OMRON

Mobile Robot Software Suite

User's Guide

I614-E-01

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Chapter 1: Introduction

Omron Adept Technologies, Inc. autonomous intelligent vehicles (AIVs) can autonomously navigate within dynamic environments, such as a factory, warehouse, or laboratory, without external guidance or control. The Mobile Robot Software Suite has tools for programming and configuring individual AIVs and fleets, and has tools for centralized job dispatch and real-time monitoring.

> **NOTE:** This guide uses the term autonomous intelligent vehicle (AIV) to denote the combined mobile robot platform (the part of the AIV containing the core (CPU), battery, drive train, navigation sensors, etc.) and the payload structure (the structure that performs the actual work of lifting, transporting, etc.).

This user's guide covers the basic procedures for installing and using the Mobile Robot Software Suite. Some advanced operating procedures are discussed in later chapters of the guide, and additional advanced procedures will be added to this guide as it is revised for future software releases.

The following topics provide an introduction to the Mobile Robot Software Suite.

About Mobile Robot Software Suite

The Mobile Robot Software Suite is a suite of mobile-robotics software applications for programming and operating one or a fleet of mobile robots and the optional Enterprise Manager (EM). It uses a graphical user interface (GUI) for communicating with and configuring the mobile robots, and to display and edit mobile robot map files. The mobile robots use map files to determine where they are, plan navigable paths to goals, execute tasks at programmed goals, and to control other autonomous robot tasks.

> **NOTE:** Mobile Robot Software Suite version 5 software suite installs into a MobilePlanner5 directory. This different install directory allows you to use the relevant MobilePlanner version with your fleet.

The Mobile Robot Software Suite

MobilePlanner

The MobilePlanner software is the "control center" of the Mobile Robot Software Suite. Its user interface has the tools for all major AIV activities, such as observing a fleet of AIVs, commanding individual AIVs to drive, creating and editing map files, goals, and tasks, modifying AIV configurations, and more.

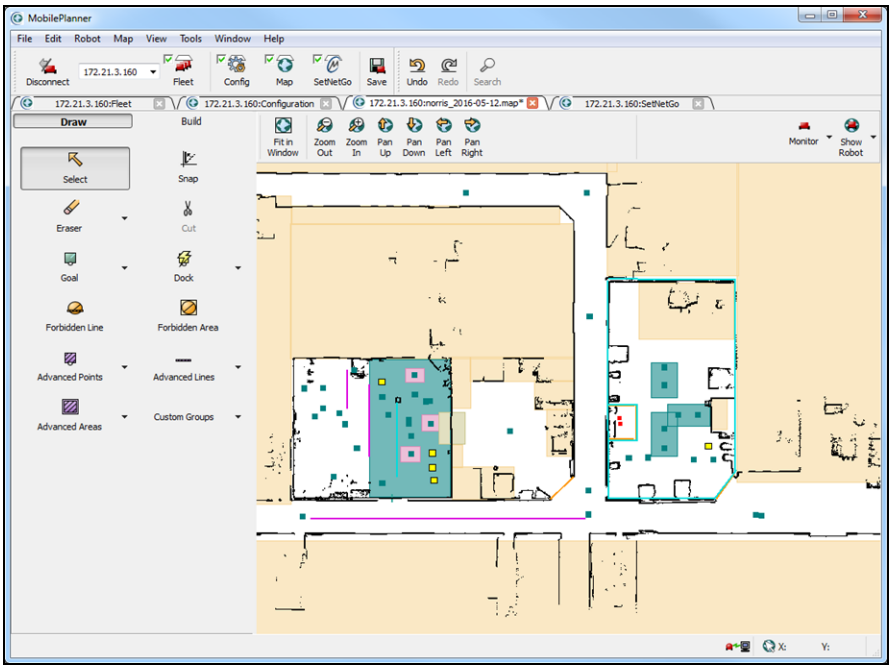


Figure 1-1: MobilePlanner Interface

From the MobilePlanner interface, you can:

- Connect to and drive the mobile robot.
- Create floorplans (maps) of the environment by importing and analyzing a robot's scan data.
- Edit maps by adding goals (and adding tasks to those goals), docks, forbidden areas, and more. You can also erase stray or unwanted artifacts, combine pieces of maps, and make other changes.

- Create a week-long schedule, which can include holidays. A schedule commands the robot to perform routes and other special activities at specified times.
- Download and upload files, including maps and scan data, to and from a robot.
- Set the system configuration parameters for the fleet.
- With the optional Enterprise Manager (EM), monitor the location and status of all robots in a fleet.
- View and interact with the job queuing manager.

For details, see The MobilePlanner Interface on page 55

MobilePlanner Operator Mode

Launching MobilePlanner without a USB license dongle opens MobilePlanner Operator Mode (which you can also open from a shortcut), which gives a limited set of tools for monitoring robot and robot job status, and allows for simple interventions in job execution sequences. For more information, see MobilePlanner Operator Mode Overview on page 57.

SetNetGo

SetNetGo is the operating system that resides on mobile robots. You can use the SetNetGo software to configure your mobile robot's communication parameters, access diagnostic information (for example, download debug info file for service provider use, manage restore points, etc.), and perform software maintenance (upgrades). You access the SetNetGo interface through a tab in the MobilePlanner software, and then use that interface to enable the parameters needed.

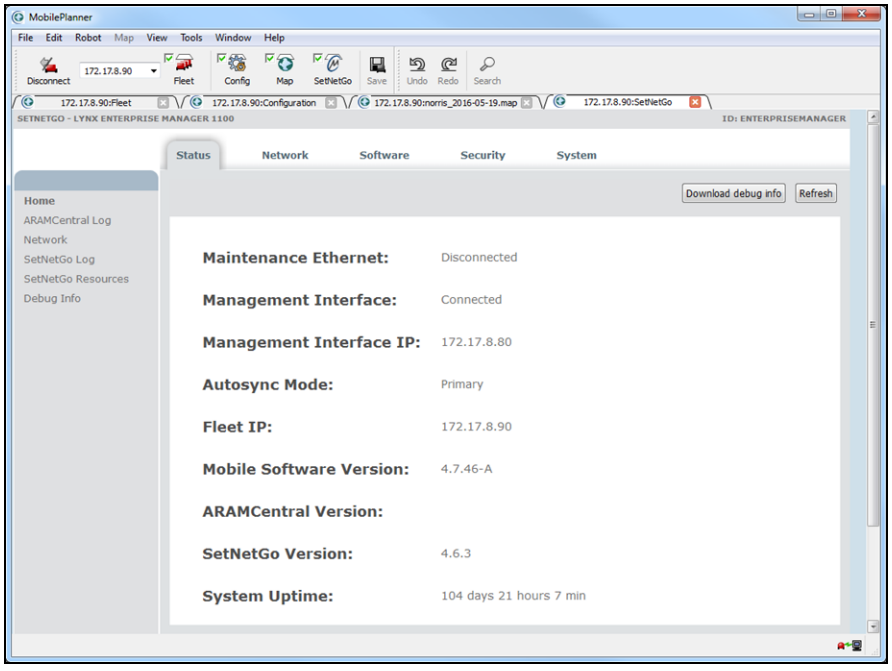


Figure 1-2: SetNetGo interface

For details, See "Overview of the SetNetGo OS"

ARAM

The Advanced Robotics Automation Management (ARAM) software runs on the robot's core, and does the following:

- Performs all the high-level, autonomous robotics functions, including obstacle avoidance, path planning, localization, and navigation, culminating in the robot’s motion.
- Manages wired and wireless Ethernet communications with off-board software, for external monitoring, development, and systems coordination, including coordination of a fleet of robots through the optional Enterprise Manager fleet management appliance.
- Enables external monitoring and control with the MobilePlanner application.

ARAMCentral

The fleet management software running on the Enterprise Manager (EM) appliance. ARAMCentral provides:

- Centralized configuration and map management.
- Job queuing and dispatch.
- Traffic management.
- Single-point of integration and communication for software clients and other automation equipment.

MARC

At the lowest level, a microcontroller running Mobile Adept Robot Controller (MARC) firmware handles the robot’s drive speed and heading. It also acquires sensor readings, such as from the encoders, gyroscope, and sonar, and manages the robot’s power and emergency stop systems, batteries, and bumpers. The MARC controller computes and reports the robot’s odometry (X, Y, and heading), and a variety of other low-level operating conditions to ARAM.

How the Mobile Robot Software Suite Components Work Together

The figure below is a basic system architecture (for a fleet of AIVs) and illustrates the interrelationship between Mobile Robot Software Suite's various applications.

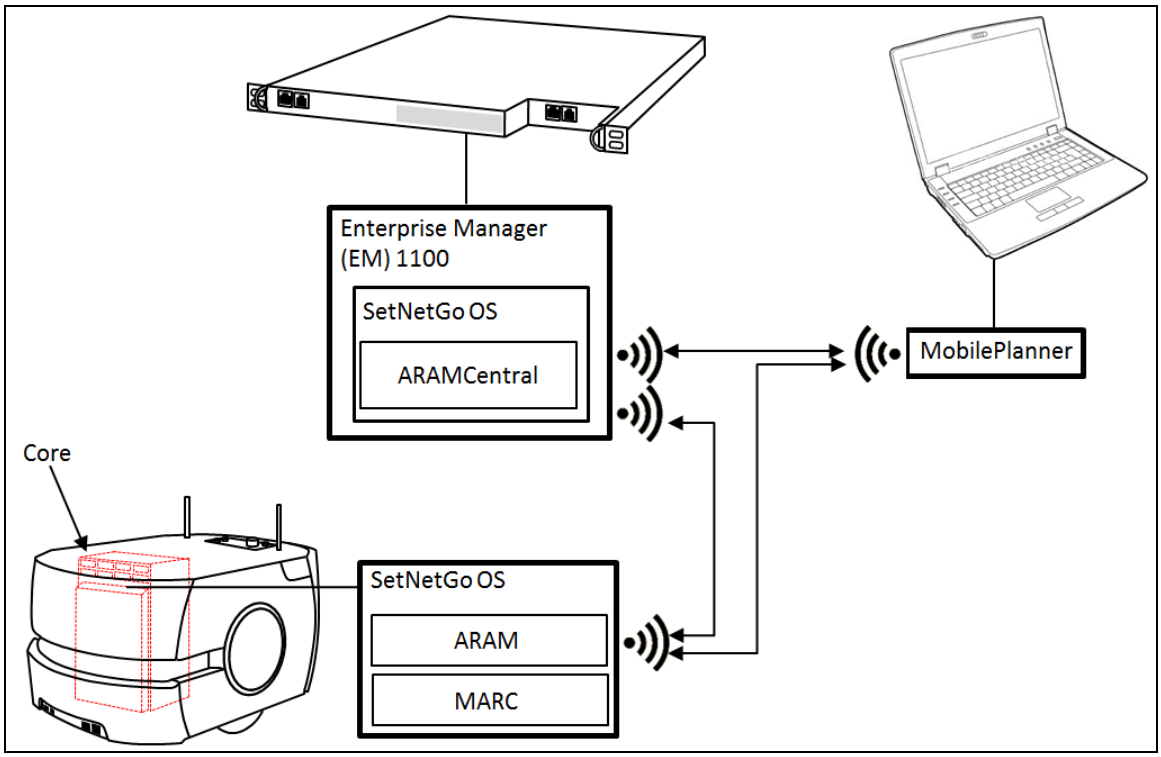


Figure 1-3: Components working together

Enterprise Manager 1100

The Enterprise Manager 1100 (EM1100) is a network appliance with built-in processor running Enterprise Manager software. The EM coordinates the movement of up to 100 autonomous intelligent vehicles (AIVs). It runs ARAMCentral software and manages maps, AIV configurations, traffic control, job queuing, and remote I/O.

ARAMCentral/ARAM

Advanced Robotics Automation Management (ARAM) Central software runs on the EM1100 (see above). ARAM runs on the AIV's core, and operates its ranging sensors, performs all high-level autonomous robot functions, and sends movement commands to the MARC.

MARC

Mobile Adept Robot Controller (MARC), which resides on the AIV's core, manages the AIV's speed and heading, sensor readings, emergency stop systems, bumpers, and joystick. It also computes and reports the AIV's odometry readings (X, Y, and heading) and other low-level operations which it reports to ARAM.

MobilePlanner

MobilePlanner software is the control center for creating maps, managing AIV configurations, and more. When installed on your PC, MobilePlanner communicates with the EM1100 and allows you to control and program your AIV.

SetNetGo

SetNetGo is the operating system residing on the robot and EM1100. You use SetNetGo to configure and establish network communication with the robot, download debug information, and perform software maintenance (upgrades). Access to SetNetGo is via the MobilePlanner interface.

> **NOTE:** Optionally, you can connect to SetNetGo through a web browser. This is useful for IT personnel who need to make changes but do not have access to (or need) the full Mobile Robot Software Suite.

Map Overview

Maps are one of the most important features of MobilePlanner. In MobilePlanner, a map is a scanned representation of the floor plan in the mobile robot's operating space. Maps contain the static features in the robot's environment, such as walls, doors, permanent shelving, etc. They also contain user-definable sectors, lines, and areas that help the robot perform its job.

Making a Map

Before MobilePlanner can create a map of the mobile robot’s operating space, you have to drive the robot through the operating space as it scans the area with its laser and (if installed) Acuity. The resulting scan file contains all the raw data for features in the space. To be usable for mobile robot navigation, you have to have MobilePlanner convert the scan file into a map file.

Generally, you only need to make a map when deploying your mobile robot for the first time in a new environment. Occasionally you might need to rescan if the workspace undergoes extensive structural modifications or lighting changes, cubicles added in what was open space, a new wing to the building, or remodel of an area. For more extensive map updates, MobilePlanner provides the tools to integrate a new map, partially or wholly, into your original application (see Inserting a Map File into an Existing Map File on page 120 for details).

The best time to create a map scan is when the environment is least busy; when you can minimize the amount of time spent avoiding people and other non-stationary obstacles, and when you can move about, opening and closing doors, without disrupting normal daily activities.

What Information is Stored in a Map File?

Map files contain four kinds of data about an operating environment that the robot uses in planning navigation and executing tasks:

- Obstacles and features scanned by a laser, and/or overhead lights acquired by Acuity.
- Objects such as goal points, forbidden lines, and sectors that control robot behavior.
- Macros and tasks associated with goals.
- Data that defines properties of special goal types and available tasks.

A map file name has an extension of .map. Scan file names have an extension of .2d.

Scan files for light localization have an extension of .z2d (scan file is a zip file referred to as the Scan Package) or .zmp (map file from scan - a zip file referred to as the Map Package).

- For information on creating a map using the scanning laser, see Scanning the Operating Area on page 1.
- For information on creating a map Creating the Light Map on page 201.

Mobile Robot WiFi Capabilities

Omron Adept Technologies' mobile robots have multiple network interfaces, including a built-in wireless communications capability to enable their autonomous operations. The on-board wireless card can use 802.11a, 802.11b, or 802.11g wireless standard on 2.4GHz or 5GHz channels, and the robot will automatically switch between wireless access points as it moves through its environment.

> **NOTE:** If the mobile robot has difficulty connecting to a wireless access point, switches between 2.4GHz and 5GHz channels, frequently disconnects, or has weak signal strength, try disabling the 2.4GHz channel. If the problem discontinues, inform your IT department of your finding.

The robots' wireless system can use the majority of the most common personal- and enterprise-grade security methods and encryption, including:

- Open
- 64-bit or 128-bit wireless equivalent privacy (WEP)
- WiFi-protected access (WPA2)-pre-shared key (PSK) ASCII or HEX passphrase
- Extensible authentication protocol-tranport layer security (EAP-TLS)
- Protected EAP-Microsoft challenge handshake authentication protocol version 2 (PEAP-MSCHAPv2), or
- Advanced encryption standard/temporal key integrity protocol/counter mode with Cypher block chaining message authentication code protocol (AES/TKIP/CCMP) encryption.

The mobile robots can also use certificates (small files containing identifying information that allows the robot to connect to secure networks that require explicit identification and pre-authorization for access) with the following extensions:

- .pem - a privacy enhanced mail (PEM)-encoded X.509 certificate
- .pem/.cer/.crt - a PEM or distinguished encoding rules (DER) encoded X.509 certificate
- .p7b - a Public Key Cryptography standards (PKCS7) file containing one or more certificates (contains no private key)
- .p12 - a PKCS12 file containing one or more certificates (includes private key)

Your certificate authority (CA) server generates these certificates based on a certificate request (.csr) file. You manually install the certificates on the robot. The robots can generate their own 1024-bit or 2048-bit RSA keys, or use keys generated by the CA.

Available Options and Peripherals

The following options and peripherals are available for your mobile robot (for more details, see the Peripherals Guide for your mobile robot):

Joystick

The joystick is an optional hand-held input device for driving the AIV. It attaches directly to the robot's joystick port, and has controls to move the AIV forward and backward, turn left or right, and adjust its speed. It also has a configurable goal button for adding goals while mapping.

Acuity

In addition to using a safety scanning laser (navigation laser) to create a map of its environment, the AIV can, with an upward-facing camera mounted on top of the platform, use overhead light localization for navigation (the laser then provides obstacle avoidance). Called Acuity, this peripheral add-on is ideal for dynamic environments - such as warehouses - in which objects on the floor undergo frequent location changes. For more information on localization, see What is Localization? on page 194.

> **NOTE:** If not installed by the factory, Acuity requires installation of the Acuity Support Package software via the MobilePlanner software suite. For information, see the *Mobile Robots - LD Platform Peripherals Guide.*, found in Omron Adept Technologies, Inc. corporate Website.

High Accuracy Positioning System (HAPS)

The HAPS peripheral uses a sensor (called GuideSensor_Front in the Robot Physical configuration) installed in the AIV to detect and follow magnetic tape applied to the floor. HAPS allows you to position the AIV at pick-up and drop-off locations with a high degree of accuracy. For more information, see the *Mobile Robots - LD Platform Peripherals Guide.*, found in Omron Adept Technologies, Inc. corporate Website.

Low Front Laser

The now standard low front laser replaced the front sonar to provide improved detection of low obstacles like empty pallets. The low front laser replaces the standard front bumper and sonar combination, and is available as a standard installation or option for mobile robots.

Side Lasers

Certain mobile robots have side lasers to detect obstacles on either side (such as overhangs, tables, etc.) to help the AIV navigate through tight areas, such as office spaces.

Touchscreen

The Touchscreen allows interaction with the mobile robot at any location. You can check the mobile robot’s status, send the robot to goals, pause or release the robot, or localize a lost robot.

Call Buttons and **Door Boxes**

Call buttons issue a request for the AIV to go to the call button’s associated goal. Door Boxes act as remote I/O, and can issue requests to open closed doors equipped with a door activator so AIVs can pass through it. For additional information, see *Mobile Robots - LD Platform Peripherals Guide.*

Glossary and Definitions

The following table lists acronyms and abbreviations, and defines key terms found in this user guide:

Term	Definition
802.11a, b, or g	Standard for wireless local area networks (WLAN) in the 2.4GHZ and 5GHz frequency bands.
Acuity	Robot-mounted camera system for localizing the robot using overhead lights versus its laser.
AES	Advanced encryption standard
AIFF	Audio interchange file format
AIV	Autonomous intelligent vehicle
ARAM	Advanced robotics automation management
ARC4	Alleged Rivest Cipher 4 (RC4)
ARCL	Advanced robotics command language. A simple, text-based, command-and-response operating language. Used with the optional Enterprise Manager (EM) appliance, ARCL can help manage a fleet of mobile robots.
ARP	Address resolution protocol
A/V	Audio/Visual
Boolean	A type of data with two values, usually 'true,' or 'false.'
CA	Certificate authority
CCMP	Counter mode with Cipher block chaining message authentication code protocol
Cost	An arbitrary numeric value assigned to map grids, lines, routes, etc. to determine the cumulative, net effect of a robot's actions. Breaks maps into discrete squares called grids. Squares with walls, etc. have an infinite cost, and free squares, by default, have a value of 0.1. By design, mobile robots always seek to execute their assigned tasks and goals at the lowest possible cost.
Cost-Based Path Planning	A method of planning optimal, 'least expensive' paths from "point a" to "point b" for the robot to follow.
CPU	Central processing unit
DER	Distinguished encoding rules

DHCP	Dynamic host configuration protocol
DNS	Domain name service
Dock	Map location where the mobile robot "looks for" the charging station. Dock map icon should be 1 to 1.5 meters in front of the charging station, with the dock icon's black line pointing to the charging station.
Dongle	A small hardware device attached to a computer that contains the software (e.g., license key) required to run a specific program.
DROPOFF	Job segment classification - tells the EM only a specific robot can be assigned to the job segment.
EAP	Extensible authentication protocol
EAP-FAST	EAP flexible authentication via secure tunneling
EM	Enterprise Manager. A network appliance for managing a fleet of robots.
Enterprise Manager 1100 (EM1100)	A network appliance with built-in processor running Enterprise Manager software. Manages a fleet of AIVs, and provides a central location to manage maps and configurations (which it automatically propagates to the fleet); has a queuing manager to match jobs to available robots; is a central point of communication for integrating fleet robots; and coordinates traffic, sharing location and trajectory information among fleet robots.
Ethernet	A type of computer network used in local area networks (LANs). Typically uses a Category 5 (CAT5) or (CAT6) Ethernet cable; supports data speeds up to 100 MHz.
FIFO	First-In-First-Out - refers to the method used to prioritize jobs (higher number equals higher priority).
Fleet	Term for the group of robots connected to the Enterprise Manager (EM)
Forbidden (lines, areas)	Lines or areas onto or into which the robot must not drive or enter on its own. In special cases, you can direct a robot to enter a forbidden area.
Goal	Map-defined virtual destination(s) for mobile robots (e.g., pickup or drop-off points).
GUI	Graphical user interface
HAPS	High accuracy positioning system. Uses add-on sensors which detect and follow magnetic tape applied to the floor. Allows for very precise robot positioning.
IP	Internet protocol. IP address is a computer's unique internet "address."
Job	A robot activity - usually consists of either one or two "job segments" (either PICKUP or DROPOFF). The EM receives all job requests from ARCL.

Joystick	A handheld, external input device for manually driving mobile robots. Connects to the mobile robot's JOYSTICK connection port.
LAN	Local Area Network
LEAP	Lightweight EAP
Localization	The process by which mobile robots determine their location in their operating environment. Laser localization uses the robot's laser to scan its environment which it compares to its internal environment map. In light localization, the mobile robot uses overhead lights to determine its location.
Macro	A virtual "container" with a series or sequence of nested tasks and/or goals. Similar to routes. You can use macros as many times as needed to perform the same sequence of discrete functions in different tasks.
MARC	The Mobile Adept Robot Controller (MARC) firmware computes and reports the robot's odometer (X. Y, and heading) readings and other low-level operating conditions to ARAM.
MobilePlanner	The primary software application for programming mobile robot actions.
MobilePlanner (Operator Mode)	The version of MobilePlanner software running without the license dongle. Has tools to monitor robots, robot statistics, monitor and add jobs. Does not have tools to create or edit maps.
MSCHAPv2	Microsoft challenge handshake authentication protocol version 2
MP3	Moving picture experts group (MPEG) -2Audio Layer III
OS	Operating system (e.g., Mac OS, Windows OS, MARC, SetNetGo OS, etc.).
Path	The manner in which the mobile robots drive from place to place in their environment.
PEAP	Protected extensible authentication protocol (EAP)
PEM	Privacy enhanced mail
PICKUP	A job segment classification - tells the EM that any available, appropriate robot can be assigned to the job segment.
PKCS	Public key cryptography standards
Platform	The base mobile robot (with or without payload) – includes chassis, drive train, suspension, wheels, battery, safety scanning laser, sonar, on-board core with gyroscope and software to navigate, interface connections for payload, and covers.
Pose	A mobile robot's position (location and heading).

Preferred (lines, directions)	Lines, directions you want the mobile robot to travel.
PSK	Pre-shared key
RC4	Rivest Cipher 4 (aka ARC4 – Alleged RC4)
Resisted (lines, areas)	Lines and/or areas the mobile robots resist (attempt to avoid) crossing or entering, unless it must drive over/through resisted lines/areas to reach a goal.
Route	A "to do" list or series of tasks, goals, or macros for the mobile robot to follow.
Safety Commissioning	Allows testing and commissioning (verification of proper function) of a robot's on-board safety systems. Uses a wizard to test E-Stop (tests brake activation) and Safety Laser (tests max speed limits and obstacle detection). Per EN-1525, Commissioning must be done by specially trained people.
Sector	Map areas that direct specific robot actions, like ignoring sensor readings, driving on the right or left, limiting the number of robots in the area at one time, etc.
SetNetGo	Software OS, resides on mobile robots and the optional Enterprise Manager appliance. Used to configure mobile robots' communication parameters. Accessed via the SetNetGo tab in MobilePlanner.
SNG	SetNetGo. The operating system that resides on the mobile robots.
Spline	Mathematical function for smoothing arcs and curves.
SSID	Service Set IDentification – identifies a wireless LAN
Tasks	Instructions for the robot to perform certain actions like reading inputs, setting outputs, movement commands, talking, waiting, etc. Tasks have adjustable parameters, which can be individually set for each copy of the task. There are two types of tasks; instant (allows concurrent processing of tasks while original task is executing), and non-instant (can interrupt a currently running task).
TCP	Transmission control protocol
TKIP	Temporal key integrity protocol
TLS	Transport layer security
TriangleDrive	Using physical triangular-shaped features in the environment to aid in more accurate maneuvering. Traingles can be placed on charging stations, and other locations where you need accurate positioning. Associated with certain tasks.
Virtual Doors	Specially designated areas on the robot's map which the robot performs certain tasks (like 'move' or 'say' tasks, flashing lights, etc.) and/or allow the robot to drive through special areas (e.g., plastic curtains).

WAVE	Waveform audio file format – also expressed as .wav.
WEP	Wireless equivalent privacy
WPA	WiFi-protected access

Related Manuals

In addition to this manual, you may want to refer to the following manuals which are available from the Omron Adept Technologies, Inc. Website (www.adept.com, or www.ia.omron.com):

Manual	Description
Mobile Robot Safety Guide	Describes safety information for Omron Adept mobile robots.
Omron Adept Mobile Robot User's Guide	Describes the installation, start-up, operation, and maintenance of the mobile robot you are using.
Advanced Robotics Command Language Enterprise Manager Integration Guide	Describes the Advanced Robotics Command Language (ARCL) version for use with the Enterprise Manager software. ARCL is a simple text-based command and response server used for integrating the Mobile Robot Software Suite platform with an external automation system.

How Can I Get Help?

For details on getting assistance with your Omron Adept Technologies, Inc. software or hardware, you can access the Omron Adept Technologies, Inc. corporate website at www.ia.omron.com.

Chapter 2: Safety and Regulatory Information

Safety and Regulatory

Omron|Adept Technologies' mobile robots adhere to the following domestic and international safety regulations:

- EN 1525 "Safety of Industrial Trucks. Driverless Trucks and their Systems"
- ANSI 56.5:2012 "Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles"
- JIS D 6802:1997 "Automated Guided Vehicle Systems - General Rules on the Safety"

Warnings, Cautions, and Notes

Where needed, this user guide calls out critical, important, or emphasized text via special alert notifications. Below are explanations of the special alert notifications used in this manual:

WARNING: This indicates a potentially hazardous situation which, if not avoided, will result in minor or moderate injury, or serious injury or death. Additionally, there may be significant property damage.

CAUTION: This indicates a situation which, if not avoided, could result in minor or moderate injury or in property damage.

NOTE: Notes provide supplementary information, emphasize a point or procedure, or give a tip for easier operation.

General Safety Precautions

Read the installation and operation instructions, as well as the Mobile Robot LD Safety Guide, before using the equipment.

- Do not ride on the mobile robot.
- Do not exceed the mobile robot's maximum weight limit.
- Limit operation to areas with no slope.
- Do not drop the mobile robot, run it off a ledge, or otherwise operate it in an irresponsible manner.
- Do not get the mobile robot wet, or expose the mobile robot to rain or moisture. The robot has an IP rating of IP40.

- Do not use power extension cords with the docking station unless properly rated.
- Do not run the mobile robot if hair, yarn, string, or any other items are wound around the mobile robot's axles or wheels.
- Never access the mobile robot's interior with the charger attached. Immediately disconnect the battery after opening the battery compartment door.
- Never short the battery's terminals together.
- Do not use parts (including chargers, etc.) not authorized by Omron Adept Technologies, Inc..

Safety Commissioning

EN 1525: "Safety of Industrial Trucks. Driverless Trucks and their Systems," requires testing of the mobile robot's safety systems, both before leaving the factory, and again at the customer's site by a trained and qualified person. Safety Commissioning runs from within the MobilePlanner main menu.

To test E-Stop

1. In the MobilePlanner main menu, select **Robot > Safety Commissioning**.
2. In the Introduction window, click the **ESTOP** radio button, then click **Next**.
3. **Press** the AIV's **E-Stop** button, listen for the brakes to engage, then click **Next**.
4. Select **Yes** (or **No** if the brakes did not engage - contact an Omron Adept Technologies, Inc. representative).

To test the Safety Laser

1. In the MobilePlanner main menu, select **Robot > Safety Commissioning**.
2. In the Introduction window, click the **Safety Laser** radio button.
3. With the AIV in an open area (at least 2 meters clearance around front and side), press the **E-Stop** button.
4. Remove side panels, use the metal pins to hold the wheels off the ground.
5. Release the **E-Stop** button.
6. In the Safety Laser Commissioning window, click **Next**.
7. Click and hold the **Drive** button (until prompted to release), and verify Speed Zones trigger.
    a. If AIV fails, select **No**, and contact an Omron Adept Technologies, Inc. representative.
    b. If AIV passes, select **Yes** and proceed to next step.
8. Follow the setup instructions (and place an object in front of the AIV), then click **Next**.
9. Press and hold the **Drive** button until prompted to release.
10. When the wizard informs you the E-Stop triggered, click **Continue**.

What to Do in an Emergency

Press the **E-Stop** button (a red push-button on a yellow background/field) and then follow the internal procedures of your company or organization for an emergency situation. If a fire occurs, use a type D extinguisher: foam, dry chemical, or CO_2.

Additional Safety Information

We provide other sources for more safety information on our website at www.adept.com or www.ia.omron.com.

Mobile Robot Safety Guide

The *Mobile Robot Safety Guide* provides detailed information on safety for our robots. It also gives resources for more information on relevant standards. The robot safety guide ships with each robot.

Chapter 3: Getting Started

The Mobile Robot Software Suite has the tools and features to help you get your mobile robot up and running quickly. The following topics cover the initial steps needed to access your robot with the PC and to begin using the Mobile Robot Software Suite.

How Do I Begin?

Before you can start using your mobile robot, there are a number of initial set-up and configuration steps you need to complete.

> **NOTE:** The specific procedures for unpacking and powering the robot are beyond the scope of this user guide. Step 1 (below) is a very general sequence. For detailed set-up information, refer to your mobile robot's user guide.

1. Unpack the robot, install the battery, power-up the robot, and install a dock. See the robot user's guide for more information.
2. Install the MobilePlanner software on your PC (see Install the Mobile Robot Software Suite on page 31).

   > **NOTE:** While you can run MobilePlanner without the license dongle (which results in a version of MobilePlanner called Operator Mode), you will need at least one license per fleet of robots before you can create a map the robots need to navigate.

3. Connect your PC to the mobile robot via Ethernet cable (Step 1: Connect Your PC to the Mobile Robot via Ethernet on page 32).
4. Configure your PC's IP address (see Step 2: Set the IP Address on Your PC on page 33).
5. Connect to the SetNetGo interface (see Step 3: Access SetNetGo Software on page 34).
6. Configure the mobile robot for wireless communication (see Step 4: Configure Your Robot's Network and Security Settings on page 35).
7. Establish a wireless connection to the robot (see Step 5: Connect to the Robot Wirelessly on page 37).
8. Scan your environment (see Scanning the Operating Area on page 45.).
9. Convert the scan to a map (see Convert the Scan into a Map on page 46).
10. Use MobilePlanner software to edit (erase stray and other dynamic features from) the map (see Editing a Map File on page 114).
11. Add docks, forbidden zones, goals, and route(s) between goals, etc. to the map (see Working with Map Files on page 111).

    > **NOTE:** It's important to add a dock to the map so the robot can recharge when its battery runs low.

12. Save the edited map on the robot (see Saving the Map on the Robot on page 124).
13. Localize the robot (see Set the Robot's Initial Location on page 50).
14. Create some tasks, and have the robot begin performing them (see Start the Mobile Robot Performing Tasks on page 1).

Install the Mobile Robot Software Suite

Before setting up a wireless connection to your mobile robot, you should install Mobile Robot Software Suite on your PC.

System Requirements

Verify your system meets the following requirements to install Mobile Robot Software Suite:

- **OS**: Windows 7 (32-bit/64-bit), Windows 8 (32-bit/64-bit),or Windows 10 (32-bit/64-bit).
- **CPU**: 1.5 GHz Dual-core.
- **RAM**: 1.5 GB (min) 4 GB RAM recommended).
- **GPU**: 256 MB (min).
- **HDD/SSD**: At lease 200 MB available space.
- **Monitor**: XGA 1024 x 768.
- **Language support**: English, Japanese
- **USB port** with a Omron Adept Technologies, Inc.-supplied dongle with the MobilePlanner software license.

> **NOTE:** Using MobilePlanner software to manage a fleet of robots requires at least one licensed installation (the license is supplied on a hardware dongle enclosed in the robot documentation package or sold separately). However, you can run MobilePlanner (Operator Mode) without a license dongle.

Installing Mobile Robot Software Suite

Ensure your PC meets the system requirements, then install (or download and install) the Mobile Robot Software Suite.

> **NOTE:** Mobile Robot Software Suite version 5 software suite installs into a MobilePlanner5 directory. This different install directory allows you to use the relevant MobilePlanner version with your fleet.

1. Use one of the following methods to download and/or install MobilePlanner software:
    a. **By USB drive**: insert the software media (USB drive included with your robot's documentation) into your PC, and browse to the USB drive to locate the software.
    b. From **SetNetGo:** When connected to the robot via Ethernet, you can open SetNetGo, click the **Software** tab, and install MobilePlanner.
    c. **By download:** Open a browser, and browse to http://www.adept.com/support/downloads/file-search, and log in (you must register first). In the Downloads Search tab, enter "**mobileplanner**" in Option 1, or select "**Mobile Robot Software**" from the drop-down list in option 2, then press **Begin Search**. In the Search Results field, select Download ID **900031**, **Adept MobilePlanne**r. In the Download Details tab, select **Download**.
2. Launch the installer and, when the welcome screen appears, follow the prompts in each installation wizard window to complete the installation.

3. When the Installation Complete window appears, you can leave the ReadMe and/or Launch MobilePlanner checkboxes checked, or uncheck them to not have those items launch.
4. Click **Finish** when done.

Configure the Mobile Robot's Wireless Communications

Before you can start working with your mobile robot, you have to configure it for wireless communication (via WiFi) with your PC (there are special conditions under which WiFi is not necessary - contact Omron Adept Technologies, Inc. for guidance). To do this, you will first have to connect your PC to the robot via Ethernet cable to gain access to the robot's wireless settings. In general, the set-up process is as follows:

- Connect your PC to the mobile robot via Ethernet
- Set your PC's IP address
- Connect to SetNetGo
- Configure the mobile robot's network settings
- Establish a wireless connection to the mobile robot

NOTE: The setup steps above assume that the mobile robot is powered up and ready. If this is not the case, please refer to your mobile robot's user guide for complete setup instructions.

Step 1: Connect Your PC to the Mobile Robot via Ethernet

To connect your PC to the mobile robot (MH60/MH90 mobile robot shown - check the guide for your particular robot):

1. Open the mobile robot's maintenance access panel (left side, upper right corner), by pressing the access panel's upper left corner (see image below) into the side of the AIV.

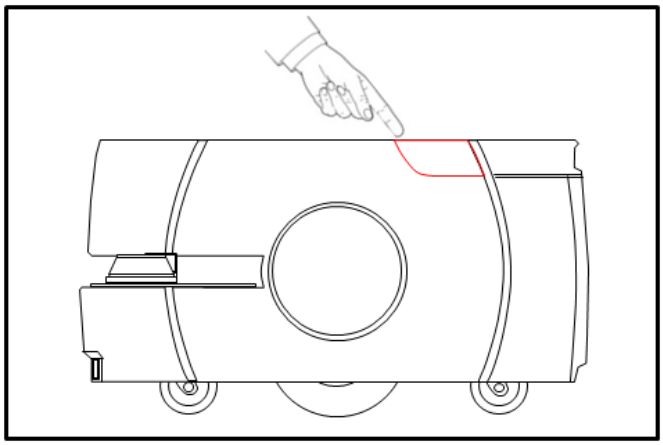


Figure 3-1: Maintenance Door location

2. Using a standard (pass-through) or cross-over CAT-5E Ethernet cable, connect your PC directly to the robot's maintenance Ethernet port (see below). The robot will auto-detect the cable type.

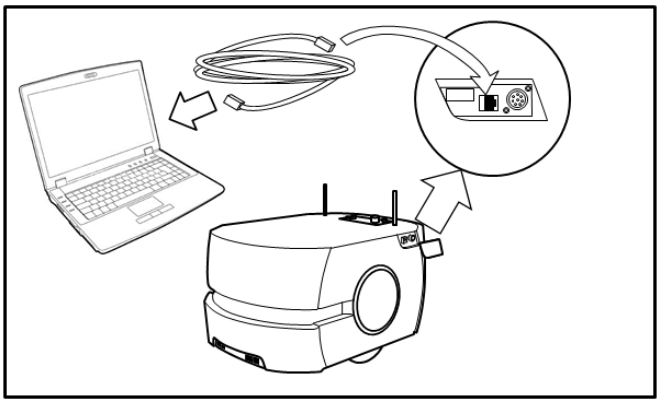


Figure 3-2: Ethernet Connection

Step 2: Set the IP Address on Your PC

Manually set your PC's Ethernet port IP address to 1.2.3.x, where x is any number 1 - 254, except 4 (which the mobile robot uses), and a Subnet mask of 255.255.255.0. No special DNS or gateway settings are needed.

NOTE: The robot's maintenance Ethernet port is always enabled and permanently set to IP address 1.2.3.4, with a Subnet mask of 255.255.255.0, for direct, wired access to the on-board systems.

1. Open your PC's Network Connections window.
2. Right-click on your PC's **Local Area Connection** Ethernet connection, and select **Properties**.

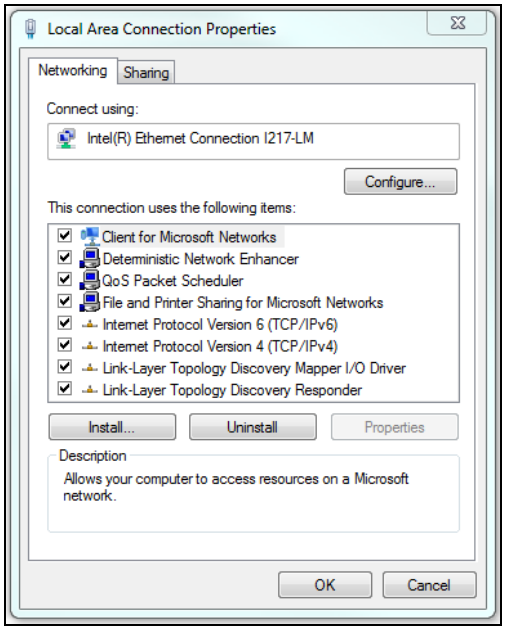


Figure 3-3: Windows Local Area Connection Properties dialog

3. In the Local Area Connection Properties dialog box, click on the TCP/IP protocol your network uses (for example, Internet Protocol Version 4 (TCP/IPv4)), then click **Properties.**

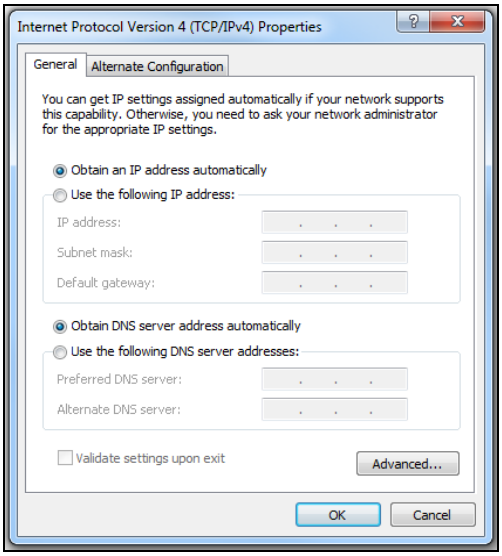


Figure 3-4: Windows Internet Protocol Properties dialog

4. In the TCP/IP properties dialog box, click the **Use the following IP address:** radio button and enter an appropriate IP address (for example, 1.2.3.5) and Subnet mask 255.255.255.0.
5. Click **OK**.
6. Close the Network Connections window.

Step 3: Access SetNetGo Software

The SetNetGo software lets you manage a variety of settings related to the robot's connectivity. You can access SetNetGo from MobilePlanner (most common), or secure web browser (for example, Chrome, Firefox, or Internet Explorer) if receiving help from your IT department, or you don't have access to MobilePlanner, etc.

To access SetNetGo from MobilePlanner

NOTE: Only start the following procedures if your computer is connected to the AIV via Ethernet cable.

1. Open the MobilePlanner software.
2. Enter **1.2.3.4** into the robot address field, then click **Connect**.
3. Click the **SetNetGo** button (the large part of that icon, not the checkbox).
4. Click the **SetNetGo** tab.

To access SetNetGo via web browser

1. Start a web browser on your computer.
2. Enter the URL **https://1.2.3.4** in the address bar of the web browser.

   This is the AIV's maintenance Ethernet address. When accessing the software from a wired maintenance Ethernet port, you do not need a username or password.

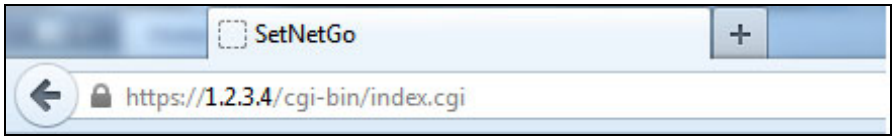


Figure 3-5: Browser address field

NOTE: You can ignore the certificate error that appears on the SetNetGo web-page; the error appears because the hardware is not attached to the Internet.

The SetNetGo startup screen is shown below.

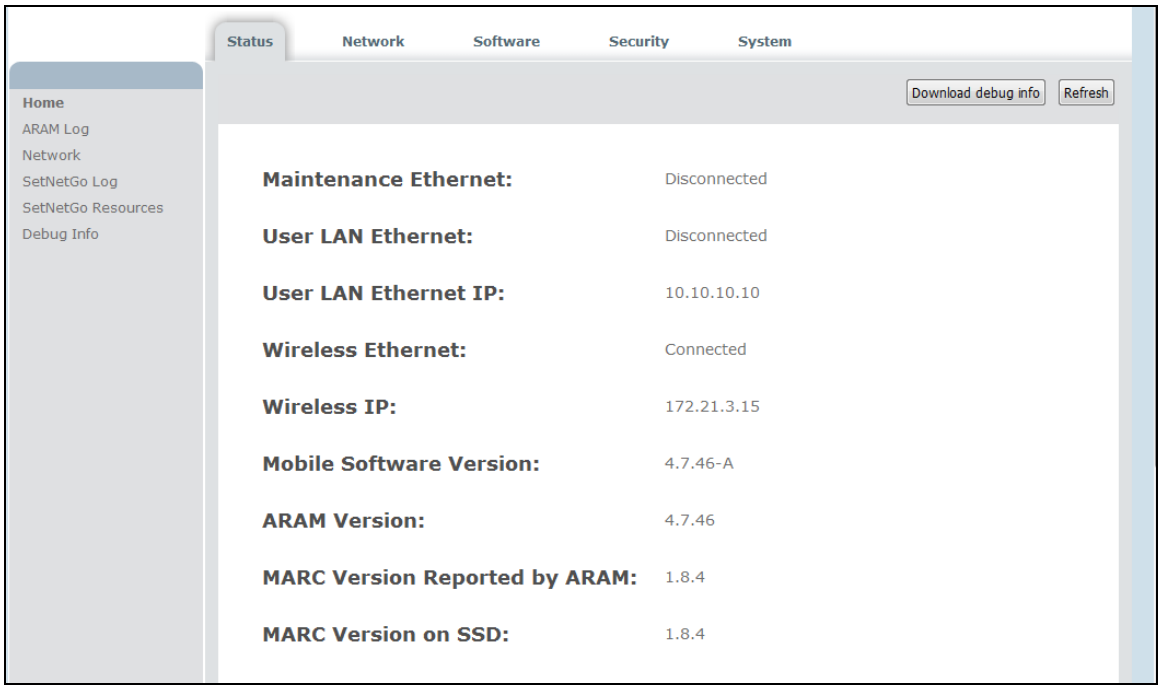


Figure 3-6: SetNetGo interface

Step 4: Configure Your Robot's Network and Security Settings

To access your mobile robot remotely, you should set up a static IP address. The SetNetGo interface allows you to configure your hardware's Ethernet settings, configure serial and TCP forwarding, and upgrade the

on-board software. If you are not familiar with setting up a network or do not have an assigned IP address for the robot, please see your system administrator.

NOTE: If you change any values in a SetNetGo screen, you must click **Apply** before switching to another sub-screen, or those values will not be saved. For example, when changing wireless Ethernet settings, be sure to click **Apply** before navigating back to the dashboard.

To configure network settings, click on the **Network** tab at the top of the SetNetGo screen.

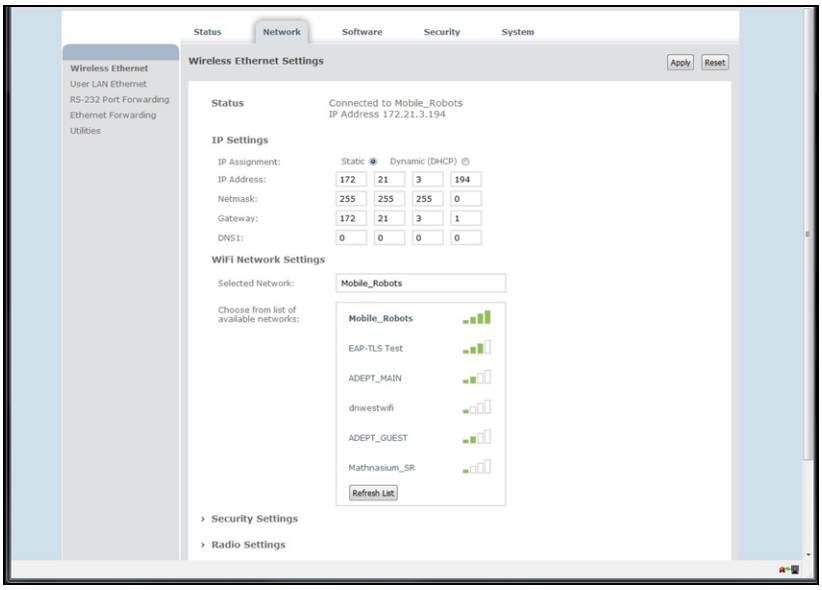


Figure 3-7: SetNetGo interface

Network Menu	Description
Wireless Ethernet	Sets up your wireless Ethernet connection to your mobile robot, including IP settings, WiFi network settings, security settings, and radio settings.
User LAN Ethernet	This screen has user-configurable settings for interface mode, IP address, net-mask, DHCP server for accessories, and DHCP IP range.
RS-232 Port Forwarding	Controls forwarding of serial data to a TCP port on the wireless and internal wired Ethernet networks, where the data is re-directed to a TCP port on an IP address accessible via the Wired Ethernet interface (which must be set to accessory mode). There is also port-forwarding for the two extra on-board serial ports to a TCP port on the wireless Ethernet interface.
Ethernet Forwarding	Use the settings on this screen to control TCP port forwarding from your User LAN Ethernet interface to the wireless Ethernet interface.
Utilities	Use this screen to ping an IP address for testing and diagnostic purposes.

Set the Username and Password to secure access to the robot

You should secure access to your robot(s) by enabling Access Control, adding one or more users, and assigingn an access password. Click the **Security** tab, then click the **Enabled** radio button and populate the username/password fields (see Setting Up User Accounts on page 104).

Step 5: Connect to the Robot Wirelessly

Now that you have installed the Mobile Robot Software Suite and configured the robot for wireless communications, connect to your robot.

1. (If not already running) double-click the MobilePlanner icon on your PC desktop.

Figure 3-8: MobilePlanner desktop icon

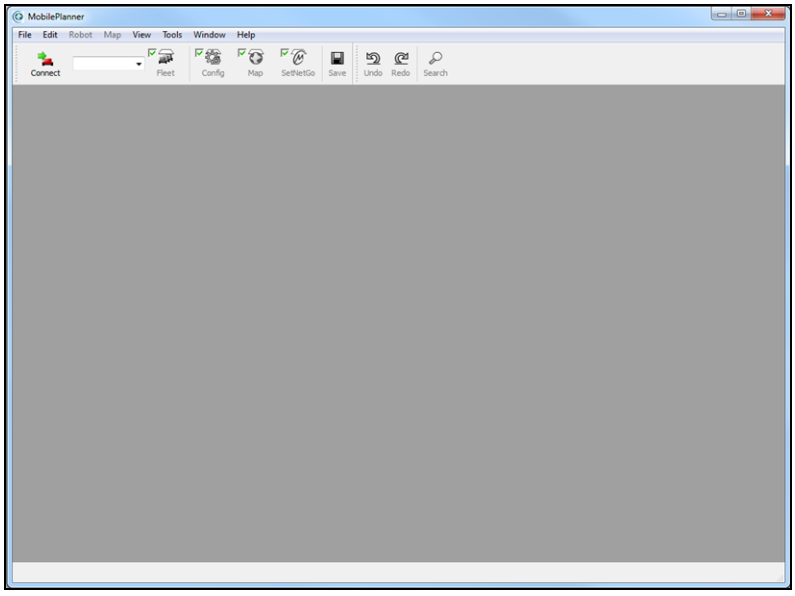


Figure 3-9: MobilePlanner Interface

> **NOTE:** If running MobilePlanner without a license dongle, the interface will look slightly different than above.

By default, the Fleet, Config, and Map buttons have checkmarks indicating those features will automatically load when you connect to the robot.

2. In the **Connect** field, enter the IP address of the mobile robot, then click **Connect**.

3. Enter User Name and Password in the User Name and Password dialog box, then click **OK**.

   > **NOTE:** If the SetNetGo button is checked, this User Name and Password dialog appears. Enter the Username and Password you configured in Step 5: Connect to the Robot Wirelessly on page 1.

   If user accounts are enabled, a login dialog appears in which you must enter a user name, password, and robot server IP address.

   > **NOTE:** After connecting to the robot the first time, MobilePlanner remembers your user name. When connecting to the robot again, you can select your user name from a combo box instead of having to re-enter, but you must still enter your password.

MobilePlanner completes its connection to the mobile robot. At this point, there is no map to load, so MobilePlanner opens with a blank map window.

What's Next?

Now that you have established a wireless connection to your mobile robot, you are ready to create a map of the mobile robot's environment. In general, the process is as follows:

- Review the section on scanning (see Scanning Overview on page 39), and the section on scanning tips.
- Review the section on driving the mobile robot (see Mobile Robot Driving Overview on page 41)
- Decide whether you will drive the robot by joystick or your PC (see Mobile Robot Driving Overview on page 41).
- Scan the mobile robot's operating space (see Scanning the Operating Area on page 45).

Scanning Overview

Before the AIV can perform autonomous tasks, it needs to have an accurate map of its environment. It is best to create a scan that includes as many stationary features as possible in the workspace. After scanning, use MobilePlanner to turn the scan into a map, then begin assigning tasks to your AIV.

How Does the Robot Scan Its Environment

The AIV uses its forward laser, which scans in a 250 degree arc.

What Gets Scanned?

Scans are on a thin horizontal plane. For most platforms, the scan is taken about 8 inches (203 mm) off the floor. So tables appear as four legs; a pedestal appears as a single pole, minus the feet.

Distance From Walls

The AIV's sensing range is 14 meters (about 46 feet). While scanning, keep walls within that range as you drive throughout the workspace. For instance in a large warehouse, run the AIV along the outer walls as well as through the middle of the space.

Uni-directional Versus Bi-directional Scanning

Uni-directional scanning (or scanning in a single direction) works very well for hallways and small rooms. Bi-directional scanning (or scanning in two directions) will ensure complete scanning of all features (such as vending machines or bookshelves).

Doors and Windows

When scanning environments with doors, ensure the doors are open in places where the AIV will drive. Some glass surfaces, particularly those with dark backgrounds, reflect the range finder signals; others don't or reflect weakly. Consider retrofitting particularly troublesome places with tape or other treatments to obtain proper scans. Optionally, you can designate these features as obstacles in the map using the forbidden zone sector.

Dynamic Features

During scanning, MobilePlanner sees people walking by, swinging doors and other things moving throughout the workspace. If a group forms during scanning, have them follow behind (not stand in front of) the robot's scanner so they do not become permanent features of your map. When editing the map, erase dynamic features (like the group) to improve the map's quality.

Docks

When scanning, scan and press the goal button to mark the robot's dock so it can recharge when its battery runs low.

Scanning Tips

The following general tips will help increase the mobile robot's scanning accuracy, and reduce possible map errors:

- Remove any features like chairs, rolling cabinets, etc. that might not be present during normal operations.
- Walk behind the AIV while scanning (and ensure others walking with the AIV also walk behind the laser's sensing area.
- Drive the mobile robot into tight corners, down small corridors, and between stationary objects (with enough room).
- Scan in multiple directions - scan clockwise for one scan, counter-clockwise for another.
- If scanning rough terrain (like diamond plate flooring), drive slowly (to reduce the chances of wheel slip) and in multiple directions. This will help minimize introducing errors into the scan.
- Open doors that might be open during normal operations, and doors the robot will have to drive through.
- Drive the mobile robot through previously scanned areas.

> **NOTE:** Driving the robot back through previously scanned areas, and returning to its starting position can help minimize errors.

Mobile Robot Driving Overview

Now that you have installed the Mobile Robot Software Suite and set up a wireless connection to your robot, you are just about ready to drive the mobile robot around your workspace. You can drive the mobile robot using either the joystick and walking around your environment, or operating it from the MobilePlanner software. Using the mouse and keyboard, you can dock and undock the mobile robot from its charging station, drive the robot forward, backward, turn the robot, and control its speed.

CAUTION: Before attempting to drive the robot, be sure to read the appropriate Omron Adept mobile robot user's guide so you are familiar with the robot's operation.

Before Driving the Mobile Robot

Whether you are driving the robot with the joystick or from MobilePlanner, be sure the robot is not docked.

Safe Mode

Safe Mode is the mobile robot's default driving mode, and ensures the mobile robot does not run into anything in its environment. When driving the robot using MobilePlanner, Safe Mode prevents the mobile robot from entering forbidden or restricted spaces. If driving the robot using the joystick, you can have the robot enter forbidden or restricted spaces, but the robot always obeys the lasers for obstacle avoidance.

If you turn Safe Drive mode off, you can force the robot to continue driving (e.g., through a set of plastic curtains in a doorway). Safe Mode only affects MobilePlanner, not the joystick.

When Safe Drive mode is off, the map background turns yellow (see below).

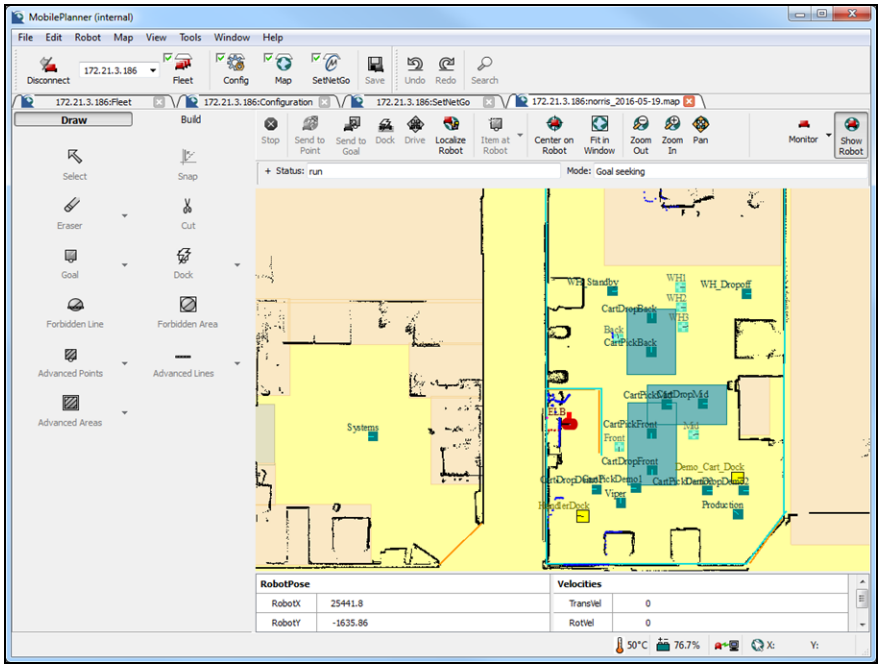


Figure 3-10: MobilePlanner, safe mode OFF

To drive with safe mode off:

1. In the MobilePlanner main menu, click **Robot > Robot Tools > Safe Drive**.
2. Click **Yes** to acknowledge the Disable Safe Driving dialog prompt.

NOTE: If you turn Safe Drive mode back on when the robot is in a restricted or forbidden area, it will not be able to drive itself out of the restricted area, and will require you driving it out using the joystick (which always ignores location-dependent areas). Also, while a robot is in a forbidden area, even with Safe Drive mode still off, pressing the Send Robot button will not cause the robot to drive out of the forbidden area. You must drive the robot out of a forbidden area using the joystick or your PC's arrow keys (see Driving Using the Software Interface (Drive Pad or keyboard) on page 43).

Driving Using the Joystick

This section provides information on the joystick. See your mobile robot's user guide for further details.

Preparation

1. If not already done, power up the robot (press and release the mobile robot's ON button) (the full power-up sequence can take several minutes).
2. Wait for MobilePlanner and/or the mobile robot to indicate it is ready (via wheel lights, LCD or touch screen).
3. Plug the joystick into the robot's JOYSTICK connection port (MH-LD shown below):

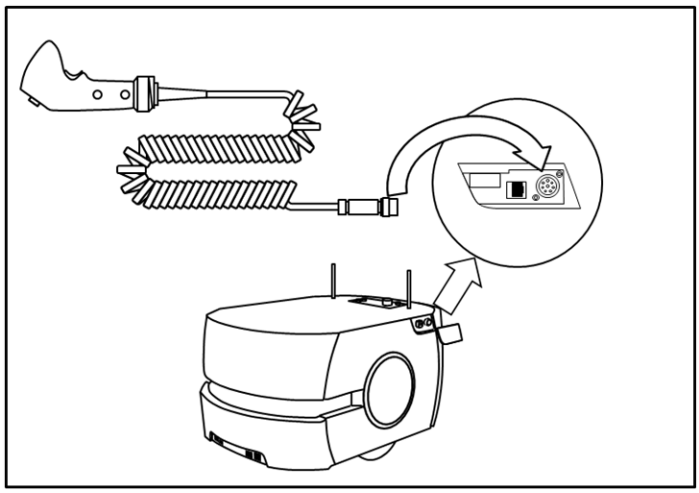


Figure 3-11: Connecting the joystick to the robot

CAUTION: Driving the robot with a joystick overrides the hardware safety features (E-stop, sonar). Use caution when driving the robot with a joystick.

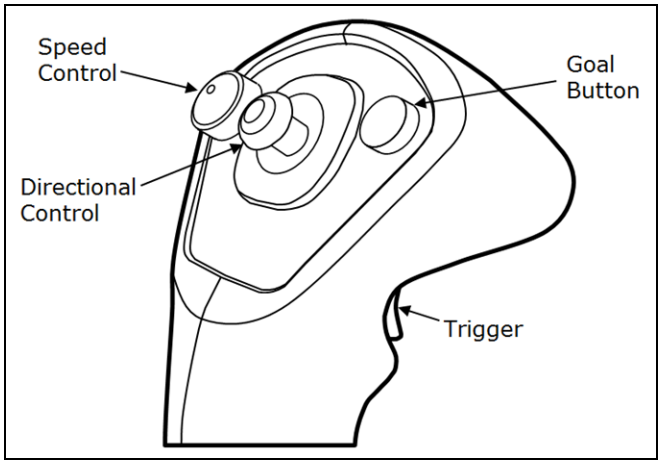


Figure 3-12: Joystick

- Squeeze and hold the trigger in, then:
  - Push the directional control forward or back to drive the robot forward or back.
  - Push the directional control to the left or right to turn the robot to the left or right.
- The robot slows to a stop when you release the trigger. To stop more quickly, continue to hold the trigger down and pull or push the directional control to its limit in the opposite direction of the robot's travel.
- Speed is related to the positions of the directional control and the SPEED control.
- The joystick's GOAL button is primarily for marking positions while making a map scan, but can be configured to perform other actions while not making a map scan.

If driving with the joystick, proceed to Scanning the Operating Area on page 45

Driving Using the Software Interface (Drive Pad or keyboard)

Using MobilePlanner software and your PC's mouse and keyboard, you can: dock and undock the mobile robot from a charging station; drive the robot forwards, backwards, and turn; and control the speed.

To drive the mobile robot from the software:

1. Ensure **Show Robot** is active, then click **Center on Robot** to locate the robot (a red oval icon) in the map window (shown below).

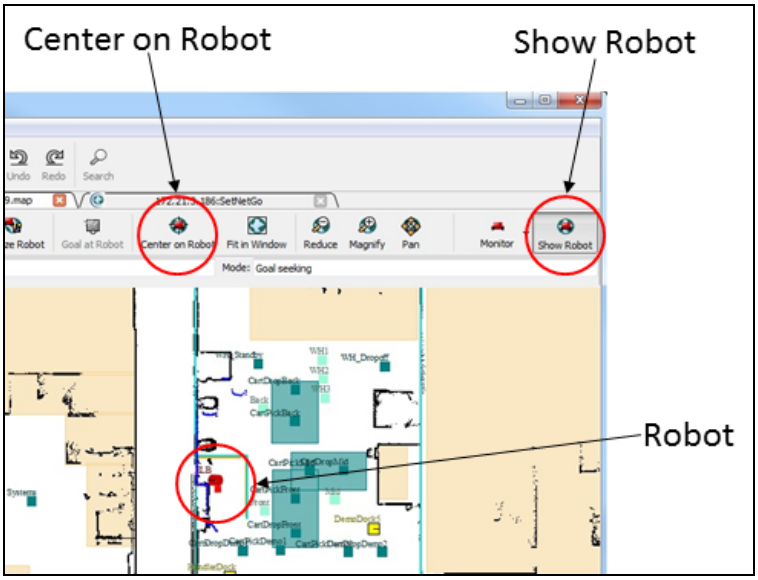


Figure 3-13: Robot on map (Show Robot active)

2. Select **Robot > Undock** from the main menu, or click **Dock** (on the robot tool bar) to turn docking off. In the map window, you should see the robot move away from the charging station.
3. If the background in MobilePlanner is yellow (the robot is not in Safe Drive mode), select **Robot > Robot Tools > Safe Drive** from the MobilePlanner main menu.
4. Click **Drive** to display the MobilePlanner Drive pad with Speed slider (figure below).

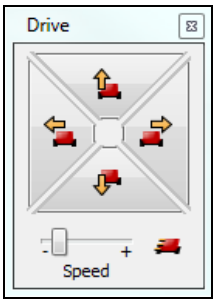


Figure 3-14: Drive pad with speed slider

5. Highlight (click on) the map window, and use the mouse to click on the drive pad buttons, or use keyboard's arrow keys to control the robot's direction. Use the speed slider (at the bottom of the Drive pad) to control the robot's speed.

> **NOTE:** If the speed slider is all the way to the left (-), the speed is set to zero and the robot will not move.

Continue with Scanning the Operating Area on page 45

Scanning the Operating Area

Be sure to drive the robot to all of the places you would expect it to go on its own. Drive all the way around a room, not just in and out of the doorway. Turn the mobile robot to point into corners and move around stationary features. In other words, be thorough!

Also, while driving the robot, orient and stop it along the way to mark important goals (especially a dock object). Later, you can edit these and add additional goals within MobilePlanner software.

1. (If not already done), Launch MobilePlanner and connect to the robot.

   > **NOTE:** Before starting these steps, make sure the robot is not charging. If the robot is docked, undock it by clicking **Robot > Dock** (in the MobilePlanner main menu bar), or by clicking the Dock button in the MobilePlanner toolbar (only visible if Show Robot is active).

2. From the MobilePlanner main menu, select: **Robot > Map Creation > Start Scan**.

3. Enter a name for your scan file in the **New Scan Name** field and click **OK**.

   This initiates the scanning process.

   > **NOTE:** Before driving the robot, make sure it is in Safe Drive mode (a yellow background in MobilePlanner indicates the robot is not in Safe Drive mode). To enable Safe Drive mode, click **Robot > Robot Tools > Safe Drive** in the MobilePlanner main menu bar.

4. Use either the joystick or drive pad and drive the robot around its operating space.

   > **NOTE:** Be sure to drive the robot around the entire operating area to create an accurate scan of your environment.

5. If you want to create a goal at the point where the robot is stopped, press the joystick's black GOAL button to mark a goal.

6. Continue driving the robot around until you have a thorough scan of your environment.

7. Return the robot to its starting position, and

8. After you have finished the scan, select **Robot > Map Creation > Stop Scan** from the MobilePlanner menu.

The resulting scan file resides on your mobile robot, but not on the PC running MobilePlanner. The file name is the name you entered for the scan with the '.2d' extension. If scanning using Acuity, the file name has '.z2d' appended to it, and includes additional data such as camera images used to map overhead lights.

Convert the Scan into a Map

After the robot scans the operating environment, you need to turn the scan file into a map file. To do this, open the scan file (.2d) in MobilePlanner.

> **NOTE:** MobilePlanner can process only one scan file at a time. Opening a second scan file disables the toolbar Start button until the first scan is finished.

1. Open the MobilePlanner software.
2. Select **File > Open on Robot,** then select the robot, either from a list or by IP address.

   The Open File on Robot dialog box appears.

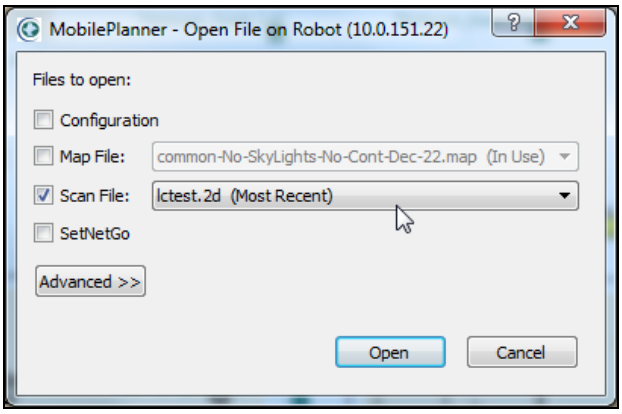


Figure 3-15: Open File on Robot dialog

3. Check the **Scan File:** checkbox, select the scan file you just created from the pulldown list, and click **Open**.

   A new map window and the Scan Tools toolbar appear, and the conversion (registration) process begins automatically. Initially, the map shows a red robot icon in the map window. During file processing, the software adds scan points to the map window and updates the robot's position showing a blue trail to trace the robot's previous positions.

   > **NOTE:** Be patient! Converting a large scan file can take considerable time (and memory), and is based on the size and layout of the area being scanned (for example, a small facility could take 20 seconds, a 20,000 square foot facility could take over an hour). If the small robot icon in the lower right corner of the map window is still moving, the conversion process is still underway.

   > **NOTE: Windows users**: PC memory (RAM) is critical when processing a very large scan file. Processing large scan files with insufficient RAM can significantly degrade the performance of all applications. If this occurs, it might be necessary to create smaller scan files and use the Map Insert feature to assemble the pieces (see Inserting a Map File into an Existing Map File on page 120 for details)

   When processing is complete, the robot icon and its trail disappear from the map window, and the scan icon in the status bar stops animating. If the map has too many stray objects or otherwise does

not appear as you need, you can adjust the scan settings and re-process the scan file (for details, see Changing the Scan Settings on page 48).

4. **Save** the cleaned map file locally on your PC.
5. In the Scan Tools toolbar, click **Finish** to complete the conversion process.

   NOTE: Unless working in batch mode, you must finish converting one scan before opening and converting another scan.

6. Edit the map file to erase (**Draw pane > Eraser**) stray, non-stationary objects (like chairs, people, etc.); add forbidden areas and sectors; create goals and macros; and assign tasks to your mobile robot (see Editing a Map File on page 114 for more information).
7. Select **File > Save on Robot** to save the finished map file on the robot, then select your robot from the MobilePlanner menu. Optionally, you can enter an Enterprise Manager address so it can be shared between multiple robots.

   NOTE: Select **Yes** when prompted to make the new map the robot's current map so the robot can localize, and appear on the map (when you click Show Robot).

Map Data

The finished map consists of points and lines (vectors derived from points) representing the walls and other real features detected by the scanning laser.

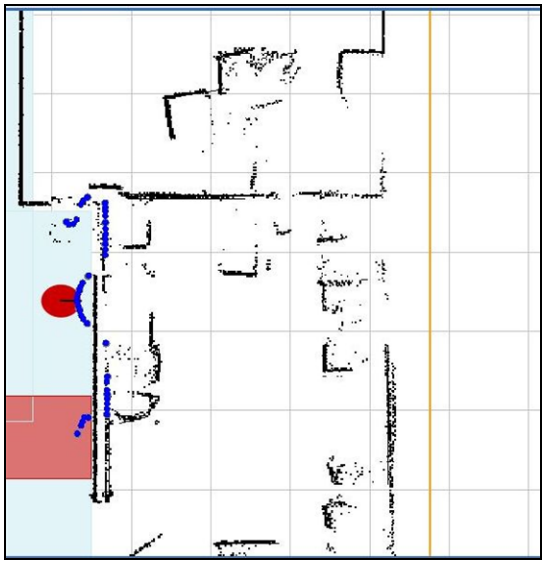


Figure 3-16: Scanned environment

Now What?

If you need to adjust the scan settings, see the next section. Otherwise, you need to localize the mobile robot (let it know where it is). See Set the Robot's Initial Location on page 50.

Changing the Scan Settings

To adjust the processing, scan, clean, and map settings, click **Settings** from the Scan Tools toolbar.

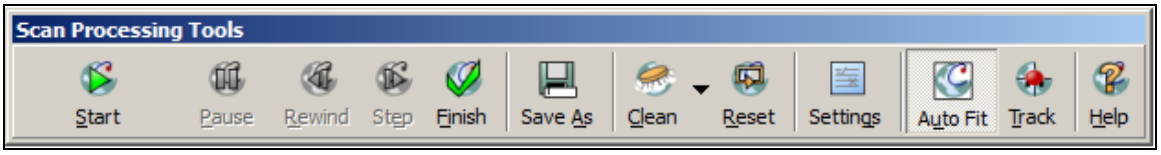


Figure 3-17: Scan Processing Tools toolbar

Button	Description
Start	Initiates the scan session.
Pause	Temporarily pauses the scan session.
Rewind	Rewinds the robot's path (blue trail) through the scanned area as shown on the MobilePlanner map.
Step	Allows you to step through the robot's path, one segment at a time.
Finish	Completes the scan conversion process.
Save As	Allows you to save the newly created map with a specific name and location.
Clean	Allows you to manually remove unwanted scan points from the map.
Reset	Reset "uncleans" any cleaning work you have done on the map.
Settings	Allows you to change scan tool configurations.
Auto Fit	Scales the scan file image to the MobilePlanner map window as you add more information.
Track	Centers the robot in the scan image - works similarly to 'center on robot' in a normal map
Help	Opens a help file to search for specific help topics.

The Scan Settings dialog box appears as shown below

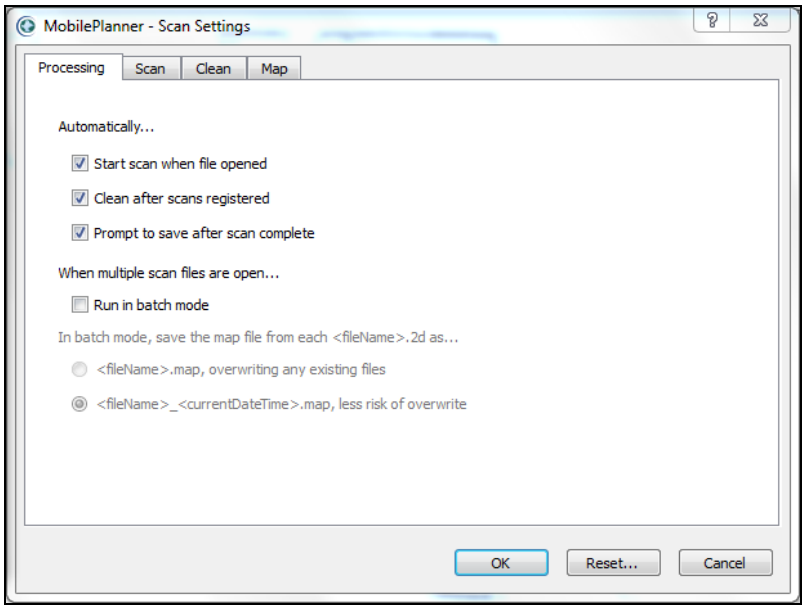


Figure 3-18: MobilePlanner Scan Settings dialog

The following table describes the settings available from the Scan Settings dialog box.

Processing Settings	Description
Start scan when file opened	Disable this option to prevent the scan conversion process from automatically starting when you open the scan file in MobilePlanner. Allows you to adjust the scan settings before conversion. To start the process, click on the **Start** button from the Scan Tools toolbar.
Clean after scans registered	Disable this option to leave all scan points in the map. Any cleaning must be done manually by pressing the Clean button.
Prompt to save after scan complete	If this option is disabled, then the Save Map File As window is not automatically displayed.
Run in batch mode	Enable this option to process multiple scan files at the same time. **NOTE:** The files must all be of the same type. For example, they all must be basic scan files or all must be light localization scan files, they cannot be a combination of the two.
<filename>.map, overwriting any existing files	Select this option to overwrite the filename in batch mode.

<filename>_<currentDateTime>.map, less risk of overwrite	Select this option to have the current date and time added to the filename with each new scan conversion processed in batch mode.
Scan Settings	**Description**
Maximum Range	Specifies the maximum distance, in mm, used for the laser data.
Linear Error	The forward/reverse error, expressed as the average variation (in mm) per meter of travel.
Lateral Error	The left/right error, expressed as the average variation (in mm) per meter of travel.
Use Loop Closing	Used for open areas - indicates that the robot has returned to a known location. Minimum Loop Probability allows you to set how closely the current position must match a previous scan. Default is 80%.
Use Gyro Error Model	Specifies allowable error to correct for when registering laser scans collected during mapping.
Scan Matching Mode	Choose between Normal or Fast matching. If you select Fast, the scan match is performed only when MobilePlanner is in the registration phase.
Clean Settings	**Description**
Grid Size	Sets the size (in mm) of grid cells used to check whether the reading represents a real map point. A small value gives more cleaned readings; a large value includes more points in the map.
Max Range	Sets the maximum distance (in mm) from the robot in which readings are considered for inclusion in the map. This value only affects the cleaning process; it does not affect the range used during the registration phase.
Map Settings	**Description**
Resolution	This adjusts the resolution of the map created from the scan file.

Set the Robot's Initial Location

It is important to establish the mobile robot’s starting location, which is also known as localizing your robot. When you "localize to a point" on the map, you provide the mobile robot with location data. This data allows the robot to match its current location with the same location on the map.

As the mobile robot attempts to find its location on the map, it provides a localization score, or confidence level. This confidence level should be at 80% or better for the mobile robot to navigate properly.

For more detailed information on localization, refer to Robot Localization on page 193.

To set the robot's starting location:

1. Click the **Map** button, then click **Show Robot**.

   The Map tool bar displays robot control icons.

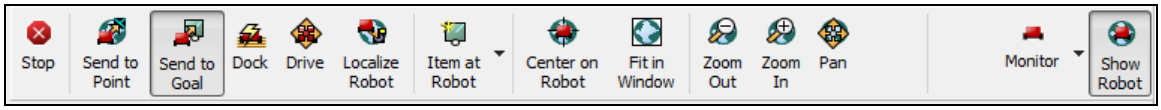


   Figure 3-19: MobilePlanner Map toolbar

2. Click **Localize Robot**.

   This puts the map into localize-to-point mode (and changes the cursor to indicate the new mode).

3. Click and hold on a spot on the map where you want the mobile robot located. This is where you want the confidence threshold, or Localization Score, to be 80% or better as shown below.

   While still holding the mouse button down, drag the localization mark's direction indicator to the direction the robot is facing. The robot will choose the most likely pose near the clicked location. If the initial localization does not look correct, localize the robot again until it appears in the correct location.

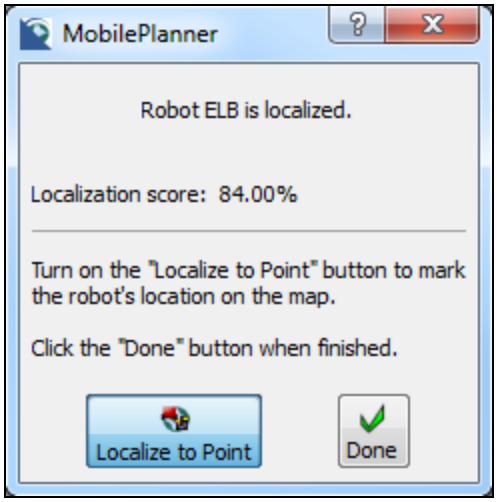


   Figure 3-20: Localize to Point Dialog Box

6. Click **Done** when the robot's localization score is where you want it to be.

   The robot is now localized and you have successfully set the robot's current position.

> **NOTE:** You must set the robot's current position the first time you put the robot in a different map.

What's Next?

Now that your robot is configured, you have scanned its operating space and created a detailed map, you can do any of the following:

- To edit your map further, see Working with Map Files on page 111.
- To learn about, and start using, MobilePlanner software, see Using MobilePlanner Software on page 53.
- To configure your mobile robot, see Configuring the Robot on page 125
- If you are familiar with MobilePlanner and want to set up goals and tasks for your mobile robot to perform, see Working with Macros, Tasks, and Route Builder Tools on page 131

After Driving the Mobile Robot

After you're done driving the mobile robot, select **Robot > Dock** from the software main menu, or click **Dock**, to return the mobile robot to a charging station.

Auto Dock

The **Config > Robot Operation > Docking > Autodock** parameter is the primary control for the robot's automatic docking, and is normally set to True.

If the Autodock parameter is set to False, and you don't want to manually dock the robot each time, using the Auto Dock menu item (**Main Menu > Robot > Robot Tools > Auto Dock**) will override the configuration parameter. The robot will return to a charging station when the charge is running low.

> **NOTE:** If the Autodock parameter is set to True, you can override that behavior by turning off automatic docking. If you do this, remember to turn it back on when you are done, or the robot will not recharge and eventually stop running.

What next?

Now, set the mobile robot's initial position (also referred to as its 'pose'). See Set the Robot's Initial Location on page 50.

Chapter 4: Using MobilePlanner Software

The MobilePlanner software is the "control center" of the Mobile Robot Software Suite. Its user interface has the tools for all major AIV activities, such as observing a fleet of AIVs, commanding individual AIVs to drive, creating and editing map files, goals, and tasks, modifying AIV configurations, and more.

The following topics provide details on understanding and using the MobilePlanner features.

Overview of MobilePlanner

MobilePlanner has features you can use to scan the robot environment, configure the robot, create and edit maps, and more. The interface is designed to be user-friendly and efficient, which reduces the learning curve and the time needed for deployment.

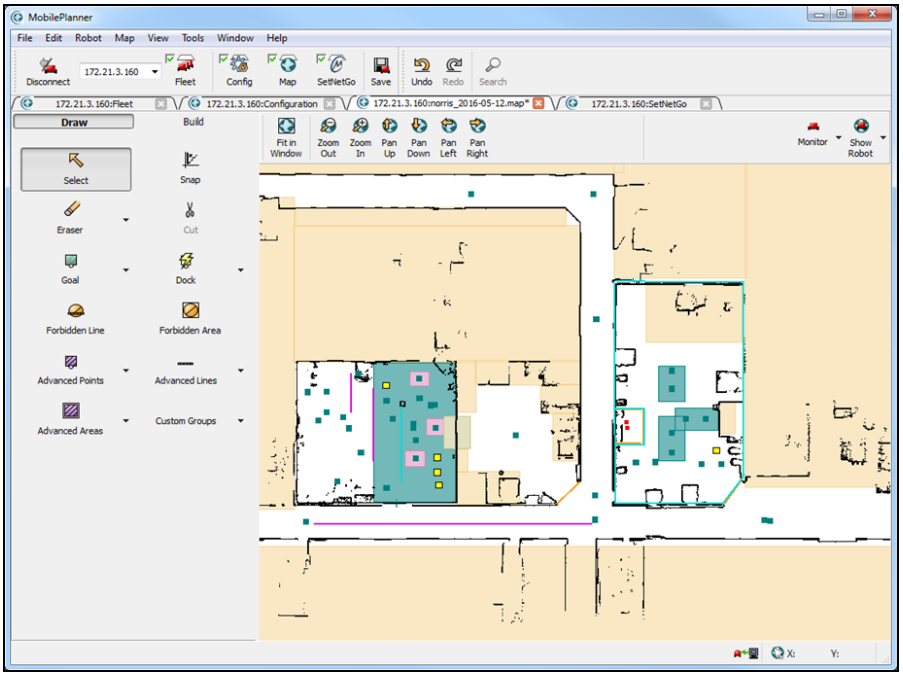


Figure 4-1: MobilePlanner user interface (with map)

> **NOTE:** While MobilePlanner is not necessary for each robot, you must have at least one licensed copy of MobilePlanner to create a map.

From the MobilePlanner interface, you can:

- Connect to and drive the mobile robot.
- Create floorplans (maps) of the environment by importing and analyzing a robot's scan data.
- Edit maps by adding goals (and adding tasks to those goals), docks, forbidden areas, and more. You can also erase stray or unwanted artifacts, combine pieces of maps, and make other changes.
- Create a week-long schedule, which can include holidays. A schedule commands the robot to perform routes and other special activities at specified times.
- Download and upload files, including maps and scan data, to and from a robot.
- Set the system configuration parameters for the fleet.
- With the optional Enterprise Manager (EM), monitor the location and status of all robots in a fleet.
- View and interact with the job queuing manager.

These features allow you to create a map with goals, docks, and advanced lines and areas, and start the robot working in its environment.

The MobilePlanner Interface

The MobilePlanner interface consists of the following main sections:

- Toolbar: Provides quick access to connection, mode buttons (Fleet, Config, Map, SetNetGo), file save, and undo/redo functions. Some of these items are also available from the File and Edit menus. For details, see Opens a submenu, which lets you select and open a file located on a particular robot or the Enterprise Manager (EM). on page 61 and Lets you undo the most recent action on the map file. on page 62.
- Fleet button
- Config button
- Map button
- SetNetGo button

  NOTE: By default, the Fleet, Config, and Map buttons are checked, and will open each when you launch MobilePlanner and connect to a robot.

The following figure is an example of the MobilePlanner interface showing a map of a single mobile robot, containing routes and goals. Show Robot is on, in the figure.

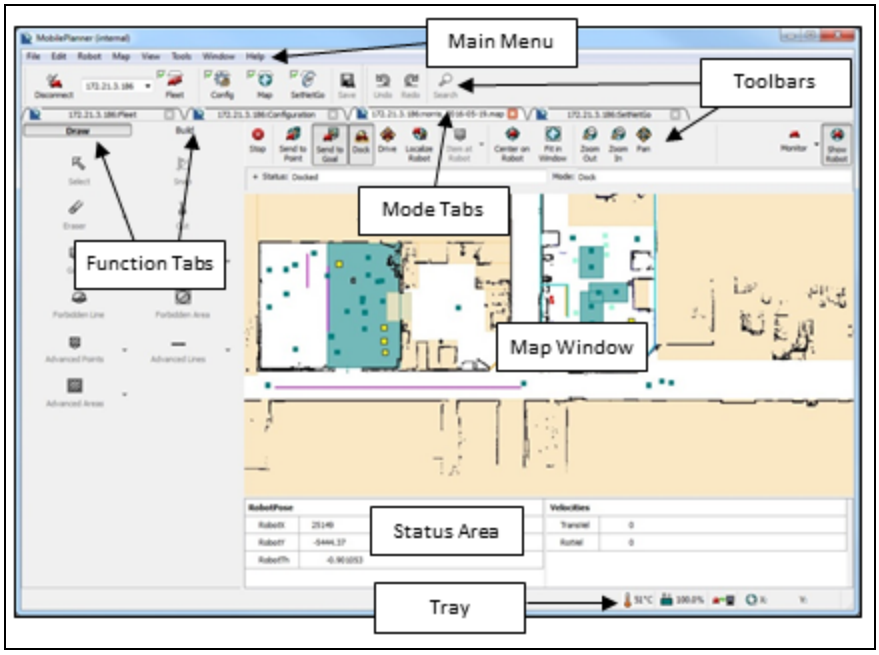


Figure 4-2: The MobilePlanner Interface (Example)

Configuration (Config Tab)

There are five tabs under the Config tab: Robot Interface, Robot Operation, Robot Physical, Enterprise, and Debug. The many configuration parameters are covered in Configuring the Robot on page 125.

Map Tab

- When the map (<*IPaddress*>.map) tab is selected, the main window displays a map of the mobile robot's operating space. The map consists of points and lines representing the walls, doors and other stationary features within the environment. For more details, see The MobilePlanner Map Window on page 74.
- The Draw and Build Tabs, to the left of the map window, provide map editing tools, and tools for setting the mobile robot up to do tasks at goals (route building).
- Robot tools are above the map window, and visible when Show Robot is toggled on. You can use these tools to drive, dock, adjust speed, etc. These items are also available from the Robot menu. For details, see Activates the Drive pad for driving the robot in its environment. on page 63.
- To the right of the Robot tools is the Monitor icon. For details, see Using Monitor Robot on page 72.
- The Status area, located below the map window, (shown with Show Robot button toggled on) provides information on the robot position, temperature, odometer, wireless connection, and more. For details, see MobilePlanner Status and Tray Displays on page 84.

Map Features Legend

To view available map features in MobilePlanner, click **Map > Legend**. If Show Robot is on, the legend also shows map items associated with the robot, like sensor readings, paths, etc. Use the scroll bar to see more.

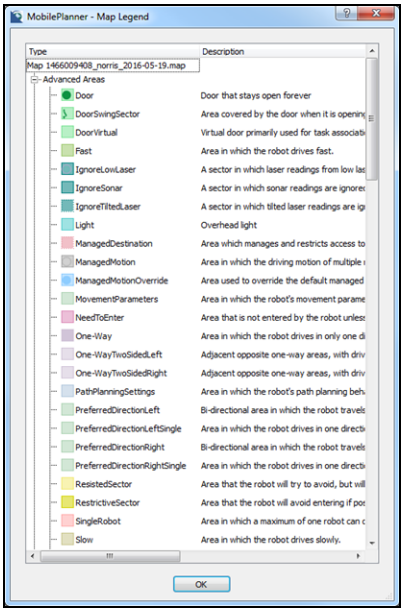


Figure 4-3: Map legend list

SetNetGo Tab

The SetNetGo tab connects to the robot's SetNetGo interface, and displays the various configurations associated with the mobile robot.

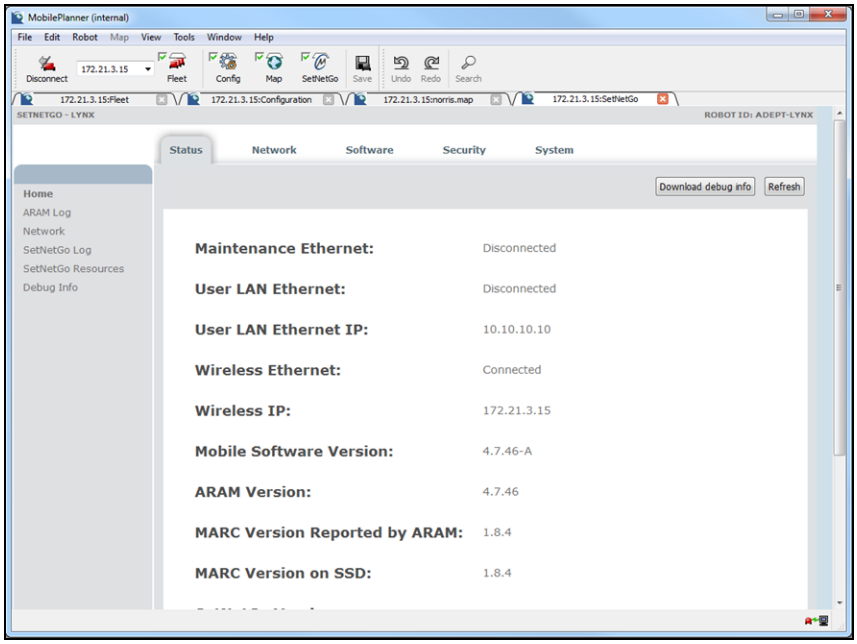


Figure 4-4: SetNetGo interface

For details on the interface elements, see the remaining topics in this chapter.

MobilePlanner Operator Mode Overview

Launching MobilePlanner without the license dongle automatically opens a version of MobilePlanner called Operator Mode (you can also select Operator Mode from the Windows Start menu).

Operator Mode provides a limited set of tools for interfacing with mobile robots or the Enterprise Manager (EM). Its main window, the Fleet window, shows the status of all mobile robots in your fleet and their jobs, and allows for simple interventions in job execution sequences. Operator Mode does not support any setup operations, and the Map, Config, and SetNetGo windows are unavailable.

MobilePlanner Operator Mode Interface

Operator Mode's simplified user interface focuses on monitoring fleet robots and jobs. It uses graphical elements to represent robot statuses, and the status of all jobs (complete, in-progress, canceled, etc.).

To launch MobilePlanner Operator Mode, click the Windows Start menu, and select **Start > All Programs > Omron > MobilePlanner (Operator Mode)**. When MobilePlanner (Operator Mode) opens, enter the IP address of a robot IP address or EM, and click **Connect**.

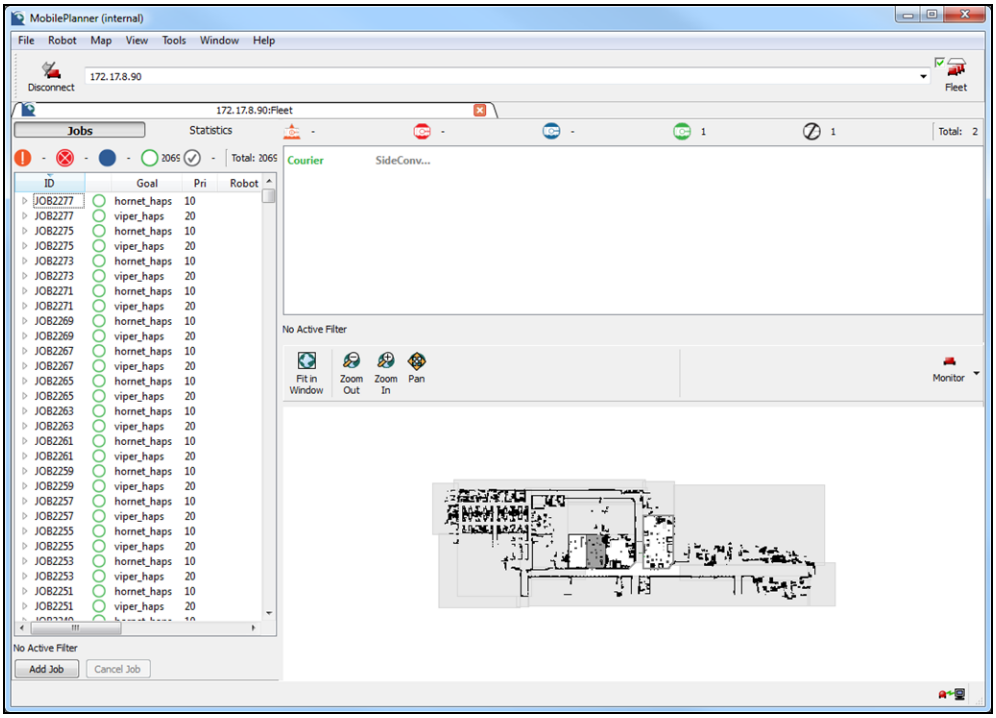


Figure 4-5: MobilePlanner Operator Mode UI

The MobilePlanner (Operator Mode) interface allows you to connect to - and monitor - multiple robots.

MobilePlanner Operator Mode Jobs Tab

The Jobs tab displays all jobs assigned to the robots (listed by job ID). For debugging purposes, you can also add a job to the currently monitored robot by clicking the **Add Job** button (lower right corner of the window), which displays the Add Job window.

> **NOTE:** The Add Job window is not the primary method for submitting jobs to the fleet.

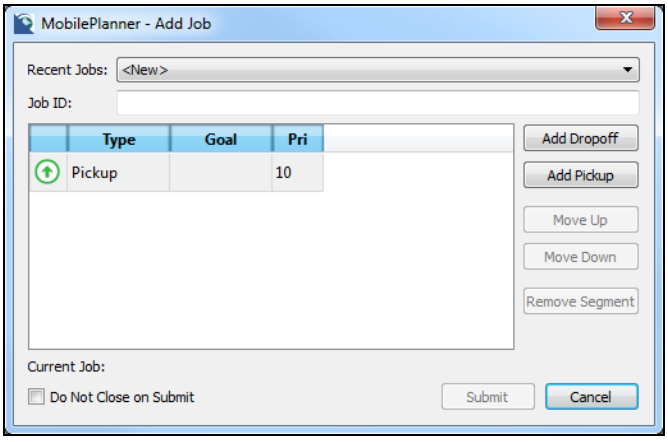


Figure 4-6: MobilePlanner Operator Mode Add Jobs window

Each job consists of multiple segments, and each segment has an associated goal. In this window, you can add or remove segments to or from a job, then submit the entire job to the queuing manager.

In this window, you can also add another job to the current job queue, assign a Job ID, set the job goal (double-click the field below Goal to display a drop-down list of goals), and set the job's priority.

Statistics Tab

The Statistics tab displays relevant statistics for your robots. Those statistics include:

- **FleetRobotInformation**: the number of robots currently connected to the Enterprise Manager (EM); their progress, and which are available and unavailable.
- **JobCounts:** the number of completed, canceled, and modified jobs and job segments.
- **LastTripReset:** the time (in sec), and human-readable date and time since last reset.
- **QueueInformation:** lists information about pending and in-progress jobs.
- **StateInformation:** information about the robots' states (driving time/distance, parking time, docking info, etc.).
- **TripJobCounts:** statistics related to the robots' job completion (number of completed, canceled, or modified jobs/segments).
- **TripStateInformation:** statistics about the robots' trips when completing jobs (distance driven or time spent at a particular job).

The MobilePlanner Menu

The MobilePlanner interface includes a menu bar to access to the tools for editing the robot's map file. It also applies to other non-map windows, provides tools for driving the robot, initiating scans, route building, and searching the Config, and importing/exporting Config files.

Figure 4-7: Menu Bar

The following table describes the menu bar selections.

Menu Option	Description
File	Allows you to open a local scan or map file, a map, scan, or configuration file on a mobile robot, save the map file, insert another map into the existing map file, and download or upload a files to/from a robot. For more details, see File Menu on page 61.
Edit	Allows you to undo or redo your last command. For more details, see Edit Menu on page 62.
Robot	Gives you control over various robot activities (stop, drive, dock/undock), allows you to monitor the robot dashboard and/or enterprise details; create custom commands; create an enterprise message of the day; and reload a configuration or stop the robot. For more details, see Robot Menu on page 63.
Map	Allows you work with and edit the displayed map file. For more details, see Map Menu on page 64.
View	Allows you to change the units used in the map, and turn the toolbar labels on and off. For more details, see View Menu on page 65.
Tools	Allows you to update map features and preferences. For more details, see Tools Menu on page 65
Window	Allows you to access the different files open in the workspace and change the way the windows in MobilePlanner are displayed. You can choose to tile them in the work-space or have them cascade. For more details, see Window Menu on page 66.
Help	Provides help on the MobilePlanner interface. For more details, see Help Menu on page 66.

File Menu

Menu Option	Description
Open...	Opens a dialog, to search for and select a local map or a scan file to open.
Open on Robot	Opens a submenu, which lets you select and open a file located on a particular robot or the Enterprise Manager (EM). • ***Robot Host Name or IP Address*** opens the login page, if the robot associated with that robot name or IP address is configured for authentication. This submenu shows a list of the most recently used robots or EMs. • **Select Robot...** allows you to open the login dialog box and choose a file located on a different robot. Displays the MobilePlanner Robot Login dialog box. Once you select a robot, you can search for and select a Map or Scan file (if available) to open. You can also access the Configuration and SetNetGo software on the robot.
Close	Closes the active file.
Import Config...	(Available when the Configuration Editor is selected.) Opens a dialog to import a robot configuration file into MobilePlanner.
Insert Map...	(Available when the Map mode tab is selected.) Opens a dialog to search for and select a local map file to open and insert into the active map file. Used for small changes to the physical environment that affect the robot's route, eliminates the need to rescan the entire workspace. See Inserting a Map File into an Existing Map File on page 120 for more information on this feature.
Save	Writes changes to the active file, and saves either onto a robot (if opened from a robot) or disk (if opened from a PC).
Save As...	Opens the Save As dialog. Used to save the active file under a different name and to a particular location on the local PC. Note that you can also save to different file formats (such as JPG or SVG). In those cases, the new file is not displayed in the editor.
Save on Robot	Opens a submenu for saving changes to a particular robot's map file. • ***Robot Name or IP Address*** opens the login page for the robot associated with that IP address. This submenu lists the five most recently used robots. • **Select Robot...** opens the login dialog box for choosing a different robot on which to save the map file.

	If configured for the robot, the MobilePlanner Robot Login dialog box displays. Once connected to the robot, you can save the map file. This menu option is only available in Map mode.
Download/Upload	Opens a submenu to transfer any type of file to and from a particular robot (most commonly, a sound file to use with 'play,' or playBackgroundSound'). • ***Robot Name or IP Address*** opens the login page for the robot associated with that IP address. This submenu lists the five most recently used robots. • **Select Robot...** opens the login dialog box for choosing a different robot on which to save the map file. The MobilePlanner Robot Login dialog box displays. Once connected to the robot, you can upload the map file to the robot or download a map file from the robot.
Exit	Closes the application.

Edit Menu

Menu Option	Description
Undo	Lets you undo the most recent action on the map file. This menu option is only available in Map mode. **NOTE:** Undo is unavailable if you saved the map.
Redo	Lets you repeat the most recent action that you undid in the map file. This menu option is only available in Map mode.

Robot Menu

Menu Option	Description
Stop	Stops the mobile robot when it is in motion.
Drive	Activates the Drive pad for driving the robot in its environment.  **CAUTION:** Toggle the Safe Drive button **ON** to prevent the robot from running into anything while you are driving it. if Safe Drive mode is disabled, the map background turns yellow, indicating "use caution" while driving. **NOTE**: With Show Robot turned ON, you can access robot drive icons from the Map view.
Dock	Sends the robot to a dock.
Undock	Releases the robot from the dock.
Monitor	(Same as the Monitor button in the map and robot tools menu). Allows you to view and/or configure various AIV details - battery info, digital inputs and outputs, audio, add and execute tasks, macros, and routes.
Debug	Allows you to trace underway tasks for debugging. **NOTE:** This is an advanced feature, used for debugging advanced functionality.
Custom Commands	Allows you to create and send custom commands to the robot, such as connection tests, debug log file starts and stops, and simple pop-ups (not an all-inclusive list - many other custom commands are available).
Map Creation	Allows you to start and/or stop the robot's scanning process, from which you can build a map file.
Messages	Allows you to create custom Enterprise and/or Robot messages of the day.
Robot Tools	Provides access to advanced robot tools, including localizing, reloading configurations, auto-docking, and issuing shutdown commands for a single robot or all robots in the fleet.
Safety Commissioning	Allows testing and commissioning (verification of proper function) of a robot's on-board safety systems. Uses a wizard to test E-Stop (tests brake activation) and Safety Laser (tests max speed limits and obstacle detection). Per EN-1525, Commissioning must be done by specially trained people. See Safety and Regulatory Information on page 25 for details on Safety Commissioning.

Map Menu

Menu Option	Description
Fit in Window	Adjusts the map so it all fits within the map window.
Grid	Displays the grid on in the map window. Grid line spacing is at 1 meter intervals. **NOTE:** The MobilePlanner grid is not the path planning grid or localization grid. It is simply for reference.
Origin	Displays the X/Y coordinates of the overall map. You must zoom the map view out to see the origin lines.
Robot Data	Allows you to control the display of various robot-related map features such as sonar, laser, path, and localization.
Map Data	Opens a submenu, which lets you toggle the features to view on the active map file: • Points • Lines • Lights (if using Acuity)
Rotate	Opens a submenu, which lets you rotate the entire map in the map window. • Rotate Right • Rotate Left • Rotate Full 180° • Reset to None You can also save the rotated map as the default orientation.
Legend	Keeps track of all of the different features available in the map file. Each feature is identified on the map with a different color rectangle or line. For more details, see Map Modes on page 76.

View Menu

Menu Option	Description
Units	Opens a submenu in which you can change map units. You can select: • Millimeters (default) • Meters • Feet/Inches • Inches The units apply to values displayed in the status bar, in map object edit boxes, and when using a measuring stick. See The MobilePlanner Toolbars on page 67 for details.
Toolbar Labels	Toggles toolbar labels on or off. To hide the labels, uncheck this menu option.

Tools Menu

Menu Option	Description
Update Map Features...	Opens a dialog box in which you can choose to update the current map.
Preferences...	Opens a dialog box with tabs for Comm and Computer ID parameters. • **Comm Tab:** Allows you to select Robot Server (from pick list), and set connection attributes for TCP/IP only, or Reuse login information when reconnecting. • **Computer ID Tab:** Includes a field that displays the name of the computer on which the MobilePlanner installation exists (e.g., "John Doe's Laptop"), and allows you to select the goal nearest the robot's current position. Click **OK** after making any configuration changes. Click **Reset...** reverts to initial installation-like state - resets all previous changes. Click **Cancel** to stop without making any changes.

Window Menu

Menu Option	Description
Tab	Arranges the open windows in tabs, just below the main toolbar. This is the default display mode.
Tile	Arranges the open windows as tiles, open next to each other.
Cascade	Arranges the open windows in a cascade, or waterfall, formation.
1:<*IPaddress*>:map	Contains a list of the open map and/or configuration files, or SetNetGo. Select from the list to make that the active window.
2:<*IPaddress*>:Configuration	
3:<*IPaddress*>:SetNetGo	

Help Menu

Menu Option	Description
About MobilePlanner...	Provides information on the current version of MobilePlanner.
About Qt...	Provides information on Qt, the toolkit MobilePlanner uses for the user interface.
Mobile Robot Software Suite User's Guide	Allows you to open a Windows type help version of this guide while using MobilePlanner software.
What's This?	Selecting this menu option, or using the shortcut Shift + F1, and then clicking on the MobilePlanner workspace displays a pop-up containing a brief description of some features.
Open Output Log Folder	Opens the folder containing saved MobilePlanner output logs.

The MobilePlanner Toolbars

There are three toolbars possible in the MobilePlanner interface:

- The main toolbar, which is located at the top of the MobilePlanner interface.

In Map mode only:

- The map toolbar, which is located above the map.
- The robot toolbar, also above the map.

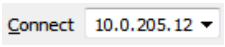
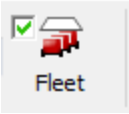
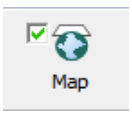
The following sections describe each set of tools.

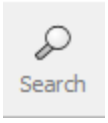
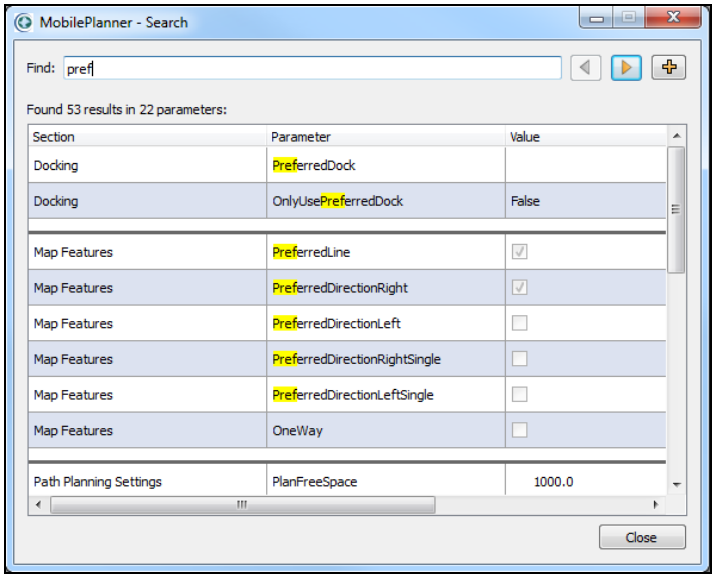
Main Toolbar

The MobilePlanner main toolbar is located at the top of the window, under the main menu.

Figure 4-8: Main Toolbar

The following table lists the toolbar icons and describes their functions:

Toolbar Icon	Description
	Connects to the robot or server at the specified IP address. Use the drop-down list to select a previously-used IP address, or type a new IP address directly in the field. When a robot or server is connected, this toggles to Disconnect.
	Opens the Fleet window, which shows status and job statistics for all robots in your fleet. It uses graphical icons to represent interrupted, canceled, in-progress, pending, and completed jobs. Click the checkbox to have the Fleet window open when you connect to a robot or EM.
	Displays the Configuration mode tab, which is used to set configuration parameters. For details, see Configuring the Robot on page 125. Click the checkbox to have the Config tab open when you connect to a robot or EM.
	Displays the Map mode tab, which is used to edit the map. For details, see Editing a Map File on page 114. Click the checkbox to have the map load when you connect to a robot or EM.

	Displays the SetNetGo mode tab, which is used to access the SetNetGo interface. For details, see Using the SetNetGo Software on page 87. Click the checkbox to have SetNetGo open when youconnect to a robot or EM.
	Saves changes to the active map or configuration file on the robot.
	Lets you undo the most recent action performed on the map file.
	Lets you restore the most recent item you undid in the map file.
	When MobilePlanner is in the Config mode, allows you to search all configurations for specific key words. Allows you to find parameters by name, or search for a specific word in a parameter's description (searching for 'preferred' in the example below). You can edit the Config values in the main tab, but not in the search results.  *Figure 4-9: Search window - searching for 'preferred'*

Robot and Map Toolbars

The map toolbars control the view of the map, set a goal at the robot position, and localize the robot. There are two different map toolbars available: one when the Show Robot button is toggled ON (the robot is displayed on the map); the other with the Show Robot button toggled OFF (and the robot is hidden from the map).

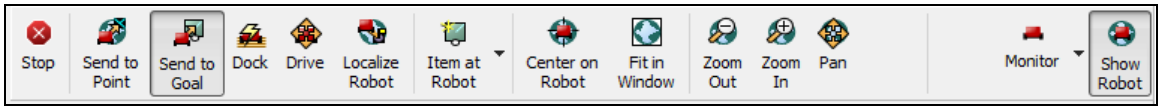


Figure 4-10: Robot Toolbar (Show Robot ON)

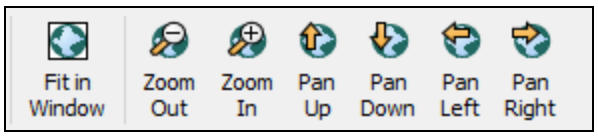
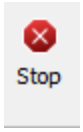
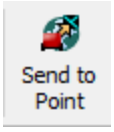
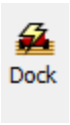
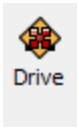
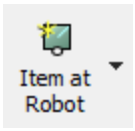
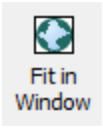
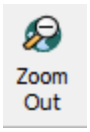
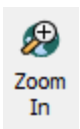


Figure 4-11: Map Toolbar (Show Robot OFF)

The following table lists the toolbar icons and describes their functions.

Toolbar Icon	Description
Some of the following icons are available when the Show Robot button is toggled ON, but are disabled if the robot cannot service the request because of low state of charge, or if E-Stop is pressed.	
	Stops the mobile robot any time you click this icon, even when navigating in autonomous mode. **NOTE:** You can also use your keyboard's **Esc** key to stop the robot.
	Sends the robot to a point you select on the map.
	Sends the mobile robot to a goal you select on the map.
	ON when the robot is on a dock or heading to a dock. Also sends the robot to a dock. When OFF, releases the robot from the dock.

	Opens the Drive pad, which is used to move the robot in its environment. Be sure that you have the Safe Drive button toggled ON, which prevents the robot from running into anything while you are driving it. Highlight (click on) the pop-up window, and use the mouse or the arrow keys on the keyboard to move the robot in the direction you want it to go.  **CAUTION:** When Safe Drive mode is disabled, the background of the map turns yellow, indicating "use caution" while driving.
	Opens the Localize Robot dialog, which is used to localize the robot to a point selected on the map.
	Allows you to create a goal and/or door with goals, place a cart, or place a dock at the robot's current location.
	Centers the map on the current robot. This is helpful when you have multiple robots in your workspace and you need to locate a specific robot quickly. It also allows you to watch the robot as it performs tasks and moves through its route.
	Adjusts the map view to fit in the map window.
	Zooms map out (reduced magnification, more map visible). **NOTE:** You can also zoom the map by using Shift + left click, or Shift + right click, or by clicking and holding either the right mouse button or scroll wheel, while moving the mouse around the workspace.
	Zooms map in (increased magnification, more details visible).
	Allows you to pan around the map. 1. Click on the **Pan** icon to display the Pan Map box.

	2. Click on any of the four arrows of the Pan Map box to move that direction in the map. The keyboard arrow keys perform the same function as clicking on the Pan Map arrows. **NOTE:** If Center on Robot is turned on, you cannot pan the map window. **NOTE:** You can also pan the map by clicking and holding either the right mouse button or scroll wheel, while moving the mouse around the workspace.
The Pan Up, Pan Down, Pan Left and Pan Right icons are available when the Show Robot button is toggled OFF.	
Fit in Window, Zoom In/Out	See descriptions above.

Using Monitor Robot

The Monitor robot feature is available only when the Show Robot button is toggled on. It provides a convenient place to monitor important robot details (battery info, state, job counts, sensors, and queuing stats), and the status of digital inputs/outputs.

It also provides a place for sending a robot on a route, adjusting audio input/output volumes, and inputting *Say* commands (phrases that the robot speaks with its text-to-speech converter).

To access the Monitor:

1. Click the **Show Robot** button to toggle it on.

   This exposes the Robot toolbar. For more details on the Robot toolbar, see The MobilePlanner Toolbars on page 67.

2. Click **Monitor** on the Robot toolbar to display a sub-menu with various robot attributes you can monitor.

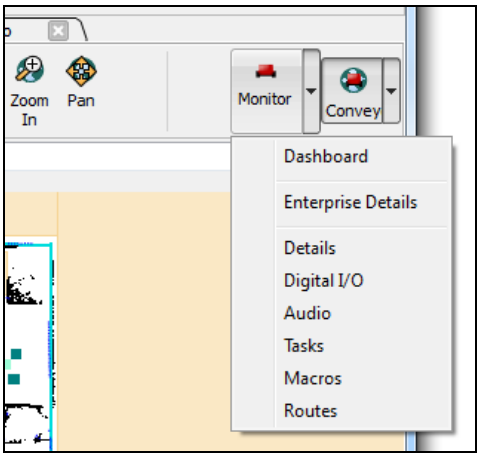


Figure 4-12: Monitor robot drop-down menu

The following table describes the various robot attributes you can monitor.

Item	Description
Dashboard	Displays an information window listing jobs (number of interrupted, canceled, in-progress, pending, and completed) and robots (that need assistance, had E-Stop pressed, busy, available, and unavailable).
Enterprise Details	Lists information about robots in the fleet - availability, status of assigned jobs, queuing and state information, system status, and memory use. **NOTE:** A robot must be in the Available state to be selected for a job.
Details	Lists specific details about the currently monitored robot - battery/charge stats, robot pose information, wireless data.

Item	Description
Digital I/O	Allows you to monitor custom input/output states, and toggle output states ON (green) or OFF (black).
Audio	Controls incoming and outgoing audio volume. Audio Incoming: MobilePlanner Out: controls the level out (for example, 'sendSpeech'). Audio (Output): Robot Out controls the volume of speech audio files the robot plays.
Tasks	Lists current tasks assigned to monitored robot, and allows you to add them to the selected route builder list (normally a goal versus a route).
Macros	Lists, and allows immediate execution of all existing macros.
Routes	Lists, and allows immediate execution of all existing routes.

Adjusting Audio Levels

The robot monitor also allows you to adjust the incoming and outgoing audio levels. These levels are set by the slide controls shown in the following figure.

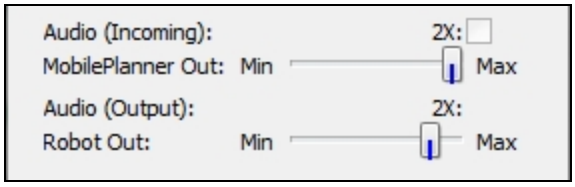


Figure 4-13: Audio Controls

You can adjust audio levels by moving the slide controls to the right (louder) or left (softer). You can also amplify the effect of the incoming audio control setting by selecting the 2X check box.

Making the Robot Talk

The monitor robot window includes a text-to-speech feature. You can use the "Say" field to input a word or phrase that you want the robot to speak.

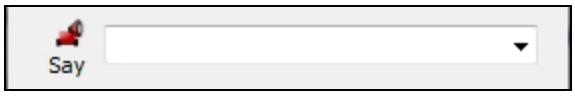


Figure 4-14: Say Controls

When you click the **Say** icon, the text is converted to synthesized speech through the text-to-speech converter.

The MobilePlanner Map Window

The MobilePlanner Map window displays the map file that you are editing. When you first start MobilePlanner, no map is displayed until you connect to a robot or Enterprise Manager appliance. You can also open a map saved locally on your computer or network. For details on opening maps, see Loading a Map File.

Below is an example of the MobilePlanner interface with a map file opened. Note that the Show Robot button is toggled OFF, which exposes the tools on the Draw function tab.

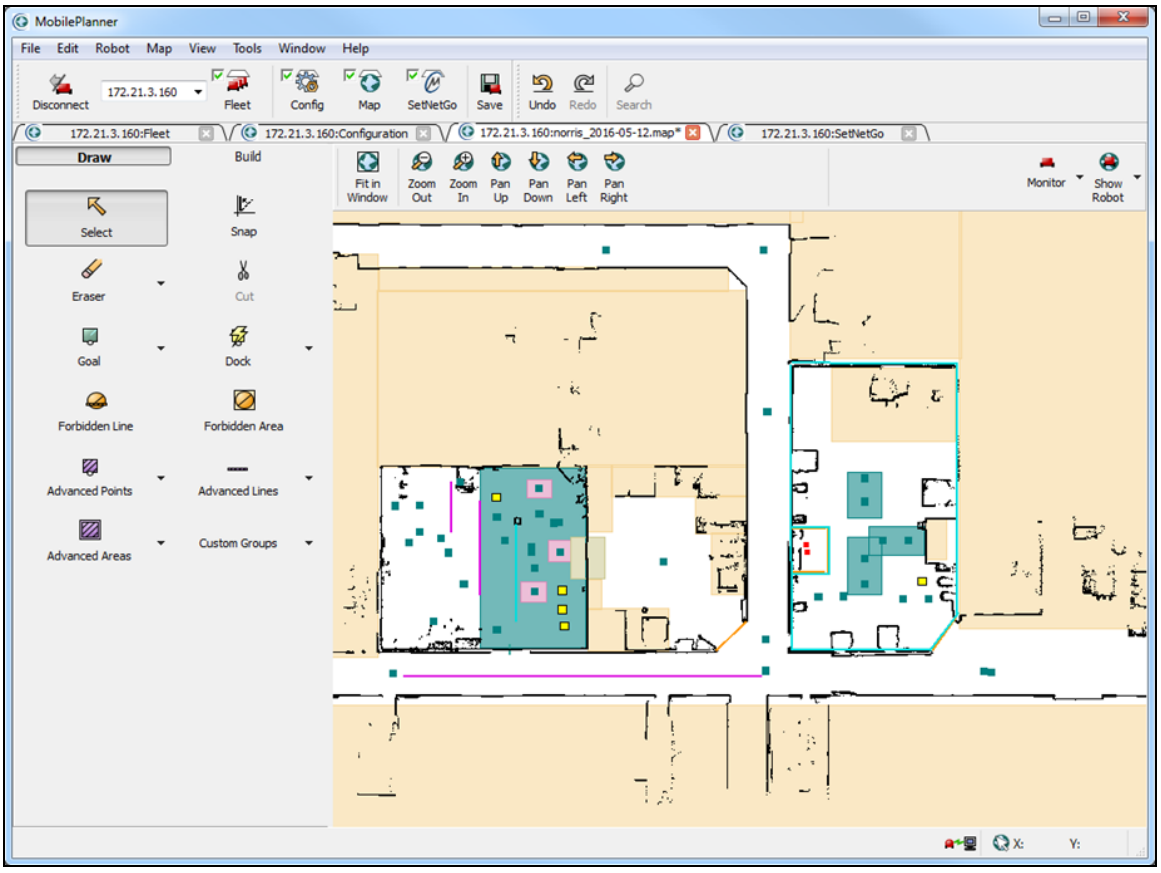


Figure 4-15: The MobilePlanner Interface, Map Tab, Show Robot OFF

> **NOTE:** To create the initial map, you must first use MobilePlanner to scan the robot's environment and then turn the scan into a map. For details, see Scanning Your Environment.

Map Zoom

Maps initially open zoomed out to give you an overall view of the robot's environment. To quickly find the current robot in the map, click the Show Robot button, then click Center on Robot. The map zooms in, focused on the robot.

> **NOTE:** The Show Robot button must be **ON** to display the Center on Robot icon.

Map Controls

You can use the mouse or the keyboard to adjust the map view. The following table describes the map controls.

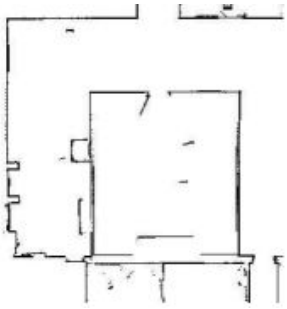
To...	Do this...
Pan	**Mouse:** press and hold the right mouse button (or use the scroll wheel), move the mouse around the workspace. **Keyboard:** use the arrow keys to move right, left, up and down. **NOTE:** You can't pan the map when the Center on Robot toolbar icon is toggled ON.
Zoom in	**Mouse:** press the Shift key and click the right mouse button; or you can rotate the scroll wheel forward (without the Shift key). **Keyboard:** press the Shift key and the Up arrow.
Zoom out	**Mouse:** press the Shift key and click the left mouse button; or you can rotate the scroll wheel backward (without the Shift key). **Keyboard:** press the Shift key and the Down arrow.

Map Features

Map features can be as simple as the static features of the environment (walls, doors, etc.) or, depending on the features you add to the map, they can be quite intricate. In general, more map detail improves robot navigation.

To create a detailed map of the environment, you need to scan the environment thoroughly and then edit the map. This is done in the MobilePlanner software. For more information on environment scanning and map editing, refer to Scanning Your Environment and Editing a Map File on page 114.

The following table describes the different features shown on the map.

Map Feature	Definition
	This rounded rectangle represents the robot. Notice that the black line indicates the direction the robot is currently facing.
	The black dots and lines on the map are the walls, doors, and other static fixtures in the environment.

Map Feature	Definition
	The blue dots and lines are the features the robot "sees" with its navigation laser. Some robots have additional lasers which produce different colored dots.
	The yellow squares represent the location where the robot should go, and the black line is the direction it should face, when it starts to dock. The dock object should be approximately 1 to 1.5 meters in front of the dock.
	The green squares represent a goal. The line indicates the robot's desired heading when it reaches the goal. Goals are predefined locations where you can send the robot.

Map Modes

When Show Robot is on, there are several map modes which provide a different robot function (see the following table):

Icon	Map Mode	Definition
	Send Robot	Allows you to send the robot to a certain spot on the map. When active, clicking on the map causes the robot to move to that spot. To activate this mode, click **Send Robot** on the Toolbar, then click on the map with the left mouse button to send the robot to that point. You can also send the robot by holding down the **Ctrl** key and clicking on the map. To specify the robot's desired heading when it arrives at the designated spot, press the mouse button and drag. To deactivate this mode, click the **Send Robot** icon to toggle it off. After you click a point on the map, the mobile robot (the red oval) autonomously drives to the point you selected.
	Robot Control	Allows you to drive or send the robot using the keyboard. To activate this mode, hold down the **Ctrl** key and press the arrow keys.
	Localize to Point	Allows you to localize (mark the robot's location) the robot on the map. See Robot Localization on page 193 for details.

NOTE: When Show Robot is OFF, the cursor shape indicates what your mouse click or movement will do (see the following table). These cursors are visible after selecting an object.

Cursor	Function	Appears when you...
	Open the Edit window (double-click), or drag the object within the map.	Double-click or click-and-hold on an object, other than on a heading marker or endpoint.
	Change the heading of a goal or dock, or resize a line.	Click on the goal/dock heading marker or either end of a line.
	Resize a rectangular object (the cursor is rotated 90° depending on which corner you pick).	Click on a corner of an area or sector.
	Rotate the object.	Click on the heading arrowhead of an area.

Map Legend

As you edit the map file, you can create goals, lines, forbidden areas, docks and many other features in the environment. Use the Map Legend to keep track of all of the different features that can be added to your map file.

Select **Map > Legend...** from the main menu to open the Map Legend window.

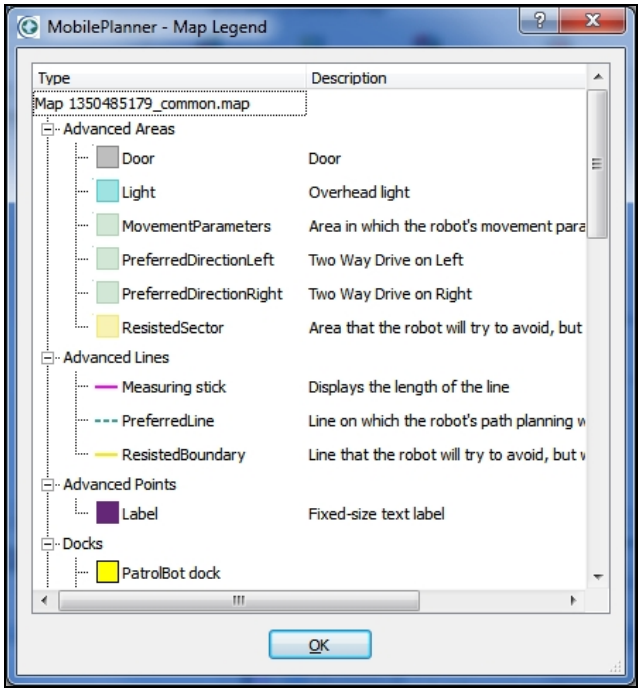


Figure 4-16: Map Legend

Draw Tab

You can use the Draw tab to add and edit map items (for details on map editing, see Working with Map Files on page 111).

> **NOTE:** The Draw tab is only active when the Show Robot button is toggled OFF.

The following table lists the toolbar icons and their functions.

Item	Description
	Select a feature (point, line, area, etc.) on the current map. The status bar on the bottom left side of the window displays information about the feature you selected. 
	Remove points or lines from the active map. Does not remove custom/landmark objects. 1. Click on the **Eraser** icon. 2. Use the pull down menu to select the eraser size from 5 mm to 10000 mm. 3. Click and hold the left mouse button, while moving the mouse over the points and lines you want to erase.
	Click **Goal**, then click on a map location to add a goal. In the Edit Goal dialog box you can: • label the goal • provide a description • select the type of goal (if available) • adjust the X/Y position and heading. You can adjust the heading after placement by holding the left mouse button down, and dragging around the goal. The heading will follow the cursor.
	Click **Dock**, then click in the map at the new dock's location. In the Edit Dock dialog box you can: • label the dock • provide a description • select the type of dock (if available) • adjust the X/Y position and heading. You can adjust the heading after placement by holding the left mouse button down, and dragging around the dock. The heading will follow the cursor.

 	Mobile robots will not cross forbidden lines, or enter forbidden areas. To add a forbidden line or area: 1. Press and hold the left mouse button. 2. Drag the mouse to create the line or area and to adjust the size. 3. Release the mouse button (the line or area remains selected). 4. Press and hold the left mouse button. 5. Drag the selected line/area to move its location on the map. 6. For an area, click and hold on the heading arrowhead, then drag to rotate the area.
	Allows you to measure distances, display a measuring stick, add Preferred or Resisted Lines, or a Map Data Line to your map.
	Place lines and rectangles to the x/y axis (or 45 degree angles). Deselect this button to draw or rotate at any angle. To temporarily toggle this button while drawing a line or rotating a rectangle, press and hold the Ctrl key. Release the Ctrl key after making the edit.
	Places special areas on the map that the robots will avoid entering or crossing (e.g., door swing sectors, need to enter sectors, resisted sectors, etc. To add an advanced area to the map: 1. Press and hold the left mouse button. 2. Drag the mouse to create the line or area and to adjust the size. 3. Release the mouse button (the line or area remains selected). 4. Press and hold the left mouse button. 5. Drag the selected line/area to move its location on the map. 6. For an area, click and hold on the heading arrowhead, then drag to rotate the area.
	Opens a submenu for adding a label to any advanced feature on the map. 1. Click on **Advanced Points**, then select **Label** from the submenu. 2. Click on a feature in the map you want to label, then use the Edit Label dialog box to enter a label, provide a description, and adjust the X/Y position and heading. **NOTE:** The label box is a special text box that does not scale when zoomed.

Using Advanced Lines and Areas

Advanced lines and areas (in **Config > Robot Operation > Map Features**) control the robot's behavior. You can alter traffic flow, restrict the robot from entering an area, and have the robot use a preferred route. For more information on creating these features and more, refer to Traffic Management on page 167.

Advanced Lines

Advanced Line	Definition
Measuring Stick	Places a line on the map to measure distances in the map. You can change the measurement units by selecting **View > Units** from the main menu.
Preferred Line	Places a line on the map representing the path that you prefer the robot use.
Resisted Boundary	Places a boundary line that the robot resists crossing. If there is no other way around an obstacle, the robot will cross a resisted boundary (though at a higher cost). For more information, see Cost Based Path Planning on page 171. You can adjust the amount of line resistance, which is preferred over a restricted boundary.
Restricted Boundary	Places a boundary line that the robot will avoid if possible.
Switchable Forbidden Line	Places a boundary line that you can control with tasks or through ARCL.

Advanced Areas

Advanced Area	Definition
Door	Places an area on the map to handle doors.
DoorSwingSector	Places a sector on the map that corresponds to a door's swing arc.
Door Virtual	Places a goal on the map for the robot to drive to before entering a door.
IgnoreLowLaser	Enables a sector in which the robot ignores low laser readings (e.g., for driving up and down ramps, crossing the threshold gap in an elevator, etc.).
IgnoreSonar	Places an area on the map that will disable the sonar sensors. This can be useful for crossing known thresholds, so the sonar doesn't prevent the robot from driving over the threshold. **NOTE:** If you have the low front laser, this section does not apply.
IgnoreTiltedLaser	Instructs the robot to ignore inputs from side-mounted lasers.

ManagedDestination	Allows use of multiple goals as a single destination to determine robot occupancy of the sector.
ManagedMotion	Limits the number of robots allowed to drive in an area (sector) at the same time.
ManagedMotionOverride	Makes contained robots appear to be driving. Used primarily in constricted areas.
Movement Parameters	Places an area on the map where you can change movement parameters, such as velocity, acceleration, and deceleration, in real time.
Need to Enter	Places an area on the map that the robot can drive to only if it is already in the area or a goal that it needs to drive to is in the area.
PathPlanningSettings	Places a sector that changes path planning settings.
PreferredDirectionLeft, PreferredDirectionRight	Places an area on the map that directs the robot to travel along the right or left side of the path, unless there is an obstacle in the way. The robot chooses the preferred side regardless of which way the robot is traveling. In other words, it follows the preferred side whether it is traveling up the hallway or down the hallway.
PreferredDirectionRight Single, PreferredDirectionLeft Single	Enable sectors that cause the robot to prefer driving on the left or right, in one direction only. Generally, the bi-directional PreferredDirectionRight/Left should be used instead. if two single direction sectors are placed next to each other, they must be aligned with care so robots do not collide. Using a preferred direction single tells the robot to travel along the right (or left) side of the path unless there is an obstacle in the way. The robot chooses the preferred direction in one direction only. In other words, the robot will prefer to travel on the right (or left) side only when it is traveling up the hallway.
SingleRobot	Places an area on the map that only a single robot can be in at any one time.
SwitchableForbiddenArea	Places an area on the map that can be controlled with tasks or through ARCL.
TaskSector	Places an area on the map that has a task list of what the robot will do immediately upon entering and exiting the sector.
VolumeAdjustment	Places an area on the map where the robot's audio output can be changed.

The Build Tab

The Build tab allows you to create macros, and add tasks for the robot to perform.

To display the route building tools, click the **Build** tab. The Build tools, shown in the following figure, are displayed on the left side of the map window. The Build tab displays two scrollable panes, each using tabs to organize the lists available for use.

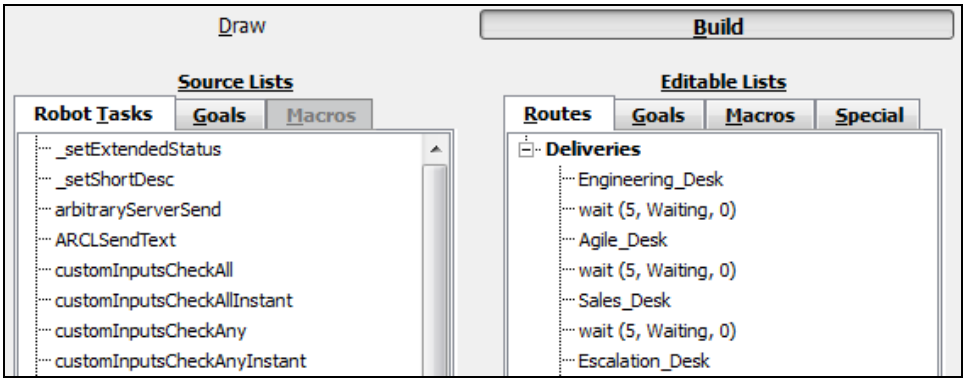
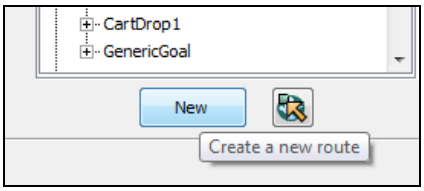
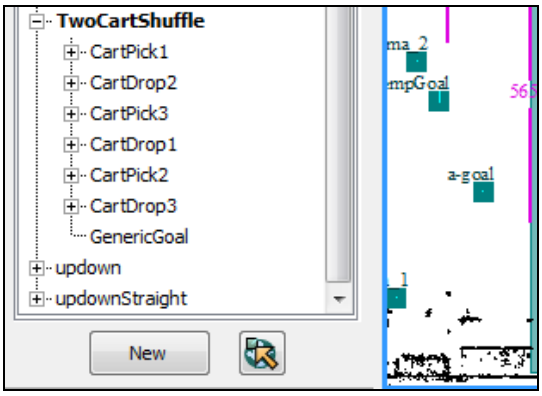


Figure 4-17: The Source Lists and Editable Lists Pane

The following table lists the toolbar icons and describes their functions.

Item	Description
Source Lists pane	Contains lists of robot tasks and goals that you can use to create macros or routes for the robot to navigate. You can also put macros in other macros as well. To view the different lists, select the appropriate tab.
Editable Lists pane	Contains lists of all current routes, goals, and macros. You can also add new tasks the existing lists that tell the robot what to do in certain circumstances, such as after reaching a goal, when docking, and when specific event occur, such as bumping into something.
	If the MobilePlanner workspace is filled with multiple windows and some tabs are not visible, move between tabs using the arrows.
New Route/Macro Button 	Creates a new route and/or macro (depending on which window in which you are working), and adds it to the Routes tab. 

Item	Description
Pick Goal Button 	When ON and a route is selected, lets you click goals on the map, to add to the route. After adding the goals to the route, you can drag the goals up/-down to set their order. 

For more information on creating tasks, goals, routes and macros, see Using the Route Builder on page 152.

MobilePlanner Status and Tray Displays

The status and tray displays allow you to monitor the status of the robot (or robots) directly from the software interface.

Status Information

The status of the selected (red) robot is displayed directly beneath the map, as shown in the following figure.

NOTE: In MobilePlanner, the Status area is only visible when the Show Robot button is toggled ON.

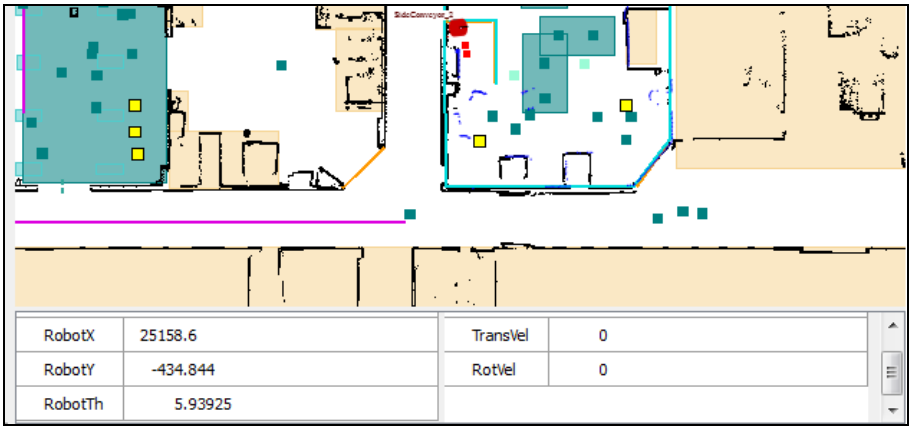


Figure 4-18: Status Information

The following table describes some of the available status information.

NOTE: By default, the status area shows only a small sub-set of available robot details. To view other data, see Displaying Other Robot-Specific Details (below).

Status Detail	Description
RobotX and RobotY	The current X and Y position of the robot in its operating space.
RobotTh	Robot theta - the robot's heading (which way it's facing), in degrees, measured counter-clockwise. 0 is the x axis.
TransVel	The velocity of the robot.
RotVel	The robot's rotational velocity (how fast it is turning).

Displaying Other Robot-Specific Details

There are many other robot-specific parameters you can choose to display in the status area. To view and/or add other robot details, in the MobilePlanner main menu, select **Robot > Monitor > Details**.

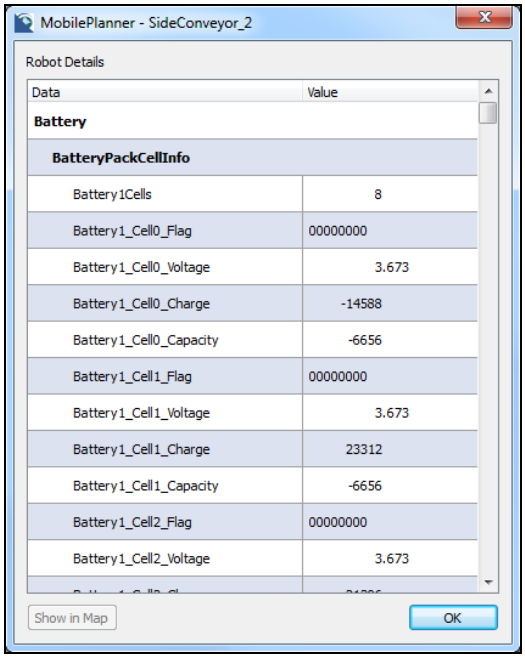


Figure 4-19: Robot details window

If you want to add a detail to the status area, click on the detail, then click the **Show in Map** button (lower left corner). Or, you can right-click in the status area to Hide in Map.

Tray Information

Below the status area, there is a tray that contains information such as connection status and the pointer location.

> **NOTE:** The tray information is always visible.

Figure 4-20: Tray Information

The following table describes the items available in the tray.

Tray Icons	Description
	Displays the temperature reading of the current robot.
	Indicates the state of charge (in %). The icon turns yellow when the charge begins to run low, flashes red when the battery is low and the robot needs to dock.

Tray Icons	Description
	Status of the wireless connection from MobilePlanner to the robot/EM.
X:	Shows the X position of the pointer.
Y:	Shows the Y position of the pointer.

Chapter 5: Using the SetNetGo Software

The SetNetGo OS resides on the mobile robot and EM (optional for a single robot, required for a fleet of robots using a shared space), and sets the configurations for certain onboard systems, such as wireless communication settings.

You can access SetNetGo either from the MobilePlanner SetNetGo interface, or directly on the robot using a secure web-based server. If needed, your organization's IT group can configure your wireless Ethernet for you, without needing the dongle to run the MobilePlanner software.

Overview of the SetNetGo OS

The SetNetGo software allows you to configure certain on-board systems, such as the Ethernet interface settings, serial and TCP port-forwarding, and to perform systems diagnostics, such as examining and retrieving log files.

Connecting to SetNetGo

The recommended way to connect to the SetNetGo OS is through the SetNetGo interface in the MobilePlanner software.

Connecting to SetNetGo via web browser:

You can also access the SetNetGo software via a web browser (such as Chrome, Firefox or Internet Explorer) if, for example, your IT department is helping with network configurations, or you don't have access to your laptop with MobilePlanner installed on it.

> **NOTE:** Web browser access must be enabled in **SetNetGo > Security tab > SetNetGo Access**.

To do this, connect one end of a CAT 5 Ethernet cable to your computer (which you have set to IP address 1.2.3.* (not 4)), then connect the other end directly to the robot's Ethernet Maintenance Port. The robot's maintenance Ethernet address URL: https://1.2.3.4, and uses no user name or password.

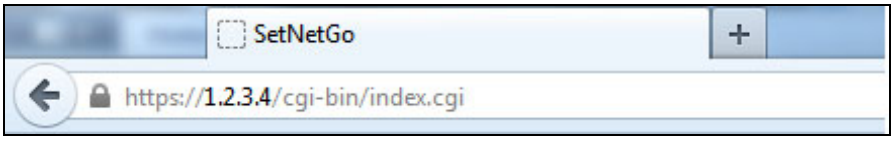


Figure 5-1: Browser URL address

> **NOTE:** You can ignore the SetNetGo certificate error. Click "**Continue to this website (not recommended)**." to display SetNetGo.

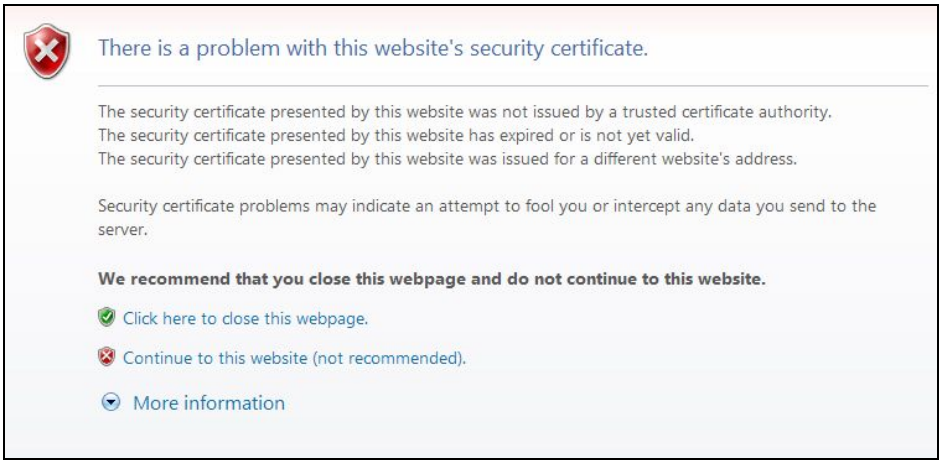


Figure 5-2: Browser certificate warning

Using the SetNetGo Interface

The SetNetGo OS resides on the mobile robot and Enterprise Manager(EM), and is accessible through the SetNetGo interface in MobilePlanner.

NOTE: If you are unable to access MobilePlanner, you can still access SetNetGo by connecting your PC directly to the robot's Ethernet Maintenance Port (using CAT5 Ethernet cable). Or, you can launch a Web browser (if Web Availability is enabled in **SetNetGo > Security tab > SetNetGo Access**), and entering the URL **https://1.2.3.4** (the robot's maintenance Ethernet address).

The SetNetGo start-up screen (from MobilePlanner) is shown below.

NOTE: If you need to request support, click the Download debug info button to obtain a debug file for troubleshooting.

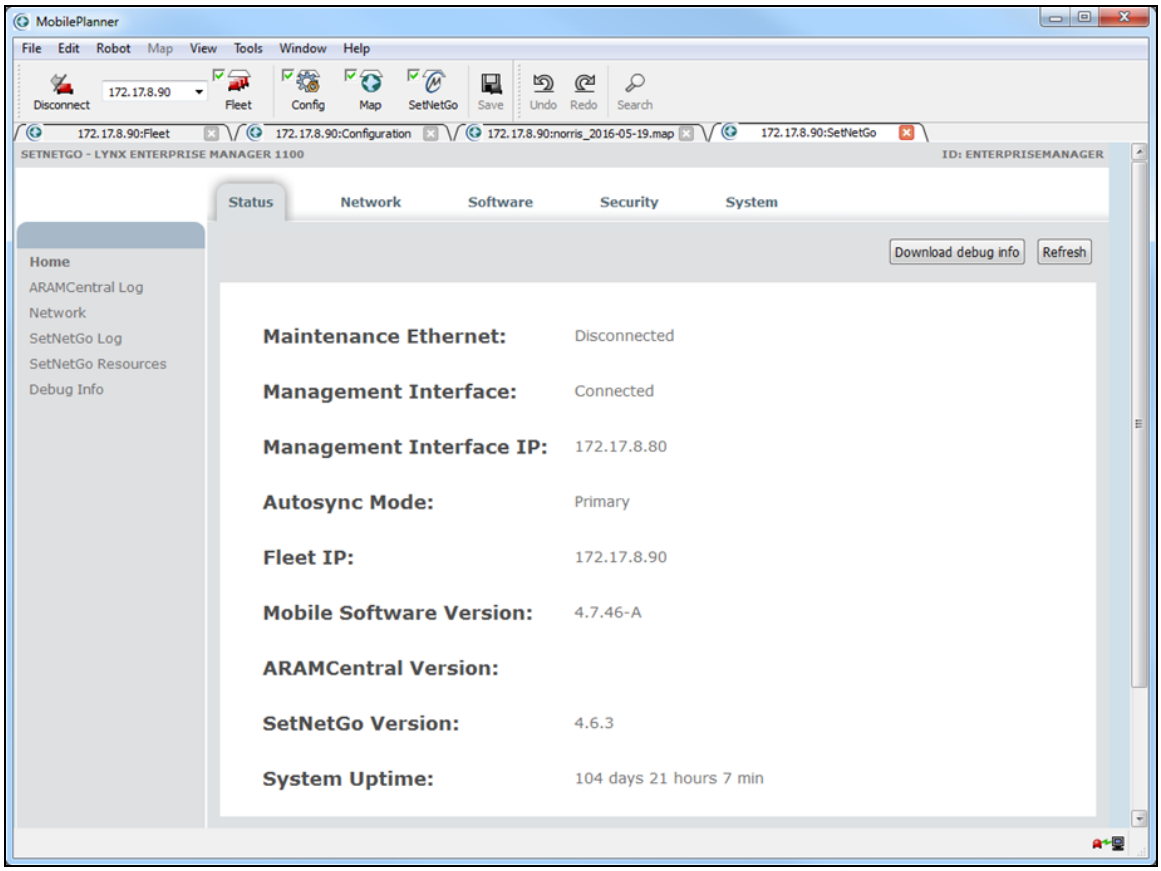


Figure 5-3: SetNetGo interface

The SetNetGo menu, shown at the top of the screen, consists of the following tabs:

Menu Option	Sub-Menu Option	Description
Status	This menu option displays various logs and status updates. See Viewing the Status Logs on page 93 for details.	
	Home	Returns you to the SetNetGo home screen.
	ARAM (robot) ARAMCentral (EM) Log	Gives the option to display the entire ARAMCentral log, the last 200 lines, or continuous refresh displaying the last 200 lines of the ARAM log within SetNetGo. It also allows you to view the current log file or download of the last 7 log files.
	Network	Displays the current status of network interface, the wireless interfaces status and the routing table.
	SetNetGo Log	Displays the SetNetGo log file.
	SetNetGo Resources	Displays status of your resources, including processes currently running on the robot or EM, Kernel Log, Disk Usage, Memory Usage, the Interrupts table, IO Memory usage and IO Port usage tables, and USB Devices.
	Debug Info	Downloads a .zip file containing detailed information on system status for troubleshooting. **NOTE:** Download a debug file before requesting support.
Network	Configurations for setting up your network. See Network Tab on page 94 for details.	
	Wireless Ethernet	These parameters allow you to enter static or dynamic IP settings (IP Assignment and Address, Netmask, Gateway, and DNS1); select a WiFi network; configure security settings (i.e., encryption and authentication); and configure Radio settings, including Watchdog Timer.
	User LAN Ethernet	This screen has settings for interface mode, IP Address, Netmask, DHCP Server for Accessories, and DHCP IP Range. If you are using an Enterprise Manager or a network-based hardware accessory for a mobile robot, you must set up a wired Ethernet port. Use Accessory mode (default) for individual mobile robots, and server mode with an Enterprise Manager.
	RS-232 Port Forwarding	Forwards a custom TCP port on the wireless Ethernet interface to an RS-232 port on the robot's core. The TCP port and serial port settings are configurable.

	Ethernet Forwarding	Supports forwarding a custom TCP port on the wireless Ethernet interface to a custom TCP port on an IP address of a device connected to the User LAN interface. The TCP port numbers and IP address are user-configurable.
	Utilities	Use this tab to ping a specific IP address, initiate trace route (display packet path), and display the ARP table (correlate MAC address and corresponding IP address).
Software	Configurations for ARAM settings (including install new ARAM version)	
	ARAM Settings	Change advanced settings for recovery, such as reverting the configuration back to defaults.
	Manage Installed Software	This tab displays current versions of installed software, with options to view release notes, restart, uninstall, or disable application(s), and view runtime logs. Also allows you to download MobilePlanner, and update the mobile software.
Security	Manage user accounts and robot access (disabled by default).	
	ARAM Access Control	This tab allows you to enable or disable access controls that restrict who can access to robots and Enterprise Manager with MobilePlanner. Disabling removes access controls. If enabled, allows you to specify specific access controls for admins, MultiRobot access, and certain users (click the Modify Permissions link to the left of Delete, under Apply to view the default permissions for each user). You can also add new users to the access list.
	SetNetGo Access	Allows you to enable or disable Web availability via Wireless/User LAN interface, and set access password.

System	Manage date/time, upload new SetNetGo OS, conduct backup and restore operations.	
	Date/Time	Set time, zone, and NTP Server. **NOTE:** The robots will automatically synchronize with an EM. Use NTP on the EM or for single robot operations.
	Upload SetNetGo OS	Upload and install a new SetNetGo version. **NOTE:** The system can store two different OS images. You can select which version to load into each slot, and choose which is the bootable image.
	Backup/Restore Options	Allows you to configure restore settings (from the same, or a different robot), set a new backup restore point, or revert to a different restore point.
	Reboot	Allows you to reboot the robot's computer (core) or Enterprise Manager (EM). Normally not a visible option unless enabled by checking the Remote Reboot radio button in **SetNetGo > Security > SetNetGo Access**.  **CAUTION:** Rebooting the robot's core interrupts all robot operations, and could cause damage to the robot. Rebooting the EM will disrupt all jobs and robots.

Viewing the Status Logs

SetNetGo keeps track of various robot activities, including ARAM, networking, and resource use. This information is stored in status logs that you can view through SetNetGo.

To view the status logs:

1. Connect to SetNetGo through the MobilePlanner SetNetGo interface.
2. Select the **Status** link at the top of the SetNetGo screen.

   The SetNetGo Status screen appears as shown in the following figure:

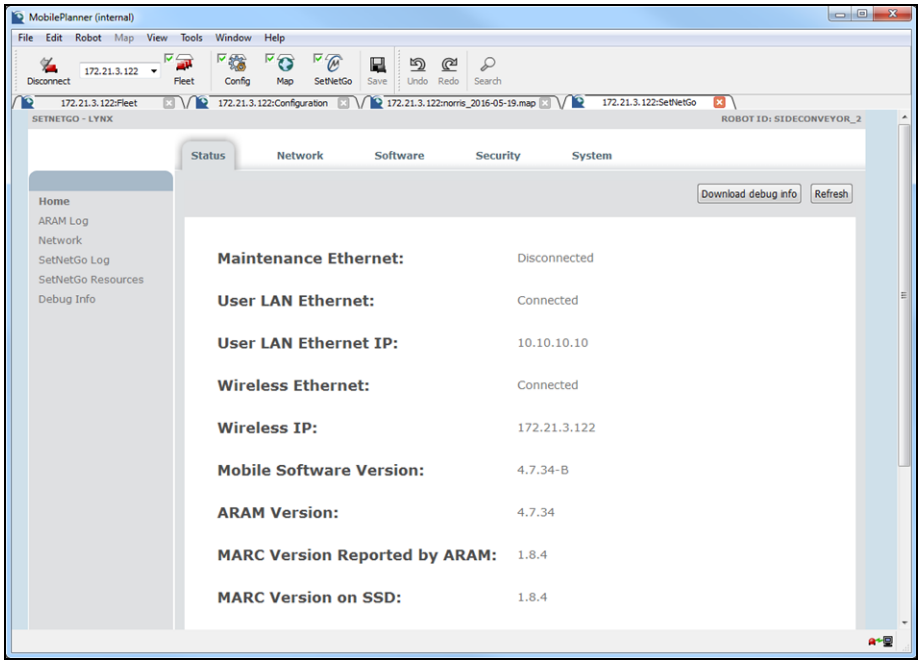


Figure 5-4: SetNetGo interface

> **NOTE:** The Download debug info button is critical for taking a backup of the current configuration, and providing this information when requesting support.

The status logs you can view depend on whether you are connected to SetNetGo through an Enterprise Manager or a single mobile robot. Generally you can view the following type of status logs:

- ARAM (on the robot), ARAMCentral (on the EM1100)
- Network
- SetNetGo Log
- SetNetGo Resources
- Debug Info

Network Tab

Use SetNetGo to configure the mobile robot's network settings. For remote access to your mobile robot, you should set up a static IP address. If you are not familiar with setting up a network or do not have an assigned IP address for the robot, please refer to your system administrator.

> **NOTE:** After changing a value in each SetNetGo screen, you must click **Apply** before switching to another sub-screen, or those values will not be saved.

To configure your mobile robot's network settings:

1. From the MobilePlanner SetNetGo interface, connect to SetNetGo.
2. Select the **Network** link from the top of the SetNetGo screen.

   The SetNetGo Network screen appears as shown in the following figure.

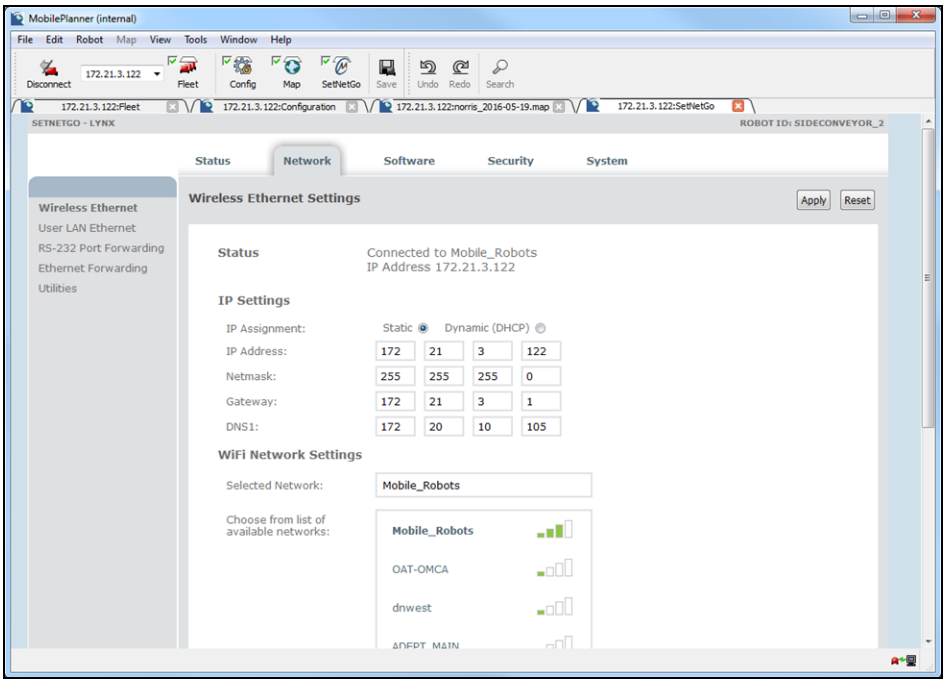


Figure 5-5: SetNetGo interface - Network tab

Wireless Ethernet Settings

Select **Network > Wireless Ethernet** to set up the wireless Ethernet interface. The table below describes the parameters that you can modify.

Wireless Ethernet Menu	
Parameter Setting	**Definition**
IP Assignment	Select the Static radio button to set a known IP address. You can also use DHCP, but a static IP address is recommended.
IP Address	Enter the IP address assigned to the mobile robot you want to access.
Netmask	Enter the Netmask.
Gateway	Enter the Gateway address.
DNS1	Enter the DNS1 address or leave it as 0.0.0.0 to disable.
WiFi Network Settings	
Selected Network	Displays the wireless network to which you are currently connected. **NOTE:** Clicking on a network name in the list will automatically populate the encryption and authentication fields.
Network list	Displays a list of available WiFi networks.
Security Settings **NOTE:** The fields listed below will change based on the security method you select, and could include username, password, private key (download or create new)/key length, hostname, and certificate (choose an existing or upload new). If unsure about settings, ask your IT department for assistance.	
Encryption	Set this to match the encryption method that is used on your network. Options are 64-bit or 128-bit WEP, TKIP/RC4, CCMP/AES, and TKIP/CCMP/AES.
Authentication	Set to match your authentication type. Use OPEN (default) when using no authentication or when using WEP. Select WPA-PSK for WPA Pre-shared key, PEAP-MSCHAPv2, or EAP-TLS.
Pre-Shared Key (PSK)	If using WPA/WPA2-PSK, enter the shared key in this field.
Key Type	Select from (click the radio button) Passphrase (8-63 ASCII only), or Raw Hex (64 Hex only).

Radio Settings	
Mode	Set to Managed/STA to operate as a standard wireless client.
Radio Mode	Select the mode that your network uses: 802.11a, 802.11b, or 802.11g. Select Auto to allow the robot to choose the most suitable channel (may lead to longer roam times).
Channel Set	Set to match the channels that are used at your site or leave them all selected (default) to allow the robot to find the most suitable channel. Roam times will be faster if there are fewer channels selected.
802.11b/g Channels (2.4 GHz)	Use this list to select a specific WiFi channel (1 through 13) in the 2.4 GHz range
802.11a Channels (5GHz)	Use this list to select a specific WiFi channel (36 through 165) in the 5 GHz range
Wireless Log Level	Determines the level of WiFi scanning detail in log files and debug info. Default is Normal. Set to **Verbose** for debugging efforts. If set to Verbose, log files cover a much shorter period of time. Recommend leaving at **Normal**.
RSSI Roam Threshold	Determines the frequency of background scanning. Default is 50. If signal strength is higher than the threshold, scanning happens at 10X the Background Scan Interval. If signal strength is below the threshold, scanning occurs every Background Scan Interval seconds.
Background Scan Interval (sec)	Works with the RSSI Roam Threshold to determine how frequently the robot performs background scanning. Default is 3 seconds (recommend leaving at default)
Watchdog	If enabled, automatically pings the Enterprise Manager (if used) or the gateway IP address. If successive pings fail for Watchdog Timer seconds, the robot automatically resets the wireless interface.
Watchdog Timer (sec)	If pings to the EM fail consecutively for Watchdog Timer seconds, the wireless Ethernet interface automatically resets and attempts to reestablish communications.

User LAN Ethernet Settings

This section allows you to set the IP address

User LAN Ethernet Settings	
Parameter Setting	**Definition**
Interface Mode	Use to set up a wired accessory interface (e.g., Acuity or the touchscreen) for the mobile robot. This mode allows you to connect network-based, hardware accessories to the jack. Onboard accessories will be able to communicate with the software running on the robot's core, and reach the rest of the network via the robot's wireless interface.
IP Address	Set the IP address for this interface. Select a subnet that does not conflict with settings on the wireless Ethernet interface.
Netmask	Enter the Netmask.
DHCP Server for Accessories	Disable or enable (default) a DHCP server for an accessory on the robot. **NOTE:** You must enable this parameter for both Acuity and the touchscreen (for more information on these options, see the *Mobile Robots - LD Platform Peripherals Guide.*).
DHCP IP Range	Allows you to set the DHCP IP range for the address automatically assigned to the accessories.

Port Forwarding

If your robot's payload has devices connected to the User LAN or Serial (RS-232) port, you can forward those ports and make the payload's device accessible via WiFi. Configure both RS-232 and Ethernet port forwarding in SetNetGo in the **Network** tab.

RS-232 Port Forwarding

Controls forwarding serial data to a TCP port on the wireless and internal wired Ethernet networks. You can link an internal serial device and route it to an external port at a defined baud rate. This is useful for RS-232 devices connected to the robot's core, an accessing them over WiFi.

Ethernet Forwarding

These settings forward a TCP port on the User LAN Ethernet interface to a port on the Wireless Ethernet interface. The Internal IP Address is the IP address of the device connected to the robot core's User LAN connection. Internal and External port setting route the Ethernet connection through WiFi.

Utilities

These tools allow you to view the ARP table, and ping or run a trace route to a specific IP address.

Software Tab

The SetNetGo software tab has settings for ARAM, and to Manage Installed Software:

ARAMCentral/ARAM

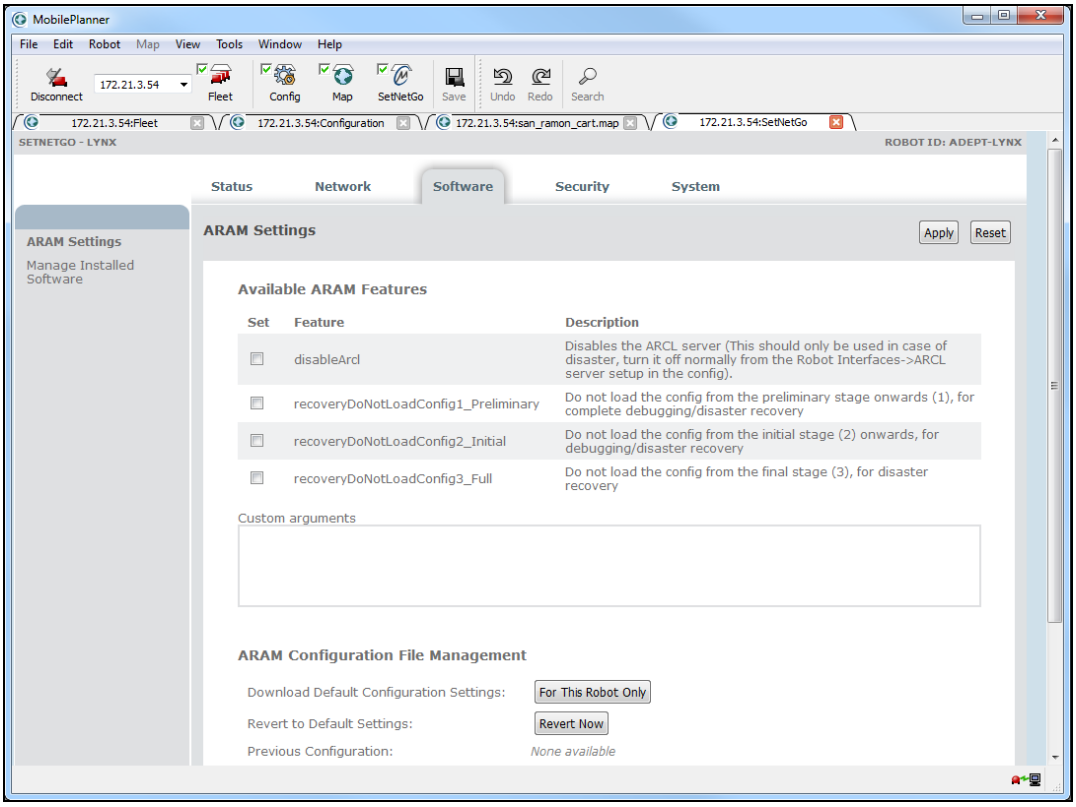


Figure 5-6: SetNetGo, Software tab - ARAM Settings

- ARAMCentral Settings (main software on the EM) - configure ARAMCentral's features (disabling ASync logging, disabling ARCL, and disaster recovery settings.
- ARAM Settings (main software on the robot) - configure ARAM's features (disaster recovery settings).

Manage Installed Software

The settings in this section allow you to view current versions and status (for example, Enabled Running, or Disabled Not Running) of software installed on the EM or robot, upload.

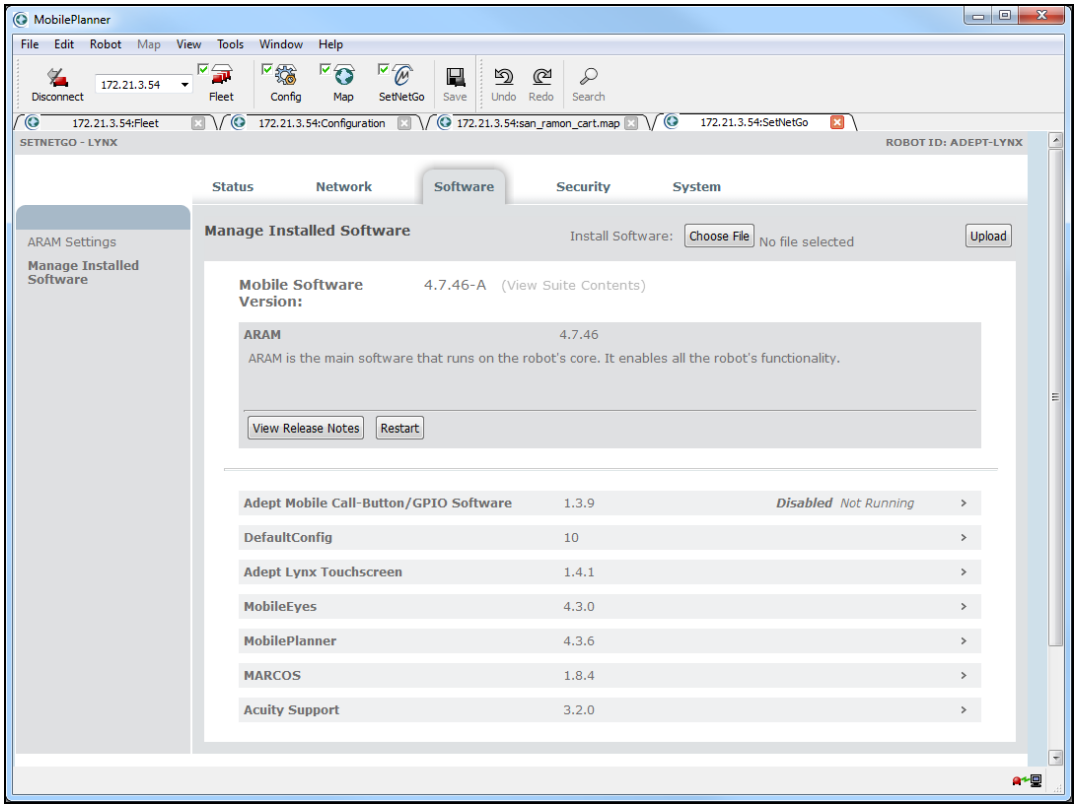


Figure 5-7: SetNetGo, Software tab - Manage Installed Software

You can also use the functions on this tab to restart, disable, install and/or uninstall MobilePlanner software, the MARC microcontroller firmware, and (for robots configured with Acuity) the Acuity Support package.

Uploading, Backing up, and Restoring SetNetGo

Through MobilePlanner, you can upload (upgrade to) a new version of SetNetGo by simply choosing the proper file.

Your upload options allow you to choose whether to upload a new version of SetNetGo into the Boot Image A slot (which is the default image slot), or the Boot Image B slot (which you then have to make bootable), or have versions in both slots.

In case of a software failure, you can also restore SetNetGo from a file maintained on the same (or a different) robot. You can only restore to a specific restore point on a robot (identified by its date/time), but only from the last restore point, and only on that robot.

Uploading a New SetNetGo OS

1. In the MobilePlanner tool bar, click the **SetNetGo** button, then click the **System** tab, then click the **Upload SetNetGo OS** menu item (left-side pane).

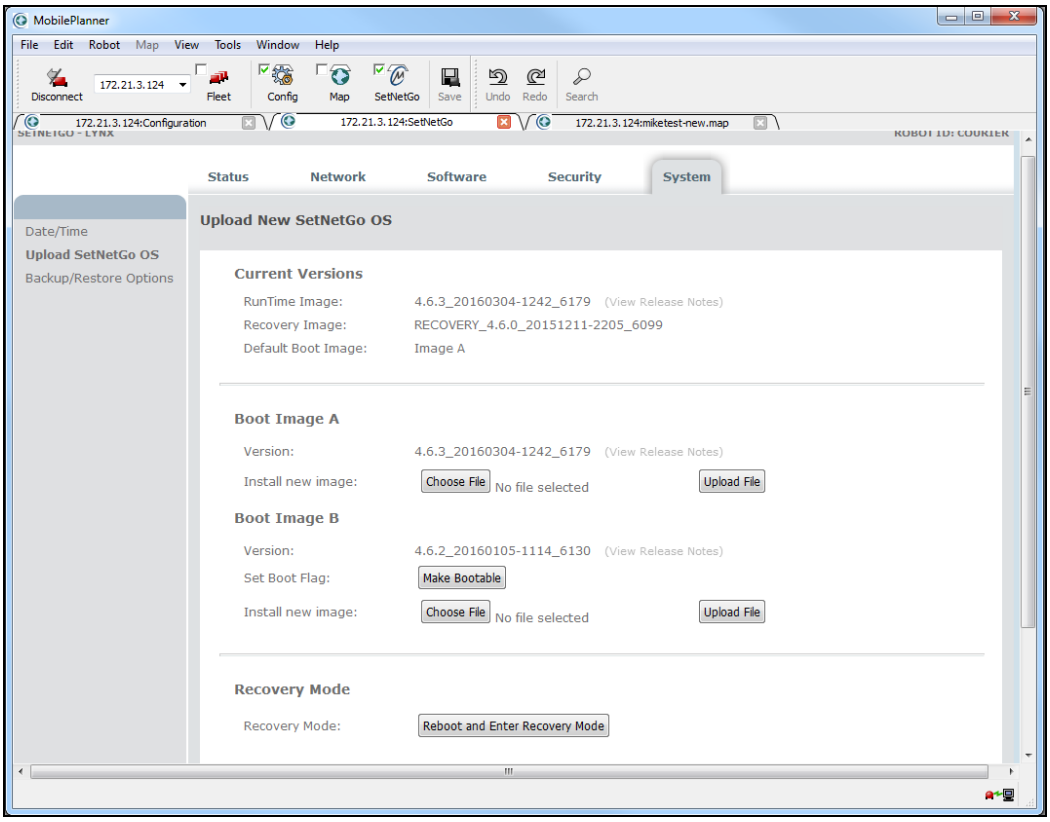


Figure 5-8: SetNetGo, System tab

The Upload New SetNetGo OS page, Current Versions field, contains information about the current installed version (with option to view its release notes), and which image is the current bootable image (Image A in the example above).

2. To install a new SetNetGo version into the Boot Image A slot, click the **Choose File** button, and browse to the location of the new image file. To upload a file, click the **Upload File** button.

> **NOTE:** Clicking the Upload File button will upload a new SetNetGo package, which will overwrite the existing image in the Boot Image A slot, and ask you to confirm before proceeding.

3. Click **Open** when done.
4. To install a new image file into the Boot Image B slot (and make it bootable), click the **Choose File** button then, when you've chosen the file, click the **Make Bootable** button.

Backing Up and Restoring SetNetGo

As with any system, it's a good idea to back up your system files frequently, especially after making configuration changes. After backing up, you then have a file from which you can restore your system back to working condition if a version becomes corrupted, if you swap robot cores, or add a new robot to your fleet that's identical to the others.

Creating a restore point

When you back up your system, the resulting file is date and time stamped with the current day and time of backup, and becomes a specific restore point (overwriting the your previously saved restore point).

1. In SetNetGo, click the **System** tab, then click the **Backup/Restore Options** item.
2. In the Restore-Point field, click the **Backup now** button.

   The following advisory dialog appears.

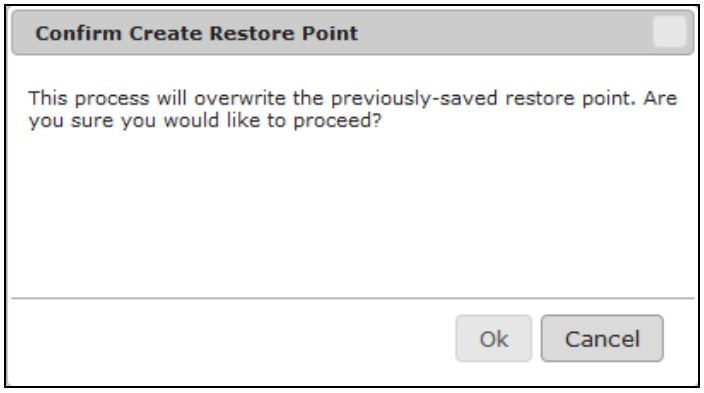


   Figure 5-9: SetNetGo Create Restore Point dialog

3. Read the confirmation then, if sure you want to proceed, click **Ok**.

Reverting to a Restore Point

Reverting to a previously saved backup (restore point) takes your robot's core back to its configuration as of the date and time of the restore point file you select. During the restore, you will lose your connection to MobilePlanner while the restore process resets your configurations.

1. In SetNetGo, click the **System** tab, then click the **Backup/Restore Options** item then, under the Restore-Point heading, click the **Restore Now** button.

   The following advisory dialog appears:

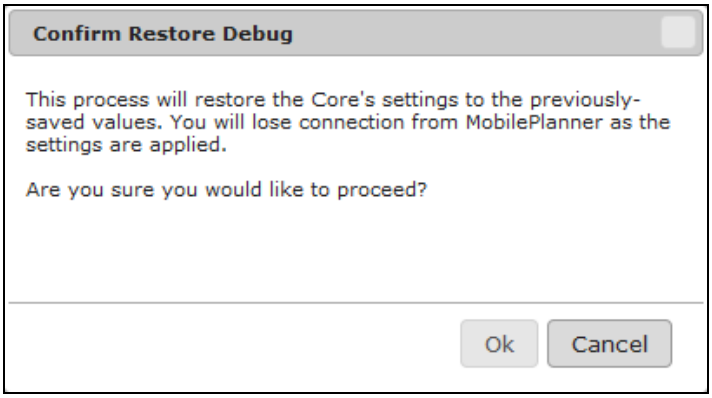


Figure 5-10: SetNetGo Confirm Restore dialog

2. Read the confirmation then, if sure you want to proceed, click **Ok**.

   The selected file overwrites the previous settings in the robot's core, and the robot disconnects from MobilePlanner. After the restore is complete, you can reconnect to the robot.

Restoring Settings from DebugInfo File

If you swap a robot's core, and want to update the new core with all of the existing configuration info from that robot onto the new core, you would use the **Restore from same robot** option. This process does not overwrite other software on the core; you should verify those software versions.

> **NOTE:** The Restore from same robot option does not include WiFi credentials (i.e., key, passphrase, certificates) or overwrite currently existing versions of other software (you should determine which versions to use).

If you have a fleet of one type of robot and are adding another robot of that type to your fleet, you would use the **Restore from different robot** option. This feature gives a quick method of configuring the new robot so it performs identically to the others.

> **NOTE:** The Restore from different robot option does not change IP address or robot calibration data (including robot identifier). After using this option, you will need to re-set your robot's WiFi, IP address, and identifier.

1. In SetNetGo, click the **System** tab, then click **Backup/Restore Options** from the list on the left.
2. Under the Restore Settings from DebugInfo File heading, click **Choose File** for either the Restore from same robot option (see explanation above for example use case), or the Restore from different robot option (see explanation above for example use case).
3. In the Open window, browse to and select the file you want to upload, then click **Open**.
4. Verify the correct file name appears next to the Choose File button, then click the **Upload** button.

   The following advisory dialog appears:

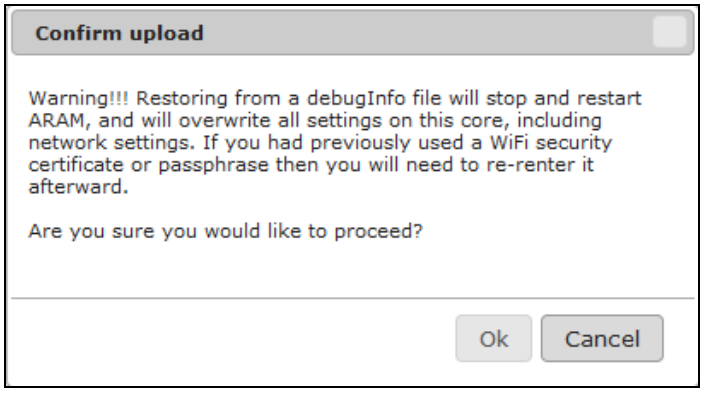


Figure 5-11: SetNetGo Confirm Upload dialog

5. Read the confirmation then, if sure you want to proceed, click **Ok**.

> **NOTE:** Both of these processes creates a new restore point.

SetNetGo Recovery Mode

If your system experiences a serious software malfunction, you can reover

1. In SetNetGo, click the **System** tab, then click on the **Backup/Restore Options** item.
2. At the bottom of the window in the Recovery Mode field, click the **Reboot and Enter Recovery Mode** button.

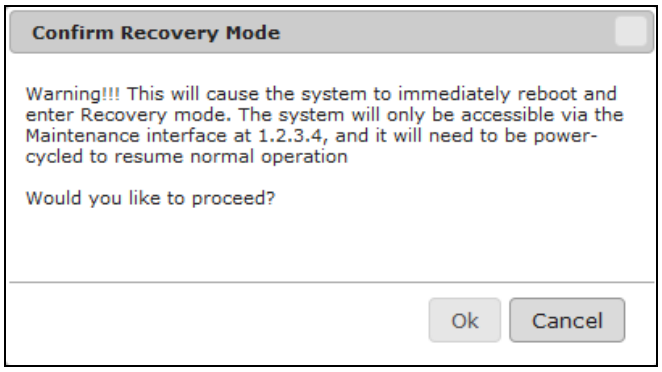


Figure 5-12: SetNetGo Recovery Mode

3. If you are certain you want to proceed, click **Ok**.
4. After the system reboots into recovery mode, power the robot down, and follow normal start-up procedures.

Configuring ARAM

This section covers using the SetNetGo to set up and manage accounts, and to update the ARAM software.

Setting Up User Accounts

The SetNetGo Security tab allows you enable or disable access control for accessing robots and Enterprise Manager (EM) via MobilePlanner. This allows you to restrict users from performing specific tasks.

1. From MobilePlanner, click the **SetNetGo** button, then click the **Security** tab.

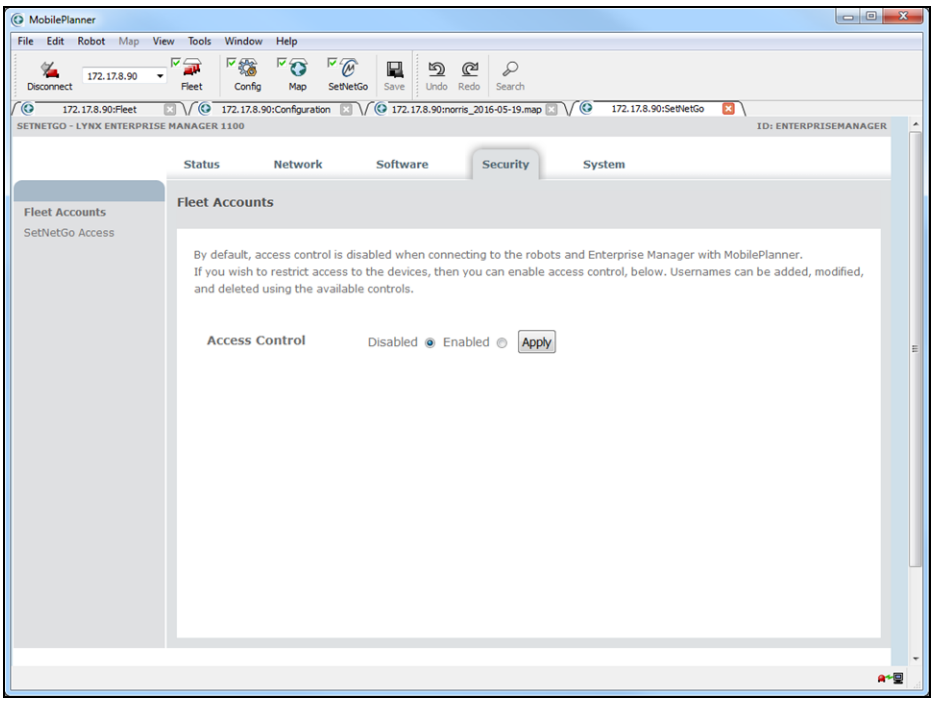


Figure 5-13: SetNetGo interface - Security tab

By default, access control for connecting to robots and/or Enterprise Manager is disabled.

2. To enable access controls, click the **Enabled** radio button.

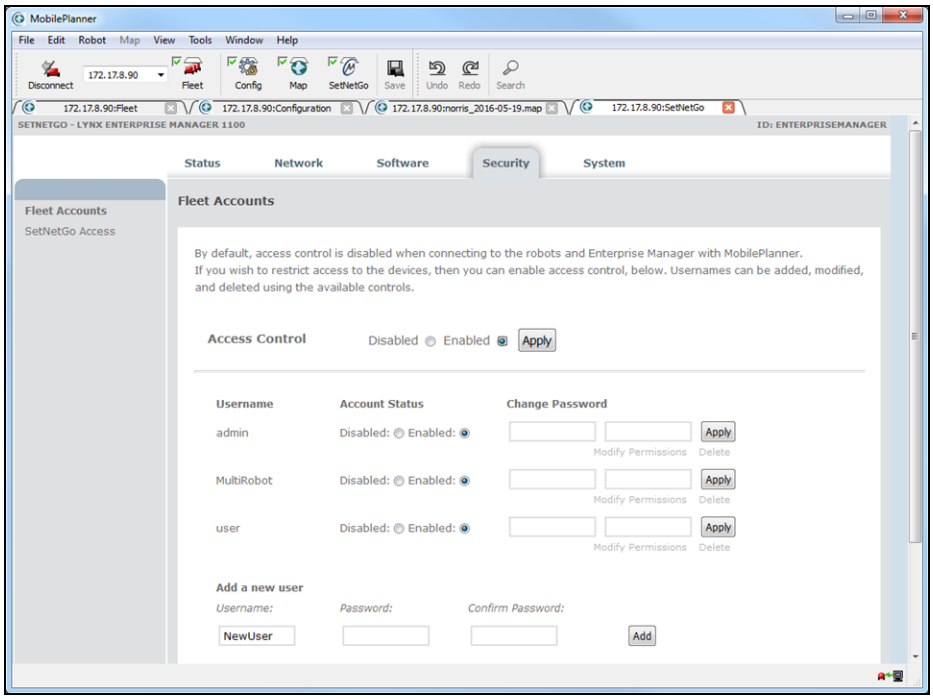


Figure 5-14: SetNetGo interface - Security tab

3. Click **Apply** to enable the account feature.
4. To both enable and set or change the access password for the admin, MultiRobot, or user account, click the associated **Enabled** radio button, then click **Apply** next to each modified username.
5. Continue to the next section to set up user accounts.

To set up and manage user accounts

1. In MobilePlanner, open SetNetGo.
2. Click on the **Security** tab to display the ARAM Accounts page.

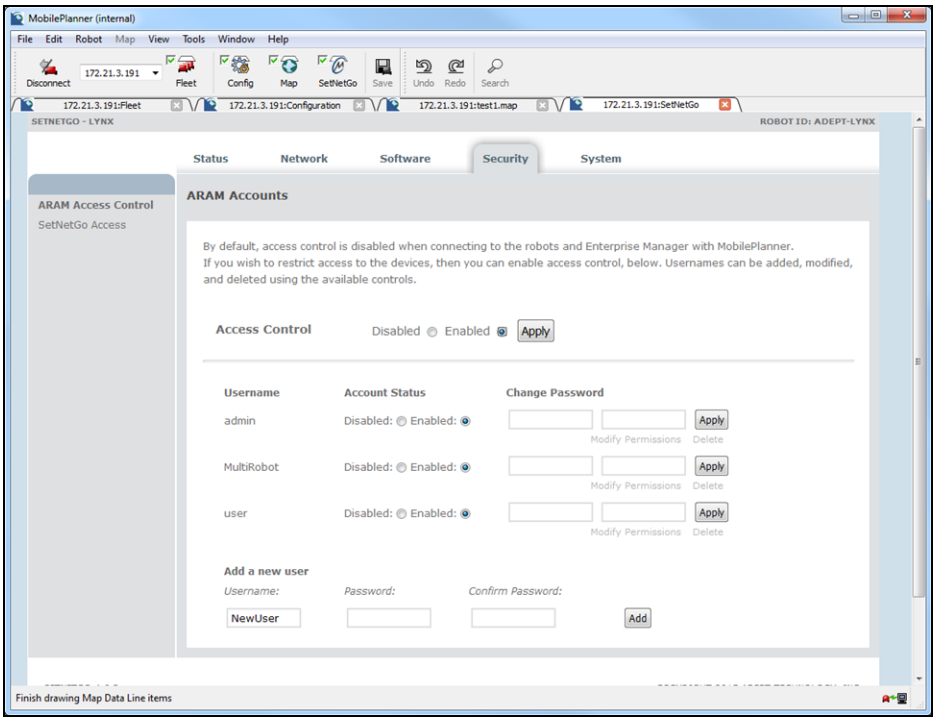


Figure 5-15: SetNetGo interface - Security tab

3. Follow the instructions in the table below to add, delete, or edit a user account.

To...	Perform the following steps
Add a user account	1. Enter a username in the **Add a new user** field. 2. Enter a password in the first password field (on the same line as the username). User names and passwords can have letters, numbers, special Unicode marks, underscores, and periods (.). Do not use spaces and other special characters. 3. Re-enter the same password in the second password field. 4. Click **Add**, and verify the new user account appears under the Username column.
Delete a user account	1. Select the checkbox next to the username you want to delete. 2. Click **Apply** to remove the user account from the list in the Username column.

Permission Groups

For each user account, you can enable and disable access to various features in MobilePlanner. For example, enabling FileUploading allows the user to upload and download files from MobilePlanner to the robot.

1. To modify account permissions for each user (for example, admin user), click **Modify Permissions** (to the left, and below the Apply button) to display the Change Account Permissions page.

   The example below shows account permissions page for the admin user who, by default, has all permissions assigned. Other users have different sets. Use the side scroll bar to see all permissions.

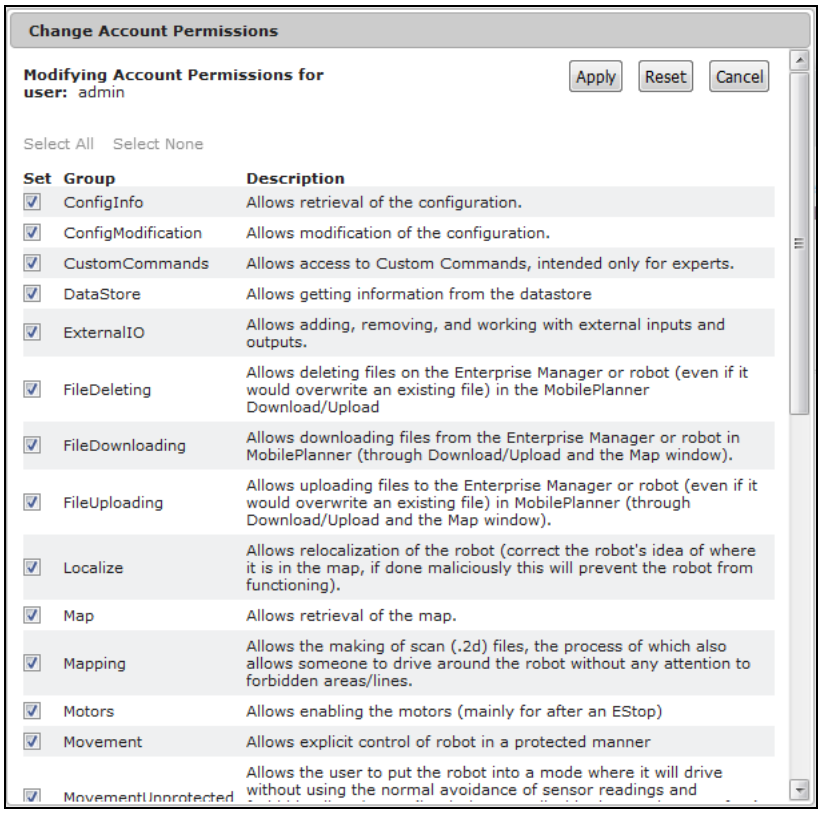


   Figure 5-16: Change Account Permissions page

2. Select the checkbox(es) next to the permission(s) you want to grant to the selected user account.

   You can quickly assign all permissions by clicking **Select All**, or click **Select None** to clear all assigned permissions.

3. Click **Apply** to set the selected account's permissions, and return to the ARAM Accounts page.

Updating the Enterprise Manager software

For an updated Mobile Robot Software Suite package, contact Omron Adept Technologies, Inc. (see How Can I Get Help?).

To update the Mobile Software suite:

1. In MobilePlanner, click the **SetNetGo** button, then click the **Software** tab, then click **Manage Installed Software** from the left side list.

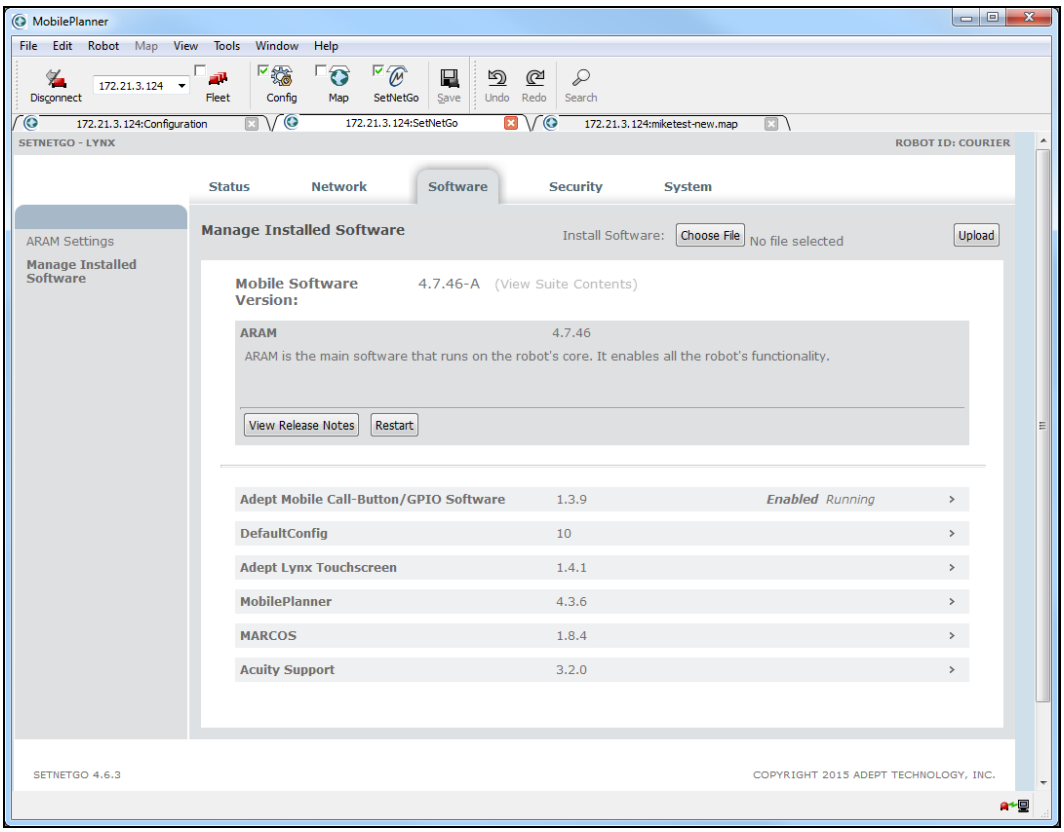


Figure 5-17: SetNetGo interface - Software tab

2. Click the **Choose File** button to access the directory where the update file is located, and click **Open**.
3. Confirm the correct file name is listed next to the Choose File button, then click **Upload**.

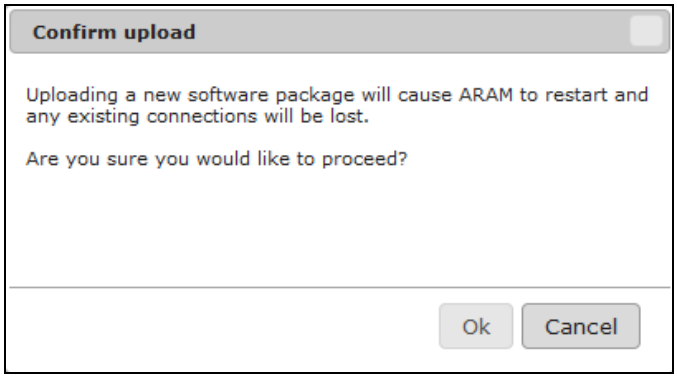


Figure 5-18: Confirm Upload dialog

4. If you are certain you want to proceed, click **Ok**.

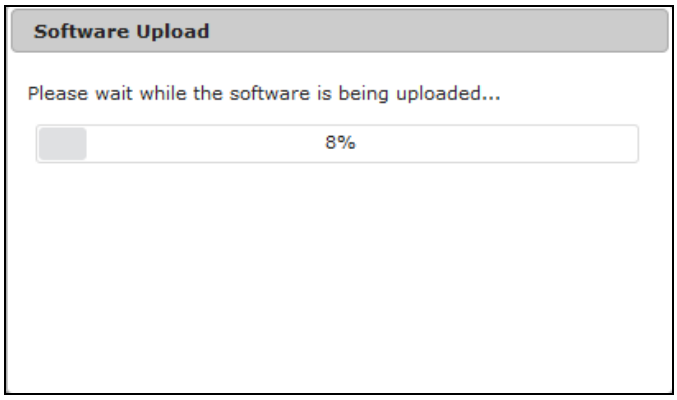


Figure 5-19: Software Upload Status

The robot will be unavailable as it goes through its restart sequence (a status window shows restart progress).

If the installation was successful, the new Mobile Software version appears in Manage Installed Software.

Viewing Software Packages

Clicking a package name expands the selection and shows the options for that package, which can include:

- Release notes.
- The option to enable or disable the package (if the package is executable).
- Log files.
- Uninstall (if available).

Restarting ARAM

ARAM automatically stops when any changes are made, but you can click the **Restart** button to force ARAM to restart.

Chapter 6: Working with Map Files

With Mobile Robot Software Suite software, AIVs know where they are and drive from one place to another by themselves–without a human operator. To do this, the mobile robot must have a prepared map of the static features in its operating environment. MobilePlanner software makes creating maps for one, or an entire fleet of robots fast and easy.

This section explains map files and how to work with them in the MobilePlanner software.

Loading an Existing Map File

There is no map to display when you first start up the MobilePlanner software. You must use MobilePlanner, with 'Map' checked, and connect to a robot or EM to open a map file to edit. Or, you can open a map saved locally on your computer or (when the Map button is checked) open a map that is currently in use on a specific robot. You can also open maps on the robot that are currently not in use.

Opening a Map saved on your PC

When you use the Map button to open and edit your map files, you can save them locally on your computer until you are ready to upload them to the robot. Local map info is also written in the debug info files.

Selecting **File > Open** from the MobilePlanner main menu displays a dialog that lets you search for and select a local map file to open.

Opening a Map stored on a Robot

You can also click the Map button to edit a map file that is already in use on a mobile robot, which is helpful for making quick changes to the map or the robot's route.

1. In the MobilePlanner main menu, select **File > Open on Robot** to display a submenu that lets you select a particular robot.
2. Either choose from the displayed robot IP addresses, or enter a new robot IP address to open a map on the specified robot.

   A dialog box appears in which you can choose between Configuration, Map, Scan, and SetNetGo files.

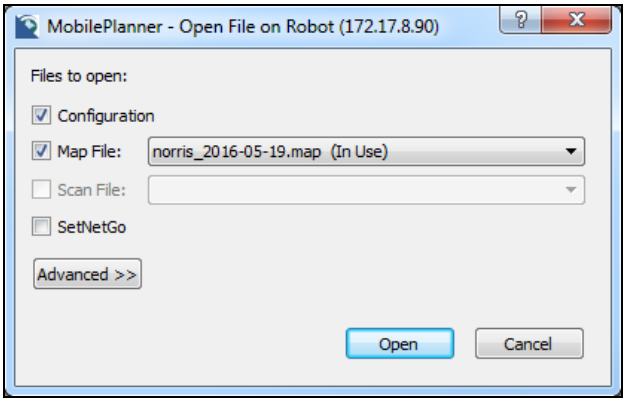


Figure 6-1: Open File on Robot dialog

3. Check **Map File** to choose a map file located on the robot.

   You can use the Map File list and/or click the **Advanced** button to search for and select a map file to open, as shown in the following figure:

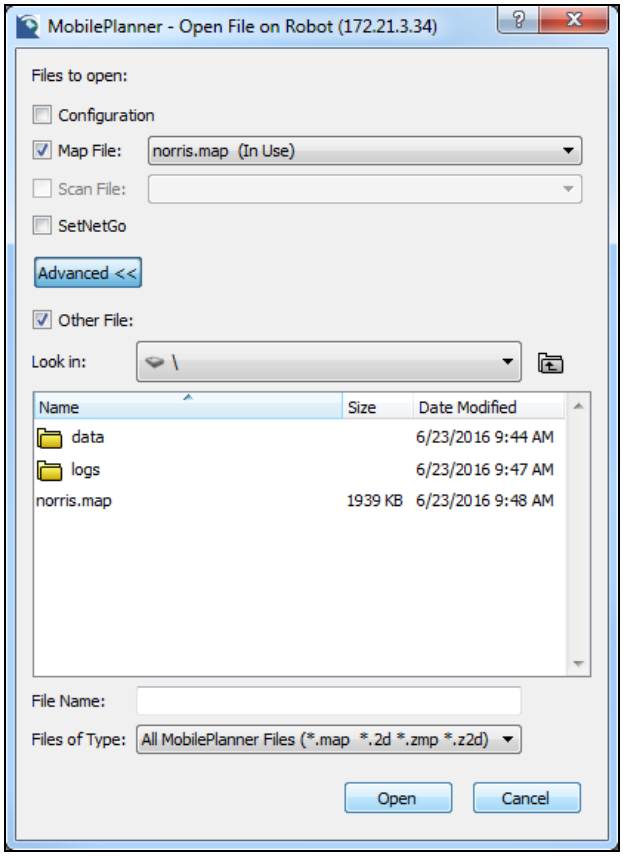


Figure 6-2: Open File on Robot, Advanced dialog

4. Select the map file you want to edit.
5. Click **Open** to load the map file into MobilePlanner.

Editing a Map File

After you create the initial map of your environment, you can use MobilePlanner to edit the map. First, use the Eraser tool (Draw pane) to remove map features that are temporary or moveable fixtures, such as chairs or forklifts.

Using the Drawing Tools

When editing your map file, you use the drawing tools to select and erase objects in the map, add goals, docks, forbidden lines and areas, as well as advanced lines and areas. The drawing tools are shown below.

> **NOTE:** These drawing tools are inactive (grayed-out) if Show Robot is active. The Cut icon is inactive until you select something.

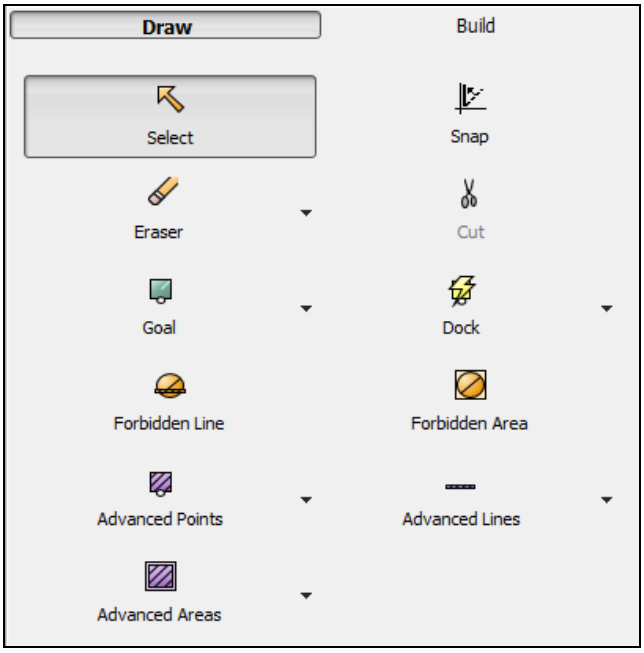


Figure 6-3: MobilePlanner Draw tab

Selecting and Erasing Objects in the Map

Use the **Select** button to select and highlight objects on the map. Press and hold the left mouse button to move the object around the map window. Click the right mouse button to display a pop-up menu that allows you to edit, duplicate, align, copy and cut the object.

If there are overlapping objects on the screen, you can right-click on the overlapping map objects. A sub-menu lists all objects under the cursor so you can select the desired object.

Use the **Eraser** button to remove data points and lines from the map. Press and hold the left mouse button to move the eraser over the data points or lines you want to remove. You can adjust the size of the eraser by selecting the pull-down menu from the Eraser button. Choose an eraser size from 5 to 1000 mm.

Cutting a Selection

Use the **Cut** icon (or **Delete** key) to remove any objects you have selected from the map.

Snapping Objects in Place

Use the **Snap** button to force rotate objects (goals, docks, lines, and areas) at multiples of 45 degree angles. Deselect this button to draw or rotate at any angle.

Adding Forbidden Lines and Areas

You can place forbidden lines and areas on the map to prevent the mobile robot from crossing the line or entering a specified area.

> **NOTE:** Forcing the robot to cross a forbidden line or enter a forbidden area is a special circumstance discussed in Restricting Traffic on page 181.

1. With the map active, click the **Draw** tab, then click **Forbidden Line** or **Forbidden Area**.
2. Click on the map where you want to place the forbidden line or area. Be sure to add forbidden lines or areas around the robot's work space so it doesn't try to navigate outside of its space.
3. Hold the left mouse button , then drag the mouse to the location you want the line or area to end.
4. Click the right mouse button to display a pop-up menu that allows you to edit, copy or cut the forbidden line or area.

Creating and Adding Goals and Docks

Goals are virtual destinations that the mobile robot drives to in its environment. Docks are locations to which the robot drives to prepare to recharge. You need to add both of these features to the map for the mobile robot to successfully navigate through the workspace.

You can quickly add a goal or dock to the map using the Item at Robot button (robot tool bar), which allows you to add the object at the robot's location. Once added, you can move goals and docks around by clicking on them with the left mouse button, holding the button, and dragging them to the desired location. You can also click on the heading line and drag it around, or put it in the middle to turn the heading off.

Types of Goals

You can choose from different types of goals:

- **Door Goal:**Doors and virtual doors are spots at which the robot positions itself before entering or leaving a doorway (see Using a Door Goal on page 117). They appear green on the map, and are only available if the Doors parameter is enabled (click the **Config** button, then click the **Robot Operation** tab, then select **Map Features**).
- **Goal:** This is the default goal. The X and Y positions are automatically entered based on the location you selected on the map. Click on the check box to enable a heading and enter a heading in degrees (you can also do this on the map by dragging the mouse cursor - see Editing a Map File on page 114.). The goal heading specifies the orientation of the robot when it arrives at the goal.
- **Standby:** Standby goals serve three purposes, each designed to help keep the robots out of the way of traffic and regions of interest (goals, tools, etc.);

- **Buffering:** waiting at a standby goal for another robot to clear an occupied goal or sector. See Standby-Buffering_goals
- **Parking:** allows available robots to drive to a waiting area for assignment to another goal. Other parking goals include Preferred Parking goals (also known as 'park at pickup/dropoff' goals). See Standby-Parking_goals
- **Multi-Robot Standby (MRS):** (also referred to as Taxi Line) allows (and enforces) sequenced, orderly queuing of multiple robots from the same start (standby) position to the same goal. For more information, see Traffic Control Concepts on page 169

To create a goal/dock:

1. With the map active, click on **Draw tab > Goal** or **Draw tab > Dock**.
2. Click the mouse on the map where you want to locate the goal/dock. Then, while holding the left mouse button, drag the mouse around the goal/dock to set its heading.

> **NOTE:** Place a dock object where the robot should go to "look at" the dock, not where the dock actually is. The dock object should be 1 to 1.5 meters in front of the dock, pointed at the dock. See the figure on the next page.

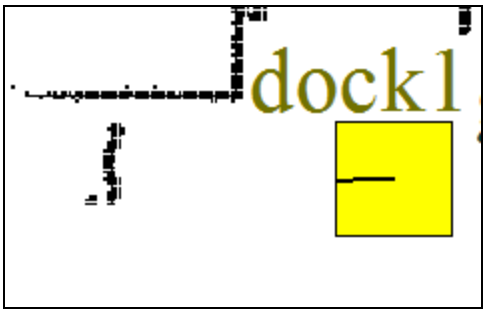
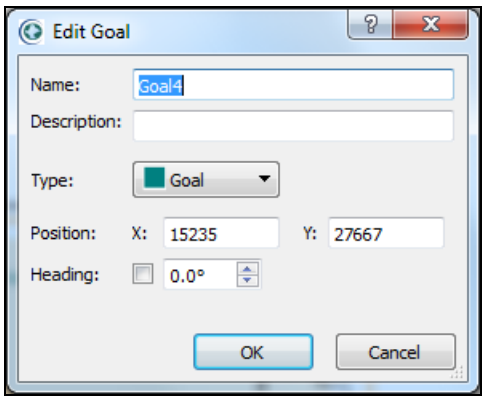
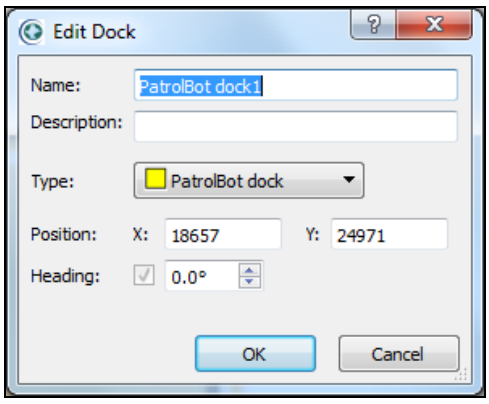


Figure 6-4: Dock as imaged by robot



Edit Goal Dialog Box



Edit Dock Dialog Box

3. In the appropriate dialog box (Edit Goal or Edit Dock), enter the name of the goal/dock you want to add to the map, for example "Reception."
4. Enter a description of this goal or dock (optional).
5. Select the Type of goal or dock you are adding.
6. Enter the X and Y position to adjust the location.
7. Enter a heading value in degrees (required for docks, optional for goals).
8. Click **OK** to place the goal or dock on the map.

Using a Door Goal

The door goals appear as a green square on the map. They allow you to mark a spot for the robot to position itself before entering or after leaving a doorway. The following dialog box appears when setting up a door goal.

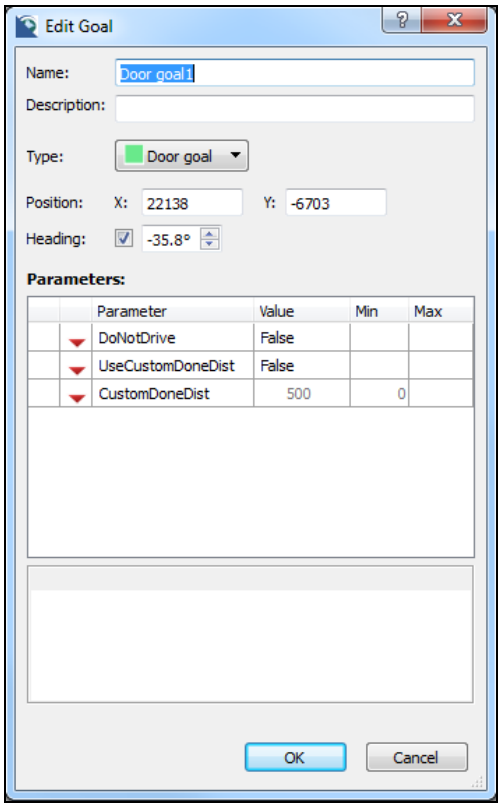


Figure 6-5: MobilePlanner Edit Goal dialog

Click on a parameter to see its description near the bottom of the dialog box.

Goals Using High Accuracy Positioning System (HAPS)

If your robot has one or more optional HAPS sensors installed, you can create goals that require the robot to approach and position itself closely.

The most simple of these types of installations have a goal on the robot's map, a length of magnetic tape on the floor (the track), and one marker. The robot's goal is to approach and proceed down the track, and stop at the marker.

You can also install tracks with multiple locations at which the robot stops. Each stop needs one track, one marker, one goal per marker, and an Engage task for each goal.

Standby Goals

Standby goals allow you to set up buffering when a robot's destination is already occupied by another robot, and send robots to a parking area after completing a queuing job.

> **NOTE:** To use standby goals, you must enable them. Click the **Config** button, then click the **Robot Operation** tab, then click **Map Features** (in the left pane), then click the checkbox for the **Standby** parameter.

Using Standby-Parking Goals

It's best to place standby-parking goals in areas out of the way of traffic and other areas of interest.

To place a Standby-Parking goal on your map, do the following:

1. With the map active, click on the **Draw** tab, then click on the **Goals** drop-down list.
2. Select the **Standby** goal type.
3. Place the goal(s) on the map, then change the PrimaryPurpose parameter to **Parking**.
4. Use at least as many Parking goals as robots.

Using Standby-Buffering Goals

If a robot is waiting for another robot to clear a goal, it will use one closest to its destination. Best practice, then, is to place Standby-buffer goals near tools and areas of interest, in locations that will not block robots leaving the goal.

To place a Standby-Buffering goal on your map, do the following:

1. With the map active, click on the **Draw** tab, then click on the **Goals** drop-down list.
2. Select the **Standby** goal type.
3. Place the goal(s) on the map, then change the PrimaryPurpose parameter to **Buffering**.
4. Use at least as many Buffering goals as the anticipated number of waiting robots.

Adding a goal at the robot's current position

You can add a goal (generic, door goal, cart goal, or docking station) at the robot's current position as follows:

1. With Show Robot active, click the drop-down arrow on the **Item at Robot** button (robot toolbar).
2. Select the type of goal you want to add.

   If you select one of the default goals (e.g., docking station), information about that goal is pre-populated in the dialog box.

3. If you selected a generic goal, fill in the name, description, and type then click **OK**. For a default goal, click **OK**.

Accessing the Docking Parameters

Docking parameters define the robot's actions during the docking process. To access the Docking parameters, click the **Config** button, click the **Robot Operation** tab, then click **Docking**.

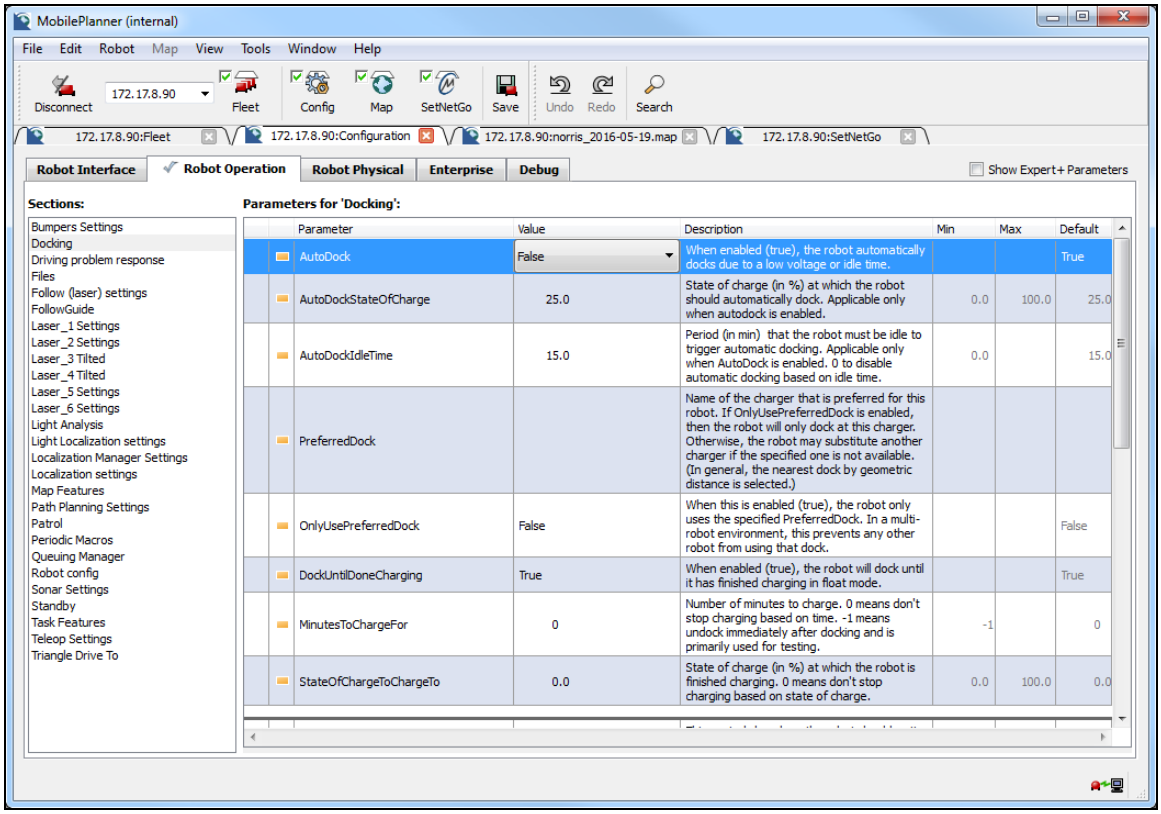


Figure 6-6: MobilePlanner Config - Robot Operations tab, Docking parameters

NOTE: MobilePlanner software defines the various docking parameters, which will not be repeated here. However, there are some parameters under **Config > Enterprise > Fleet Docking** that control docking behaviors.

Advanced Lines and Areas

MobilePlanner has tools for adding special, or advanced, features to your map that perform the following functions:

- **Advanced Areas:** these are areas in which you can add doors (and their swing sector), control speed (Fast or Slow), direct the mobile robot to ignore laser or sonar inputs, limit the number of robots operating in the space at one time (ManagedMotion), set the robots' preferred travel direction, direct the robots to enter (or resist entering), to name a few.
- **Advanced Lines:** these include lines to measure distances on the map (measuring stick), lines representing the robot's preferred path (preferred line), lines the robot will resist crossing unless there is no other way around an obstacle (resisted boundary), lines the robot will avoid if possible, and lines that can act like forbidden lines (SwitchableForbiddenLine).

Adding an advanced area or line

Advanced lines, points, and areas include features like closed doors, measuring sticks, switchable forbidden lines or areas, one-ways, and many more. You must enable some of these features under the Config button, Robot Operations tab, Map features (likewise, you can also disable those you do not want to use). See Restricting Traffic on page 181.

1. With the map active, click the **Draw** tab, click the drop-down menu triangle for either **Advanced Lines** or **Advanced Areas,** to display the available types, then select the type you want to add.
2. Click on the map where you want to start placing the line or area and, while holding the left mouse button down, drag the mouse to where you want the line or area to end.
3. If an Edit Advanced Line/Area dialog box appears, enter the needed information, then click **OK**.
4. Click the right mouse button to display a pop-up menu that allows you to edit, copy and cut the forbidden line or area.

Inserting a Map File into an Existing Map File

The Insert a Map feature is helpful there have been small or medium changes to the robot's environment. You do not need to rescan the entire workspace and recreate the map file. Using the Insert Map feature you can scan the area of the environment that has changed, turn that into a map, and insert it into an existing map.

In certain situations, you might want to insert only a subset of the region's data into the original map. For more information, refer to Using the Advanced Insert Option on page 123.

Inserting a Map Into An Existing Map File

In MobilePlanner, select a map to insert into an existing map.

- Select **File > Insert Map** from the main menu. A dialog box appears, which lets you search for and select a local map file to open.

The new map appears in the active map as a blue rectangle, and the Insert Map toolbar allows you to manipulate the inserted map.

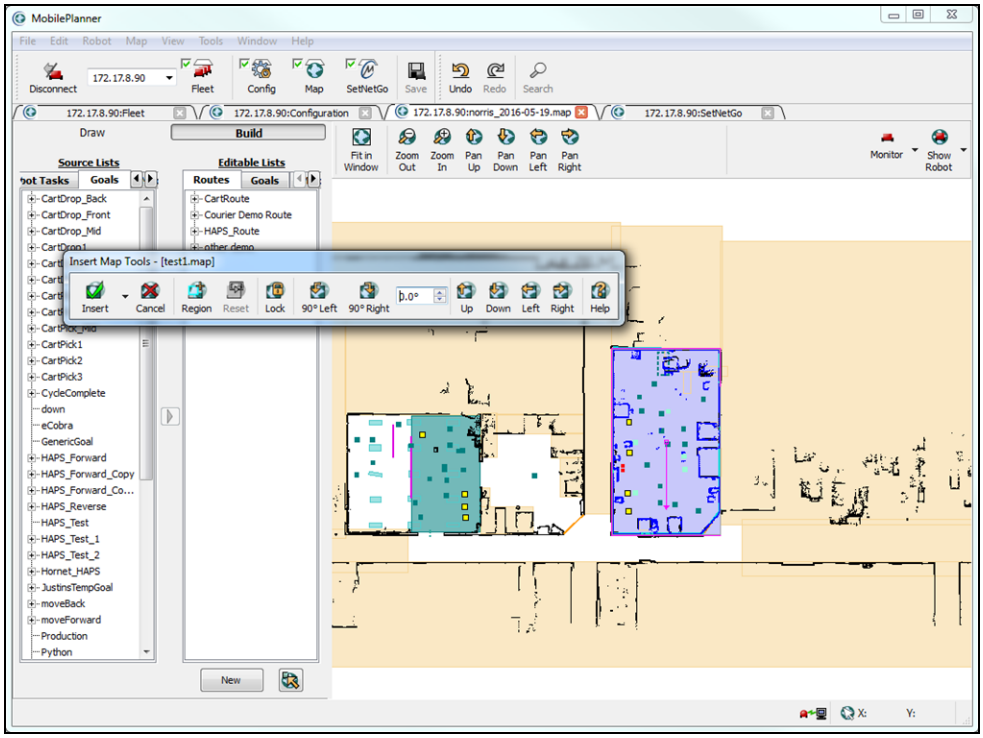


Figure 6-7: MobilePlanner, Insert Map Tools

Using the Insert Map Toolbar

Use the **Insert Map Tools** to position the inserted map into the existing map. After selecting a map section to insert, the toolbar automatically displays.

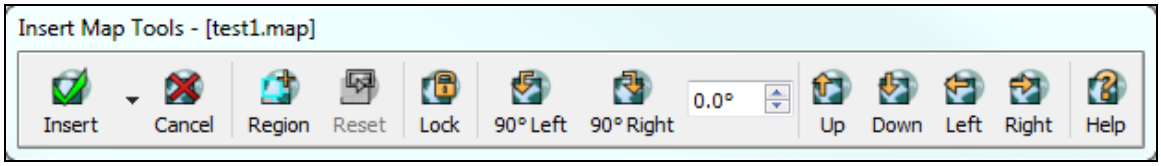


Figure 6-8: Insert Map toolbar

The following table describes the buttons on the Insert Map Tools toolbar.

Insert Map Tool-bar Button	Description
Insert	Works on intrinsic map data (points, lines, lights, etc.), and inserts the new map into the existing map at the blue rectangle. The Advanced insert lets you choose a subset of the previously mentioned data, and make other adjust-ments like inserting user-created map items (e.g., goals, docks, sectors, etc.). See Using the Advanced Insert Option on page 123 for details.
Cancel	Cancels the insertion.
Region	Defines the region to insert (useful if the default insert region is too big), or to have the newly inserted area properly overlap the old area. See Define the Insert Region on page 122.
Reset	Erases all rectangles and restarts the region definition.
Lock	Locks the inserted map at its current position in the map. This can prevent accidental changes when panning and zooming the map. Turn off the button to enable more changes.
90° Left/90° Right	Rotates the inserted map 90° left or right. Use the Degrees field to set degrees of rotation (as measured from the x-axis in the counter-clockwise dir-ection).
Up/Down/Left/Right	Moves the inserted map up, down, left or right. Allows small adjustments to the inserted map's position.
Help	Opens help information on the insertion process.

Position the Inserted Map

You can adjust the inserted map's location and orientation to position it correctly in the existing map as fol-lows:

1. Hold down the left mouse button and drag the inserted map like any other object.
2. Use the Insert Map Tools' **Up**, **Down**, **Left**, and **Right** buttons to make small adjustments to the insert's position.

Adjustment size depends on the map's zoom. To make a very small adjustment, zoom in; zoom out for a lar-ger adjustment.

Define the Insert Region

The shaded blue rectangle is where the inserted map will replace a portion of the existing map. By default, all black data points on the blue background will be deleted (unless doing an advanced insert with 'retain overlapping,' in which they will remain).

If the default insert region is too big, click the Insert Map Tools' **Region** button to define a new one. The default region clears (and becomes gray) and the insert locks at its current position. Use the mouse to draw a set of blue rectangles over the exact area to be replaced.

You should define the insert region after moving the map insert to the correct location.

You can use **Edit /Undo** and **Redo** from the MobilePlanner main toolbar while defining the insert region (Undo deletes the last added rectangle). To erase all rectangles and restart the whole process, press the Insert Map Tools' **Reset** button.

Complete the Insertion

After correctly positioning the map insert and defining the insert region, click **Insert** to finish the insertion. It might take a few seconds for the original map to update. The process is complete when the shaded blue area disappears and the Map Insert toolbar closes.

If the resulting map is not correct, then press **Edit / Undo** from the MobilePlanner main toolbar to restore the map to its original state (which might take a few seconds).

> **NOTE:** The insertion process is not automatically resumed; you must restart it.

Using the Advanced Insert Option

Occasionally, you might want to insert only a subset of the region's data into the existing map.

To use advanced options

1. In the Insert Map toolbar, left-click on the **Insert** button.
2. In the pulldown menu, select **Advanced**.

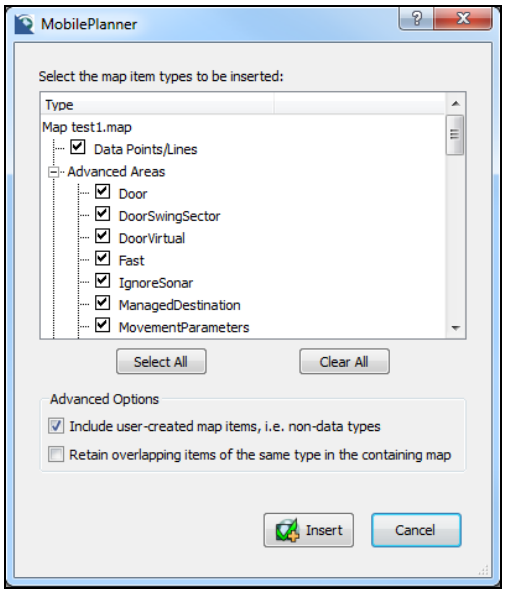


Figure 6-9: MobilePlanner, Advanced Insert options dialog

The dialog box has check boxes for each data type in the inserted map. To display non-data types, click the **Include user-created map items...** checkbox (shown checked in the image above).

3. Click the checkbox for each data type that you want to insert. Note that any corresponding map items are displayed in blue.

4. To retain the original map data as well as the inserted data, check the **Retain overlapping items . . .** checkbox.
5. Click the **Insert** button to complete the insertion and close the dialog box.

Saving the Map on the Robot

The scan file that came from your robot is saved on your local PC until you explicitly save it elsewhere.

To save the map on the robot, from the MobilePlanner menu, select:

File > Save on Robot

Select the .map file that you just edited, and click **Save** to save the map onto your robot.

Chapter 7: Configuring the Robot

There are hundreds of parameters you can set in MobilePlanner to customize your robot's operation in your environment. Other sections in this manual describe localization and mapping parameters; this section describes robot operation parameters.

This section covers the following topics:

Types of Configurations

MobilePlanner allows you to view, modify, save, and import various robot and enterprise, and debug configurations. You can set robot interface, operation, and physical configurations; enterprise configurations (queuing tasks, enterprise features, and EM connection), and debug configurations that control the output of debug log files.

General Configurations

General configurations include site-specific parameters for the robot interface (A/V config, connection timeouts, language/location, speech synthesis, etc.), robot operation (bumper settings, docking behavior, localization settings, path planning settings, task features, etc.), enterprise features and EM connection, and debug information. General configurations are consistent across your site. If you have a fleet of robots, the general configurations reside on the Enterprise Manager (EM). If you have a single robot, the general configurations reside in the robot's core.

Model and Calibration Configurations

These configurations relate to the robot itself. Model configurations include robot model-specific parameters like movement maximums, battery information, Acuity camera configurations, the MARC configuration, robot type, sensor type(s) and location(s), enterprise queuing tasks, etc. Calibration configurations include general physical robot information and parameters. Model and calibration configurations always reside in the robot's core.

Setting the Configuration Parameters

Configuration parameters determine the available features on your robot. You can enable or disable them, or assign them a value. You can set these parameters in MobilePlanner.

Using the tabs listed here, you can set parameters for everything from audio feeds, to docking, mapping, localization, server setup, move settings, and many more.

There are five robot parameter tabs:

- Robot Interface
- Robot Operation
- Robot Physical
- Enterprise
- Debug

Click on a tab, such as Robot Interface, to open and view its sections. Clicking on a section name displays the individual parameters in that section. The following graphic shows the A/V Config section selected:

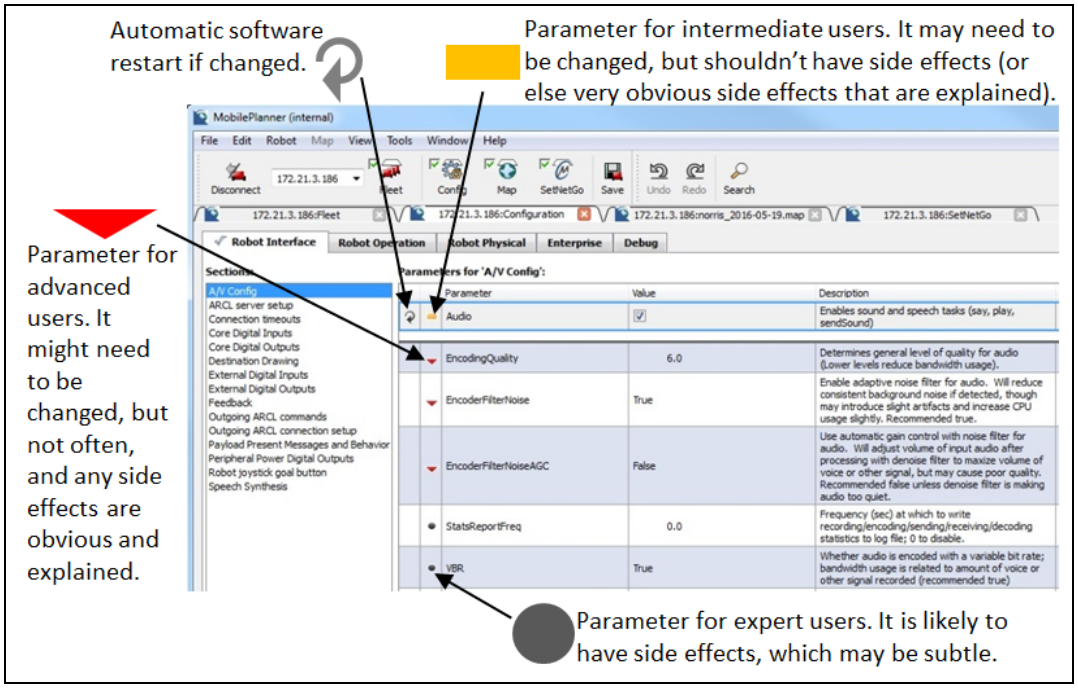


Figure 7-1: Robot Interface Pane, A/V Config Parameters (not all shown), Parameter Icons

Most configuration windows in MobilePlanner software describe most of the parameters, and most are not repeated here. Where needed, this user guide explains more complex parameters.

To set a parameter, select one of the tabs in MobilePlanner, then select a Section in that tab to see the available parameters. You can then modify the specific parameter in the parameter table.

In this table's Value column, you can enter a value (numeric or text), choose a value from a drop-down selection, or click a checkbox. Most text fields have drop-down menus for selection.

Most parameters are not stand-alone and interact with other parameters. This user's guide discusses various parameters. For example, if you are localizing the robot, you will find the parameters related to localization in the Using Laser Localization on page 197 section of this guide.

If you change any parameter settings, you have to click **Save** for those changes to take effect. When MobilePlanner sends the update to the robot, a small spinning icon and "Update Pending" message appear in the MobilePlanner status bar until the robot applies the changes (at its next idle period). You can also stop the robot if you want the changes to be applied more quickly.

If the parameter has a restart icon then, after ARAM writes the change, it displays the following dialog indicating the configuration change:

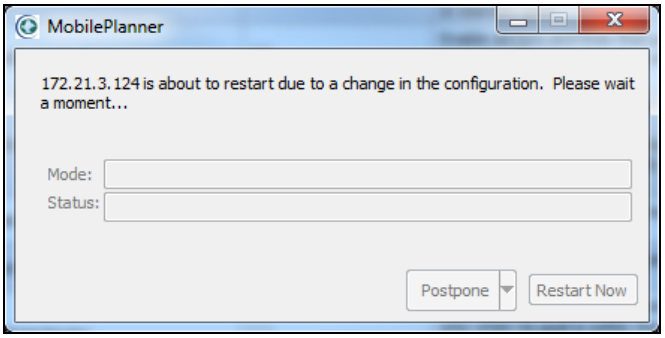


Figure 7-2: Robot Configuration Change

NOTE: ARAM automatically restarts automatically after some parameter changes.

Saving and Importing the Configuration Parameters

You can save parameter settings on either a robot or in the Enterprise Manager appliance:

1. In MobilePlanner, click the **Config** tab.
2. In MobilePlanner's main menu, select **File > Save As**, and give a file name and location for the file on your local PC.

   The Save <robot IP address> Configuration window opens.

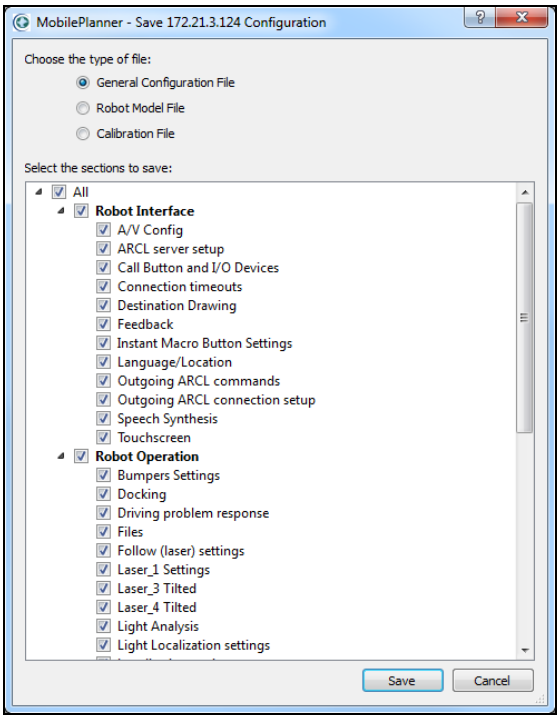


Figure 7-3: Save Robot Configuration window

3. In the Save <robot IP address> window, select the type of file you want to save (General, Robot Model, or Calibration), then either accept all checked configurations (default), or de-select the individual configurations you don't want.
4. Click **Save** when done.

Importing

You can import parameter settings from your PC to either a robot or the Enterprise Manager (EM) appliance:

1. Select **MobilePlanner > Config.**
2. From the main menu, select **File > Import Config ...**, then select the file from your local PC.
3. Click **Save** from the main toolbar.

> **NOTE:** If ARAM restarts after saving a configuration, you will need to repeat the above steps until the software no longer restarts.

Managing Files

MobilePlanner allows you to manage files associated with Mobile Robot Software Suite, including:

- raw map-scans (.2d) files
- maps (.map) files
- log files
- data files

Downloading/Uploading, and Saving Files

You can upload/download map, scan, log, and data files using **File > Download/Upload** from the top bar. Select the robot you want to use, and then select the file or folder on the robot and the file or folder on the PC that you want, and click either Upload or Download.

You can save map files using **File > Save As...** or, if the file already exists and you just want to save modifications, use **File > Save** (Save only affects the previously saved file).

You can also simply click the **Save** icon in the Toolbar.

You can import a configuration file onto the current robot using **File > Import Config...**

> **NOTE:** Import Config applies to the config copy on MobilePlanner, and must be saved before it is on the current robot.

Setting Up Data Logging

The ARAM software can log all kinds of data into one or more files. These data logs allow you to manipulate the data, using your own third-party data-processing software.

> **NOTE:** Log Config is a Section of parameters you can set in MobilePlanner. These logs are not the same as the files generated with data logging.

To set up data logging, click the **Config** tool, then click the **Debug** tab. When checked, the Show Expert+ Parameters checkbox displays advanced parameters that, by default, do not appear in the parameter list.

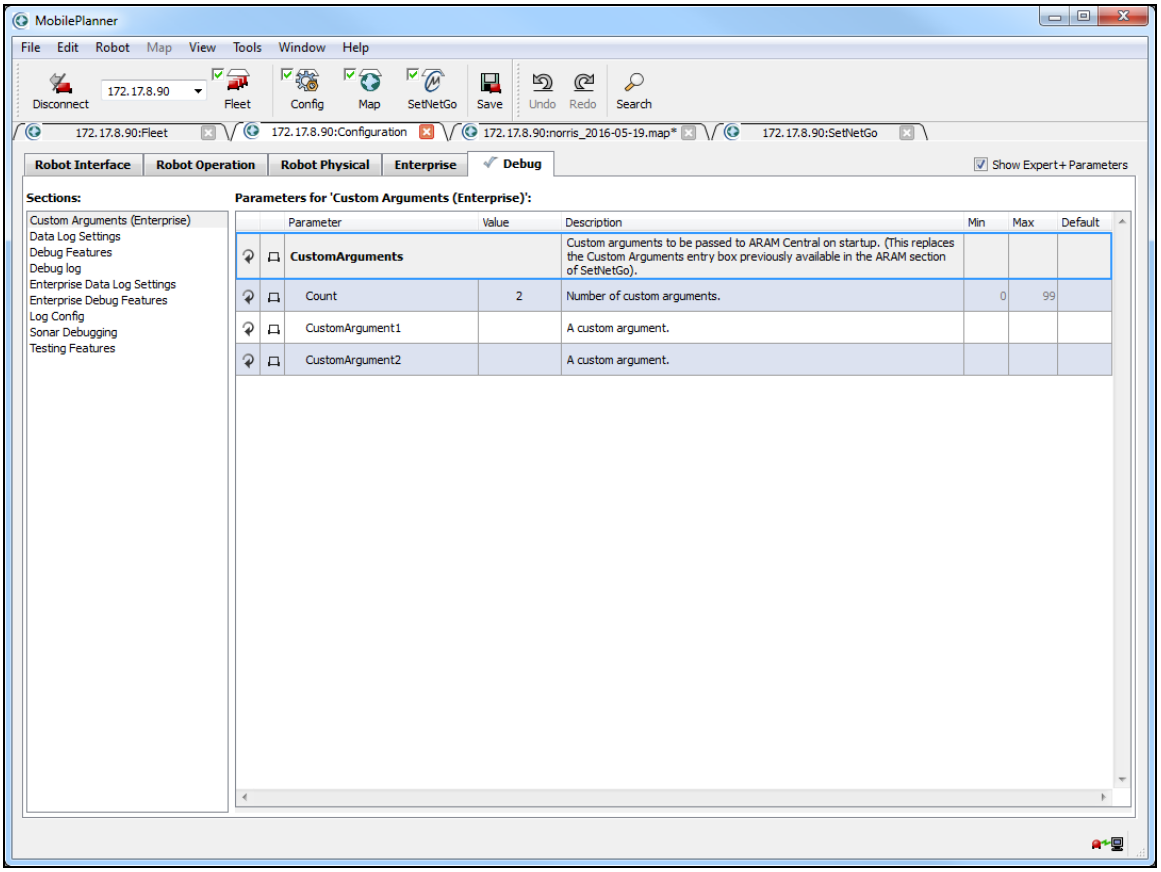


Figure 7-4: MobilePlanner Config, Debug tab (Show Expert+ Parameters checked)

The Debug tab has sections for configuring debug files and setting logging parameters.

> **NOTE:** Each section has a description of what it does (though some parameters are not visible until you check the "Show Expert + Parameters" checkbox).

Chapter 8: Working with Macros, Tasks, and Route Builder Tools

An AIV is unique in its ability to navigate freely and safely in a workspace, autonomously driving from one goal to another to perform various tasks (the lowest-level work the robot performs). MobilePlanner gives you the flexibility to manually program a complex series of tasks for the robot to perform at a goal before moving on to the next goal and performing additional tasks.

Or, instead, you could create macros that include all of the tasks the robot is to perform at a given goal. You can add tasks and goals to macros, then use the macros within a route or several routes. In other words, macros are "reusable." You can also have individual tasks call a macro and execute the sub tasks within the macro.

For example, you could create a macro in which the robot heads to Goal1, speaks a phrase and waits for a human action, after which it then heads to Goal2, where it waits for a specified time, then heads to Goal3.

You can use the MobilePlanner software to add tasks, goals, and macros into your facility's map, associate tasks with routes and goals, and assemble series of goals, tasks, and macros into routes.

This chapter discusses the following topics:

Robot Tasks

Tasks are activities that the mobile robot can perform, such as going to a goal or checking sensors. The robot executes tasks at goals to accomplish useful work, such as enabling DIO and telling the robot to move. These tasks are already available on the robot but need to be defined and associated with the map that you are creating.

There are both instant and non-instant tasks available for the mobile robot to perform. Instant tasks allow other tasks to be started before the instant task finishes. Non-instant tasks force the next task to wait until they are completed.

You can add tasks to goals and routes. For details, see Using the Route Builder on page 152.

Assigning Tasks

You can assign tasks to a route or goal, or use them in macros. You can find available tasks under the Robot Tasks tab in the Source Lists pane.See Setting Up Special Tasks on page 146.)

Many tasks need to have their corresponding ARAM parameters enabled to be available. For more information on enabling ARAM parameters, refer to Configuring ARAM on page 104. If you don't see a task displayed in the Source Lists pane, it might have previously been turned off. To display the task, enable (or re-enable) the appropriate ARAM parameter.

Assigning tasks

1. In MobilePlanner, click the **Map** button, then click the **Build** tab.

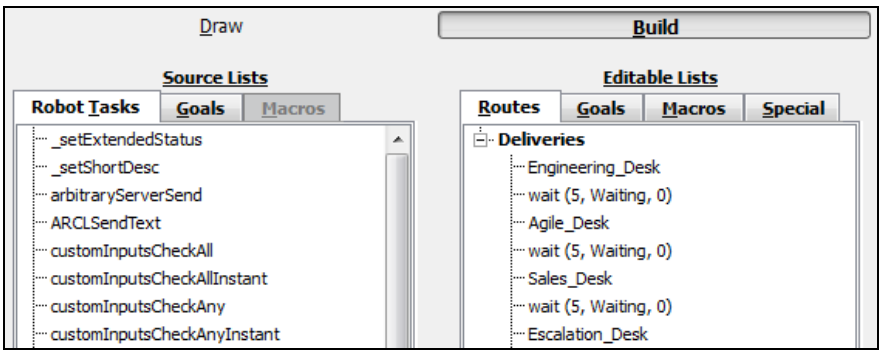


Figure 8-1: The Route Builder

2. In the Source Lists pane, click **Robot Tasks** tab to view tasks that are available on the robot.
3. In the Editable Lists pane, click the **Routes**, **Goals**, **Macros**, or **Special** tab that corresponds to where you want to assign the task.
4. To assign a task to a route, in the Source Lists, Robot Tasks tab:
    a. Click on the task you want to assign, and drag it over to the desired route, goal, macro, or special item, or
    b. Highlight the task, then highlight the desired goal, macro, special item or route, and click the **Add** button (the arrow between the lists).

NOTE: By default, tasks added to goals become part of the goal's "after" list (the robot will perform the task after it arrives). The process also creates a "before" list for tasks the robot will execute before driving to the goal (you can also move tasks to the "before" list).

If the task has associated parameters, the dialog box shown below (for a "sayInstant" task) opens:

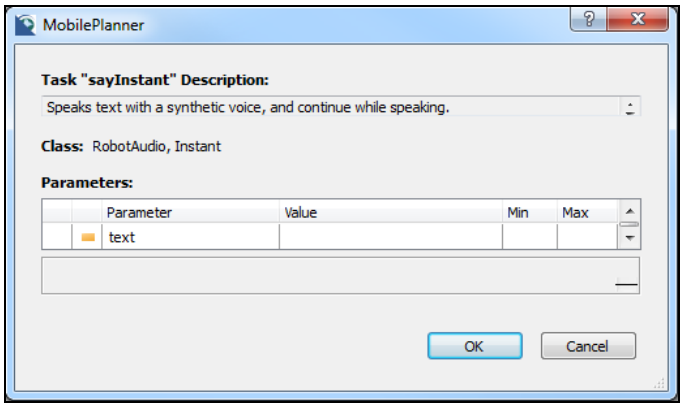


Figure 8-2: MobilePlanner task description dialog

5. Click inside the **Value** field to add and edit each parameter's values.

   For more information on using individual tasks, refer to the task type (such as wait, driving, etc.) in the Working with Macros, Tasks, and Route Builder Tools on page 131 section.

Using Instant and Non-Instant Tasks

In general, there can be only one sequence of non-instant tasks running at a time. Robots can start an instant task without waiting for a previous instant task to finish. Non-instant tasks must finish before the robot starts another task. In other words, both kinds of tasks are on the task list, but the non-instant tasks must finish before the robot starts next task on the list. When an instant task runs, the task after it can start right away, in other words, can happen without interrupting whatever else is happening.

Instant Tasks

Instant tasks allow the next task in the list to start while the instant task is still running, so the robot can be running two tasks at once. The following are examples of instant tasks available in the software. The complete list of instant tasks and descriptions are available directly in the software.

Instant Task	Description
ARCLSendText	Sends a given string to the ARCL server.
customOutputOff	Turns a custom output OFF.
customOutputOn	Turns a custom output ON.
playBackgroundSound	Plays a random background sound (at 'Least Important') from a set of prefixes and suffixes (wild cards do NOT work), waiting a length of time between sounds, optionally resuming interrupted sounds, and with the ability to stop playing in some different circumstances. **NOTE:** to interrupt this sound, set the audio task **Cancel less important** to **True**.
playInstant	Play a sound file and then continue while the sound plays.
popupSimple	Requests client applications to show a simple pop-up message (Client applications include MobilePlanner).
sayInstant	Speaks text with a synthetic voice.
sendSoundInstant	Send sound from a robot sound file to all clients and continue immediately.
sendSpeechInstant	Send synthesized speech to all clients and continue immediately.

Non-Instant Tasks

Non-instant tasks run in their own time slot (the robot must wait for them to complete before starting the next task in the list).

The following are examples of non-instant tasks . The complete list of non-instant tasks and descriptions are available directly in the software.

Non-Instant Task	Description
arbitraryServerSend	Sends the given text to a specified server and port.
cartCapture	Task to capture a cart.
cartRelease	Task to release a captured cart.
customInputsCheckAll/Any/Each	Checks whether all/any/each specified custom inputs properly triggered and executes a macro.
deltaHeading	Changes the heading by the specified relative amount.
followGuide	Used with HAPS - task to follow a magnetic guide strip on the floor.
gotoRandom	Drives to a random goal (could be optionally constrained by a matching name prefix).

Non-Instant Task	Description
laserCheckBox	Waits for something to enter the rectangular area surrounding the robot. Macros may be triggered upon detection or timeout.
laserCheckEmptyBox	Waits for the rectangular area surrounding the robot to be empty. Macros can trigger upon detection or timeout.
macroRepeat	Repeats the specified macro a given number of times or until it fails.
move	Moves forward by the specified distance, provided that no obstacles are encountered.
play	Plays a sound file and waits until it finishes playing.
say	Speaks text with a synthetic voice and waits until it is finished.
sendSound	Sends sound from a robot sound file to all clients, continues when done.
sendSpeech	Sends synthesized speech to all clients.
setHeading	Turns to a specified global orientation / heading.
triangleDriveTo	Drives to the triangle, stops a specified distance in front of it. The 'Triangle Drive To' parameters in the Robot Configuration apply to instances of this task.
triangleDriveToAdvanced	Drives to the triangle, stops a specified distance in front of it. Allows override of all of normal triangle driving parameters.
trianglePointAway	Turns away from the most recent triangleDriveTo destination.
trianglePointAwayAdvanced	Turns away from the most recent triangleDriveToAdvanced destination.
wait	Waits for the specified number of seconds. The wait may be interrupted by an explicit continue command.
waitActive	Calls a macro, and optionally waits a given number of seconds or until told to continue by command and control.
waitIndefinitely	Waits until commanded otherwise.

To verify if a task is instant or non-instant, right-click on the task and select **Description**. Or, go into 'custom responses' (**Build** tab **> Editable Lists > Special** tab) and click into one of them - the non-instant

tasks are grayed out, instant tasks are active. Task classification appears in the "Class" category, as shown in the following figure.

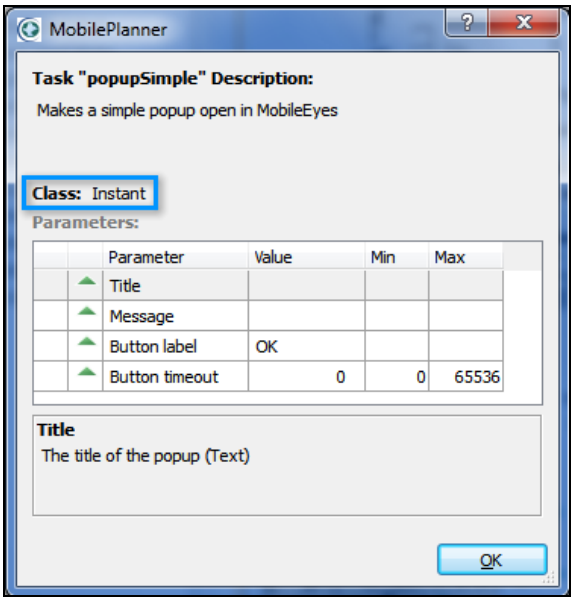


Figure 8-3: Task Class Category

Using a Wait Task

A wait task tells the mobile robot to wait a given number of seconds (or until told to continue by another command), before continuing. A wait task is not an instant task.

1. Open the map you want to edit. For details, refer to Using MobilePlanner Software on page 53.

   NOTE: Ensure that Show Robot is **OFF**, or you will not be able to proceed.

2. Click the **Build** tab.
3. Click the **Robot Tasks** tab in the Source Lists pane to view the tasks currently available on the robot.
4. Add the Wait task to the route, goal, or macro where you want the mobile robot to pause before continuing its route. Refer to Assigning Tasks for details.
5. Enter the number of seconds you want the mobile robot to wait in the Value field of the seconds to wait parameter, as shown below.

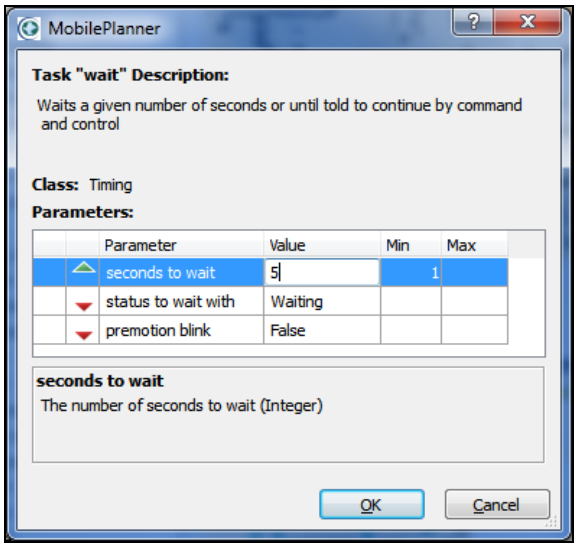


Figure 8-4: Parameters for wait Task

6. Click **OK** to close the parameter dialog box and save your changes.

Using Driving Tasks

Driving tasks cause the robot to move about its environment, carrying out various tasks at each goal. Driving tasks can include the following:

Task	Task Description
move	Tells the robot to move the specified distance.
deltaHeading	Changes the robot's heading.
setHeading	Turns the robot toward a specified heading.
triangleDriveTo	Tells the robot to move the specified distance away from the triangle (or dock) that is in front of the robot
trianglePointAway	Tells the robot to point away from the triangle (or dock) that it went to last.

TriangleDriveTo Tasks

Triangle drive is a method for accurate mobile robot maneuvering, relative to a physical triangle placed in its environment. Triangles can aid in precise positioning at docks, conveyors, and other areas where you need the robot to accurately position itself.

TriangleDriveTo tasks require placing a physical triangle somewhere in the robot's environment. The shape should be unique to the immediate surroundings so the mobile robot can clearly image the shape, and not confuse it with other surrounding features. If you need to build a custom triangle, use a shape and size similar to the triangle on the mobile robot's dock, and position it so it sits 3 inches above and below the mobile robot's laser. In the image below, the mobile robot's laser correctly images the triangle shape.

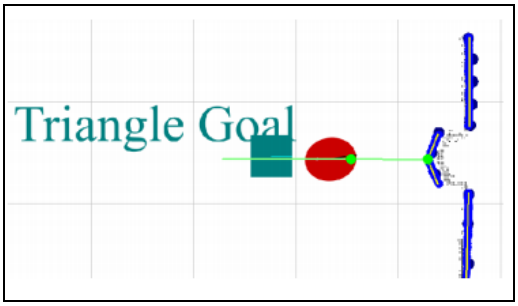


Figure 8-5: Triangle Goal map representation

MobilePlanner can show the line extending out of the triangle's vertex (enable 'TriangleAdvancedNewApproach' in MobilePlanner via **Map > Robot Operation > Task Features** and/or **Triangle Drive To**).

By default, the TriangleDriveTo and TriangleDriveToAdvanced tasks are enabled. You can find them by clicking the **Config** button, then selecting the **Robot Operation** tab, and clicking on **Task Features** and/or **Triangle Drive To**. Once enabled, you can add them to goals or macros from the Build tab > Source Lists > Robot Tasks.

Most configurable parameters have explanations in the help text at the bottom of the task window. The following table explains some of the more complex parameters:

Parameter	Description
MaxLateralDist	A value other than 0 varies the allowable distance between the mobile robot's center point and triangle's vertex line.
MaxAngleMisalignment	A value other than 0 disallows triangles if the robot's heading and triangle's vertex line differ by the set value (a good parameter is 10 degrees).
ApproachDistFromVertex	The distance between the triangle's vertex and robot's initial approach point. Must be 250-500mm greater than the value for FinalDistanceFromVertex (below).
TriangleRotVelMax and TriangleTransVelMax	Can improve accuracy (with cost in speed). Value of 100mm/s and 20 degrees/s yield highest accuracy, but lowest speed.
FinalDistanceFromVertex	The robot's final position after completing the triangle drive movement.The robot's front clearance must be large enough to allow the robot to move this close to the triangle. Value is in mm.
AngleBetweenLines	Angle of the triangle's vertex. Outward facing triangles (vertex points towards robot) use positive values; inward triangles use negative values.

Step 1: Enable Movement Tasks

Not all available tasks are enabled by default. Before you can use those tasks, enable them in MobilePlanner by clicking the **Config** button, then clicking the **Robot Operation** tab, then clicking **Task Features**. After

clicking the checkboxes you want to enable, click **Save** to save your changes.

The following table lists some examples of the driving and movement parameters that you can enable.

> **NOTE:** Some of the parameters in the following table require checking the Show Expert + checkbox.

ARAM Parameter	Description
Engage	When used with HAPS - calls a macro when the AIV arrives at the goal, so the AIV can be sent on a series of tasks, such as a followGuide task to go to a marker on the magnetic strip.
MovementParametersTempTasks	Enables tasks for temporarily changing movement parameters.
TriangleDriveTo	Enables the triangleDriveTo task.

Step 2: Assign Movement Tasks

Driving tasks are not instant, but the MovementParametersTempTasks are.

1. Open the map you want to edit.
2. Click the **Build** tab to display Source and Editable Lists panes.
3. In the Source Lists pane, click the **Robot Tasks** tab to view available tasks.
4. Add the driving task to the route or macro (for details, see Assigning Tasks on page 132.
5. Enter the parameter values for the assigned task.

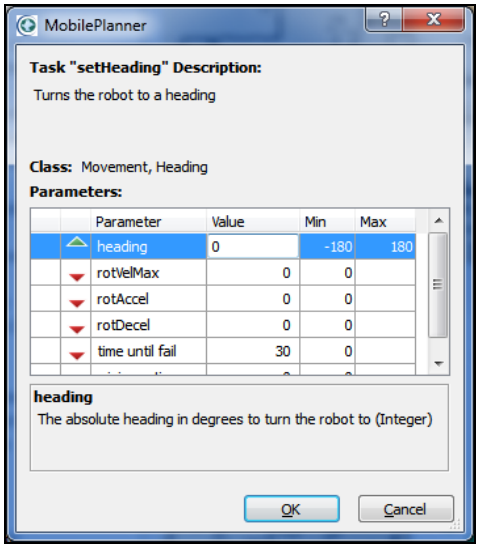


Figure 8-6: Parameters for setHeading Task

The following table shows examples of some of the task parameters and the tasks that use them.

Task Parameters	Parameter Definition	Associated Task(s)
heading	(Integer) The number of degrees to turn the robot. Positive values turn the robot left or counterclockwise. Negative values turn the robot right or clockwise. For deltaHeading, if the absolute value exceeds 360, the robot makes at least one full rotation.	deltaHeading, setHeading
distance	(Integer) The distance (in mm) the robot should move from the current position.	move, move2, moveProx
speed	(Integer) The speed (in mm/sec) the robot should move from the current position.	move, move2, moveProx

6. Click **OK** to accept the parameter value and save any changes you made.

Using Speech and Sound Tasks

Speech and sound tasks control the robot's audio. As the mobile robot navigates the operating space, it can (for example) play a sound file while driving, make a noise to alert anyone in the area that it is entering a room, or announce what task it intends to perform next.

The speech and sound tasks combine instant and non-instant tasks, as shown in the following table.

Instant Tasks	Non-instant Tasks
• playInstant • sayInstant • sendSoundInstant • sendSpeechInstant • playBackgroundSound	• play • say • sendSound • sendSpeech

Instant tasks send audio to the mobile robot as it continues on its path. Non-instant tasks cause the robot to wait until the speech or sound is done playing. For example, if you want the mobile robot to announce that it is entering a room and then wait for a moment to allow people to get out of its way, use the *say* task rather than the *sayInstant* task.

The robot speaks *say* tasks with a computerized voice. *Play* tasks play a sound file on the mobile robot. *Sound* tasks encode a file from the robot and send it out to all MobilePlanner instances connected to that robot.

To use speech and sound tasks

> **NOTE:** Speech and sound tasks are normally enabled by default.

1. Click the **Config** button, then click on the **Robot Interface** tab, then click on **A/V Config,** and enable the **Audio** parameter (click the checkbox). For more details, see Configuring the Robot on page 125.
2. For sound tasks, ensure the sound file is stored on the robot. You can use **File > Upload/Download**.
3. Click the **Map** button, then click the **Build** tab.

   > **NOTE:** Ensure Show Robot is **OFF**, or you will not be able to draw or edit objects in the map pane.

4. In the Source Lists pane, click the **Robot Tasks** tab to view tasks currently available on the robot.
5. Add the speech or sound task to the goal, route, or macro. For details, see Assigning Tasks on page 132.
6. Enter the parameter values for the assigned task. If using a *speech* task, enter the text for the robot to speak in the **Value** field. If using a *sound* task, enter the name of the sound file in the **Value** field. If needed, click the **Browse** button to search for the sound file.
7. Click **OK** to accept the parameter value and save any changes.

Using Sound Files with Tasks

Both the *play* and *sound* tasks use sound files. *Play* tasks play a file on a specified mobile robot. *Sound* tasks encode a file from the robot and send it out to all the MobilePlanner instances connected to that robot.

All sound files must be in AIFF WAVE (.wav files), .ogg files, or MP3 format.

Making the Mobile Robot Speak

Using MobilePlanner software, you can make the robot talk while it continues with other tasks.

Adjusting the Audio

You can use the MobilePlanner software to adjust the audio input and output (if turned ON), and adjust both the software and robot audio using the audio slide bars.

1. Click the **Map** button from the main window to display the map window.
2. Click the **Monitor** icon to display the list of available items to monitor (see below).

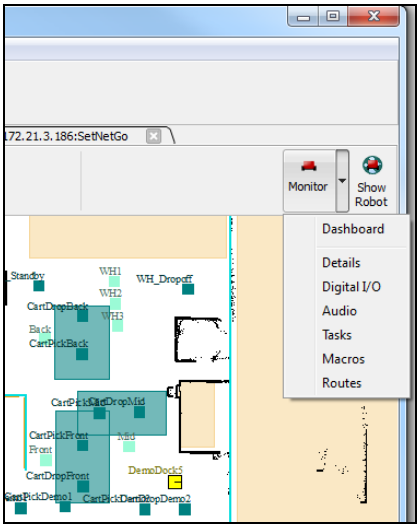


Figure 8-7: MobilePlanner Monitor drop-down menu

3. Click **Audio** to display the Audio dialog.

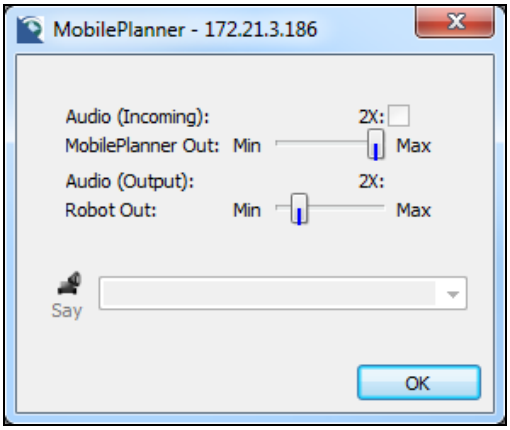


Figure 8-8: MobilePlanner Audio dialog box

4. Click on a slider bar to move it right (increase) or left (decrease) audio in or out.
5. If desired, you can enter a text string the robot will speak (when configured to do so).
6. Click **OK** when done.

Accessing and Adjusting the Audio Parameters

1. Click the **Config** tool, then click the **Robot Interface** tab.
2. Select **A/V Config** from the Sections column to display audio and video parameters.

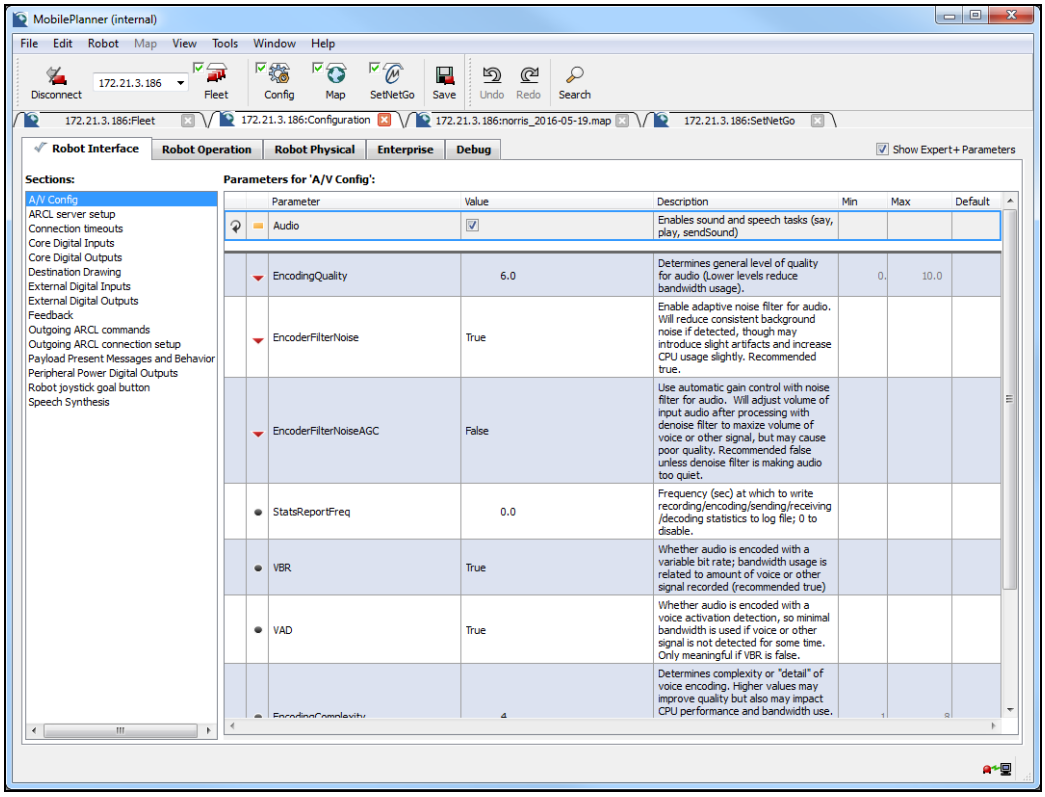


Figure 8-9: MobilePlanner A/V Configuration page

I/O Tasks

Digital Input/Output (I/O) provides an interface between the robot's equipment and sensors and the payload which often requires power (I/O inputs and outputs can, for example, control conveyor rollers). For example, if you have a robot with a conveyor payload aboard, you can use digital I/O to turn the rollers on and off, check sensor inputs, and execute one or more macros based on a tote's location (whether the tote is on the robot's conveyor or on the feed conveyor).

The mobile robot's core provides 16 digital inputs and outputs, and has a User Interface connection for creating custom user interfaces with the robot's E-Stop, ON, OFF, keyswitch, and brake release buttons.

With MobilePlanner, you can:

- Configure core digital inputs and outputs, and give these inputs and outputs aliases which make it easier to use them when needed.
- Create custom I/O tasks that turn payload power on or off to activate automatically-toggled proximity sensors.
- Detect single inputs and execute specific macros.

Using I/O Tasks

Custom inputs and outputs are digital inputs, outputs, and peripheral power outputs. You make them custom by setting their input type to custom, and (optionally) giving them an alias.

1. Click the **Config** button, click the **Robot Interface** tab, then click **Core Digital Inputs** or **Core Digital Outputs** in the **Sections** column.
2. Configure the devices, then click **Save**.
3. In MobilePlanner's main menu, click **File > Open** to open the map you want to edit.

   > **NOTE:** Ensure that Show Robot is **OFF**, or you will not be able to proceed.

4. Click the **Map** button, then click the **Build** tab.
5. In the **Source Lists** pane, click the **Robot Tasks** tab to view the tasks currently available on the robot.
6. Add the task to the route, goal, or macro (see Assigning Tasks for details).

Digital Inputs

To configure the digital inputs, click the **Config** button, then click the **Robot Interface** tab.

Tasks: customInputsCheckAll** and **customInputsCheckAllInstant

These tasks check whether all specified custom inputs trigger and properly execute a macro.

Parameters	Description
timeout	Duration (in sec) to check the custom inputs.
timeoutMacro	Macro to invoke if no inputs are triggered before the timeout.
triggerMacro	Macro to invoke if all inputs are triggered before the timeout.
input<n> n = 1 to 8	Names of the custom inputs to check. Prefix the names with '!' to check the inverted value.

Tasks: customInputsCheckAny** and **customInputsCheckAnyInstant

These tasks check whether any of the specified custom inputs trigger and properly execute a macro.

Parameters	Description
timeout	Duration (in sec) to check the custom inputs.
timeoutMacro	Macro to invoke if no inputs are triggered before the timeout.
triggerMacro	Macro to invoke if any of the inputs are triggered before the timeout.
input<n> n = 1 to 8	Names of the custom inputs to check. Prefix the names with '!' to check the inverted value.

Tasks: customInputsCheckEach** and **customInputsCheckEachInstant

These tasks check the custom inputs and executes a particular macro for each triggered input (on only if 'tasksForBetterCustomIO' is ON).

Parameters	Description
timeout	Duration (in sec) to check the custom inputs.
timeoutMacro	Macro to invoke if no inputs are triggered before the timeout.
input <n> n = 1 to 8	Names of the custom inputs to check. Prefix the names with '!' to check the inverted value.
input <n> macro n = 1 to 8	Macro to invoke if input <n> is triggered before the timeout.

Digital Outputs

To configure the digital outputs in MobilePlanner software, click the **Config** button, then click the **Robot Interface** tab.

Task: customOutputOff

This task turns off the specified custom output.

Parameters	Description
output	Name of the custom output to turn off.

Task: customOutputOn

This task turns on the specified custom output.

Parameters	Description
output	Name of the custom output to turn on.

Setting Up Special Tasks

You can set up and use tasks for the mobile robot to perform in certain situations, such when docking or at every goal. You can also make the robot say a phrase when an specific event occurs (e.g., when path planning is failing, replanning has happened, or the robot failed at a goal, etc.). These Special tasks allow you to define custom responses to events that the robot might encounter.

Special tasks can include:

- Performing a task before or after every goal.
- Performing a task at a dock.
- Custom responses.
- Queuing Manager tasks.

NOTE: Special events don't have to be unusual. Going to a Goal or Point can be a special event.

To customize robot operation:

1. In MobilePlanner, click the **Map** button, then click the **Build** tab.
2. In the Editable Lists pane, click on the **Special** tab.

   Since you cannot assign a goal to a Special task, the Goals tab is grayed out. Also, selecting one of the special events in the Special tab only enables instant tasks. All custom responses have to be instant, but other lists in this tab can allow non-instant tasks.

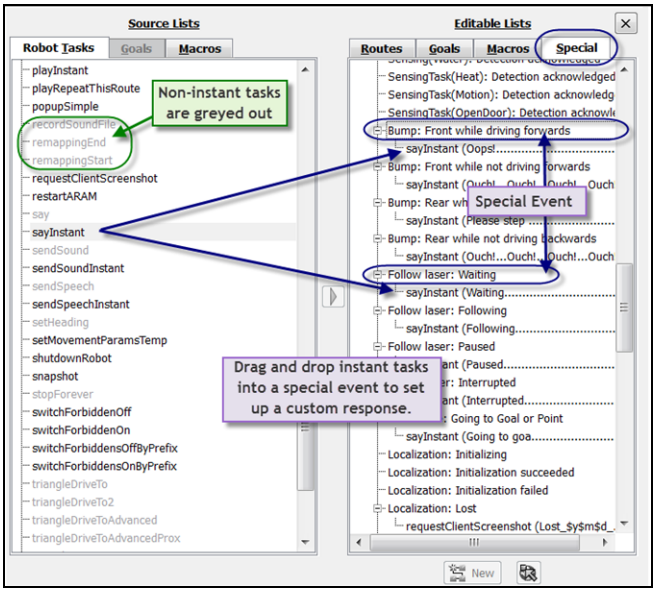


Figure 8-10: Build tab lists - details

3. In the Source Lists pane, highlight a task from the **Robot Tasks** tab and drag it to the desired special event in the **Special** tab.

> **NOTE:** Most custom responses (e.g., Dock responses) have to be instant; all others can be non-instant.

Custom Responses

You can customize the mobile robot's operation using the Custom Responses found in the Special tab. The predefined conditions or events that trigger a custom response include:

> **NOTE:** The following list is not an exhaustive list. The Custom Responses defined for a particular mobile robot depend on the parameters that you enabled or disabled. For configuration details, see Setting the Configuration Parameters on page 126.

- Fault responses.
- Localization.
- Path Planning (Failed, replanning).
- 'sayInstant' tasks (such as 'excuse me').
- Bumping into something (has four sub-events, based on what the robot is doing when the bump occurs).
- Map Creation (has two sub-events, for starting and stopping a scan).
- Patrolling a route (has four sub-events).

Using custom responses, you can make the mobile robot talk when it encounters one of these events, and tell the people around the mobile robot what to expect.

All custom responses must contain instant tasks, such as *sayInstant*. Although the conditions that trigger a custom response are predefined for the robot, you can customize the robot's operation by adding one or more instant tasks to these events. For example, if the mobile robot bumps something in front of it, the robot can respond appropriately (for example, the robot could speak a phrase when it bumps into something).

Events automatically trigger the custom responses that make the robot respond to its environment.

If there is no task associated with a specific Custom Response, the robot won't do anything special when that condition occurs.

Performing a Task Before/After Every Goal

Special tasks can include instant and non-instant tasks the robot performs before the robot departs for a goal or after it reaches any goal.

Drag instant tasks from the Source Lists pane to either event in the Special tab in the Editable Lists pane.

> **NOTE:** You can override these tasks for specific goals within specific routes by un-checking the before/after this goal checkbox.

Performing a Task at a Dock

Special tasks can include instant tasks the robot performs when docking. The robot already has a set of defined docking events, including:

- Forced dock
- Idle dock
- Requested dock
- Driving to dock
- Driving into dock/docked
- Dock now unforced
- Dock now forced
- Undocking/undocked

You can add instant tasks to these docking events (e.g., have the robot announce it is going to dock because it is 'idle.'). Drag instant tasks from the **Source Lists** pane to the appropriate event in the Special tab in the **Editable Lists** pane.

Queuing Manager List

Robots can perform a variety of special tasks when they reach goals. For example, you can use the JobTypeCheck task to specify different macros depending on whether a goal is pickup, dropoff, or neither. Other examples of special tasks include:

- Before/After Pickup
- Before/After Dropoff

Drag instant tasks from Source Lists to a queue-related event in the Special (Editable Lists pane).

Editing a Special Task in the Editable Lists pane

1. Right-click on the task you want to edit.
2. In the pop-up window, click **Edit**.

   If the task has associated parameters, the following dialog box opens:

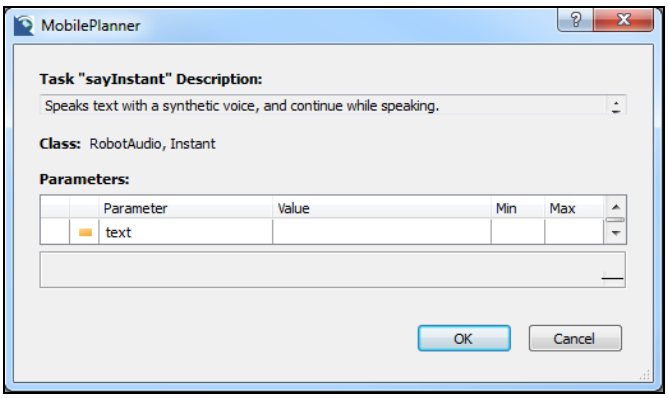


Figure 8-11: MobilePlanner parameter description dialog

Click in the **Value** field to add and edit the parameter's value . Click on a parameter to see its description.

3. Click **OK** when done.

Copying a Special Task from the Editable Lists pane

1. Right-click on the task you want to copy.
2. In the pop-up window, clicking **Duplicate** creates a copy of the task.
3. Drag the copied task anywhere within the current tab.

Deleting a Special Task from the Editable Lists pane

1. Right-click on the task you want to delete.
2. In the pop-up window, click **Cut** (or press the **Delete** key) to remove the selected task.

Editing a Task

To edit a task, from the Editable Lists pane:

1. Right-click on the task you want to edit.
2. In the pop-up window, click **Edit**.
3. Click inside the Value field to edit the value for each parameter.

> **NOTE:** You can reorder or move tasks to another goal/macro/route by dragging them there.

Copying a Task

To copy a task, from the Editable Lists pane:

1. Right-click on the task you want to copy.
2. In the pop-up window, clicking **Duplicate** adds a copy of the task.
3. Drag the copied task to any position within the current tab.

Deleting a Task

To delete a task, from the Editable Lists pane:

1. Right-click on the task you want to delete (or click, the press the Delete key).
2. In the pop-up window, clicking **Cut** removes the selected task.

Robot Jobs Overview

Jobs are basic activities for the robot(s) to execute. Advanced Robotics Command Language (ARCL) sends job requests to the Enterprise Manager (EM) for assignment to a robot.

> **NOTE:** Jobs are the recommended method for commanding the robot or fleet of robots.

Jobs typically have one or two job segments (if queueMulti is enabled). All segments are classified either as PICKUP or DROPOFF.

- **PICKUP:** A PICKUP job request tells the EM that any available, appropriate robot can be assigned a PICKUP task.
- **DROPOFF:** A DROPOFF job request tells the EM that only a specific robot can be assigned a DROPOFF task.

Once the EM receives the job request from ARCL, it assigns a job ID and unique job segment ID (or, you can optionally assign a job ID).

Job Priorities

MobilePlanner prioritizes submitted job requests either by Non-First-In-First-Out (Non-FIFO) or First-In-First-Out (FIFO) priority. The requestor can specify the job priority, or jobs can use the default value for queuePickup, queuePickupDropoff, and queueDropoff commands. You can enable this in **Config > Enterprise tab > Enterprise Features**, *EnterpriseQueuingConsumptionMethod.*

- **Non-FIFO:** Non-FIFO executes the highest priority jobs first, followed by lower priority jobs. Its goal is to minimize the robots' driving distance.
- **FIFO:** In FIFO, the system prioritizes jobs by which was submitted first, second, and so forth.

The default PICKUP priority is 10, and the default DROPOFF priority is 20. You can expedite a job by raising the pickup priority, while keeping the dropoff priority the same. For example,

- queuePickupDropoff goal1 goal2 10 20
- queuePickupDropoff goal3 goal 4 10 20
- queuePickupDropoff goal5 goal6 11 20

If you queued all of the above jobs at the same time, the third job's higher priority means the robot will execute the third job before jobs 1 and 2. Otherwise, job1 or job2 will start.

Job vs Job Segment

All submitted jobs carry a specific JobID (also referred to as the "job). Each part of a job is a 'job segment,' even if the job has multiple parts to it (for example, a Pickup-Dropoff sequence).

Custom Job ID

MobilePlanner uses the jobID is to track the status of a request, and a job ID must be unique among active jobs. Active jobs can share a jobID with previously completed or cancelled jobID still in the system. You can

use a custom job ID that matches some other information in your automation system when submitting the pickup or pickupDropoff request.

Basic Job Commands

The following are some basic example job commands:

- "queuePickup goal1": submits a request to send any available robot to "goal1."
- "queuePickupDropoff goal1 goal2": requests that any available robot first drives to "goal1," then, once completed, drives to "goal2."
- "queueCancel jobid JOB7": immediately cancels job7, regardless of whether a robot is performing that job.

Basic Job-Supporting ARCL Commands

The following ARCL commands support job queuing:

> **NOTE:** In ARCL command syntax, commands are not case sensitive, values in angle brackets < > are required, and values in braces [ ] are optional. Refer to the *Advanced Robotics Command Language Reference Guide*, and *Advanced Robotics Command Language Enterprise Manager Integration Guide* for more information.

- queuepickup <goal_name> [priority] [job_id]
- queuepickupdropoff <PICKUPgoal_name><DROPOFFgoal_name> [PICKUPpriority] [job_id]
- queuecancel <canceltype> <cancelvalue> [echo_string] [reason]
- queuedropoff <goal_name> [priority] [job_id]
- queuequery <querytype> <queryvalue> [echo_string]
- queueshow [echo_string]

Job Example

The following is an example of a job with two simultaneous connections.

- Connection 1 submits a job "queuePickup goal1 goal2."
- The EM assigns a job ID of JOB7 and job segment IDs of PICKUP7 and DROPOFF8.
- Connection 2 sees the broadcast messages about the jobs entering the "Pending" state, but does not see the command response.

Using the Route Builder

With MobilePlanner Route Builder, you can set up tasks for the robot to perform and goals for it to drive to. You can also customize robot operation and build routes for the robot to follow. All of this information is embedded into the map file. Once you download the map file to the mobile robot, you can use MobilePlanner to drive the robot in its operating environment, and perform tasks.

> **NOTE:** Jobs are preferred over routes in industrial environments.

Use the Route Builder to set up the following:

- **Tasks:** Activities that the mobile robot can perform, such as going to a goal or checking sensors. Tasks give the robot useful work to perform. These tasks are already available on the robot, but need to be defined and associated with the map that you are creating.
- **Goals:** Virtual destinations that the robot drives to in its environment. These goals are defined in the map, and represent real-world places in the operating environment.
- **Macros:** Containers for sequences of tasks and goals. Once these macros are created, you can select the macro, rather than all of the individual tasks and goals, for the robot to perform. You only have to define a macro once, but can use it as many times as necessary. You can also use macro templates, which are special macros that can accept simple parameters. You define parameter types when you create a new macro template, and specify the values when you use the template in another macro, route, etc.
- **Custom responses:** Actions such as making the robot talk (e.g., when its path is blocked, fails the path, or does global replanning, etc.), performing a particular or sequence of tasks at all goals, when docking, or when a special event (such as a bump or E-Stop) occurs.
- **Routes:** A "to do" list or a series of tasks, goals, or macros for the mobile robot to follow.

The Route Builder Interface

MobilePlanner's Route Builder allows you to set up macros, tasks, goals, and routes for the mobile robot to follow.

1. Click the **Map** button, then click the **Build** tab.

   The Route Builder (Build tab) appears in the window, as shown in the following figure.

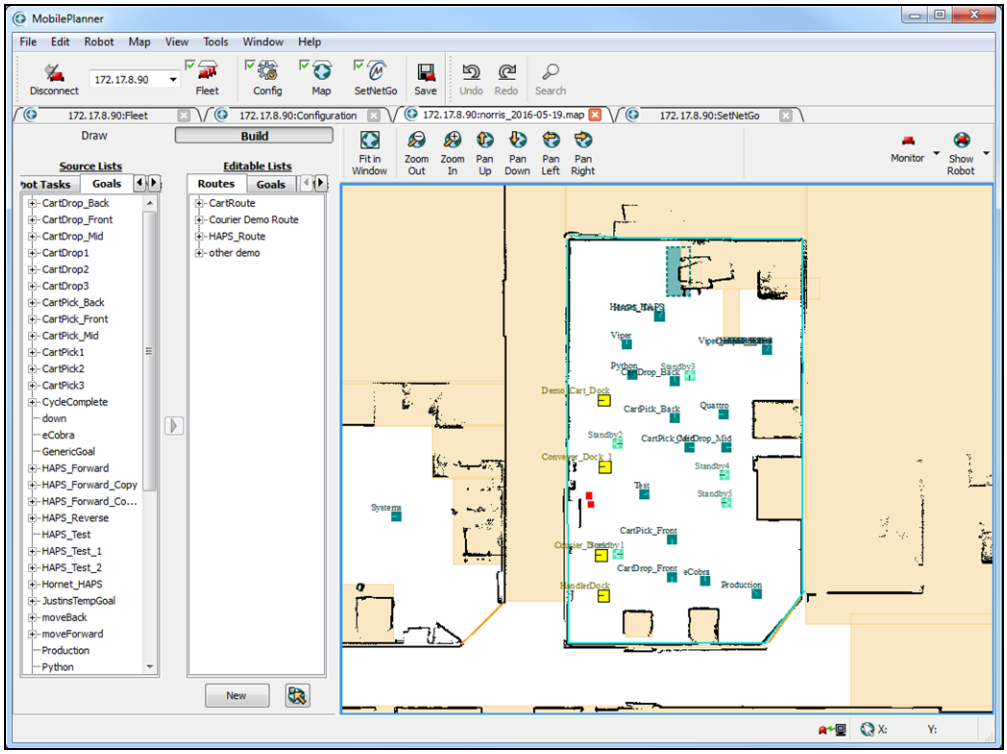


Figure 8-12: The MobilePlanner Map Workspace with the Route Builder Open

The Route Builder Elements

The Route Builder has two panes: Source Lists and Editable Lists. Each section uses tabs to switch between the different available options.

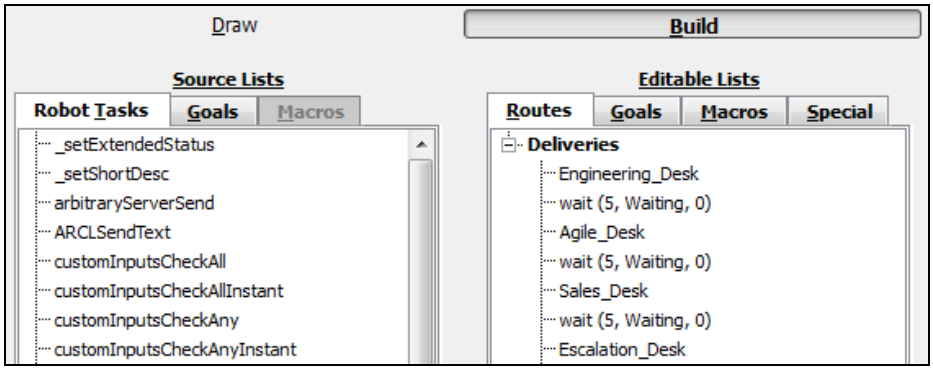


Figure 8-13: The Route Builder Elements

The Source Lists pane lists available robot tasks, goals, and macros you can add to new routes, goals, macros, and special tasks.

The Editable Lists pane displays routes, goals, macros, or special tasks. The tabs allow you to switch between the different types of objects that you can build.

You can drag Source Lists objects into any of the Editable Lists routes (or macros) you are working on, or use the arrow icon between the lists.

Source Lists: Robot Tasks, Goals, and Macros Tabs

The tabs in the Source Lists pane display the tasks, goals, and macros you can use in building new routes, adding tasks to goals, and building macros and special tasks.

> **NOTE:** Some of the Robot Tasks listed below need to be specifically enabled by clicking the **Config** button, then clicking the **Robot Operation** tab, and the **Task Features** section.

- **Robot Tasks:** Lists the tasks available for creating new objects (routes, macros, etc.) on the map. Tasks are robot and accessory-related operations, such as moving the robot, talking, or playing a sound. These tasks are already available on the mobile robot, however you must include them in one of the Editable List items for the robot to know when and where to perform them. For more information on using tasks refer to Robot Tasks on page 132.
- **Goals:** Lists the goals available for creating routes or macros. Goals are locations on the map that are destinations for the mobile robot. For more information on using goals, see Setting Up Goals.
- **Macros:** Lists available macros which you can add to tasks or goals. Macros are reusable containers for multiple tasks. For more information refer to Creating Macros on page 156.

For detailed information about a task, goal, or macro, right-click on the item and select **Description**.

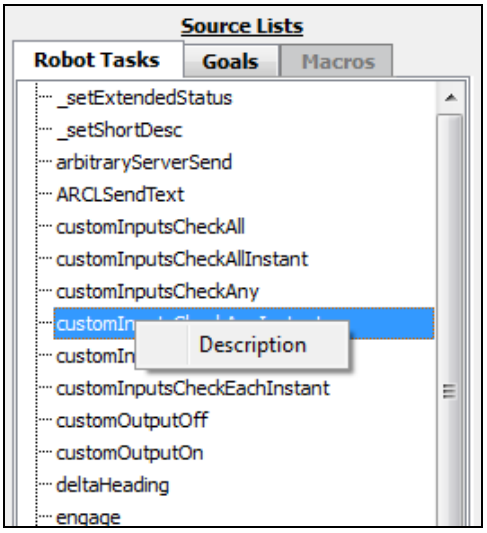


Figure 8-14: Accessing the Task Description

Click on the task parameter to read a brief description of the selected task. The figure below shows an arbitraryServerSend task. To set up different tasks and their parameters, refer to the specific task (Using Audio Tasks, for example).

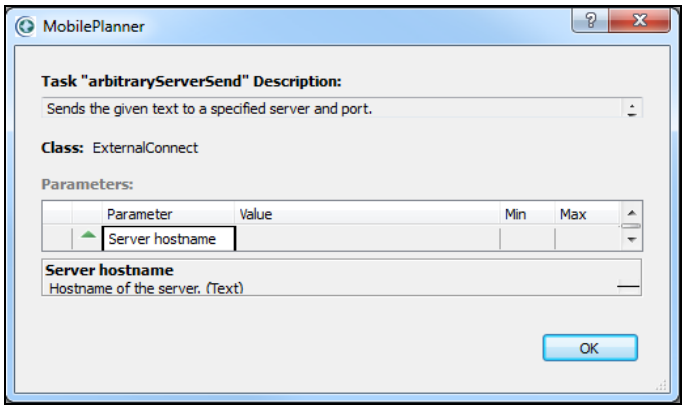


Figure 8-15: arbitraryServerSend Task Description

Editable Lists: Routes, Goals, Macros, and Special Tabs

- **Routes:** Lists created routes, and allows you to build new routes. For details, see Creating Routes on page 163.
- **Goals:** Lists created goals or destinations. You can add tasks for the robot to perform at the specified goal. For more information on using goals, refer to Setting Up Goals.
- **Macros:** Lists created and defined macros, and allows you to create new macros. Refer to Creating Macros on page 156 for more information.
- **Special:** Used to customize robot operation. Custom tasks allow you to have the robot perform certain activities at every goal or at a dock. They also allow you to program the robot to take special actions when specific events happen. For more information, refer to Setting Up Special Tasks on page 146.

Macros

Macros are reusable sequences of tasks which have their parameters set when you add them to the macro. So every time you use a macro, the tasks inside use the same settings. Macros are extremely effective if you have groups of tasks that you need to repeat in multiple places.

For example, you might have a robot delivering parts to various places. At each of the multiple delivery locations, it needs to navigate to each, pause, announce its arrival, wait for the part recipient to retrieve the part, then move on to the next delivery site. Instead of manually programming each of these tasks at each goal, you can use macros to replicate this same functionality across multiple goals.

You can create macros in Editable Lists (in the Build pane) by clicking the **New** button. Then, drag the appropriate tasks from the Robot Tasks list (under Source Lists) into the macro in the desired point. After adding the tasks to the macro, you can reorder and reconfigure them as needed.

Macro Templates

Macro templates are simple, text-only features for adding simple parameters to macros. Allowed parameters for macro templates are named $1 to $9. They do not allow variables or expressions.

To create a macro template, click the **Map** button, **Build** tab, then use the **New** dropdown menu directly below the Editable Lists pane and select **Macro Template**.

For details, see Macro Templates on page 158.

Creating Macros

Macros are containers that hold a series of tasks, goals, and other macros. After you create a macro, you can reuse it as many times as needed. Macros can hold goals and use tasks with conditionals, and they can be embedded within macros and other tasks. As a result, macros are very versatile.

To create a macro:

1. Click the **Map** button, then click on the **Build** tab.

   The Source and Editable Lists appear on the left side of the map.

2. Under Editable Lists, click the **Macros** tab.

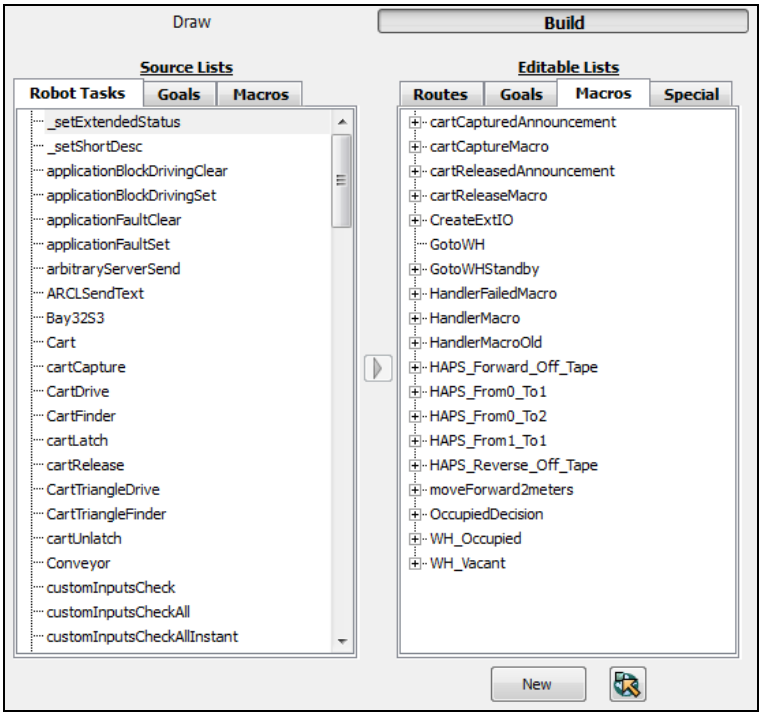


Figure 8-16: MobilePlanner Build tools - Macros tab

3. Click on the **New** button an the bottom of the Editable Lists pane.

   This adds a new macro to the Macros tab which, by default, has the name "Macro1." This new macro name increments by 1 with each new added macro. See Renaming the Macro on page 158 for directions on changing the macro name.

4. Highlight a task from the Robot Tasks list and either drag it to the desired macro in the Macros tab or click the **Add** arrow (between the two panes).

The new macro expands with each added task, as shown below.

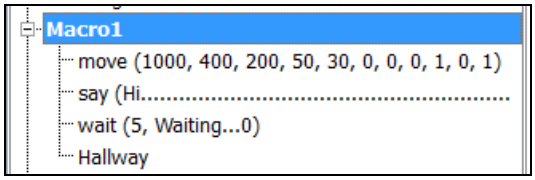


Figure 8-17: Macro detail

5. Click the **Goals** tab to access the goals available to add to the macro, then drag the desired goal into the new macro you are creating. You can also pick a goal from the displayed map to add to the macro (see Picking a Goal From the Map on page 158 for details).
6. Click the **Macros** tab to access existing macros. You can then drag an existing macro into the new macro.

The macro below shows an example of tasks, a goal, and a macro named "Greeting" added to the new Macro1 macro.

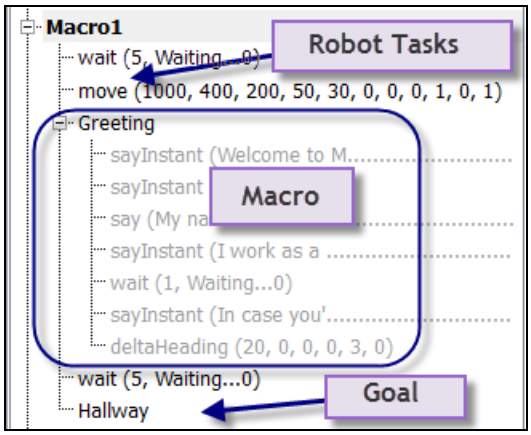


Figure 8-18: Macro details

Using the Add Button

In addition to dragging a task, you can use the arrow (Add) button to add a task to the macro.

1. Click on the **Macros** tab in the Editable Lists pane.
2. Highlight the macro to which you want to add a task, goal, or macro.
3. Click on the **Robot Tasks**, **Goals**, or **Macros** tab from the Source Lists pane.
4. Select the task, goal or macro you want to add to the new macro.
5. Click the **Add** button to add the task, goal, or macro.

   If parameters are associated with the task, a dialog box appears that allows you to adjust parameters appropriately.

   For specific parameter information, refer to the task type (such as a wait task) for more information.

Picking a Goal From the Map

You can add goals to macros by clicking the goal on the map. This allows you to add multiple goals within the same vicinity.

1. Be sure that the goals you want to add to the macro are visible in the map window. For details, see Using MobilePlanner Software on page 53.
2. From the Editable Lists pane, select the **Macros** tab, then select the appropriate place in the desired macro to add the goal.
3. Click the **Pick Goal** button at the bottom of the pane (next to the New button).
4. In the map, click on the goal to add the goal to the macro (you can select multiple goals without having to click on the Pick Goal button each time).

To move the goal within the macro:

1. Click on the goal name in the macro list.
2. Drag it to the position you want the goal to be.

Renaming the Macro

1. Right-click on the macro you want to rename.
2. In the pop-up window, click **Rename** to change the macro name to editable text.
3. Type in the new name for the macro.

Copying a Macro

1. Right-click on the macro you want to copy.
2. In the pop-up, click **Duplicate** with the left mouse button.

   A copy of the macro appears in the Macros tab.

Deleting a Macro

1. Click the macro then hit the **Delete** key, or
2. Right-click on the macro you want to delete then, in the pop-up window, click **Cut** with the left mouse button to delete the selected macro.

Macro Templates

Using macro templates, you can easily add a variable to a set of tasks. This makes reusing macros or task sets with slight differences (depending on the goal or application) fast and easy. For example, you can create macro templates for changing wait times, status to wait with, line to log, activating a different IO, etc.

> **NOTE:** If you are using a map created under an older version of MobilePlanner, you will need to update it. After updating, it will not be backwards compatible with older MobilePlanner versions.

To update your map

1. In MobilePlanner's main menu, click on **Tools > Update Map Features**.

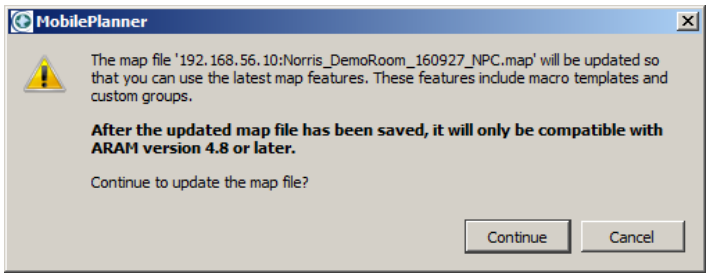


Figure 8-19: Update Map dialog

2. Read the notes and information in the pop-up window, then click **Continue** to update the map.
3. After updating the map, you will need to save and reload the map.

   Macro Templates and Grouped Items will then be available for use, and there will also be a few default group items like door goals, docks, and cart transporters.

Creating a new macro template

NOTE: To use macro templates, you must have (at minimum) MobilePlanner 4.4.0 and ARAM 4.8.

1. In the Build pane, Editable Lists, click on the **Macros** tab, then click the **New** button drop-down arrow, and select **Macro Template**.

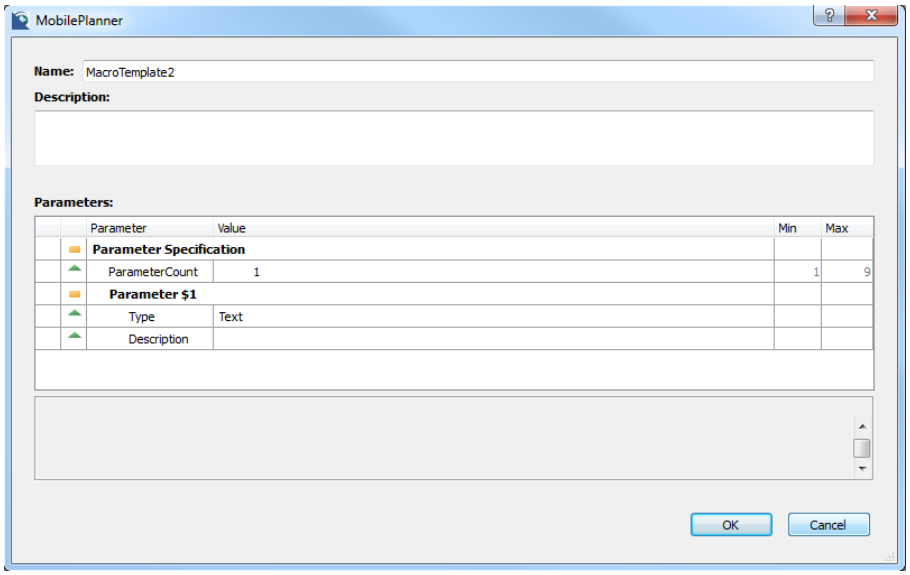


Figure 8-20: New Macro Template dialog

2. Enter a name and description for the template, and set variable number(s), type(s), and descriptions.

   Types can be Text, Integer, Double, or Boolean.

Type	Allowed Value	Default
Text (or String)	Any letters or numbers	Zero
Integer	Number without decimal	Zero
Double	Number either with or without a decimal	Zero
Boolean	True or False	False

3. Enter up to nine parameters in the macro template.

   Parameter names use '$1' to '$9.' You can enter a text description of each '$#' variable in the Description field.

4. Add tasks to the template.

   Add '$#' to call a variable ('#' is limited to previously defined parameters).

5. To add the new macro template, drag and drop from the Source list into the Editable list.

Custom Groups

Using custom groups, you can define a reusable group of complex map objects, such as goals, sectors, etc. This allows you to place repeatable tasks (e.g., cart goals) on your map quickly and consistently, which helps to speed up application building time. Custom groups can interface with macro templates. Once created, you can add grouped items from the build tab as you would an advanced area.

Notes on using custom groups:

- You cannot edit or delete custom group definitions.
- You cannot modify originally selected map items, and they do not automatically become members of a new group instance.
- You cannot nest groups. The software ignores groups already in the original selection list.
- You cannot ungroup groups (i.e., you cannot convert them to top-level objects).

Custom groups also contain all tasks and macros (which you can individually edit) from every goal and sector that you included in the group.

Creating a new custom group

> **NOTE:** Update the map format, then create a backup of your map before creating the custom group.

1. Ensure Show Robot is **OFF**.
2. Highlight all map objects (goals, sectors, etc.) you want to include in the group.
3. Right-click on the map location that is the group's anchor point (its origin), and select **Advanced > Create Custom Group**.

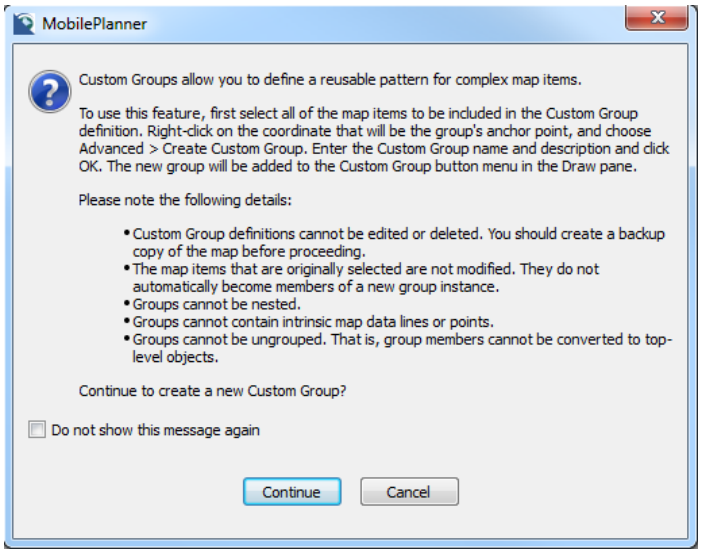


Figure 8-21: Create Custom Group explanation dialog

4. Read the information in the pop-up, then click **Continue** to create the custom group.

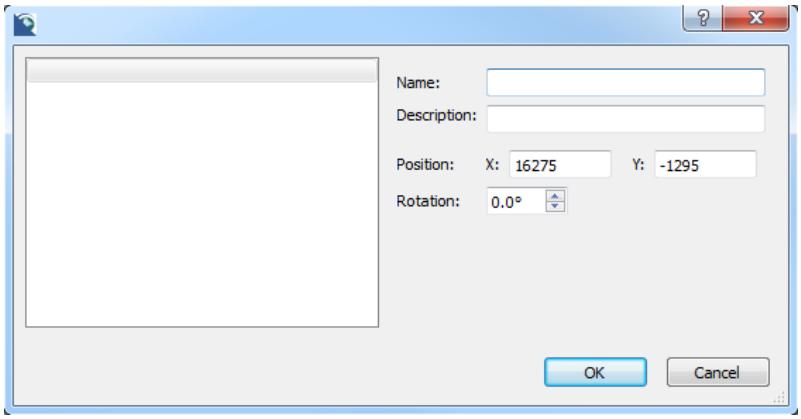


Figure 8-22: Create Custom Group dialog

5. Enter the custom group's name and description.
6. Click **OK**.

   The new group will appear under the Custom Groups button drop-down menu in the Draw pane.

To edit a single item in the group, right-click and select the component you want to edit.

Adding a grouped item

After you create a grouped item, you can add it to the map as follows:

1. Verify that Show Robot is **OFF**.
2. In the Draw tab, click the **Custom Groups** drop-down arrow, and select a grouped item.
3. Move the cursor (appears as a 'pencil') to the grouped item's intended location, and click to place the item on the map.

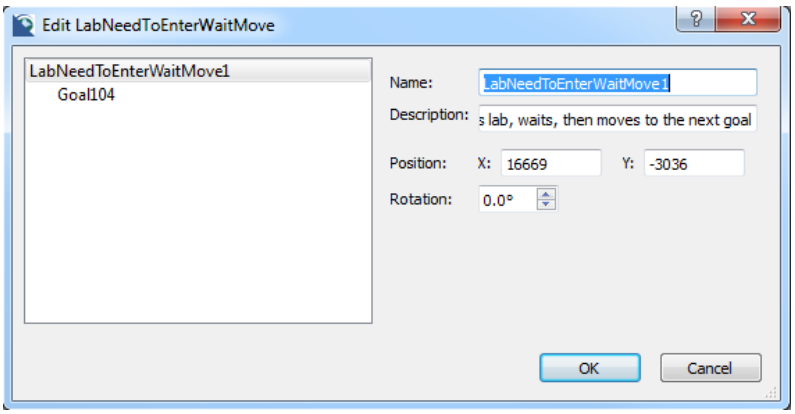


Figure 8-23: Add Grouped Item dialog

4. Click **OK** to add the grouped item.

Adding New Goals to the Robot's Current Location

MobilePlanner software's robot monitor allows you to interact with the robot (for example, you can move the robot to a new location or goal, then add another new goal to where the robot is located).

1. Drive the robot to the location where you want to add a goal or task (for details, see Driving the Robot for the First Time).
2. When the robot is at the desired position, click the **Item at Robot** button (in the toolbar), and select **Create Goal**.

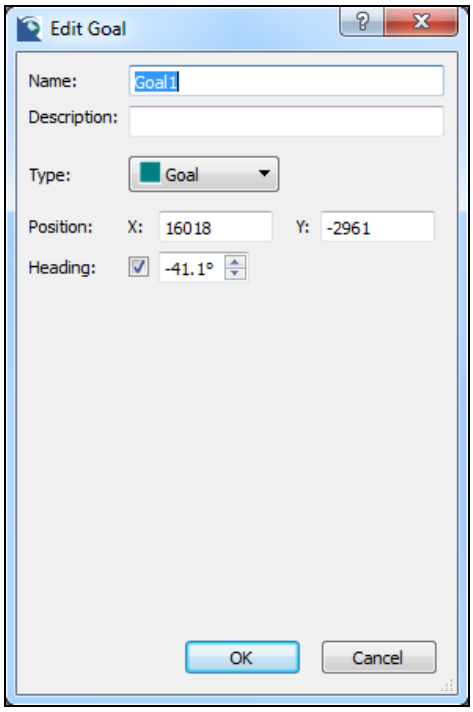


Figure 8-24: Edit Goal dialog

3. In the Edit Goal dialog, enter the information, then click **OK**.

Creating Routes

A route is essentially a "to do" list for the mobile robot. It is a series of ordered tasks, goals, and macros for the robot to complete. Tasks are robot and accessory-related operations, such as talking or playing a sound, reading inputs, and triggering outputs.

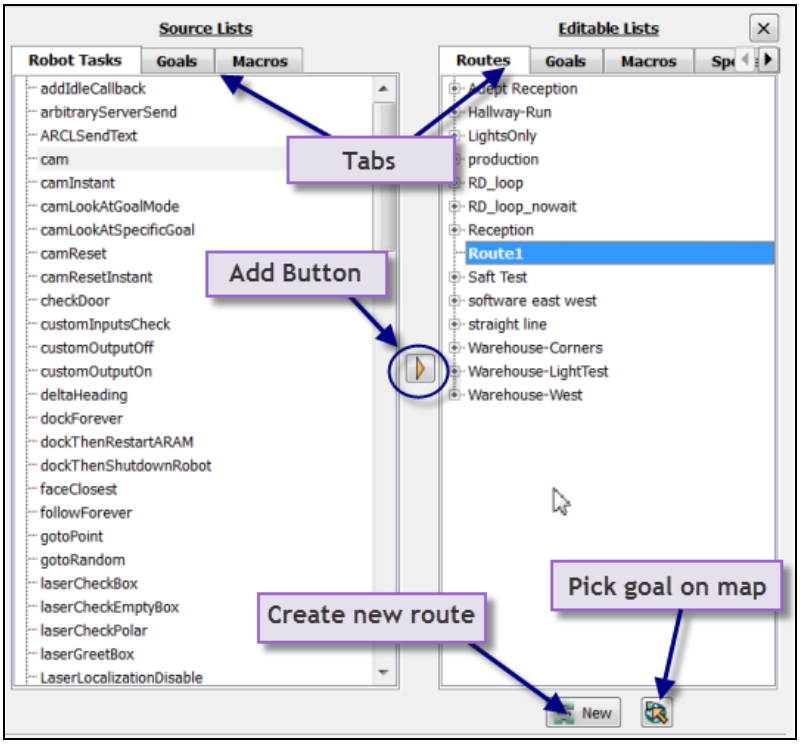


Figure 8-25: MobilePlanner interface - Build tab lists

Building Your Route

To build routes for the robot, simply drag a task, goal, or macro from the Source Lists to the **Editable Lists > Routes** tab, as described in the following procedure.

To build a new route:

1. Click the **Build** tab to display the Route Builder.
2. Click on the **Routes** tab in the Editable Lists pane.
3. Click on the **New** button on the bottom of the Editable Lists pane to add a new route to the Routes tab.

   The default name for this new route is "Route1," and each new route name increments by 1. See Renaming the Route on page 166 for details on renaming a route.
4. Highlight a task from the Robot Tasks tab (in the Source List pane) and drag it to the desired route in the Routes tab.

   The new route expands with each added task, as shown below.

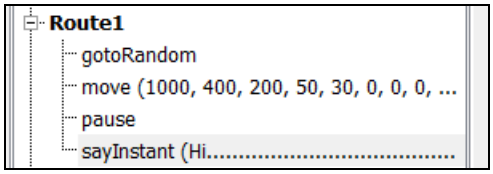


Figure 8-26: Route detail

5. Click the **Goals** tab to access the goals available to add to the route, then drag the desired goal into the new route you are building. You can also pick a goal from the displayed map to add to the route, see Picking a Goal From the Map on page 166 for details.
6. Click the **Macros** tab to access the macros available to add to the route, then drag the desired macro into the new route you are building.

   The route below shows an example of tasks, goals and macros added to the new Example route.

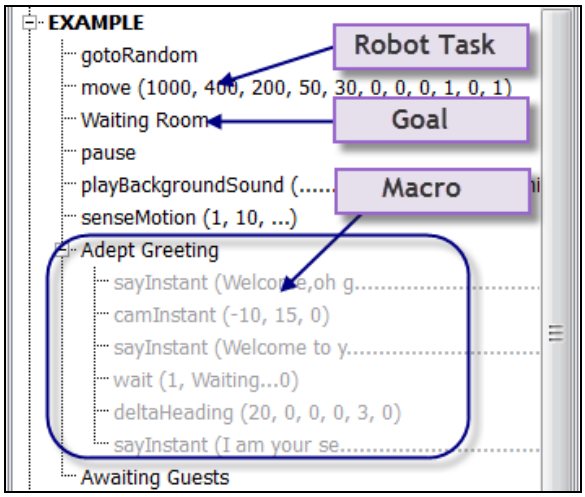


Figure 8-27: Route details

Using the Add Button

In addition to dragging a task, goal or macro into your route, you can use the arrow button to add the task to the route.

1. Click on the **Routes** tab in the Editable Lists pane.
2. Highlight the route to which you want to add a task, goal or macro.
3. Click on the **Robot Tasks**, **Goals** or **Macros** tab from the Source Lists pane.
4. Select the task, goal or macro you want to add to the route.
5. Click the **Add** button to add the task, goal or macro to the route.

   If parameters are associated with the task, a dialog box appears in which you can adjust parameters appropriately. For specific parameter information, refer to the task type (such as a wait task) for more information.

Picking a Goal From the Map

You can add goals to routes simply by clicking the goal on the map. This allows you to easily add multiple goals to the route that are in the same vicinity on the map.

1. Be sure that the goals you want to add to the route are visible in the map window (see Using MobilePlanner Software on page 53 for details on using the workspace).
2. From the Editable Lists pane, select the **Routes** tab.
3. Click on the **Pick Goal** button at the bottom of the pane.
4. Highlight the route in which you want to add the goal.
5. In the map, click on the goal you want to add to the route.

   This adds the goal to the route. You can select multiple goals without having to click on the Pick Goal button each time.

To move the goal within the route:

1. Click on the goal name in the route list.
2. Drag it to the desired position.

Renaming the Route

1. Right-click on the route you want to rename.
2. In the pop-up window, select **Rename** to change the highlighted route to editable text.
3. Type in the new name for the route.

Copying a Route

1. Right-click on the route you want to copy.
2. In the pop-up window, select **Duplicate** with the left mouse button.

   A copy of the route is displayed in the Routes tab.

Deleting a Route

1. Right-click on the route you want to delete.
2. In the pop-up window, select **Cut** (or use the Delete key) with the left mouse button to delete the selected route.

Chapter 9: Traffic Management

This section describes managing traffic flow in your operating environment. Whether you are using a single mobile robot or a fleet of mobile robots, defining how the robot moves within the space allows you to better control the robot's behavior. As a result, you can prevent the robot from running into problems, allowing it to complete the tasks assigned to it more efficiently.

In MobilePlanner, you can add objects and areas to the map and manage how the robot moves through its environment. You can add areas that direct or restrict traffic, and that control speed and docking behavior.

Understanding Traffic Control

MobilePlanner provides traffic control guidelines for the robot to determine the best path through the operating space. You can control robot traffic by adding areas to the map that tell the mobile robot which direction to go, how fast to drive, or how many robots you want to allow in an area at one time. With MobilePlanner, you can add these features and more to the map.

This section discusses the following traffic control features:

- Using Preferred Lines on page 175
- Using Preferred Directions on page 176
- Using Forbidden Lines and Areas on page 181
- Adding Switchable Forbidden Lines and Areas to the Map on page 182
- Using Resisted Lines and Sectors on page 185
- Using Need to Enter Sectors on page 188
- Using Single Robot Sectors on page 189
- Controlling Robot Speed on page 179

Traffic Control Concepts

In environments with more than one mobile robot, managing traffic becomes increasingly more critical. The main goals in managing traffic flow are safe and efficient operations, and minimizing traffic jams and collisions. The following sections describe some of the more important traffic control concepts.

Taxi Line (Multi-Robot Standby goal)

Much like a row of taxis waiting outside the airport, the concept allows multiple mobile robots to approach and arrive at the same Standby goal (called a 'Multi-Robot Standby' goal), in sequence, without bunching up and causing a traffic jam.

The Multi-Robot Standby (MRS) goal acts as a traffic control tool. The MRS goal extends the standard Standby map object to enforce sequenced queuing for multiple robots at a single starting point, each of which then moves linearly - in sequence - to an end point. Along the way, the robots become available as they reach the end of their 'after' task.

The following figure shows the general design. The MRS start point is at the left, the MRS end point is on the right.

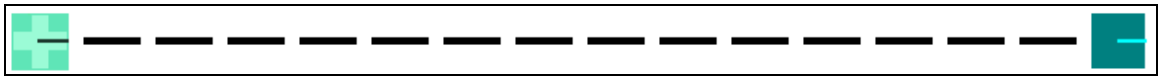


Figure 9-1: Taxi Stand (Multi-Robot Standby) goal design

An ideal implementation is at a map corridor that frequently becomes congested with multiple robots. By placing the start point some distance from the goal (for example, at the corridor entrance), the robots move through the corridor - in sequence - and reach the end point of the 'after' movement near the corridor's exit. Another ideal implementation is for high throughput sources of parts that need to go to many places (like a plant that has a few gantries serving a few hundred goals. The robots waiting in line near the source means a much higher throughput.

Implementing Taxi Line

Using this feature requires setting the Boolean 'AllowMultipleRobots' on standard standby objects (standbys with this Boolean flag active become Multi-Robot Standbys), and each goal using a nearby MRS must also have a Managed Destination sector placed over it, with the 'AlwaysBuffer' parameter enabled, and the sector's ReservedBuffer parameter set to the name of the MRS.

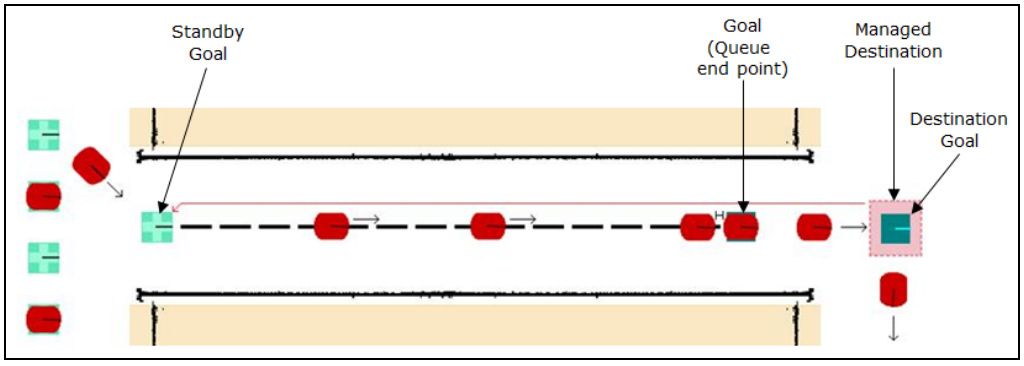


Figure 9-2: Taxi Stand implementation example

NOTE: You can only use MRSs as ReservedBuffers. An MRS with no sector referencing it as a ReservedBuffer will display an error when saving the map, and will be ignored during normal operations. Each MRS can ONLY be reserved by one map object.

A typical implementation is to place a standard goal on the map to use as the end point of the buffering line. The figure below shows how this would work with a single robot (the dashed lines are for illustrative purposes only - they do not appear in the map).

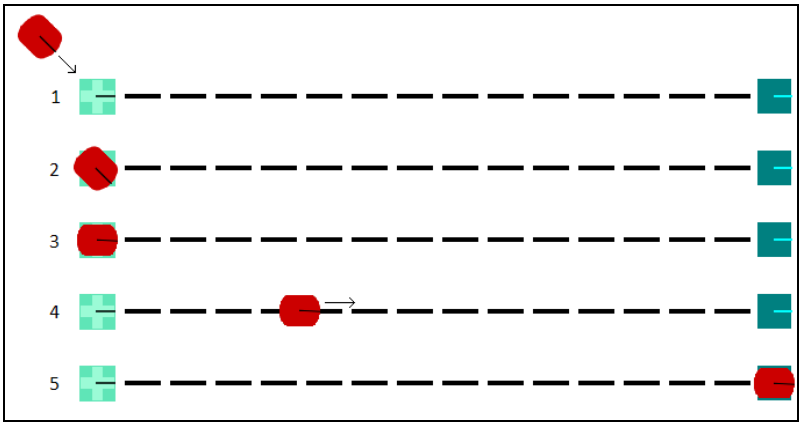


Figure 9-3: Taxi Stand (Multi-Robot Standby) goal design, single robot use

As shown above, each mobile robot drives to the MRS start point (line 1), rotates to the correct pose (line 2), signals the Enterprise Manager (EM) of its arrival, then executes an 'after' task (in this case, a 'gotoStraight') to the associated goal (lines 4, and 5). With multiple robots, the sequence works as shown below. In line 1, a second robot is moving towards the end goal, which is already occupied by another waiting robot. It assumes a position behind the first robot (line 2), and is then joined by two more robots (line 3).

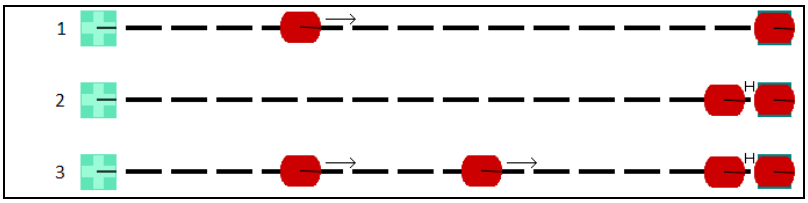


Figure 9-4: Taxi Stand (Multi-Robot Standby) goal design, multiple robot use

Managed Motion Sectors

Certain situations might require multiple robots drive in narrow spaces, like hallways and aisles. Without proper management, the robots could bunch up and cause traffic deadlocks. The Enterprise Manager (EM) uses managed motion sectors to control robot traffic flow in difficult areas, by directing the robots to wait at standby goals while awaiting permission to enter the sector. It allows only one robot to drive autonomously through the sector at a time, while still performing tasks (such as pickup/dropoff) without requesting EM permission. Managed Motion can use Taxi Line queuing, with each sector capable of having up to four reserved buffers.

Standby Buffering

Standby buffering is another type of 'StandBy' behavior in which a mobile robot must wait for another robot to clear a sector or goal. The awaiting mobile robot can automatically select and move to a nearby 'StandBy' goal to wait.

Preferred Lines, and Directions

You can specify preferred lines, and directions that govern how your mobile robots move through their environment. Once placed on a map, the mobile robots will, if possible, use the preferred areas. If something prevents a mobile robot from keeping to the preferred line or direction, it will seek out another path.

Resisted Areas and Lines

You can also place areas and lines on the map that you want your mobile robots to avoid, but, if unable to complete a goal without moving into - or crossing over - one of these areas, it will do so (with a higher cost). Typically, resisted areas, lines, or directions are for special cases, such as setting up travel lanes in which moving is allowed but should be avoided (for an explanation of cost-based path planning, see Cost Based Path Planning on page 171).

Forbidden Areas and Lines

As the name implies, these areas, lines, and directions are areas or lines the mobile robot's must never enter or cross over. These could be loading docks (or other areas that might lead outside), stairs, internal structures with walls, or other areas where the robot could pose a hazard.

DistanceUncrossable and DistanceAdjustment Lines

If the straight-line path between the robot and its goal intersects a DistanceUncrossable line, the robot will not drive to the destination. You can use these lines to guide a robot to the appropriate dock or standby goal. The DistanceAdjustment line artificially increases the distance calculation between two points. Queuing uses the distances to determine such actions as which dock to go to.

Path Planning and Collision Avoidance

MobilePlanner's tools allow you to plan the most expedient routes for your mobile robots, while keeping them from running into objects in your facility - and each other. There are may traffic control mechanisms associated with path planning.

This section discusses cost-based path planning, difficult spaces, and virtual doors.

Cost Based Path Planning

ARAM uses a path planning scheme called Cost Based Path Planning. In this scheme, a robot instructed to proceed to a goal searches the map for the most efficient path from its current location to the goal, based on what it knows about the map. This path, called the global path, is the optimal path from point a to point b. The robot then follows that path to the goal while avoiding unmapped obstacles. If the robot detects unmapped obstacles, it alters its local path to avoid them. If unable to proceed along the global path, the robot can re-plan a new global path.

The Path Planning Grid

The 'cost-based' aspect of this path planning scheme breaks a map into discrete 100mm squares (typically sufficient), called the path planning grid (which is not the same as MobilePlanner's 1000mm (1 meter) reference grid), and assigns a cost to each square. Free (empty) squares (those not close to any obstacles) have a cost of 0.1. The cost for squares containing walls and other fixed objects is infinite (meaning the robot will never enter those squares because the cost is far too high).

> **NOTE:** Although you can improve path planning accuracy by decreasing the path planning grid squares (done in the PlanRes parameter), doing so increases robot processing time. For example, changing the PlanRes parameter (**Config > Robot Operation** tab **> Path Planning Settings** section) from 100mm to 50mm quadruples processing time.

Using cost-based path planning, the robot plans a path with the lowest cost, and follows that path to its goal. If it detects any unmapped obstructions, it alters its path to avoid them. And while the resulting path deviation might be longer, the robot will always choose the path of lowest cost.

Factors Affecting Cost

Generally, a grid's cost increases as its distance to an obstacle decreases, and occupied grid squares have infinite cost. Preferred lines and directions generally have the lowest cost, while resisted lines and areas have higher costs. Forbidden lines and areas (like those with walls or other fixed obstructions, loading docks, etc.) have an infinite cost, meaning the robot will never cross or enter them

For more information about preferred, resisted, restricted, and forbidden lines and areas, see Understanding Traffic Control on page 168.

Path Planning Parameters

MobilePlanner has dozens of path planning-specific parameters that control how the robot moves through its environment, including (not an all-inclusive list):

- The robot's maximum traveling and rotating speed.
- Turning radius.
- Grid resolution.
- Fast and slow speeds.
- Robot padding and clearances (at fast and slow speeds).
- Robot rotational speeds at goals.
- The amount of resistance for resisted sectors and lines.
- Preferred and resisted lines, areas, and directions.

To view and set these path planning parameters (when connected to a robot), click the **Config** button, then click the **Robot Operation** tab, and select **Path Planning Settings**.

> **NOTE:** MobilePlanner has the most complete and up-to-date descriptions of all path planning parameters, which will not be repeated here.

Dealing with Difficult Spaces

Clearance settings limit how close the robot can move to detected obstacles. You can increase or decrease the required clearance based on the robot's speed, and have the software stop the robot if it will come too close to an obstacle in its path before it can stop by decelerating.

Changing clearance settings alter the robot's behavior if it moves very slowly through doorways or other tight spaces, or stops too quickly when it senses an approaching obstacle. Conversely, if your robot moves too close to obstacles or doesn't slow down rapidly enough, these settings can improve its behavior.

You can set the clearance and padding parameters in MobilePlanner by clicking the **Config** button, then clicking on the **Robot Operation** tab, and selecting **Path Planning Settings**.

- Front Clearance: a narrow (100 mm/ 3.9 inches default), fixed buffer zone at the front of the robot that does not change with robot translational velocity.

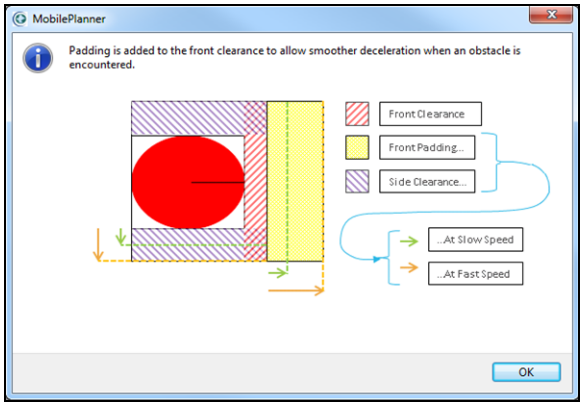


Figure 9-5: Front Clearances

- Side Clearance at Slow Speed (75 mm/ 2.9 inches default) is the minimum side clearance applied at any translational velocity.

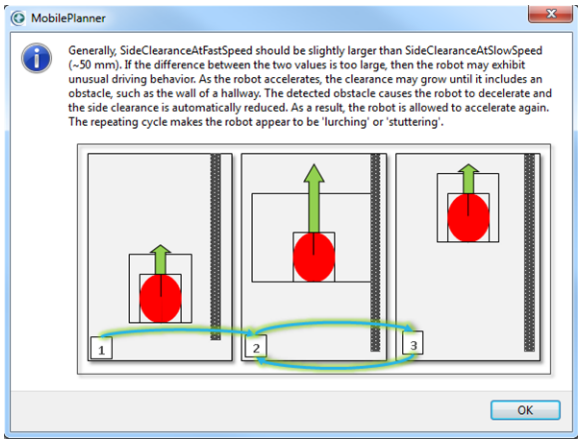


Figure 9-6: Side Clearances

- Front Padding and Side Clearance grow as robot speed increases if you set these parameters. This is done as a safety precaution for faster-moving robots. The values for Front Padding at Slow and Fast Speeds, as well as Side Clearance at Slow and Fast Speeds can be set larger or smaller than the values shown in the figure above based on your facility, the expected level of traffic, and the general nature of the environment the robot will be working in.

  As the robot accelerates, Front Padding and Side Clearance increase from Slow Speed size towards Fast Speed size.

  > **NOTE:** If side clearance at high speed is set too large, the robot will speed up and slow down in hallways and similar spaces. This is because the side clearance grows until it touches the wall, forcing the robot to slow down until its side clearance shrinks. It is best to have a small gap between sideClearanceAtSlowSpeed and sideClearanceAtFastSpeed.

Virtual Doors

Virtual doors (DefaultDoorWithGoals, for example) are areas on the map that allow the robot to drive, automatically and seamlessly, through special areas. For instance, they allow a robot to drive through plastic curtains that it would normally avoid.

When a robot plans a path through a virtual door, it instead drives to a specified goal beforehand, and optionally to another specified goal afterward. As with normal goals, tasks can be done at the goals associated with virtual doors.

The following dialog opens when you insert a virtual door in a map:

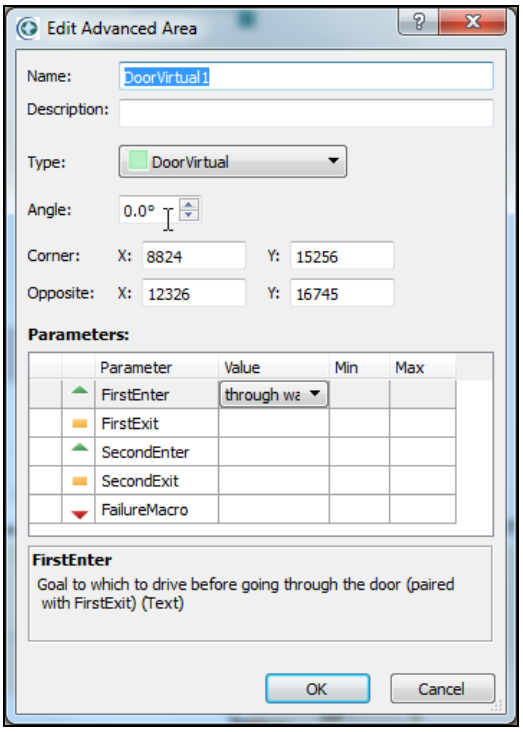


Figure 9-7: Edit Advanced Area dialog

Directing Traffic

With MobilePlanner, you can direct robot traffic by adding preferred lines and directions to your map.

Preferred lines make the robot drive as though it's on a virtual rail, and reduce the 'cost' of grid squares it crosses. Though a preferred line might be longer than a straight path from Point A to Point B, the preferred line reduces the cost of each cell it crosses (the Preference parameter divides the cost of each cell the line crosses by 2, which means it costs half as much to drive close to the line), so it could be the least expensive in terms of the cost.

Using Preferred Lines

Before adding a preferred line to the map, enable (click the checkbox for) the PreferredLine parameter (in **Config** > **Robot Operations** > **Map Features**, PreferredLine row):

1. Click the **Map** button to open the map you want to edit (see Using MobilePlanner Software on page 53 for details).

   > **NOTE:** You can have MobilePlanner add grid lines to the map to help you place lines and areas more accurately. In MobilePlanner's main menu, click **Map > Grid**.

2. In the Draw pane, click **Advanced Lines,** then select **PreferredLine** from the list (the cursor changes to indicate it is in drawing mode).

3. Place the mouse cursor on the map where you want the preferred line to start.

4. Click and hold the left mouse button, drag the mouse to where you want the preferred line to end, then release the mouse button.

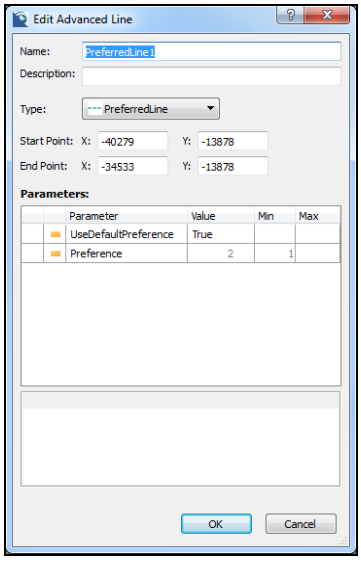


Figure 9-8: Edit Advanced Line dialog

The following table describes the parameters available on the Edit Advanced Line dialog box.

Parameter	Definition
Name	An optional name for the preferred line.
Description	An optional description for the preferred line.
Type	Set to PreferredLine. Selecting a different type from the pull-down menu changes the map's highlighted area to the selected type and updates the dialog box.
Start Point	X and Y coordinates of the PreferredLine starting point.
End Point	X and Y coordinates of the PreferredLine end point.
UseDefaultPreference	True or False (Boolean) value. If set to: • **True:** uses the default preference setting, ignores the Preference value. • **False:** the robot overrides the path planning settings with the value of the Preference parameter. Use Path Planning Settings to specify default settings (see Path Planning and Collision Avoidance on page 171 for details).
Preference	Integer representing the line's preference. A normal line has a cost of '1', so a setting of '1' turns off the line's preferred behavior. A line with a preference of '2' means driving on the line costs half as much. Higher preferences yield a lower cost. Applies only when UseDefaultPreference is false. See Cost Based Path Planning on page 171 for more information.

Using Preferred Directions

Preferred directions cause the mobile robot to attempt to drive on the specified side. In the image below, the robot does not move directly down the center of the hall, but along the right wall (the preferred directions).

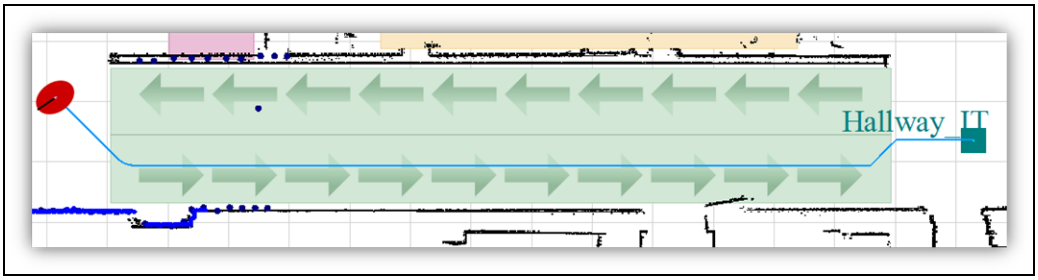


Figure 9-9: Preferred direction

If the robot cannot drive in the preferred direction for some reason, it will change its path to reach its goal, including driving against the preferred direction on the left side of the hallway (above). MobilePlanner allows you to add the following preferred directions to the map:

> **NOTE:** You must enable each of the preferred directions listed below (**Config** button **> Robot Operation** tab **> Map Features**) and **Save** before they will appear in the Advanced Areas pulldown menu (in the Draw tab).

- **PreferredDirectionLeft:** Places an area on the map that tells the mobile robot to drive on the left, in both directions.
- **PreferredDirectionLeftSingle:** Places an area on the map that tells the mobile robot to drive on the left, in one direction only. If you use this option and have two of these areas next to each other, align the two areas carefully. This is an advanced option. Use **PreferredDirectionLeft** for most applications.
- **PreferredDirectionRight:** Places an area on the map that tells the mobile robot to drive on the right, in both directions.
- **PreferredDirectionRightSingle:** Places an area on the map that tells the mobile robot to drive on the right, in one direction only. If you use this option and have two of these areas next to each other, align the two areas carefully. This is an advanced option. Use **PreferredDirectionRight** for most applications.

Adding a preferred direction to the map

1. Click the **Config** button, then click on the **Robot Operations** tab, and select **Map Features**.
2. In the PreferredDirection (Right or Left) row, enable the PreferredDirection parameters you want to use, then **Save** the map.
3. Click the **Map** button to open the map you want to edit (see Using MobilePlanner Software on page 53 for details).

   > **NOTE:** You can have MobilePlanner add grid lines to the map to help you place lines and areas more accurately. In MobilePlanner's main menu, click **Map > Grid**.
4. In the Draw pane, click **Advanced Areas**, then select the **PreferredDirection** from the list.
5. Place the mouse cursor on the map where you want the preferred direction to start.
6. Click and hold the left mouse button, drag the mouse to where you want the preferred area to end, then release the mouse button.

   The new area appears on the map, and the Edit Advanced Area dialog box appears.

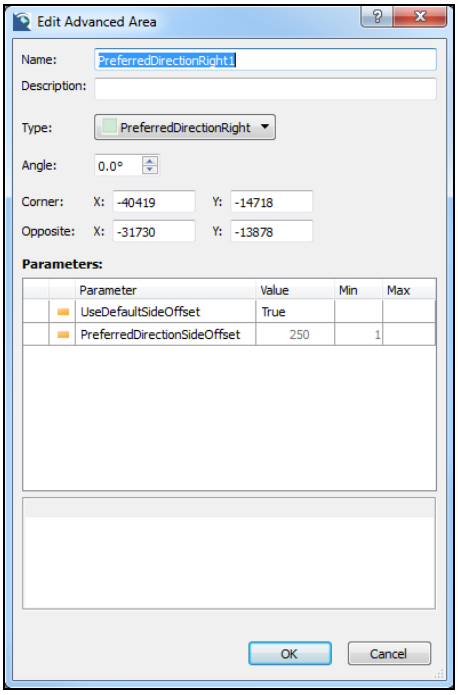


Figure 9-10: Edit Advanced Area dialog

Edit Advanced Line Parameter	Definition
Name	Optional name for the preferred area.
Description	Optional description for the preferred area.
Type	Set to the type of preferred area you selected.
Angle	The preferred area's rotation angle.
Corner	The X and Y coordinates of the preferred area's starting corner.
Opposite	The X and Y coordinates of the preferred area's ending corner.
UseDefaultSideOffset	True or False (Boolean) value. If set to: • **True:** uses the default side offset. • **False:** the mobile robot overrides the path planning settings with the value of the **PreferredDirectionSideOffset** parameter. Use Path Planning Settings to specify default settings (see Path Planning and Collision Avoidance on page 171 for details).

Edit Advanced Line Parameter	Definition
PreferredDirectionSide Offset	(Integer) Represents how far away from the edge of the preferred direction area the robot can drive.  **CAUTION:** Setting this value too low can cause the robot to drive out of the preferred area.

Controlling Robot Speed

You can control the robot's speed in certain areas by adding Movement Parameter Areas to the map.

Adding Movement Parameter Areas to the Map

NOTE: Movement parameters take effect after the robot is in them.

1. In MobilePlanner, click the **Config** button, then click the **Robot Operations** tab, then select **Map Features**, then scroll down and click in the checkbox to enable MovementParameterSector.
2. Click the **Map** button to open the map you want to edit (see Using MobilePlanner Software on page 53 for details).
3. In the MobilePlanner main menu bar, click **Map > Grid** to display the grid lines on the map.

   NOTE: You can have MobilePlanner add grid lines to the map to help you place lines and areas more accurately. In MobilePlanner's main menu, click **Map > Grid**.
4. In the Draw pane, click **Advanced Area**, then select **MovementParameters** from pull-down menu.

   The cursor changes to indicate it is in drawing mode.
5. Place the mouse cursor on the map where you want the area to start.
6. Click and hold the left mouse button, drag the mouse to where you want the sector to end, then release the mouse button.

   The new area appears on the map.

Editing Movement Parameter Areas

1. In the Draw pane, click **Select**, then click on the area you want to edit to highlight it.
2. Right-click on the highlighted area, and select **Edit** from the pop-up menu.

   The Edit Advanced Area dialog box appears.

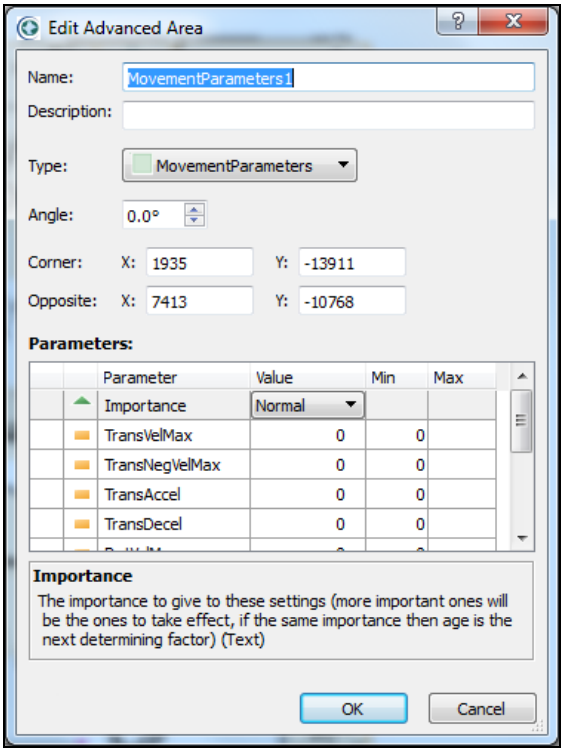


Figure 9-11: The Movement Parameters dialog box

The following table describes the parameters available in the Edit Advanced Area dialog box.

Parameter	Definition
Name	An optional name for the area.
Description	An optional description for the area.
Type	Set to **MovementParameters**. If you select a different type of advanced area, the highlighted area on the map changes to the selected type and the dialog box updates.
Angle	The angle the area is rotated within the map.
Corner	The X and Y coordinates of the starting corner of the area.
Opposite	The X and Y coordinates of the ending corner of the area.
Parameters	Parameters that affect the robots' behavior in the sector you drew on the map. A value of 0 means use defaults.

Restricting Traffic

You can restrict the mobile robot's movement by adding forbidden lines and areas to the map. These areas typically correspond to an area of the operating environment that you don't want the mobile robot to enter, or in which you want to restrict the number of robots operating at the same time (managed motion sectors). You can also add advanced features to the map that control traffic flow based on certain conditions. For example, you might want the robot to avoid an area during monthly maintenance. You can set that up using switchable forbidden areas. You might also have an area in which you want only one robot at a time.

You can set the parameters for these features in MobilePlanner by clicking the **Config** button, then clicking the **Robot Operations** tab, and selecting **Map Features**.

The following features allow you to restrict mobile robot traffic in your operating space:

- Adding Switchable Forbidden Lines and Areas to the Map on page 182
- Using Resisted Lines and Sectors on page 185
- Using Need to Enter Sectors on page 188
- Using Single Robot Sectors on page 189 (helpful when you have multiple robots operating in the same environment).

Using Forbidden Lines and Areas

You can place lines and areas on the map that correspond to places in your operating environment where you do not want the mobile robot to go. You can also add lines and areas that can be temporarily forbidden.

Forbidden lines are invisible barriers (virtual walls) in the operating space that the robot will not cross when driving in Safe Drive mode (the default driving mode). The cost of map squares under a forbidden line is infinite. For more information see Driving in Safe Mode on page 1.

Forbidden areas are places in the map that you do not want the robot to enter. For example, if your operating environment has a loading dock that is open to the outside you might not want the mobile robot to accidentally drive outside, and off the loading dock. The area might be accessible on three sides, so you could place forbidden areas on the map corresponding to the loading dock.

You can also add forbidden lines and areas that you can turn on and off (switchable forbidden lines and areas).

Adding Forbidden Lines and Areas to the Map

> **NOTE:** There are no required parameters for Forbidden Lines and Areas, which are always enabled.

1. Click the **Map** button to open the map you want to edit. Refer to Using MobilePlanner Software on page 53 for details.

   > **NOTE:** MobilePlanner can add grid lines to the map to help you place lines and areas more accurately (main menu, click **Map > Grid**). Also, ensure Show Robot is **OFF**.

2. In the Draw pane, click on either **Forbidden Line** or **Forbidden Area**.

The cursor changes to indicate it is in drawing mode, using a box around the icon to indicate an area.

3. Place the mouse cursor on the map where you want the forbidden line or area to start.
4. Click and hold the left mouse button.
5. Drag the mouse to where you want the line or area to end and release the button.

   The new forbidden line or area is selected and displayed in the map.

Adding Switchable Forbidden Lines and Areas to the Map

You can have certain tasks activate switchable forbidden lines and areas. These tasks can toggle individual lines and areas or they can toggle groups of switchable forbidden lines and areas.

1. To enable the **SwitchableForbiddenAreaAndLine** parameter, click the **Config** button, click on the **Robot Operation** tab, select **Map Features**, and click the checkbox to the right of the SwitchableForbiddenAreaAndLine parameter.

   > **NOTE:** The server will automatically restart when you change the parameters.

2. Click the **Map** button to open the map you want to edit. See Using MobilePlanner Software on page 53 for details.

   > **NOTE:** You can have MobilePlanner add grid lines to the map to help you place lines and areas more accurately. In MobilePlanner's main menu, click **Map > Grid**. Also, ensure Show Robot is **OFF** to enable the Draw tools.

3. In the Draw pane, click **Advanced Lines** or **Advanced Areas**, depending on what you want to add to the map.
4. Select **SwitchableForbiddenLine** or **SwitchableForbiddenArea** from the corresponding pull-down menu.

   The cursor changes to indicate it is in drawing mode, using a box around the icon to indicate an area.

5. Place the mouse cursor on the map where you want the line or area to start.
6. Click and hold the left mouse button, drag the cursor to where you want the line or area to end, then release the mouse button.

   The new switchable forbidden line or area appears on the map, and the Edit Advanced dialog box appears.

Editing Forbidden and Switchable Areas

> **NOTE:** The following procedures only apply if you want to edit an existing advanced area.

1. Verify Show Robot is **OFF** then, in the Draw pane, click **Select**.
2. Either double-click (or right-click) on the area or line in the map, and select **Edit** from the pop-up menu.

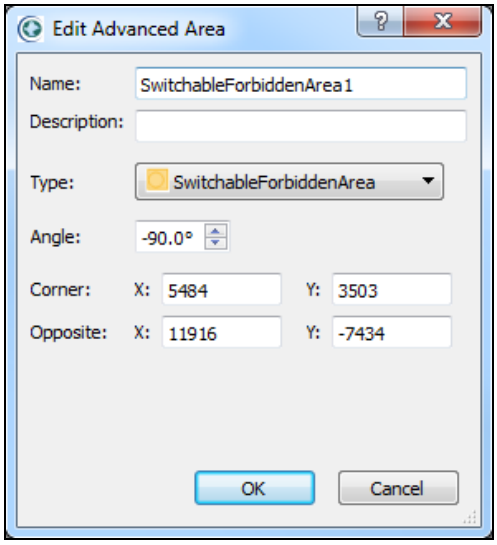


Figure 9-12: Edit Advanced Area dialog

The following table describes the options available in the dialog box.

Parameter	Definition
Name	A name for the forbidden area. **NOTE:** Since you switch forbidden areas by name, it's useful to use a common prefix when naming the ones you want to group together.
Description	An optional description for the forbidden area.
Type	Not displayed for ForbiddenLine. If you select a different type of advanced area in the drop-down list, the highlighted area on the map changes to the selected type and the dialog box updates accordingly.
Angle	The forbidden area's rotation angle (in degrees) in the map.
Corner	The X and Y coordinates of the forbidden area's starting corner.
Opposite	The X and Y coordinates of the forbidden area's ending corner.

To edit a forbidden line or a switchable forbidden line:

1. Verify Show Robot is OFF then, in the Draw tab, click **Select**.
2. Either double-click (or right-click) on the line in the map, and select **Edit** from the pop-up menu.

   If you selected a forbidden line, the Edit Forbidden Line dialog box appears. The Edit Advanced Line dialog box appears if you selected a switchable forbidden line.

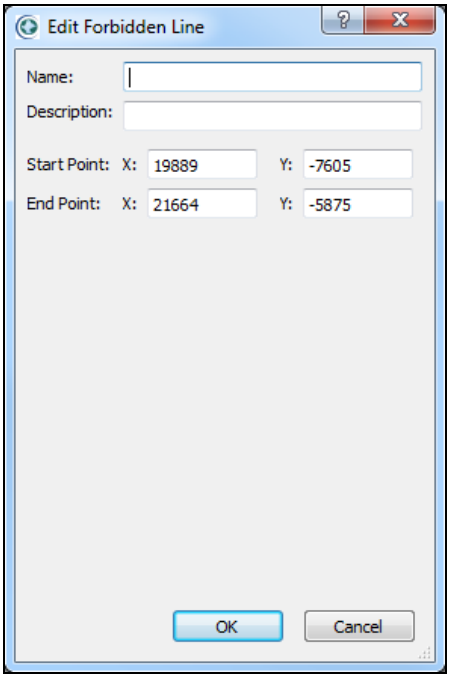


Figure 9-13: Edit Forbidden Line dialog

Edit Forbidden Line Parameter	Definition
Name	An optional name for the forbidden line.
Description	An optional description for the forbidden line.
Type	Displayed for SwitchableForbiddenLine. If you select a different type of advanced line from the drop-down menu, the highlighted line changes to the selected type and the dialog box updates.
Start Point	The X and Y coordinates of the starting point of the forbidden line.
Opposite	The X and Y coordinates of the ending point of the forbidden line.

Switchable Forbidden Lines and Areas

There are two ways to turn on or off a Switchable Forbidden Line or Area:

- Tasks
- ARCL

NOTE: ARCL is outside the scope of this manual. Refer to the corresponding reference guides for those products.

There are four tasks you can use to turn a Switchable Forbidden Line or Area on or off:

- switchForbiddenOff
- switchForbiddenOn
- switchForbiddenOffByPrefix (you can specify a text prefix that turns all switchable areas with that prefix OFF)
- switchForbiddenOnByPrefix (you can specify a text prefix that turns all switchable areas with that prefix ON)

Driving into a Forbidden Area

Occasionally you might need the mobile robot to drive into a forbidden area. You can make the robot do this by turning off Safe Drive mode, or using the joystick (even with safe mode on).

1. Click the **Map** button to open the map containing the forbidden area.
2. Attempt to drive the robot into the forbidden area from multiple sides - the robot should slow down and stop just before the forbidden area.
3. Click the **Safe Drive** toolbar button to turn Safe Drive mode **OFF**.

   WARNING: Turning Safe Drive OFF disables the robot's obstacle-avoidance. Use extreme caution when driving the robot under these circumstances.

4. Select **Yes** to turn Safe Drive mode off.
5. Drive the mobile robot into the forbidden area - this time the robot should drive into the area.

NOTE: Safe Drive mode must remain **OFF** to drive the mobile robot out of the forbidden area. Notice that the background color of the map changes to yellow when Safe Drive mode is turned off.

Using Resisted Lines and Sectors

You can add lines and areas to the map, called resisted lines and sectors, that the mobile robot will attempt to avoid because they cost more to drive through. The robot's path planning system is similar to a GPS system that recalculates a route to avoid road construction. However, if another route is not available, the robot follows the original. Similarly, the mobile robot will resist entering a sector or crossing a boundary if it is possible to avoid it; however, if it needs to drive through a resisted sector to reach its goal, it will.

Adding Resisted Boundaries and Sectors to the Map

1. In **MobilePlanner > Config > Robot Operation > Map Features**, enable ResistedSectorAndLine. See Setting the Configuration Parameters on page 126
2. **Save** your change to the robot.
3. Click the **Map** button to open the map you want to edit.

> **NOTE:** You can have MobilePlanner add grid lines to the map to help you place lines and areas more accurately. In MobilePlanner's main menu, click **Map > Grid**.

4. Ensure Show Robot is **OFF**, then click **Draw > Advanced Lines** or **Draw > Advanced Areas**, depending on what you want to add to the map.
5. In the pull-down menu, select **ResistedLine** or **ResistedSector**, and note the cursor changes to indicate it is in drawing mode (has a box around the icon to indicate an area).
6. Place the mouse cursor on the map where you want the resisted line or sector to start.
7. Click and hold the left mouse button.
8. Drag the mouse to where you want the line or sector to end and release the button to display the new resisted line or sector in the map, and the Edit Advanced Area dialog box.

Editing Resisted Sectors

1. Verify that Show Robot is **OFF** then, in the Draw tab, click **Select**.
2. Either double-click (or right-click) on the sector in the map and select **Edit** from the pop-up menu.

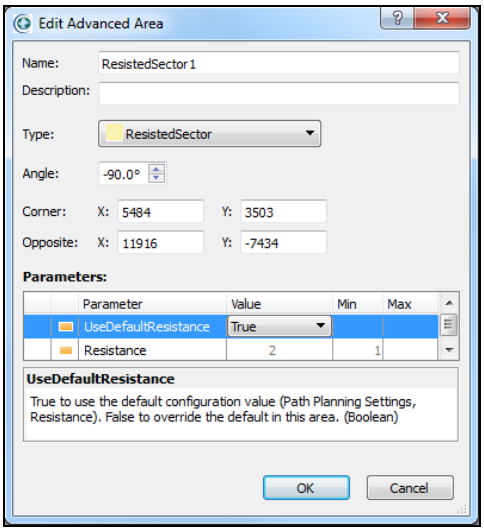


Figure 9-14: Edit Advanced Area dialog

Edit Advance Area Parameter	Definition
Name	A name for the resisted sector.
Description	An optional description for the resisted sector.
Type	Set to **ResistedSector**. If you select a different type of advanced area, the highlighted area changes to the new type and the dialog box updates.
Angle	The rotation angle of the resisted sector in the map.
Corner	The X and Y coordinates of the resisted sector's starting corner.
Opposite	The X and Y coordinates of the resisted sector's ending corner.
UseDefaultResistance	(Boolean) value. A True setting uses the default resistance setting , and ignores the Resistance value (default settings are set using the Path Planning Settings - see Path Planning and Collision Avoidance on page 171). If this is False, the robot overrides the path planning settings with the value of the Resistance parameter.
Resistance	(Integer) Determines the cost of crossing the area. Defines how much the robot will resist driving through a particular sector, and find an alternative path. The cost of driving through a resisted sector is multiplied by its resistance value. A normal area or sector has a cost value of 1. Set this value to 1 to turn off the resistance behavior.

Editing Restrictive Lines

1. Verify that Show Robot is **OFF** then, in the Draw tab, click **Select**.
2. Double-click (or right-click) on the boundary in the map, and select **Edit** from the pop-up menu.

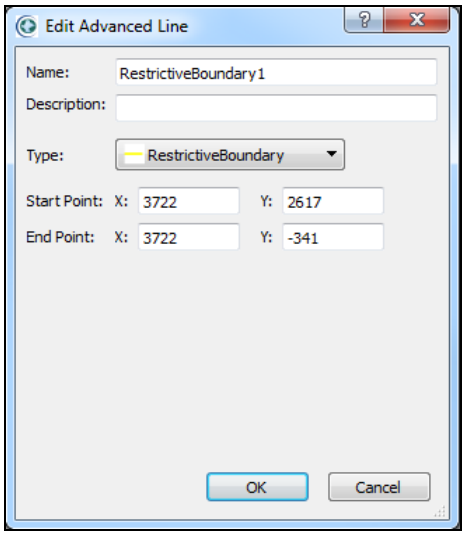


Figure 9-15: Edit Advanced Line dialog

Edit Advanced Line Parameter	Definition
Name	A name for the resisted boundary.
Description	An optional description for the resisted boundary.
Type	Set to **ResistedLine**. If you select a different type of advanced area, the highlighted area changes to the new type and the dialog box updates.
Start Point	The X and Y coordinates of the starting corner of the resisted boundary.
End Point	The X and Y coordinates of the ending corner of the resisted boundary.
UseDefaultResistance	(Boolean) A True setting uses the default resistance setting (set in the Path Planning Settings in the Advanced Areas pull-down menu). See Path Planning and Collision Avoidance on page 171 for details. If False, the robot overrides path planning settings with the Resistance parameter value.
Resistance	(Integer) Determines the cost of crossing a boundary, how much the robot resists driving across it, and finds an another path. The cost of driving across a boundary is multiplied by its resistance value. A normal area has a cost of 1, so set this value to 1 to turn off the resistance behavior.

Using Need to Enter Sectors

You can add areas to the map that only allow the mobile robot to enter if the goal the robot is trying to reach is inside the sector. These are referred to as need to enter sectors. If the robot is already in a need to enter sector, it can drive around in the sector or drive out of it.

Need to enter sectors are useful in (for example) cases in which there are loading or unloading areas where another robot could cause congestion if it tries to pass through.

Adding Need to Enter Sectors to the Map

1. In **MobilePlanner > Config > Robot Operation > Map Features**, enable NeedToEnterSector. For details on how to do this, see Configuring the Robot on page 125.
2. **Save** your change to the robot.
3. Click the **Map** button to open the map you want to edit.

   > **NOTE:** You can have MobilePlanner add grid lines to the map to help you place lines and areas more accurately. In MobilePlanner's main menu, click **Map > Grid.** Also, ensure Show Robot is **OFF** to enable the Draw tools.

4. Click **Draw > Advanced Areas**.
5. Select **Need to Enter** from the pull-down menu, and note the cursor changes to indicate it is in drawing mode.

6. Place the mouse cursor on the map where you want the sector to start.
7. Click and hold the left mouse button.
8. Drag the mouse to where you want the sector to end and release the button. The new need to enter sector highlights and appears in the map, and the Edit Advanced Area dialog box appears.

Editing Existing Need to Enter Sectors

1. Click **Select**.
2. Either double-click on the resisted sector in the map, or right-click on the sector, and select **Edit** from the pop-up menu to display the Edit Advanced Area dialog box.

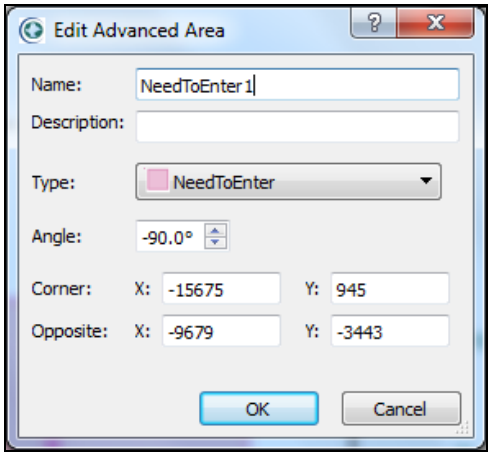


Figure 9-16: Edit Advanced Area dialog

The following table describes the options available on the Edit Advanced Area dialog box.

Parameter	Definition
Name	A name for the need to enter sector.
Description	An optional description for the need to enter sector.
Type	Set to **NeedToEnter**. If you select a different type of advanced area, the highlighted area on the map changes to the selected type and the dialog box updates accordingly.
Angle	The angle the sector (rectangle) is rotated within the map.
Corner	The X and Y coordinates of the starting corner of the sector.
Opposite	The X and Y coordinates of the ending corner of the sector.

Using Single Robot Sectors

Single robot sectors allow you to add areas to the map that only allow one mobile robot at a time to be in the specified area. This is useful for narrow hallways or narrow areas with only one entry/exit.

Adding Single Robot Sectors to the Map

1. In **MobilePlanner > Config > Robot Operation > Map Features**, enable **SingleRobotSector**. See Configuring the Robot on page 125 for details.
2. **Save** your change to the robot.
3. Open the map you want to edit. See Using MobilePlanner Software on page 53 for details.
4. Ensure Show Robot is **OFF**, then click on the **Grid** toolbar icon to display the grid lines on the map. This helps you to place the lines and areas more accurately.
5. Click **Draw > Advanced Areas**.
6. Select **SingleRobot** from the pull-down menu (the cursor changes to indicate it is in drawing mode).
7. Place the mouse cursor on the map where you want the single robot sector to start.
8. Click and hold the left mouse button.
9. Drag the mouse to where you want the sector to end and release the button to highlight the new area in the map.

Editing Existing Single Robot Sectors

1. Click **Select**.
2. Either double-click on the sector in the map, or right-click on the sector, and select **Edit** from the pop-up menu to display the Edit Advanced Area dialog box.

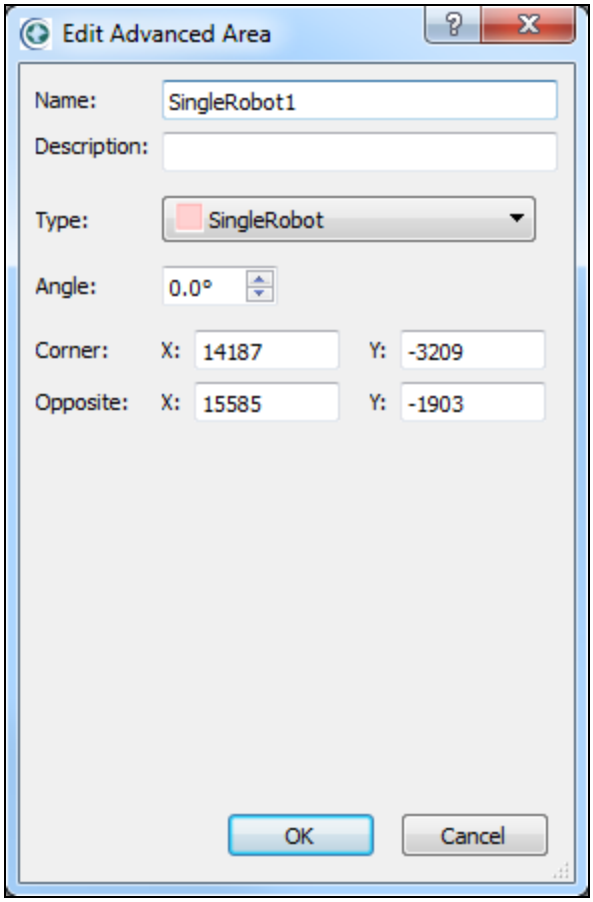


Figure 9-17: Edit Advanced Area dialog

The following table describes the options available on the Edit Advanced Area dialog box.

Parameter	Definition
Name	A name for the single robot sector.
Description	An optional description for the single robot sector.
Type	Set to **SingleRobot**. If you select a different type of advanced area from the pull-down menu, the highlighted area on the map changes to the selected type and the dialog box updates accordingly.
Angle	The angle the sector is rotated within the map.
Corner	The X and Y coordinates of the starting corner of the area.
Opposite	The X and Y coordinates of the ending corner of the area.

Chapter 10: Robot Localization

When a moving robot is operating in an environment such as an office building or a warehouse, it must have some way of tracking its position and orientation on a map. This tracking is called localization. Accurate localization is a prerequisite for intelligent navigation.

This section discusses the types of localization your mobile robot uses. For more information, refer to the following:

What is Localization?

Localization is the way in which the mobile robot knows its location on the map. It is a process the robot uses to estimate its position in its environment based on data collected during operation. Currently, the mobile robots can use two types of localization:

- Using Laser Localization on page 197

  Laser localization uses data from the robot's laser in conjunction with the map to calculate the robot's position. This is the default way the mobile robot keeps track of its position in the operating space and is most useful in a static environment such as an office building or hospital.

- Using Acuity For Light Localization on page 201

  Optionally, a robot can use overhead lights to track its position in the environment. This localization process is often used in dynamic environments, such as a warehouse, where objects move too frequently for the robot to localize based on their past positions.

The key to localization is obtaining an accurate map of the environment (see Working with Map Files on page 111). The robot compares the map to the data collected from its sensors to correct its position. With this information, the robot knows its position on the map.

> **NOTE:** The robot combines data collected with either of these methods with data from encoders on its wheels and the gyroscope in its core to determine its location.

Overview of Localization Process

Localization requires an iterative process of correcting for errors in the robot odometry. When a robot is powered up, it must determine its initial position (which could be its last position when it shut down). During operation, the robot calculates the current position based on its last known position, along with the robot's speed and direction. The mobile robot periodically recalculates its position to make sure it knows where it is. If the robot cannot calculate a reliable pose, it is lost and must stop. After the robot recalculates its position, the current location becomes the last known location.

Comparing Laser and Light Localization

As discussed earlier, localization is the process the robot uses to determine its position in its environment. The mobile robot can use data from its laser or from the position of overhead lights (or a combination of the two), to accurately determine where it is in its physical space and in the map.

The following table highlights the differences between laser and light localization. For more information on each localization process, refer to the appropriate section.

	Laser Localization	Light Localization
Description	Uses a laser range finder located on the mobile robot to perform localization.	Uses a camera located on the mobile robot to monitor overhead lights in the environment as points of reference to perform localization.
Equipment	Laser range finder (standard)	Upward-facing camera option.
Accuracy vs. Reliability	Provides more accurate location data, but the robot cannot deal with highly dynamic environments.	Provides more reliable localization in a dynamic environment, because there is less chance for the robot to get lost, but the robot positioning is less accurate.
Recommended Environment	Static (such as an office building)	Dynamic (such as a warehouse)

What Causes the Robot to be Lost?

When a robot no longer has enough confidence in its position, it broadcasts that it's lost, and stops driving until a human intervenes. When a robot is lost, it stops moving and broadcasts a notification (in the form of the dialog box below) that it needs attention.

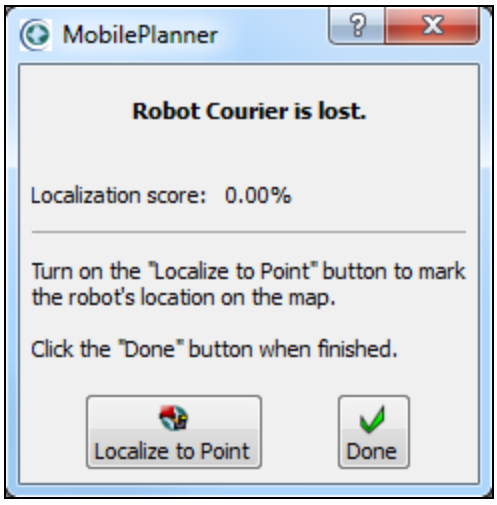


Figure 10-1: Localization dialog - lost robot

Localizing a Lost Robot

1. Click **Localize to Point** in the lost robot dialog box.

2. Click and hold the mouse on the map where you want to localize the robot (at the robot's current physical location) and, while holding the left mouse button, drag the mouse cursor to set the robot's heading.

   The Localization Score (or confidence threshold) should be 80% or better for optimum navigation.

3. Click **Done** when the robot's localization score is where you want it to be.

Adjusting the Confidence Threshold

The PassThreshold and LostThresholdDistance parameters (**for laser localization**) and LockThreshold and LostLockUncertaintyThreshold parameters (**for light localization**) set the criteria for when a robot is lost. With each localization, the robot generates a localization score. The robot is not considered lost until the localization score drops 20% below the PassThreshold parameter (**for laser localization**) or -100 on the LostLockUncertaintyThreshold (**for light localization**), and fails to recover. Once the localization score drops below PassThreshold/LockThreshold, the robot will move up to LostThreshold-Distance/LostLockUncertaintyThreshold, trying to raise its score. If it fails, it is considered lost. You can adjust the parameter values as needed.

LostThresholdDistance is the maximum distance (in mm) that the robot will move from the last localized pose before the robot will be considered lost. This parameter will only come into play if none of the samples during the sensor correction is higher than PassThreshold. As soon as this happens, the position uncertainty distance will grow based on the movement from the last localized pose.

1. In MobilePlanner, click the **Config** button, then click the **Robot Operation** tab, and select **Localization settings** (or **Light Localization settings**).

2. Click on the **PassThreshold Value** (or **LockThreshold value** for light localization) field and enter a new threshold value (the minimum score to consider the robot localized).

3. Click on the **LostThresholdDistance Value** (or **LostLockUncertaintyThreshold value** for light localization) field and enter a new distance value if desired.

Optimizing Localization

Localization accuracy depends on the accuracy of the map and sensor measurements. Typically, the mobile robot should be able to localize in most indoor environments. Occasionally, however, the robot encounters situations in which it has trouble localizing, which can impact its ability to navigate.

The most common problem with localization is map accuracy. It might not have been accurate enough to begin with, or the environment might have changed enough (partitions moved, etc.), that the map no longer reflects the working environment.

You can improve localization accuracy, to some extent, by adjusting the localization parameters. However, changing one parameter generally affects other parameters. Therefore you will likely need to adjust several parameters to fine tune the localization score.

Laser and Light Localization use different parameters that you can adjust. Those parameters are discussed in Localization Parameters on page 198 and Light Localization Parameters on page 204 respectively. However, there are a few general guidelines to consider before you change parameter values.

Before Changing Parameter Values

Before changing any parameters (localization or other), make sure your map contains as much accurately scanned data as possible. The more static features the map has (walls, doors, shelves, etc.), the better the robot is at navigating its way through the space.

- Don't erase any data from the map unless those points really do not correspond to any real, fixed object.
- Rescan areas where features have been removed from or added to an area in the environment.
- If there were errors in the map-making process, and your map does not match the real space, re-scan the area again more carefully.

CAUTION: Before changing parameters, save a copy of your current config file! When experimenting with parameters, try one parameter or a small combination of parameter changes at a time. Revert to your saved config file if the robot's performance does not improve. See Configuring the Robot on page 125.

Using Laser Localization

Omron Adept mobile robots use one of two methods to locate their position in their environment: laser or light localization. For more information on using light localization, refer to Using Acuity For Light Localization on page 201.

Laser localization uses a laser range finder, located on the mobile robot, to detect walls and other objects in the environment. The data collected from the laser is combined with the robot's odometry information and the map, which enables the robot to determine its location.

Overview of Laser Localization

The most common way to localize a mobile robot in a given space is to use a laser range finder. The laser range finder takes a planar snapshot of the environment, then compares this with the map of the environment to determine the robot's position. This is a relatively accurate method of localization for environments that tend to be static, such as an office space.

If the laser localization cannot match the laser readings to the map, it does have some logic that allows the mobile robot to drive for a while before reporting that it is lost. However, this is only useful in temporary situations, such as the robot driving through a small area where a group of people have gathered.

In a dynamic space where unmapped cargo and equipment move in and out of the area (such as in a warehouse), data from the unmapped objects can easily overwhelm the mapped data, causing the laser localization to fail. In these situations, it is better to use light localization. See Using Acuity For Light Localization on page 201 for details.

Key Features

- Laser localization gives accurate positioning data for precise navigation, particularly in a relatively static environment.
- No potentially expensive retrofitting required to use laser localization.
- The map only needs to be updated if there is a change in the static environment.
- The mobile robot continues to operate even if some of the map features have changed, resulting in a flexible solution.

Limitations of Laser Localization

Laser localization is an accurate method of localization in a static environment such as an office, but has some limitations to consider:

- The laser cannot see glass, mirrors, or shiny objects. Environments with a lot of these objects make it difficult for the robot to localize.
- In dynamic environments in which objects frequently change positions (such as a warehouse), laser data might not match mapped data closely enough for the robot to localize. In these areas, the map won't contain objects added or moved after you created the map.
- In an environment with a lot of high racks for the robot to navigate through, the confidence threshold could fall below 20% and cause the robot to become lost.

Localization Parameters

In MobilePlanner, you can access the robot's localization parameters and adjust them as needed.

To access the laser localization parameters, click the **Config** button, then click the **Robot Operation** tab, and select **Localization settings**.

Improving Accuracy and CPU Usage

For laser localization, two settings directly affect the CPU usage for each localization:

- **GridRes** represents the size of the grid used for localization. The smaller the value is, the more accurate the localization score.
- **NumSamples** represents the number of poses sampled (or checked) each time the robot moves; this number scales linearly, so adjusting a value of 2000 to 3000 takes up 1.5 times more processing power.

Other factors, such as TriggerDistance and TriggerAngle determine how often it attempts to re-calculate (or re-localize) its position. Recalculating uses a lot of CPU so, if the value of NumSamples is set too high, the robot will localize less often. This can actually cause more problems than a robot that localizes less accurately, but more often.

The K parameters (KMmPerMm, KDegPerDeg and KDepPerMm) are error parameters, and are explained below.

Using Laser Localization Parameters

With MobilePlanner, you can access the robot's configuration parameters and adjust them as needed.

To access the laser localization parameters, click the **Config** button, then click on the **Robot Operation** tab, and select **Localization settings**.

In general, high CPU use for one laser scan might prevent the robot scanning as often as needed. Setting these parameters requires balance.

You can change parameters that affect the level of detail in a robot's scan, how many possible locations (poses) the robot will compare those results with, and how frequently, both in time and travel, it rechecks its location. There are also parameters to adjust the amount of expected error, both linear and rotational.

Localization Parameters and Effects on CPU Use

Parameter	Description	Effect(s) on Localization
AdjustNumSamples Flag	Varies the number of samples based on the localization score.	When enabled, lowers the number of samples when the robot is moving and the localization score is high. Reduces CPU demand.
AngleIncrement	Separation (in degrees) required between laser settings used for localization.	Discards readings too close together. Reduces CPU demand.
GridRes	Resolution (in mm) of map grids.	Scan resolution. Decreasing this value increases localization accuracy, but increases demand on RAM.
KMmPerMm	Millimeters of linear error per linear millimeter of travel.	Allowed percentage error (in mm) of the robot's linear odometry readings. If set too high, sample poses are too spread out for the robot to determine its location. If set too low, the robot might not be able to localize.
KDegPerDeg	Degrees of error per degrees rotated.	Allowed percentage error (in deg) of the robot's rotational odometry readings. If set too high, sample poses too spread out for the robot to determine its location. If set too low, the robot might not be able to localize.
KDegPerMm	Degrees of error per linear mm traveled.	Allowed error (in deg) of the robot's rotation per one mm of linear travel. If set too high, sample poses too spread out for the robot to determine its location. If set too low, the robot might not be able to localize.
NumSamples	Number of pose samples robot uses for localization.	Scan resolution. Increasing this value increases localization computations. If too low, the robot fails to localize.
TriggerDistance	Distance robot travels (in mm) before localizing.	How often to localize – helps reduce CPU demand. The robot only localizes when it travels beyond listed value.
TriggerAngle	Angle (in deg) robot turns before triggering localization.	How often to localize – helps reduce CPU demand. The robot only localizes when it rotates beyond the listed value.

Using Acuity For Light Localization

Light Localization uses a wide-angle camera mounted on the mobile robot to detect the fixed overhead lights in the operating environment. After combining light position data with its odometry readings and map data, the robot knows where it is in physical space on its map.

> **NOTE:** The navigation laser remains active for obstacle avoidance even when not being used to for navigation.

Overview of Light Localization

Using overhead lights as landmarks, the mobile robot is able to reliably calculate its position within its environment.

Light Localization allows the robot to localize in a dynamic environment where change is frequent. A warehouse, for example, includes many boxes, pallets, vehicles and people that move frequently. In this situation, the robot can use the overhead lights to determine its position in the environment. The mobile robot uses both camera and odometry data to calculate its current position.

Key Features

Key features of light localization include:

- No expensive retrofitting required to use light localization.
- The lights do not require special maintenance.
- Because the lights are overhead, they are not blocked by ground level obstructions that could prevent laser sensors from working.
- The map does not need to be updated because the light positions typically do not change.
- Even if some lights are burned out, the mobile robot still has a reliable solution and continues to operate.

> **NOTE:** Using light localization in spaces with lights at different heights, or places with lights visually behind others, can require different scanning techniques not covered in this guide. For details, see the Mobile Robots - LD Platform Peripherals Guide.

Creating the Light Map

Before creating a Light Localization map, be sure you are familiar with creating an initial map scan. Refer to Scanning Your Environment for more information.

> **NOTE:** When scanning the operating environment using Light Localization, be sure to drive under the lights or as close to the lights as possible. You need to do this in both directions, to make sure the camera sees the lights from all angles, collecting pan and tilt data along the way.

Compared with laser localization scan files, Light Localization scan files contain additional information about the robot's operating environment and, therefore, require extra processing steps. The resulting map

files also contain information about the location and height of overhead lights detected during the scanning process.

Light Localization is only available on mobile robots equipped with it, and you must enable the LightLocalization parameter in the MobilePlanner software. Refer to Configuring the Robot on page 125 for details.

Adjusting the Light Analysis Parameters

1. In MobilePlanner's **Config** window, select **Robot Configuration**.
2. Click on the **Light Analysis** section from the left window pane to view parameters associated with the light analysis in the right window pane.
3. Select **Show Expert+ Parameters** to access the main light analysis parameters.

The following table describes the most important parameters for light analysis:

Parameter Name	Description
3d:MinLightHeight	Minimum height (in mm) of the lights above the floor. This value is approximate and should be lower than the real value. It is used to establish a valid range and eliminate false positives. (Double)
3d:MaxLightHeight	Maximum height (in mm) of the lights above the floor. This value is approximate and should be higher than the real value. It is used to establish a valid range and eliminate false positives. (Double)
3d:MinLightLength	Minimum length (in mm) of the lights. This value is approximate and should be slightly lower than the real value. If -1, then this value is ignored. (Double)
3d:MaxLightLength	Maximum length (in mm) of the lights. This value is approximate and should be slightly higher than the real value. If -1, then this value is ignored. (Double)

Set the 3d:MinLightHeight and 3d:MaxLightHeight parameters to a range that encompasses the ceiling and light heights, but not too large (a few meters).

If the lights are fluorescent tubes or the lights are partially hidden from the camera's view, you may also need to adjust the 3d:MinLightLength and 3d:MaxLightLength parameters.

After making these adjustments, reprocess the light scan in MobilePlanner. This does not require redoing the laser portion of the map creation, just reprocessing the light data.

Creating The Light Map

1. Turn all lights **ON** in the operating environment.
2. Open MobilePlanner and start the scan process. See Scanning Your Environment for details.

3. Drive the robot around the environment, paying special attention to the overhead lights. Drive under the overhead lights in both directions.
4. Stop the scan.
5. Turn the scan into a map (see Creating an Initial Map of the Environment for details).
6. Verify the scanned map shows overhead lights in the correct position and with the correct height.

   You can view the height data by moving the mouse over the light icon on the map. The overhead lights appear as blue squares, rectangles or points (depending on the type of light), as shown below.

Figure 10-2: MobilePlanner light map - detail

7. If the light map looks correct, click **Finish** on the Scan Tools toolbar.
8. If the light map does not look correct, you will need to adjust the light analysis parameters and reprocess the scan. See Creating the Light Map on page 201 for details.

By default, the overhead lights are hidden from the map after turning the light scan into a light map. You can view the lights by selecting **Map > Map Data > Light Items** from the MobilePlanner main screen.

The light map contains data (such as height) about the lights seen by the camera , but does not contain images of the lights themselves.

Limitations of Light Localization

Light Localization is a reliable method of localization, even in a dynamic, frequently changing environment such as a warehouse. The number of lights visible lights affects the accuracy of the robot's estimated position and, if the mobile robot travels for a long time in a sparsely lighted area, it will end up with a low localization score. However, in general, the robot tends not to get lost as often using light localization which is, therefore, more reliable in a dynamic environment.

Consider the following limitations:

- The lights must be on and visible for light localization to work.
- Skylights can be problematic.
- Currently, light localization works with LED lights, can lights (displayed as squares on the map) and fluorescent tube lights (displayed as rectangles).
- The more lights visible to the robot, the better. Light localization does not work well with only one or two lights in an area.
- The lighting must be direct. The robot must see a bulb or diffuser, not just a light reflection off of another surface.
- An environment that has lights of varying brightness might have problems.
- The tilt of the camera is assumed to be fixed. A change to this, such as when the robot is on a tilted floor in the building, adversely affects the light localization.
- The accuracy of the localization depends on the accuracy of the light map. If the lights in the map are incorrect due to mapping errors, the localization will show a similar offset.
- The vertical distance from the camera to the lights should be at least a couple of meters for the light localization to work well. If the lights are too close to the camera, the error will be more than when the lights are farther away.

Light Localization Parameters

In MobilePlanner software, you can access the robot's configuration parameters and adjust them as needed:

Accessing Light Localization Parameters

1. Select **Config > Robot Operation** from the main menu.
2. Click on the Light Localization settings section from the left pane to see parameters associated with the light localization in the right pane.

The parameters for light localization are described in the software, and are not repeated here.

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