 Receive any error or failure alarms from robot
- F001.01 Send work tasks (keep track or clock and time)
- F001.02 Receive robot location
- F001.03 Interact with wired communication
- F001.04 Request and receive management data
- F001.05 Keep track of completed tasks
- F001.06 Controls the start and stop time of a shift
- F001.07 User I/O

F002 Wired Communication
- F002.00 Communication from Supervisory Station to all Wireless Communication Nodes
- F002.01 Communication from Wireless Communication Node to all Wired Communication and in turn all Wireless Communication nodes
- F002.02 Communication from Wireless Communication Node to Supervisory Station
- F002.03 Able to retransmit message to all nodes Wireless Communication or Supervisory Station
- F002.04 Able to request retransmission from all Wireless Communication nodes and Supervisory Station

F003 Wireless Communication
- F003.00 Allow Tx, Rx between ceiling nodes to robots
- F003.01 Able to communicate and bridge with wired
- F003.02 Each node and robot needs to be specifically addressable
- F003.03 Branch data with central control on each robot
- F003.04 For robot to robot communication, the steps for communication need to be as follows: robot – ceiling – robot
- F003.05 Make location available to navigation
- F003.06 Obtain current location from Navigation.

F004 Navigation
- F004.00 Accepts destination commands
- F004.01 Get position from wireless and send movements to wireless
- F004.02 Decide how to get to final location from current location
- F004.03 Give motor control requests for movement
- F004.04 Know map of mine
- F004.05 Accepts completed movements from motor control

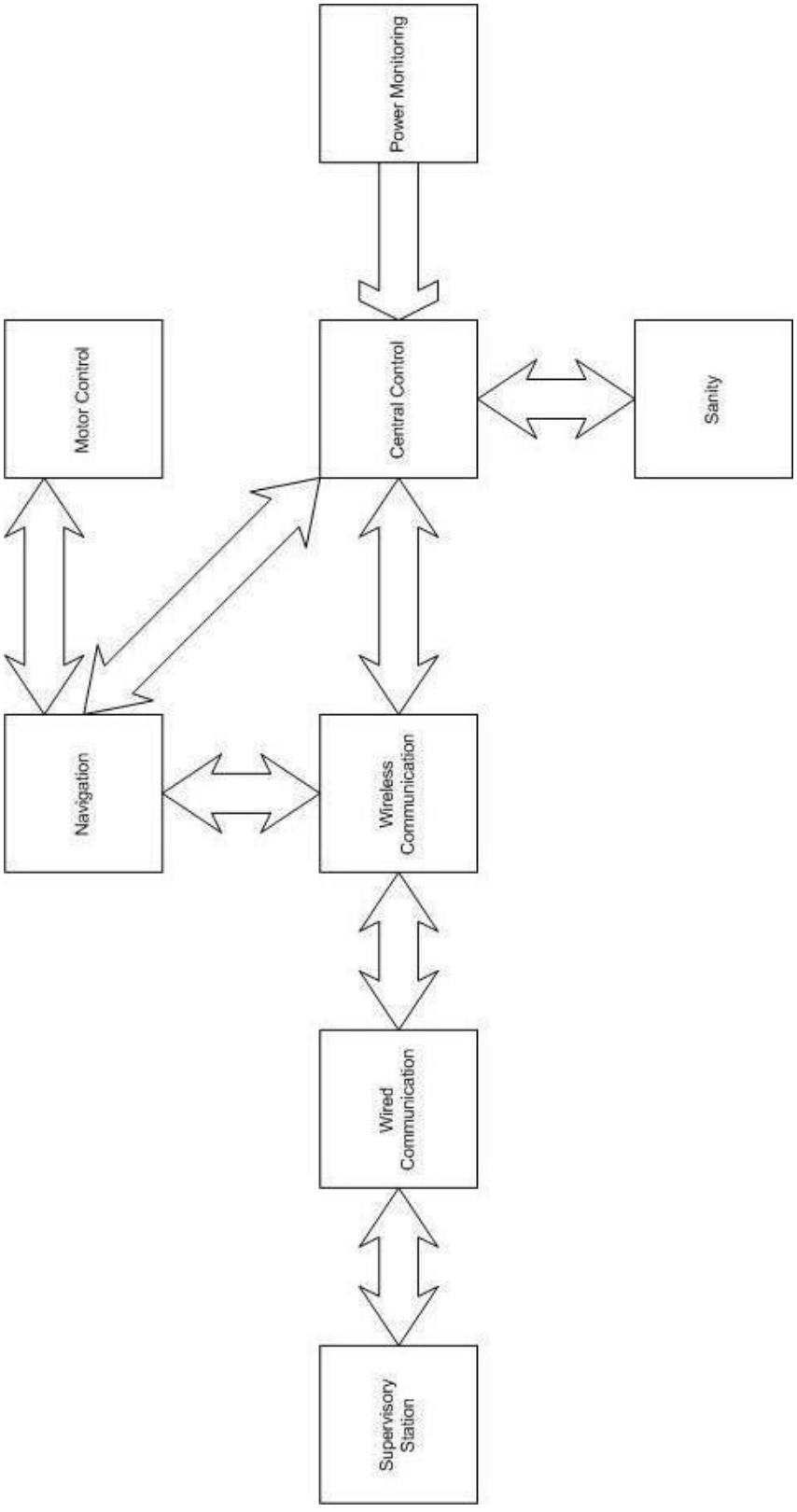
F005 Motor Control
- F005.00 Follow tape and steer accordingly
- F005.01 Take requests from navigation for major movements
- F005.02 Issue control movements specific to each motor
- F005.03 Panic Shutoff
- F005.04 Bump Sensor
- F005.05 Inform navigation of intersections, destination and completion of assigned tasks
- F005.06 Determines speed of motors
- F005.07 Respond if robot goes off tape

F006 Power Monitoring/Distribution
- F006.00 Passively distributes power to all functional blocks on the robot
- F006.01 Informs central control of low battery life
- F006.02 Current overdraw
- F006.03 Sends low battery alarm

F007 Sanity
- F007.00 Sanity System – resets central control

F008 Central Control
- F008.00 Transmit and receive with communication network
- F008.01 Issues mine assignment to navigation
- F008.02 Control system restart
- F008.03 Receive faults from robot systems and pass to supervisory station
- F008.04 Communicate with all robot subsystems
- F008.05 Handshake with sanity
- F008.06 Manages shift status
- F008.07 Manages supervisor commands
- F008.08 Manages startup position reports

Functional Block Diagram
Version 1.01



System Requirements vs. Functional Block Requirements
Version 1.01