FEDERAZIONE ITALIANA
DI ATLETICA LEGGERA

SENSORIZE
SPORT & REHABILITATION TECHNOLOGY

A practical guide for using

SENSORIZE *FreeRun*

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SUMMARY

Introduction

FreeRun is an innovative technological solution developed by SENSORIZE in collaboration with the Italian Track and Field Federation (FIDAL) for the analysis of sprint performance directly on the track by using a single measurement device worn by the athlete.

Main output performance parameters, like flight and contact times and progression velocity relative to each step, are derived from measured inertial sensors data (sampled at 200Hz) and GPS velocity data (sampled at 10Hz).

In the box

The indispensable hardware components for using FreeRun are:

- measurement device
- neoprene belt (for device fixing)
- USB cable (for plugging the device into the PC)
- FreeRun software

How to use

Motion signals are recorded on board and written into a file saved on the internal memory of the device. The user has to import the file on the PC using the FreeRun software. The software will automatically process the recorded signals into the desired performance parameters.

To collect motion data during a sprint test it is necessary to know the main functions you can access by the 9-buttons device keyboard and how to configure the device.

A description of each function follows:

- **On/off (button 1)**: to switch on/switch off the device press button one for at least 3 seconds, since the display switch on/off.
- **Modality (button 3)**: be sure to be in *stand alone* mode, as from default settings. If you are in wireless mode, press this button to go back in stand alone mode.
- **Enter (button 5)**: press it to confirm the chosen selection.
- **Menu (9)**: press it to go to the main menu. From main menu it is possible to select the operative mode, to set date/time and to access to firmware information.

- **Navigation (2-4-6-8)**: by the fourth navigation buttons (red dotted) it is possible to navigate into the menu.

Configuring the device for using in with FreeRun

A device first configuration is needed to start acquisition:

- Sample frequency of inertial sensors is 200Hz
- Accelerometers full-scale is 6g
- GPS module ON and GPS signal READY

Switch on the device (button 1):

Check battery level as from picture below:

Default parameters are set as shown below:

To set **sample rate frequency** go to “Main Menu” (button 9) and push down (button 8) till selecting “Parameters” (button 5):

Right click to access “Set frequency” (button 5):

Select the first digit (button 4) and increase it using button 2 till it becomes “2”:

Press “enter” to save settings.
To go back to the main menu, press button 9.
To set 6g accelerometers **full-scale** go down till “Parameters” and select “Set sensitivity”. Press button 5 to switch the full-scale. Selected full-scale will be shown on the display:

Press button 9 to go back to the main menu.

GPS module is switched off as default. To activate it, access to “Main Menu” (button 9) and go down (button 8) till selecting “Parameters” (button 5):

Go down (button 8) till selecting “Set GPS”:

Press “enter” (button 5) to activate GPS:

Going back to main menu (button 9), the display will appear as from below:

- Sample rate frequency “200Hz”;
- Full-scale “6g”;
- “GPS on”.

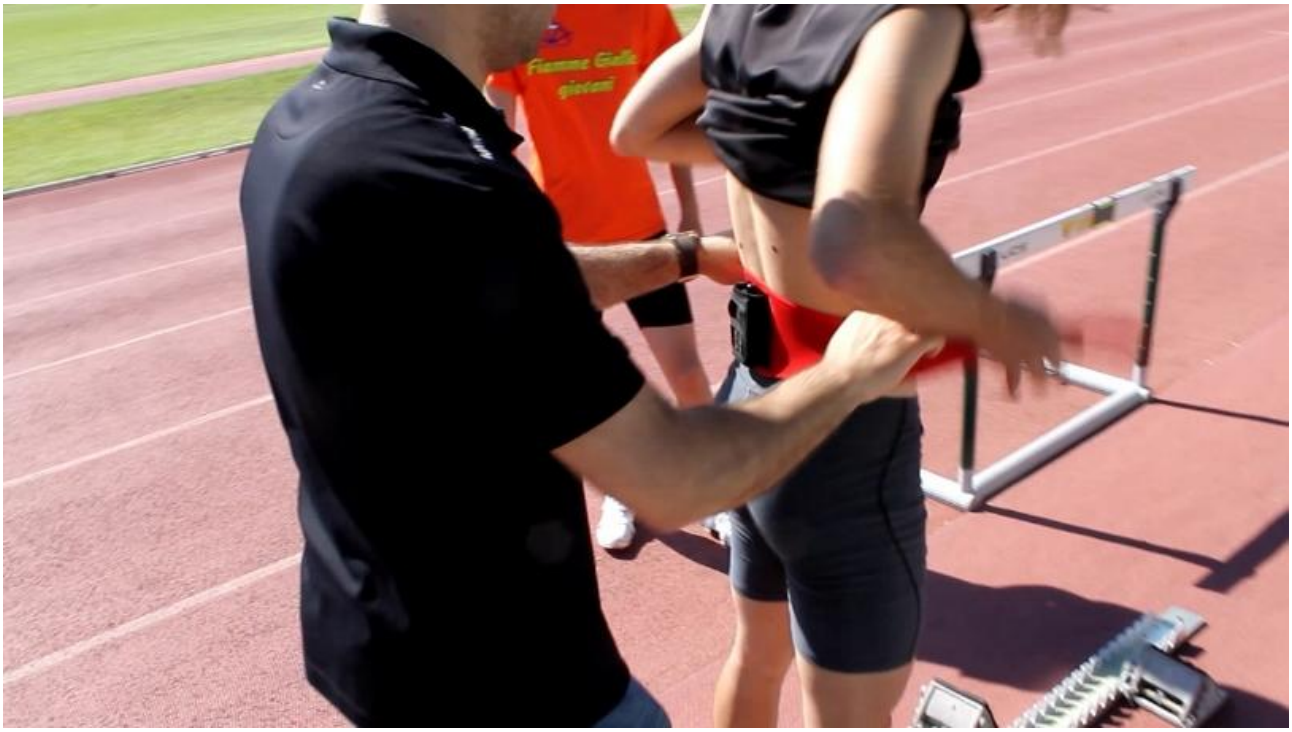
It will be necessary to wait few minutes OUTSIDE to allow GPS to catch satellite signals and wait for “GPS On” to change in “**GPS Ready**”:

Now, it is finally possible to start FreeRun stand alone data acquisition.

Performing a test

Device positioning and fixing

Put the device into the elastic belt, with GPS antenna **up-oriented and display externally-oriented:** this orientation has not to be changed once the belt has been worn. Device should be positioned close to the central lumbar region.



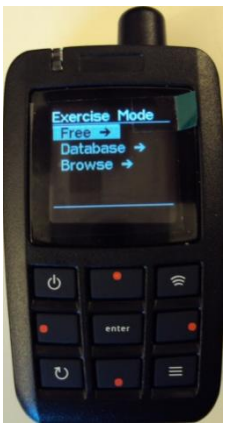
Elastic belt has to be worn firmly: **grabbing the device outward, no more than 2 cm have to be between the belt and the skin**.

N.B.

Parameters accuracy is strictly dependent from the correct belt wear: if it's too loose measured signals will be affected by vibrations not related to the real movement and flight/contact times should be not so accurate.

Initiate data recording

User has now to start acquiring stand-alone data, that will be saved on-board. Enter in the "Main Menu" (button 9) and go down (button 8) till selecting "Standalone"; "enter" (button 5) into the "Exercise Mode":



select “Free” (button 5); now, device will automatically come back to the main window and a green check in the low-right side will be displayed. Device is now ready to start file acquisition. File name will be shown in the right upper side of the display:

Filename is identified by:

name “DATAXXXX”, where “XXXX” is an increasing number from 0001 to 0100.

In the example, device is ready to acquire “DATA0002” file.

All file saved by the user are recorded into the on-board SD memory and can be accessed when device will be connected to PC.

N.B.

It is not possible to modify file name: so, we suggest the user to create a written athletes list and connecting each athlete’s name to his/her related files.

User has 1 minute to start the acquisition after the green check has been displayed. If no action is performed, green check will disappear and all previous steps to start an acquisition have to be performed again. Filename not created will be saved as an empty file (0 Kb dimension) and a new 1-unit incremented file name will be displayed in the upper side of the display.

To start the acquisition press “enter” (button 5): device display will light off and the device led will start blinking from orange to green, confirming that the acquisition has started correctly.

Athlete’s start running

After starting the acquisition, athlete is ready to start (standing or from start blocks).

Before start running, athlete has to stay steady for at least 3 seconds (athlete can start waiting ok from his trainer or after counting till 3).

Waiting 3 seconds before starting movement allows the software to well identify the first movement instant.

If this condition is not taken in account (i.e. athlete moves oscillating his body) software starts acquiring data before the real first movement and this can cause a bad data elaboration.

Stop data recording

At the end of the run, acquisition has to be manually stopped from the trainer or the athlete himself. To stop acquisition press “enter” (button 5) 2 times. Display will light on and the same initial setting information about “DATA0002” file will be shown:

At the end of the acquisition, a red check will be shown in the lower right side of the display.

To acquire other tests repeat the same steps as above.

Field test diary

Essential data to be registered are:

1. Association between file name and athlete's name (i.e., file "DATA0001" corresponds to the first test of Mario Rossi)
2. Distance covered (i.e. chronograph, photocell)
3. The foot (right or left) that strikes first after the start (i.e. the rear foot when the athlete is in start position)

Information about points 2 and 3 are useful when user wants to import file into the FreeRun software.

Test elaboration with the software

Plugging the device to the PC

Files relative to each performed sprint test are stored in the internal memory of the measurement unit. The latter has to be plugged to the PC using the proper USB cable furnished in the kit. Once the device is plugged, two disks will be available: files are contained in the disk named **DATA_XXX** (where XXX is the ID of the device used, for instance"DATA_519").

NOTE: do not open or use the second, virtual, disk named **VRT_XXX**.

Files can be imported in the software directly from the internal disk of the device, but the user can also backup the collected files on the PC by accessing to the folder "DATI" in "DATA_XXX" disk.

Running the software and creating the athlete in the database

Preliminary things to do:

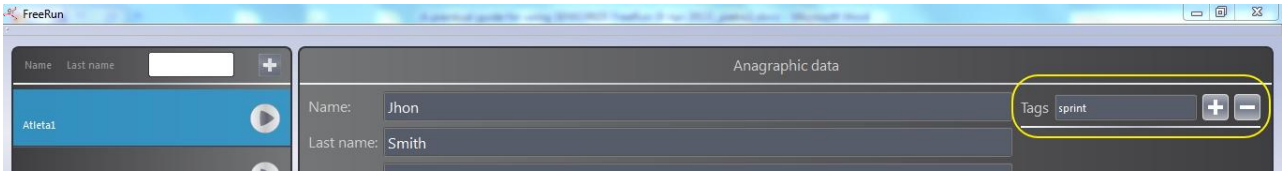
1. install FreeRun software and the relative license;
2. plug the Bluetooth dongle into the PC;
3. open FreeRun software.

Initial software window looks like this:

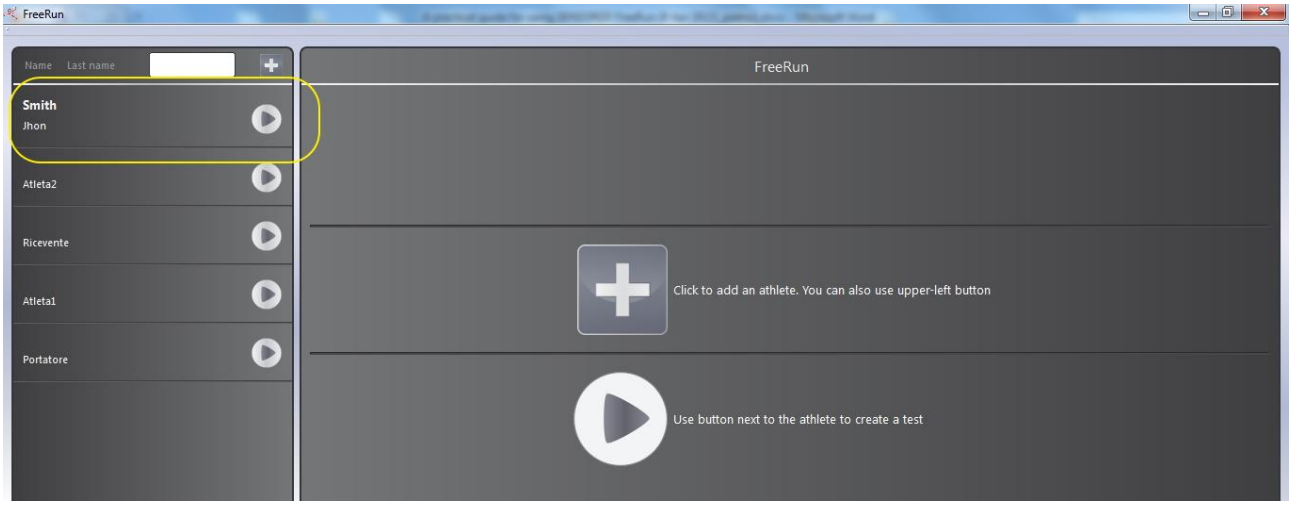
To create an athlete, press the “+” button as showed in the picture:

The fields “Name” and “Last name” are mandatory (if one of these two fields is unknown at the moment of creating the athlete, it is preferable to leave the field empty so that the button “Save” is enabled); all the other fields can be filled also later.

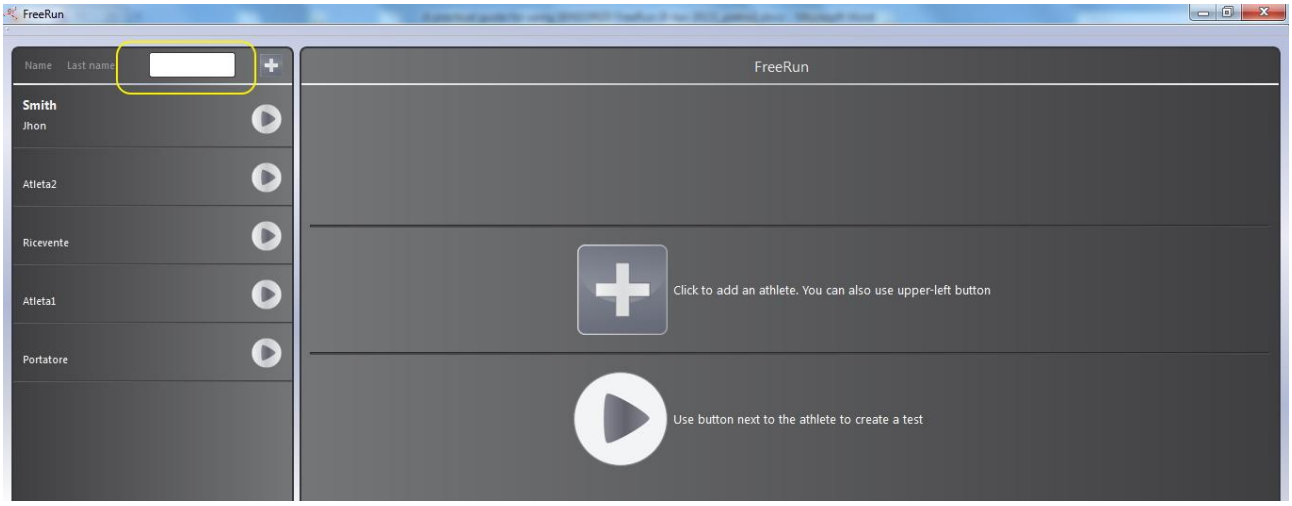
It is suggested to add one or more tags to specify athlete’s characteristics, such as his/her sport discipline:



Press “+” to add a *tag*. Click on “Save” to include athlete into database. Athlete’s name will appear in the left side column of the software main window:



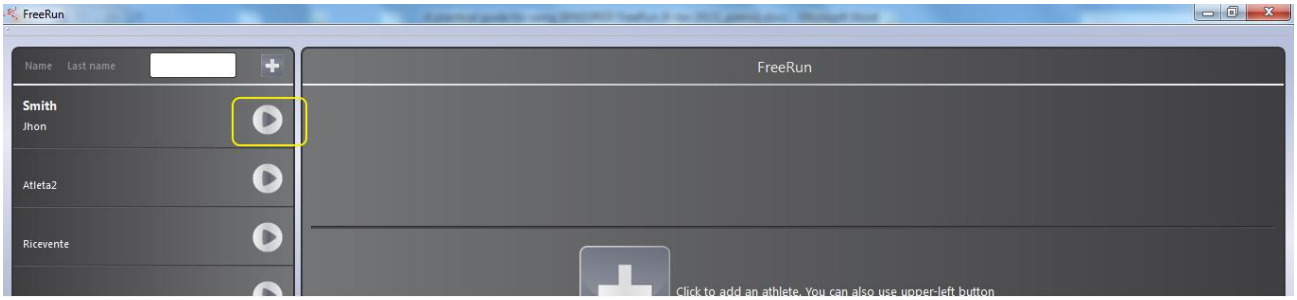
User can find an athlete by typing his “Name”, “Last Name” or “Tag”’ into the search field:



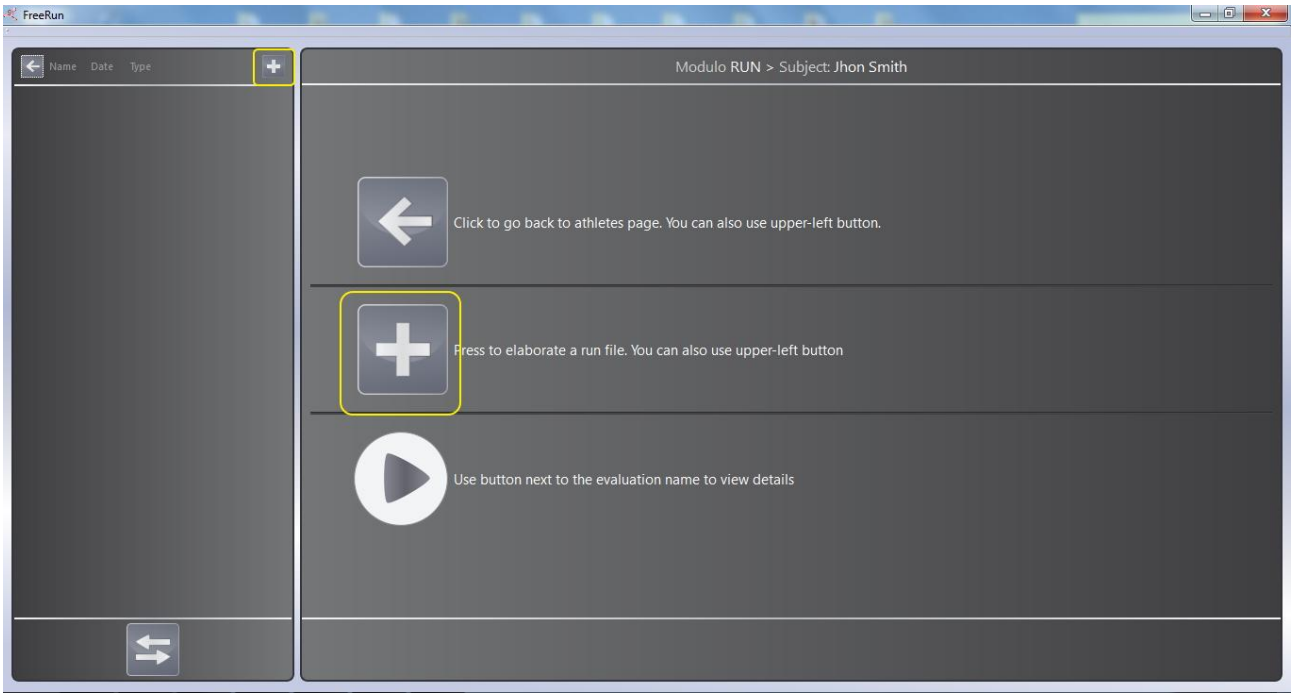
To modify athlete’s information or to cancel it from database, click on athlete’s name and chose “Modify” or “Delete”. In “Modify” mode, anagraphic data window will appear and it will be possible to add/modify data fields. Click “Save” to confirm changes.

Adding a test and importing raw file from the device

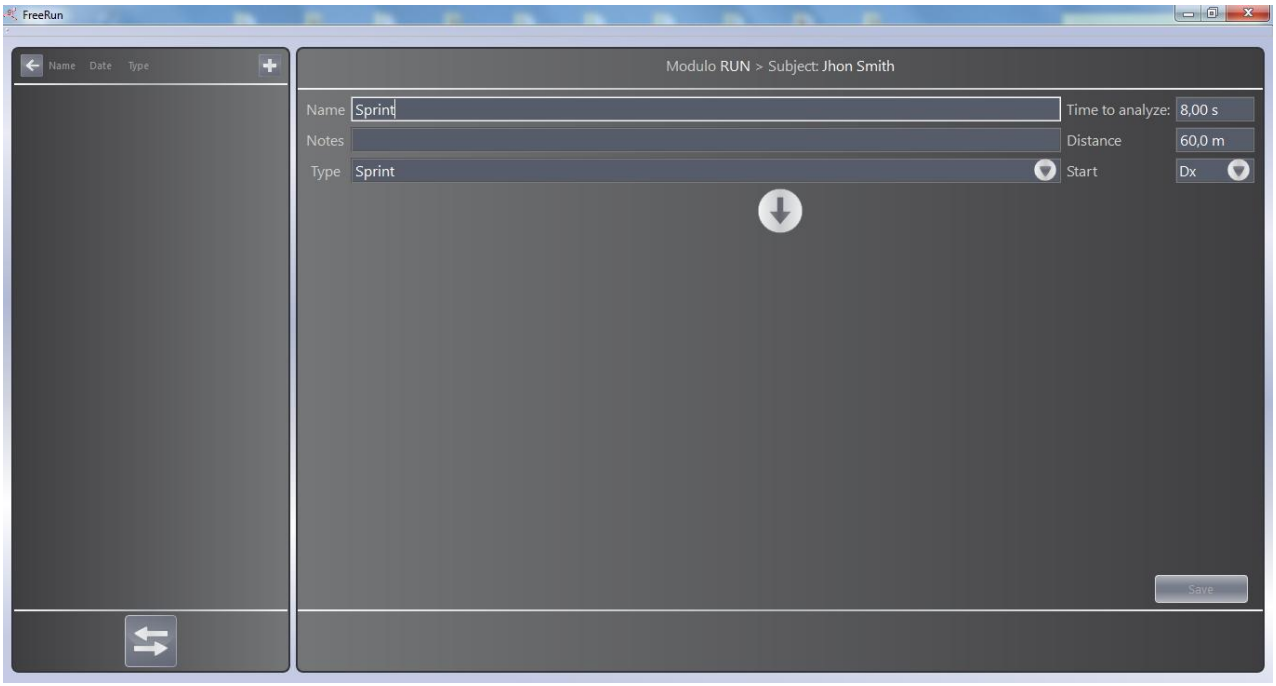
Enter into athlete’s name to access all his/her by clicking on arrow icon, as shown below:



Click ‘+’ to add a test:

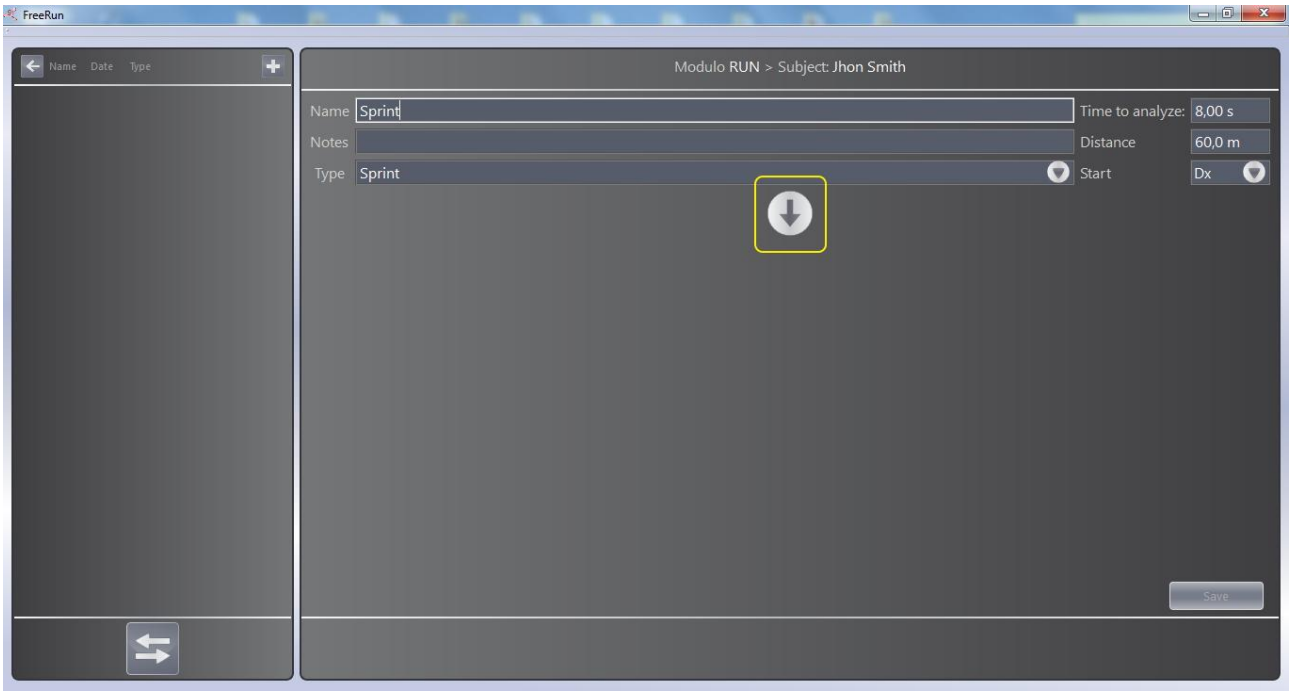


This is the import test window:



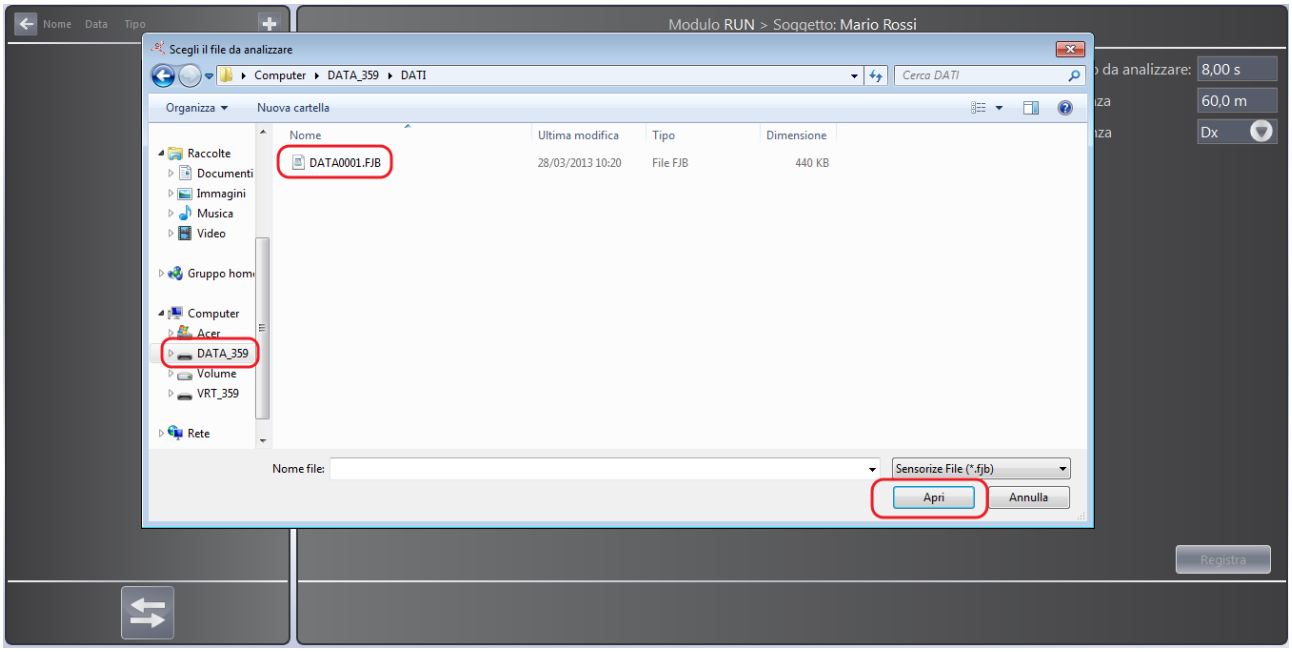
User is requested to:

- assign a name to the test (default name is “Sprint”)
- insert sprint duration to be analyzed (i.e. all the sprint duration)
- insert sprint distance performer by the athlete
- specify first strike foot used for the sprint
- import file related to the relevant test using the yellow-circled icon as shown below:



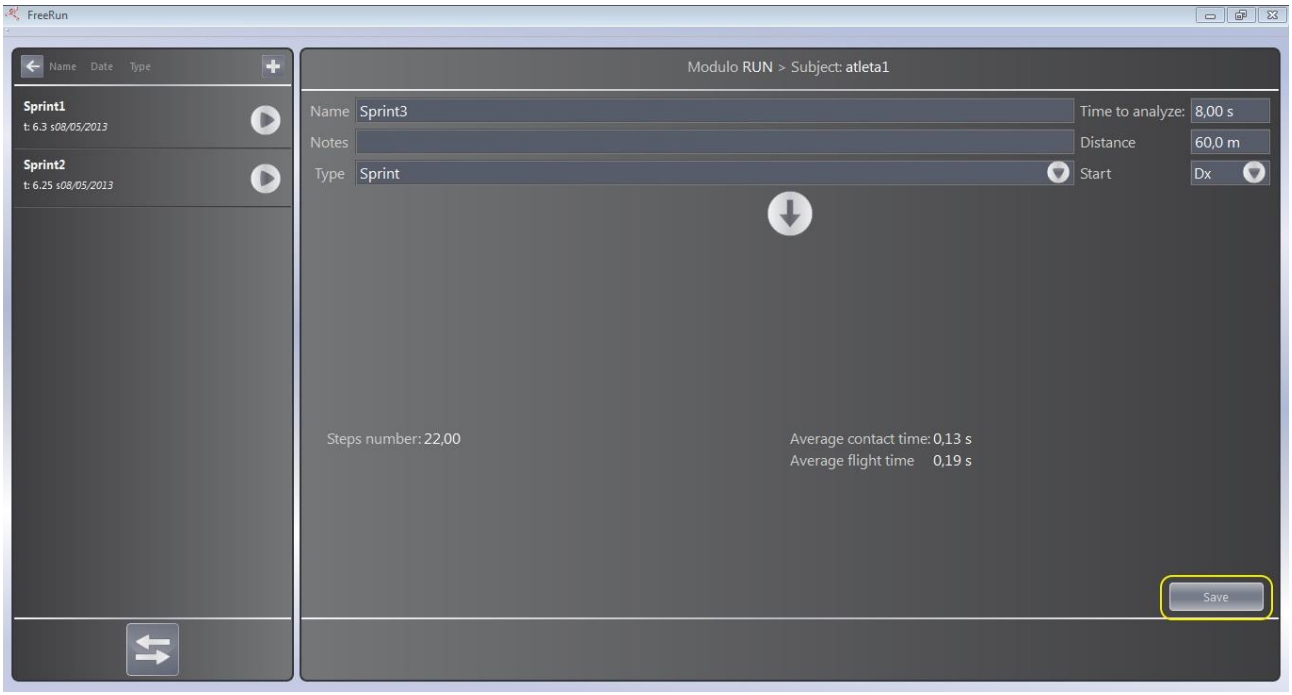
“Note” field is optional and “type” only contain the option “Sprint”.

An explorer window will be opened to select disk unit “**DATA_XXX**” and into this to select the athlete’s relevant filename. DATA folder can be located into SD device Disk or into PC hard disk, if copied there before by the user. In this case file address has to be selected by the explorer window:

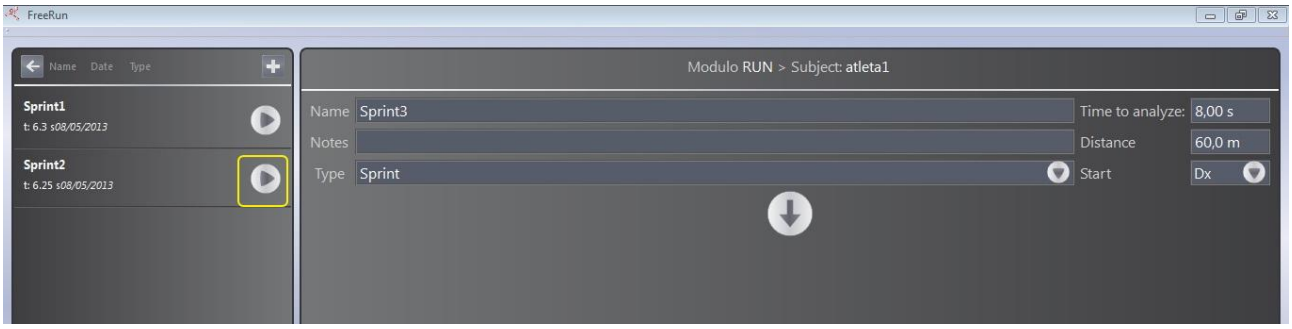


Software will need few seconds to import selected file.

If the file has been correctly imported, the window below will appear:



Click “Save” to record elaborated test: it will appear in the left side of that athlete’s test:



To look at test results, click the arrow icon close to the test name or import another test by clicking on “+”, following same steps as described above.

Test results are organized as follows:

Test results are organized into three different tabs.
"**Times and velocities**" contains

- flight/contact times (upper graph)
- step duration (middle graph)
- medium progression velocity (lower graph)

for each step, divided into right and left limb.

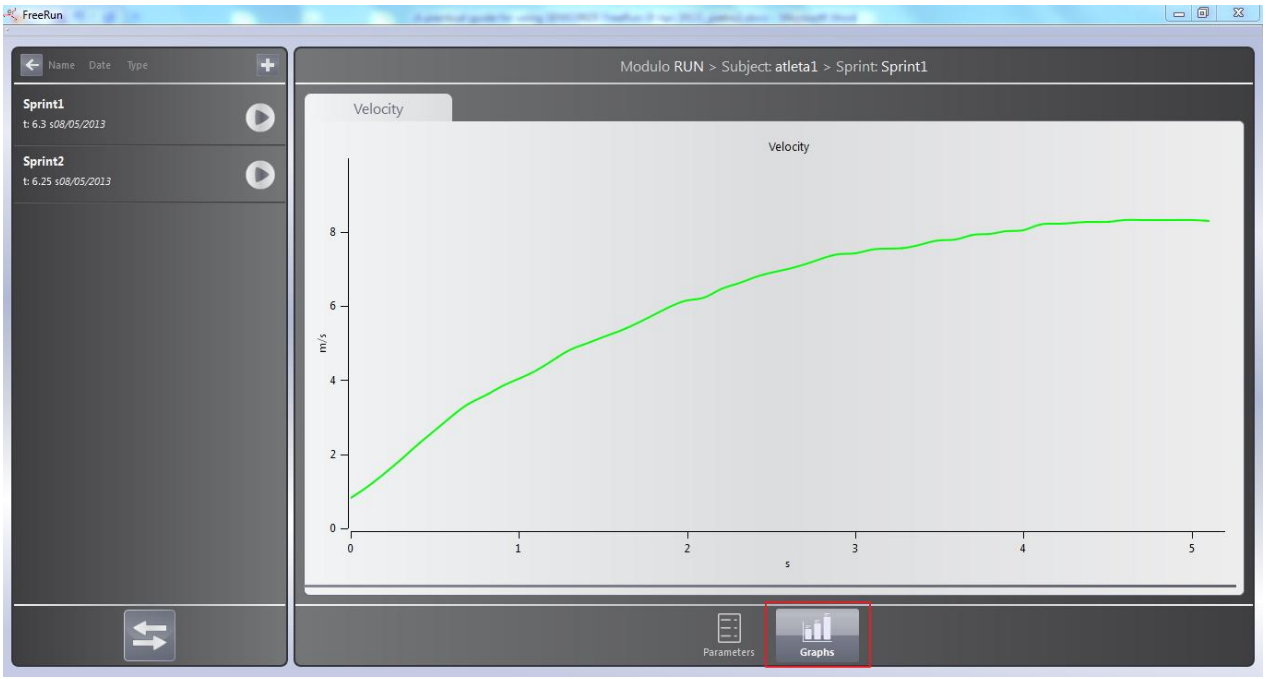
"**Displacementi**" contains

- Centre of Mass Elevation
- Horizontal Centre of Mass displacement

for each step, divided into right and left limb.

"**Table**" contains all numerical FreeRun parameters (columns) for each step (rows).

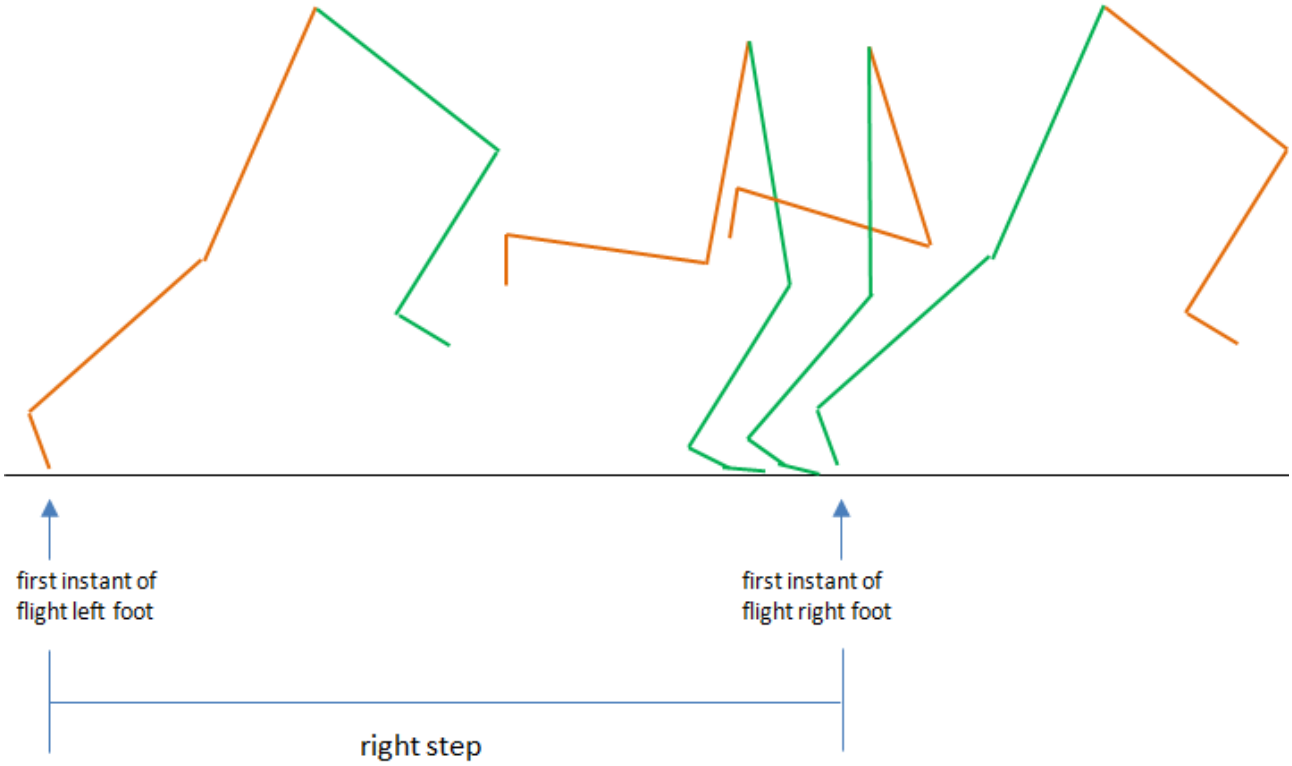
"**Graphs**" contains velocity progression graph from GPS signal vs time, about all test length:



Output parameters

All software parameters are referred to the step.

A step is composed by a flight phase and the subsequent stance phase of the foot with the ground.



The first information returned by the software is the first flight phase subsequent to the take-off of the front foot.

In the following example, the athlete uses his left foot as front foot, so the right foot will be the first foot that strikes after the first flight phase:

oot)

So, when importing a test file, the user has to specify the side corresponding to the foot that strikes first after the first flight phase, which is basically the rear foot in start position; in the following example, the specified side has been the right foot, so the first flight phase is labeled as “right”:

For Each step, software gives:

- **Flight time** (Tv) and **contact time** (Tc), in seconds, calculated from inertial sensors signals as from the following scientific publication:
  Bergamini E et al (2012), *Estimation of temporal parameters during sprint running using a trunk-mounted inertial measurement unit*, Journal of Biomechanics, 45(6): 1123–1126.
- **Step time** (T), in seconds, calculated as T = Tv+Tc
- **Medium horizontal speed** (v), meter/seconds, as measured by GPS;
- **Centre of Mass elevation** (e), meter, calculated from flight time as = Tv*Tv*1.226
- **Centre of Mass horizontal displacement** (s), meter, calculated as s = v*T

N.B.

1. the total number of steps counted by the trainer may not coincide with those returned by the software since the sprint duration entered data import might have fall during a flight phase (in this case the last parameter is related to the previous stance phase) or during a stance phase (in this case the stance phase is excluded and the last available parameter is the previous flight time;
2. centre of Mass horizontal displacement IS NOT equal to step length;
3. the sum of the horizontal displacements at each step IS NOT equal to the total sprint length.

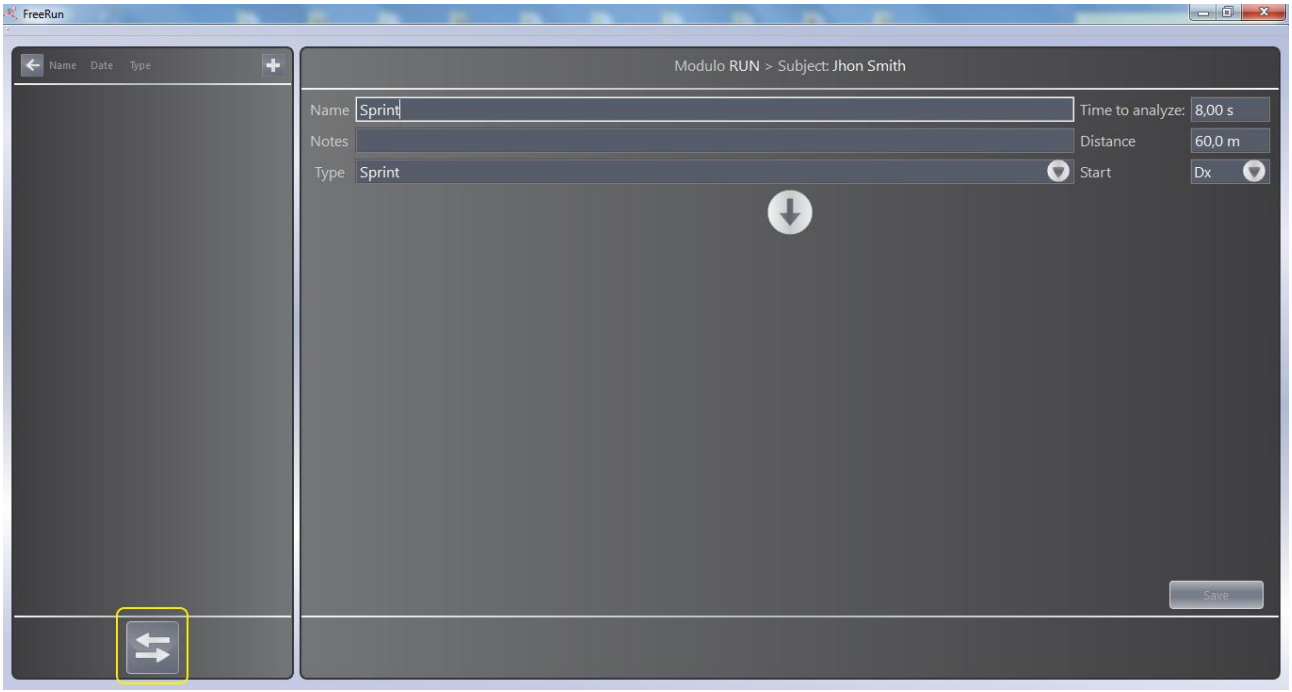
On the accuracy of results

Flight/contact times: software resolution is 5 thousand/second (0.005 s) so, it is not possible to detect times under 0.005 s; this is due to the fact that FreeRun inertial sensors sample at 200Hz and flight/contact times derive from these signals.

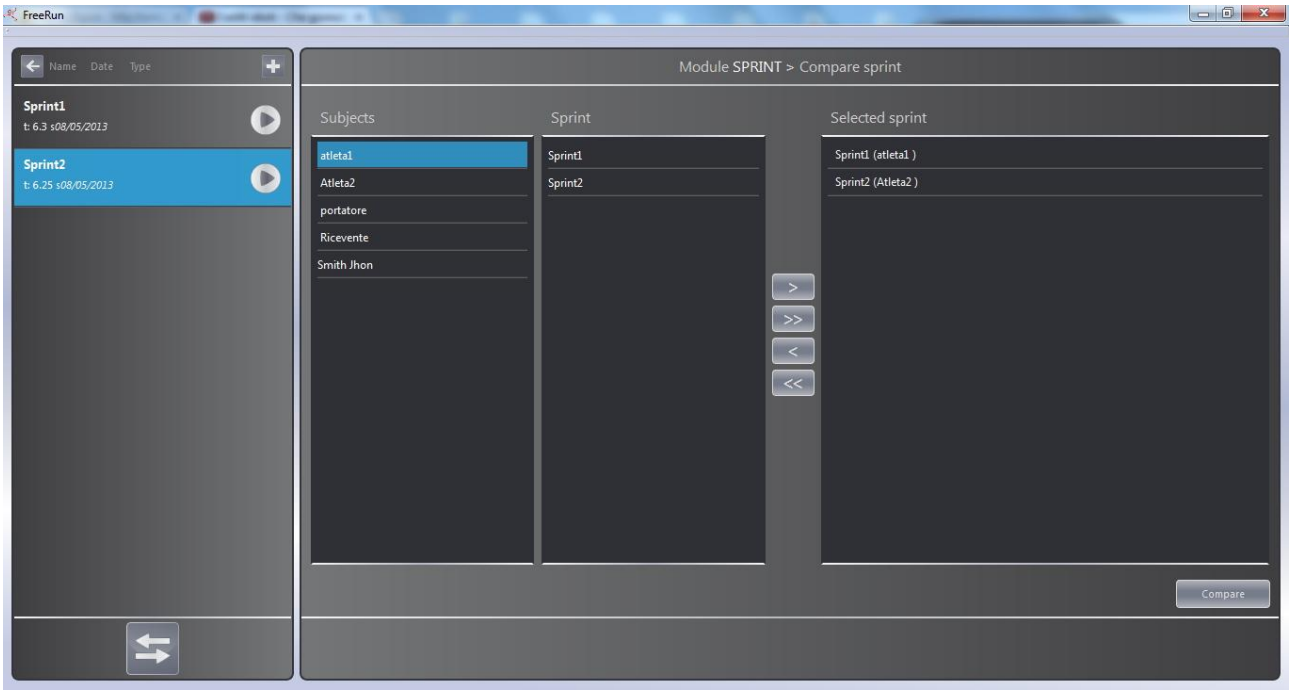
Progression Speed: in ideal conditions (i.e. no clouds in the sky), GPS signal error in calculating progression speed is 0.1 m/s.

Comparing tests

FreeRun software allows to make a comparison between speed of different tests of the same athlete or between different athletes.
To compare tests click the yellow-circled icon as shown below: to access this icon it is required to enter into an athlete selected from those one available in the main software window.

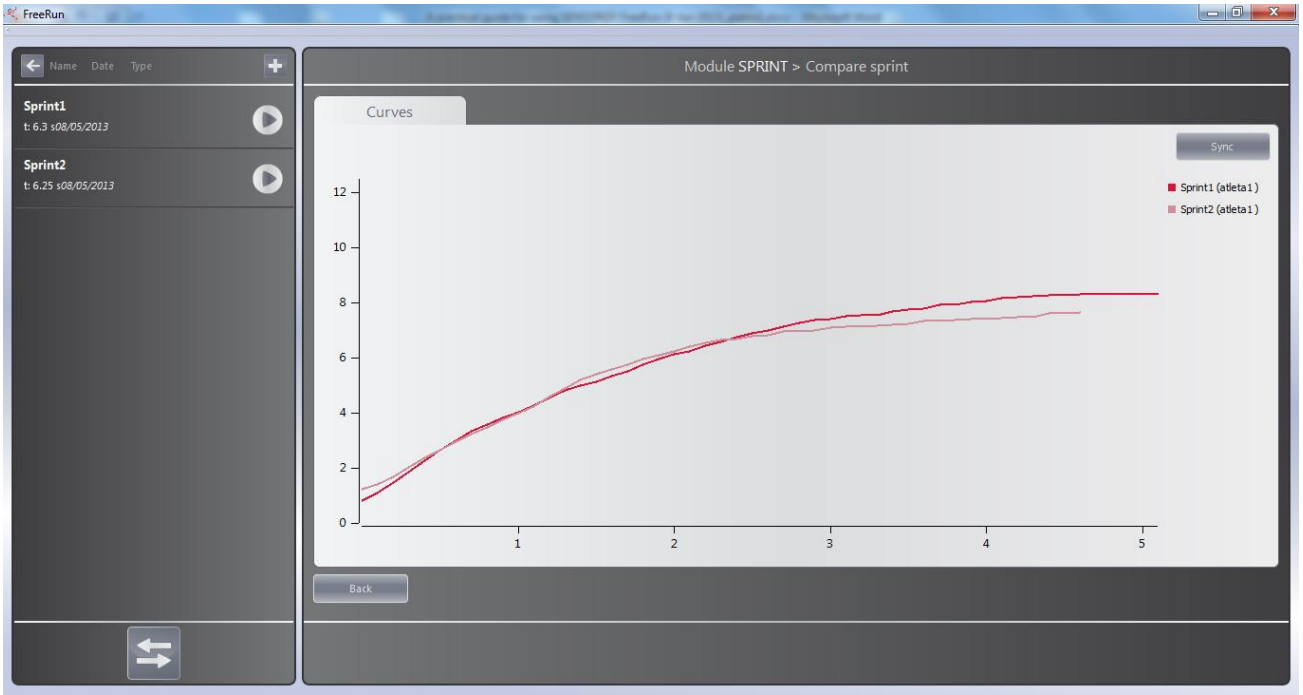


After that, this window will be shown:



Selecting a name in “Subject” column, his/her related “Sprint” tests are shown.

Now, just select one or more tests and click ‘>’ to include them into “Selected Sprint” list. Button ‘>>’ allows to include simultaneously all the athlete’s test. Buttons ‘<’ and ‘<<’ exclude, respectively, one or all the selected sprint from “Sprint list”.
If user want to select tests of different athletes, just include their tests into “Selected Sprint” list doing, for each test, the same actions listed above. Data comparison will be shown after clicking “**Compare**”:

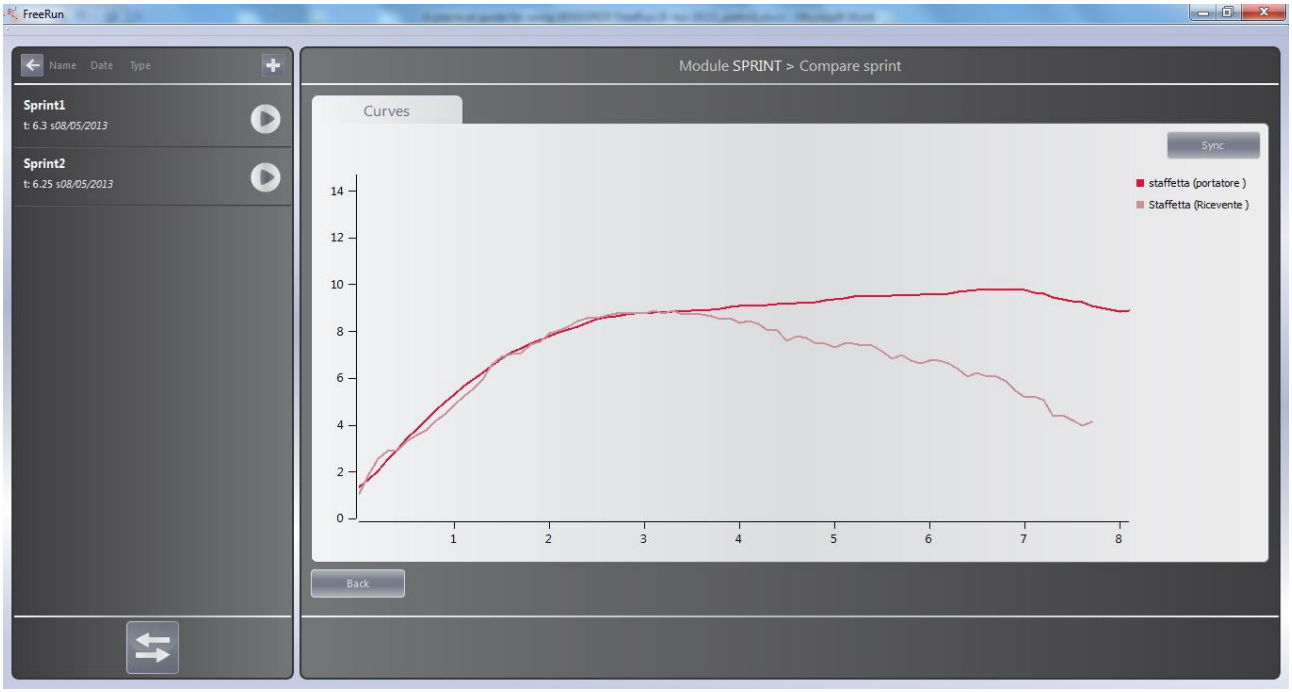


In the example above, two progression speeds (respect of time) are compared: they are automatically synchronized for the first movement instant.

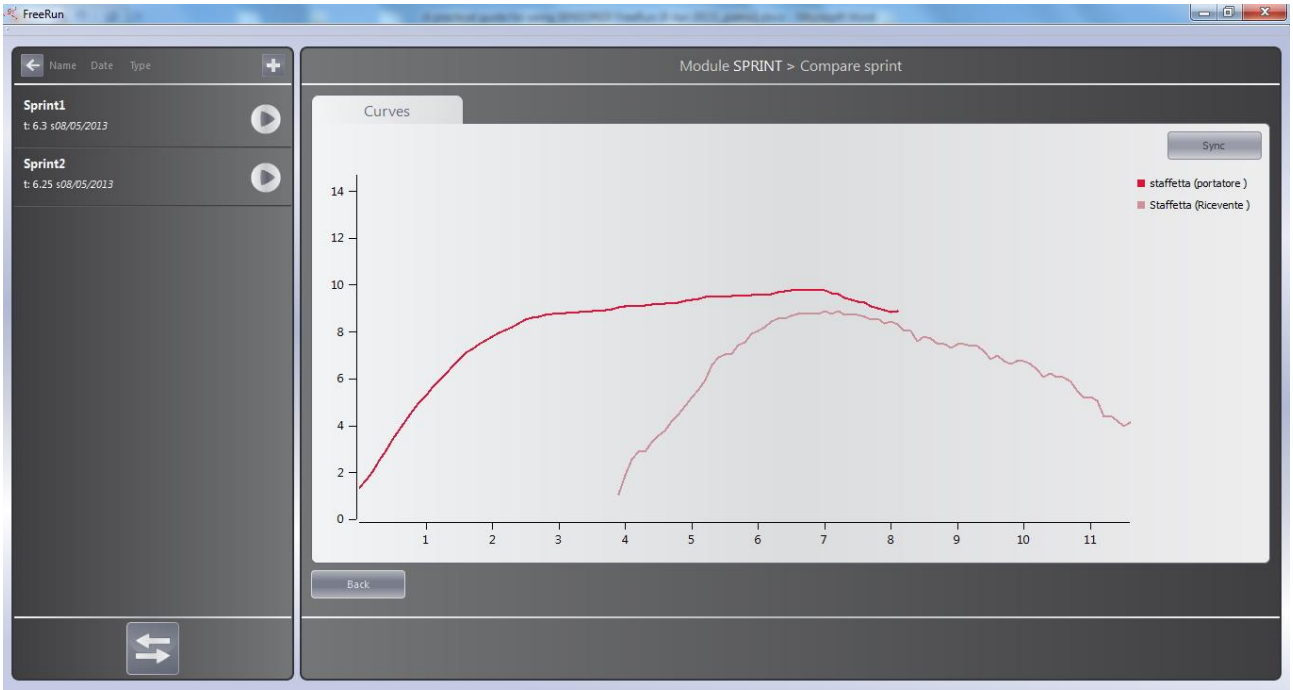
"Relay race" software functionality

"Synch" synchronizes execution times between tests and curves respect of *global GPS clock*. This function is implemented to analyze "relay races" and the baton exchange between racers. It is possible, infact, to compare their speed profiles by synchronizing them and identify if athletes have the maximum speed at the same time, i.e. when the baton has to be exchanged between an athlete and the other.

As shown from the windows below, two tests of two different athletes involved in the same relay race are compared without synchronization::



Here, same tests are compared after synchronization, pressing "Synch":



N.B.

This function has to be used only if tests are executed in the same period. If a comparison is executed between two tests acquired in two different period, they will not be overplayed correctly because two different GPS clock will be considered!

Export test

The software allows you to visualize, process and manage data using commercially available software packages such as Microsoft Excel, Matlab, Dartfish, LabView.

	Flight time[s]	contact time[s]	Step time [s]	velocity[m/s]	elevation[m]	hor displacement [m]	side
1	0.145	0.180	0.325	2.269	0.026	0.737	Destro
2	0.060	0.200	0.260	3.349	0.004	0.871	Sinistro
3	0.070	0.170	0.240	3.833	0.006	0.920	Destro
4	0.070	0.185	0.255	4.543	0.006	1.158	Sinistro
5	0.060	0.185	0.245	4.990	0.004	1.223	Destro
6	0.089	0.158	0.247	5.150	0.010	1.273	Sinistro
7	0.125	0.115	0.240	5.746	0.019	1.379	Destro
8	0.125	0.115	0.240	6.137	0.019	1.473	Sinistro
9	0.135	0.115	0.250	6.600	0.022	1.650	Destro
10	0.120	0.115	0.235	6.883	0.018	1.618	Sinistro
11	0.125	0.110	0.235	7.130	0.019	1.676	Destro
12	0.120	0.115	0.235	7.418	0.018	1.743	Sinistro
13	0.130	0.110	0.240	7.537	0.021	1.809	Destro
14	0.120	0.115	0.235	7.676	0.018	1.804	Sinistro
15	0.125	0.110	0.235	7.922	0.019	1.862	Destro

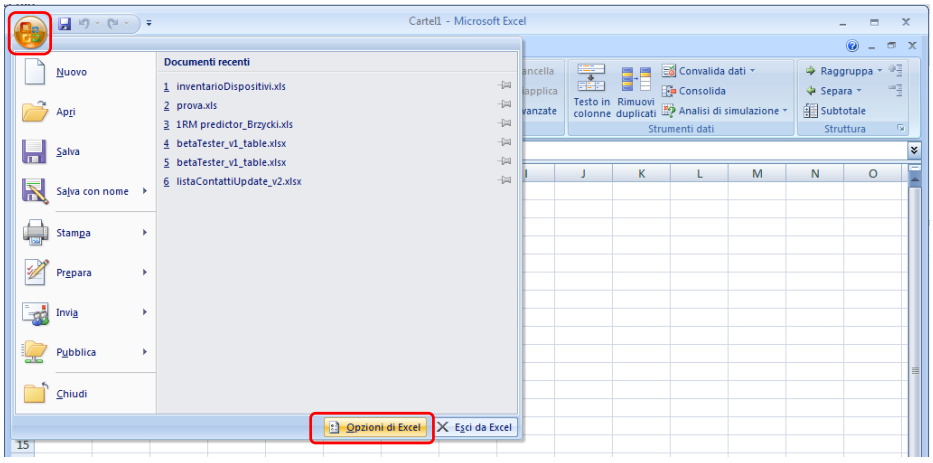
To create a compatible file, click on “Export” to open a browser window where to specify file name and destination folder. File created will have a .txt extension and a csv format (i.e. comma separated value): this file format uses ‘,’ to organize columns and ‘.’ for decimals.

To open such a file in Excel, user has to set ‘.’ as decimal separator and ‘,’ as thousands separator. To do this follow the steps below.

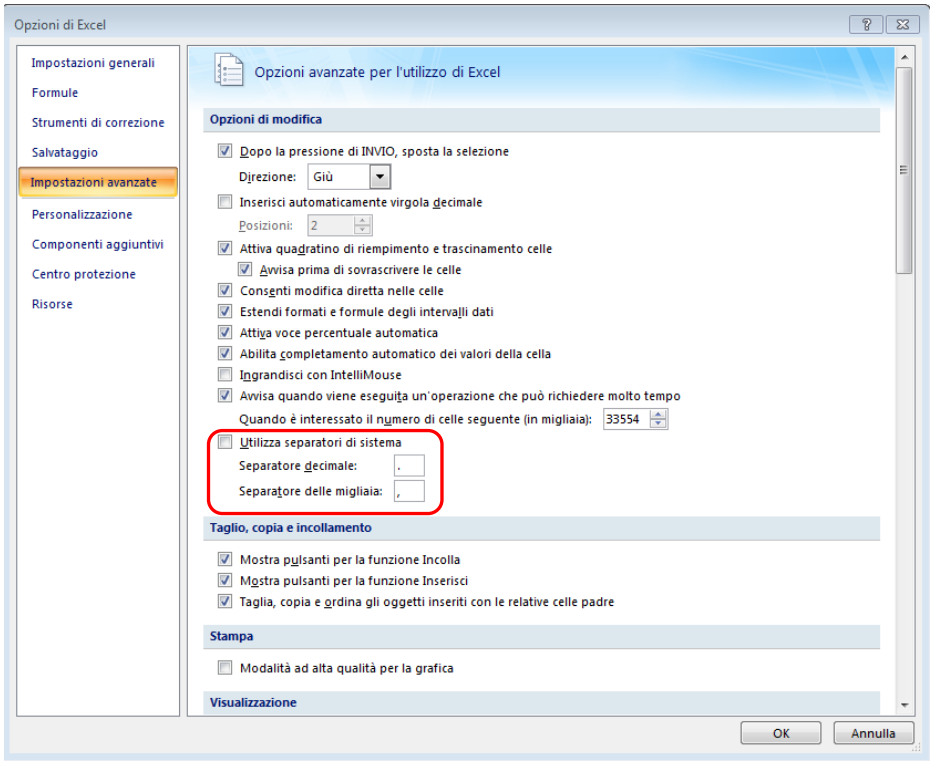
APPENDIX A

Import data in Microsoft Excel 2007

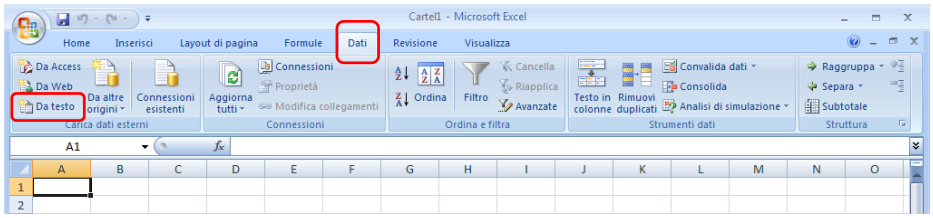
To import FreeRun .txt exported data in Excel, first of all configure it to consider dot as decimals separator and coma as thousands separator. To do this just go in Options of Excel (as shown below):



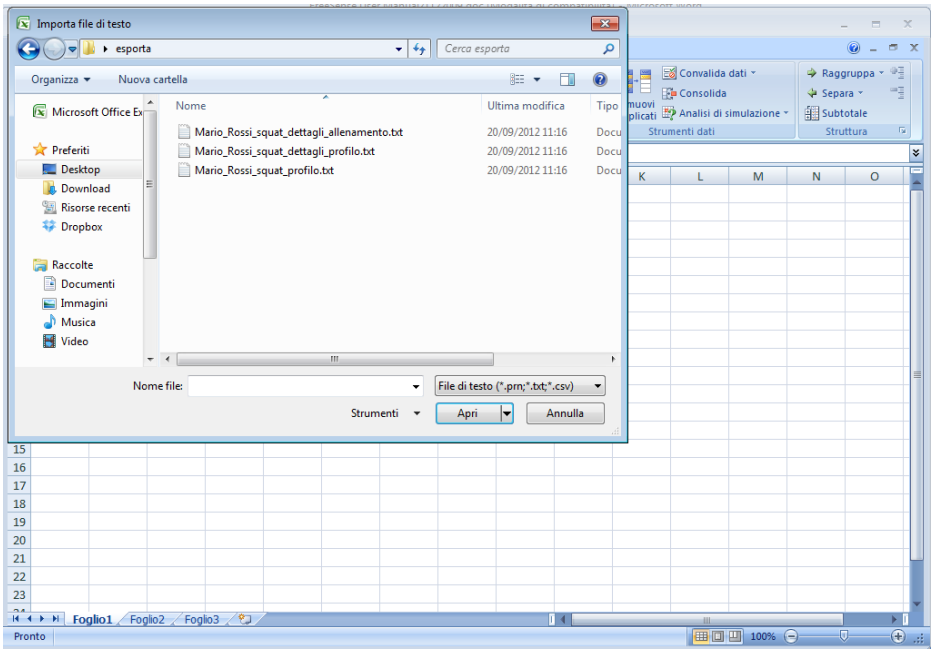
Choose “Advanced options” to set separators as above.

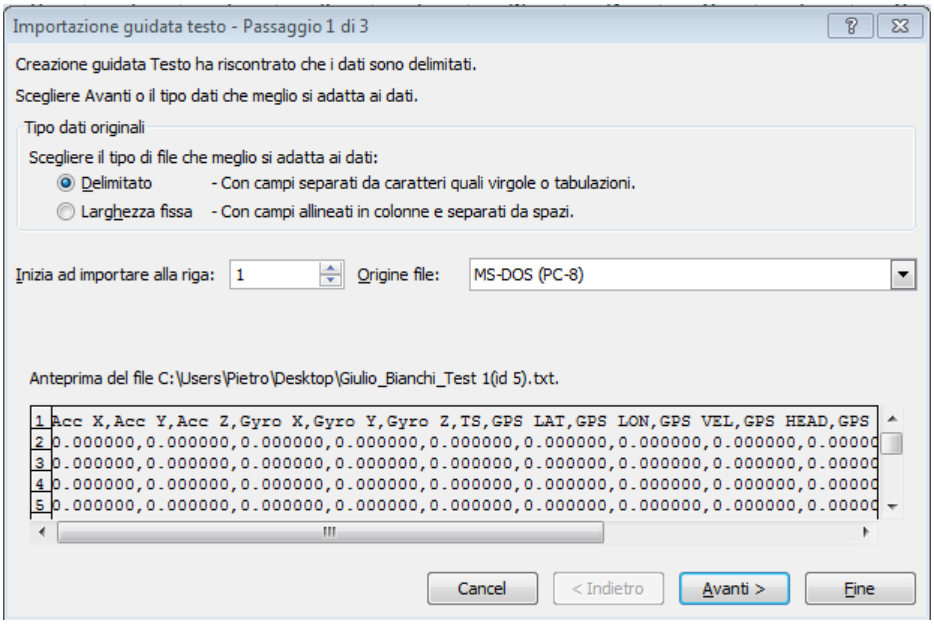


Now, click on “Data” and then select “From Text”:

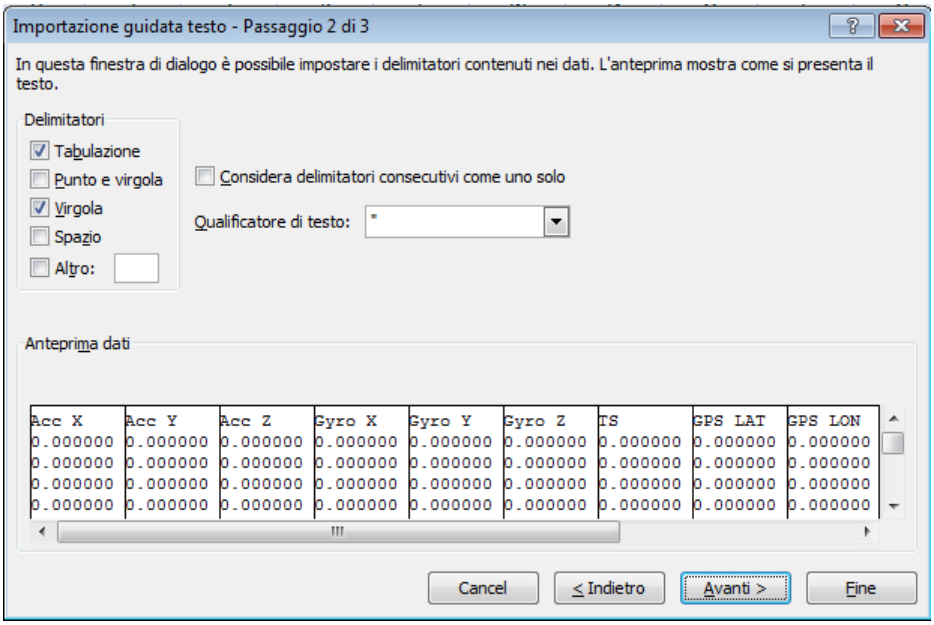


Select now which is the file to import and choose “Delimited” as file data disposition

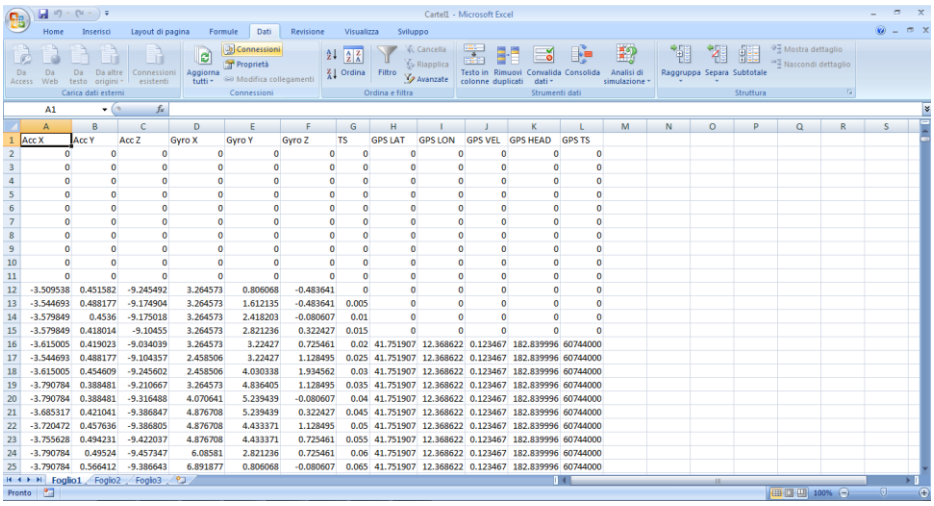




By clicking forward, choose “coma” option as separator



By clicking on “End”, data will be now displayed as follows:



	A	B	C	D	E	F	G	H	I	J	K	L
1	Acc X	Acc Y	Acc Z	Gyro X	Gyro Y	Gyro Z	TS	GPS LAT	GPS LON	GPS VEL	GPS HEAD	GPS TS
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	-3.509538	0.451582	-9.245492	3.264573	0.806068	-0.483641	0	0	0	0	0	0
13	-3.544693	0.488177	-9.174904	3.264573	1.612135	-0.483641	0.005	0	0	0	0	0
14	-3.579849	0.4536	-9.175018	3.264573	2.418203	-0.080607	0.01	0	0	0	0	0
15	-3.579849	0.418014	-9.10455	3.264573	2.821236	0.322427	0.015	0	0	0	0	0
16	-3.615005	0.419023	-9.034039	3.264573	3.22427	0.725461	0.02	41.751907	12.368622	0.123467	182.839996	60744000
17	-3.544693	0.488177	-9.104357	2.458506	3.22427	1.128495	0.025	41.751907	12.368622	0.123467	182.839996	60744000
18	-3.615005	0.454609	-9.245602	2.458506	4.030338	1.934562	0.03	41.751907	12.368622	0.123467	182.839996	60744000
19	-3.790784	0.388481	-9.210667	3.264573	4.836405	1.128495	0.035	41.751907	12.368622	0.123467	182.839996	60744000
20	-3.790784	0.388481	-9.316488	4.070641	5.239439	-0.080607	0.04	41.751907	12.368622	0.123467	182.839996	60744000
21	-3.685317	0.421041	-9.386847	4.876708	5.239439	0.322427	0.045	41.751907	12.368622	0.123467	182.839996	60744000
22	-3.720472	0.457636	-9.386805	4.876708	4.433371	1.128495	0.05	41.751907	12.368622	0.123467	182.839996	60744000
23	-3.755628	0.494231	-9.422037	4.876708	4.433371	0.725461	0.055	41.751907	12.368622	0.123467	182.839996	60744000
24	-3.790784	0.49524	-9.457347	6.08581	2.821236	0.725461	0.06	41.751907	12.368622	0.123467	182.839996	60744000
25	-3.790784	0.566412	-9.386643	6.891877	0.806068	-0.080607	0.065	41.751907	12.368622	0.123467	182.839996	60744000

Foglio1 Foglio2 Foglio3

Pronto

Cartel1 - Microsoft Excel

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I11

	A	B	C	D	E	F	G	H	I
1	durata volo[s]	durata contatto[s]	durata passo[s]	velocità[m/s]	elevazione[m]	lunghezza passo[m]	lato		
2	0.07	0.205	0.275	2.017	0.006	0.555	Destro		
3	0.07	0.175	0.245	4.265	0.006	1.045	Sinistro		
4	0.06	0.195	0.255	5.288	0.004	1.349	Destro		
5	0.065	0.185	0.25	6.23	0.005	1.557	Sinistro		
6	0.055	0.19	0.245	6.719	0.004	1.646	Destro		
7	0.089	0.161	0.25	6.986	0.01	1.747	Sinistro		
8	0.125	0.12	0.245	7.146	0.019	1.751	Destro		
9	0.14	0.11	0.25	7.526	0.024	1.882	Sinistro		
10	0.125	0.125	0.25	7.67	0.019	1.918	Destro		
11	0.125	0.115	0.24	7.712	0.019	1.851	Sinistro		
12	0.125	0.115	0.24	7.964	0.019	1.911	Destro		
13	0.135	0.115	0.25	8.319	0.022	2.08	Sinistro		
14	0.12	0.115	0.235	8.689	0.018	2.042	Destro		
15	0.13	0.12	0.25	8.674	0.021	2.168	Sinistro		
16	0.115	0.115	0.23	8.879	0.016	2.042	Destro		
17	0.13	0.12	0.25	8.828	0.021	2.207	Sinistro		
18	0.115	0.115	0.23	8.874	0.016	2.041	Destro		
19	0.135	0.11	0.245	8.879	0.022	2.175	Sinistro		
20	0.12	0.12	0.24	8.854	0.018	2.125	Destro		
21	0.125	0.11	0.235	8.812	0.019	2.071	Sinistro		
22	0.125	0.125	0.25	8.776	0.019	2.194	Destro		
23	0.125	0.115	0.24	8.869	0.019	2.129	Sinistro		
24	0.12	0.12	0.24	8.91	0.018	2.138	Destro		
25	0.12	0.125	0.245	9.075	0.018	2.223	Sinistro		

Foglio1 Foglio2 Foglio3

Pronto

Deleting files from the device

Internal SD memory contains 256Mb and, considering that a 100 meter sprint requires about 200Kb, it can contain about 1000 tests. We suggest to empty memory before a new test session, by saving data on PC memory.

To delete data from SD memory, access to “DATA” folder into “DATA_XXX” disk and cancel files as usual in Windows. Device will continue to add files by increasing progressively the old file name: to avoid this and restart from a complete new file name number, reset device by pressing buttons 2 and 8 at the same time, till “resetting” will be shown on device display; then, wait for the device to restart.