2 Specifications

2.1 Robot overview

TIAGo 's main parts are depicted in figure 2, and its main specifications are summarized in table 1.

Figure 2: TIAGoś main components

Dimensions	Height	110 – 145 cm
	Weight	60 Kg
	Base footprint	Ø 54 cm
Degrees of freedom	Mobile base	2
	Torso lift	1
	Head	2
Mobile base	Drive system	Differential
	Max speed	1 m/s
Torso	Lift stroke	35 cm
Electrical features	Battery	36 V, 20 Ah
Sensors	Base	Laser range-finder
		Sonars
		IMU
	Torso	Stereo microphones
	Head	RGB-D camera

Table 1: The robot's main specifications

2.2   Mobile base

TIAGoś mobile base is provided with a differential drive mechanism and contains an onboard computer, batteries, power connector, laser-range finder, three rear sonars, a user panel, a service panel and two WiFi networks to ensure wireless connectivity. Furthermore, the version of TIAGo with a docking station has a charging plate on the front.

Figure 3: Mobile base front view

Figure 4: Mobile base rear view

2.2.1 Onboard computer

The specifications of TIAGo 's onboard computer depends on the configuration options you have ordered. The different possibilities are shown in table 2.

Component	Description
CPU	Intel i5 / i7 Haswell
RAM	4 / 16 GB
Hard disk	256 / 512 GB SSD
Wi-Fi	802.11 a/b/g/n/ac
Bluetooth	Smart 4.0 Smart Ready

Table 2: Onboard computer main specifications

2.2.2 Battery

The specifications of the battery supplied with TIAGo are shown in table 3.

Type	Li-Ion
V_nominal	36.0 V
V_max	42.0 V
V_cutoff	30.0 V
Nominal capacity	20 Ah
Nominal energy	720 Wh
Max. continuous discharge current	20 A
Pulse discharge current	60 A
Max. charging current	15 A
Charging method	CC/CV
Weight	7.5 kg

Table 3: Battery specifications

TIAGo can be equipped with two batteries. In this case, the *total Nominal capacity is 1440 Wh.*

2.2.3 Power connector

TIAGo must only be charged only with the supplied charger. To insert the charger connector, open the lid located on the rear part of the robot, as shown in figure 5a.

Connection   Insert the charging connector with the metal lock facing up and push it, as shown in figure 5b until you hear a 'click'.

Disconnection   Once the charge is completed, the connector can be removed. In order to remove it, press the metal lock and pull the connector firmly, see figure 5c.
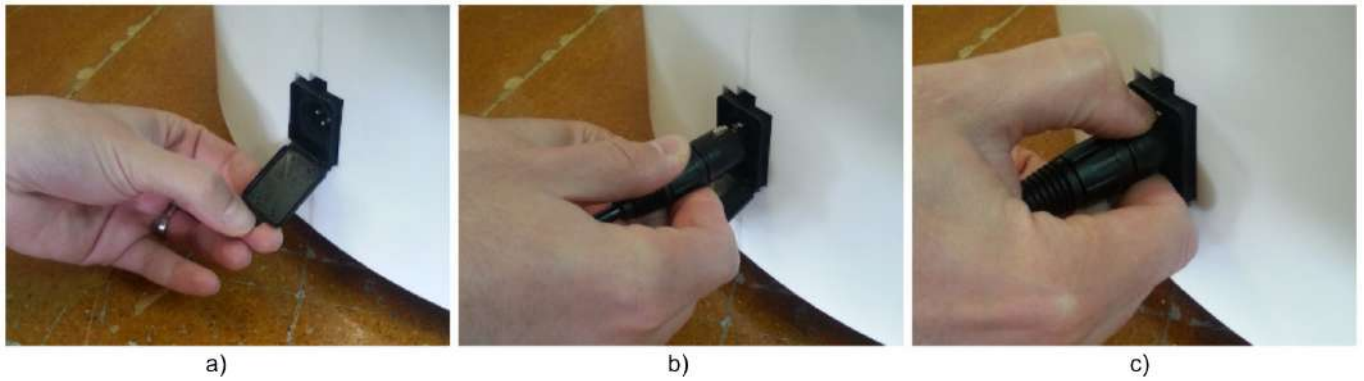
Figure 5: a) connector entry b) connector insertion procedure c) connector removal procedure.

2.2.4   Laser range-finder

The specifications of the laser on the front part of the mobile base depend on the configuration options you have ordered. The lasers supported are shown in table 4.

Manufacturer	Hokuyo	Manufacturer	SICK	Manufacturer	SICK
Model	URG-04LX-UG01	Model	TIM561-2050101	Model	TIM571-2050101
Range	0.02 - 5.6 m	Range	0.05 - 10 m	Range	0.05 - 25 m
Frequency	10 Hz	Frequency	15 Hz	Frequency	15 Hz
Field of view	180°	Field of view	180°	Field of view	180°
Step angle:	0.36°	Step angle:	0.33°	Step angle:	0.33°

Table 4: Lasers range-finder specifications

2.2.5   Sonars

The rear part of the mobile base has three ultrasound sensors, here referred to as sonars. One is centered and the other two are placed at 30° on the left and right. See table 5 for the sonar's specifications.

Manufacturer	Devantech
Model	SFR05
Frequency	40 kHz
Measure distance	0.03 - 1 m

Table 5: Sonar's specifications

2.2.6   IMU

The Inertial Measurement Unit is mounted at the center of the mobile base and may be used to monitor inertial forces and attitude. The specifications are presented in table 6.

Manufacturer	InvenSense
Model	MPU-6050
Gyroscope	3-axis
Accelerometer	3-axis

Table 6: IMU's main specifications

2.2.7   User panel

The user panel is on the top, rear part of TIAGo mobile base. It provides the buttons to power up and shutdown the robot, and a screen to give visual feedback on the robot's status. All the specific elements of the user panel are shown in figure 6 and the description of each element is presented in table 7.

Figure 6: User panel

Number	Name / Short description
1	Emergency stop
2	Information display
3	On/Off button
4	Electric switch

Table 7: User panel description

Electric switch   The electric switch is the main power control switch. Before turning TIAGo ON make sure first that this switch is ON, i.e. its red light indicator is ON. On the other hand, when TIAGo is not going to be used for a long period, please press the switch so that its red light indicator turns OFF. Note that this switch should not be turned OFF before using the On/Off button to turn OFF the onboard computer of the robot. Turning OFF this switch will cut instantaneously the power supply to all the robot components, including the onboard computer. Do not use this switch as emergency stop. For the emergency stop please refer to the next section.

Emergency stop   When pushed, motors are stopped and disconnected. The green indicator of the On/Off button will blink fast in order to notify the user of the emergency state.

To start normal behaviour again, a two step validation process must be executed: the emergency button must be released by rotating clockwise, and then the On/Off button must be pressed for one second. The green light indicator of the On/Off button will change to a fixed state.

Information display   A 320x240 Color TFT display shows the battery level on the top right corner.

On/Off button   The standby control button is a pushbutton with a green light that indicates the system's current status.

Light	State	Name / Short description
Off	Fixed	Standby
On	Fixed	Running
On	Slow-blink	System in process of shutdown
On	Fast-blink	Emergency state

Table 8: Green light indicator possible modes

After the main power is connected, i.e. the electric switch is ON, see figure 6, the user must press this button for one second in order to start TIAGo.

To re-set the system in standby mode when the robot is running, press the button again. The green light will blink slowly during shutdown procedure and light-off when standby mode reached.

2.2.8   Service panel

It is possible to access the service panel by removing the cover behind the laser, see figure 7.

This service panel gives the user access to video, usb and the On/Off button of the robot's computer. It can be used for reinstallation or debug purposes.
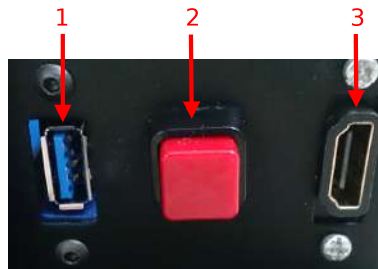

Figure 7: Service panel

Number	Name / Short description
1	USB 3.0
2	On/Off button for the computer
3	HDMI

Table 9: Service panel description

2.2.9 Connectivity

TIAGo is equipped with a dual band Wireless 802.11b/g/n/ac interface, plus bluetooth 4.0 and two WiFi antennas. When the WiFi interface is configured as access point, it has a 802.11g interface.

There are two Gigabit Ethernet ports, ports 2 and 3 in figure 10, that can be used to connect to the robot's internal network. For this network, the IP address range *10.68.0.0/24* has been reserved. *The IP addresses used in the building network MUST not use this range because it can interfere with the robot's services.*

2.3 Torso

TIAGo 's torso is the structure that supports the robot's arm and head, and is equipped with an internal lifter mechanism which allows the user to change the height of the robot. Furthermore, it featuresan expansion panel and a laptop tray.

2.3.1 Lifter

The lifter mechanism is placed underneath the industrial bellows, shown in figure 8. The lifter is able to move at 50 mm/s and has a stroke of 350 mm. The minimum and maximum height of the robot is shown in figure 9.

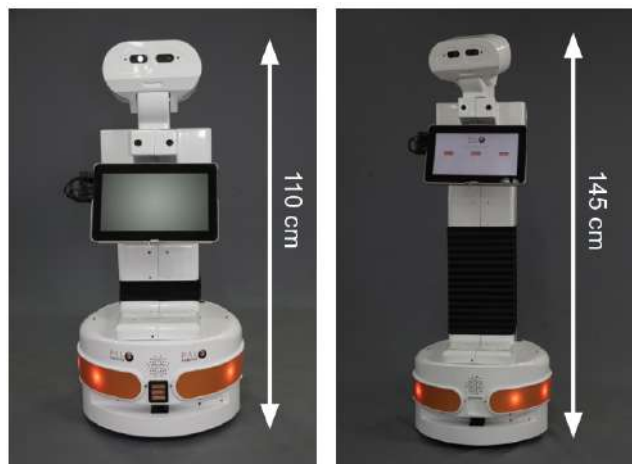Figure 8: Industrial bellows of the lifting torso

Figure 9: Height range of the robot

2.3.2 Expansion panel

The expansion panel is located on the top left part of the torso and the connectors exposed are shown in figure 10 and specified in table 10.

Figure 10: Expansion panel

Number	Name / Short description
1	CAN Service connector
2	Mini-Fit Power supply 12 V and 5 A
3	Fuse 5 A
4	GigE port
5	GigE port
6	USB 2.0 port
7	USB 3.0 port

Table 10: Expansion Panel description

The CAN service connector is reserved for maintenance purposes and shall not be used.

2.3.3 Laptop tray

The laptop tray, see figure 11 is the flat surface on top of the torso just behind the robot's head, see figure 11. It has mounting points to add new equipment, supporting to 5 kg, or it can be used to place a laptop in order to work in place with the robot making use of the WiFi connectivityor using one of the ethernet ports in the expansion panel.

Figure 11: Laptop tray dimensions

Figure 12: Laptop placed on the rear tray of the robot

2.4   Touch monitor

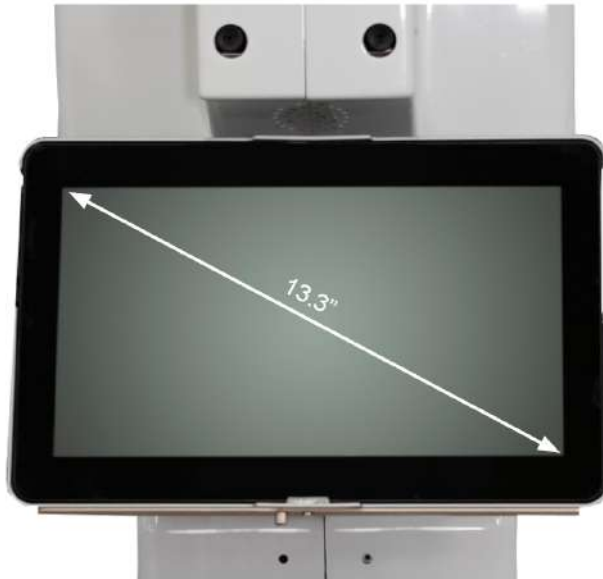TIAGo may be equipped with a touch monitor as shown in figure 13.

Figure 13: Laptop placed on the rear tray of the robot

The main technical specifications are shown in table 11.

Panel type	13.3" TFT IPS LCD (16:9 wide) LED Backlight
Touch type	Projective capacitive touch monitor, support 10-finger multi-point touch
Resolution/Color depth	1920x1080/16.7 M colors
Active area	294x165 mm
Contrast ratio	700:1
Response time	14 ms

Table 11: Touch monitor

2.5   Head

TIAGo 's head is equipped with a pan-tilt mechanism, i.e. 2 DoF, and is equipped with stereo microphones, a speaker and an RGB-D camera. Furthermore, on top of the head there is a flat surface with mounting points to allow the user to add new sensors or equipment. Note that the head has a payload of 0.5 kg when adding new equipment. Figure 14 shows the location of each component and the two joints of the pan-tilt mechanism.
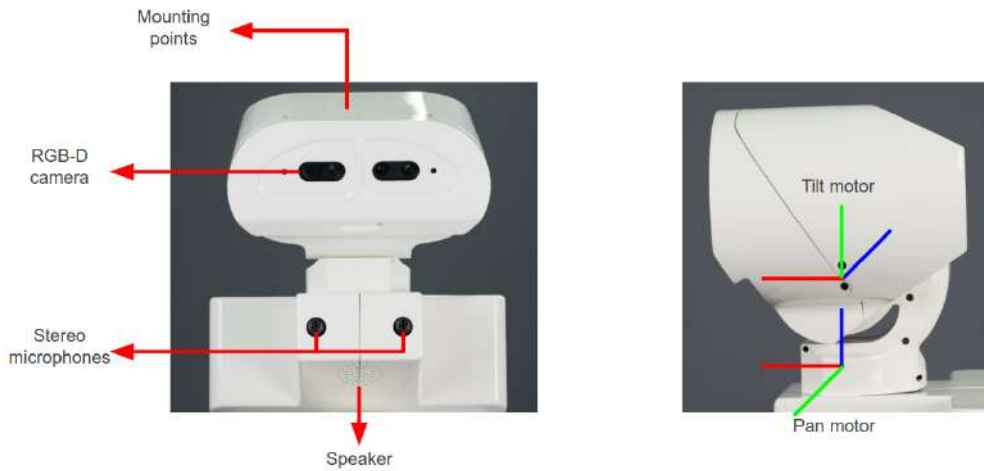

Figure 14: Head parts and components

2.5.1   Pan-tilt mechanism

Actuators	Description	Reduction	Max speed [rpm]	Max torque [Nm]	Absolute encoder
	Pan motor	200:1	63	6	12 bits
	Tilt motor	200:1	63	6	12 bits

Table 12: Head pan-tilt main specifications

2.5.2   Speaker

The speaker specified in table 13 is provided below the robot's head.

Manufacturer	VISATON
Model	FRS 5
Rated power	5 W
Max power	8 W
Nominal impedance Z	8 Ohm
Frequency response	150-20000 Hz

Table 13: Speaker main specifications

2.5.3   Stereo microphones

The Andrea SuperBeam Stereo Array Microphone is integrated just below the head of the robot. The specifications of the audio card are presented in table 14 and the specifications of the Stereo Array Microphone are detailed in table 15.

Manufacturer	Andrea Electronics
Model	SuperBeam Stereo Array Microphone
Electrical characteristics	
Mic supply voltage	1.4-5.0 VDC
Supply bias resistor	2.2k-39.9k Ohm
Operating current (each channel)	0.5 mA
Output impedance at 1 kHz	200 Ohm
Max input sound level at 1 kHz, 3% THD	115 dB
Output signal level at THD < 3% @ 1 kHz	24-120 mVrms
Sensitivity at 1 kHz (0 dB = 1 V/Pa Vdc=1.6 V)	-40 to -37 dBV
Frequency response at 3 dB variation noise	20 uVrms
Operating temperature	0-70C°C
Acoustic characteristics	
Recommended operating distance	30.5-122 cm
Acoustic signal reduction at 1 kHz outside of 30° beamform	15-30 dB
Noise reduction	20-25 dB

Table 14: Stereo microphones main specifications

Manufacturer	Andrea Electronics
Model	PureAudio USB-SA
Supply voltage	4.5 - 5.5 VDC
Total power consumption	120 mA
A/D conversion resolution	16 bit
THD + N	-84 dB
Supply bias resistor	2.2 kOhm @ 3.3 VDC
Frequency response	20-20000 Hz
Input range	0 - 1.25 Vrms
Dynamic range	95 dB
Record gain range	-6 to 33 dB

Table 15: USB external audio card main specifications

2.5.4   RGB-D camera

TIAGo 's head includes an RGB-D camera, specified in table 16.

Manufacturer	Orbbec
Model	Astra
Field of view	60° H, 49.5° V, 73° D
Interface	USB 2.0
Color stream modes	QVGA 320x240 @ 30 fps, VGA 640x480 @ 30 fps, 1280x960 @ 10 fps
Depth stream modes	QVGA 320x240 @ 30 fps, VGA 640x480 @ 30 fps, 160x120 @ 30 fps
Depth sensor range	0.6 - 8 m

Table 16: RGB-D main specifications

2.6   Electrical parts and components

Neither TIAGo nor any of its electrical components or mechanical parts are connected to external ground. The chassis and all electromechanical components are physically isolated from the ground by the isolation rubber under its feet. Avoid touching any metal parts directly to prevent discharges and damage to TIAGo 's electromechanical parts.

Electrical power supply and connectors

The power source supplied with TIAGo is compliant with the Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment 2002/95/EC (RoHS) and with the requirements of the applicable EC directives, according to the manufacturer. The power source is connected to the environment ground, whenever the supplied wire is used (Phase-Neutral-Earth).

TIAGo

Storage

3 Storage

3.1 Overview

This section contains information relating to the storage of TIAGo .

3.2 Unpacking

This section explains how to unbox TIAGo safely. TIAGo is shipped with the flightcase shown in figure 15.

Figure 15: TIAGo flightcase

The flightcase **MUST be always transported vertically** to ensure the robot's safety. In order to move the flightcase, pull the handle on the back, as shown in figure 16. To place the flightcase in a given location use one of your feet to help you carefully set the flightcase in an upright position.

Figure 16: Moving the fligthcase

Open the door of the crate, see figure 17a, and unfold the ramp, as shown in figure 17b. Remove the foam wedges holding the mobile base in place, as shown in figure 17c. Finally, remove the robot from the crate by pulling on the upper part of its back and, if necessary, from its shoulders, as shown in figure 17d. **Do not pull on any part of the mobile base cover,** as it could cause damage to you or the robot.
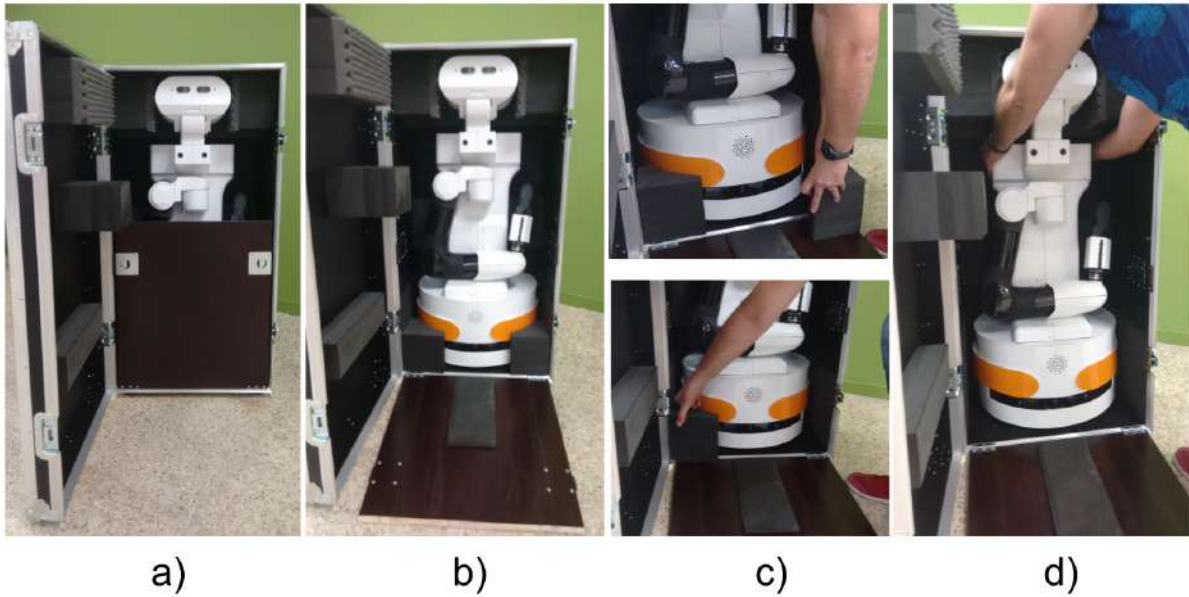
Figure 17: Unboxing procedure

3.3 Storage cautions

- Always store TIAGo in a place where it will not be exposed to weather conditions.
- The storage temperature range for TIAGo is between $0°C \sim +60°C$.
- The storage temperature range for the batteries is between $+10°C \sim +35°C$.
- It is recommended to remove the battery from TIAGo when the storage period exceeds two weeks.
- It is recommended to charge the battery to 50% when storing it for more than two weeks.
- Avoid the use or presence of water near TIAGo.
- Avoid any generation of dust close to TIAGo.
- Avoid the use or presence of magnetic devices or electromagnetic fields near TIAGo.