Isolating Vibrations on Laser Range Scanners Mounted on Agricultural Vehicles to Improve the Detection of Foreign Objects

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Abstract.

Laser Measurement Systems (LMS) are used in autonomous agricultural vehicles for guidance and obstacle detection purposes. In the particular case of agricultural vehicles, the efficiency of LMS measurements is affected by mechanical vibrations induced by the operation of these machines on uneven terrains. The objective of this study was to evaluate the effectiveness of a mounting system capable of reducing the transmission of mechanical vibrations to an LMS sensor installed on an agricultural tractor for the purpose of improving the detection accuracy of obstacles during field operation.

A stabilization system (SS) was designed for a SICK LMS 291-S14 scanner. The LMS sensor and the SS were installed on an agricultural tractor to scan four objects positioned at known locations in the field. An experimental analysis was carried out to evaluate the detection accuracy of the LMS sensor under different operating conditions: with and without SS; with and without support bars (S); and for different types of terrains (in terms of roughness) and field operating speed. The detection accuracy of the LMS sensor was assessed by determining the difference between the known location of the four objects and their corresponding estimated location from the LMS measurements.

The increase of tractor speed had a negative effect on the accuracy of the LMS sensor with an increase in the positioning error of up to 75%. However, it was not possible to establish a clear relationship between terrain roughness and the accuracy of the LMS sensor. The addition of the S systems positively affected the accuracy of the LMS sensor and resulted in a 41% decrease of the average positioning error from 0.340 to 0.201 m. Finally, the used of the SS mounting system decreased the average positioning error by 57% from 0.382 to 0.161 m. These experimental results confirmed the effectiveness of the joint

use of the SS and S mounting systems in improving the accuracy of the LMS sensor mounted on an agricultural tractor through a reduction in transmitted vibrations.

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Nomenclature

A	ampere
A	area, m^2
AAC	Advanced Antivibration Components
ASABE	American Society of Agricultural and Biological Engineers
CAD	Canadian Dollar
cm	centimetre
cos	cosine function
CSV	Comma Separated Values
DARPA	Defense Advanced Research Projects Agency
dB	decibel
DGPS	Differential Global Positioning System
Dx1RP	distance error deviation in X direction between the objects' image and the location of the objects represented with 1RP
Dy1RP	distance error deviation in Y direction between the objects' image and the location of the objects represented with 1RP
Dx2RP	distance error deviation in X direction between the objects' image and the location of the objects represented with 2RP
Dy2RP	distance error deviation in Y direction between the objects' image and the location of the objects represented with 2RP
dist_scan	distance travelled during each scan [m]
E	eccentricity
EH.NET	Economic History Association

f	scan frequency [Hz]
FMTC	Flanders' Mechatronics Technology Centre
FOG	Fibre Optic Gyroscopes
FRFs	Frequency Response Functions
g	gram
GDS	Geomagnetic Direction Sensors
GPS	Global Positioning System
H	measured height of the LMS sensor
Hz	hertz,
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
Ix, Iy	centroid coordinates of objects' image, pixels
IMU	Inertial Measurement Unit
INS	Inertial Navigation Systems
kg	kilogram
km/h	kilometres by hour
kPa	kilopascal
kW	kilowatts
m/s	meter by second
L	length
LMS	Laser Measurement Systems
LS	Laser Scanner
m	meter

MD	mean error distance
MeBioS	Mechatronics, Biostatistics and Sensors
mm	millimetre
NASA	National Aeronautics and Space Administration
nS	no support bars or without support bars
nSS	no stabilization system or without stabilization system
Pa	Pascal
Pn	plane number
PNG	Portable Network Graphics
PT	plowed terrain
PVC	Polyvinyl chloride
R	pixel of origin
RMS	root mean square
RP	rectangular shaped post
rpm	revolutions per minute
RT	rough terrain
RTK GPS	Real-Time Kinematic Global Positioning System
S	support bars or with support bars
s	second
SE	structuring element
sin	sine function
Sn	scan number
SP	square shaped post

SS	stabilization system or support system
ST	smooth terrain
STDX	standard deviation along X direction
STDY	standard deviation along Y direction
theta	angle of the LMS sensor from the horizontal line
USD	United States Dollar
V	volt
V	vehicle velocity [m/s]
W	watts
W	width, m
WBV	Whole Body Vibration
Xn	surrounding pixels number
X,Y,Z	Cartesian coordinates system
$x1RP$, $y1RP$	centroid coordinates of objects with 1RP
$x2RP$, $y2RP$	centroid coordinates of objects with 2RP
Y_{pts}	Y Cartesian point from the data value provided by the LMS sensor
Z_H	height of the point in the horizontal plane
Z_{pts}	calculated height of the point
1F	first flag
1RP	1 reference point
2F	second flag
2D	two-dimensional space
2RP	2 reference points

3D	three-dimensional space

Chapter 1: Introduction

1.1. Introduction

In the last two decades many researchers around the world have focused on the development of autonomous agricultural vehicles. This has been due to challenges that have confronted the agricultural industry for many years, such as the decline in labour force, globalization, wars, social conflicts, and human responsibility for the maintenance of the global ecosystem (IAASTD, 2011). These challenges have affected food production causing uncertainties about the future of world food prices and they have also increased chronic diseases that are partially a consequence of poor nutrition and poor food quality (IAASTD, 2011). For these reasons autonomous agricultural vehicles have become an element of solution towards increasing food production with high levels of productivity and efficiency.

Autonomous agricultural vehicles have gone through many stages of development. The first attempts at autonomous agricultural vehicles can be traced back to the 1920's and the design of a tractor capable of following furrows by means of mechanical linkages (Reid et al., 2000). Since then, the agricultural machinery industry has benefited from development in others areas, such as automatic control and computers. This has allowed for the creation of sensors, systems, and algorithms that can allow agricultural autonomous vehicles to sense and understand their surrounding environment (Blackmore and Griepentrog, 2006).

Laser Measurement Systems (LMS) have been one of the more widely used sensors for autonomous agricultural vehicles. They have been used in essential tasks such as vehicle guidance and the detection of objects that may become obstacles to the operation of the autonomous machines. However, the accuracy of the LMS sensors mounted on agricultural vehicles can be negatively affected by the mechanical vibrations that change randomly with time and operating conditions.

In agricultural vehicles, vibrations and unwanted shocks are mainly due to soil roughness, operating speed, and moving mechanical components within the vehicles (Balasubramanian, 2006). Since the mechanical vibration sources are very difficult to eliminate, an alternative solution is to isolate the LMS sensor from the sources that generate vibrations. Previous studies have recommended the installation of more appropriate stabilization system (SS) as a potentially effective and workable solution to reduce the transmission of vibrations between the vehicle and the LMS sensor.

1.2. Objectives

The general objective of this study was to evaluate the efficiency of isolating vibrations that affect the LMS sensor mounted on an agricultural tractor with the ultimate goal of improving the detection of foreign objects in the field. Three specific objectives were addressed in this research work:

- To design a SS capable of reducing the effect of vibrations in the measurements of LMS sensor;
- To evaluate the efficiency of the SS and of the structure designed for the LMS sensor under different machine and field operating conditions;
- To improve the methods used for the graphical representation and location of the objects detected by the LMS sensor in the field.

1.3. Thesis Organization

This thesis is structured into five chapters: Introduction (chapter 1); Literature review (chapter 2), Materials and methods (chapter 3); Results and discussion (chapter 4); Conclusions and recommendations (chapter 5).

Chapter 2. Literature Review

2.1. Autonomous Agricultural Vehicles

In recent years, the agricultural industry has experienced a number of rapid changes because of the need to increase food production worldwide. As a consequence, agricultural equipment manufacturing companies around the world have been incorporating the latest technology in the design of agricultural machines to improve their effectiveness and their user friendliness (e.g. precision agriculture, reduced human intervention). A large variety of specialized machines and equipment are used in modern production agriculture.

Autonomous agricultural vehicles and precision farming are regarded as solutions for increasing food production with high levels of productivity and efficiency. For these reasons many researchers are working on the concept of fully autonomous agricultural vehicles. These are defined as driverless agricultural vehicles or machinery capable of driving from one point to another at the same time that they perform their function with a minimum supervision by an operator. These vehicles may operate in different ways, although there are two main tendencies emerging: tandem vehicles or vehicle fleets, and swarms of small vehicles (Heraud and Lange, 2009).

Tandem vehicles or vehicles fleets are based on multiple vehicles following the path defined by the main vehicle with appropriate margins of longitudinal and lateral separation. All vehicles are required to be in communication with one another and with the person supervising and controlling them (Heraud and Lange, 2009). Swarms of small vehicles take advantage of the possibilities offered by small vehicles such as autonomy, efficiency, lower cost, and safety. In this approach the vehicles perform diverse tasks with a high degree of autonomy while supervised by a person (Heraud and Lange, 2009).

The development of autonomous agricultural vehicles relies on a number of modern technologies. It is a difficult process involving the sequential execution of research, design, and manufacture. In addition, many companies are reluctant to invest in these types of vehicles because farmers may not be financially able to participate in their development (Li et al., 2009). Other companies are relying on solutions that were previously tested and used in mining, defence, and other industries.

Furthermore, the agricultural environment adds additional factors that complicate the development of autonomous agricultural vehicles; for example, the diversity of areas of operation, the presence of obstacles in fields, uneven terrains, and the varied number of tasks to be carried out. Equally, soil quality, variation of crop physical characteristics and environmental conditions such as rain, fog, and dust need to be considered (Li et al., 2009).

On the other hand, agricultural fields have some advantages. Landmarks can be easily set up, and crops are located at the same places most of the time (Li et al., 2009). Therefore, even though there are more disadvantages than advantages associated with the development of autonomous agricultural vehicles, there are other major reasons that promote and force their development.

2.1.1. Reasons for Developing Autonomous Agricultural Vehicles

Autonomous agricultural vehicles have become a need due to the challenges that have faced the agricultural industry for many years. Over time, emigration of the population from rural to urban areas has resulted in a decreased availability of skilled workers (Katupitiya and Eaton, 2008). In addition, the globalization of agriculture is causing difficulties for farmers and small communities to sustain its progress, resulting in a decrease in the number of farmers, farm fields, and utilization rate of cultivated land (Katupitiya and

Eaton, 2008). Other challenges are recently emerging, such as social and economic inequities; political uncertainties related to war and social conflicts; the appearance of new competitors for agricultural crops and products, such as biofuels; changes in the economics of fossil-based energy use; and human responsibility for the maintenance of the global ecosystem (IAASTD, 2011).

All these challenges have affected food production, causing uncertainties about the future of world food prices; increasing chronic diseases that are partially a consequence of poor nutrition and poor food quality; and changing environmental conditions (IAASTD, 2011).

In order to confront these challenges, the overall effectiveness and efficiency of agriculture machines must be increased. This need is driving engineering research to develop more efficient, precise, and ultimately autonomous vehicles to decrease costs and increase productivity. For these reasons there are many researchers around the world working on the development of fully autonomous agricultural vehicles. They are developing autonomous farming systems, capable of deploying autonomous sensors using autonomous agricultural vehicles. This is not a recent concept, and many antecedents to the status quo can be found in the literature (Li et al., 2009).

2.1.2. Antecedents Autonomous Agricultural Vehicles

Over the years, agricultural vehicles have gone through many stages of development. The first agricultural power units that could replace animal and human power appeared in 1868 and were engine-powered farm tractors that used steam. Later came the gasoline powered engine created by Charter in Illinois in 1887. This was followed by many attempts until the early 1900's, when gas tractors came into use in areas of extensive farming. By the late 1910's, MS&M Co. engineers started to design smaller, cheaper, and more compact tractors, improving production and agricultural efficiency (EH.NET, 2011).

As early as 1913, some of the first ideas towards autonomous agricultural machines appeared, such as the Big Four tractor and its furrow-following automatic steering aid (Heraud and Lange, 2009). In 1920's started the first attempts at autonomous agricultural vehicles when a tractor was designed capable of following furrows based on mechanical linkages (Reid et al., 2000). During the same period a significant number of patents started to appear related to automatic vehicle guidance. Although these innovations were successful because they solved particular tasks and dealt with the agricultural complexity of those times, they were just a small contribution to the complexity and efficiency needed by autonomous agricultural vehicles.

Agriculture has benefited from the development in others areas. The potential of automatic control and computers rapidly began to spread in all areas, agriculture among them. Since the 1980s, researchers have worked on several successful guidance technologies adapted to agricultural vehicles. Combining computers with image sensors provided great opportunities for machine vision based guidance systems on vehicles (Li et al., 2009). In the 1990's this method started to be studied at some universities. Standing out is Carnegie Mellon University where a vision based autonomous harvester for alfalfa was developed. This was just one of a few autonomous agricultural machines developed during that period (Griffith, 2009).

Many researchers are working in developing autonomous agricultural vehicles in Japan looking for alternative ways to increase food production. Late in the 1990's, at the Institute of Agricultural Machinery in Saitama, researchers retrofitted a commercial tractor with a range of positioning systems such as Real-Time Kinematic Global Positioning System (RTK GPS), odometer, digital compass, and inertial measurement (Blackmore and Griepentrog, 2006). This tractor, Robotra, performed tilling activities with positive results. After that, an automated rice transplanter with autonomous guidance operation was developed by Nagasaka using RTK GPS and fibre optic gyroscope (FOG) sensors that established precise operations. The results were accurate enough for rice transplanting operation, but not accurate enough for spraying or mechanical weeding operations (Nagasakai et al., 2004).

The University of Florida has been researching this topic for many years (Subramanian and Burks, 2005). There, researchers developed an autonomous steering system on a common tractor for use in a citrus grove. They retrofitted the tractor with a machine vision sensor, laser radar, and a rotary encoder. The machine vision sensor was used primarily for guidance, while laser radar can be used for both guidance and obstacle detection. A rotary encoder was used to feedback. This study demonstrated high levels of precision and reliability with an average error of 2.8 cm using machine vision guidance and an average error of 2.5 cm using laser radar guidance.

In France, researchers studied a method of obstacle avoidance for the safe operation of an autonomous agricultural vehicle. While earlier studies tried to detect and avoid obstacles, this one proposed the concept of allowable speed and trajectory that allow the vehicle to cross the area with obstacles keeping its integrity. The allowable speed and trajectories depend on the vehicle capabilities, its dynamics constraints and speeds, and the three-dimensional space (3D) rendering image of the environment (Debain et al., 2010). This idea is interesting because it is an alternative to face small obstacles and rough terrains. It would be an alternative in case the obstacles are difficult to avoid.

Two autonomous agricultural tractors were unveiled in 2011. The first was developed by a partnership between two American companies: Jaybridge Robotics, a rapidly growing developer of software solutions for autonomous vehicles, and Kinze Manufacturing, a leading agricultural equipment manufacturer based in Iowa (Jaybridge Robotics, 2011). They designed an autonomous grain cart system which is driverless and fully controlled by advanced software. This system is capable of performing a complete workflow during the harvest process. This includes locating a moving harvester in the field, synchronizing with it, collecting the grain unloaded by the harvester, and delivering the grain to trucks near the field for transportation (Jaybridge Robotics, 2011).

The second tractor was built by Flanders' Mechatronics Technology Centre (FMTC) and the Mechatronics, Biostatistics and Sensors (MeBioS) division of K.U. Leuven's Biosystems Department in Germany. This new tractor can automatically adjust its speed and turning radius with exceptional precision and without the intervention of a driver, during its pre-programmed route over a field. Its precision is less than a centimetre, which only experienced tractor operators can achieve. The tractor works in real-time with a Global Positioning System (GPS) and adjusts its position according to real situation (Kane, 2011). This prototype tractor represents a significant a step towards automated agriculture.

Prototype autonomous agricultural vehicles have become increasingly successful and popular. Although they remain at the research stage and development worldwide, most of the components and sensors for their development exist in the market and others are in continuous improvement. This suggests that agriculture is coming close to the age of autonomous agricultural vehicles.

2.1.3. Benefits of Autonomous Agricultural Vehicles

It is believed that the potential benefits associated with the use of autonomous agricultural vehicles in agricultural production warrant their continued development. Such machines can allow for the farming of land under minimal human supervision, especially in environments featuring large areas and single crops. In such cases, fleets of smaller autonomous vehicles could be managed by one human. These vehicles would be able to operate during long uninterrupted periods with fewer restrictions as compared to human-operated machines (Rovira-Más and Han, 2006). The persons supervising the operation of autonomous agricultural machines may not need to be physically on board, thus reducing their exposure to noise, vibration, and other hazardous conditions. It is generally believed that the use of autonomous agricultural vehicles can increase the productivity and field capacity of agricultural operations, reduce the costs associated with agricultural machines, and therefore decrease the production costs of agricultural crops and products.

2.2. Sensor Systems for Autonomous Agricultural Vehicles

Obviously, autonomous agricultural vehicles must be able to interact with their environment in a sensible and reliable manner. Consequently, they may be provided with sensors, systems, and algorithms to sense and understand their surrounding environment (Blackmore and Griepentrog, 2006). There are three main tasks that an autonomous agricultural vehicle must fulfill:

1- The need for auto guidance,

2- The ability to detect nearby objects (e.g. obstacles) that need to be avoided.

3- The need to identify characteristics about a particular target or point of interest.

2.2.1. Machine Vision

Machine vision has been widely used with mixed results. It consists of the measurement of relative position and heading using an image sensor mounted on the vehicle (Li et al., 2009). The guidance information can be measured using different types of sensor modalities and various methodologies of image processing have been investigated. Positioning of the sensor on the vehicle requires an understanding of the geometric relationship between the image sensor, the vehicle, and the field-of-view that the sensor uses for guidance information (Li et al., 2009).

Researchers around the world have investigated the use of vision sensors for detecting a guidance reference line on row crops, soil tillage, and the edges along harvested crops (Reid et al., 2000). This method has been studied in some universities such as Michigan State University, Texas A&M University, and the University of Florida when exploring machine vision guidance (Li et al., 2009). Additionally, a guidance system for a New Holland hay windrower using machine vision to sense the edge of the uncut crop was developed by Carnegie Mellon University and the US government's National Aeronautics and Space Administration (NASA). The edge of cut/uncut vegetation was tracked by two colour cameras on either side of the vehicle (Reid et al., 2000).

In addition, other methods of vehicle sensing have been introduced by other researchers to improve the estimations obtained by machine vision such as the use of wheel position sensors, ground tracking, and feelers. These methods have become useful to add corrections and improve vehicle estimations (Wilson, 2000).

Some researchers combined two monocular field images taken simultaneously from a binocular camera to provide a 3D field image. This was called stereovision system. Such 3D images are reconstructed based on the different-disparity monocular images to decrease the ambient light influence (Li et al., 2009). A stereovision-based agricultural machinery crop-row tracking navigation system was developed by Kise (2005b). He achieved from 3 to 5 cm root mean square (RMS) error of lateral deviation, following both straight and curved rows at speeds up to 3.0 m/s (Kise et al., 2005b).

2.2.2. Global Positioning Systems (GPS)

In the 1980s, the GPS was open to civilian use and in 1995, it reached full operation capability. Rapidly, GPS started to be used by many researchers around the world with a significant effect on all areas. This system became very popular in agriculture due to a quick return on investment, ease of operation and installation, as well as its availability and lower cost (Heraud and Lange, 2009). In addition, GPS has been effective in allowing real time measurement. It has several levels of accuracies such as autonomous GPS (less than 15 m), differential GPS (DGPS) (less that 1 m), and real-time kinematic GPS (RTK GPS) (less than 2 cm) (Heraud and Lange, 2009).

Because of its high positioning accuracy, RTK GPS can be used for guidance and other applications such as seed mapping, traffic control, and tillage control (Li et al., 2009). Since GPS does not depend upon the visual appearance of the crop, as machine vision sensors do, it is not adversely affected by weed density, shadows, missing plants or other conditions that degrade the performance (Li et al., 2009). However GPS cannot be used alone for positioning since this may lead to compounded errors. The most important incorrigible error is multipath interference in the user's local environment, when the vehicle moves under tree canopies. For this reason this system cannot be used effectively in any grove (Subramanian and Burks, 2005).

Many studies have been carried out where GPS has been used in autonomous agricultural vehicles, most of them in combination with other sensors such as inertial navigation systems (INS), laser radar, inertial measurement unit (IMU), and FOG. For example, an RTK GPS system was used to control the guidance system of a tractor modified as an autonomous vehicle. The results showed a RMS error of 6 cm with a maximum error of 13 cm following a sinusoidal path with a 2.5 m amplitude and 30 m wavelength at 6.5 km/h (Kise et al., 2001).

More accurate results were obtained by researchers at Hokkaido University in Japan. They integrated an IMU with an RTK GPS. This combination showed a tracking error of less than 5 cm on both straight and curved paths (Li et al., 2009).

2.2.3. Dead Reckoning

This technology is used by aircraft, military vehicles and marine navigation. It is based on using a simple mathematical procedure to determine the current vehicle position (Reid et al., 2000): "If a vehicle starts from a known location and travels in a known direction for a known time, its final position is known." (Lawrence, 1993). These sensors are inexpensive and reliable for short distances. Its simplest form is odometer, while the most used form in the agriculture vehicles are wheel encoders which measure the rotation of vehicle or implement wheels (Reid et al., 2000). These sensors are used in combination with other types of sensors due mainly to orientation errors which cause large lateral position errors when the distance traveled increases (Reid et al., 2000).

2.2.4. Geomagnetic Direction Sensor

Geomagnetic direction sensors (GDS) are used as heading sensors similar to an electronic compass. It is a magnetometer which senses the earth's magnetic field and is used to supplement other sensors (Reid et al., 2000). GDSs have one limitation that can be controlled, namely the influence of external electromagnetic interference from the outside environment; such as from a nearby high-tension electrical wires or electrical components installed on the vehicle (Noguchil et al., 1997). Benson et al. (1998) tracked a straight line with an average error less than 1 cm, combining GDS with a medium accuracy GPS. The maximum overshoot for a 3 m step response was 12%, compared with 50% for GPS only.

2.2.5. Ultrasonic Sensor

Ultrasonic sensors mounted on the periphery of an agricultural vehicle are used to detect objects. Sensors are set at fixed angles and each sensor emits a directed ultrasound "chirp". The time taken to pick up the returned echo is proportional to the distance to the reflecting object (Blackmore and Griepentrog, 2006). This sensor has one limitation: the target has to be perpendicular to the sensor for the ultrasonic waves to be reflected back properly (Subramanian et al., 2006). Ultrasonic sensors are used for guidance in greenhouses. Harper and Mckerrow et al. (2001) used a frequency modulated ultrasonic sensor to detect plants; they created a plant database with a return signal of sensors.

2.2.6. Inertial Sensors

Inertial sensors or INS take measurements of the internal state of the vehicle. Accelerometers and gyroscopes are the most common types of inertial sensors. While accelerometers measure acceleration relative to an inertial reference frame, gyroscopes measure the rate of rotation independent of the coordinate frame (Li et al., 2009).

There are others terms to refer to inertial sensors such as inertial guidance system, inertial reference platform, inertial instrument, and IMU and many other variations (Schmidt, 2011). They are used on vehicles such as aircraft, submarines, ships, and spacecraft. The major advantage of INS is that they are packaged and sealed from the environment, which makes them potentially robust under harsh environmental conditions (Li et al., 2009). There are other important advantages such as that they provide 3D position information, and have the potential to detect wheel slippage. The major disadvantage is that they are prone to positional drift (Li et al., 2009).

There are many examples where these types of sensors are used in combination with laser scanners, GPS or machine vision. At the Institute of Agricultural Machinery in Saitama, Japan, researchers retrofitted a commercial tractor with a range of positioning systems such as RTK GPS, odometer, digital compass, and IMU (Blackmore and Griepentrog, 2006). Zhang and Reid (Nagasakai et al., 2004) presented an on-field navigation system with a vision sensor, FOG and RTK GPS. In both cases the results show that inertial sensors were good assisting the navigation systems (Li et al., 2009).

2.2.7. Laser-based Sensors

Today LMS or Laser Scanner (LS) or Lidar are used in many applications in different sectors. Carmer et al. (1996) discussed the use of LMS for various applications in robotics. In agriculture, several types of LMS have been used as a fundamental tool in obstacle detection, mapping, and navigation (Lee and Ehsani, 2008; Doerr, 2009).

The LMS uses a pulsed laser signal to measure the distance between the sensor and nearby objects. This distance is proportional to the time between the transmission and reception of the LMS signal. The pulsed laser signal is diverted sequentially with a specific angular interval by an internal rotating mirror (Lee and Ehsani, 2009). The contour of the surrounding area is estimated from the sequence of impulses received.

LMS have some advantages over other sensors. They are insensitive to environmental condition such as snow, fog, rain, and strong light change, while stereo and camera vision sensors are not. In addition LMS sensors are not affected by shadowing produced by buildings and trees, while GPS are (Li et al., 2009). Unlike the sound waves of ultrasonic sensors, a laser beam of LS can travel a long distance in a straight line while maintaining a narrow beam. However, laser measurements become increasingly noisy when vehicles are traveling on uneven ground or at high speed (Lee and Ehsani, 2008).

LMS have been used in many studies involving agriculture vehicles for guidance system and obstacle detection. Particularly as a guidance system, the LMS have been used with good results in small vehicles moving through orchards due to the fact that tree canopies frequently block the satellite microwaves to the GPS receiver. Barawid et al. (2007) developed an automatic guidance system using a two-dimensional (2D) LMS sensor as navigation sensor on an agricultural tractor traveling between tree rows. The results showed an accuracy of 11 cm lateral error and 1.5° heading error.

Subramanian and Burks (2005) combined a machine vision and an LMS sensor as guidance system for citrus grove navigation. While the average error was 2.8 cm using machine vision guidance, using the LMS sensor, it was 2.5 cm during vehicle testing at a speed of 3.1 m/s (Subramanian and Burks, 2005). This result showed that the accuracy of LMS sensor is higher than that of machine vision sensor as guidance system, even though both had very good precision.

LMS have been used in all the competitions of the DARPA Grand Challenge, an off-road race of autonomous robot vehicles. The top finishing vehicles in this competition have used LMS sensors for the detection of both obstacles, and lane boundaries of dirt paths (Hamner et al., 2010). Also, these authors retrofitted an electric utility vehicle with LMS sensors to detect trees and other objects in its vicinity. These LMS build a model of the row of trees, and use this model to safely steer the vehicle along the row. This vehicle has been capable of continuously driving orchard blocks (Hamner et al., 2010).

Lee and Ehsani (2009) developed an LS based measurement system to quantify tree geometric characteristics such as tree canopy height, width, surface area, and volume. In general this study demonstrated that the LS can measure the tree geometric characteristics with relatively good accuracy (Lee and Ehsani, 2009).

2.2.8. Summary

Appropriate and reliable sensors constitute a key requirement for the development and successful and safe operation of agricultural autonomous vehicles. It is critically important that the sensors used on these machines be optimal in terms of the tasks performed by the vehicle, the environmental conditions in which it operates, and overall costs. For auto guidance of agricultural autonomous vehicles, the blends of some of the sensors such as GPS, vision system, inertial sensor, and LMS have lead to better results; whereas LMS sensors as the main component combined with other sensors have been confirmed as the better choice for obstacles detection.

2.3. Methods and Algorithms

Methods and algorithms have been developed to extract important information from the data and images provided by sensors. In the field of autonomous agricultural vehicles some methods have been studied to generate maps of obstacles and surroundings areas of vehicles. Most of these methods work with a known position of the sensor and allow the vehicles to make decisions (Li et al., 2009).

Among the methods that have been used in the development of autonomous agricultural vehicles with LS are Hough transform, occupancy grid density, occupancy grid density and connectivity, Kalman filter, and average height. Some of these methods have showed better effectiveness than others, demonstrating that the choice of method should be made according to test requirements.

Kise et al. (2005a) used a template matching function and a Kalman filter to detect the location of an obstacle. They reconstructed a 2D silhouette of the detected obstacle, and estimated its relative motion in real time within a semicircle of 8 m radius. The results had sufficient accuracy to provide safety warning and collision avoidance for autonomous tractors in field operation (Kise et al., 2005a).

Also, Rovira-Más and Han (2006) combined the global positioning data obtained from a DGPS receiver with the local information generated by a monocular camera mounted at the front of an agricultural tractor. A Kalman Filter blended the data from both sensors and was able to reduce the effects of noisy trajectories resulting in more stable control commands (Rovira-Más and Han, 2006).

Due to the fact that most crops are cultivated in rows, there are several studies of the application of machine vision on agricultural vehicle guidance system in which the Hough transform method is used. The use of this method is due to its advantage for seeking a straight line. Basically this method was used to process images, create an elevation map, and determine navigation point. The study also dealt with crop row detection for autonomous tractor guidance. (Li et al., 2009).

Research performed at the University of Ottawa by Doerr (2009) evaluated the effectiveness of various algorithms such as average height, density, discontinuity, and connectivity methods. This author mounted an LMS sensor on an agricultural tractor and changed various test parameters such as speed, scanner angle, and crop to detect foreign objects. The results showed that the average height and density methods had greater obstacle detection rates of 72.4% and 49.4%; while the discontinuity and connectivity methods featured lower detection rates of 20.6% and 18% respectively (Doerr, 2009).

2.4. Autonomous Agricultural Vehicles Safety

Agriculture remains among the most dangerous industries in the world, even in developed countries, the operation of farm machines and equipment continues to be the cause of many accidents. Government regulations and worker protection standards that promote safe workplaces and protect agricultural workers have been put in place as a result. Studies show that the majority of agricultural vehicle accidents occur as the direct result of human error, thus the responsibility for safety rests in the operator and the way they operate the vehicles.

One main advantage of autonomous agricultural vehicles is the removal of human operators from the stressful and potentially dangerous situations that result from operating agricultural machines during long periods. These activities include tillage, seeding, and some harvesting operations with high levels of precision, as well as spraying that may be harmful due to the use of chemicals. However, many researchers agree that security issues in autonomous agricultural vehicles are the more difficult problem to overcome due to their complex implementation. “Autonomous agricultural vehicles create a new challenge for operation safety” (Kise et al., 2005a).

For this reason, autonomous agricultural vehicles must be designed with safety in mind. They must ensure operator safety, the integrity of surrounding areas and their own safety (Doerr, 2009). This can be done by providing these vehicles with features including obstacle detection and collision avoidance (Kise et al., 2005a). Also, flashing lights and audible beepers may be fitted to the vehicle to indicate autonomous operation. Software must be designed to stop the vehicle immediately if a collision seems imminent or any of the software or hardware systems fail (Hamner et al., 2010).

It is also important to be safety conscious when working with any agricultural vehicle. Operators must avoid coming near the vehicle during autonomous operation. They should always be thinking ahead and anticipating potential hazards

One of main tasks that an autonomous agricultural vehicle must accomplish is the ability to sense nearby objects that may become obstacles. An object becomes an obstacle when it can obstruct the navigation of the vehicle (Blackmore and Griepentrog, 2006). Obstacles or barriers can be described as (Doerr, 2009):

- Material barriers such as buildings, walls, fences.
- Functional barriers that can impede the work to be conducted, usually pre-conditions.
- Symbolic barriers such as reflective posts, road signs, visual or auditory.
- Immaterial barriers such as rules, guidelines, laws, property lines.

2.5. Vibration on Agricultural Vehicles

Agricultural vehicles are subjected to mechanical vibrations that change randomly with time and operation. Since agricultural vehicles are generally designed without suspension, tires represent the only suspension elements working as damping elements (Clijmans et al., 1998). Vibrations and unwanted shock are generated mainly due to soil roughness, driving speed, and moving mechanical components within the vehicles (Balasubramanian, 2006).

Especially in tractors there are safety and health concerns produced by the vibrations. In this sense, vibrations may be uncomfortable to the driver, may increase the noise level, and can result in inefficient control of the piece of machinery. Vibrations may affect the manual and automatic controls and so reduce the efficiency of the operations to be carried out (Clijmans et al., 1998).

Even more important are the health problems created by vibrations. They are detrimental to human body organs, due to the fact that the frequency of tractor vibrations can be the same as the frequency of human body organs (Dworecki et al., 2005). Whole body vibration (WBV), which is defined as the ride vibration transmitted to the body as a whole through the buttocks of the seated operator (Balasubramanian, 2006), is associated with several diseases. Studies have indicated that WBV produces disorders of the spine, and low back pain. Also WBV affects the gastrointestinal system, the circulatory system, the nervous system, the vestibular system and the female reproductive system (Balasubramanian, 2006).

The vibrations on tractors have been studied for years using two types of approaches, analytical and experimental (Balasubramanian, 2006). Dworecki et al. (2005) used analytical approach to determine the vibration on agricultural tractor. Its approach is based on physical laws to derivate the equations of the motion of the system considering the geometry and mechanical parameters such as masses, moments of inertia, spring stiffness, and damping constants (Clijmans et al., 1998).

On the other hand Clijmans et al. (1998) and Balasubramanian et al. (2006) conducted their research using experimental models. In these cases the physical properties of a structure were measured and experimental modal analysis was used to calculate the frequency response functions (FRFs) from measured responses to known input excitation forces (Clijmans et al., 1998). This approach gives a more accurate description of vibration levels, natural frequencies, damping and mode shape occurring under real situations (Clijmans et al., 1998).

Dworecki et al. (2005) created a simple model using the concentrated mass method that only took into account the vibration generated by the tractor wheels and dismissed all other internal sources of vibrations. The geometry and mechanical parameters such as masses, moments of inertia, springs stiffness, and damping constants of the systems were considered.

The frequencies obtained were 3.82 and 4.47 Hz, for pitch and roll vibration respectively. For vertical vibration, the frequencies were 3.16 and 3.22 Hz in the lateral and front planes respectively. These results were compared with experimental modal analysis performed on the same tractor where the frequencies were 3.86, 4.61, and 2.39 Hz for pitch, roll, and yaw respectively (Dworecki et al., 2005). They corresponded to lateral, longitudinal, and vertical vibrations. The results from the calculated and measured vibration were very similar for the pitch and roll vibrations; and relatively close for the vertical vibrations. This demonstrated that this analytical method for estimating tractor vibration through tractor moments of inertia is accurate.

Clijmans et al. (1998) applied an experimental modal analysis to investigate the vibration of an agricultural tractor. They calculated the FRFs on the tractor induced by random disturbance forces. They used an International tractor 845 which was excited using a vertical hydraulic shaker placed under a rear tire while the others three tires were flatted down to lower the tire stiffness (Clijmans et al., 1998). The responses to input excitations at the left rear wheel were measured in three directions at 35 locations of the tractor, including the body, the frame, the cab, the axles, the engine hood, and the exhaust pipe.

Ten distinct peaks between 0 and 20 Hz were found when these authors summed FRFs, each corresponding to a resonance frequency and mode shape (Clijmans et al., 1998). Table 2.1 shows the vibration frequency and mode participation in 10 points of agricultural International 845 tractor.

Table 2.1. Resonant Frequency of tractor and effect of structural modifications on resonance. (Clijmans et al., 1998).

Mode No.	Frequency (Hz)	Mode Participation (%)	Predicted Frequency after Adding Mass of 50 kg in Points “track:25” and “track:35” (Hz)	Predicted Frequency after Placing a Truss between “trak:20-24” and “trak:9-2” (Hz)	Description
1	2.68	21.0	2.62	2.43	Rigid body
2	3.06	20.2	3.04	3.13	Yawing
3	4.27	6.5	4.17	4.22	Pitching
4	5.05	3.8	5.05	6.57	Roll
5	6.82	4.3	6.80	Mode disappears	Cab (local)
6	9.64	17.9	9.59	Mode disappears	Cab and engine hood (local)
7	13.27	4.0	13.27	12.97	
8	14.70	3.0	14.70	15.00	
9	17.45	11.7	17.45	17.60	Engine hood (local)
10	19.09	7.6	19.09	19.17	Engine hood and exhaust pipe (local)

Balasubramanian et al., (2006) developed data acquisition and hardware systems for acquiring shock and vibration data in the three directions: lateral, longitudinal, and vertical. They were tested on two points of an agricultural tractor: the rear axle and operator seat. In addition they constructed a prototype obstacle course consisting on both repetitious and shock events.

The obstacle course was constructed with slats and earthen berms in two separate vibration tracks with different values of spacing among slats and earthen berms. The value of spacing in the track 1 was 61 cm while the track 2 was 46 cm. In addition, the earthen berms were constructed varying in spacing and height (Balasubramanian et al., 2006).

Several tests were performed in dissimilar conditions such as stationary tractor, and traveling on asphalt pavement as well as on the two tracks built. Three different speeds were used on these tracks 1.6, 4.8, and 6.4 km/h. The results showed that the vibration data for the stationary tractor, as well as the tractor traveling on asphalt pavement, were similar in frequency with increasing acceleration magnitudes. It was also noted that magnitudes increased with tractor speed.

In the field test, there were two significant results. The tractor vibrations magnitudes rose at low frequencies with increments of speed and obstacles. For example, when the tractor drove over track 2, which had 46 cm spacing, the acceleration magnitude in frequency below 20 Hz was increased. This was due to the interaction of tire lugs with the slats creating a significant resonance (Balasubramanian et al., 2006).

Although this study was performed on two points of the tractor it still is very useful because the authors demonstrated that both the speed and rough terrain increase considerably the vibration on an agricultural tractor. Furthermore, both the speed and rough terrain increased the acceleration magnitude in frequencies between 0 and 20 Hz.

Other interesting research was performed by Barcelo and Hilbert (2004). This study proved the influence of speed and tire pressure in the vibration of agricultural tractors. They explained that the correct tire pressure reduced the vertical vibration on agriculture tractors between 130 to 180 times. They also confirmed that the increment of speed increases the vertical vibration.

The determination of tractor vibration is difficult because this parameter is affected randomly by many factors such as speed, terrain, and rigidity of tires. Regardless of the approach used, analytical or experimental, most tractor vibration studies have been done to determine the frequency and magnitude of the vibrations that affect drivers. Accordingly, these studies have estimated the tractor vibrations on few points around the tractor's center of mass and driver seat. Several studies conclude that roll, pitch, and yaw tractor vibrations are less than 5 Hz about its center of mass.

However, the study performed by Clijmans et al. (1998) has been the most comprehensive because it measured tractor vibrations in three directions at 35 points. They found 10 distinct peaks between 0 and 20 Hz and their percent of participation mode. This study coincides with the trend found by Balasubramanian et al. (2006) where most critical vibrations found at speeds over 4 km/h were between 0 and 20 Hz along the three primary axes. Both studies are used as references for this thesis.

2.6. Stabilization Systems for Vibration Limitation

Mechanical vibrations present on agricultural vehicles can greatly affect the accuracy of sensors mounted on these vehicles. For that reason, SS are a good and workable solution to reduce the transmission of vibrations between the vehicle and the sensors. Lee and Ehsani (2008) state that laser measurements have noise when the vehicle is traveling on uneven ground or high speed. Doerr (2009) expected and noted that tractor vibrations affected the LMS when he conducted several field tests. He therefore recommended the installation of a stabilization system for the LMS to reduce the amplitude of any vibrations, as well as keeping the pitch and roll of the LMS as constant as possible (Doerr, 2009).

The SS is defined as a resonant device or equipment that suppresses or absorbs vibrations. They have a wide range of applications; basically they can be used in any application affected by vibrations. SS compounded by one or more isolators work as damping elements, increasing the damping coefficient and consequently decreasing the acceleration magnitude. When they are designed and installed correctly on an element, such as machine or structure, they dissipate the vibration energy internally, reducing the motion of the element. Although SS are extensively used especially in defence, aviation, marine, and measurement equipment, they usually are expensive because some are custom designed.

Chapter 3. Materials and Methods

3.1. Equipment

3.1.1. Laser Measurement System (LMS) Sensor

The same LMS sensor used by Doerr (2009), the LMS 291-S14, was used in this project. This sensor is manufactured by the German company SICK, which is one of the world's leading producers of sensors and sensor solutions. A picture of the SICK LMS 291-S14 is presented in figure 3.1.

Figure 3.1: SICK LMS 291-S14 scanner.

3.1.1.1. Laser Measurement System Applications

The LMS 291-S14 is a non-contact measurement system that belongs to the family of LMS2xx. They are mainly used for area monitoring, determining position, object measurement, and object detection. They scan their surroundings in a two dimensional manner with a radial field of vision using infra-red laser beams (Sensor Intelligence, 2006).

This family of LMS sensors has been used with a high level of success in other studies relevant to the development of autonomous agriculture vehicles, especially for object detection. For example, the SICK LMS 200 was used by Subramanian and Burks (2005, 2006). They have also been used by several of the top performing vehicles in the DARPA Grand Challenge (Doerr, 2009).

3.1.1.2. Laser Measurement System Operation Principle

The LMS operates according to the time of flight principle which measures the elapsed time between the emission and the reception of light pulses. A light pulse emitted for a defined length of time is reflected off a target object and is received via the same path along which it was sent (Sensor Intelligence, 2006). The time between transmission and detection is directly proportional to the distance between the LMS sensor and the object (Sensor Intelligence, 2006). The contour of objects found is determined by the measurement data received which can be processed in real time or stored for posterior evaluation. The data are expressed in polar coordinates from the initial angle.

3.1.1.3. Features of the LMS 291-S14

The LMS 291-S14 was set up with a scanning angle of 90º and an angular resolution of 0.5º. This means that a light impulse (spot) is emitted every 0.5º from the initial to the final value which results in 181 values returned by scan. The direction of transitions is counter-clockwise and the range used is up to 8.183 m. Based on the angular resolution and the range used, the spot spacing or spot diameter is 0.075 m. Figure 3.2 shows the representation of scanning angles, lights impulse, spot spacing, and range used by the SICK LMS 291-S14. Other significant characteristic are: frequency or response time of 75 Hz

(13.3 ms), resolution 0.01 m, and typical measurement accuracy of 0.035 m (Sensor Intelligence, 2006).

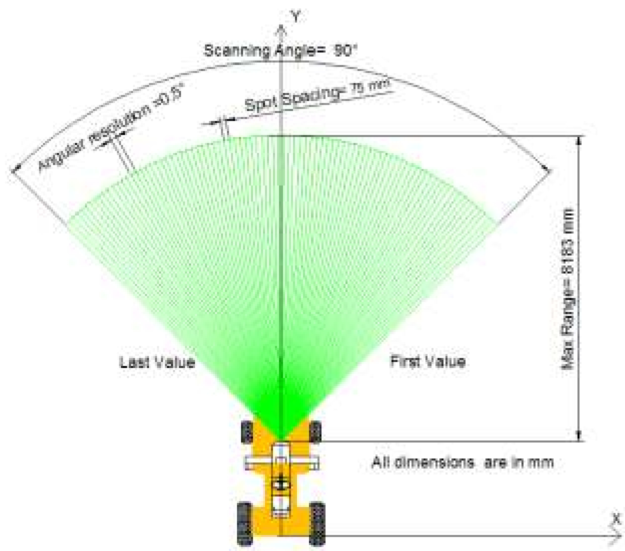


Figure 3.2: Scanning angles, light impulse, spot spacing, and range used by SICK LMS 291-S14 scanner.

This specific model of LMS was designed with completely weatherproof outdoor housing. Additionally, it can be operated under rain and snow with the ability to correct the data accordingly. Other important advantages are: (i) rapid scanning times, thus detected objects can move at high speed; (ii) background and surroundings have little influence on measurements; (iii) no illumination is required; and (iv) no special target-object reflective properties are necessary (Sensor Intelligence, 2006).

3.1.1.4. Electrical Installation of the LMS Sensor

The LMS 291-S14 requires an operating voltage of 24V±15% and a power consumption of less than 20W (Sensor Intelligence, 2006). Due to the fact that the Kubota tractor used in our study had a 12V battery, a SD-50A-24 converter was installed to supply

24V to the LMS sensor. The power was drawn from the ignition switch of the tractor with the addition of an in-line 10 A fuse holder.

The output cable from the LMS sensor has six wires. The positive wire (red) was connected to the positive output port of the converter while the negative wire (brown) was connected to the negative output port of the converter. The other wires from the LMS sensor were not used. Figure 3.3 shows the electric set-ups of SICK LMS 291-S14, the power converter SD-50A-24, and the Kubota B6200 tractor.

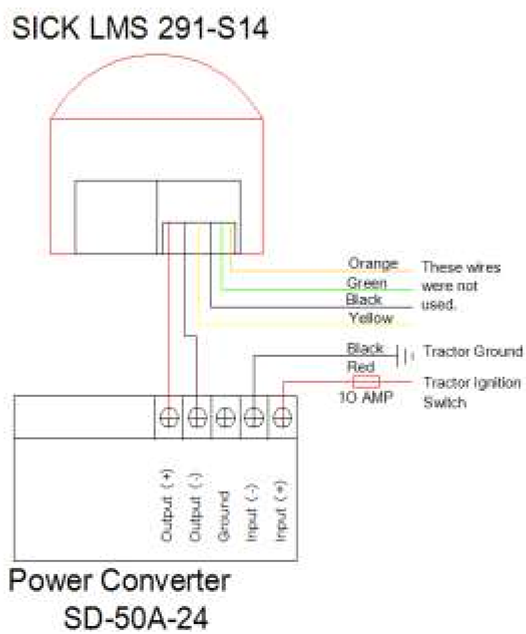


Figure 3.3: Electric set-ups of LMS sensor, power converter, and Kubota B6200 tractor.

3.1.1.5. Data Interface Installation of the LMS Sensor

The LMS 291-S14 came from the factory with a RS-232 connection. However, it had been converted to a RS-422 by Doerr (2009) for a previous study with the objective of increasing baud rates. Figure 3.4 shows the RS-232 and RS-422 serial configuration.

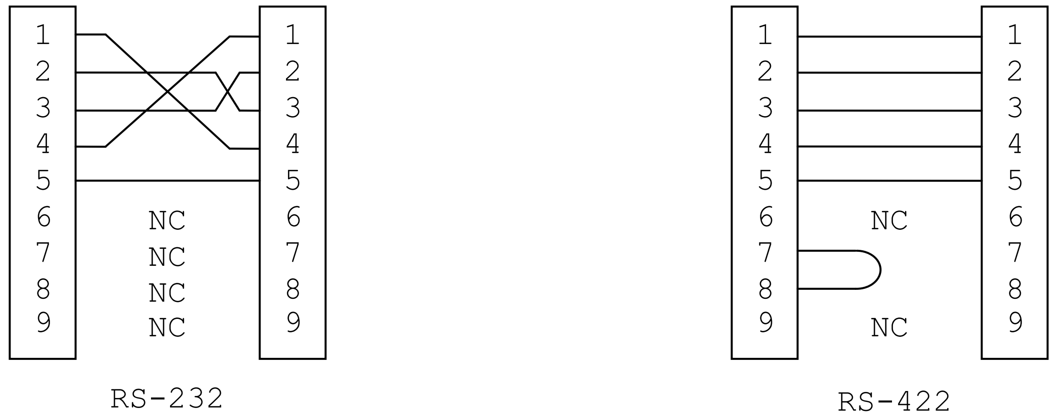


Figure 3.4: RS-232 and RS-422 serial configuration (Doerr, 2009).

3.1.2. Tractor

The agricultural vehicle used for this research was a Kubota B6200 2-wheel drive tractor, seen in Figure 3.5, graciously provided by Agriculture and Agri-Food Canada. It has a 3 cylinder Kubota Diesel Engine that produces 11.03 kW and the tractor has a mass of 500 kg.

Figure 3.5: Tractor Kubota B6200 with SICK LMS 291-S14 scanner.

3.1.2.1. Tractor Speed

Because the speedometer of the tractor was not reliable; the speed was calibrated at various engine speeds and transmission gear ratios. Time was measured on three occasions at each gear with maximum (2500 rpm) and minimum engine speed (1000 rpm) on a 20 m grass track. Later, the average of time values was used to calculate speed. The results are shown in Table 3.1.

Table 3.1 Tractor speeds at each gear with maximum and minimum acceleration.

No of test set	Gear used	Engine speed [rpm]	Time [s]			Average Time [s]	Speeds [km/h]
			Trial 1	**Trial 2**	**Trial 3**		
1	1	2500	15.35	15.80	15.35	15.50	4.65
2	1	1000	41.00	40.00	40.55	40.52	1.78
3	2	2500	10.00	9.75	9.90	9.88	7.29
4	2	1000	26.10	25.10	26.10	25.76	2.80
5	3	2500	5.90	5.60	6.40	5.97	12.06
6	3	1000	15.40	16.15	15.55	15.70	4.69

We consulted the typical operating speeds for agricultural vehicles. Typical operating speeds for agricultural vehicles are between 4 and 11 km/h depending on the operation itself, the vehicle used, as well as the specific field conditions. For example, the average operating speed for tillage and planting is 9.3 km/h, while the average operating speed for harvesting is 7.0 km/h. The overall average speed is 8.3 km/h. Table A-1 in Appendix A presents typical operating speeds for various agricultural vehicles and field operations.

Relevant to the tractor used in this study, speeds over 7.29 km/h are unsafe for performing agriculture tasks. We chose three different speeds from the table 3.1 to perform the field tests: 1.78, 4.65, and 7.29 km/h. These speed values can be classified as slow, medium, and average speed for agricultural vehicles.

3.1.2.2. Tractor Tires

Since tires are the only components that provide suspension in agricultural tractors, tire pressure was checked. Pressure of both the front and rear tires was adjusted to the optimum values of 103kPa and 151kPa respectively, following manufacturer's recommendation. This mainly ensured that the magnitude of vertical acceleration was minimized.

3.1.2.3. Mounting System

Our initial intent was to install the LMS sensor near the center of gravity of the tractor to minimize the effect of vibrations on the LMS sensor. For this reason, several possible locations for the LMS sensor near the center of gravity of the tractor were considered. However, only a few of them were practical due to the limited space available in the tractor and the limited possibilities for fastening the structure of LMS sensor to the tractor.

The best option was to set the structure of the LMS sensor at the end of the tractor frame, close to the coupling of the chassis with the gearbox of the tractor. To make this possible, it was necessary to use the screw hole on the tractor frame designed to hold the tractor engine. One of the existing screws was removed and measured: it was M10x1.25 fine thread, with a length of 25 mm. Thus, we obtained four screws M10x1.25 fine thread with length of 35 mm that would bolt brackets to the tractor frame.

We designed the structure that would hold the LMS sensor on top of the tractor engine hood in such a way so that adequate visibility of the field by the operator would not be affected while driving the tractor. The structure was composed of two brackets, two vertical bars, and a horizontal bar. Figure 3.6 shows the assembly of the structure for LMS sensor. Appendix D shows detailed drawings of parts of the structure of the LMS sensor.

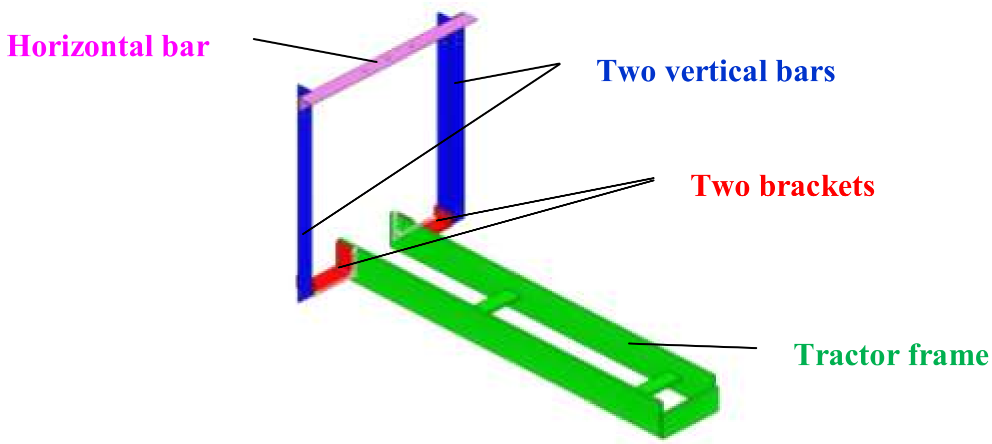


Figure 3.6: Assembly of structure for LMS sensor.

The brackets were sufficiently wide so as to not affect the operation of the steering linkages and pedals of the tractor. Equally, the two vertical bars were placed so as not to interfere with any other components of the tractor. The brackets were bolted to both sides of the chassis using the four M10x1.25x35 bolts, seen in figure 3.7(a) and (b). The two vertical bars were bolted to the brackets and the horizontal bar was bolted to the two vertical bars.

(a) (b)

Figure 3.7: Brackets bolted to the tractor chassis: (a) left side and (b) right side.

This mounting system allowed placement of the LMS sensor to move in a vertical direction from the center of gravity of the tractor, as well as from the chassis where the frequencies of vibrations are about 3 Hz, according to the research performed by Clijmans et al. (1998) (Table 2.1). This suggests that the frequencies of the vibrations that affect the LMS sensor increased up to the levels of the engine hood and the exhaust pipe. These levels are from 9 to 20 Hz according to Table 2.1.

Since the sensor is located above the hood of the tractor away from the center of gravity and because we noticed an increase in longitudinal vibrations, it was decided to add two brackets and two support bars (S) to the structure which were bolted to the front side of the chassis (Figure 3.8). This further lead to the idea of performing the tests with and without the support bars to quantify their influence on the accuracy of the measurements provided by the LMS sensor. Appendix D shows drawings of parts of the structure of LMS sensor.

(a) (b)

Figure 3.8: LMS sensor structure: (a) without support bars and (b) with support bars.

3.1.3. Objects

Four objects were used to detect their positions under different experimental conditions. With the intention of achieving more detailed and comprehensive results, the four objects were chosen with dissimilar shape, height, materials, and color. The first was a short square shaped box which was labelled “Box”. It was 0.601 m wide by 0.781 m tall. The second object was a tall square shaped post which was 0.0889 m wide by 1.829 m tall. It was labelled “SP”. The third was a cylindrical shaped tank. It was labelled “Tank” and its dimensions were 0.571 m in diameter by 0.940 m tall. The fourth object was a tall rectangular shaped post with a section of 0.108m by 0.038.1m and a height of 1.486m. It was labelled “RP”. The material and color of objects were selected according with the typical material reflectivity that appears in the Sensor Intelligence manual (Table A- 2, Appendix A). The Box was made of raw pine and the RP was made of wood. Both materials have a coefficient of reflectivity of 40%. The Tank was made of PVC but it was wrapped with aluminum paper thus its reflectivity was around 150%. The SP was made of wood but it was painted in white so its reflectivity was around 80%. Figures 3.9 and 3.10 show the dimensions and materials of the four objects respectively.

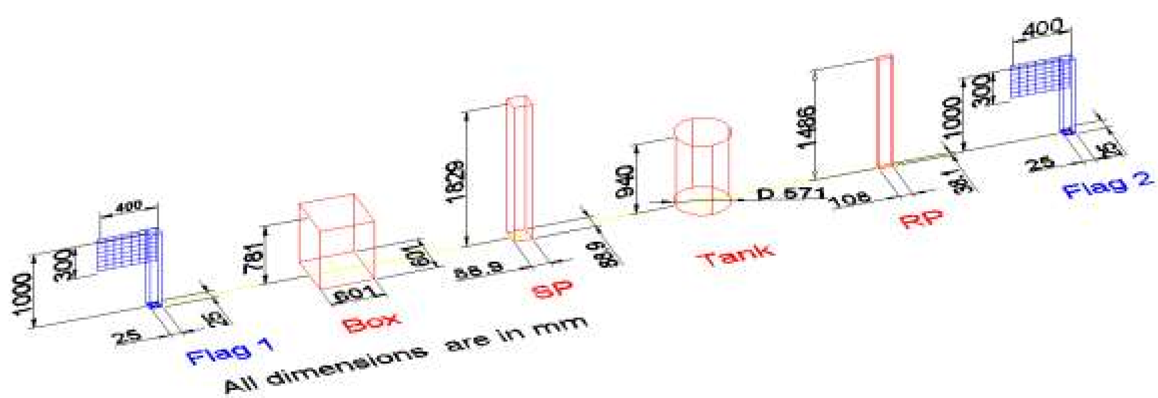


Figure 3.9: Dimensions of four objects and two flags.

Figure 3.10: Position of objects and flags on the smooth track.

The reflectivity of the objects has a significant effect on the ability of the LMS sensor to return a data point at distances greater than 10 m (Doerr, 2009). Since the maximum scanner range was 8.183 m; the reflectivity of the objects was not expected to have a significant effect on the results.

Two reference flags were placed at beginning and end of the tracks. They were used as reference points (RP) to represent the theoretical and real objects' location on the maps. Additionally, these flags allowed for measuring distance deviations produced by vibrations. Figure 3.9 shows the dimension of the flags.

Test tracks were set at 20 m, thus the four objects were placed every 4 m. The first flag was placed at 0 m, followed by the Box, the SP, the Tank, and the RP which were placed at 4, 8, 12, and 16 m respectively. Finally, the second flag was placed at 20 m. Figure 3.10 shows the position of objects and flags on the smooth track.

A 20 m rope was installed between the two flags. It was marked every 4 m and it ensured that all objects and flags were kept in the same relative positions along the track when the objects were moved to different types of terrain. Additionally, having the markings saved time at the beginning of every work day and whenever the set up needed to be changed. Figure 3.11 shows a map of the model track with the cord between flags and the position and dimensions of objects.

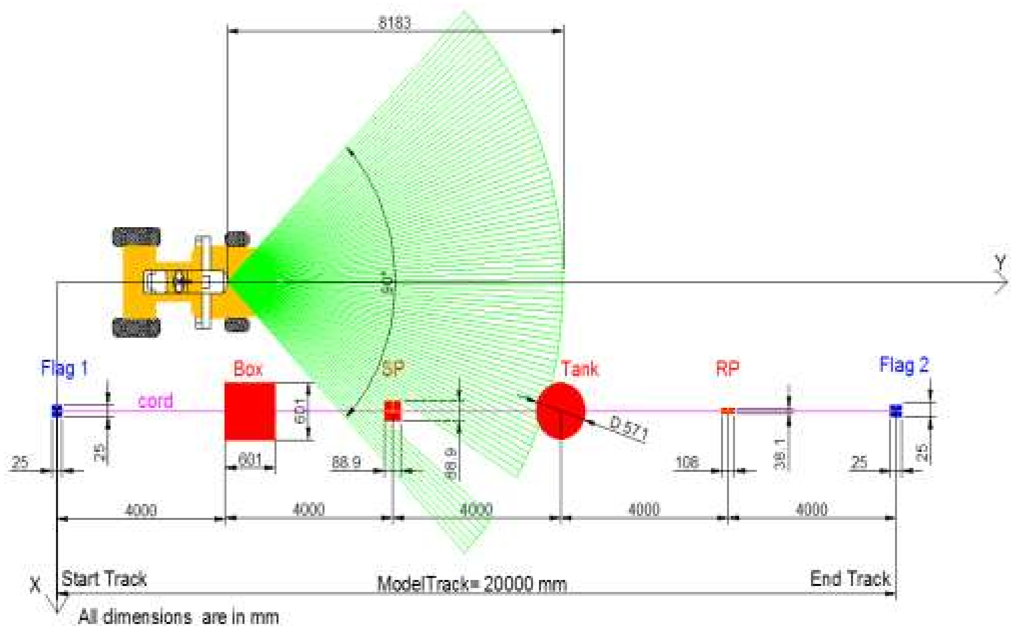


Figure 3.11: Map of the model track with the position and dimensions of objects.

3.1.4. Stabilization System (SS)

There are several ways to eliminate or reduce unwanted vibrations. First of all, we need to identify the sources that produce vibrations. As mentioned earlier, tractor vibrations change randomly with time and operations along the three axes. These vibrations and unwanted shocks are generated mainly due to soil roughness, driving speed, and rotating elements within the vehicles (Balasubramanian, 2006). In addition, the rigidity of tires plays an important role since tractors are not equipped with suspension systems (Clijmans et al., 1998).

The more efect ways to reduce unwanted vibrations are to eliminate the sources that produce them, or to redesign the system. Generally, the vibration sources are very difficult to eliminate and thus this is left to the hands of tractors' designers and agricultural engineers (Palm III, 2007). Accordingly, our decision was to redesign the system using a SS.

3.1.4.1. Design of Stabilization System

There are a number of techniques appropriate to redesign a system affected by vibrations. Among the most used are: changing the natural frequency of the system, dissipating the energy of vibration by adding a damping to the system, isolating the sources that generate vibrations to the system, using a vibration absorber, and using an active control in the system (Palm III, 2007).

Most of these techniques are useful for situations in which the vibrations are known and have a constant frequency (Palm III, 2007). In cases where the vibrations' frequencies are not constant, and/or vibrations are not harmonic, and/or vibrations are random, it is recommended to isolate the sources that generate vibrations to the system (Palm III, 2007). Since tractor vibrations are not constant, not harmonic, and random, it was necessary to reduce the vibrations by isolating their sources with an SS.

None of SS available in the market conformed to the existing requirements to reduce vibrations from the tractor to LMS sensor. SS are usually designed for specific and tailored applications. Thus, we decided to design an SS using a commercial isolator to reduce the vibration between the tractor and LMS sensor.

Basically, isolators consist of a mount and an elastic material, which usually has low Young's modulus and high strain capability (Palm III, 2007). Most isolators are made of rubber or elastomer, and their values of damping and stiffness are used to create typical curves such as transmissibility versus frequency and/or load versus deflection. These curves are generally supplied by the vendors and used as criteria to select these elements.

Since there is a wide range of isolators available in the market, we considered the most important parameters to select the isolators to design the SS. First, the frequency range must be isolated between the tractor and LMS sensor. As was mentioned in section 2.5, several studies report that the critical range of frequency that mostly affect agricultural tractors is from 0 to 20 Hz. However, in our tractor, where the LMS sensor is located close to the hood and exhaust pipe, (Figure 3.8(a) and (b)) the vibration frequency levels in the LMS sensor should be approximately the same as the frequency levels of these elements. As shown in table 2.1, the range of vibrations in the hood and exhaust pipe is from 9 to 20 Hz.

Second, it was estimated that the total load to be isolated was around 8 kg, since the LMS sensor weighs 4.5 kg and the two parallel plates and bolts weigh around 3.5 kg. Third, we considered the geometric design and mounting position of the LMS sensor. Finally, we took into account the environmental and material constraints such as temperature.

With all of these parameters understood, we reviewed dozens of distributors and producers of isolators. Equally, we consulted some specialists from these companies trying to find the isolator that best fitted our needs. We chose the isolator V10Z64-MN03 (seen in Figure 3.12) and supplied by the Advanced Antivibration Components (AAC) Company, a division of Designatronics, Inc. This isolator consists of an ultra soft silicone gel that is bonded with two metal mount. This gel has the following properties: elongation of 800%, Young Modulus 156.2 kPa, and tensile strength relation of 1.0 (Gelmec, 2010). We bought sixteen units for the price of $24.84 USD per unit.

Figure 3.12: Isolator V10Z64-MN03 (Vibrationmounts, 2010).

The V10Z64-MN03 isolator has outstanding vibration and shock absorbing properties. It is able to damp to lower frequencies than traditional rubber or neoprene stud mounts. It is ideal for pump noise control, vibration protection of truck or bus-mounted computers and devices (Gelmec, 2010). The more important characteristics of the V10Z64-MN03 isolator are in the table 3.1 in red letters.

Table 3.1. Characteristics of the V10Z64-MN isolator (Vibrationmounts, 2010).

Catalog Number*	Optimum Load lb./leg (kgf/leg)	Resonance Point [Hz]	Resonance Magnification [dB]	Recommended Frequency [Hz]
V10Z64-MN03	4.4 to 7.7 (2 to 3.5)	12 to 10	12	17 ~
V10Z64-MN05	7.7 to 12.1 (3.5 to 5.5)	11 to 10	14 to 13	16 ~
V10Z64-MN07	12.1 to 18.7 (5.5 to 8.5)	11 to 10	16 to 15	16 ~
V10Z64-MN10	18.7 to 7.6 (8.5 to 12.5)	11 to 10	20 to 18	16 ~

This isolator is not the ideal one to dampen the range of vibrations transmitted from the tractor to the LMS sensor. However, this was the isolator with characteristics that better fitted our requirements, especially its optimum load and resonance magnification. Figure 3.13 shows the frequency response for the V10Z64-MN03 isolator. We can see that for a load of 11 kg divided in 4 isolators, the resonance point is around 11Hz and the resonance magnification is around 12 dB.

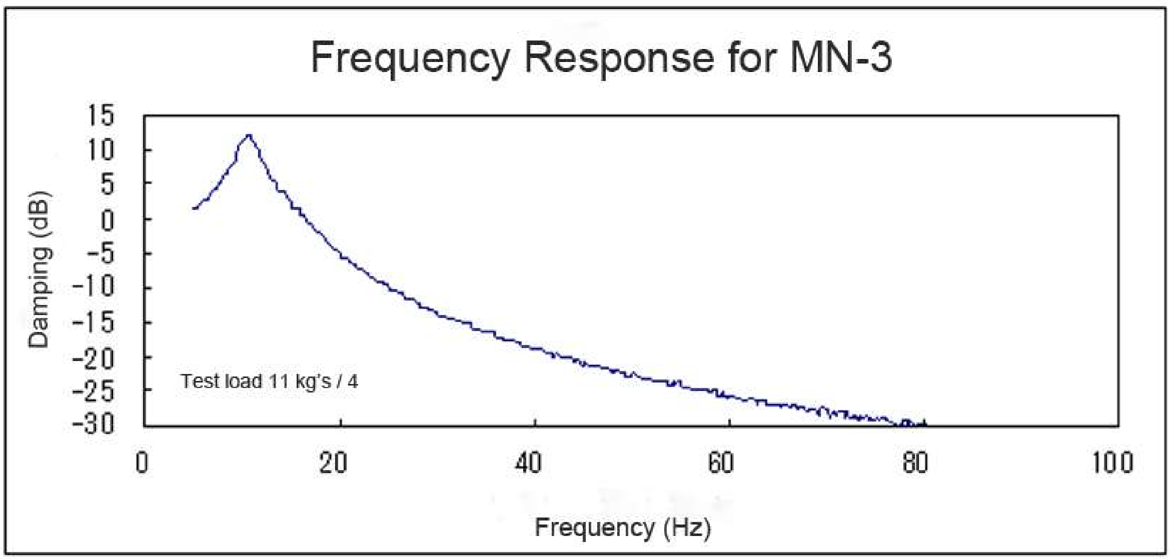


Figure 3.13: Frequency Response for the V10Z64-MN03 isolator (Gelmec, 2010).

The SS was designed taking into account several factors. First of all, the SS must reduce the vibration in the three orthogonal axes. To achieve this we provided the SS with twelve V10Z64-MN03 isolators. Six of them work in the longitudinal axis; four of them work in the vertical axis; and the last two work in the lateral axis. Figure 3.14 illustrates the SS and all its parts. Thus, two parallel lateral plates were attached with two bars and bolted to the LMS sensor. This ensemble was placed on an angle plate separating each other by the twelve isolators. Figure 3.15(a) and (b) illustrate the LMS sensor mounted on the SS.

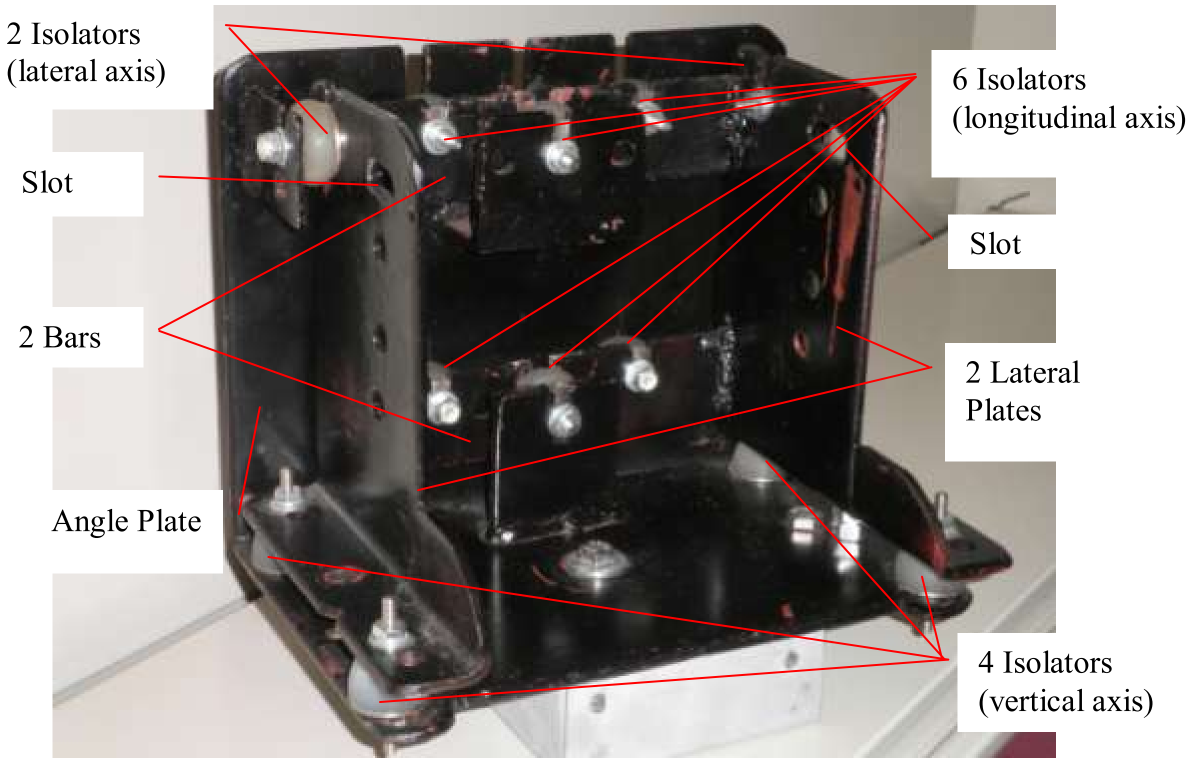


Figure 3.14: Stabilization System.

(a) (b)

Figure 3.15: SS and SICK LMS 291-S14 scanner.

Second, the SS must not obstruct the scanning angle and the rotation of LMS sensor. To achieve this, the parallel lateral plates were designed not to obstruct the front window view of LMS sensor, seen Figure 3.15(a) and (b). In addition, these parallel lateral plates were provided with a slot allowing the sensor to rotate from the horizontal line 0º to 15º down, seen Figure 3.14.

Third, the SS allows shutting off easily the damping elements. To achieve this, we designed the two lateral plates and the angle plate with concentric holes used to insert bolts that disengage the isolators in the three axes. Therefore, these nuts and bolts were adjusted to allow the SS to operate without removing the isolator from it. Figure 3.16 shows the SS with the bolts and nut that allowed disengaging the isolators.

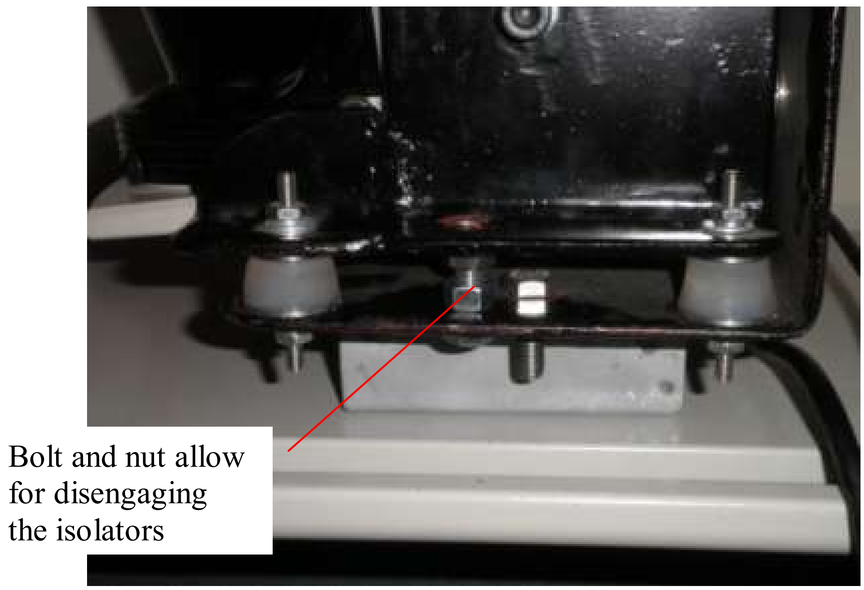


Figure 3.16: Bolts and nuts that allow for disengaging the isolators of SS.

Last, the SS must be easy to install. To achieve this, we designed the angle plate with three holes at the bottom to be able to attach the SS to the structure. Drawing of angle plate is shown in Appendix D.

The total cost of the SS and its structure was around $400 CAD. The amount was mainly due to the cost of the twelve isolators, which amounted to almost $300 CAD. The rest was due to bolts, washers, and nuts to assemble all items together. Other costs were associated to shipping, freight, handling, painting, and drill bits. We built the SS at the

Truck and Trailer S. A. workshop in North Grove, Ontario. This company graciously provided the metal needed for the manufacture of these elements and allowed for the use of their facilities. The drawings with the dimensions of the SS and its structure are included in appendix D.

3.2. Experimental Site

The tests were performed at the Central Experimental Farm, Ottawa, Ontario, from September 27 to October 8, 2010. The terrains used are located around the building number 144, which is situated along the Morningside Lane, on the south east corner of the site. The proximity of terrains with the building 144 allowed fast and comfortable travel between them. Figure 3.17 shows the exact location of building 144.

Figure 3.17: Satellite view of building number 144, tracks field ST, RT, and PT at the Central Experimental Farm, Ottawa, ON (Google, 2011).

3.3. Terrains

Due to constraints of time and resources, the tests were performed in existing fields. The test tracks were set up in three kinds of terrains: smooth, rough, and plowed. They were labelled ‘ST’, ‘RT’, and ‘PT’ respectively. All tests were performed at three different speeds (1.78, 4.65, and 7.29 km/h) and were repeated three times. Figure 3.17 shows the location for ST, RT, and PT field tracks.

For ST we used a plane terrain without irregularities, covered by grass. In this case the field tests were conducted without obstacles influence. For RT we used a field of freshly cut corn. For PT we used a plowed terrain. In the last two cases the tests were carried out transversely to the crop rows or furrows. This allowed for using the mounts of earth or berms as set of obstacles that created shock events of different magnitudes in the tractor. Figure 3.18 shows the three field tracks.

(a) (b) (c)

Figure 3.18: The three field tracks, (a) ST, (b) RT, and (c) PT.

For RT and PT, the berms varied both in spacing and height. In the case of RT, the berms had an average spacing of 0.750 m and average height of 0.05 m. In the case of PT the berms had an average spacing of 0.680 m and average height of 0.20 m. The dimensions of earthen berms for the three different terrains are shown in Figure 3.19.

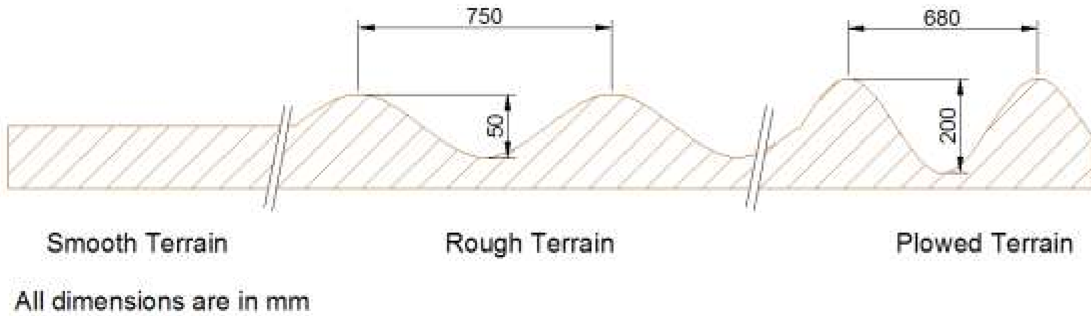


Figure 3.19: The dimensions of earthen berms for the three different terrains.

3.4. Experimental Design

Initially, the total number of setups considered for this research was 36 due to the combinations of parameters analyzed that were: three different speeds (1.78, 4.65, and 7.29 km/h); three different terrains (smooth, rough, and plowed); presence of SS (with and without SS) and presence of support bars (with and without S). Considering three trials for each setup, the total number of trials required was 108. Nevertheless, tests at 7.29 km/h on PT could not be performed since the tractor could not be properly controlled and ended up stuck in the mud. Therefore, the total number of setups performed was 32 and the total number of trials performed was 96.

Labels were assigned to each parameter and so each test would be identified by the combination of labels for parameters used. For example, a test identified as "SSTTS2SS" would mean the following combination: the first "S" for structure with support bars, "ST" for smooth terrain, "TS2" for tractor speed 2 (1.78 Km/h), and "SS" for use of stabilization system. Table 3.3 shows the parameter labelling and total number of setups and trials. For the complete list of tests, refer to appendix A, where the table A-3 shows test labelling according to number of test setup.

Table 3.2. Parameter labelling.

Order of Parameter	***Parameters***	***Type of Parameters (Variables)***	***Labelling***
1	Structure (S)	With S	S
		Without S	NSS
2	Agricultural Terrain	Smooth	ST
		Rough	RT
		Plowed	PT
3	Tractor Speed [Km/h]	1.78	TS2
		4.65	TS4
		7.29	TS7
4	SS	With SS	SS
		Without SS	NSS
Total	*4*	*10*	*10*

3.4.1. Maps Dimensions

Since we had to drive the tractor at the same time as we operated the LMS's software with the laptop computer, it was necessary to ensure an accurate measurement of objects in the field by the LMS sensor. We began to record each test around 10 m before the first flag to allow the LMS sensor, which has a range 8.183 m, to record the first flag from the bottom to the top. Also, we stopped the tractor few meters after arriving at the second flag, at the moment we stopped recording the test, the LMS sensor had scanned at least an additional 8.183 m. As a result, the maps created by the LMS sensor will have a variable length for each test. However, many of the test lengths are approximately 45 m, although the length of the model track for each test was constant at 20 m. The width of the maps created by the LMS sensor is 11.5 m and consistent with the greatest width of scanning angle. The tractor in all tests was driven to a lateral distance of one meter from the central axis of the tractor to the cord representing the central axis of the object. Figure 3.20 shows a top view of the model map created by LMS sensor. This figure shows the scanning range at the beginning and end of a test.

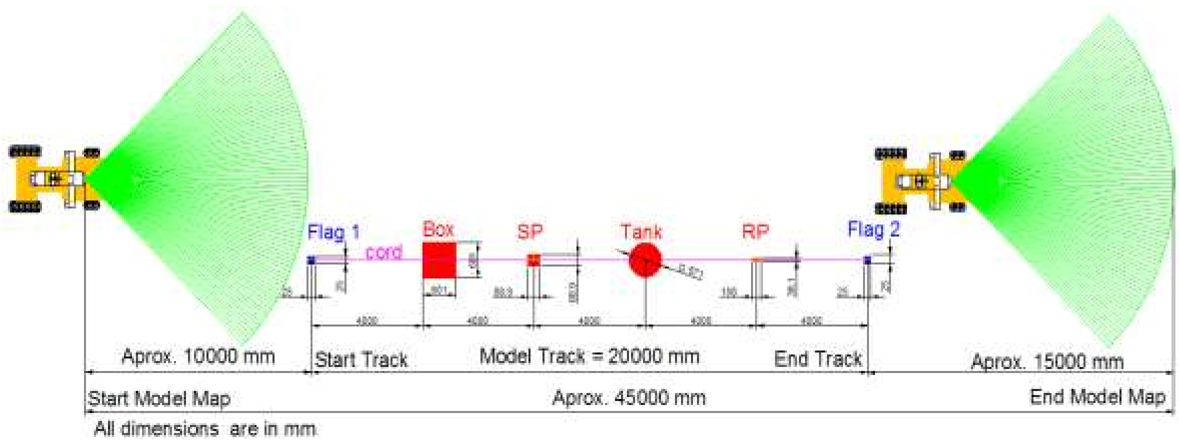


Figure 3.20: Top view of the model map created by LMS sensor.

3.5. Methodology

In this work it was necessary to find a methodology to represent the range of data provided by the LMS sensor as reliable maps. In addition, we needed to represent the known location of the objects on these maps. Then, we would be able to determine the effectiveness of LMS sensor measurement which is affected by the vibrations of the tractor.

3.5.1. Data Acquisition

The tests were performed as indicated in the previous section. In each test the LMS sensor sensed its surrounding in accordance to the time of flight light pulses. The information obtained by the LMS sensor was sent, through the software, to the computer where it was stored for posterior evaluation.

The software used was a MST demo program provided by SICK. This program records the range data directly from the LMS sensor and converts the data into text files. The first and third lines in the file are informative, which describe the structure of the file. The first line describes the information of the second line, where the file name and sensor parameters, such as start angle, stop angle, resolution, and scan step width appear. Additionally, this line specifies export channel, date, and time when the file was created.

The third line describes the information of the subsequent lines; where record number, scan index, telegram index, and interlaced scan number appear. The values of measurements provided by the LMS sensor begin at column five, separated by a semicolon. These values correspond to the distance in mm at which each light impulse was emitted by the LMS sensor and reflected by any surface, which are organized in rows and columns.

Each row corresponds to a scan number of the LMS sensor, thus the file will have as many rows as the number of scans done by the sensor. Each column corresponds to the angle value for each measurement which increases by the angular resolution. Since the angular resolution and the scanning angles are 0.5° and 90º respectively, the number of intervals is 180 and the number of columns for each scan is 181. Figure 3.21 shows a text file example of the data recorded using the MST demo program. This figure contains the first six lines of a text file where the range of data measured by the LMS sensor are shown in red.

```
Filename;StartAngle[°];StopAngle[°];Resolution[°*100];ScanStepWidth;ExportChannelNumber;Date[mm/dd/yyyy];Time[hh:mm:ss]
Sstts2ss.dat;45;135;50;1;0;10/08/2010;10:28:10
Record Number;Scan Index;Telegram Index;Interlaced Scan Number;Begin Data
1;0;0;0;8183;8183;8183;7839;7775;7715;7633;7593;7539;7478;7388;6311;6441;6281;6143;6011;5838;5688;5630;…........;8183;8183
2;0;0;0;8183;8183;8183;7832;7779;7705;7645;7597;7535;7468;7390;6318;6438;6295;6133;6012;5845;5699;5631;…........;8183;8183
3;0;0;0;8183;8183;8183;7827;7766;7711;7631;7584;7533;7479;7386;6753;6439;6296;6127;6014;5846;5697;5631;…........;8183;8183
```

Figure 3.21: Text file example of the data

3.5.2. Methods.

Several methods from the mobile robot and computer vision were reviewed. However, only a few of them were used to transform these ranges of data step-by-step in maps. These methods were occupancy grid, raster scan, labelling, average height, and image processing.

3.5.2.1. Occupancy Grid.

The occupancy grid method divides the matrix in a set of cells which have the probability to be either occupied or empty. The occupancy matrix is made up of 1's when the cell is occupied or 0's when the cell is empty (Doerr, 2009). The location of these numbers in the matrix occurs in accordance with their position into the data range, which in turn corresponds to the position of the objects in the field. The size of the rows and columns can be varied according to the parameters analyzed. Figure 3.22 shows an example of occupancy matrix.

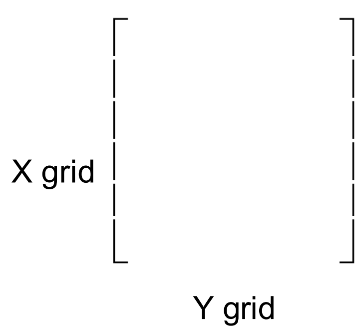


Figure 3.22: Occupancy Matrix (Doerr, 2009).

3.5.2.2. Raster Scan.

The raster scan method scans the occupancy matrix from left to right and from top to bottom, starting at cell [1,1] and ending at cell [n, n]. This method attempts to find occupied cells in the matrix, made up of 1's (Doerr, 2009). These occupied cells are converted into images where each occupied cell represents a pixel for processing in a computer system.

3.5.2.3. Labelling

The connected-component labelling, or Labelling method, is used to detect connected pixels according with their edges. It converts regions into binary digital images. The application of this simple algorithm requires two raster scans, from left to right and top to bottom, to check the connectivity of each occupied pixel (Doerr, 2009). The connectivity of a pixel with coordinates (r,c) can be 4-connectivity or 8-connectivity, seen in Figure 3.23. The 4-connectivity is carried out by checking its adjacent four pixels, those with image coordinates (r-1,c), (r+1,c), (r,c+1), and (r,c-1). While the 8-connectivity checks these pixels and also introduces the (r-1,c-1), (r-1,c+1), (r+1,c-1), and (r+1,c+1) pixels. The algorithm continues creating the group size of each connected component. It calculates new regions by replacing the cell values of each component with the size of the component itself (Doerr, 2009).

Figure 3.23 (a): 4-Connectivity, (b): 8-Connectivity (Doerr, 2009).

3.5.2.4. Average Height

In the research conducted by Doerr (2009), where he evaluated the effectiveness of various methods to detect objects in standing crops, the average height method had the greatest success. The results showed that this method had a success rate of 72.4%. For this reason, this method was used in this project. Average height is a method that determinates the height of a point (Z) with Cartesian coordinates (X, Y). Determination of Z point is made possible by combining Cartesian coordinates of the point with height and angle of the LMS sensor.

(3.1)

Z_{pts} = calculated height of the point

Y_{pts} = Y Cartesian point from the range data value provided by the LMS sensor

theta = angle of the LMS sensor from the horizontal line

H = measured height of the LMS sensor

Using the height values or Z points for each scan, an occupancy grid matrix is created which corresponds to an occupancy matrix [X, Y]. The Z value for each scan is superimposed on an overall matrix, named map matrix, where each scan is overlapped by one column. The cell size is equal to relation between the velocity and frequency of the LMS sensor. Then each occupancy matrix created per scan adds a new column to the map matrix. All new columns that overlap with previous columns are averaged for a new cell value, corresponding to an average calculated height (Doerr, 2009).

Figure 3.24 shows an example of how to create and increase the size of the map matrix with two scans (Sn from 1 to 2). S1 and S2 are superimposed on an overall map of ten columns. Each scan has nine columns. Since these scans are out of phase by one column, it is necessary to average the overlapping columns of the scans S1 and S2. Then the columns from two to nine of the S1 and the columns from one to eight of S2 are averaged. Column one of the S1 does not add new information to the map, and column nine of S2 adds new information to the map therefore they do not need to be averaged (Doerr, 2009).

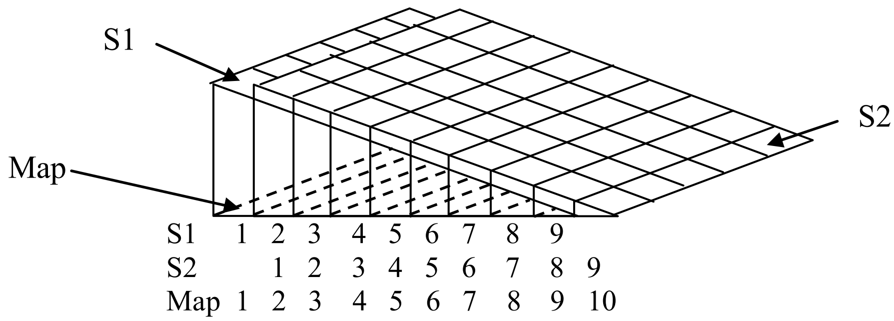


Figure 3.24: Map with two scans, S1 and S2.

3.5.2.5. Images Processing

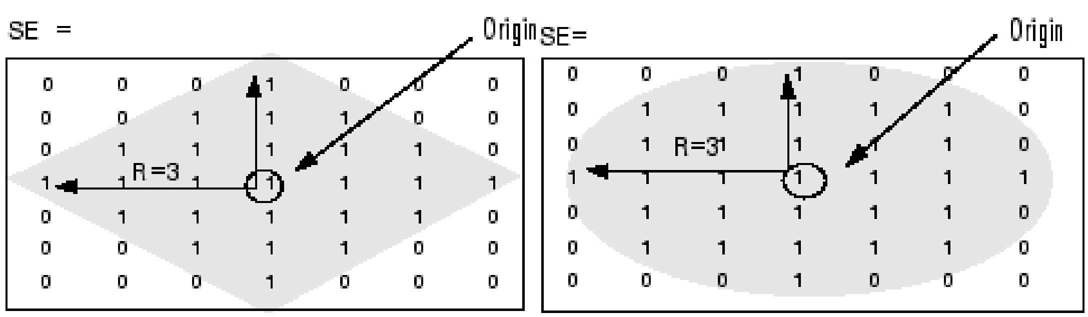
Images processing is defined as a set of computational techniques for analyzing, enhancing, compressing, and reconstructing images (Matlab, 2011). These techniques are based in mathematical operations that are applied to the data and are applied to an image captured through a devise. Later the image is imported, analysed, and manipulated using various specialized software applications. Image processing has extensive applications in many areas, including robotics and machine vision (Matlab, 2011).

3.5.2.5.1 Morphological Operations

Morphological operations are theoretical approaches to image analysis, based on shape. These operations consist in understanding the structure or form of an image through a point and its neighbourhood. It means identifying objects or boundaries within an image. Morphological operations are commonly applied in machine vision and automatic object detection (Burdick, 1997). The basic morphological functions are dilatation and erosion.

These names explain their purpose: dilatation increases the image, and erosion reduces it. Although morphological operations are usually performed on binary images where the pixel values are either 0 or 1, they can also be applied to greyscale images (Burdick, 1997).

In Matlab, morphological operations apply a structuring element to an input image, creating an output image of the same size (Matlab, 2011). In a morphological operation, the value of each pixel in the output image is based on a comparison of the corresponding pixel in the input image with its neighbours (Matlab, 2011). The morphological functions choose the size and shape of the neighbourhood. It means that the functions operate on n x m pixel neighbourhoods accordingly with the arbitrary shape chosen (e. g. box, rectangle, disk, and diamond). The pixel of interest or origin lies at the center of the neighbourhood and is labelled R while the surrounding pixels are referred to as Xn (from X_0 to X_7). The pixel R can be 4-connectivity or 8-connectivity connected with the Xn pixels. Figure 3.25(a) illustrates a diamond-shaped structuring element. In this figure the pixel of interest or origin is being processed, and the diamond-shaped with radio of 3, containing 1's define the neighbourhood of the structuring element (Matlab, 2011). Figure 3.25(b) illustrates a disk-shaped structuring element with radius of 3.



(a) (b)

Figure 3.25: Structuring elements (a) Diamond and (b) Disk (Matlab, 2011).

3.5.3. Application of Methods

Within the context of this project, these methods were applied and combined to take advantage of their characteristics. Several applications were created with objectives of reproduction, representation, and calculation of positions and shape of the objects.

Matlab was used as the platform of these applications because it is one of the most widely used tools in the engineering field nowadays. This software has the ability to perform complex numerical computation with hundreds of built-in functions. In addition, this software has the resources of simulation and visualization.

Using Matlab, we processed, calculated, and represented the data files sent by the LMS sensor in maps. First of all, we created an n by m matrix with the range of data provided by the LMS sensor, seen in Figure 3.21 in red letters. To achieve this, we eliminated the first three lines and the first four columns of the following lines that are separated by semi-colons. The subsequent data, which are the values of measurement provided by the LMS sensor, were converted into the n by m matrices. In this matrix, n represents the number of scans performed by the sensor, while m represents the number of columns for each scan. This matrix was in polar points that later was converted into a matrix [X, Y] with Cartesian points.

Each light impulse emitted by the LMS sensor travels until it is reflected by any surface. If a light impulse does not find any object it is reflected by the ground, which introduces noise to the measurements. To eliminate these noises the n by m matrix was screened. First, all values equal to the maximum range 8.183 m were eliminated because they mean that the light impulses emitted by the LMS sensor were reflected by the ground. Second we eliminated the noise introduced by weeds and land slopes using a vertical threshold between 0.150 to 0.310 m according to the terrain used. The values of threshold were seleted according to maximum height of the earthen berms in the different types of terrains plus the height of the weeds. Figure 3.26 shows light impulse emitted by the LMS sensor flights until it is reflected either by weeds or land slopes before light impulse gets the Box.

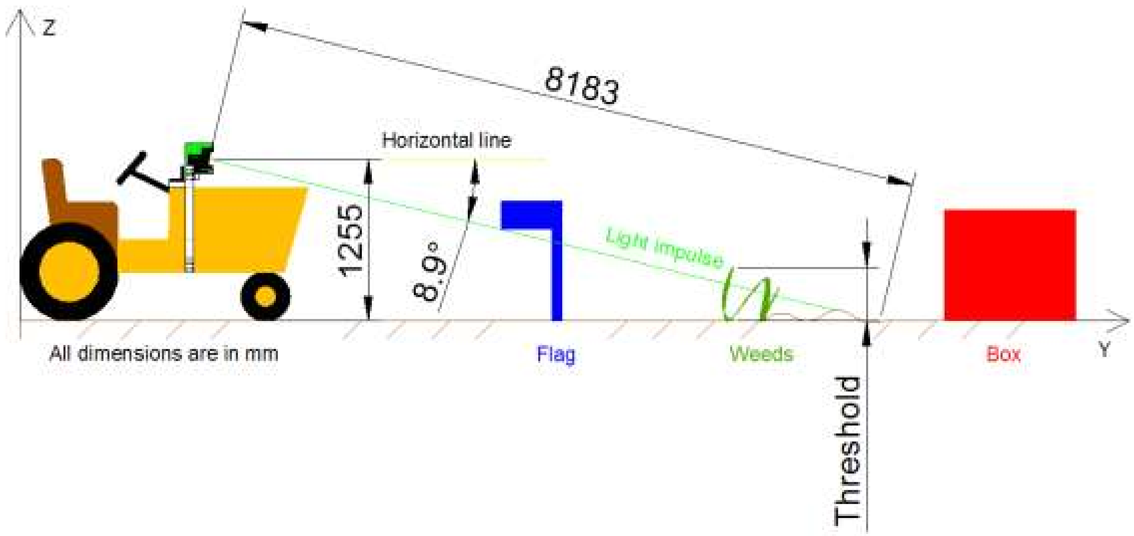


Figure 3.26: Lateral view of the LMS sensor place in the tractor.

An occupancy grid matrix was created using the Cartesian matrix. The screened values were fitted into the zeroed grid matrix. The dimension of each cell in the grid matrix in the x-direction (perpendicular to direction of travel) was kept constant at 0.075 m accordingly to the spot spacing. In the y-direction (parallel to direction of travel) the dimension of each cell in the grid matrix was distance per scan. To calculate the distance per scan we simply divided the vehicle velocity V (m/s) by the scan frequency (Hz), seen in equation (3.2).

$$dist\_scan = \frac{V}{f} \tag{3.2}$$

dist_scan = distance travelled during each scan [m]

$V =$ vehicle velocity [m/s]

$f =$ scan frequency [Hz]

Subsequently, we applied the average height method as explained in the previous section. A predicted height was calculated using the equation (3.1) and the height and angle values provided by the LMS sensor. The LMS sensor was placed on the tractor at 1.2550 m from the ground. The angle from the horizontal line was set 8.9º allowing use the maximum range of the LMS (8183 mm). Figure 3.26 shows the lateral view of the LMS sensor placed on the tractor. Then another occupancy grid matrix was created with the height values for each point (X,Y) of Cartesian matrix. The rest of the values were zeroed for all others.

Up to this point, we were able to reproduce the data delivered by the LMS sensor with the program called "Three_Trials_Representaion.m" using Matlab. This program uses data provided by LMS sensor to represent three trials for each test. In this program for each scan of each trial a plane with Cartesian points (X,Y) of the objects found was created. Then the planes were represented one after the other in a top view named "Range Data". In a view named "Density" contour plot of matrix Z were represented, where Z is interpreted as height values with respect to the (X,Y) plane. Also, the height values of all points were represented as an isometric view named "Data-Height". These three windows work synchronously with a fourth window which represents the scan number analyzed and the time elapsed. These views are illustrated in Figure 3.27. Appendix C.1 presents the program "Three_Trials_ Representaion.m".

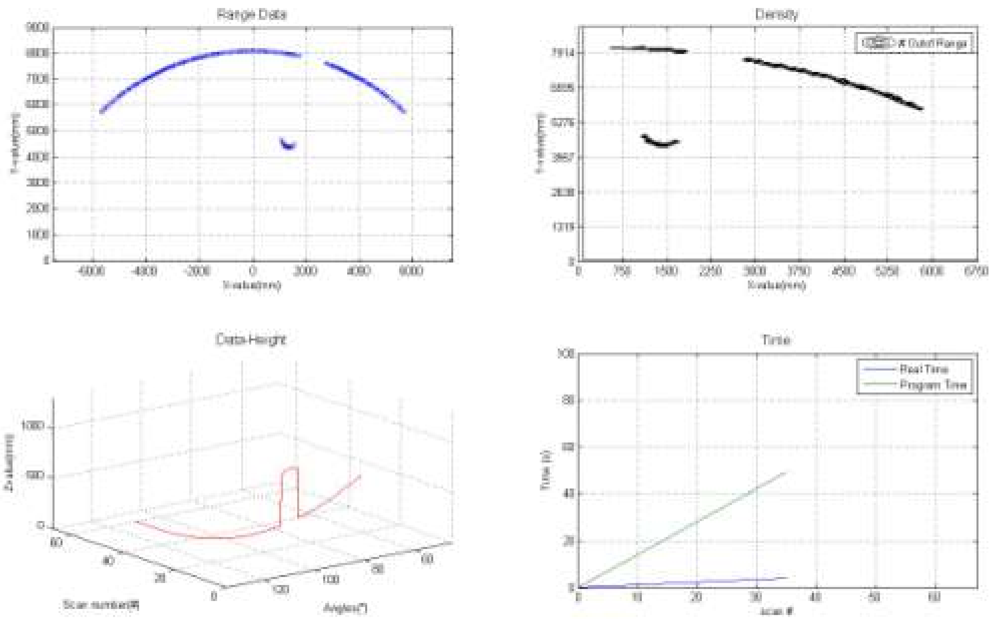


Figure 3.27: Representation of data provided by LMS sensor with the program Three_Trials_Representation.m" using the tests "SSTTS4NSS-2".

Figure 3.27 shows an example of the program "Three_Trials_ Representation.m" based on the tests "SSTTS4NSS-2". In this figure are represented four views with the results of scan number 34. In this example the blue arc in the Range Data view and the black semi arc in the Density view represent the maximum range values that were not eliminated. The points out of the arc or semi arc in Range Data and Density views are cardinal points (X,Y) and its Z value respectively of the objects found by the LMS sensor, which in this case is the Tank. In the Data-Height view are represented all the Z points standing out the height of these objects. Finally, in the Time view is represented the real time and the processing time of the data for each scan.

Next, we created an overall density map by superimposing all scans. Then, the columns of all overlapping scans were averaged to create new cell values. We found inconsistency in the maps generated by this method affecting the LMS sensor. In addition, this inconsistency is mainly related with the height of the objects as well as the speed of the tractor. For example, in occasions the Box, which is the shortest of the objects, did not appear in the maps at low speed. The tests at low speed generated more scans which lead to more overlapping columns. Some of these columns have cells with zero values that when included in the average calculation made the height to be zero. Figure 3.28 illustrates an example of the test “SSTTS2SS-2” where the first flag is not clear and the first object (Box) is missing.

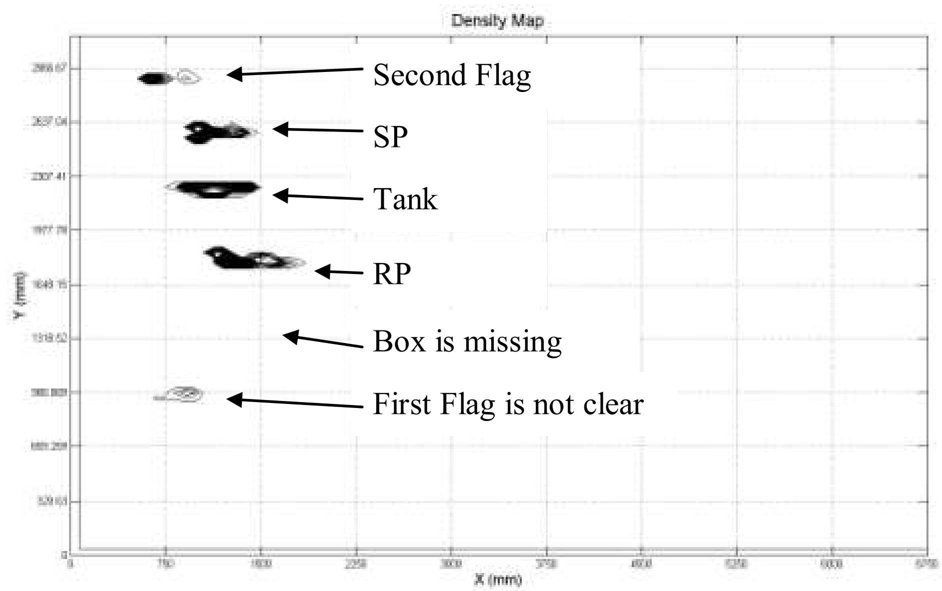


Figure 3.28: Density map with height columns averaged using the test “SSTTS2SS-2”.

We decided to apply an approach of average height method using continuous map and images processing techniques explained in the previous Section. Matlab has an Image Processing Toolbox which provides a comprehensive set of reference standard algorithms and graphical tools for image processing, analysis, and visualization (Matlab, 2011).

Since the objects remain fixed in the field while the tractor moves, the position of points found by the LMS sensor corresponding to these objects should remain constant in a continuous map. By transforming these points into images we can create images of objects represented in a continuous map without averaging the columns values in the map matrix.

As each row of the map matrix corresponds to one scan of the LMS sensor, the occupied cells in each scan were represented in a plane. Then all planes were superimposed to create an overall continuous map. This means that each time that a plane is added a new row is added to the map. The distance between rows is the distance travelled during each scan (equation 3.2). As the planes were defined ccording to the angle *theta*, so they were rotated to the horizontal plane using the equation (3.3). Another occupancy grid matrix was created with the height values for each point (X,Y) of Cartesian matrix while the rest of values were zero for all others.

(3.3)

Z_H = height of the point in the horizontal plane

Z_{pts}= calculated height of the point

theta= angle of the LMS sensor from the horizontal line

Figure 3.29 shows an example where the LMS sensor applies 15 scans (Sn) from 1 to 15 and finds the four objects and two flags. The height (Z) values of the point (X,Y) corresponding to the objects are calculated using the equation (3.1) and represented in the view named "Height". The 15 scans with Cartesian points (X,Y) become in 15 planes (Pn) from 1 to 15 according to the angle theta. Thus, the planes are rotated using the equation (3.3) to get their representation in the horizontal plane. Later the planes are superimposed to create the overall continuous map named "Map" with the position of the objects in the field.

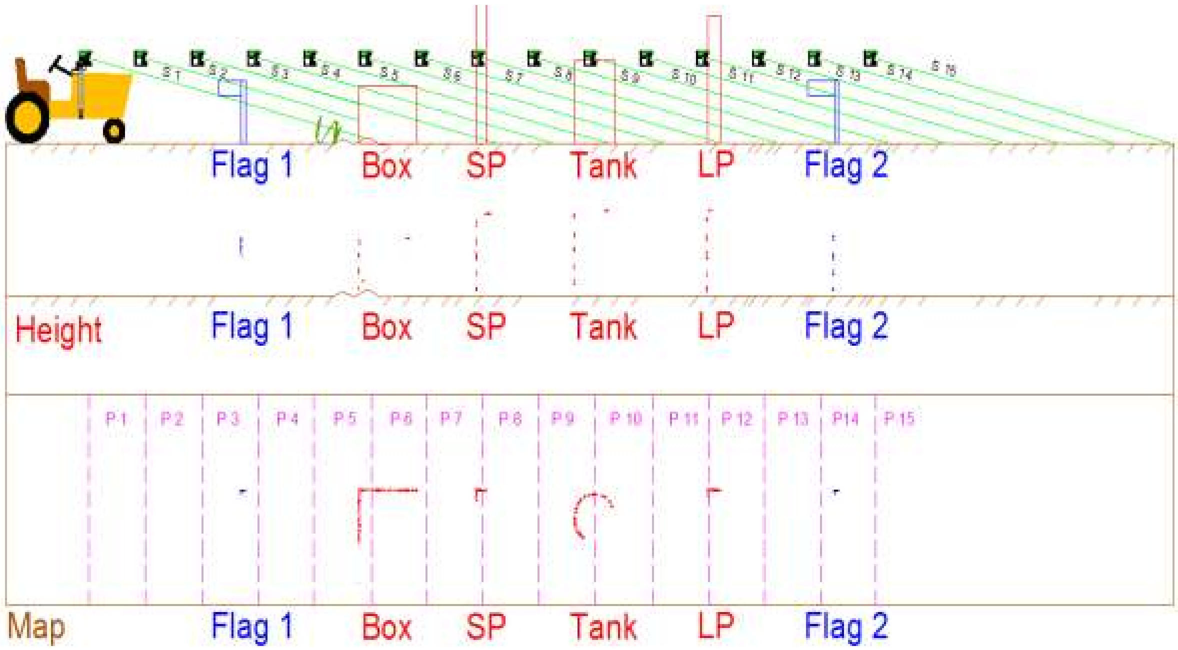


Figure 3.29: Representation of 15 scans and 15 planes that later become in a map.

Up to this point, we are able to represent the continuous map in several views using everything explained above. We developed another program called "Continuous_Map.m" using Matlab. This program represents the continuous map of objects for each trial in four views. Figure 3.30 illustrates a continuous map of the test "SSTTS2SS-2" represented in the view XY, YZ, XZ, and XYZ. This figure shows the representation of the four objects and two flags. In the view XY, the objects are clearly represented with the overall dimensions of the continuous map. The Z values start at 0.310 m in the views YZ, XZ, and XYZ because the threshold was adjusted at this height. Appendix C.2 presents the program "Continuous_Map.m".

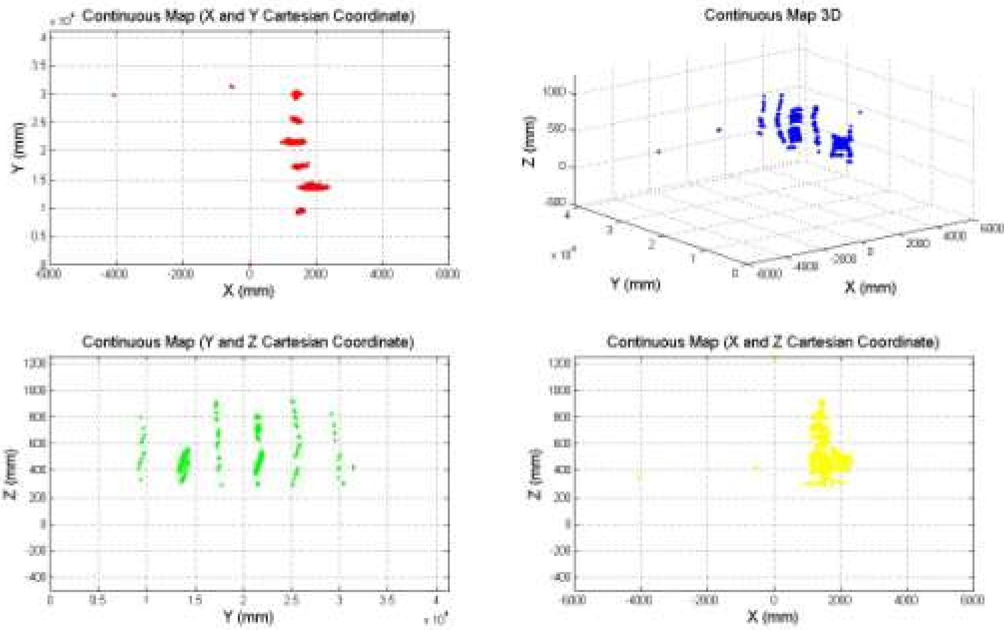


Figure 3.30: Continuous map in the planes XY, XZ, YZ, and XYZ using the test "SSTTS2SS-2" created by the program "Continuous_Map.m".

Figure 3.31 shows an example of test "SSTTS2NSS-2", where a continuous map is compared with the density map that has their height columns averaged. In this figure we can see in the continuous map the four objects and two flags visible, while in the density map the first flag and first object are represented just by their edges.

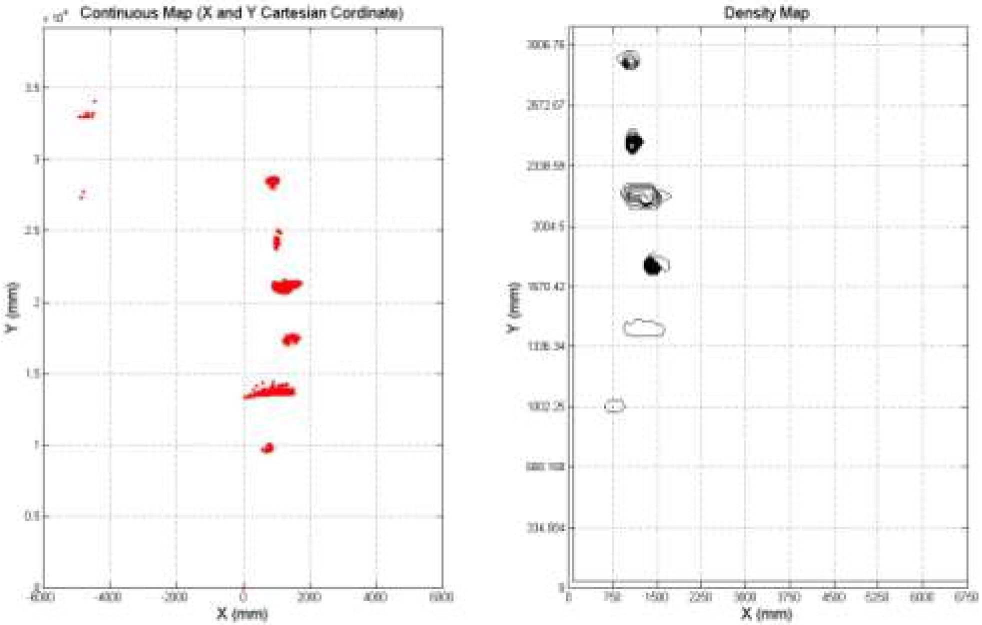


Figure 3.31: Differences between the Continuous Map and Density Map using the test "SSTTS2NSS-2".

Using Matlab morphological functions, we later built the images of the objects transforming the points represented in the continuous map in images. We created an image matrix [n,m] of 0's with the dimensions of continuous map, "n" 12 m and "m" according to scan number, distance per scan, and maximum range LMS sensor. Each cell of this matrix has Xgrid and Ygrid values of 100 mm. It means that each pixel of the image map has a physical dimension of 100 mm in the X and Y directions. We applied the Occupancy Grid method to place in the matrix the points of the objects found by the LMS sensor with 1's. After that, Raster Scan, and Labelling methods were used to convert the image matrix into map. Later, we used the function "strel" to create morphological structuring elements according to each example. Finally, we used the functions dilate, and erode to create the images of the objects. By adding to the previous program these morphological functions, we created another program called "Map_Images.m" with the representation of the images of the objects in image maps in the planes XY and YZ for each trial. Figure 3.32 uses the test "SSTTS2SS-2" to illustrate the formation of images of the objects from the points represented in the continuous map in the view XY and YZ with the program "Map_Images.m". Appendix C.3 presents the program "Map_Images.m".

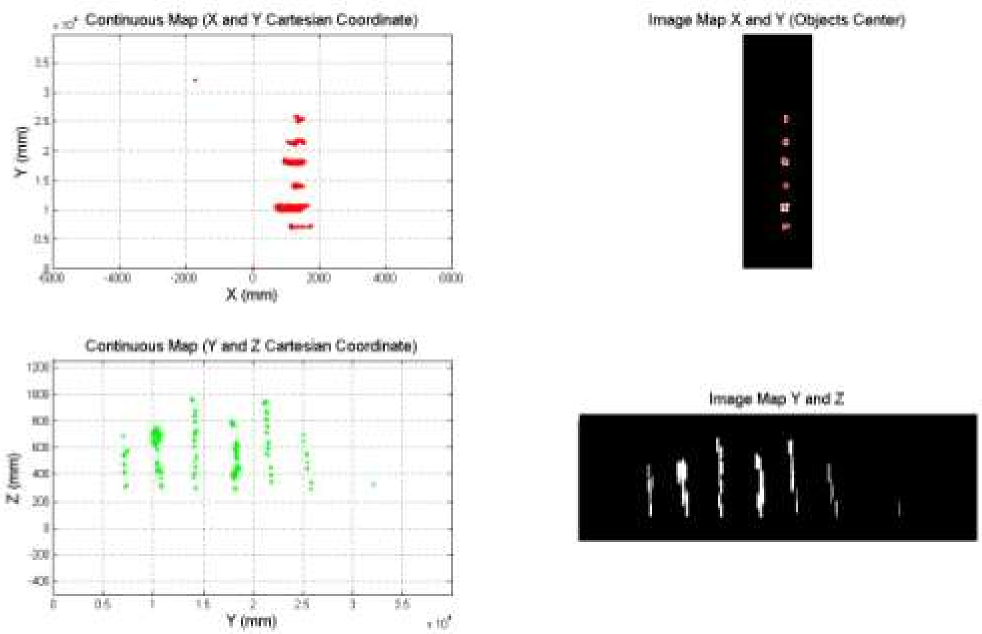


Figure 3.32: Formation of images of the objects from the points, with the program "Map_Images.m" using the test "SSTTS2SS-2".

3.6. Reference Points

The reference points are important to match the map of the model track with the image maps. The model track, which is the same for each test, has the known location of the objects in the field, seen in Figure 3.11 and 3.20. The image maps created from the continuous maps have the images of the objects found by the LMS sensor, seen in Figure 3.32. We needed to match them to calculate the deviation between the known locations of the objects and the locations of images found by the LMS sensor. This deviation is largely caused by vibrations that affect the LMS sensor.

We used two approaches. The first approach, which is called 1 Reference Point (1RP), used the first flag as the only reference. We matched the centroid of the first flag represented in the model track with the image of the first flag in the image map. The second approach, which is called 2 Reference Points (2RP), used the two flags as reference points. We matched the centroid of the two flags represented in the model track with the images of the two flags in the image map. We assumed that the tractor is moving parallel to the straight line between the two flags. Although we believe that the last approach is closer to reality, we calculated the results using both approaches.

Figure 3.33 uses the test “SSTTS2SS-2” to show the matching map, which is the blending of the model track with image map created by the LMS sensor using the reference points. In this figure the objects and flag in red were positioned according the first approach (1RP), while the objects and flags in green were positioned according the second approach (2RP). The blue points are the center of the object images. This figure shows in the first image, which is the first flag, the three colour match in the centre. In image six, which is the end flag, match the green with the blue colour as explained in the approach two. In the other cases the colours did not match showing the deviation in position between the images and real objects.

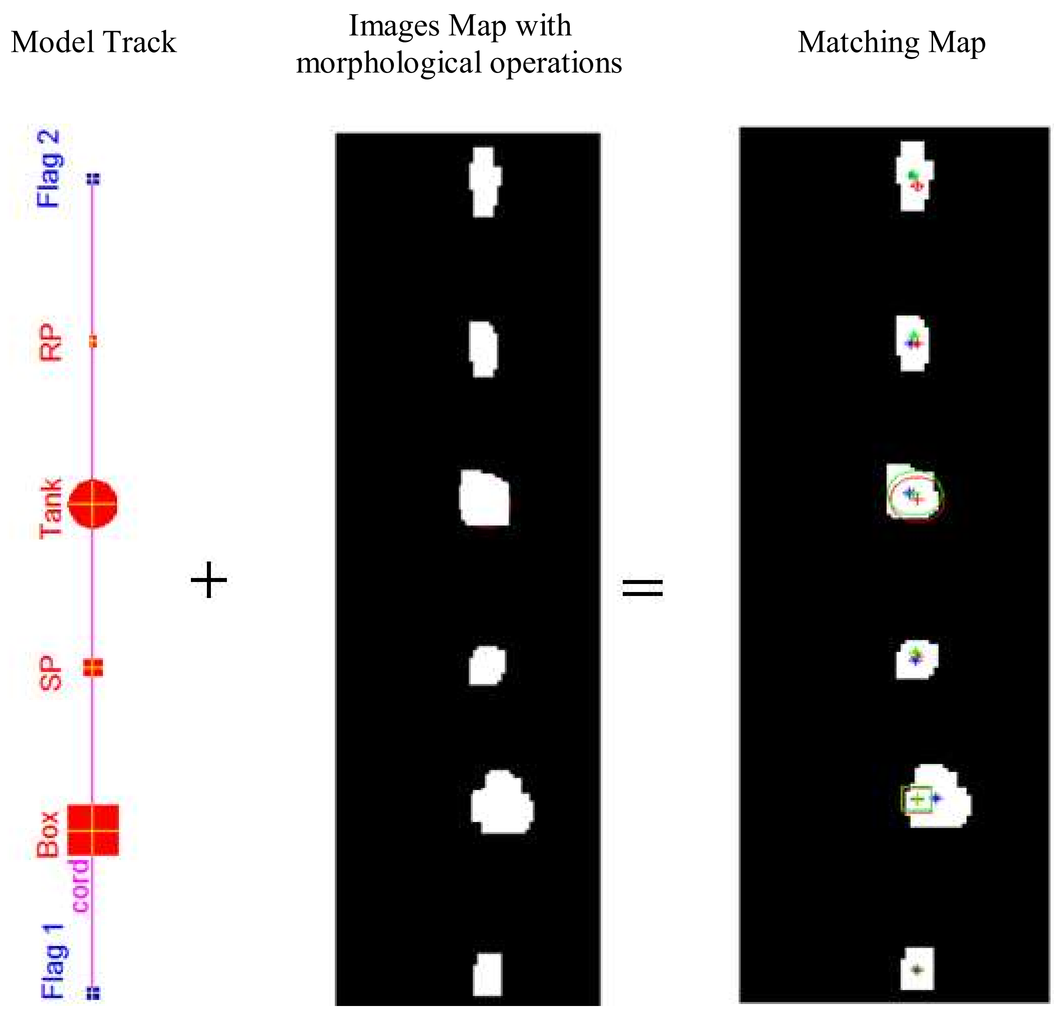


Figure 3.33: Matching map created with model track plus the images map. It has the image objects in white and the real objects in red (1RP) and green (2RP).

At this point using Matlab's "regionprops" function we were able to calculate several properties of the images found by the LMS sensor such as centroid, eccentricity, area, length, and width using the matching map. These properties were compared to the known and real properties of the test objects to determine the deviation caused by the vibrations. However, in this study we focused on the distance deviation between the known location of the objects in the field and the location of the images found by the LMS sensor to determine the efficiency of the SS.

3.7. Mean and Standard Deviation

Mean and standard deviation are normally used for interpretation of a range of data used in statistics and probability theory. For a data set, the mean or arithmetic mean is the sum of the all values divided by the number of values. Mean deviation indicates the degree to which the given values tend to spread about the mean value, which is generally used to measure dispersion (Dhilon, 2005).

Standard deviation is a measure of variability or dispersion of data in a given data set about the mean. It may serve as a measure of inaccuracy or error. A small standard deviation indicates that data points or error are closely around the mean while a large standard deviation indicates that the data points or errors are far from the mean (Dhilon, 2005).

Chapter 4. Results and Discussions

The main objective of this study was to determine the effectiveness of a vibration isolating mounting system in improving the accuracy of the LMS sensor at detecting obstacles in the field. This was achieved by comparing the exact and detected positions of the obstacles under different experimental conditions (types of terrain, operating speed, type of mounting system for the LMS sensor). The detected positions of the obstacles were obtained from LMS output data by means of the average height method and of the image processing techniques presented in Chapter 3.

4.1. Final Programs and Files Results

Three output text files associated with each test were analyzed using another computer program developed in Matlab. This program, named “Trial_and_Test_Results.m”, analyzes data collected in the files combining the average height method with images processing techniques. The program also calculates the geometric properties of the images detected by the LMS sensor, and then these properties are compared to the known objects to determine differences. Among these properties are centroid, eccentricity, area, length, and width. Centroid is defined as the geometric center of the object's shape. It was used as the main property to determine the deviation in distance between the known location of the objects in the field and the location of the images found by the LMS sensor. Appendix C.4 presents the program “Trial_and_Test_Results.m”.

In addition, the computer program calculates the mean distance and standard deviation of objects’ properties for each test using the results of three replicated trials. The program issues the results of each trial and the overall test results creating two types of files: Comma Separated Values (CSV) file and Portable Network Graphics (PNG) file. This means that for each trial, a CSV and a PNG file are created, where the results of the trial are summarized. In addition, for each test other CSV and PNG files are created where the results of the tests (three replicates) are summarized.

The CSV files store and transfer data generated by the programs to a database, while the PNG files save pictures of figures generated by the program. Both types of files have the same name of test file analyzed. For example, the test named “SRTTS2SS” has three trials where each trial has a text file, a CVS file, and a PNG file with the same name but with different file extensions. To summarize, these three trials generate two files “SRTTS2SS-T.csv”, and “SRTTS2SS-T.png”. The file “SRTTS2SS-T.csv” summarizes the result of the text; while the file “SRTTS2SS-T.png” saves the figure where the results based on errors in object location are summarized.

Table 4.1 presents an example where files’ names and quantity for the test “SRTTS2SS” are displayed. Appendix B contains all the files generated by “Trial_and_Test_Results.m” with the results corresponding to each trial and test.

Table 4.1: Names and quantity of files for the test “SRTTS2SS”.

<table>
<tr><th colspan="6">Text name: SRTTS2SS</th></tr>
<tr><th colspan="2" rowspan="2">File by</th><th colspan="4">Types of files</th></tr>
<tr><th>Text</th><th>CSV</th><th>PNG</th><th>Total by Trial/Test</th></tr>
<tr><td rowspan="3">Trial</td><td>1</td><td>SRTTS2SS-1.txt</td><td>SRTTS2SS-1.csv</td><td>SRTTS2SS-1.png</td><td>3</td></tr>
<tr><td>2</td><td>SRTTS2SS-2.txt</td><td>SRTTS2SS-2.csv</td><td>SRTTS2SS-2.png</td><td>3</td></tr>
<tr><td>3</td><td>SRTTS2SS-3.txt</td><td>SRTTS2SS-3.csv</td><td>SRTTS2SS-3.png</td><td>3</td></tr>
<tr><td colspan="2">Test</td><td>-</td><td>SRTTS2SS-T.csv</td><td>SRTTS2SS-T.png</td><td>2</td></tr>
<tr><td colspan="2">Total by Test</td><td>3</td><td>4</td><td>4</td><td>11</td></tr>
</table>

4.1.1. Results by Trial

The typical figure generated by the computer program, "Trial_and_Test_Results.m", for each trial is illustrated in figure 4.1 using the trial "SRTTS2SS-2". This figure is saved with the file name "SRTTS2SS-2.png". In this figure, the continuous map and the matching map explained in Chapter 3 are represented as view 1 and 2.

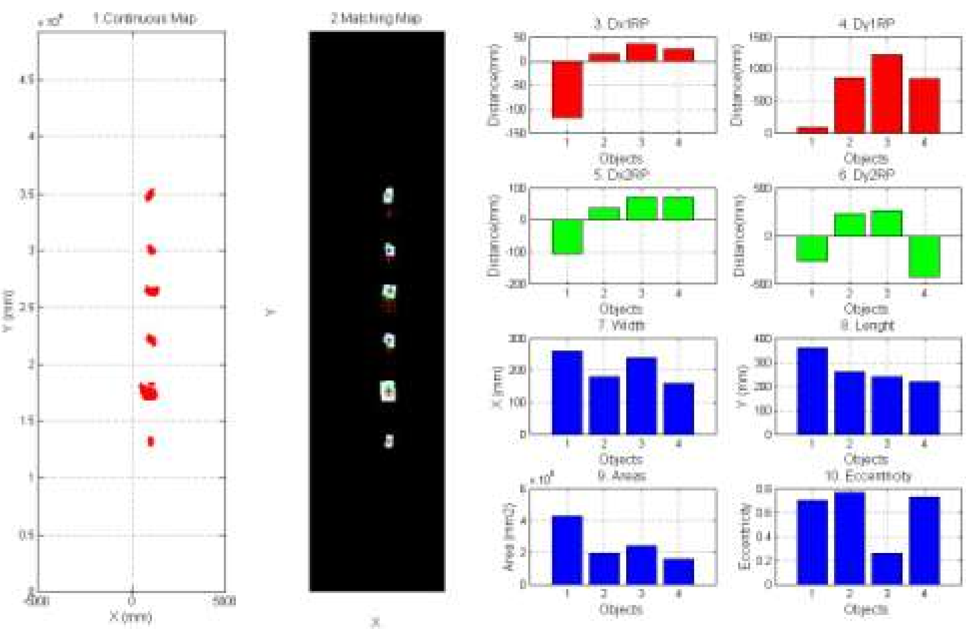


Figure 4.1: Typical results for each trial using the test "SRTTS2SS-2".

We used the matching map in this program to calculate distance deviation in the X and Y directions between the known location of the objects and the location of the corresponding images detected by the LMS sensor. We calculated the difference between the centroid of the objects' images detected by the sensor (*Ix*, *Iy*) and the centroid of the objects with 1RP (*x1RP* and *y1RP*) and 2RP (*x2RP* and *y2RP*) represented in the matching map. The results were obtained in number of pixels and later multiplied by Xgrid or Ygrid. These results are shown in views 3 to 6 at top right side of the figure, in the following order:

distance error deviation of the objects in X direction with 1RP (*Dx1RP*), distance error deviation of the objects in Y direction with 1RP (*Dy1RP*), distance error deviation of the objects in X direction with 2RP (*Dx2RP*), and distance error deviation of the objects in Y direction with 2RP (*Dy2RP*). Finally the views 7, 8, 9, and 10 represent width, length, areas, and eccentricity of image found by the LMS sensor. These views are shown in blue at the bottom right side of the figure. In all views, from 3 to 10, the objects 1, 2, 3, and 4 represent the Box, SP, Tank, and RP respectively.

4.1.2. Results by Test

To summarize the trials and create the results for each test, another figure is generated by the program “Trial_and_Test_Results.m”. This figure is saved on the file “SRTTS2SS-T.png” and has four views with the typical results of the calculations performed by the computer program for each test. This figure summarizes mean error distance and standard deviation between the known location of the objects in the field and the location of the images detected by the LMS sensor.

Figure 4.2 illustrates an example using the results of the test “SRTTS2SS”. View 1 (in red) and view 2 (in green) show the mean error distance and standard deviation in X and Y by objects with 1RP and 2RP respectively. View 3 shows mean error distance and standard deviation in X and Y of the test summarizing all objects with 1RP and 2RP. This view also shows in blue the numbers of total value of deviation for 1RP and 2RP. Finally, view 4 shows the mean error distance percent and standard deviation percent with 1RP and 2RP represented in the previous view. In this case as well, the blue numbers are total error values for 1RP and 2RP.

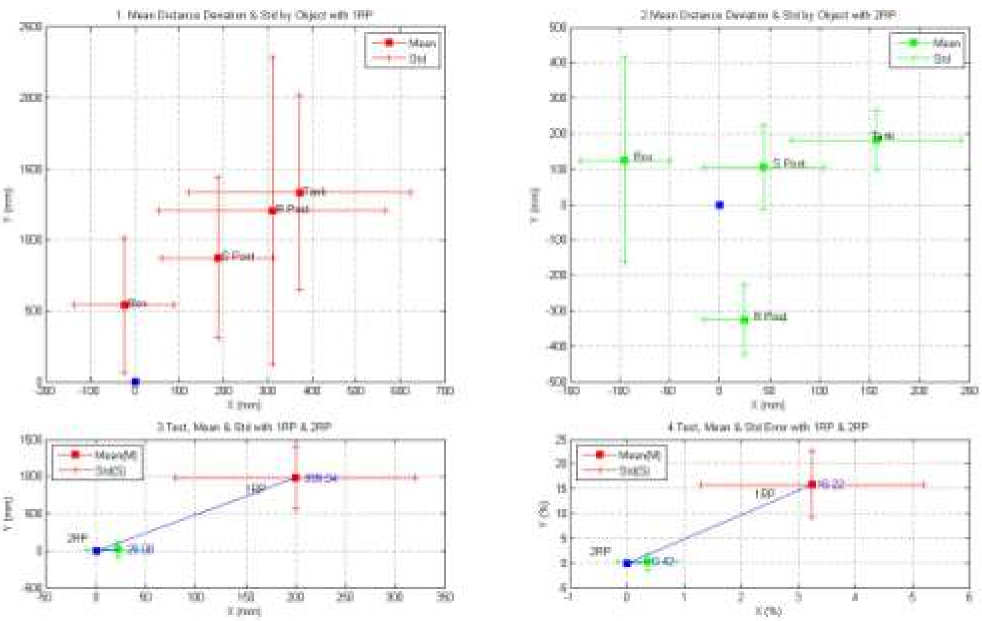


Figure 4.2: Typical results for each test using the test “SRTTS2SS”.

The results of view 3 (figure 4.2) are further split in figure 4.3 and 4.4 to be analyzed in more details. Figure 4.3 shows the mean error distance and standard deviation along the X and Y directions for the test “SRTTS2SS” calculated with 1RP. In this case, the mean error distance (MD) of the four objects in the three trials is 0.9995 m while the standard deviation along the X direction (STDX) is 0.4093 m and the standard deviation in the Y direction (STDY) is 0.1201 m. Figure 4.4 was analyzed with 2RP, it shows MD of 0.026 m while STDX is 0.0306 m and STDY is 0.0961 m.

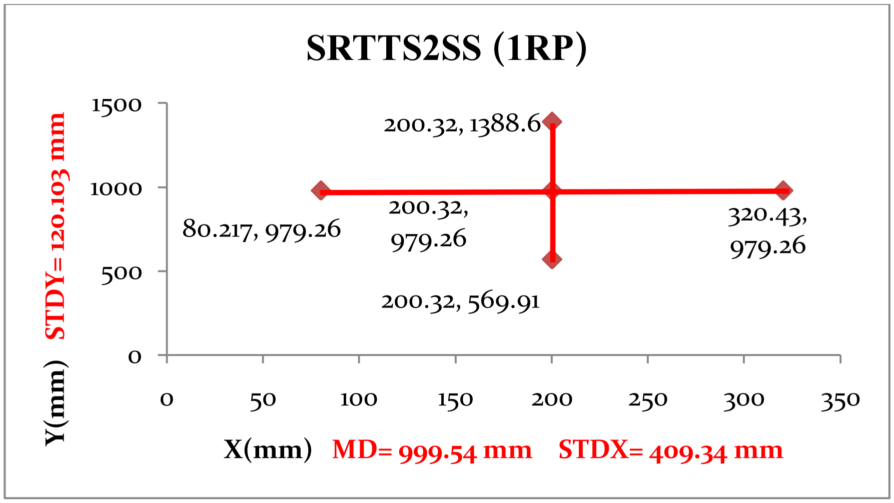


Figure 4.3: Final results of the tests “SRTTS2SS” with 1RP.

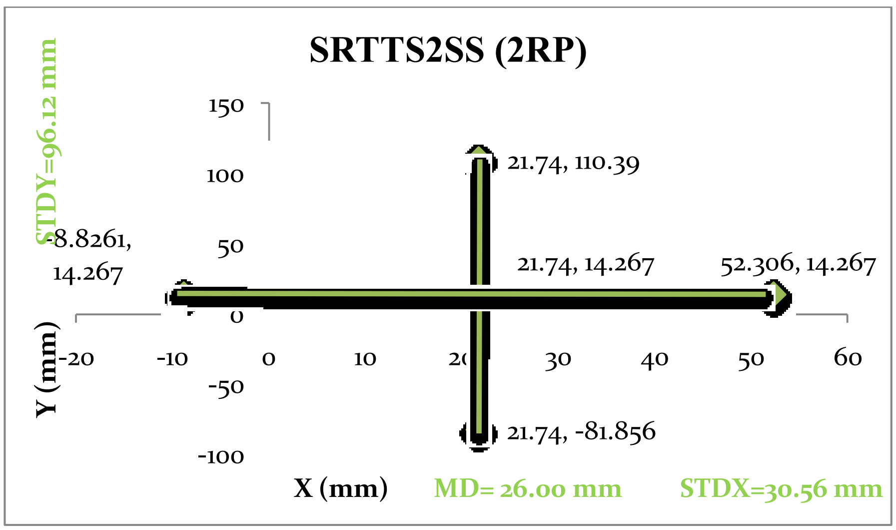


Figure 4.4: Final results of the tests “SRTTS2SS” with 2RP.

Comparing figure 4.3 and 4.4 we noticed that the 2RP method is more accurate than the 1RP method. The difference in MD, STDX, and STDY between the two approaches is large enough to consider the 2RP approach more reliable than 1RP. This happens in most of the examples. Therefore, the following results were analyzed only with 2RP, this approach corresponds more to the procedures performed and with which were obtained more accurate results.

4.2. Final Results by Parameters

We created another computer program in Matlab named “Final_Results.m”, that calculates the mean error distance and standard deviation of objects with different set of parameters using the results of each test with 2RP. Subsequently, this program compares the final results of this study and stores them in a file named “Final Results.csv”. Additionally, this program creates a file “Final Results.png” that illustrates the final results of this study, seen in figure 4.5. Appendix B presents the file “Final Results.csv” and Appendix C.5 presents the program “Final_Results.m”.

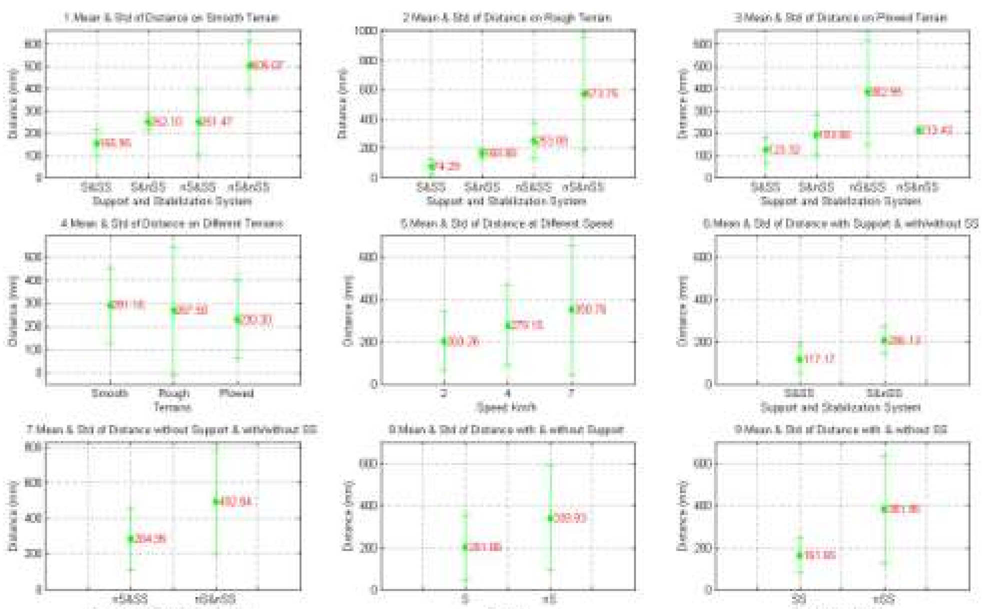


Figure 4.5: Final results of this study, “Final Results.png”

The final results were analyzed using different set of parameters to determine their influence on the accuracy of the LMS sensor. The accuracy of the sensor was deemed to be improved when both the average error distance and the standard deviations were reduced.

4.2.1. Effects of Travel Speed

Since the error distance values at the object location varied depending on the speed of the tractor, we grouped the tests according to the speeds used. This allowed us to analyze the influence of tractor speed on the vibration levels that affected the accuracy of the LMS sensor.

Figure 4.6 shows that the average error distance values and their standard deviations increased with increasing travel speeds. The mean distance values increased from 0.2033 m at 2 km/h to 0.3508 m at 7 km/h, while the standard deviation increased from 0.1369 m at 2 km/h to 0.3037 m at 7 km/h. These can be explained by the increase in vibration levels due to an increase in tractor speed. Thus, as we expected, the increase in speed has a negative effect on the accuracy of LMS measurements.

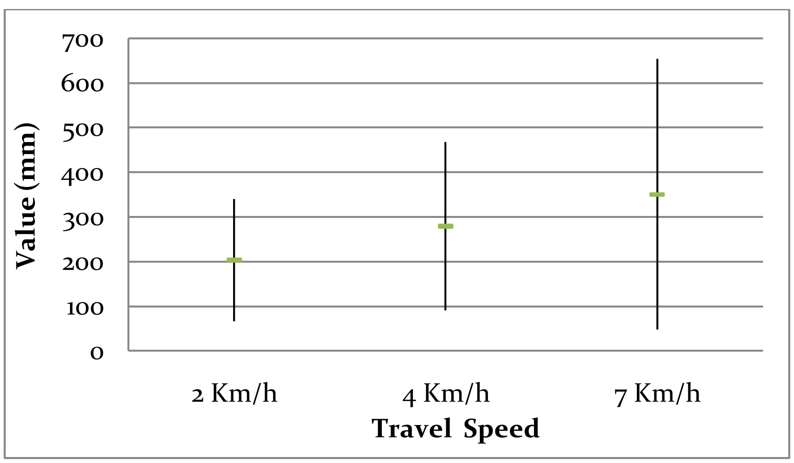


Figure 4.6: Mean error distance and standard deviation at different tractor travel speeds.

4.2.2. Effects of Terrain

Figure 4.7 shows a representation of the mean error distance and standard deviation of tests on different terrains. The average error distance deviation decreases with increasing difficulty of terrains from 0.2915 m at ST to 0.2303 m at PT. These results are contradictory, because the ST, which is a flat terrain, has a greater mean distance value than the PT, which is an uneven terrain with berms as set of obstacles that created shock events of different magnitudes in the tractor. Additionally, values of standard deviation are inconsistent; ST and PT are similar with values of 0.1623 and 0.1707 m respectively while RT has the largest value of 0.2778 m.

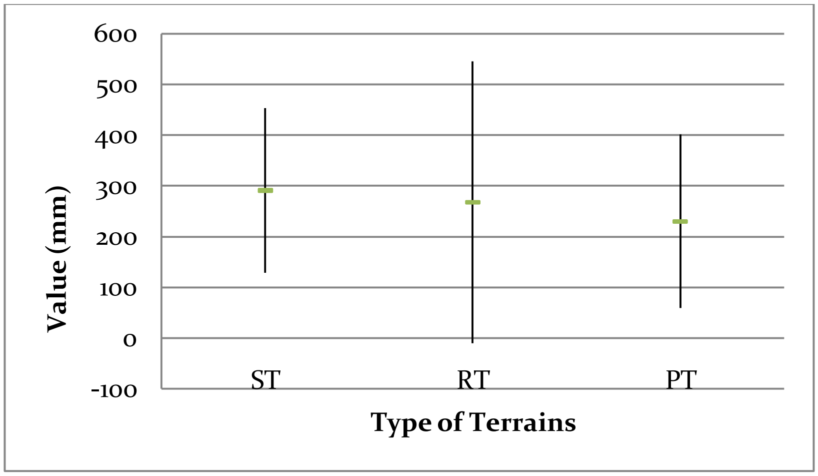


Figure 4.7: Mean error distance and standard deviation on different types of terrain.

Due to the inconsistent of the results shown in figure 4.7 we decided to analyze the results in detail for each separate terrain. Figure 4.8, 4.9, and 4.10 show the results at ST, RT, and PT respectively with and without SS and S.

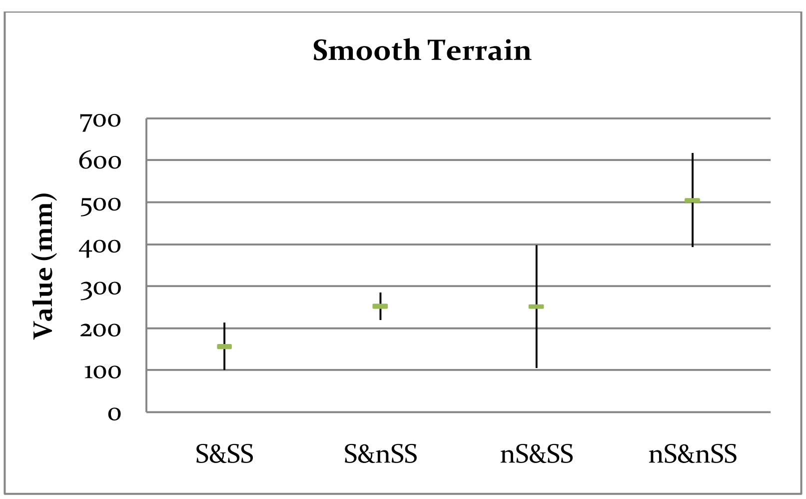


Figure 4.8: Mean error distance and standard deviation on ST.

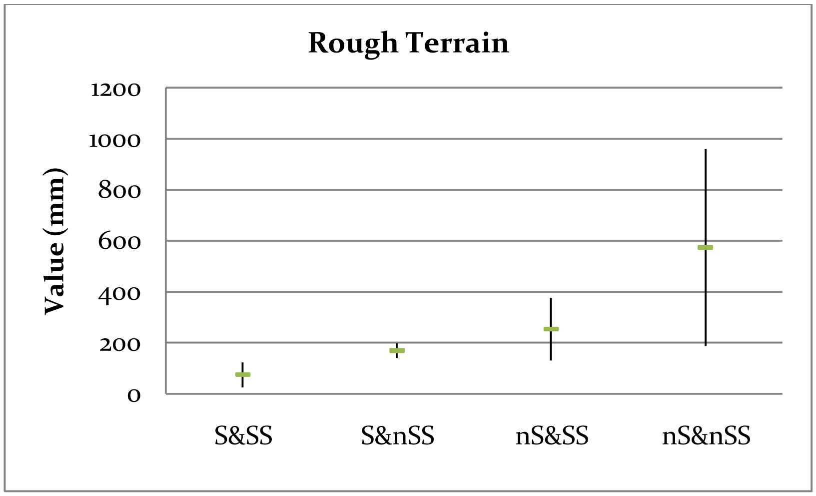


Figure 4.9: Mean error distance and standard deviation on RT.

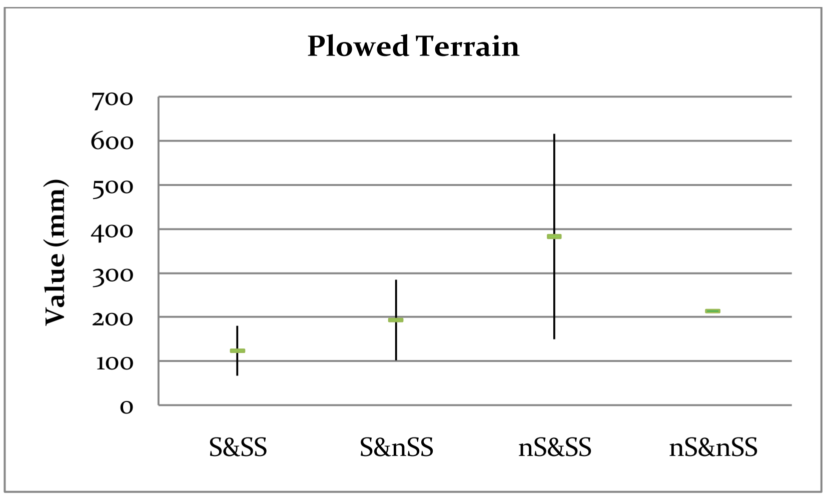


Figure 4.10: Mean error distance and standard deviation on PT.

Figures 4.8, 4.9, and 4.10 show almost the same trend in the mean distance and standard deviation values. Particularly, the lowest values of mean error distance were obtained with S and SS while larger values were obtained without S and SS. In the case of PT without S and SS it was only possible to conduct one trial, so it was not taken into account.

In all cases, tests with SS lead to mean error distance values that are reduced by 36 to 56% reduced when compared with the tests without SS. Similar results were obtained with tests performed with and without S. In these cases, the mean error distances in tests with S were reduced between 38 to 71% when compared with the tests without S. These results show the efficiency of the use of S and SS.

We believe that the unexpected results shown in the Figure 4.7 may be due to interaction of the tire lugs with the ground berms in the RT and PT tests. This interaction created a significant resonance at a speed of 2 km/h that helped to isolate the vibration levels. This could be the reason why mean error distance values at 2 km/h were lower on RT and PT than ST. These small values of mean error distance at 2 km/h on RT and PT were the ones that caused the total values in these terrains to be lower than the total values in ST.

4.2.3. Effects of Support Bars

We were also able to identify the effect of S on the tests results. Figure 4.11 compares the mean error distance and standard deviation values of tests with and without S. The mean error distance increased from 0.2010 m with S to 0.3399 m without S which represents a 70% increase. Very similar were the results of standard deviation values. They increased 56%, from 0.1558 m to 0.2483 m, when the tests were performed without S.

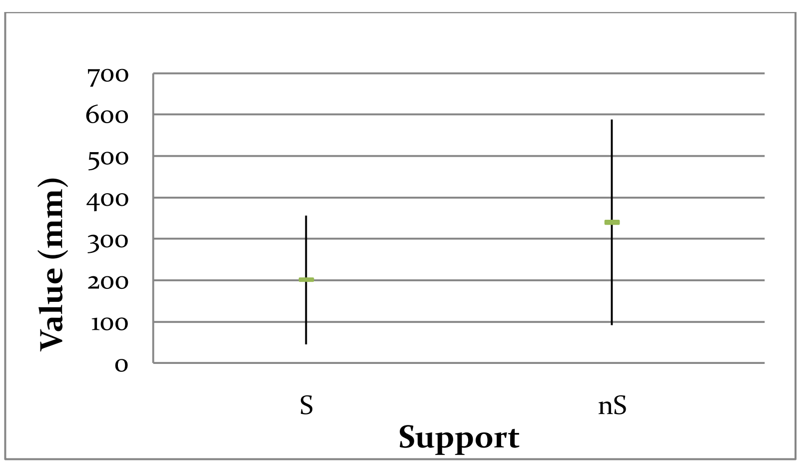


Figure 4.11: Mean error distance and standard deviation with and without S.

These results demonstrate that the LMS sensor was more accurate at detecting the location of the objects with S than without it. This means that S reduces the vibration levels transmitted from the tractor to the LMS sensor, particularly in the lateral and longitudinal axes. Therefore, the S reduced noise and objects false detection introduced by vibrations.

4.2.4. Effects of SS

In order to identify the effect of SS, we compared the tests results with and without SS. Figure 4.12 shows the mean error distance and standard deviation values of the tests with and without SS. Both the mean error distance and standard deviation values increased significantly without the SS. The mean error distance increased from 0.1657 m with SS to 0.3820 m without SS. The standard deviation value increased from 0.0783 m with SS to 0.2567 m without SS. These represent an increase of 123 and 225% respectively, which is translated into higher efficiency of the LMS sensor to locate the objects when SS is used.

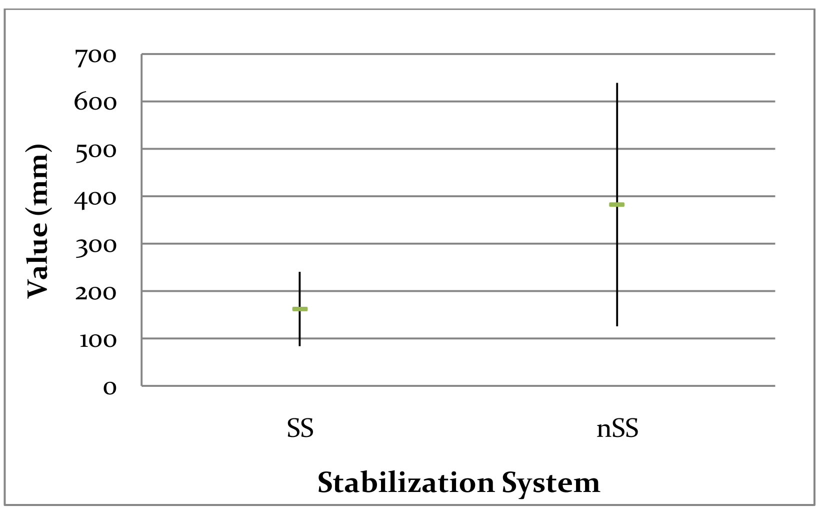


Figure 4.12: Mean error distance and standard deviation with and without SS.

Finally, we analyzed the behaviour of SS with and without S grouping in figure 4.13 for all possible combinations. Figure 4.13 shows that the best results were obtained in the tests with S and SS, while the worst result was in the tests without S and SS.

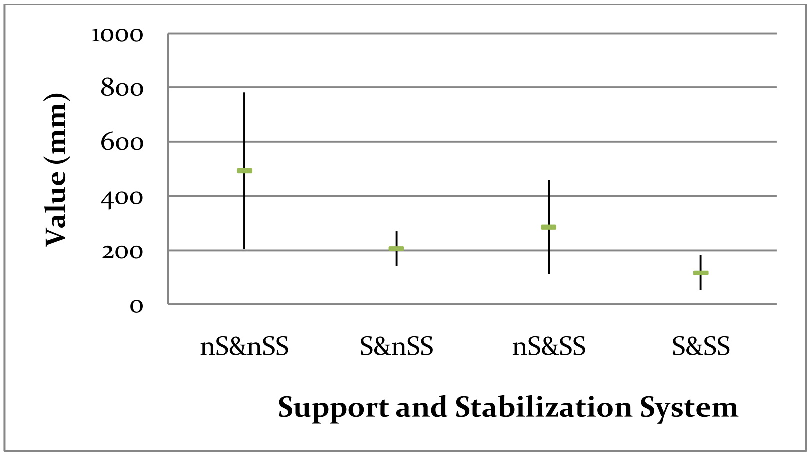


Figure 4.13: Mean error distance and standard deviation with and without S and SS.

Comparing the results of the figure 4.13 with and without SS for the tests without S, the effect of SS was very similar to the tests with S. In the first case, (nS&nSS vs. nS&SS), the mean error deviation was reduced 42.2% with the introduction of SS. While in the second case, (S&nSS vs. S&SS), the mean error deviation was reduced 43.2% with the introduction of SS.

In summary, these results quantify the influence of SS on LMS sensor measurements. Furthermore, these results demonstrate that SS works efficiently in isolating vibrations that affect the LMS sensor mounted on the agricultural tractor. Therefore, the SS as well as S reduced noise and false detection of objects introduced by vibrations. These results are also consistent with the results shown in the previous sections.

4.2.5. Effects of Object Geometry

Geometry of the objects has influenced on the measurements of the LMS sensor. As we mentioned before, the detection rate was higher for taller objects than for shorter ones, because the taller objects were detected by a larger number of scans. In addition, the location of the objects was more accurate for the objects of smaller area (SP and LP) than the objects with larger area (Box and Tank). However, the properties of the objects detected by the

LMS sensor; such as area, width, and length were more accurate for larger objects as compared to smaller ones. Additionally, we noted the influence of SS and S in the accuracy of the results.

In table 4.2, we compared real area of the objects with area of the objects detected by the LMS sensor and calculated by the program. We made this table by averaging all the tests and also averaging the tests performed with and without SS. Finally, we completed this table by averaging the tests performed with SS, both with and without S. The results with area, eccentricity, width, and length of the objects detected by the LMS sensor are in Appendix B.

Table 4.2. Real area of the objects vs. average area of the objects detected by LMS sensor.

	Average area of the objects (mm^2)					
Objects	**Real**	**All tests**	**Tests with SS**	**Tests without SS**	**Tests with SS and without S**	**Tests with SS and S**
Box	3.71E+05	3.04E+05	3.05E+05	3.02E+05	2.45E+05	3.65E+05
SP	0.08E+05	2.31E+05	2.27E+05	2.35E+05	2.16E+05	2.39E+05
Tank	2.56E+05	2.98E+05	2.95E+05	3.02E+05	3.21E+05	2.70E+05
RP	0.04E+05	2.12E+05	2.15E+05	2.08E+05	2.09E+05	2.21E+05

The results shown in Table 4.2 demonstrate the points made above. They show the huge difference between the area of small objects detected by the LMS sensor and the real area of them. The table also shows that in the case of large objects the area detected by the LMS sensor and the real area are similar, even more when the tests were conducted with SS and S. The same applies in the case of the length and the width of the objects.

In resume, the LMS sensor was more effective at measuring the geometric properties of the objects with larger areas than it was with smaller ones. Furthermore, the LMS sensor was more accurate in calculating the properties of large objects when the SS and S mounting systems were used.

Chapter 5. Conclusions and Recommendations

5.1. Conclusions

As indicated in chapter 1 of this thesis, the general objective of this study was to evaluate the efficiency of isolating vibrations that affect the LMS sensor mounted on an agricultural tractor. The paragraphs below summarize the conclusions obtained with regards to each of the three specific objectives of this study.

- To design a stabilization system (SS) capable of reducing the effect of vibrations in the measurements of LMS sensor:

A SS was designed using commercial vibration isolators for the mounting of a SICK LMS 291-S14 commercial laser scanner. The LMS sensor and the SS were installed on an agricultural tractor to detect four objects positioned at known locations in the field during the operation of the tractor under different field and operating conditions.

- To evaluate the efficiency of the SS and of the structure designed for the LMS sensor under different machine and field operating conditions:

Field tests were carried out to evaluate the detection accuracy of the LMS sensor under different operating conditions: with and without SS; with and without S; and for different types of terrains roughness and field operating speed.

The increase of tractor speed had a negative effect on the mean error distances and standard deviation values. When the tractor speed was increased, the mean error distances increased up to 75%, while standard deviation increased up to 114%. No clear trends could be observed from the results of the field tests completed on different types of terrains roughness. The mean error distances were larger for the tests completed in flat terrain conditions (ST) while they were found to be lower for the tests completed under uneven terrain conditions (RT, PT). One possible explanation could be the interactions between the tire lugs and the soil surface during the tests completed under the RT and PT terrain conditions. The additional support system S in the mounting structure of the LMS sensor had a positive effect on the accuracy of the sensor with both the mean error distance decreasing by 41% from 0.3399 to 0.2010 m, and the standard deviation decreasing by 37% from 0.2483 to 0.1558 m. This means that S generated stiffness in the structure which reduces the vibrations levels transmitted from the tractor to the LMS sensor, particularly along the lateral and longitudinal axes. Finally, the efficiency of the SS was confirmed with the mean error distance decreasing by 57% from 0.3820 to 0.1657 m and the standard deviation values decreasing by 69% from 0.2567 to 0.0783 mm. The experimental results show that the SS is the mechanical component that had the greatest influence on the accuracy of the measurements of the LMS sensor. These results also confirmed that the SS was effective at isolating vibrations that affect the LMS sensor mounted on the agricultural tractor.

- To improve the methods used for the graphical representation and location of the objects detected by the LMS sensor in the field.

The range data generated by the LMS sensor in each field test were analyzed by combining the average height method and images processing techniques. This allowed the creation of continuous maps with accurate images of the objects. Several applications were created to reproduce, represent, and calculate positions and shape of the objects. The detection accuracy of the LMS sensor was assessed by determining the difference between the known locations of the four objects and their corresponding estimated locations from the LMS measurements.

This study confirms the effectiveness of the joint use of the SS and S mounting systems at improving the accuracy of the LMS sensor mounted on an agricultural tractor through a reduction in transmitted vibrations. Therefore, this combination could increase the accuracy and safety of autonomous agricultural vehicles for essential tasks such as auto guidance and obstacle detection. These two systems could contribute significantly in future agricultural applications of autonomous vehicles and also to precision farming systems.

5.2. Recommendations for Future Work

Our recommendations for future work have been divided into two categories: testing stages and data analysis methods. These recommendations could help to improve the accuracy of the results obtained by the LMS sensor.

5.2.1. Testing Stages

The tests to evaluate the efficiency of a SS could be improved by measuring the vibration level before and after the SS at the same time that the LMS sensor is used for object detection in the field. This could be done by installing two tri-axial accelerometers, one on the structure of the LMS sensor and another on the sensor itself. Using these devises, we could determine vibration levels caused by speed, terrain, obstacles, and the presence or not of SS and S. Also, we could determine the vibration level isolated by the SS. Besides, we could obtain a relationship between the vibration level in the LMS sensor and the detection rate obtained by the LMS sensor.

We recommend designing a small obstacle course prototype to perform the tests. This course should have the objects fixed on their positions and should consist of obstacles that introduce shock and vibration events. The obstacles could vary in spacing and height.

This course would reduce the future number of field tests and eliminate the errors introduced by misplaced objects, and locate the shock and vibration events on a unique spot.

In addition, by introducing a Differential Global Positioning System Receiver (DGPS) and an Inertial Navigation System (INS) in the vehicle, it could be possible to determinate the effects of any shock and vibration events. The DGPS would give us the real position of the vehicle, while the INS would record the pitch, yaw, and roll of the vehicle, so the shock and vibration events could be associated with the obstacles present on the field. Also, these devises, in conjunction with the two tri-axial accelerometers, the SS, and the LMS sensor, could provide: a relationship among the detection rate obtained by the LMS sensor, the vibration levels that have an effect on the tractor and the LMS sensor, the efficiency of the SS, and the location of the obstacles in the field.

Additionally, we recommend introducing LMS that have modern technologies and are currently on the market, such as multi-layer technology and multi-echo capabilities. These properties would allow obtaining of accurate measurements of objects in the field. A sensor with the multi-layer technology would allow for a pitch angle compensation when the sensor is mounted to a vehicle that travels for uneven terrains. While a sensor with multi-echo capability can gather and evaluate several echoes per transmitted laser pulse. This would allow sensor measurements filtering, noise reduction, and increased accuracy.

5.2.2. Data Analysis Methods

For future work we suggest introducing real time analysis, which can be applied if the scans are analyzed individually and not in files. For this purpose, it would be necessary use an LMS sensor with higher frequency and also software as C++, to obtain a high response speed.

In addition, the algorithm could be designed to be self-tuning to deal with various changes of parameters. For example, the value of threshold could be adjusted to the noise detected by the LMS sensor; the value of distance per scan could be adjusted according to the speed of tractor; the value of morphological function could be according to the number of input pixel in the neighbours of an image; and the value of grid size could be according to the LMS sensor's frequency.

Finally, we recommend the creation of maps modeling the objects in three dimensions (3D). The images of objects in two dimensions (2D) in the three planes could be reconstructed with equivalent techniques to create 3D registration of the objects. Thus, from the 2D input images we could create 3D objects location and pose estimation that could be compared with the real image and location of objects to determine the efficiency of SS.

References

Advanced Antivibration Components. 2010. *Vibrationmounts.com.* Retrieved August 4, 2010, from http://www.vibrationmounts.com/RFQ/VM110104.htm#Middle.

Agriculture, history of. 2011.*In Encyclopædia Britannica*. Retrieved August 19, 2011, from http://www.britannica.com/EB/article-10679/Tractor.

ASABE. 2006. *ASABE STANDARDS 2006*. St. Joseph, MI: ASABE.

Balasubramanian, K., Burks, T. F., Lehtola, C. J. & Lee, W. S. 2006. *Shock and Vibration Data Acquisition System for Off-Road Vehicle Operator Health and Safety Assessment.* Journal of Agricultural Safety and Health. American Society of Agricultural and Biological Engineers. Vol. 12, Issue 4, pp. 293-313.

Barawid, J. O. C., Mizushima, A., Ishii, K. & Noguchi, N. 2007. *Development of an autonomous navigation system using a two-dimensional laser scanner in an orchard application.* Biosystems Engineering. Vol. 96, Issue 2, pp. 139-149. Retrieved August 26, 2011, from http://www.sciencedirect.com/science/article/pii/ S1537511006003400.

Barcelo, L.E. & Hilbert, J.A. 2004. *Exposición a las vibraciones del cuerpo entero en tractores - Duración permitida e la jornada laboral*. 5º Jornada the Desarrollo e Inovation. INTI. Retrieved August 24, 2011, from http://www.inta.gov.ar/iir/info/vibraciones2.pdf.

Benson, E., Stombaugh, T., Noguchi, N., Will, J. & Reid, J. F. 1998. *An Evaluation of a Geomagnetic Direction Sensor for Vehicle Guidance in Precision Agriculture Applications*. ASAE Annual International Meeting. Sponsored by ASAE, Orlando Convention Center Orlando, FL. Retrieved August 26, 2011, from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.23.902.

Blackmore, B. S. & Griepentrog, H. W. 2006*. Autonomous Vehicles and Robotic.* Section 4.3. Autonomous Vehicles and Robotics. Chapter 4 Mechatronics and Applications in CIGR Handbook of Agricultural Engineering. Volume VI, pp. 204-215. ASABE.

Burdick, H. E. 1997. *Digital Image, Theory and Applications*, McGraw-Hill, Inc. New York, NY.

Carmer, D.C. & Peterson, L. M. 1996. *Laser Radar in Robotics*. Proceedings of the IEEE. Vol. 84, Issue. 2, pp. 299-320. Retrieved August 26, 2011, from http://ieeexplore.ieee.org/stamp/ stamp.jsp?tp= &arnumber=482232.

Clijmans, L., Ramon H. & De Baerdemaeker, J. 1998. *Structural Modification Effects on the Dynamic Behaviour of an Agricultural Tractor.* Transactions of the ASABE. American Society of Agricultural and Biological Engineers. Vol. 41, Issue 1, pp.5-10.

Debain, D., Delmas, P., Lenain, R. & Chapuis, R. 2010. *Integrity of an autonomous agricultural vehicle according the definition of trajectory traversability.* Author manuscript, published in "AgEng 2010, International Conference on Agricultural Engineering, Clermont-Ferrand: France (2010)" Retrieved August 27, 2011, from http://hal.archives-ouvertes.fr/hal-00557038/en.

Dhilon, B. S. 2005. *Reliability, Quality, and Safety for Engineers*, CRC Press, Boca Raton, Florida.

Doerr, Z. 2009. *Evaluating the Ability to Detect Foreign Objects in Crops Using Laser Range Scanners Mounted On Agricultural Vehicles*. Available from the Ottawa-Carleton Institute for Mechanical and Aerospace Engineering, Ottawa, Ontario, Canada.

Dworecki, Z., Fiszer, A., Łoboda, M. & Przybył, J. 2005. *Calculation of Tractor and Agricultural Machines Moments of Inertia.* Journal of Research and Applications in Agricultural Engineering. Vol. 50, Issue 3, pp. 20-23. Retrieved August 28, 2011, from www.pimr.poznan.pl/biul/2005_3_4PDF.pdf.

EH.NET. 2011. Tractor, history in the United States. 2011. Retrieved August 20, 2011, from http://eh.net/encyclopedia/article/white.tractors.history.us.

Gelmec Vibration, Shock, Noise and Thermal Control Solutions. 2010. Gelmec.co.uk. Retrieved August 4, 2010, from http://www.gelmec.co.uk/

Griffith, J. C. 2009. *Development of a Low Level Autonomous Machine.* Available from the Department of Agricultural and Bioresource Engineering, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. Retrieved

August 22, 2011, from http://library2.usask.ca /theses/available/ etd-08252008-23054/unrestricted/griffith_j.pdf.

Hamner, B., Sanjiv, S. & Bergerman, M. 2010. *Improving Orchard Efficiency with Autonomous Utility Vehicles.* 2010 ASABE Annual International Meeting. Sponsored by ASABE. David L. Lawrence Convention Center, Pittsburgh, Pennsylvania. Retrieved August 28, 2011, from http://www.cascrop.com/ publications/20100507_Hamner_ APMrowfollowing_ASABE.pdf.

Heraud, J. A. & Lange, A. F. 2009. *Agricultural Automatic Vehicle Guidance from Horses to GPS: How we got here, and where we are going*. In 2009 Agricultural Equipment Technology Conference Louisville, Kentucky, USA: ASABE.

IAASTD. 2011. International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD). Agriculture at Crossroads. *Agassessment.org*. Retrieved August 26, 2011, from http://www.agassessment.org/reports/IAASTD/EN/Agriculture/(English).pdf.

Images Processing. 2011.*In Encyclopædia Britannica*. Retrieved October 18, 2011, from http://www.britannica.com/EBchecked/topic/283261/image-processing.

Jaybridge Robotics Partners with Kinze Manufacturing, *Develops First Autonomous Vehicle System for Row Crop Harvesting*. Retrieved September 22, 2011, from http://www.jaybridge.com/case-studies/kinze/.

Kane S. 2011. Popular Science. *Agriculture continues to plow into the future, now with autonomous robot tractors.* Retrieved September 22, 2011, from http://www.popsci.com/technology/article/2011-09/robotractor.

Katupitiya, J. & Eaton, R. 2008. *Precision Autonomous Guidance of Agricultural Vehicles for Future Autonomous Farming*. 2008 ASABE Annual International Meeting. Sponsored by ASABE. Rhode Island Convention Center, Providence, Rhode Island.

Kise, M., Noguchi, N., Ishii, K. & Terao, H. 2001. *Development of agricultural autonomous tractor with an RTK-GPS and a FOG.* Proceedings of the Fourth IFAC Symposium on Intelligent Autonomous Vehicles, Sapporo, Japan, pp. 99-104. Retrieved August 25, 2011, from http://www.ijabe.org/index.php/ijabe/ article/viewFile/160/82.

Kise, M., Noguchi, N., Ishii, K. & Terao, H. 2002. *The development of the autonomous tractor with steering controller applied by optimal control.* Proceedings of Conference on Automation Technology for Off-Road Equipment, Chicago, USA, pp. 367-373. ASABE.

Kise, M., Zhang, Q. & Noguchi, N. 2005a. *An Obstacle Identification Algorithm for Laser Range Finder-Based Obstacle Detector.* Retrieved August 25, 2011, from http://www.docstoc.com/docs/79078072/AN-OBSTACLE-IDENTIFICATION-ALGORITHM-FOR-A-LASER-RANGE-FINDER.

Kise, M., Zhang, Q. & Rovira-Mas, F. 2005b. *A Stereovision-based Crop Row Detection Method for Tractor-automated Guidance.* Biosystems Engineering, Vol. 90, Issue 4, pp. 357-367. Retrieved August 22, 2011, from http://www.age-web.age.uiuc. edu/faculty/qzhang/ Publications/ 2005BE90(4) Kise.pdf.

Lawrence, A. 1993. *Modern inertial technology, navigation, guidance, and control*. Springer–Verlag, New York.

Lee, K. H. & Ehsani, R. 2008. *Comparison of two 2D laser scanners for sensing object distances, shapes, and surface patterns.* Computers and Electronics in Agriculture. Vol. 60 Issues 2, pp. 250-262. Retrieved August 28, 2011, from http://www.sciencedirect.com /science/article/pii/S0168169907001834.

Lee, K. H. & Ehsani, R. 2009. *A Laser Scanner Based Measurement System for Quantification of Citrus Tree Geometric Characteristics*. Applied Engineering in Agriculture. ASABE. Vol. 25, Issue 5, pp. 777-788.

Li, M., Imou, K., Wakabayashi, K. & Yokoyama, S. 2009. *Review of research on agricultural vehicle autonomous guidance.* International Journal of Agriculture and Biology Engineering. Vol. 2, No.3, pp. 1-16. Retrieved August 21, 2011, from http://www.ijabe.org.

Matlab. 2008. Matlab Help Guide. In Version 7.3.0 (R2008b): MathWorks, Inc.

Matlab. 2011. User guide. Mathworks.com . Retrieved October 12, 2011, from http://www.mathworks.com/help/toolbox/images/f18-12508.html

Muzammil, M., Siddiqui, S. & Hasan, F. 2004. *Physiological Effect of Vibrations on Tractor Drivers under Variable Ploughing Conditions*. Journal of Occupational Health Vol. 46, Issue 5, pp.403-409. Retrieved September 26, 2011, from http://joh.med.uoeh-u.ac.jp/pdf/E46/E46_5_09.pdf.

Nagasaka, Y., Umeda, N., Kanetai, Y., Taniwaki, K. & Sasaki, Y. 2004. *Autonomous guidance for rice transplanting using global positioning and gyroscopes.* Computers and Electronics in Agriculture. Vol. 43, Issue 3, pp 223-234. Retrieved August 22, 2011, from http://www.sciencedirect.com/science/article/pii/ S0168169904000304.

Noguchil, N., Ishii, K. & Terao, H.1997. *Development of an Agricultural Mobile Robot using a Geomagnetic Direction Sensor and Image Sensors*. Journal of Agricultural Engineering Research. Vol. 67, Issue 1, pp. 1-15. Retrieved August 26, 2011, from http://www.sciencedirect.com/science/article/pii/ S0021863496901389.

Palm III, W. J. 2007. *Mechanical Vibrations*. John Wiley & Sons, Inc. Hoboken, NJ.

Reid, J.F., Zhang, Q., Noguchi, N. & Dickson, M. 2000. *Agricultural automatic guidance research in North America.* Computers and Electronics in Agriculture. Vol. 25, Issues 1-2, pp 155-167. Retrieved August 17, 2011, from http://www.sciencedirect.com/science/article/pii/ S0168169999000617.

Rovira-Más, F. & Han, S. 2006. *Kalman Filter for Sensor Fusion of GPS and Machine Vision*. 2006 ASABE Annual International Meeting. Sponsored by ASABE, Portland Convention Center Portland, Oregon.

Rovira-Más, F., Wang, Q. & Zhang, Q. 2007. *Design of Stereo Perception Systems for Automation of Off-road Vehicles.* 2007 ASABE Annual International Meeting. Sponsored by ASABE. Minneapolis Convention Center, Minneapolis, Minnesota.

Rovira-Más, F., Wang, Q. & Zhang, Q. 2008. *Configuration of Stereo Systems for Off-road Intelligent Vehicles*. 2008 ASABE Annual International Meeting. Sponsored by ASABE. Rhode Island Convention Center, Providence, Rhode Island.

Schmidt, G. T. 2011. *INS/GPS Technology Trends*. Retrieved August 21, 2011, from NATO. Retrieved August 25, 2011, from ftp.rta.nato.int/public/PubFullText/RTO/ EN-SET-116(2011)-02.pdf.

Sensor Intelligence, SICK. 2006. *LMS200/211/221/291 Laser Measurement Systems*. (Ed T. Description). Waldkirch: SICK.

Subramanian, V. & Burks, T.F. 2005. *Autonomous Path Navigation in Citrus Groves Using Machine Vision and Laser Radar.* ASAE Annual International Meeting Sponsored by ASAE, Tampa Convention Center, Tampa, Florida.

Subramanian, V., Burks, T.F. & Arroyo, A. A. 2006. *Development of machine vision and laser radar based autonomous vehicle guidance systems for citrus grove navigation.* Computers and Electronics in Agriculture. Vol. 53 Issues 2, pp 130-143. Retrieved August 24, 2011, from http://www.sciencedirect.com/science/ article/pii/S016816990600069X.

Wilson, J.N. 2000. *Guidance of agricultural vehicles – a historical perspective*. Computers and Electronics in Agriculture. Vol. 25, Issue 1-2, pp. 3-9. Retrieved August 22, 2011, from http://www.sciencedirect.com/science/article/pii/ S01681699990005.

Appendix A. Equipment Information and Data

Table A- 1. ASABE Typical Operating Speeds

ASABE Standards 2006 53rd Edition, Standards Engineering Practices Data, p.395, Table 3, Typical operating speeds					
Tillage and Planting	***km/h***	***Harvesting***	***km/h***	***Misc.***	***km/h***
Moldboard Plow	7	Corn picker sheller	4	Fertilizer Spreader	11
Heavy-duty disk	7	Combine	5	Boom-type sprayer	10.5
tandem disk harrow	10	Combine (SP)	5	Air-carrier sprayer	5
(Coulter) chisel plow	8	Mower	8	Bean puller-windrower	8
Field cultivator	11	Mower (rotary)	11	Beet topper/stalk chopper	8
Spring tooth harrow	11	Mower-Conditioner	8		
Roller-Packer	10	Mower-Conditioner (rotary)	11		
Mulcher-Packer	8	Windrower	8		
Rotary Hoe	19	Side Delivery take	10		
Row crop cultivator	8	Rectangular baler	6.5		
Rotary tiller	5	Large rectangular baler	8		
Row crop planter	9	Large round baler	8		
Grain drill	8	Forage Harvester	5		
		Forage Harvester (SP)	5.5		
		Sugar beet harvester	8		
		Potato Harvester	4		
		Cotton picker	4.5		
Average	9.3	**Average**	7.0	**Average**	8.5
Overall Average 8.3					

Table A- 2. Typical material reflectivity (Sensor Intelligence, 2006)

Material	**Reflectivity**
Cardboard, matt black	10%
Cardboard, grey	20%
Wood (raw pine, dirty)	40%
PVC, grey	50%
Paper, matt white	80%
Aluminum, anodised, black	110%-150%
Steel, rust-free shiny	120%-150%
Steel, very shiny	140%-200%
Reflectors	>2 000%

Table A- 3. Test labelling according to number of test setup.

Number of test setup	*Test Setup Labelling*	*Parameters*									
		Structure Support		*Terrains*			*Speeds*			*SS*	
		S	*NS*	*ST*	*RT*	*PT*	*TS2*	*TS4*	*TS7*	*SS*	*NSS*
1	SSTTS2SS	√		√			√			√	
2	NSSTTS2SS		√	√			√			√	
3	SRTTS2SS	√			√		√			√	
4	NSRTTS2SS		√		√		√			√	
5	SPTTS2SS	√				√	√			√	
6	NSPTTS2SS		√			√	√			√	
7	SSTTS4SS	√		√				√		√	
8	NSSTTS4SS		√	√				√		√	
9	SRTTS4SS	√			√			√		√	
10	NSRTTS4SS		√		√			√		√	
11	SPTTS4SS	√				√		√		√	
12	NSPTTS4SS		√			√		√		√	
13	SSTTS7SS	√		√					√	√	
14	NSSTTS7SS		√	√					√	√	
15	SRTTS7SS	√			√				√	√	
16	NSRTTS7SS		√		√				√	√	
17	SPTTS7SS*	√				√			√	√	
18	NSPTTS7SS*		√			√			√	√	
19	SSTTS2NSS	√		√			√				√
20	NSSTTS2NSS		√	√			√				√
21	SRTTS2NSS	√			√		√				√
22	NSRTTS2NSS		√		√		√				√
23	SPTTS2NSS	√				√	√				√
24	NSPTTS2NSS		√			√	√				√
25	SSTTS4NSS	√		√				√			√
26	NSSTTS4NSS		√	√				√			√
27	SRTTS4NSS	√			√			√			√
28	NSRTTS4NSS		√		√			√			√
29	SPTTS4NSS	√				√		√			√
30	NSPTTS4NSS*		√			√		√			√
31	SSTTS7NSS	√		√					√		√
32	NSSTTS7NSS		√	√					√		√
33	SRTTS7NSS	√			√				√		√
34	NSRTTS7NSS		√		√				√		√
35	SPTTS7NSS*	√				√			√		√
36	NSPTTS7NSS*		√			√			√		√

Note: Since the Matlab software does not distinguish between uppercase and lowercase, the names of files could be either in uppercase and lowercase.
* This test was not possible to do.

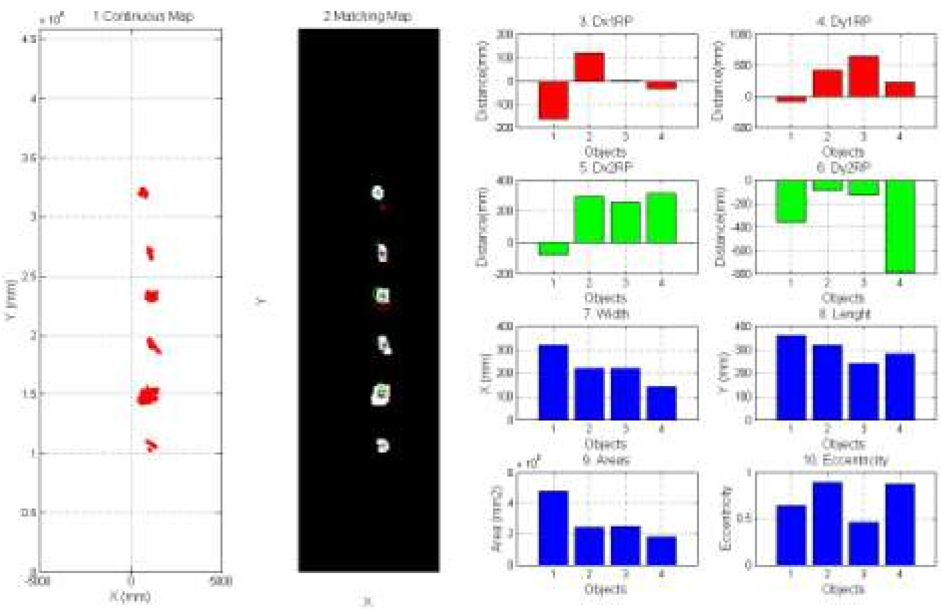
Appendix B. Complete Experimental Results

B.1 Results of PNG files

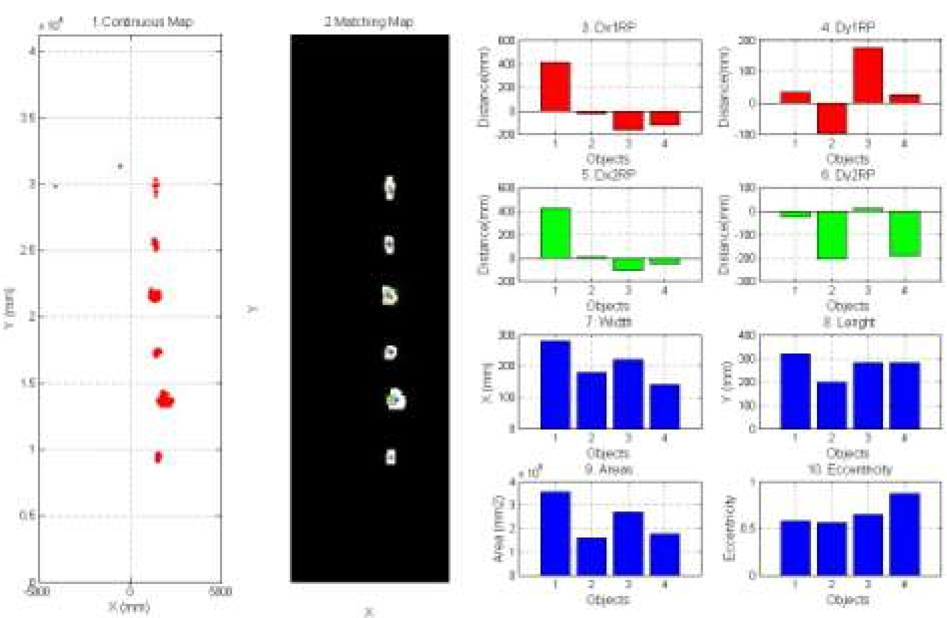
The results of the tests are shown in the same order as in table A-3.

1. Test Name: **SSTTS2SS**

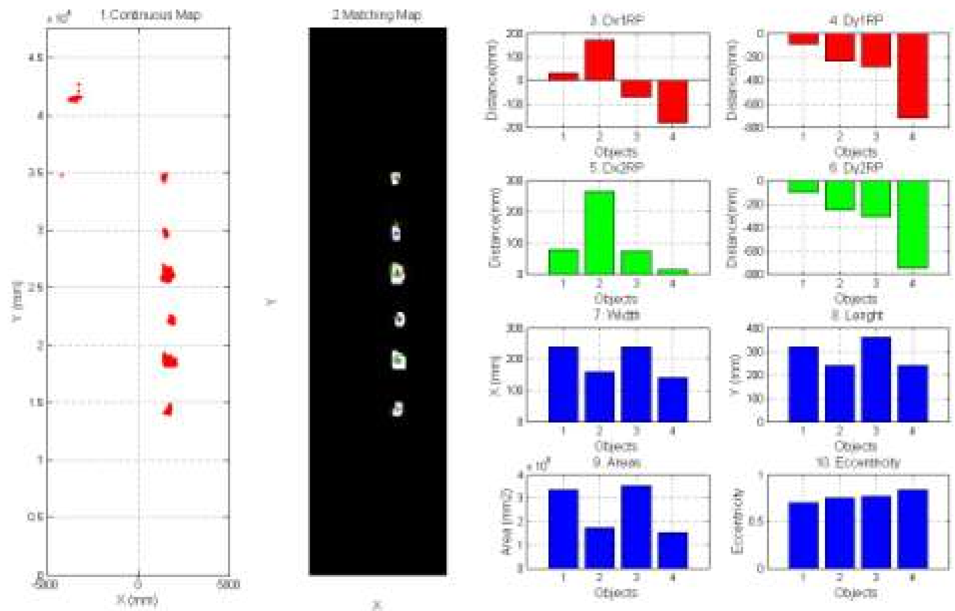
Results of trial number: 1 File name: SSTTS2SS-1.png



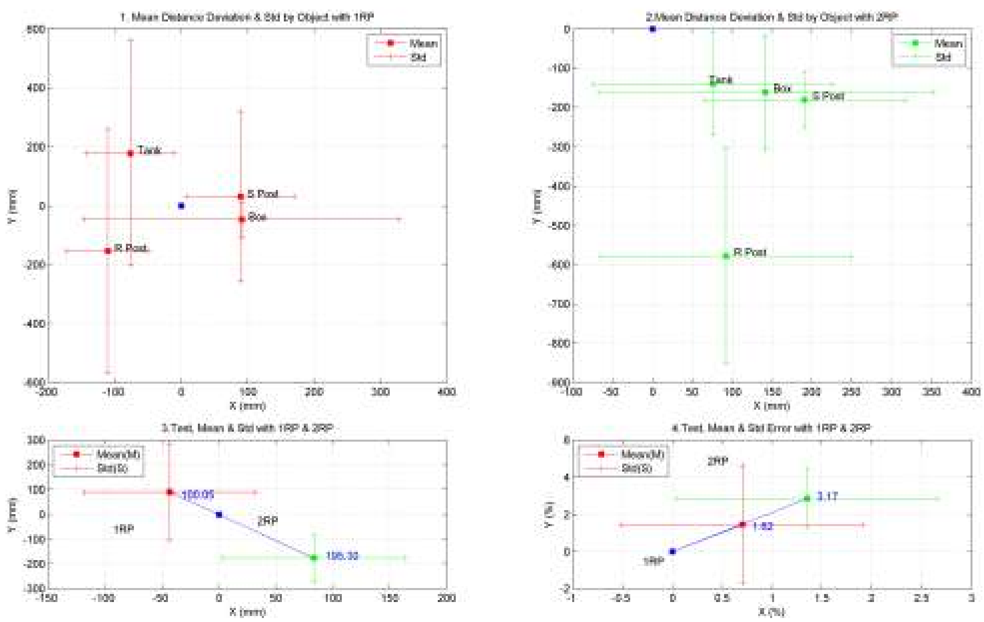
Results of trial number: 2 File name: SSTTS2SS-2.png



Results of trial number: 3 File name: SSTTS2SS-3.png

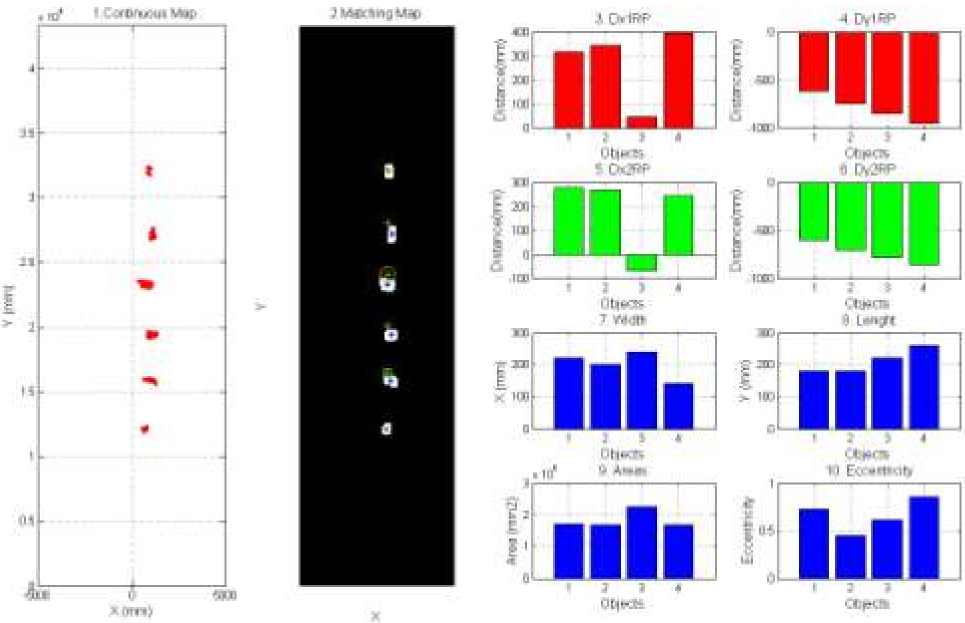


Final results of the tests File name: SSTTS2SS-T.png

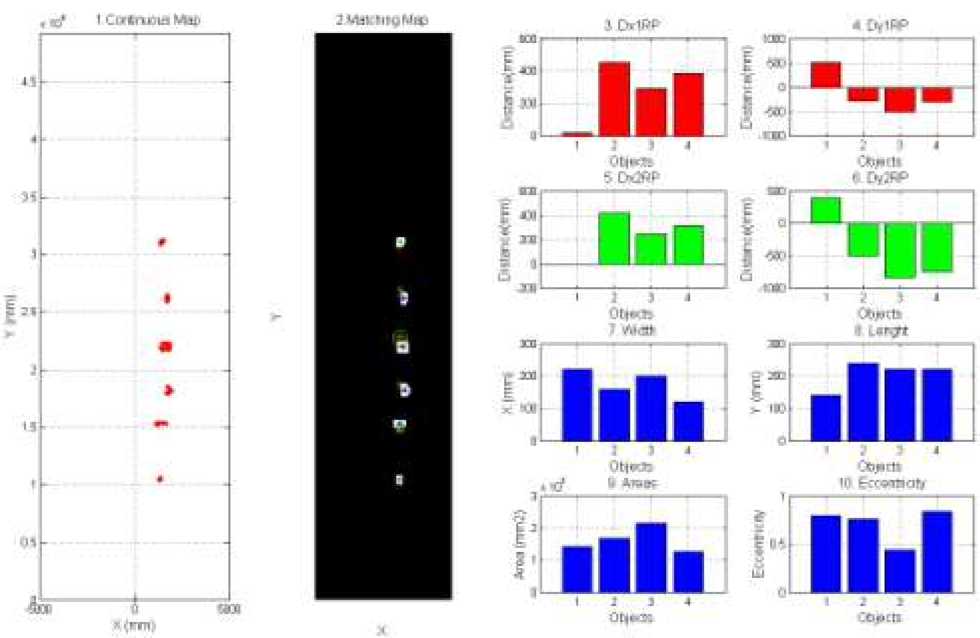


2. Test Name: **NSSTTS2SS**

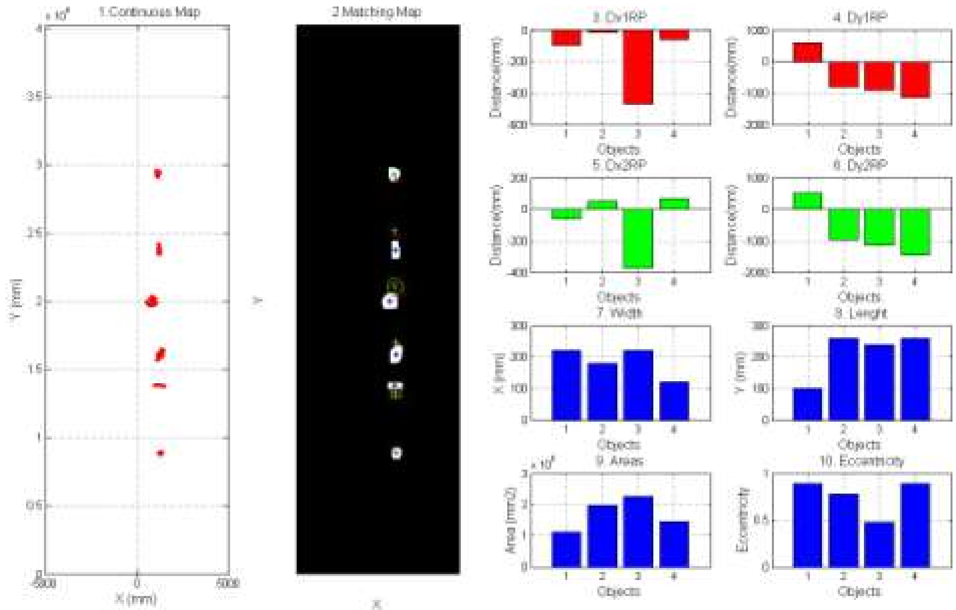
Results of trial number: 1 File name: NSSTTS2SS-1.png



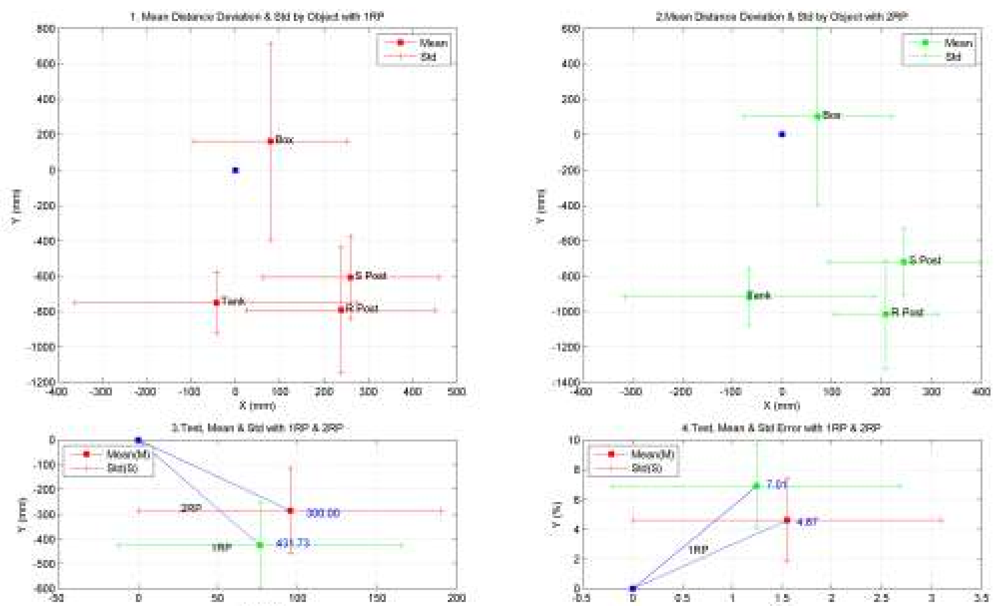
Results of trial number: 2 File name: NSSTTS2SS-2.png



Results of trial number: 3 File name: NSSTTS2SS-3.png

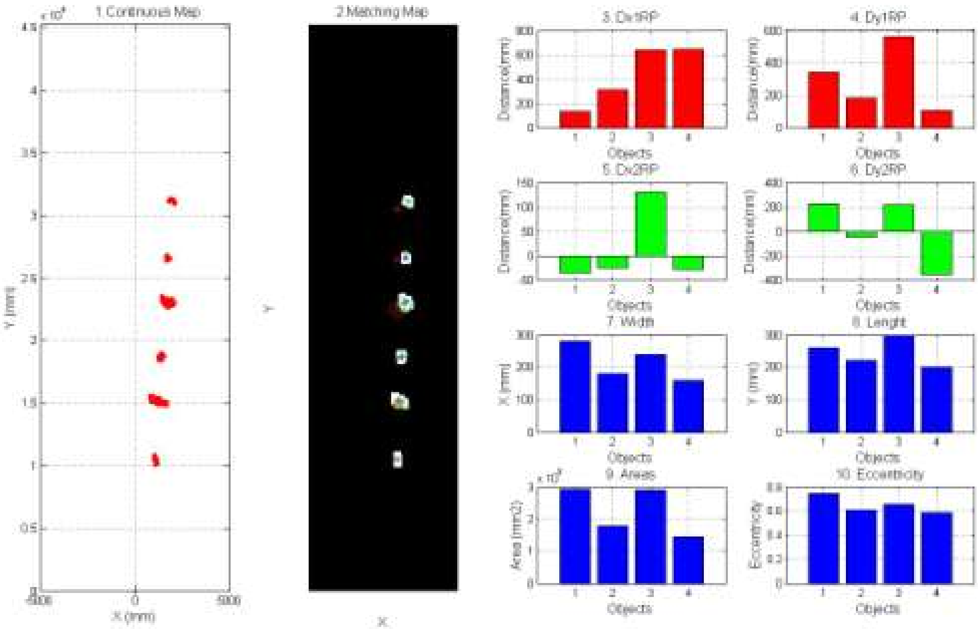


Final results of the tests File name: NSSTTS2SS-T.png

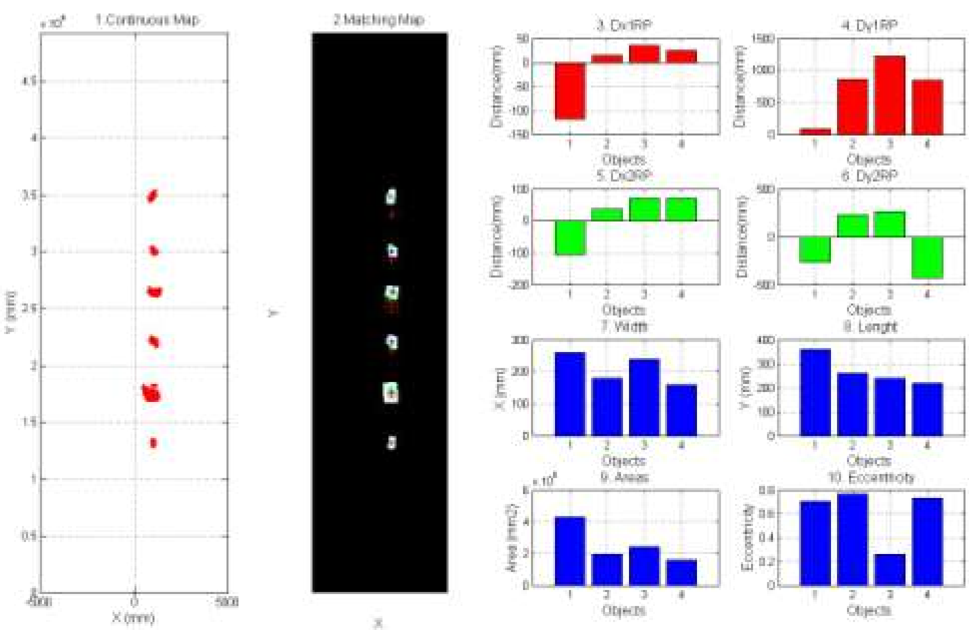


3. Test Name: **SRTTS2SS**

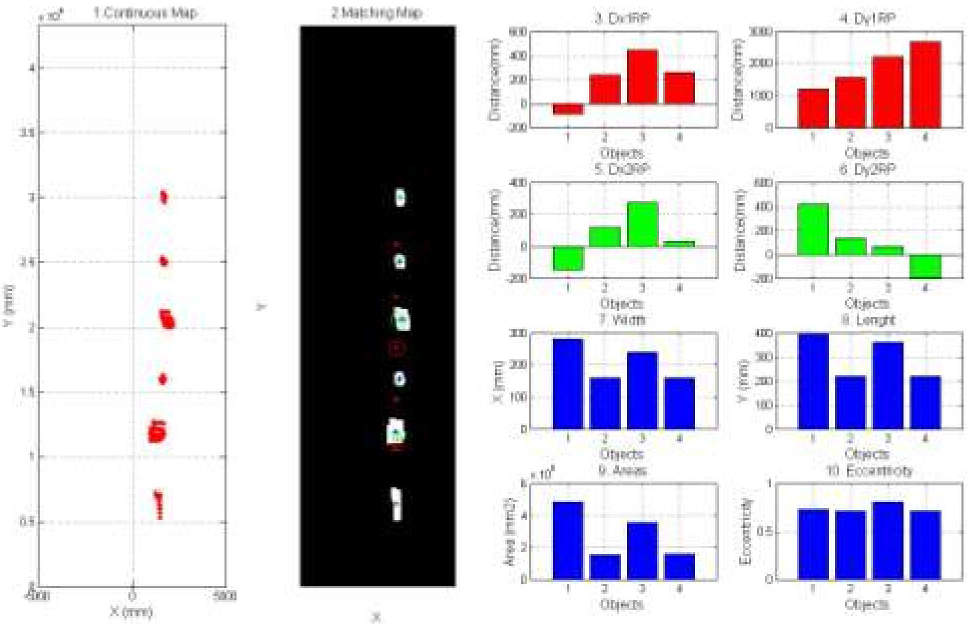
Results of trial number: 1 File name: SRTTS2SS-1.png



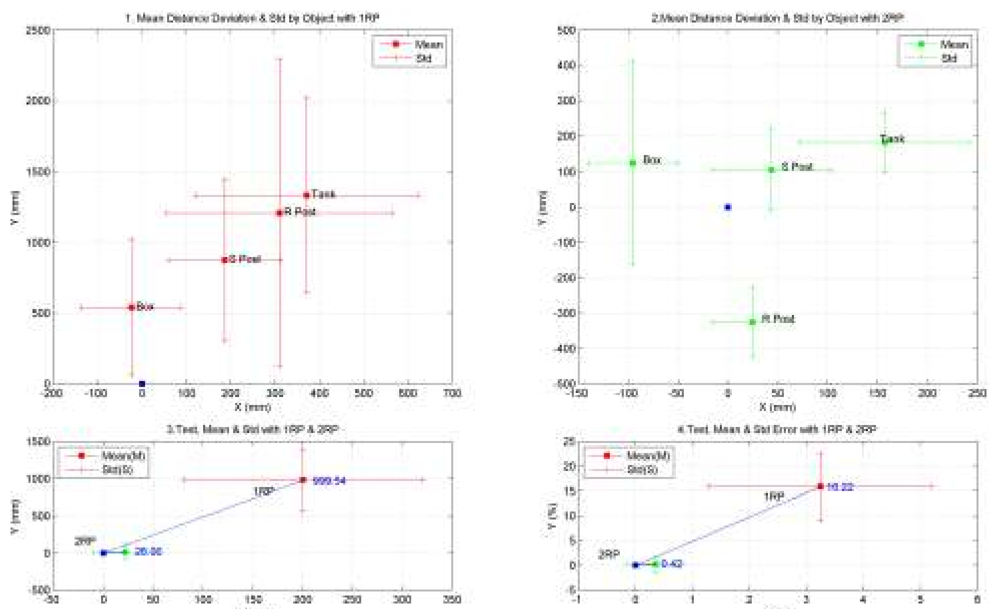
Results of trial number: 2 File name: SRTTS2SS-2.png



Results of trial number: 3 File name: SRTTS2SS-3.png

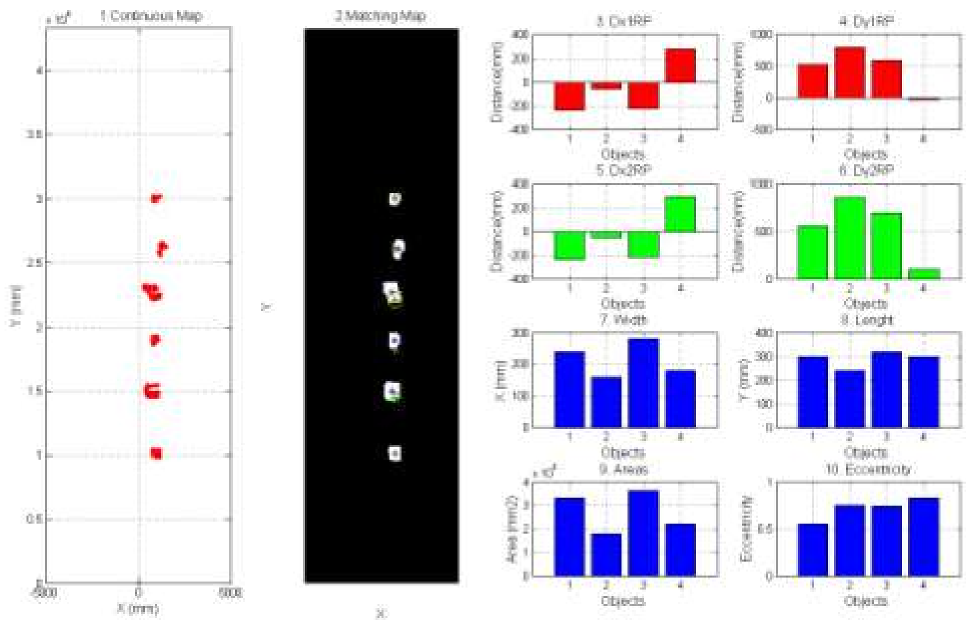


Final results of the tests File name: SRTTS2SS-T.png

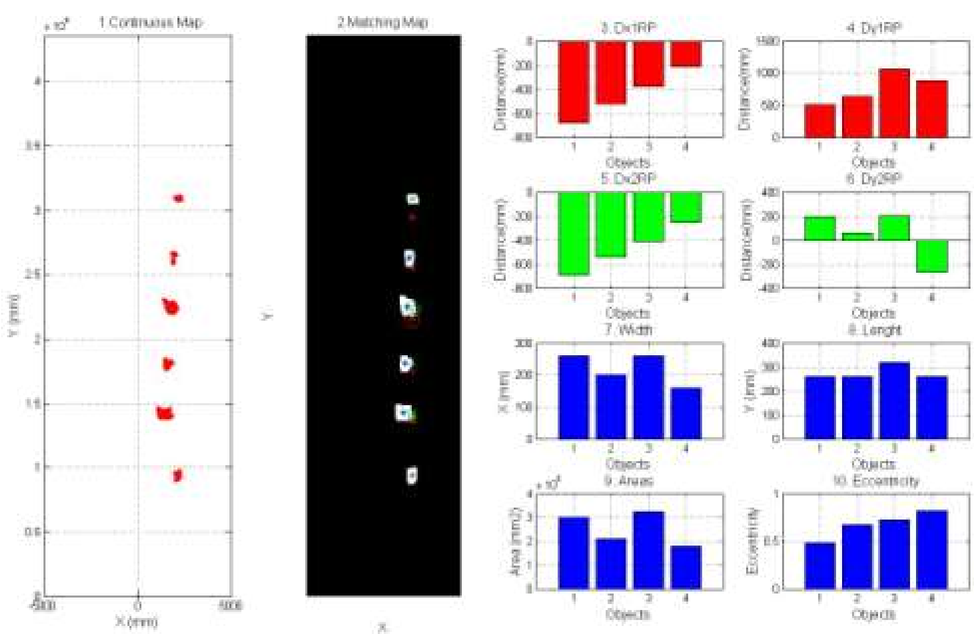


4. Test Name: **NSRTTS2SS**

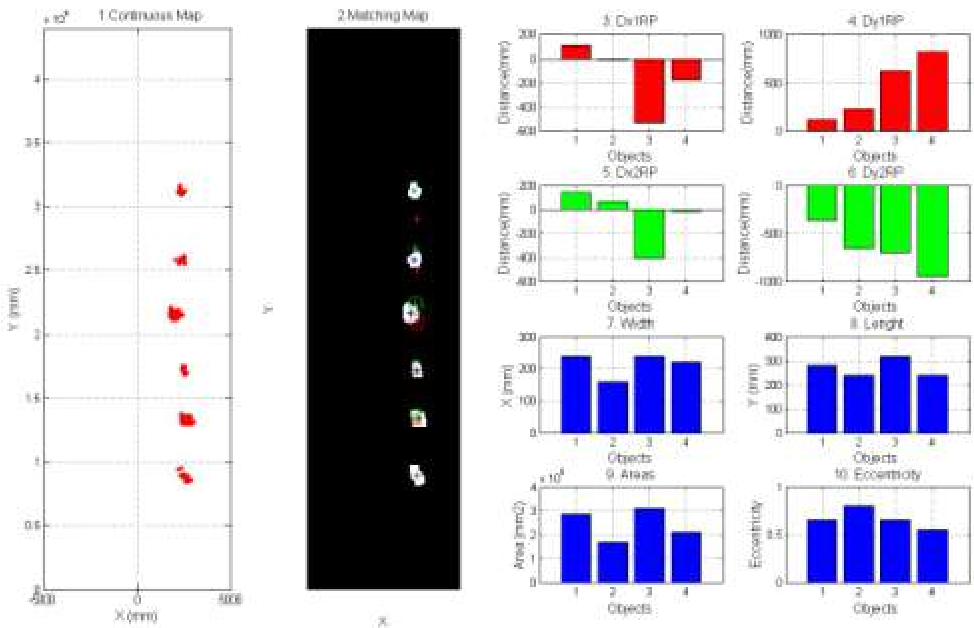
Results of trial number: 1 File name: NSRTTS2SS-1.png



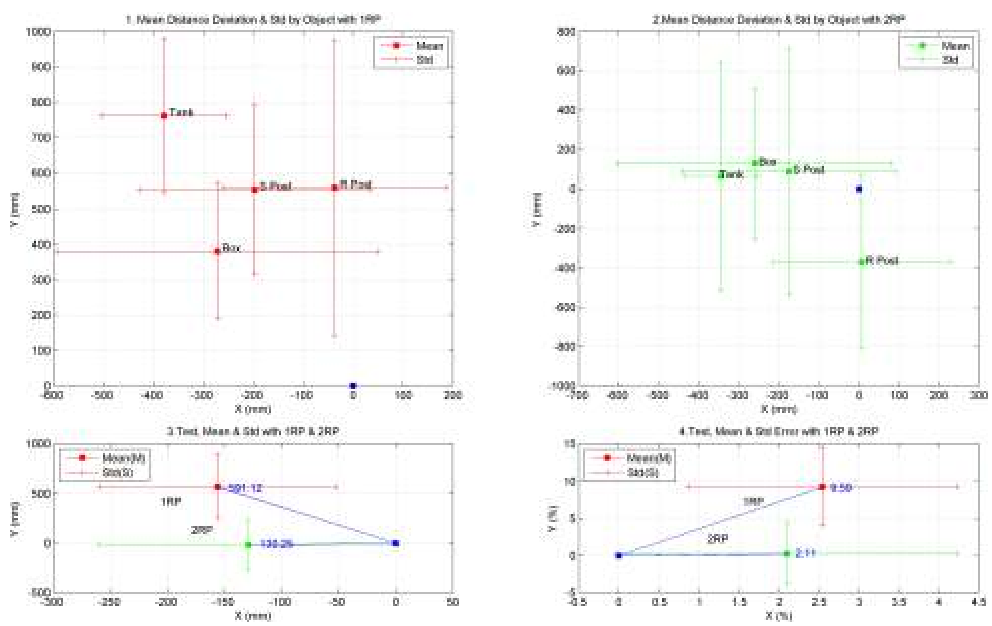
Results of trial number: 2 File name: NSRTTS2SS-2.png



Results of trial number: 3 File name: NSRTTS2SS-3.png

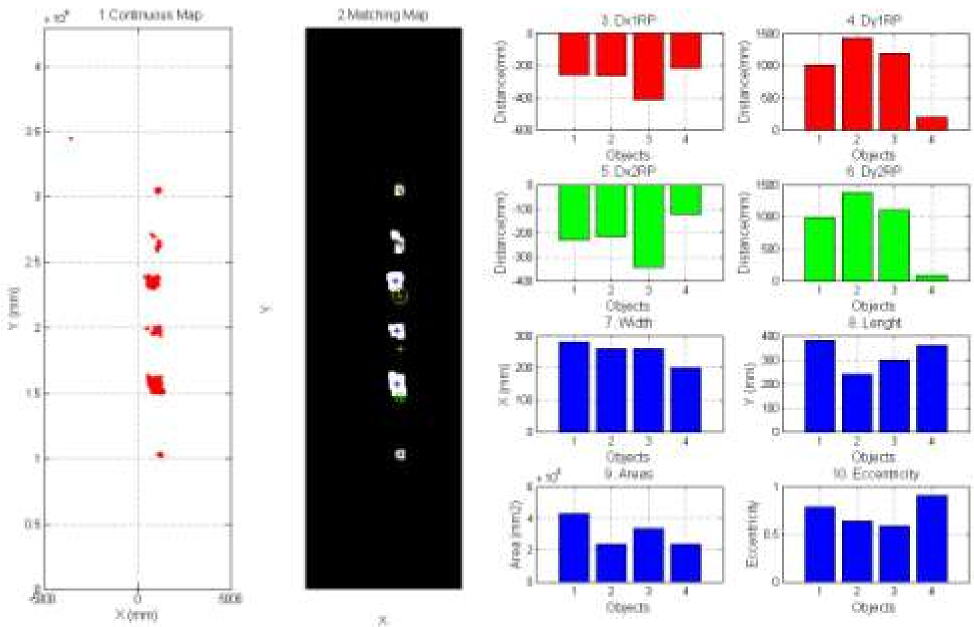


Final results of the tests File name: NSRTTS2SS-T.png

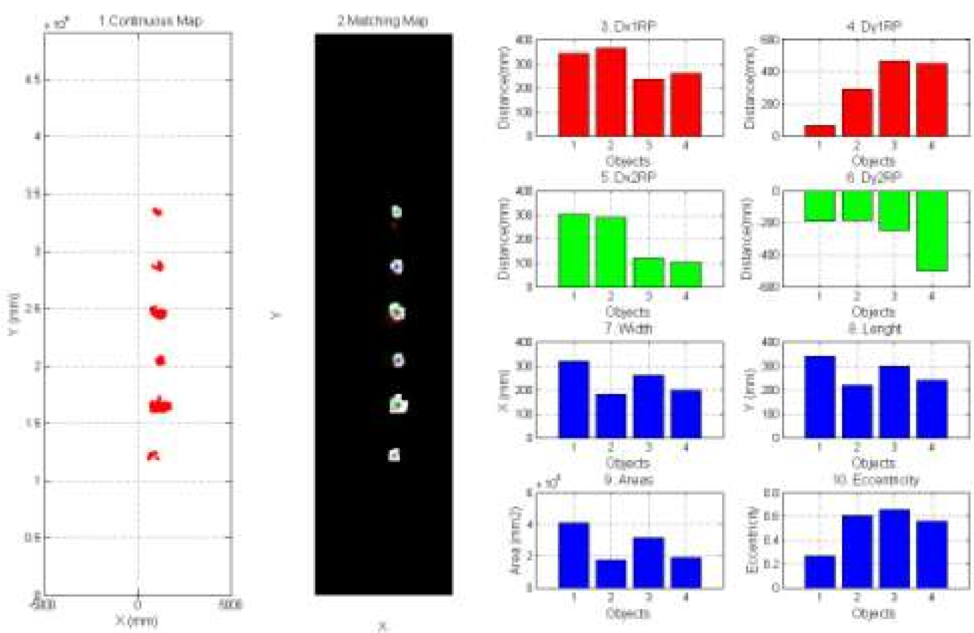


5. Test Name: **SPTTS2SS**

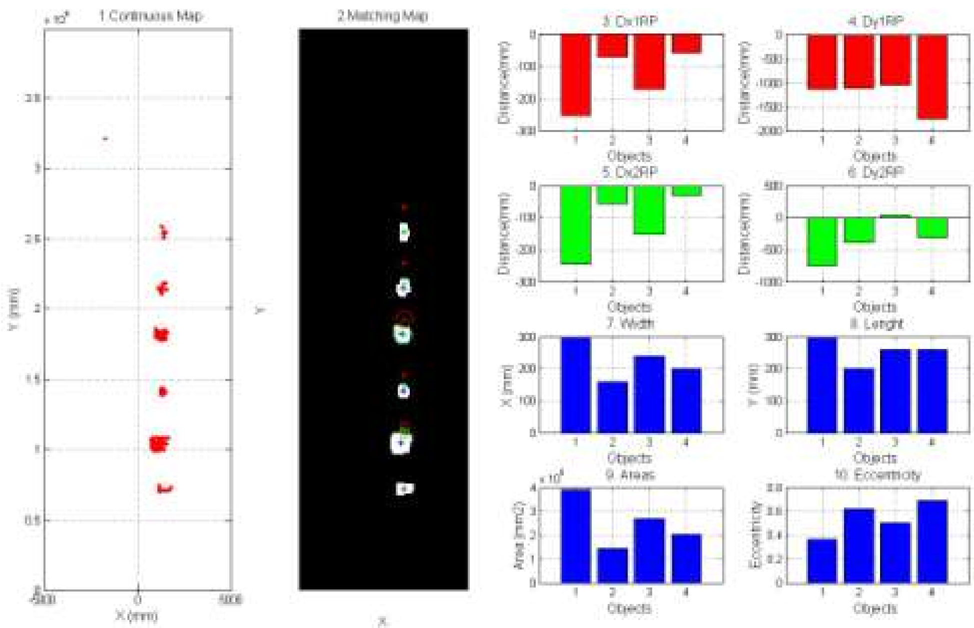
Results of trial number: 1 File name: SPTTS2SS-1.png



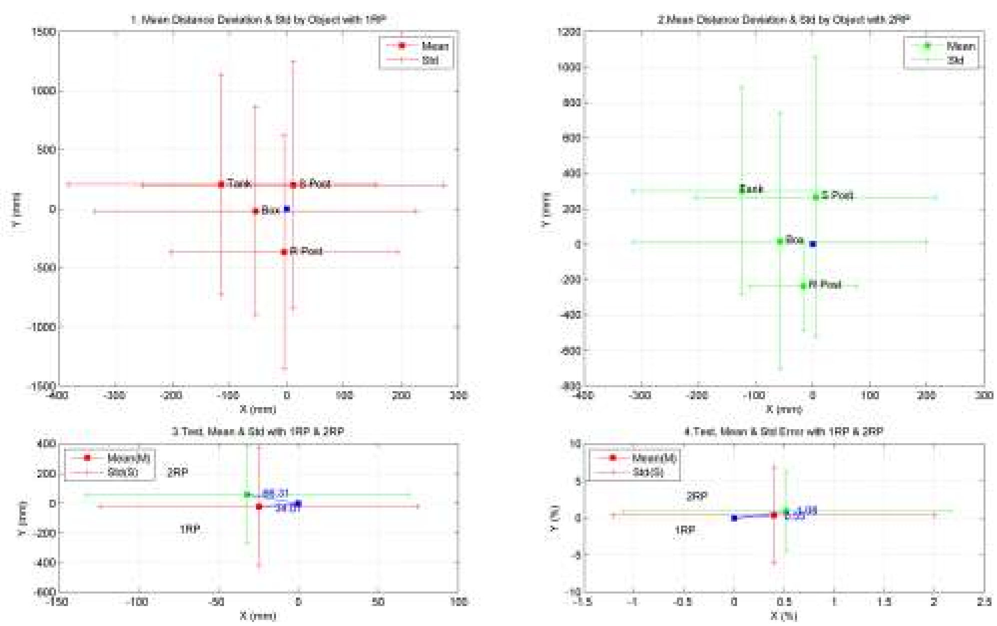
Results of trial number: 2 File name: SPTTS2SS-2.png



Results of trial number: 3 File name: SPTTS2SS-3.png

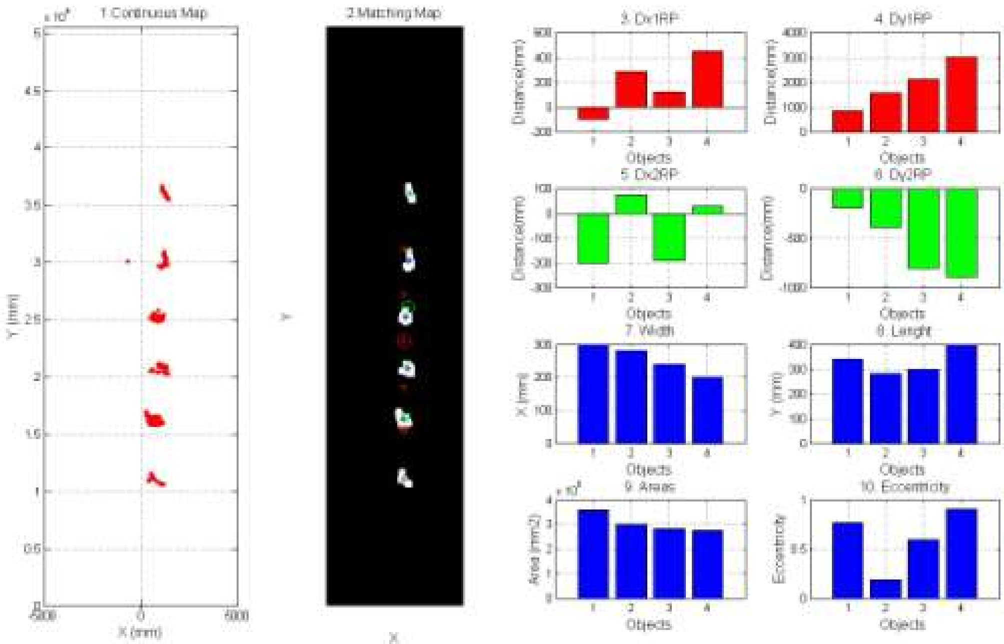


Final results of the tests File name: SPTTS2SS-T.png

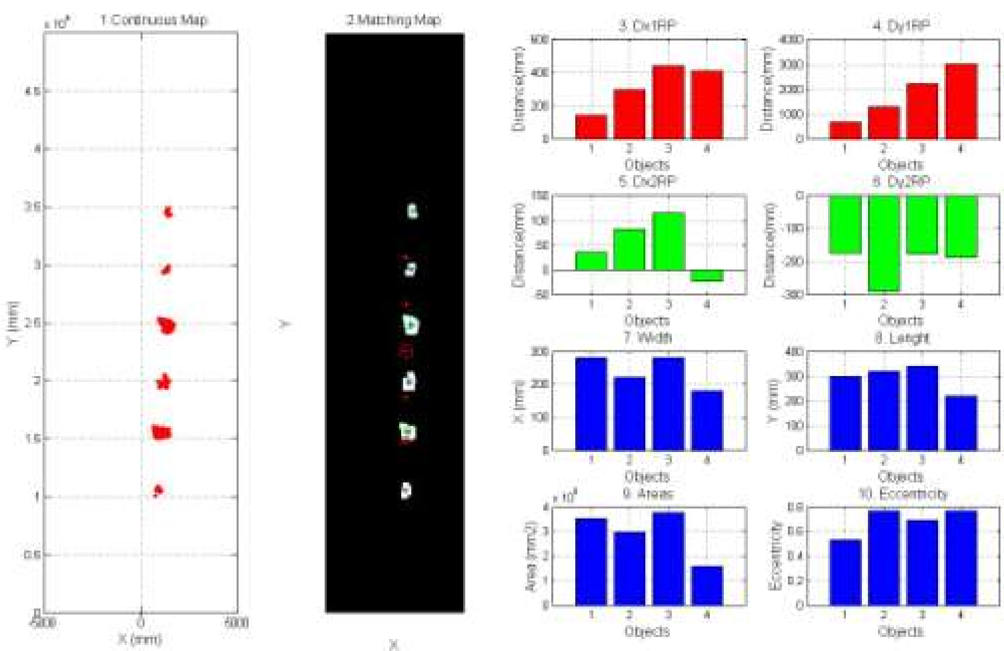


6. Test Name: **NSPTTS2SS**

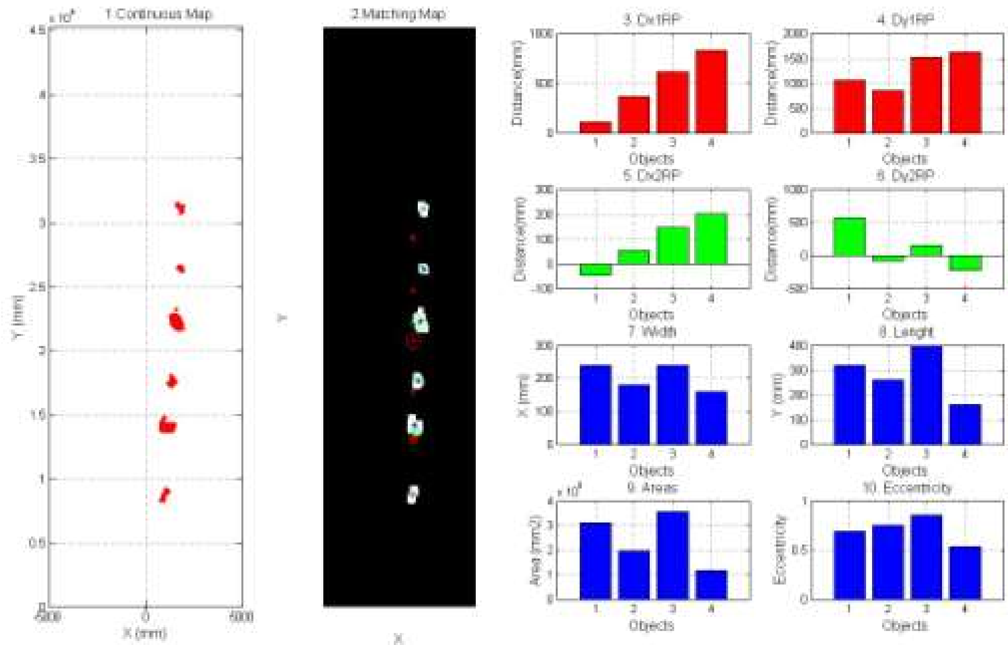
Results of trial number: 1 File name: NSPTTS2SS-1.png



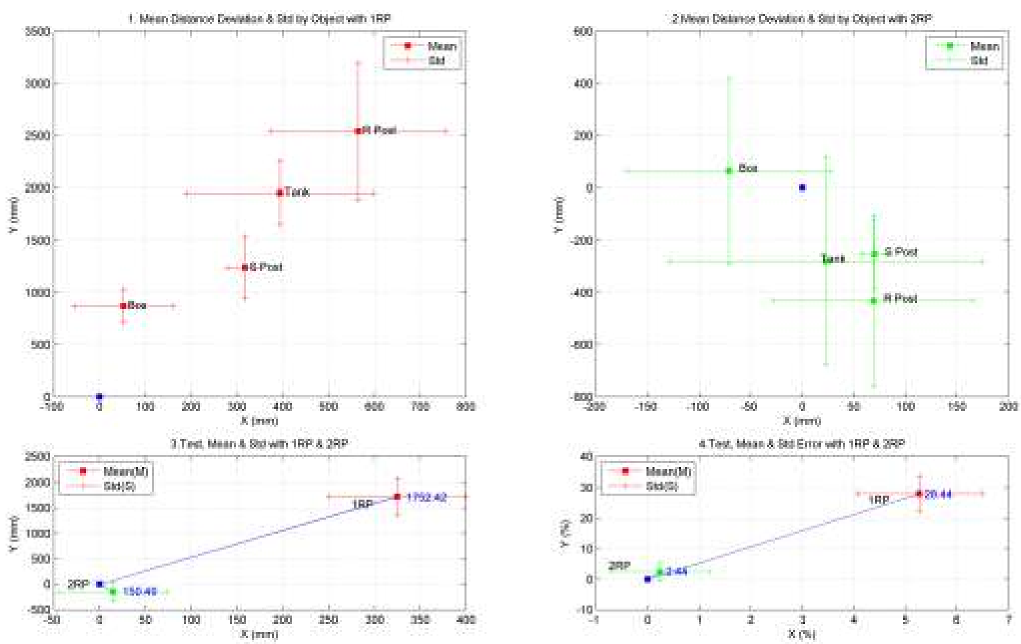
Results of trial number: 2 File name: NSPTTS2SS-2.png



Results of trial number: 3 File name: NSPTTS2SS-3.png

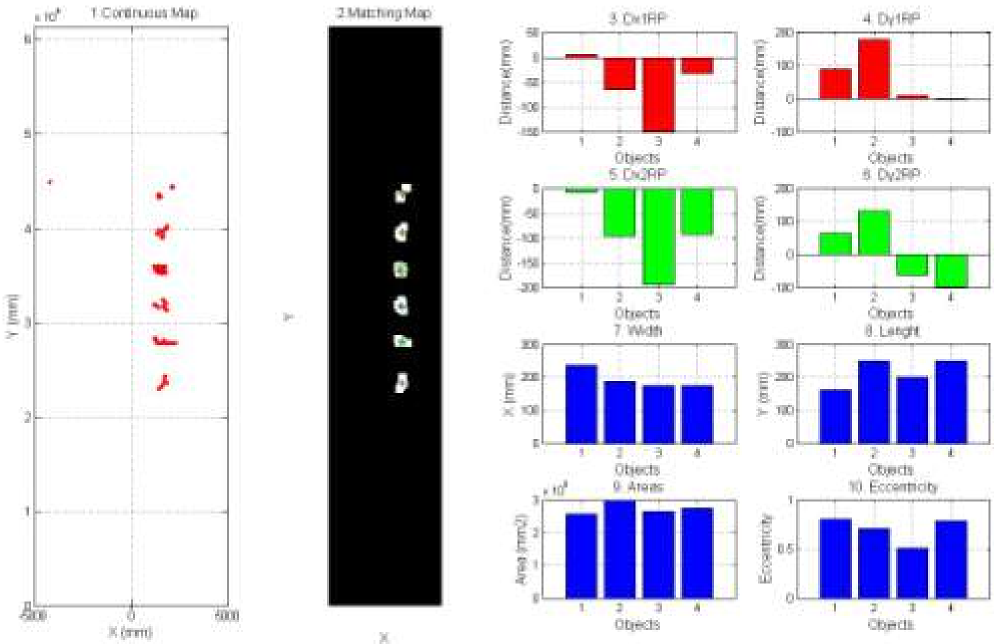


Final results of the tests File name: NSPTTS2SS-T.png

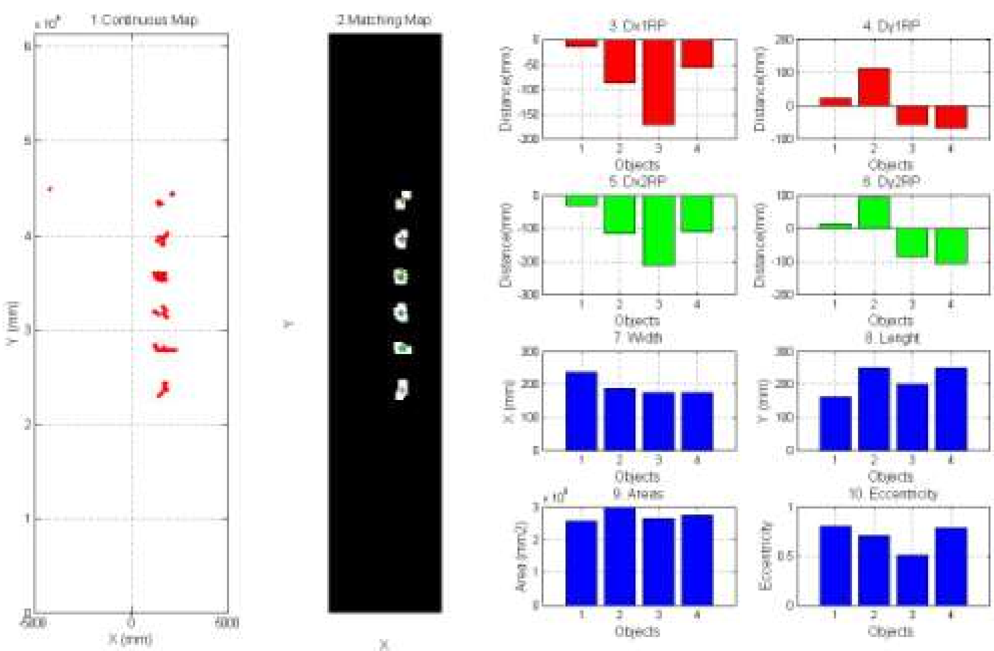


7. Test Name: **SSTTS4SS**

Results of trial number: 1 File name: SSTTS4SS-1.png

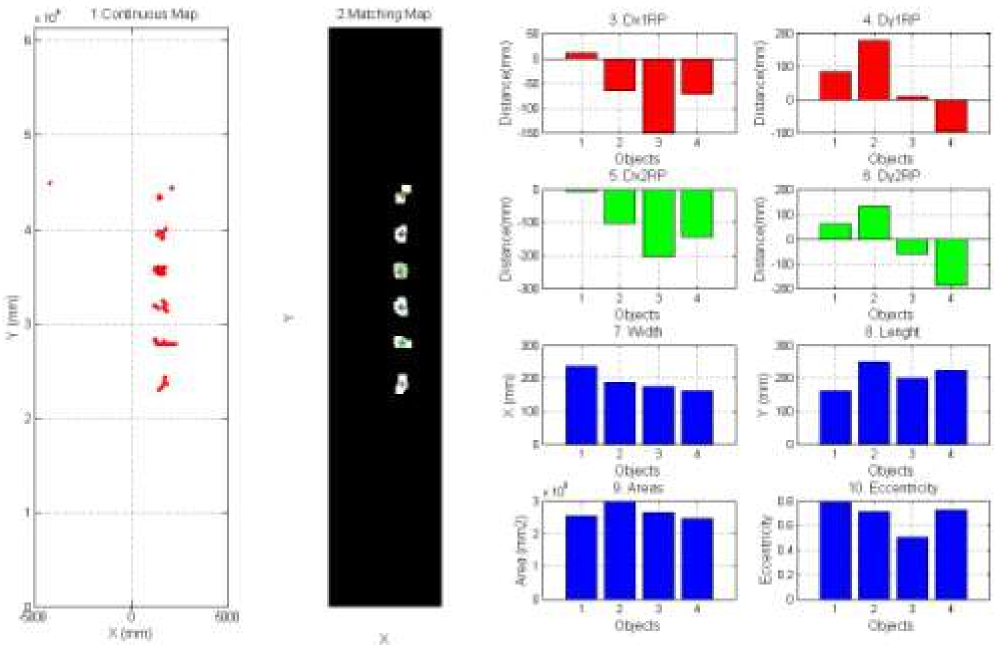


Results of trial number: 2 File name: SSTTS4SS-2.png



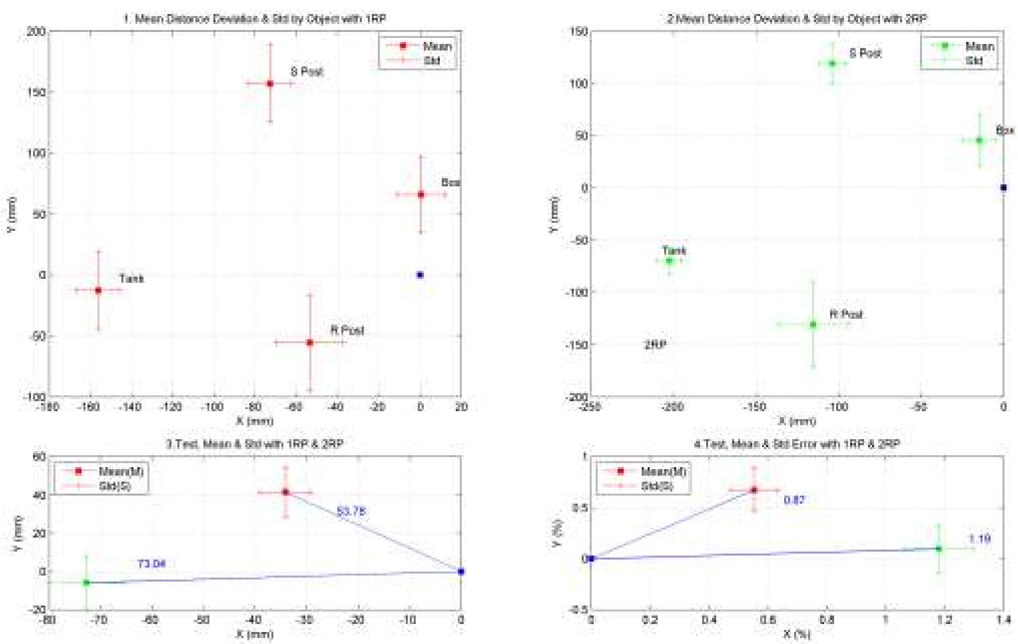
Results of trial number: 3

File name: SSTTS4SS-3.png



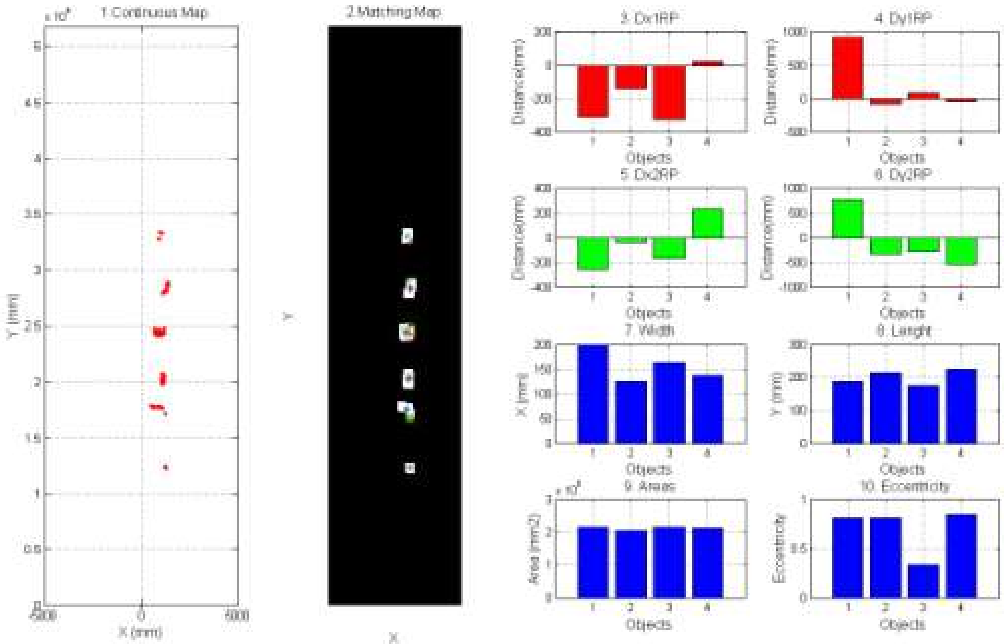
Final results of the tests

File name: SSTTS4SS-T.png

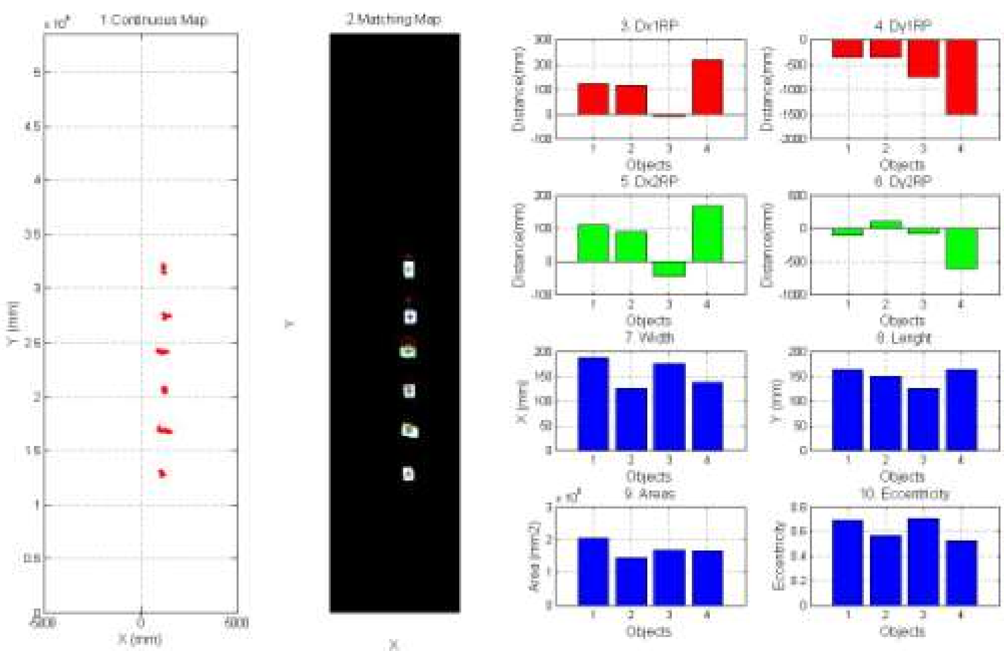


8. Test Name: **NSSTTS4SS**

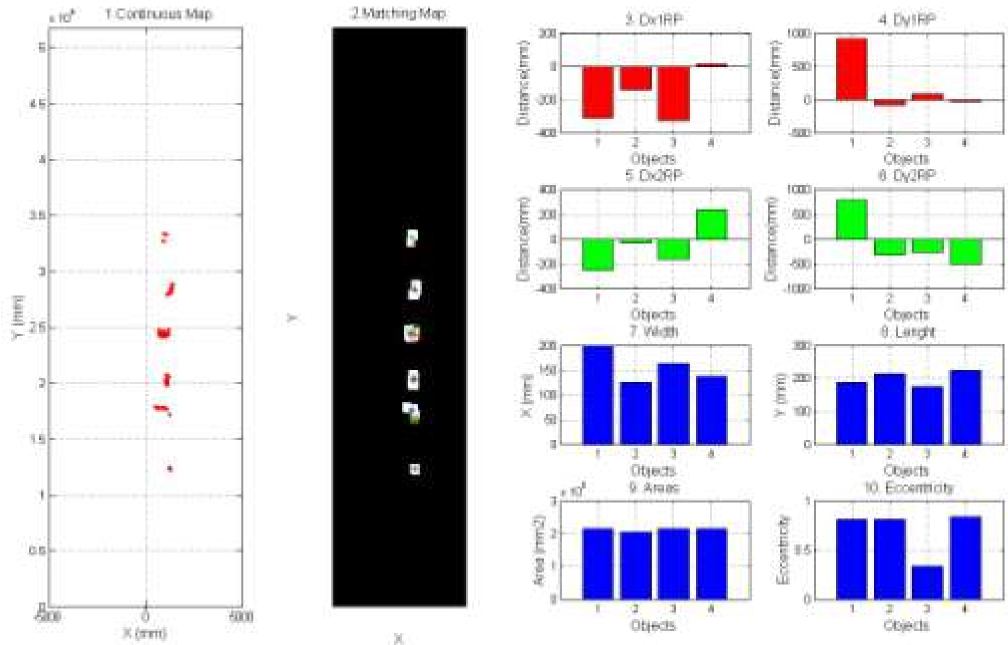
Results of trial number: 1 File name: NSSTTS4SS-1.png



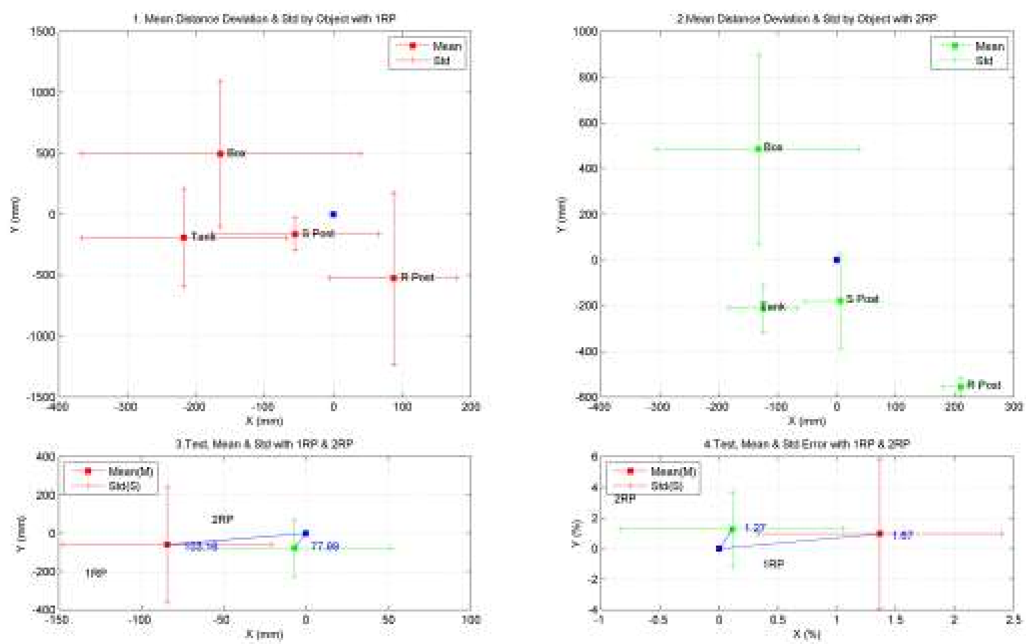
Results of trial number: 2 File name: NSSTTS4SS-2.png



Results of trial number: 3 File name: NSSTTS4SS-3.png

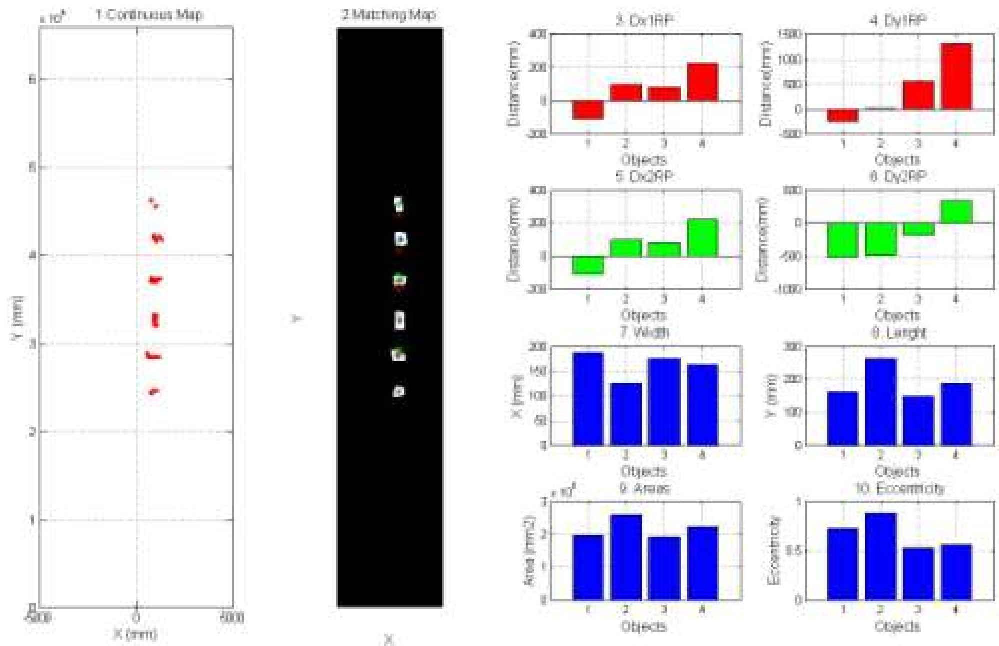


Final results of the tests File name: NSSTTS4SS-T.png

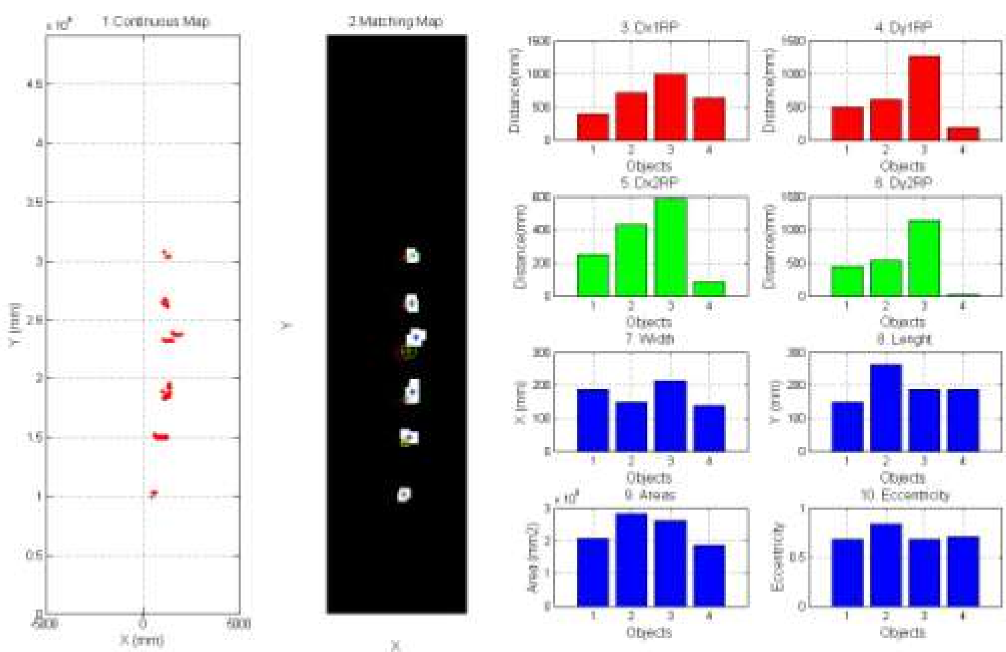


9. Test Name: **SRTTS4SS**

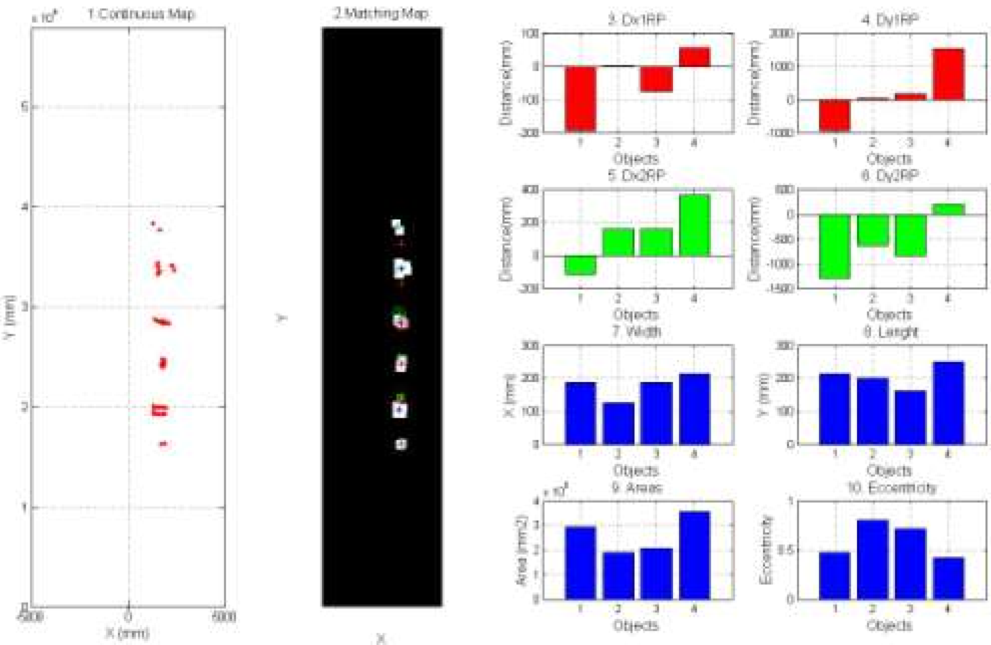
Results of trial number: 1 File name: SRTTS4SS-1.png



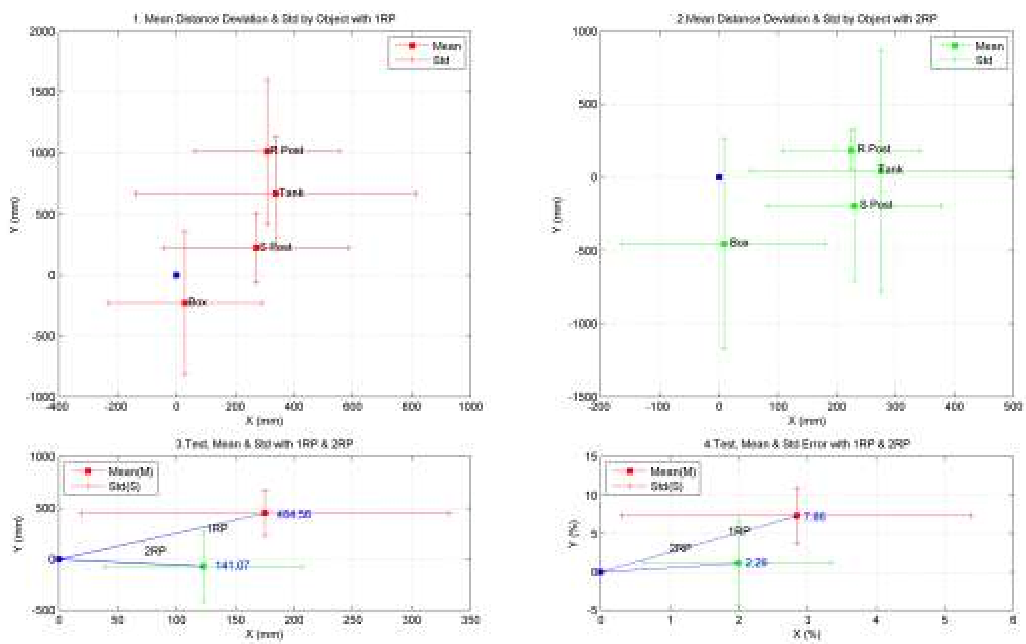
Results of trial number: 2 File name: SRTTS4SS-2.png



Results of trial number: 3 File name: SRTTS4SS-3.png

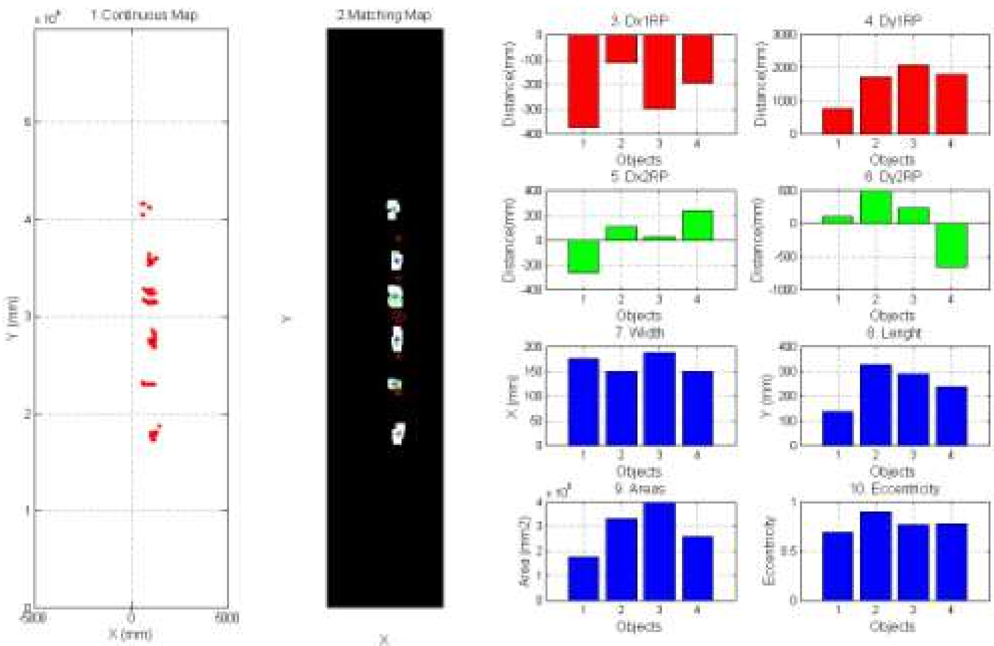


Final results of the tests File name: SRTTS4SS-T.png

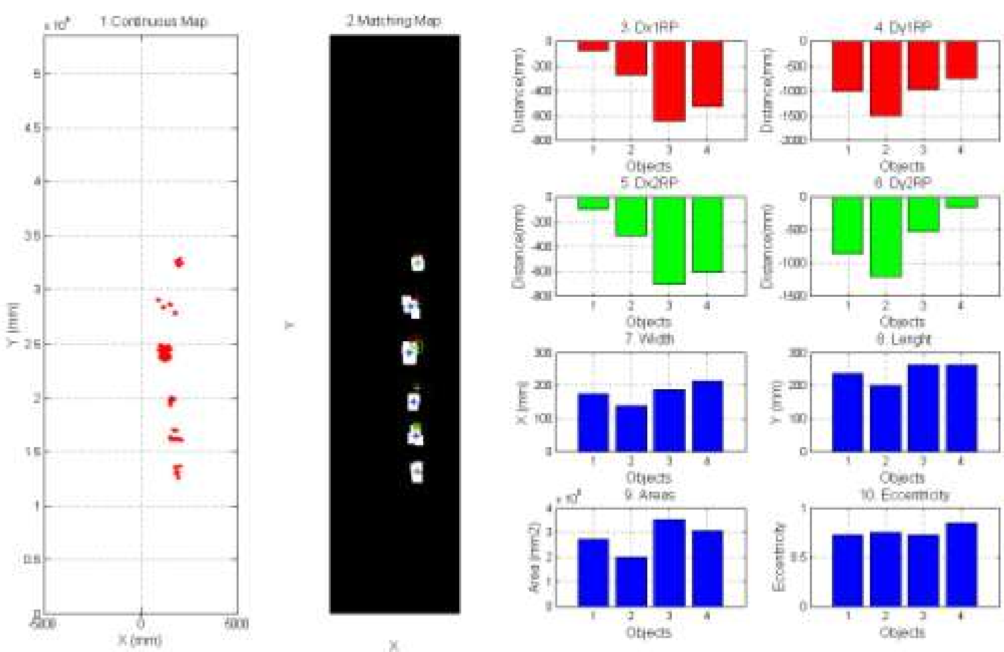


10. Test Name: **NSRTTS4SS**

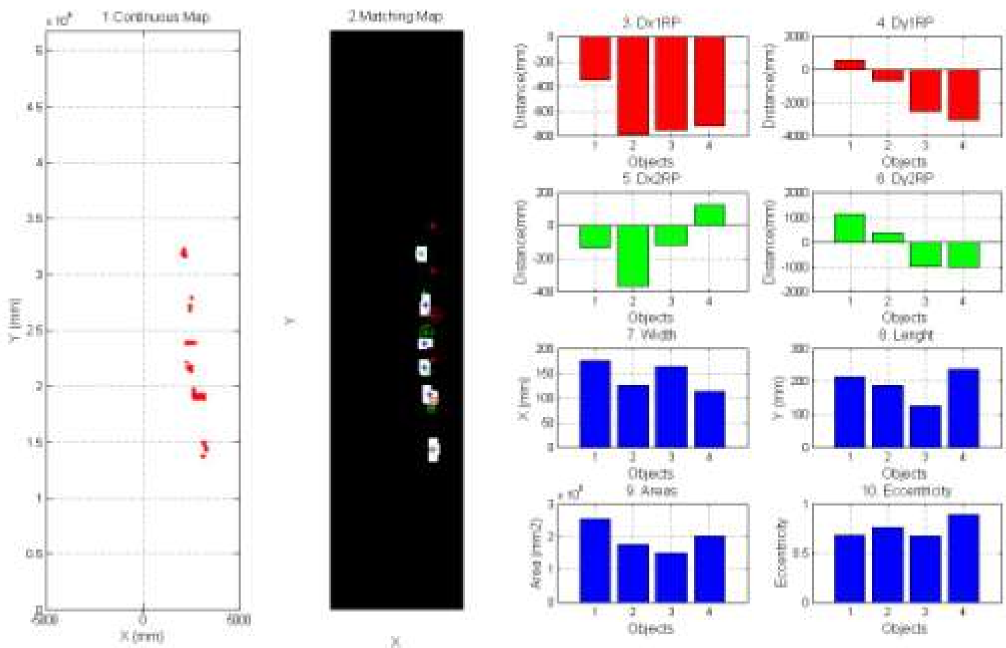
Results of trial number: 1 File name: NSRTTS4SS-1.png



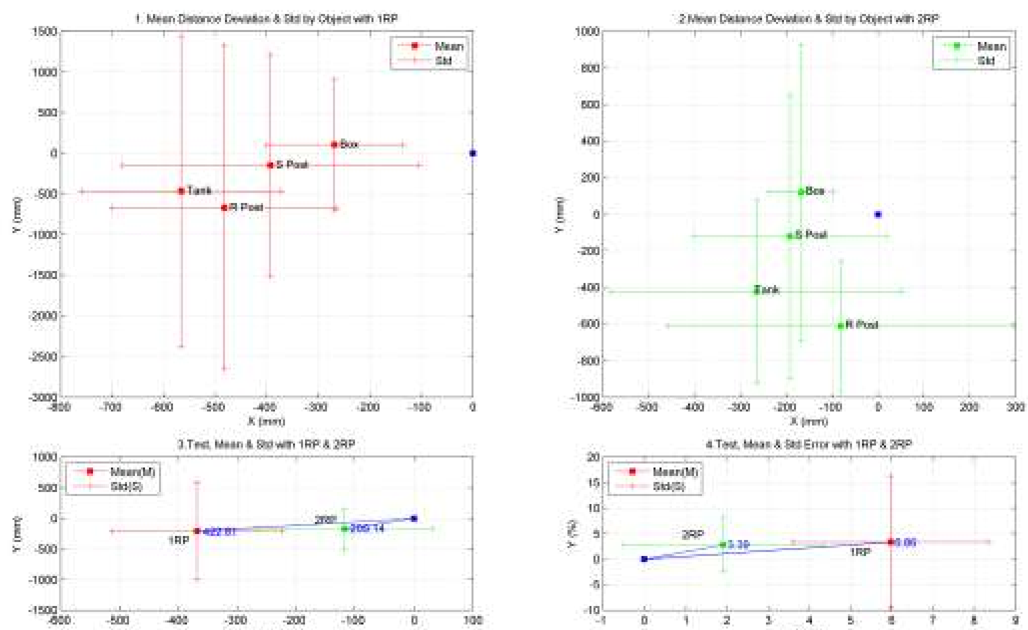
Results of trial number: 2 File name: NSRTTS4SS-2.png



Results of trial number: 3 File name: NSRTTS4SS-3.png

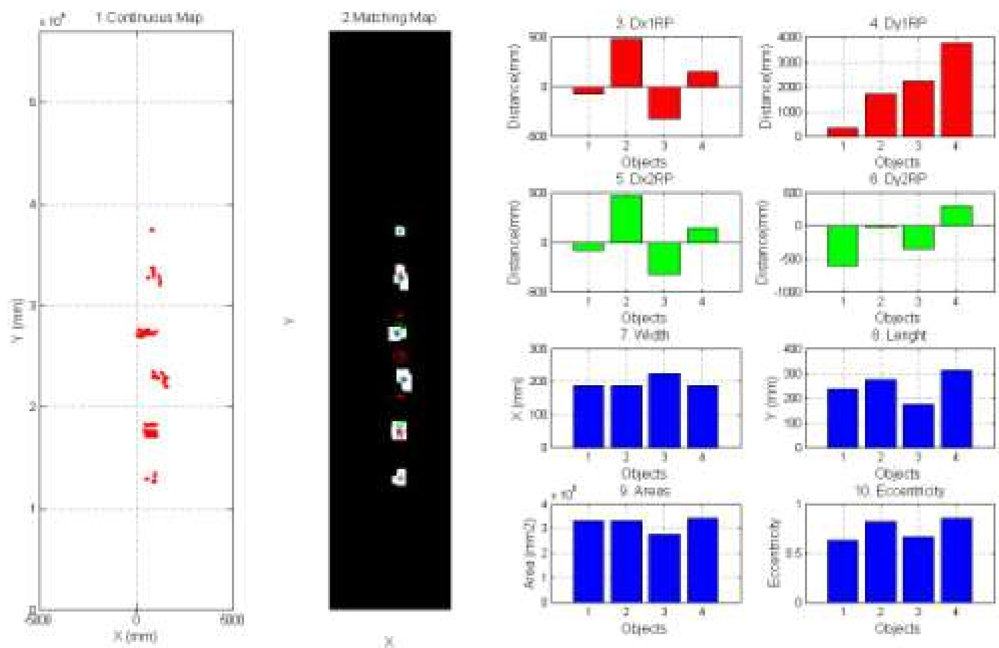


Final results of the tests File name: NSRTTS4SS-T.png

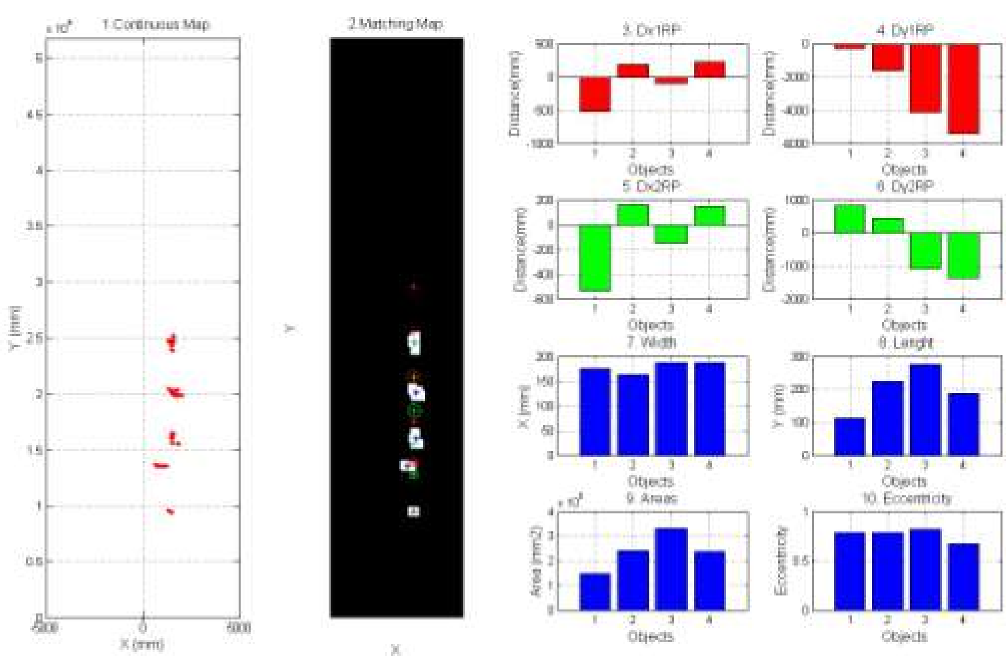


11. Test Name: **SPTTS4SS**

Results of trial number: 1 File name: SPTTS4SS-1.png

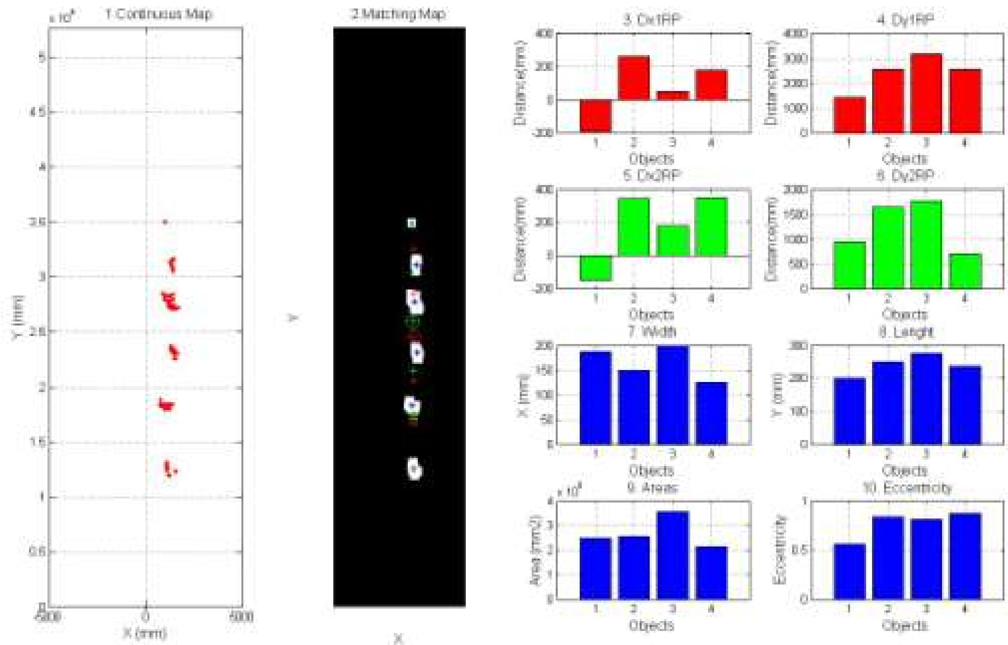


Results of trial number: 2 File name: SPTTS4SS-2.png



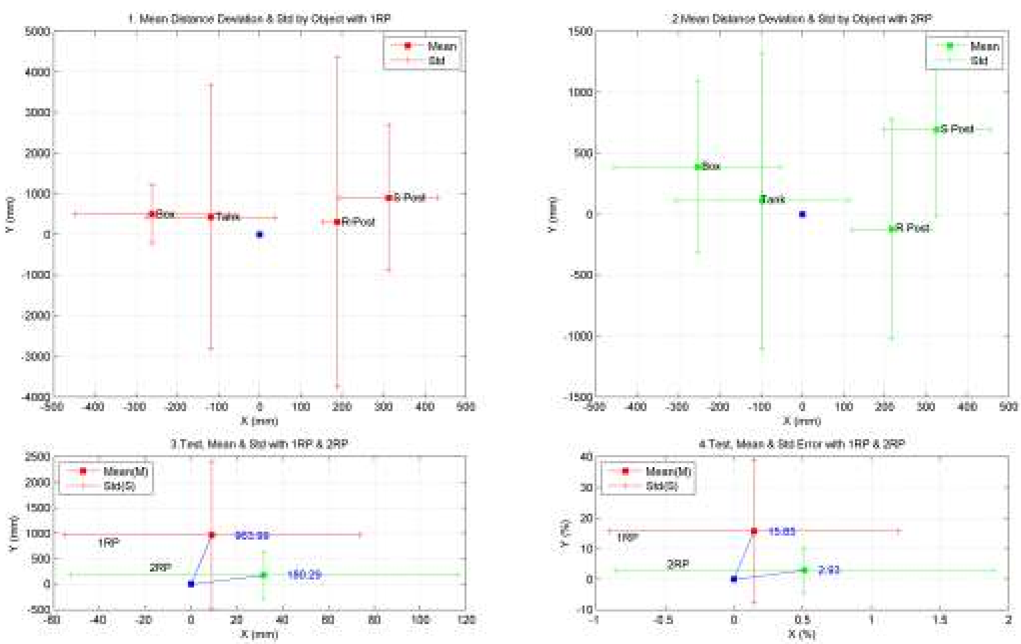
Results of trial number: 3

File name: SPTTS4SS-3.png



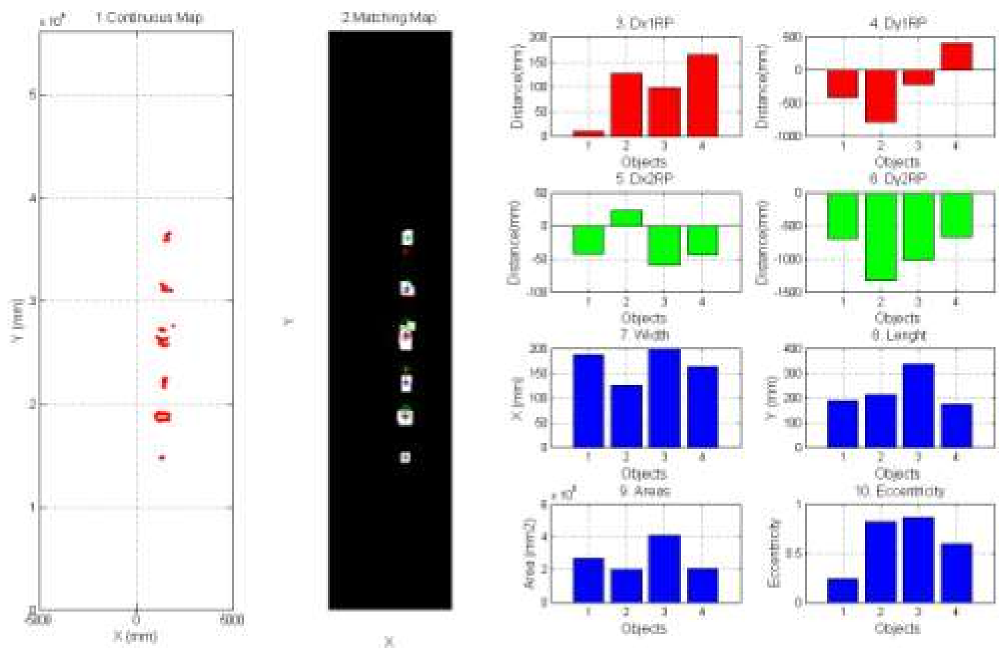
Final results of the tests

File name: SPTTS4SS-T.png

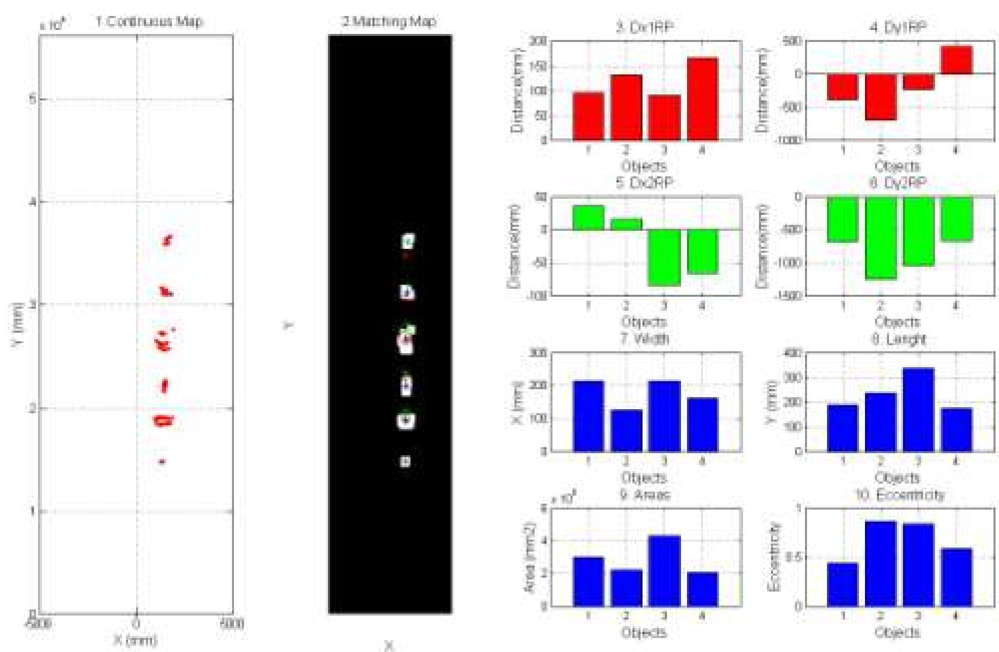


12. Test Name: **NSPTTS4SS**

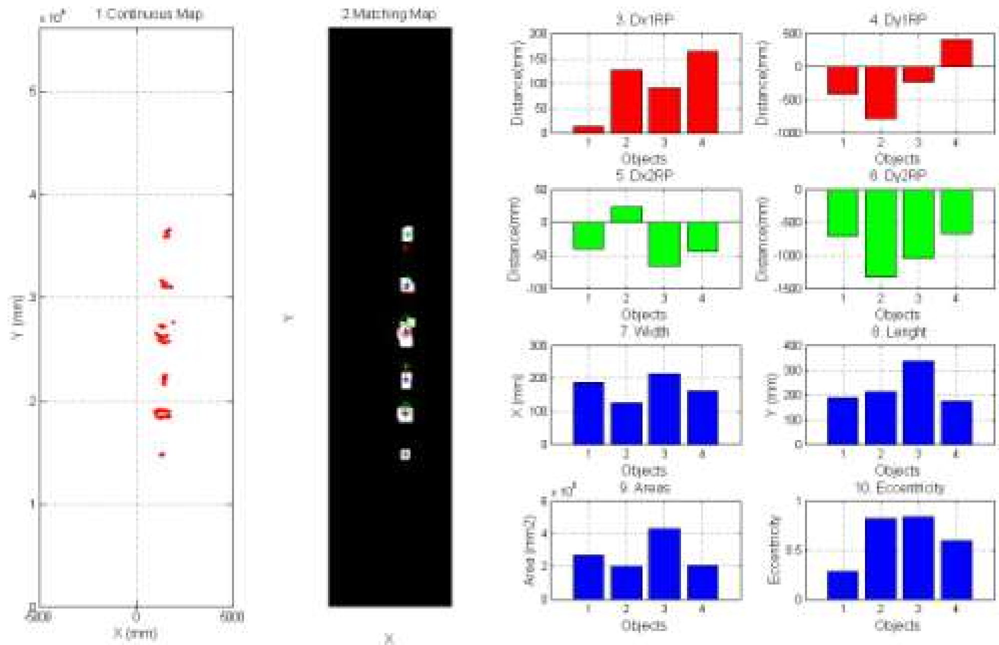
Results of trial number: 1 File name: NSPTTS4SS-1.png



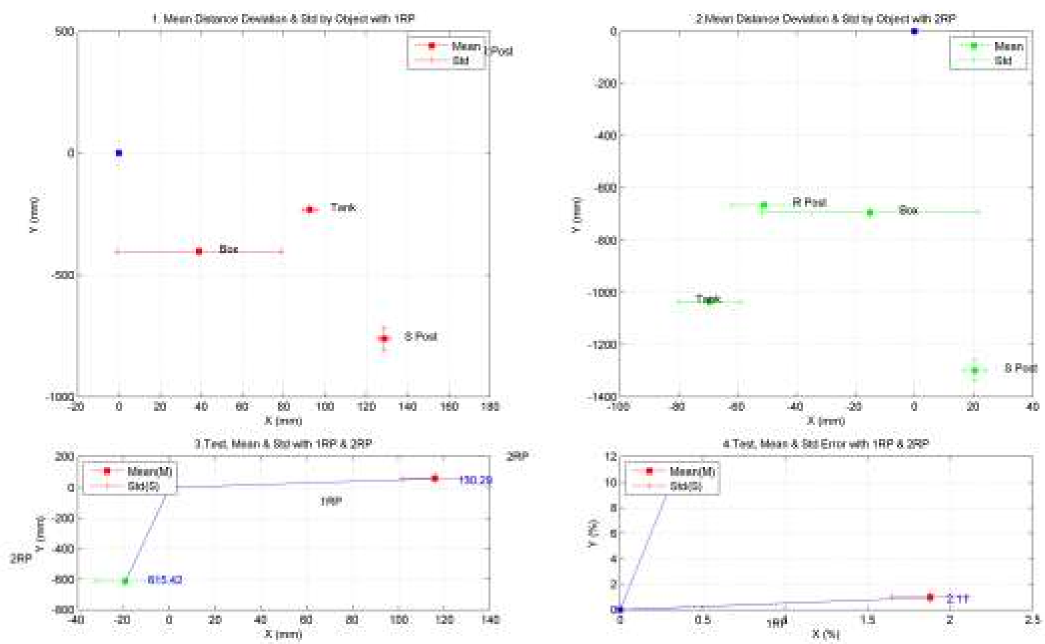
Results of trial number: 2 File name: NSPTTS4SS-2.png



Results of trial number: 3 File name: NSPTTS4SS-3.png

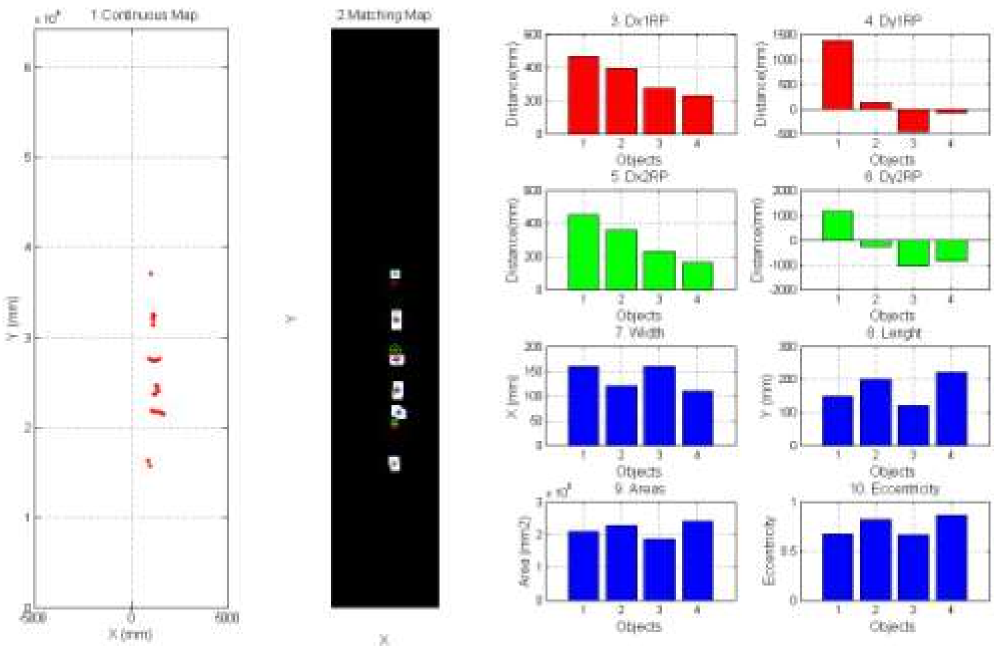


Final results of the tests File name: NSPTTS4SS-T.png

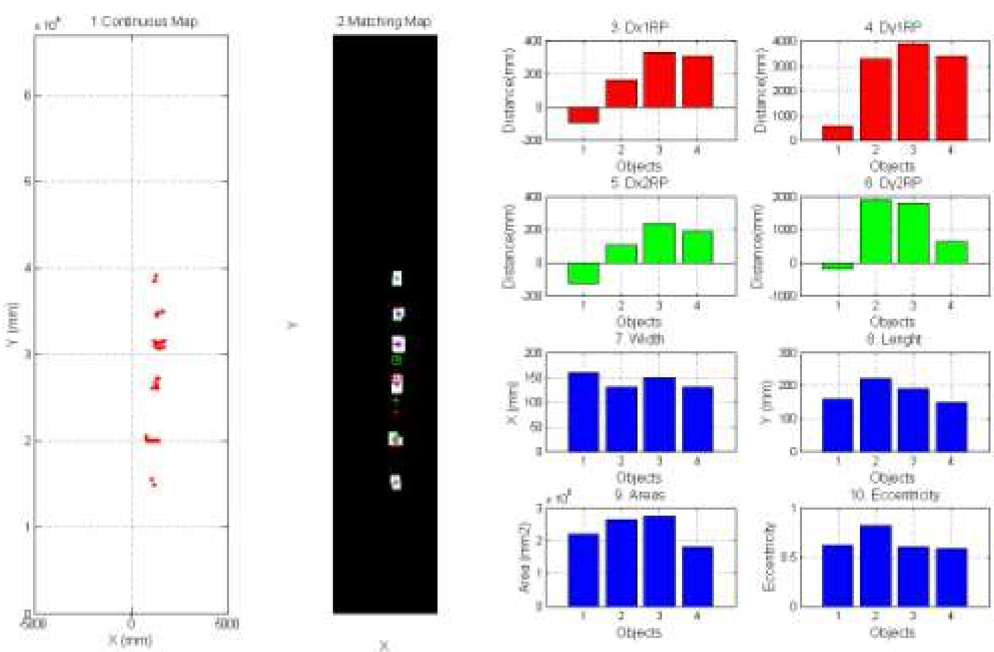


13. Test Name: **SSTTS7SS**

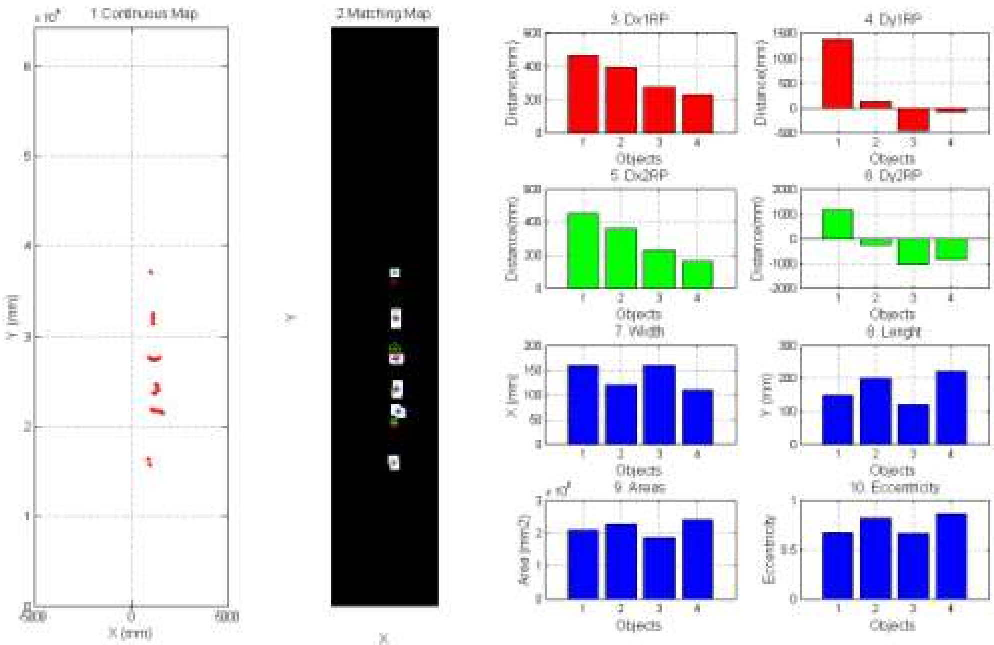
Results of trial number: 1 File name: SSTTS7SS-1.png



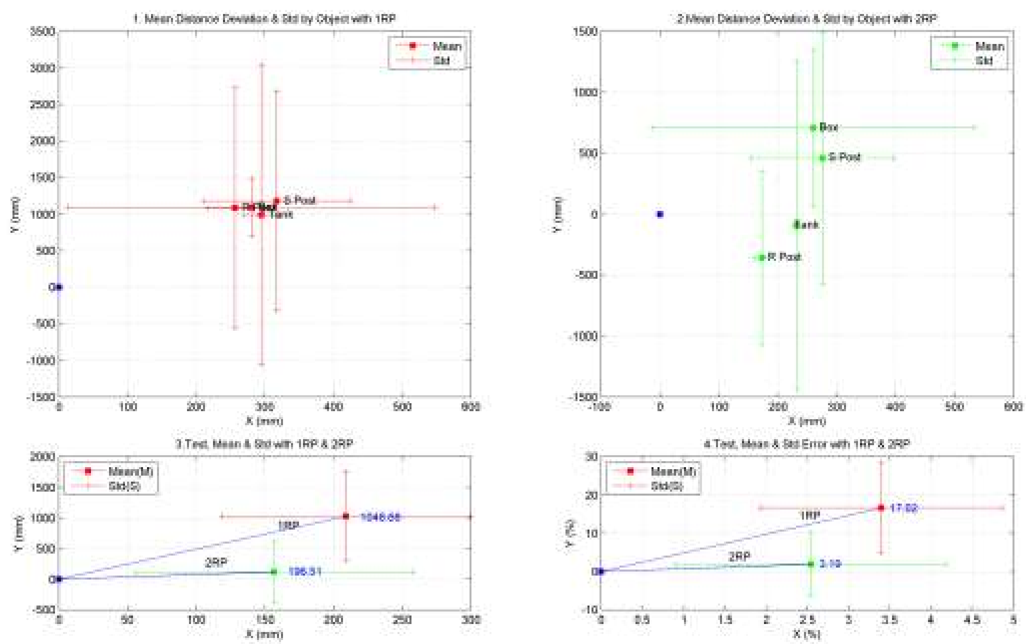
Results of trial number: 2 File name: SSTTS7SS-2.png



Results of trial number: 3 File name: SSTTS7SS-3.png

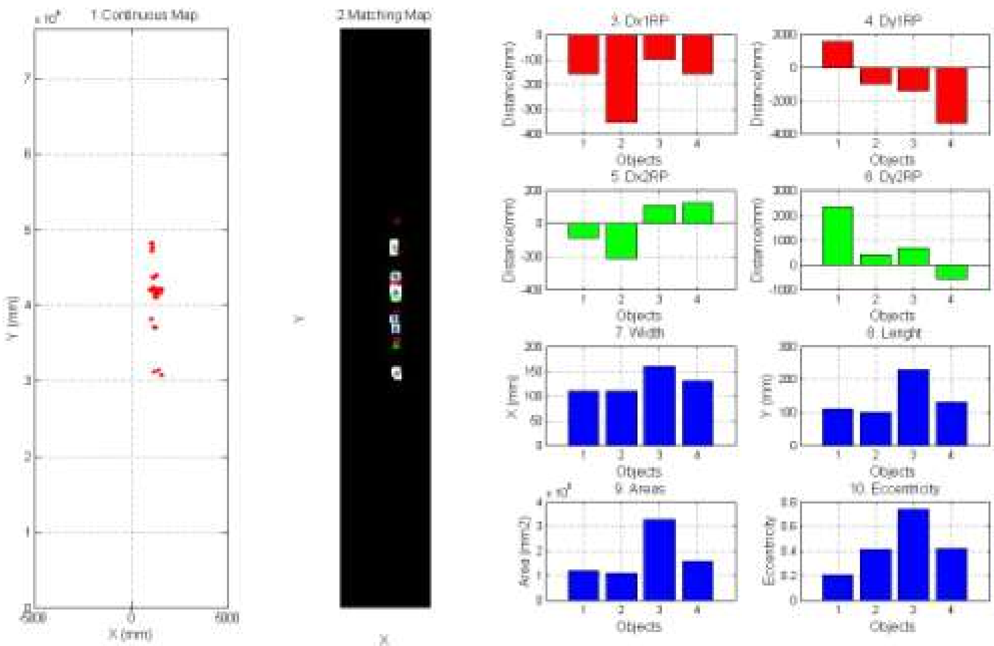


Final results of the tests File name: SSTTS7SS-T.png

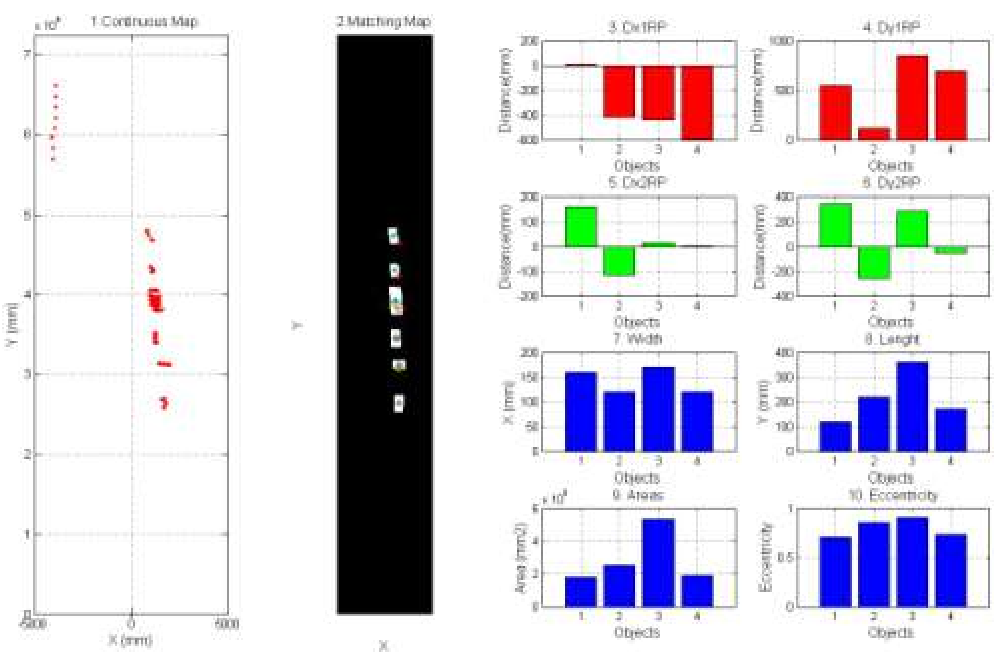


14. Test Name: **NSSTTS7SS**

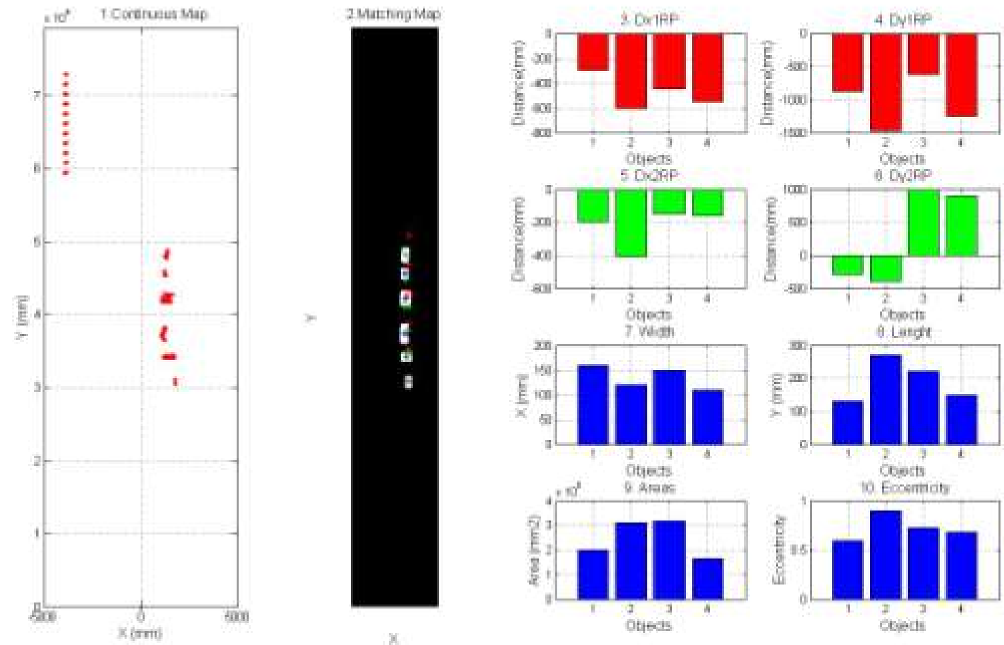
Results of trial number: 1 File name: NSSTTS7SS-1.png



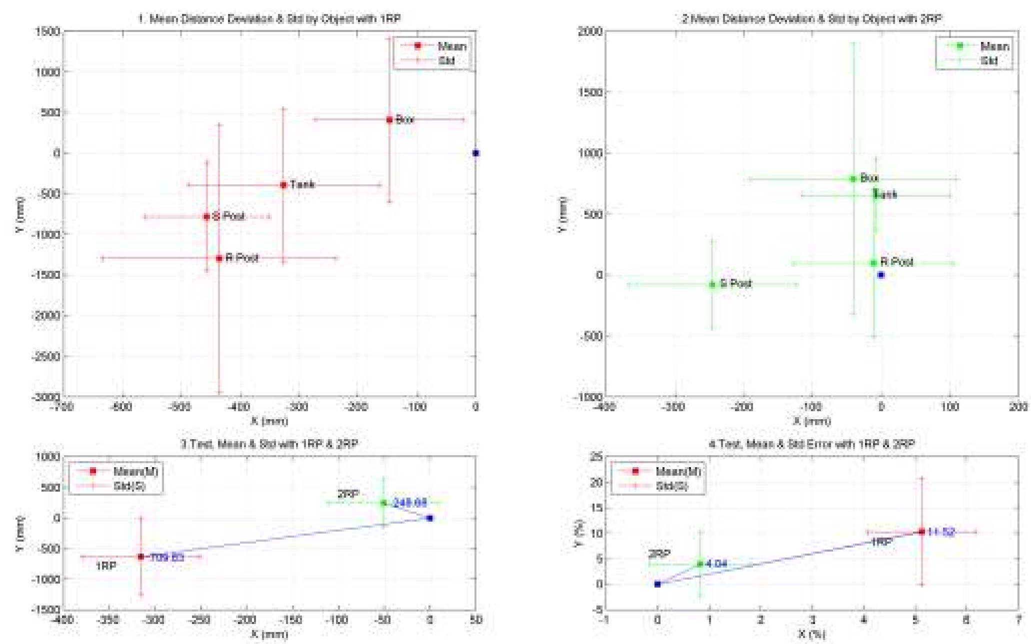
Results of trial number: 2 File name: NSSTTS7SS-2.png



Results of trial number: 3 File name: NSSTTS7SS-3.png

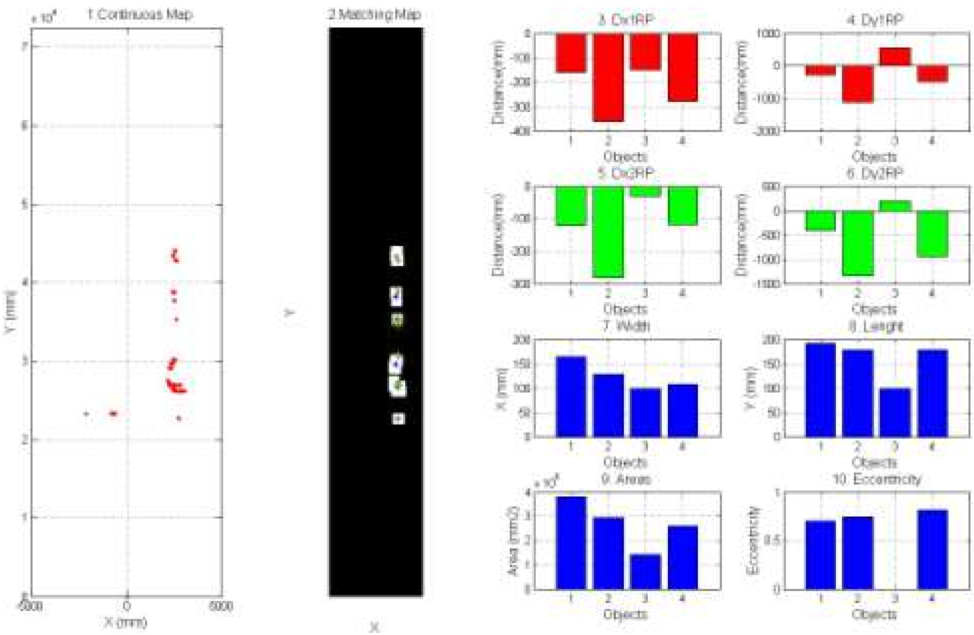


Final results of the tests File name: NSSTTS7SS-T.png

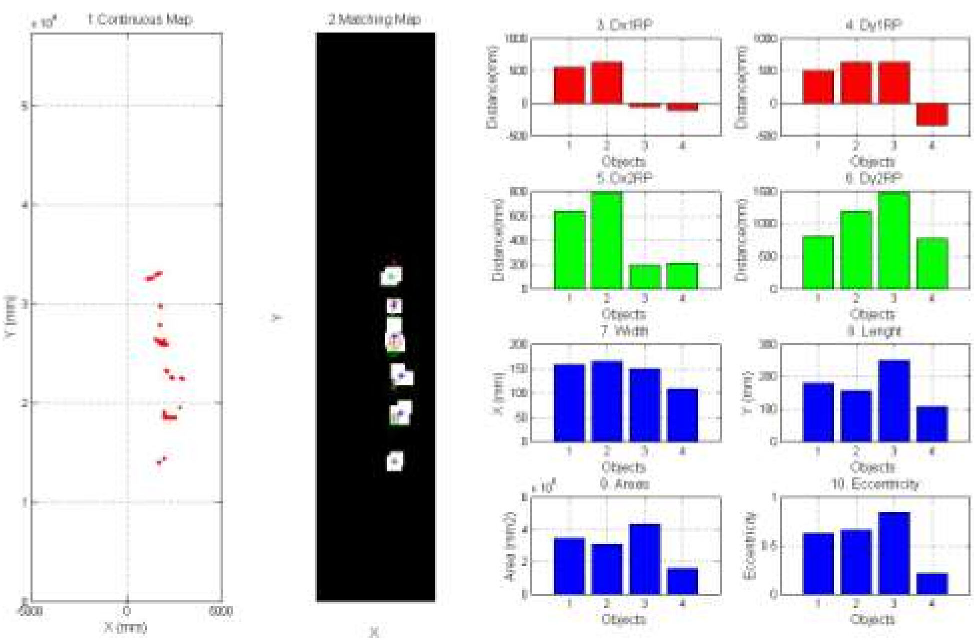


15. Test Name: **SRTTS7SS**

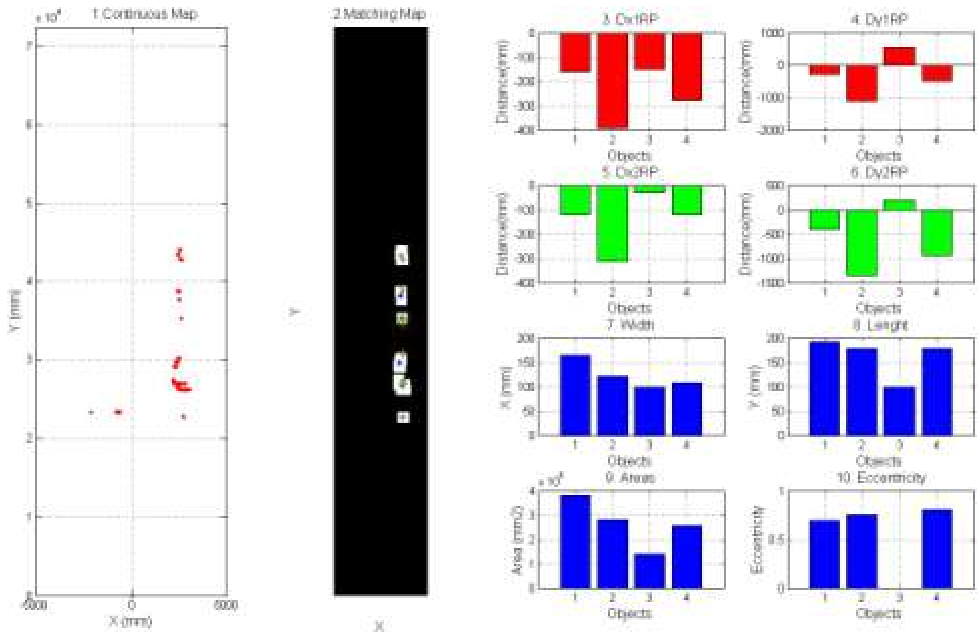
Results of trial number: 1 File name: SRTTS7SS-1.png



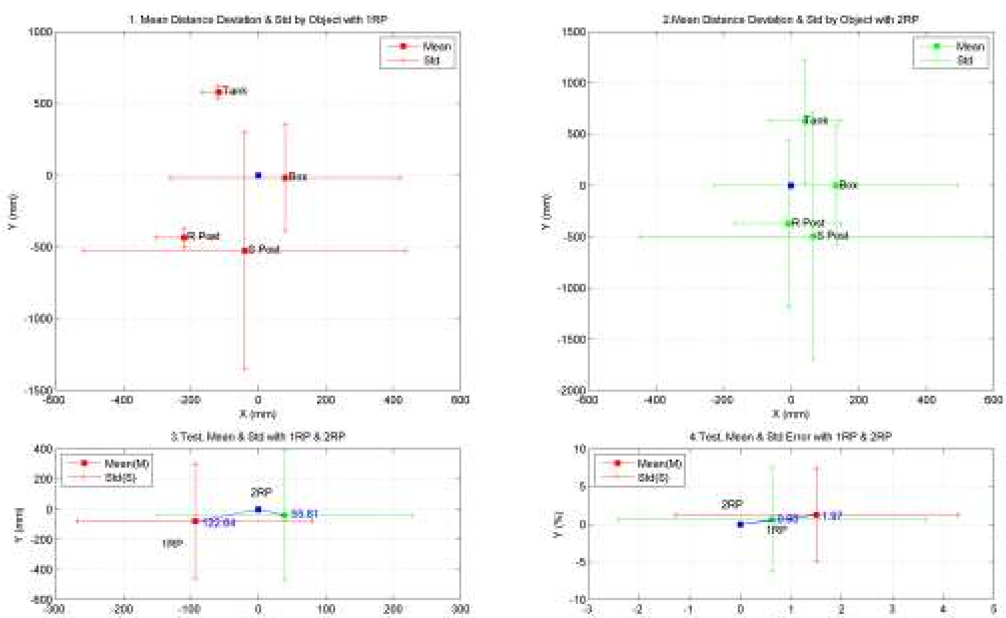
Results of trial number: 2 File name: SRTTS7SS-2.png



Results of trial number: 3 File name: SRTTS7SS-3.png

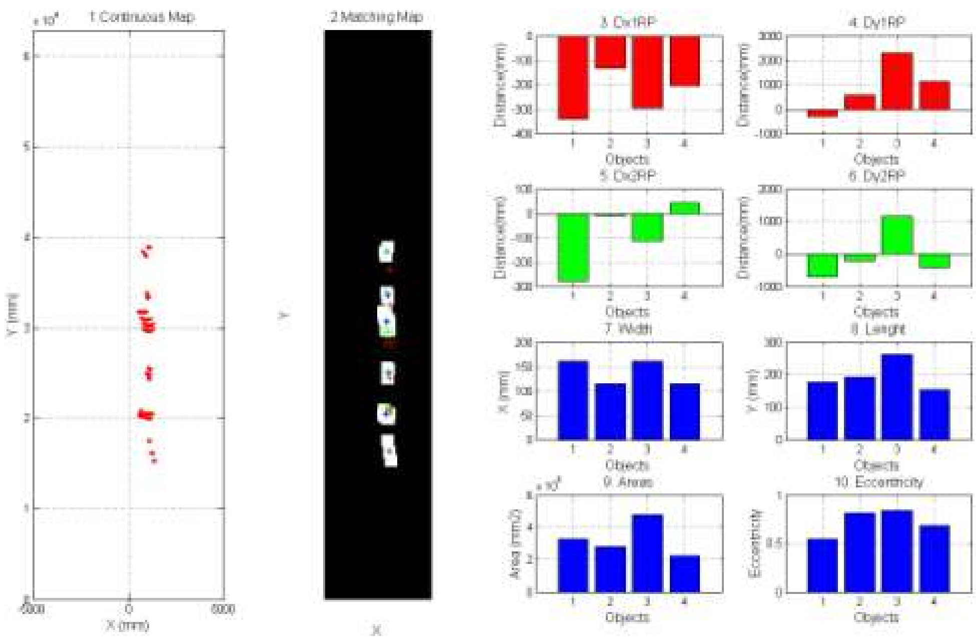


Final results of the tests File name: SRTTS7SS-T.png

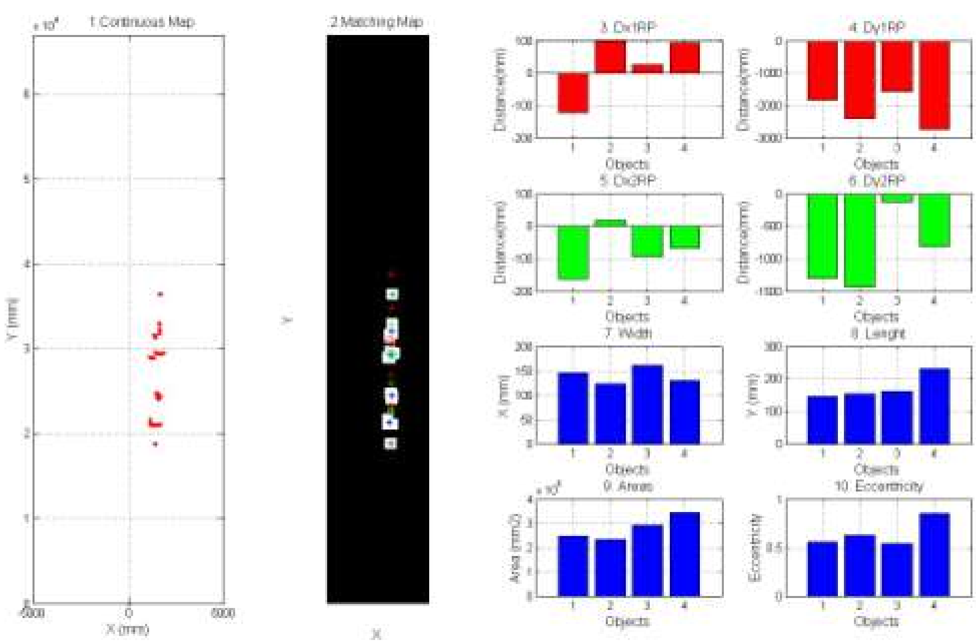


16. Test Name: **NSRTTS7SS**

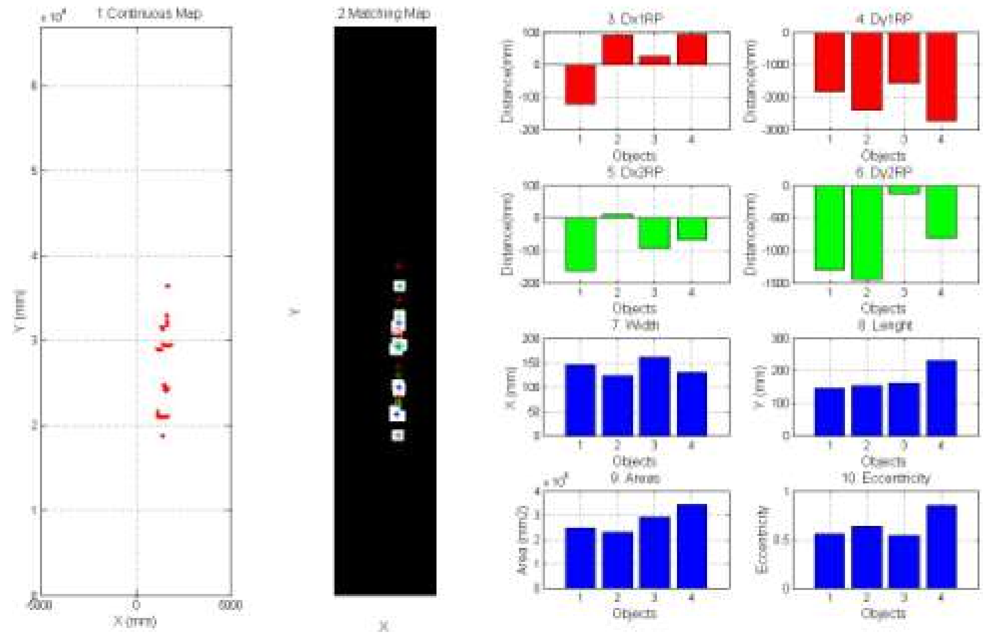
Results of trial number: 1 File name: NSRTTS7SS-1.png



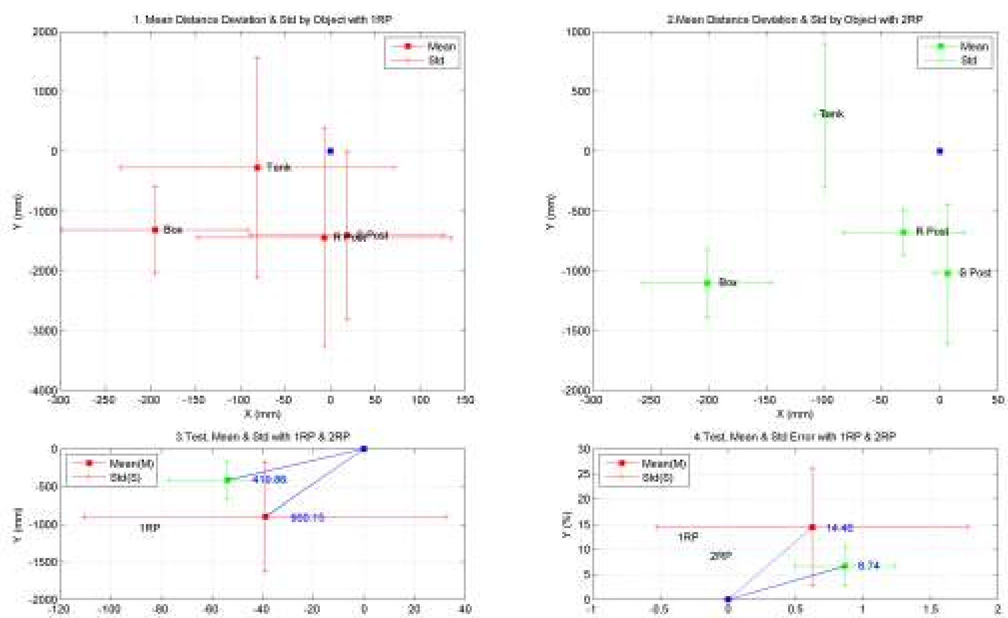
Results of trial number: 2 File name: NSRTTS7SS-2.png



Results of trial number: 3   File name: NSRTTS7SS-3.png



Final results of the tests   File name: NSRTTS7SS-T.png

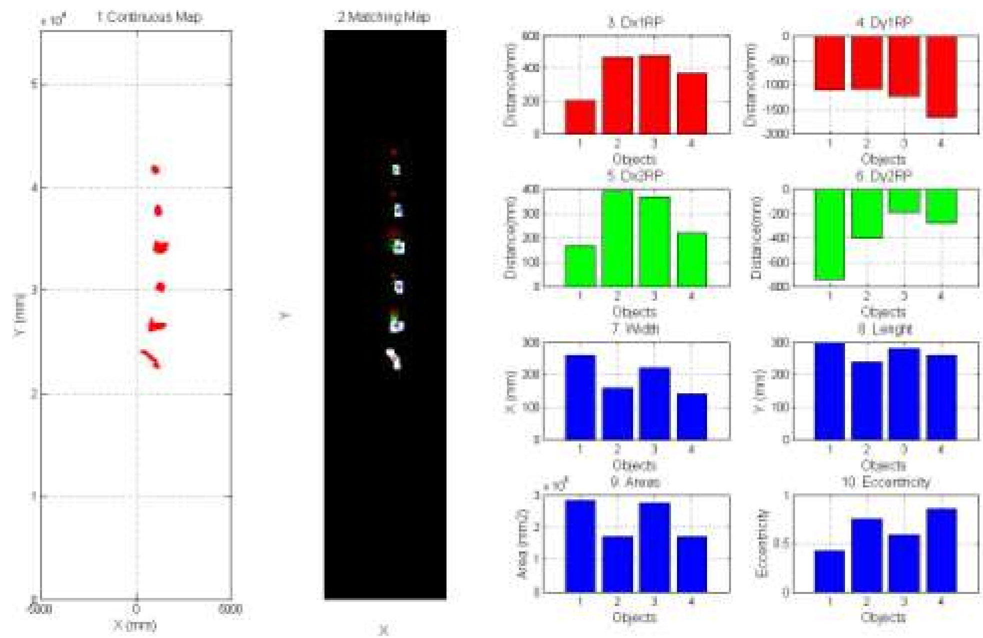


17. Test Name: **SPTTS7SS**   **This test was not possible to do**

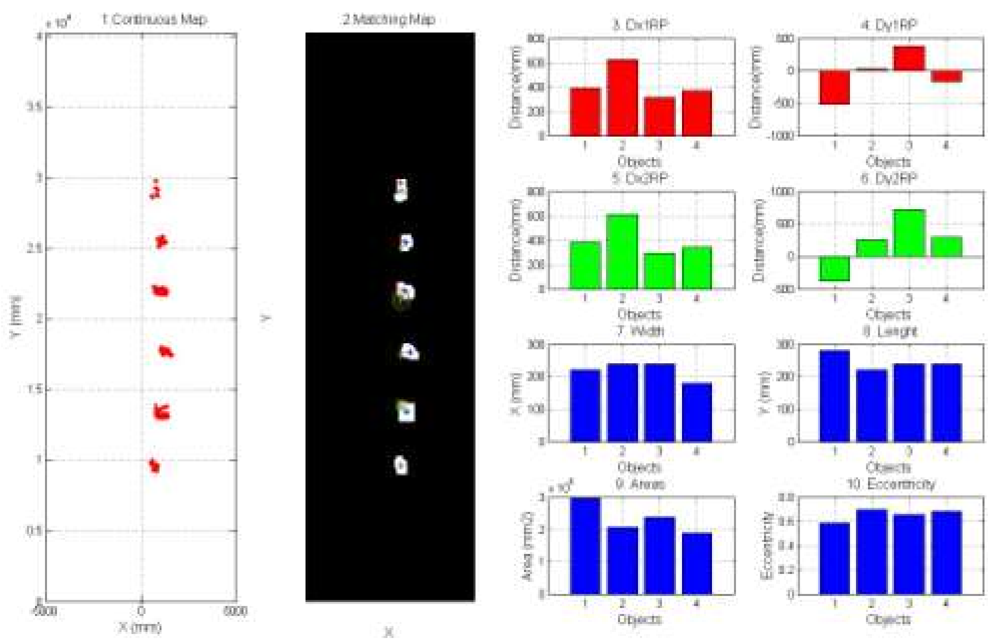
18. Test Name: **NSPTTS7SS**   **This test was not possible to do**

19. Test Name: **SSTTS2NSS**

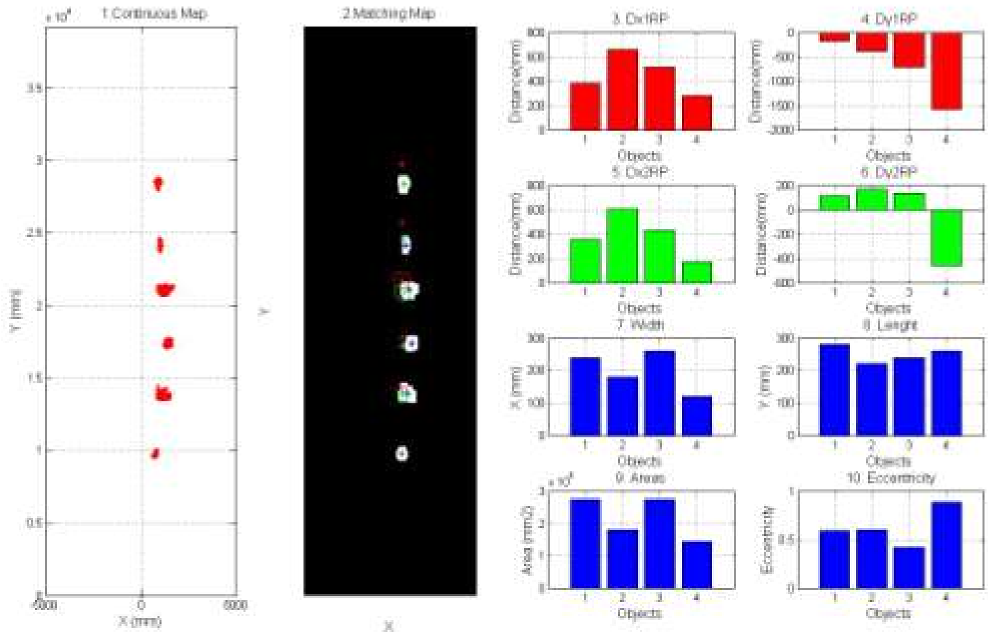
Results of trial number: 1 File name: SSTTS2NSS-1.png



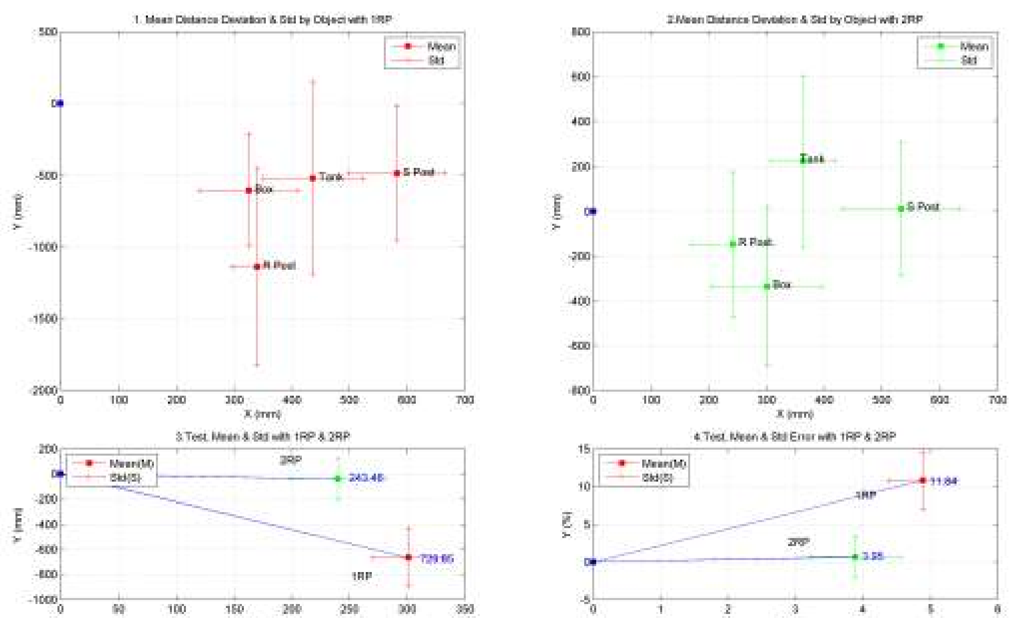
Results of trial number: 2 File name: SSTTS2NSS-2.png



Results of trial number: 3 File name: SSTTS2NSS-3.png

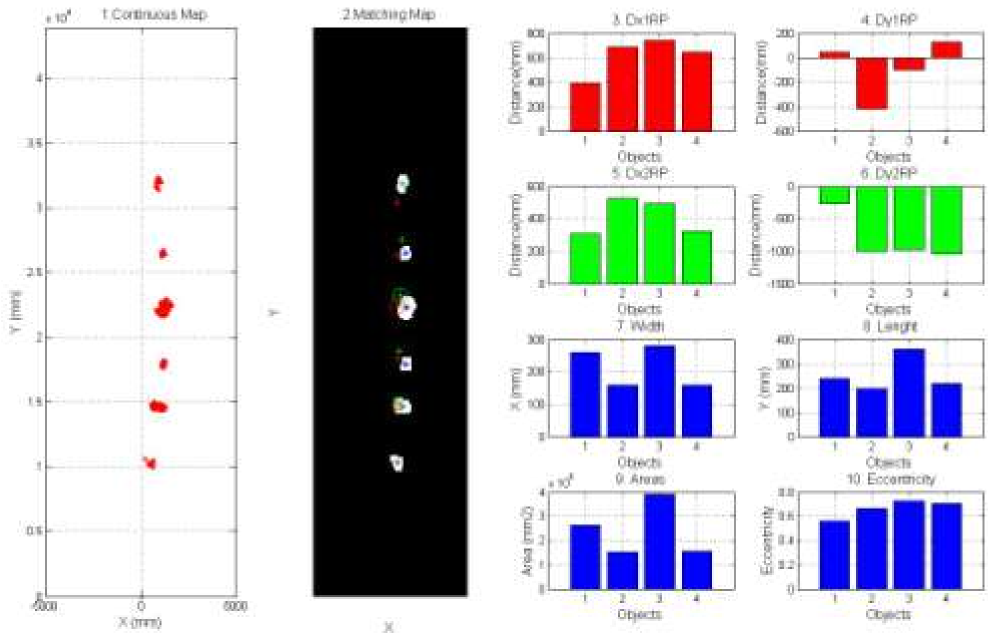


Final results of the tests File name: SSTTS2NSS-T.png

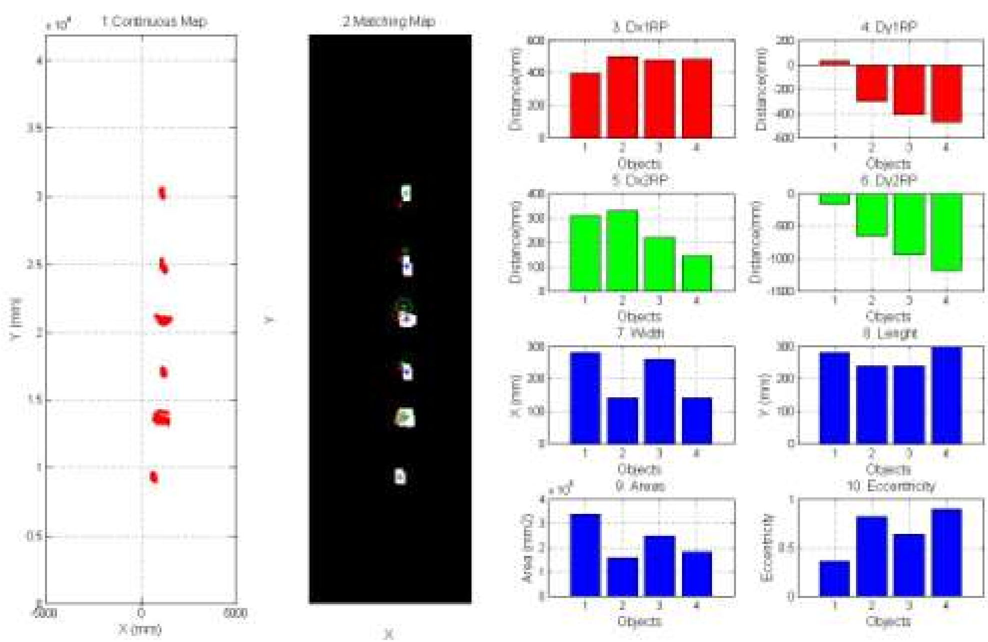


20. Test Name: **NSSTTS2NSS**

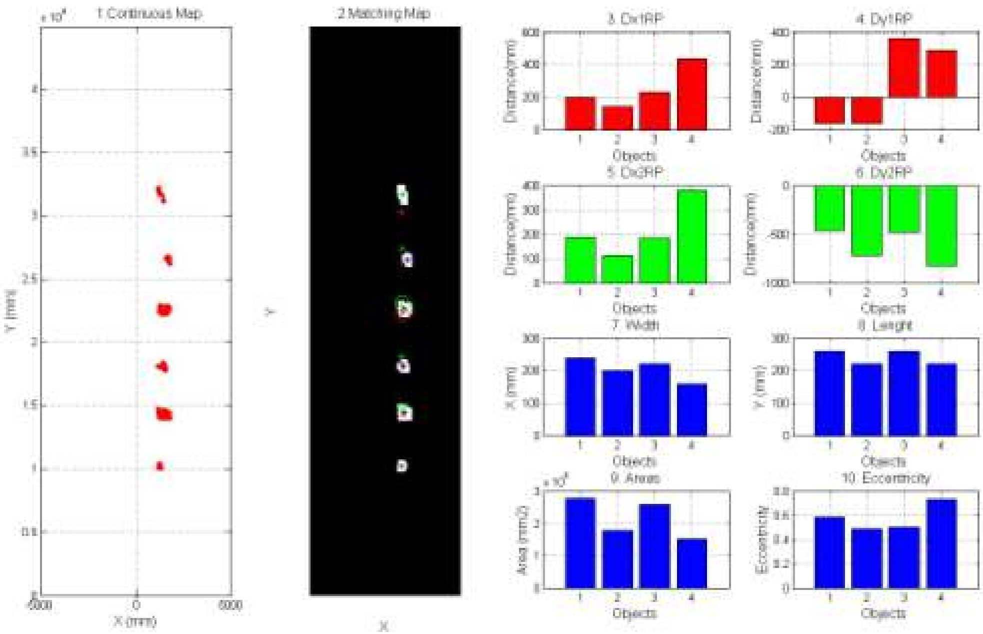
Results of trial number: 1 File name: NSSTTS2NSS-1.png



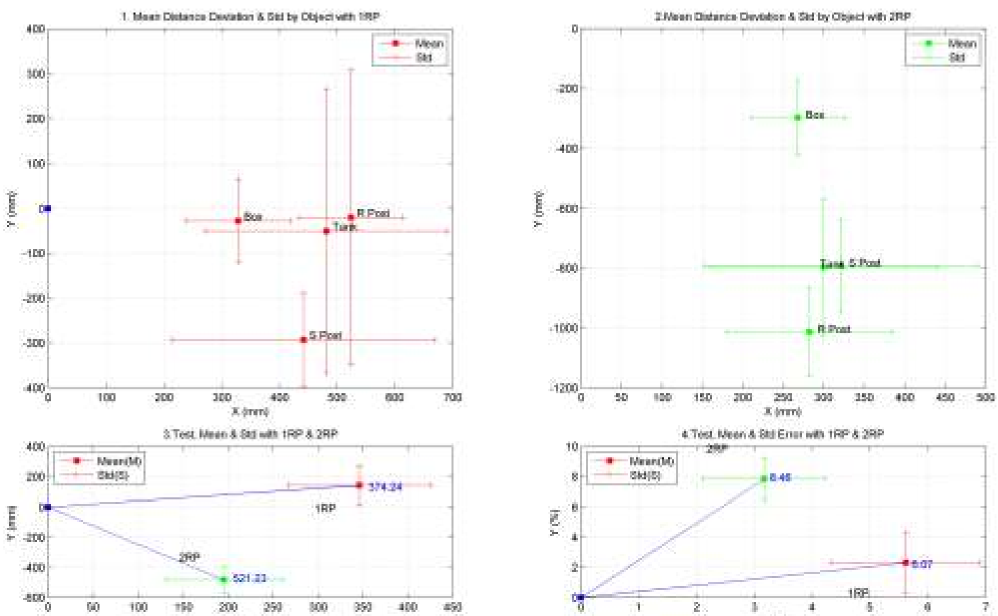
Results of trial number: 2 File name: NSSTTS2NSS-2.png



Results of trial number: 3 File name: NSSTTS2NSS-3.png

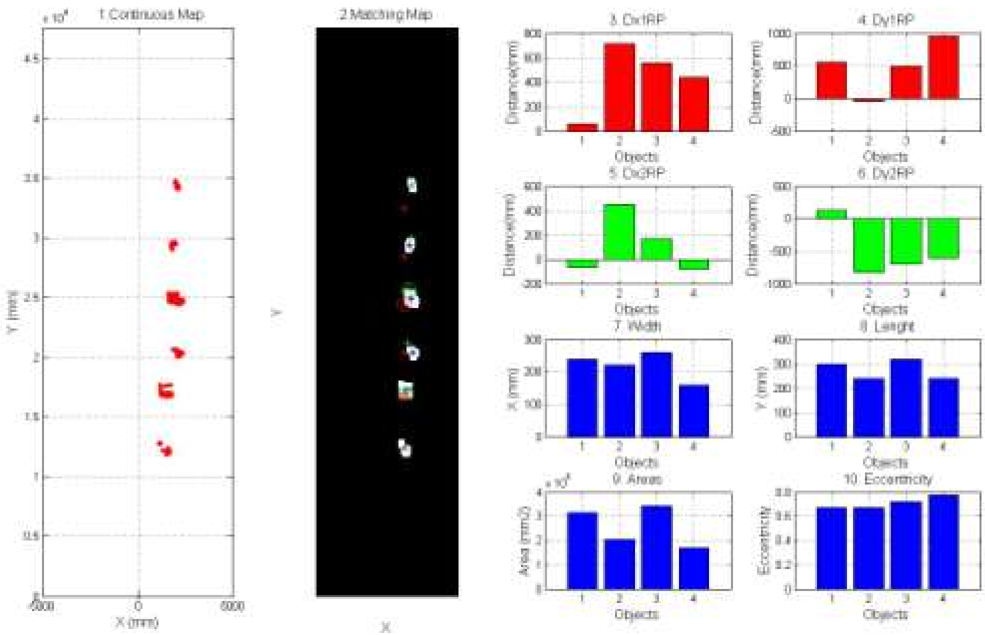


Final results of the tests File name: NSSTTS2NSS-T.png

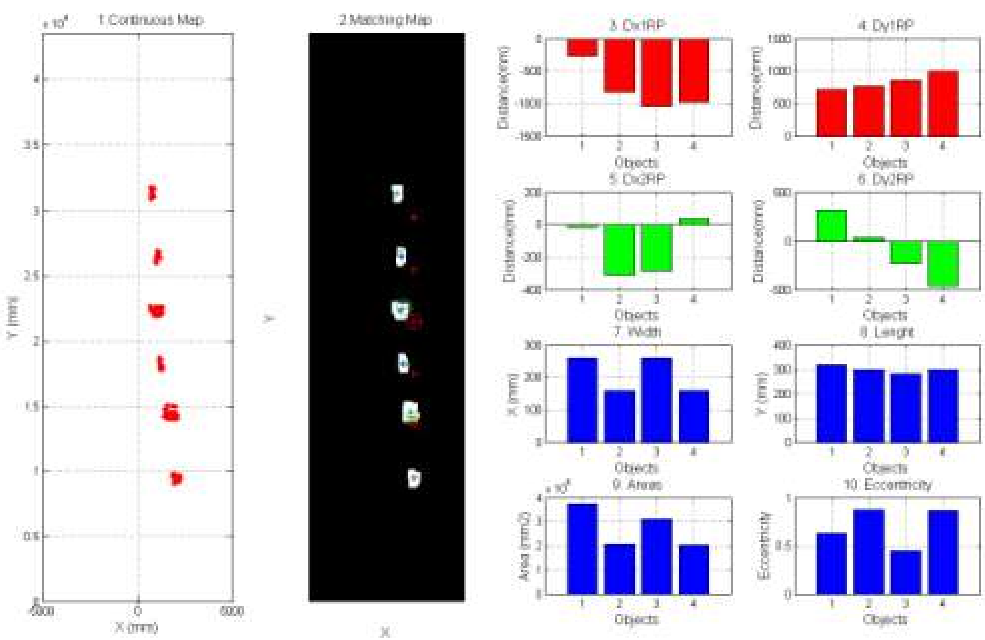


21. Test Name: **SRTTS2NSS**

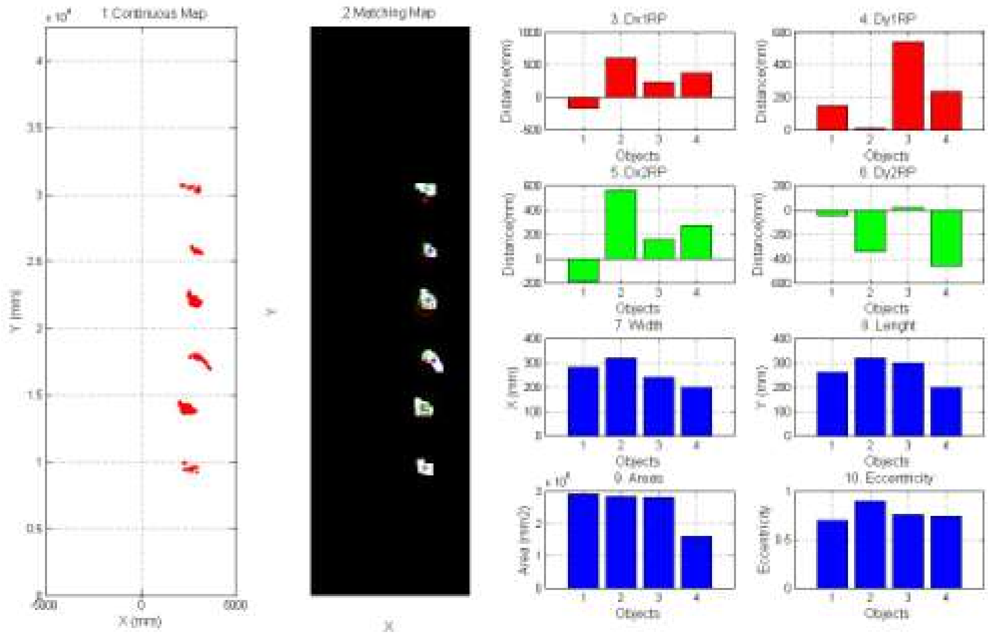
Results of trial number: 1 File name: SRTTS2NSS-1.png



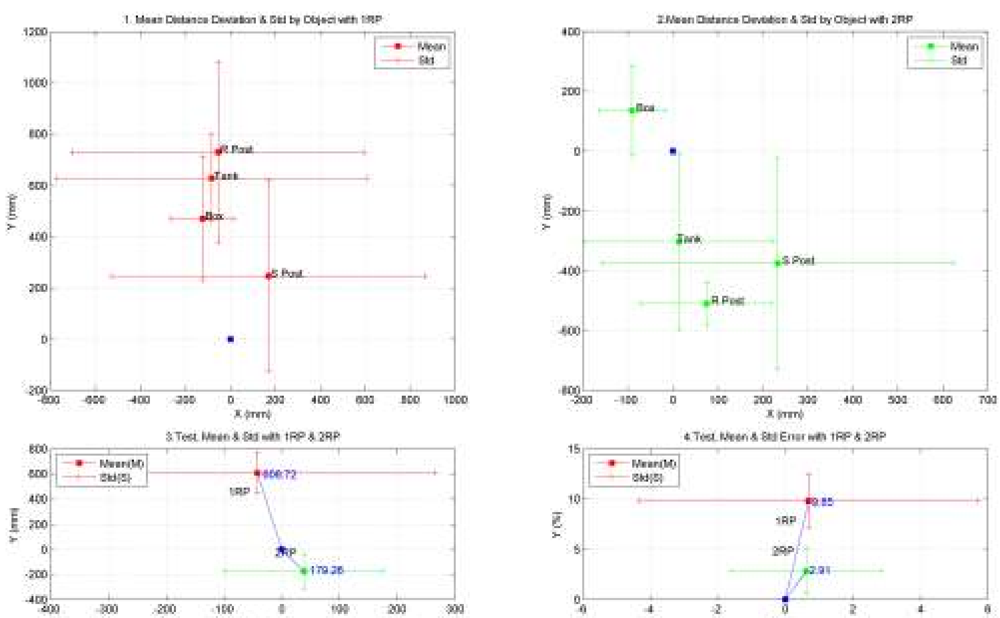
Results of trial number: 2 File name: SRTTS2NSS-2.png



Results of trial number: 3 File name: SRTTS2NSS-3.png

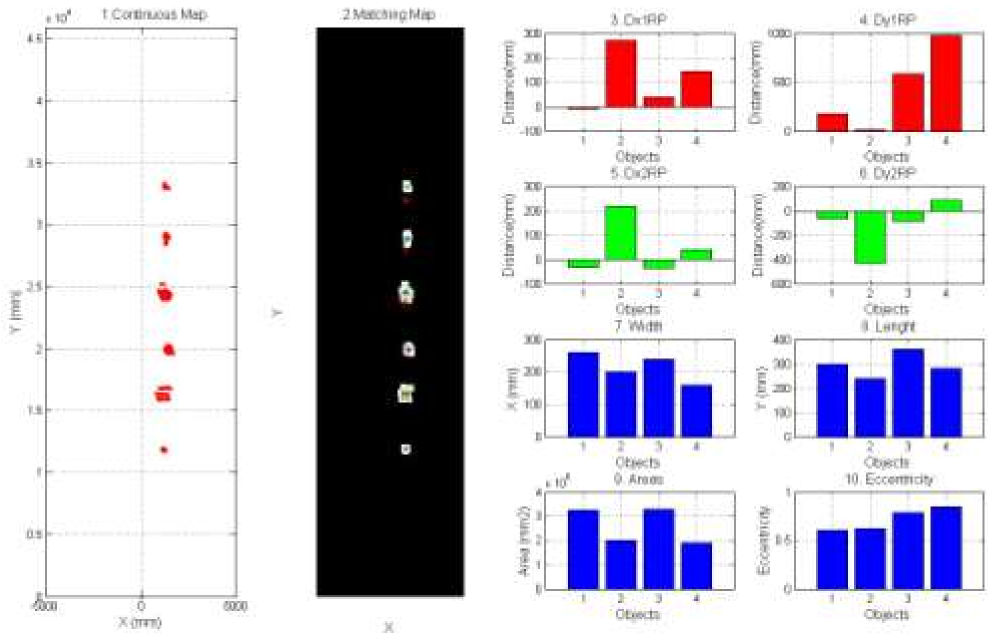


Final results of the tests File name: SRTTS2NSS-T.png

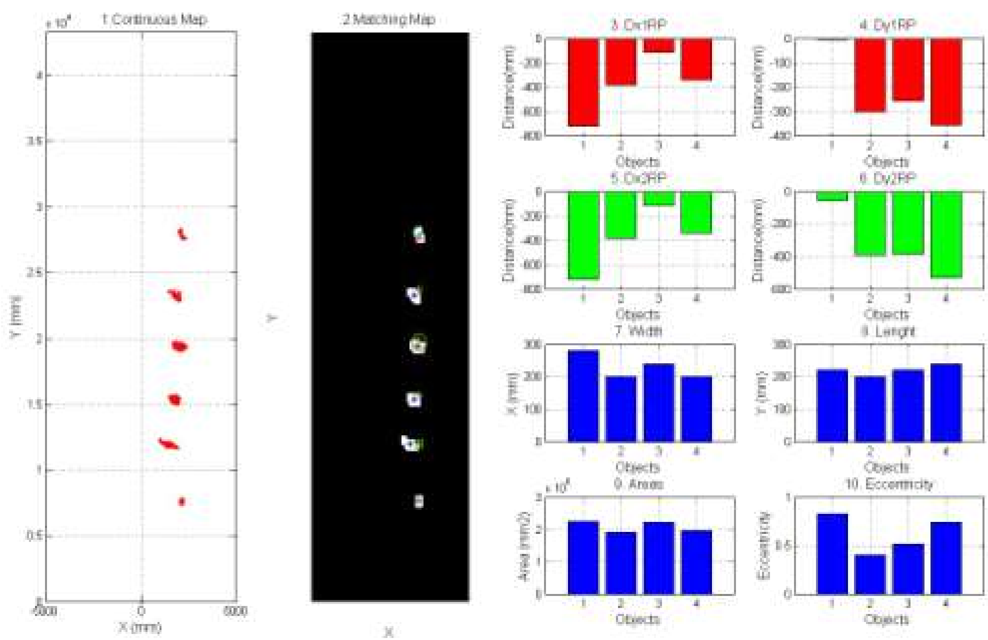


22. Test Name: **NSRTTS2NSS**

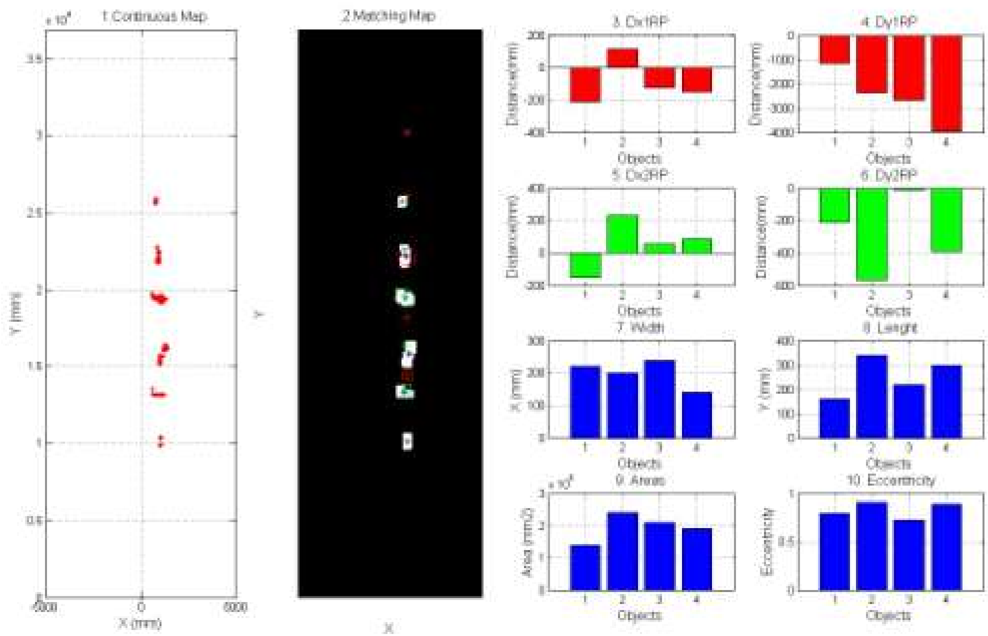
Results of trial number: 1 File name: NSRTTS2NSS-1.png



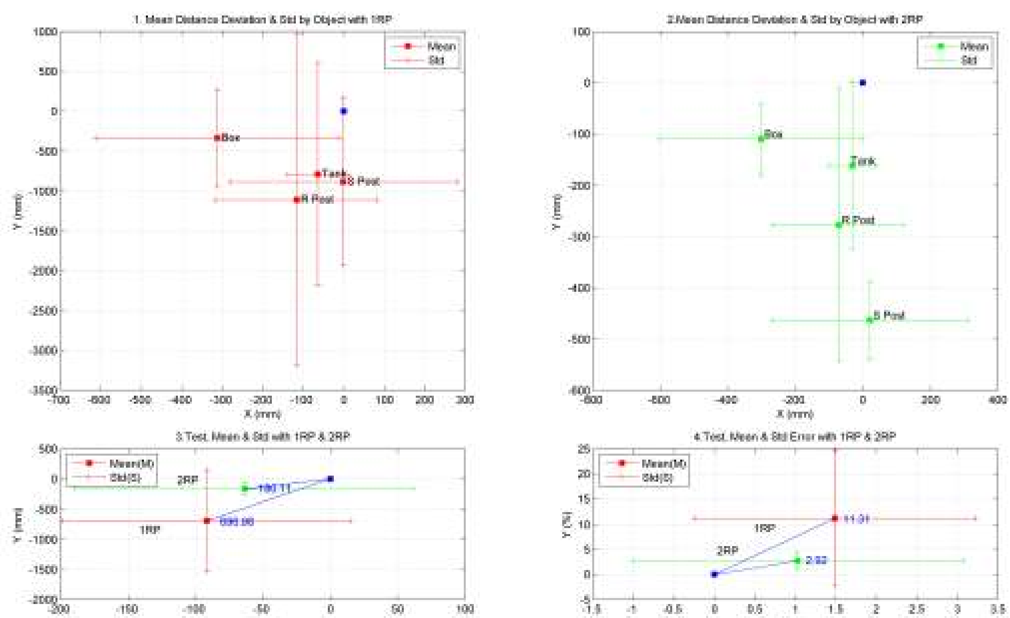
Results of trial number: 2 File name: NSRTTS2NSS-2.png



Results of trial number: 3 File name: NSRTTS2NSS-3.png

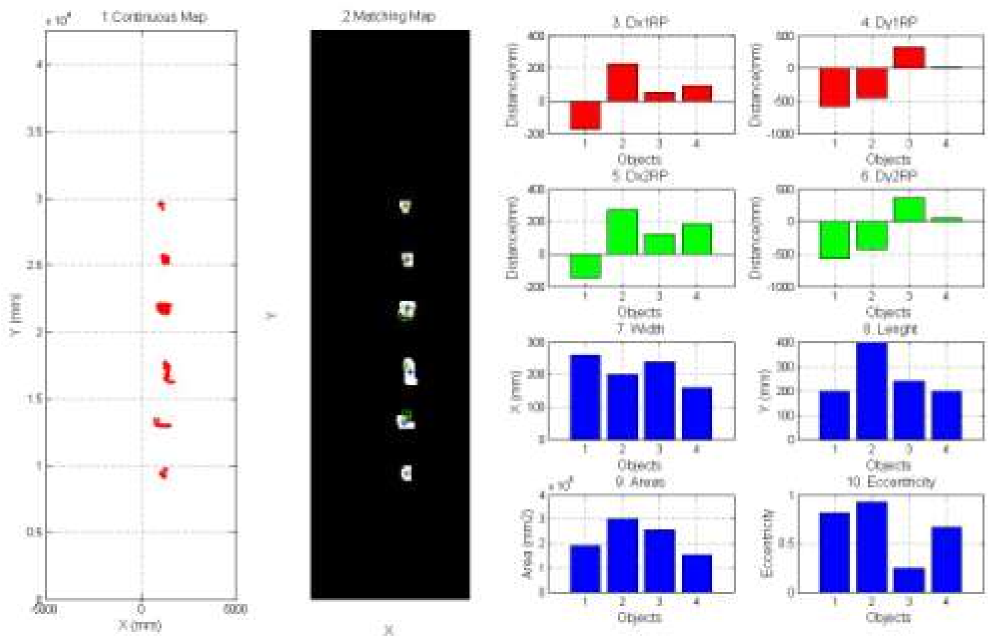


Final results of the tests File name: NSRTTS2NSS-T.png

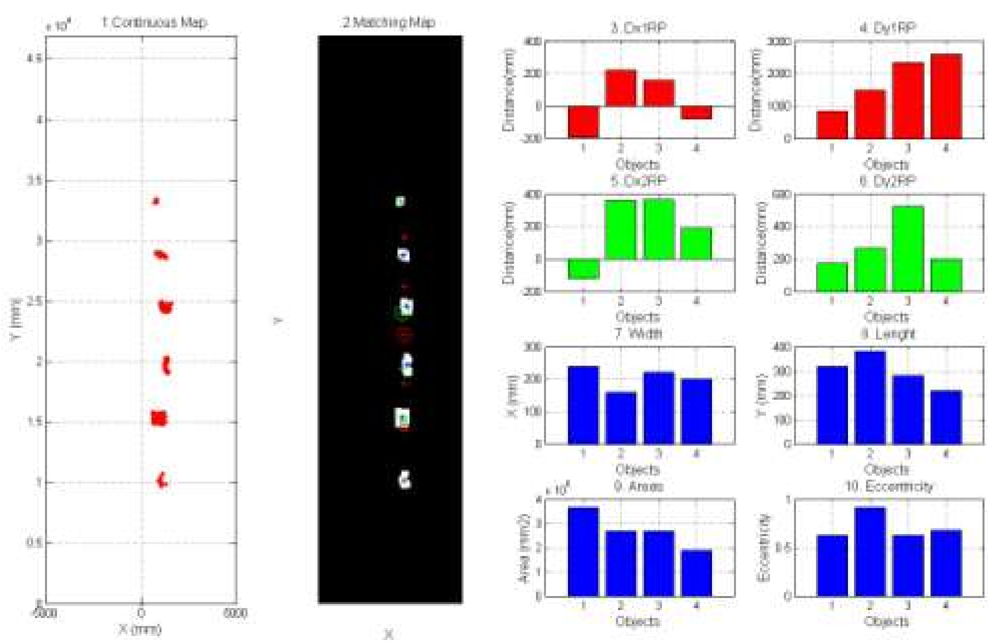


23. Test Name: **SPTTS2NSS**

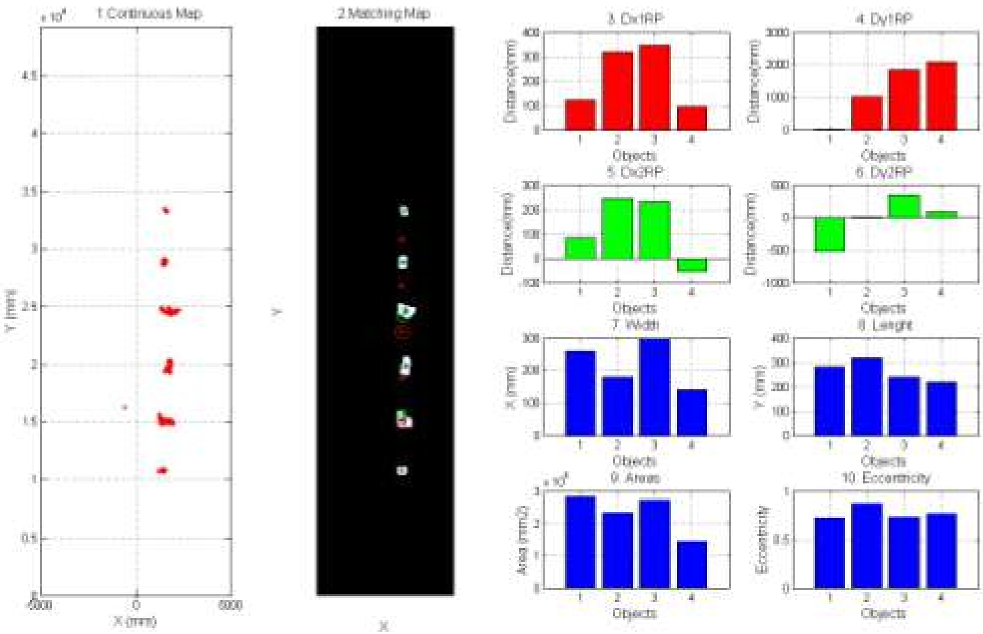
Results of trial number: 1 File name: SPTTS2NSS-1.png



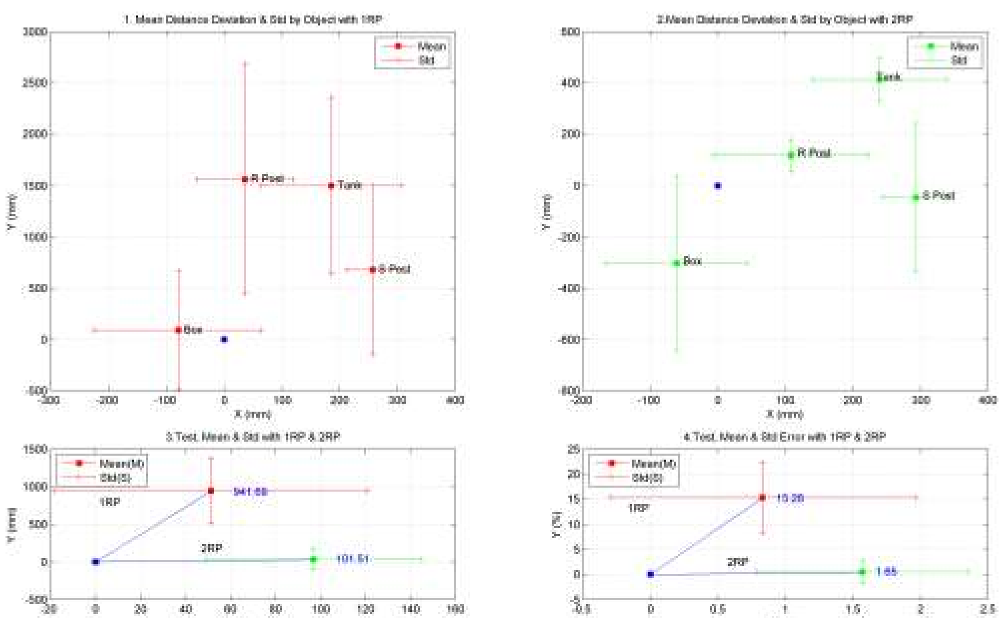
Results of trial number: 2 File name: SPTTS2NSS-2.png



Results of trial number: 3 File name: SPTTS2NSS-3.png

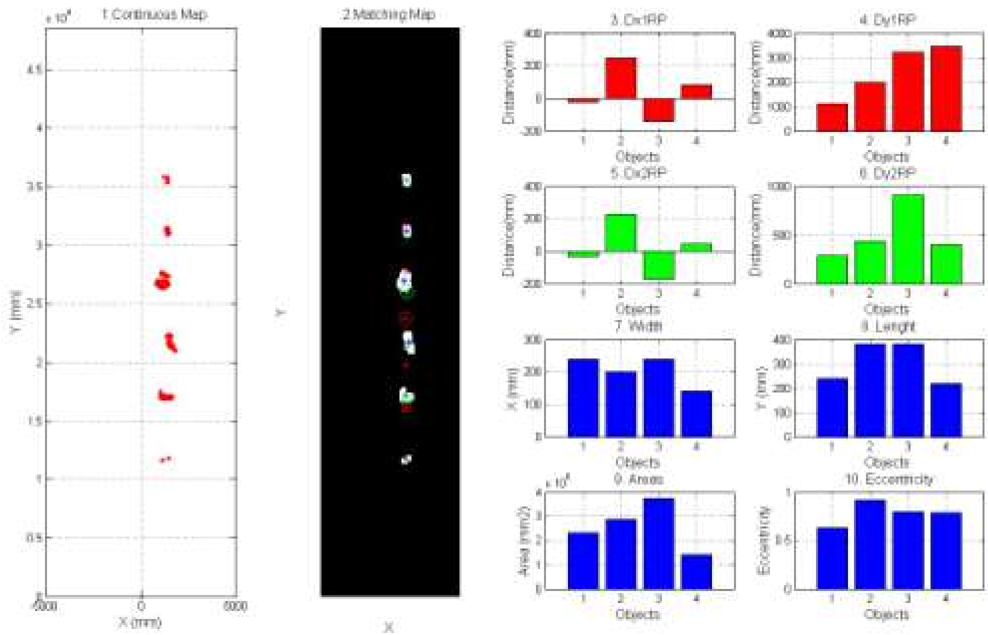


Final results of the tests File name: SPTTS2NSS-T.png

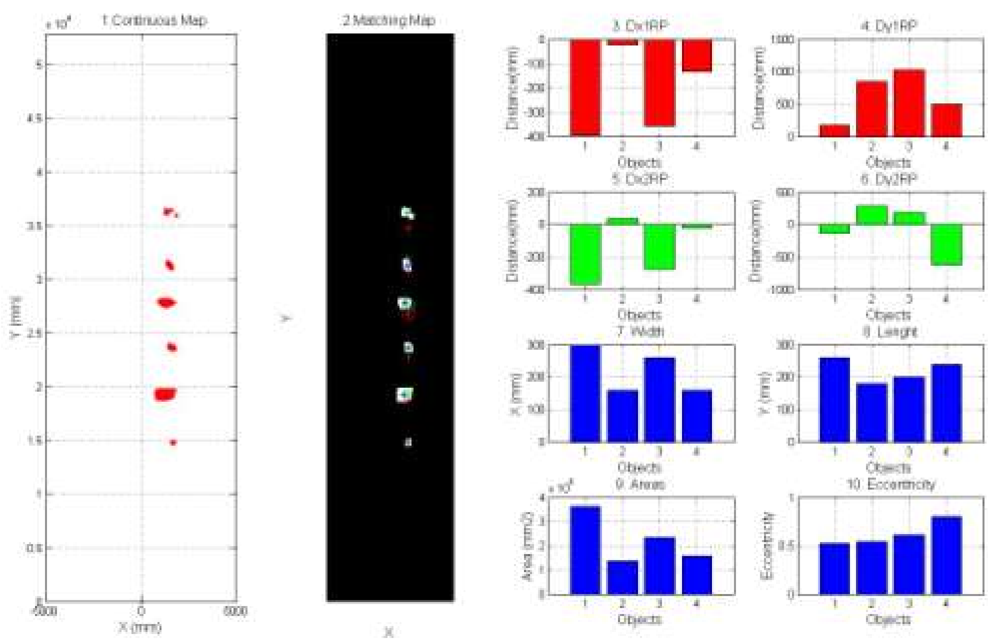


24. Test Name: **NSPTTS2NSS**

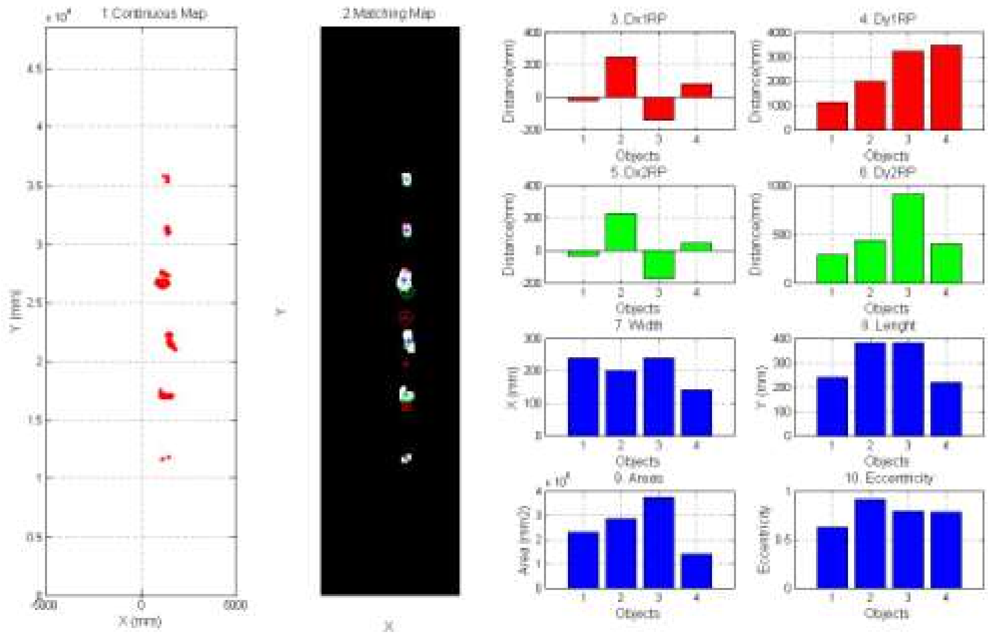
Results of trial number: 1 File name: NSPTTS2NSS-1.png



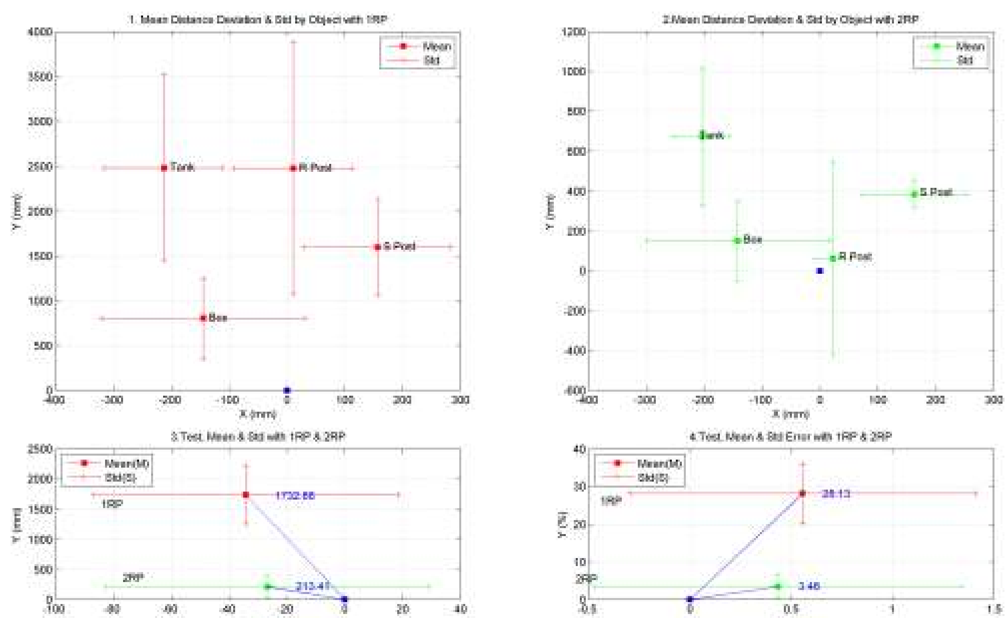
Results of trial number: 2 File name: NSPTTS2NSS-2.png



Results of trial number: 3 File name: NSPTTS2NSS-3.png

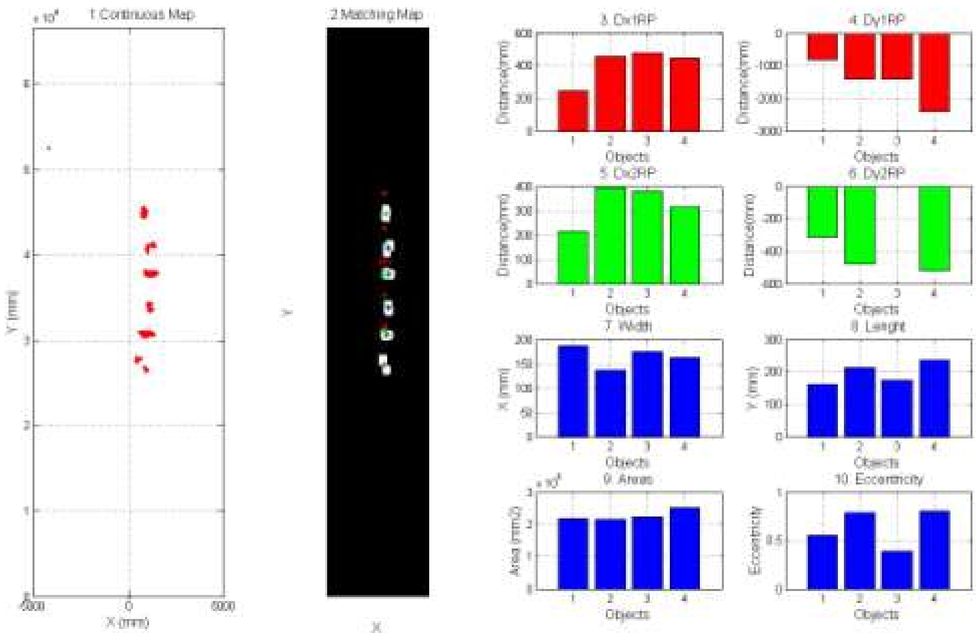


Final results of the tests File name: NSPTTS2NSS-T.png

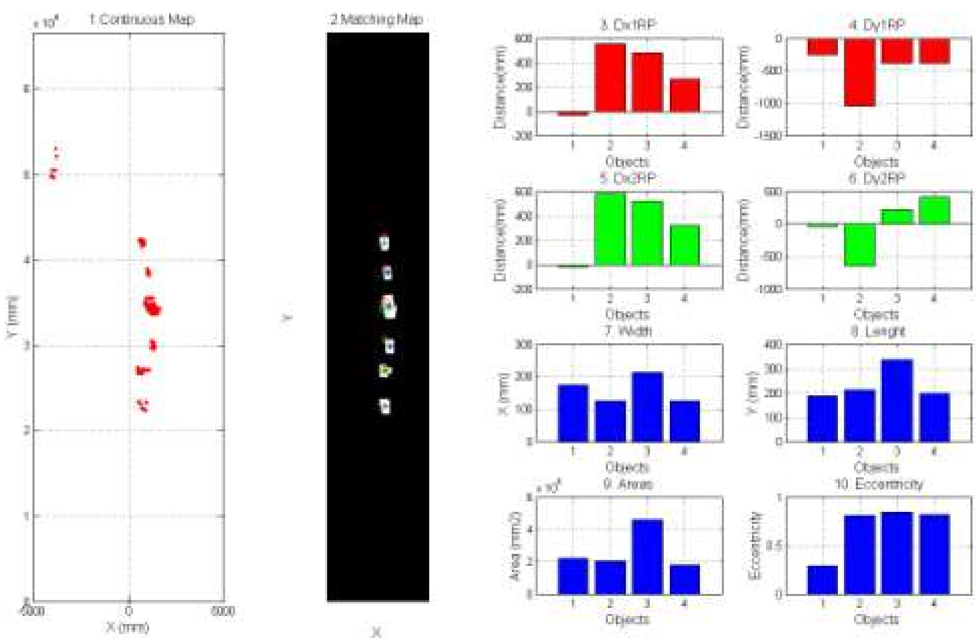


25. Test Name: **SSTTS4NSS**

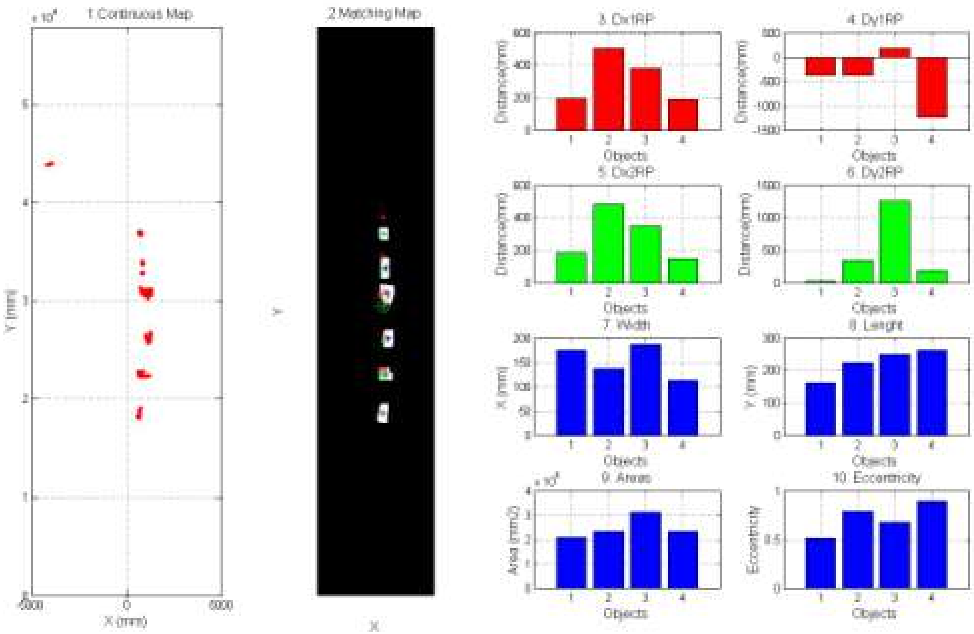
Results of trial number: 1 File name: SSTTS4NSS-1.png



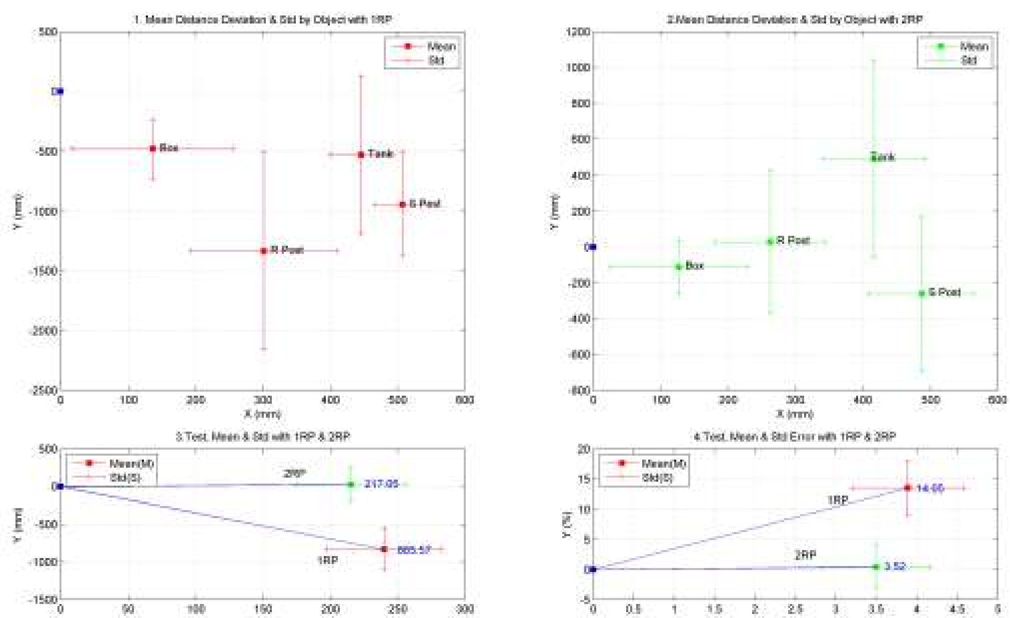
Results of trial number: 2 File name: SSTTS4NSS-2.png



Results of trial number: 3 File name: SSTTS4NSS-3.png

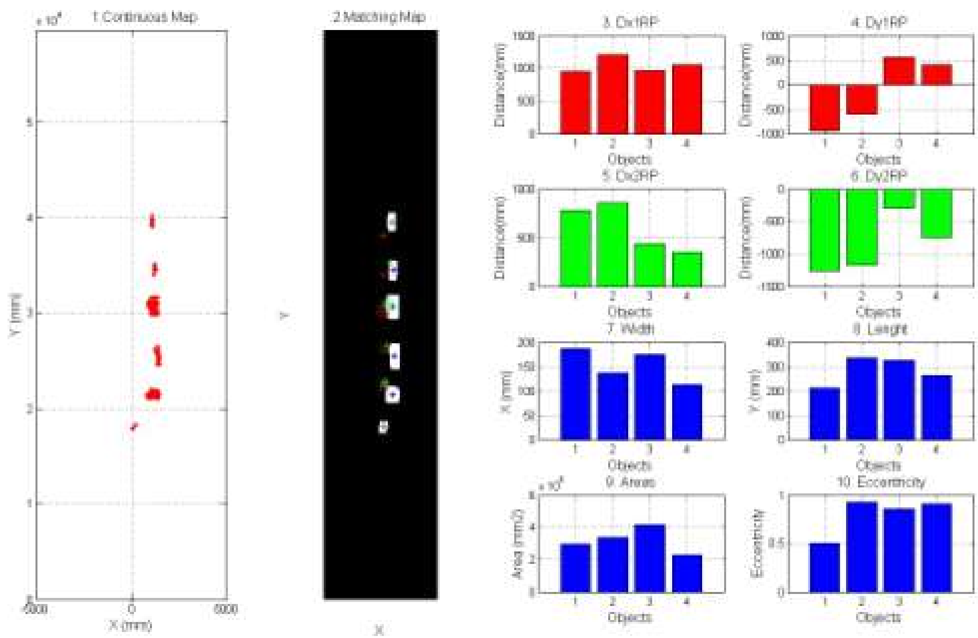


Final results of the tests File name: SSTTS4NSS-T.png

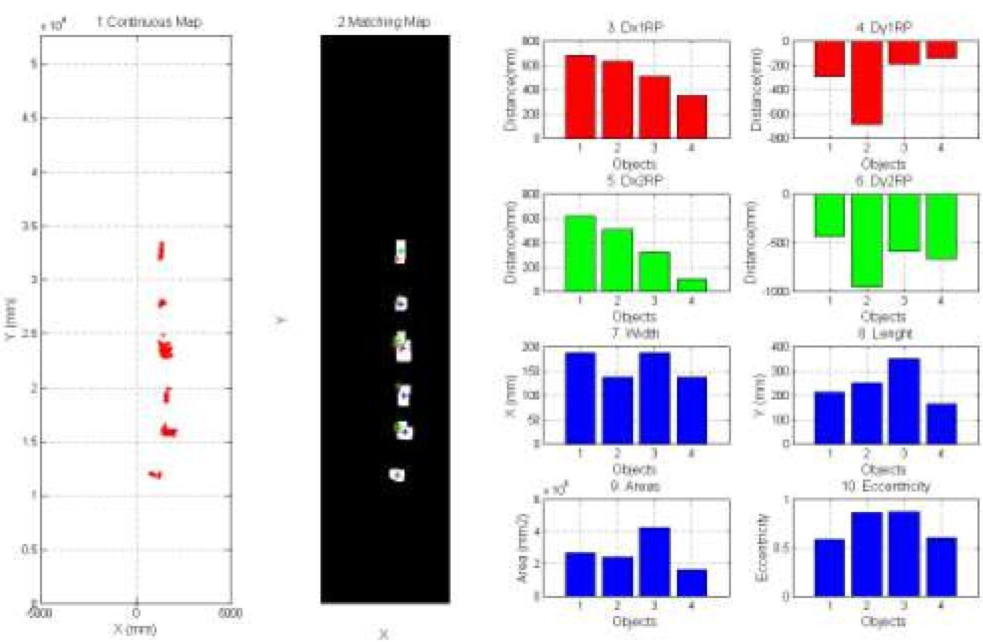


26. Test Name: **NSSTTS4NSS**

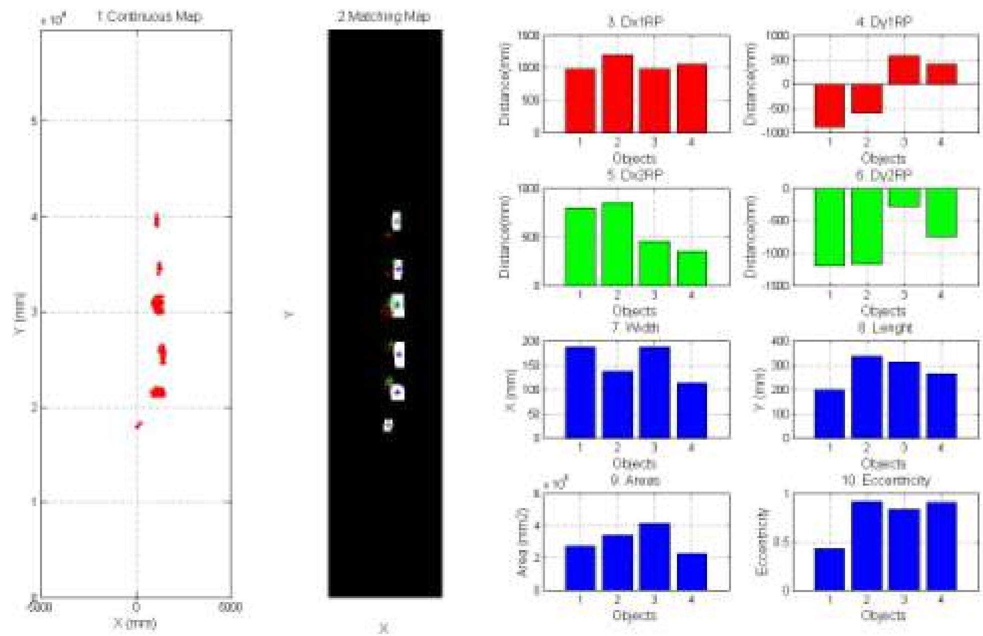
Results of trial number: 1 File name: NSSTTS4NSS-1.png



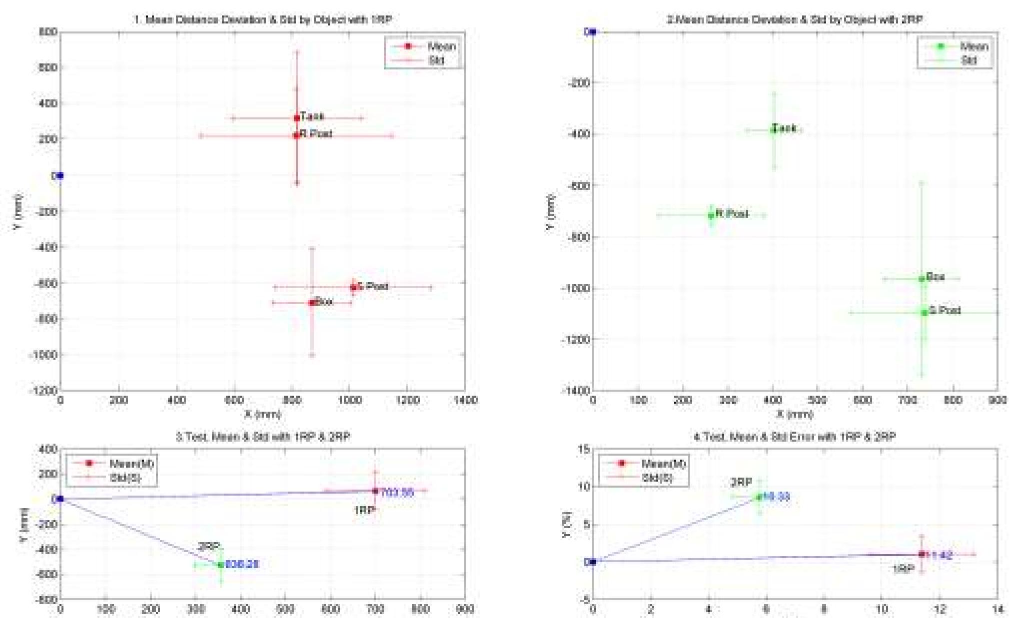
Results of trial number: 2 File name: NSSTTS4NSS-2.png



Results of trial number: 3 File name: NSSTTS4NSS-3.png

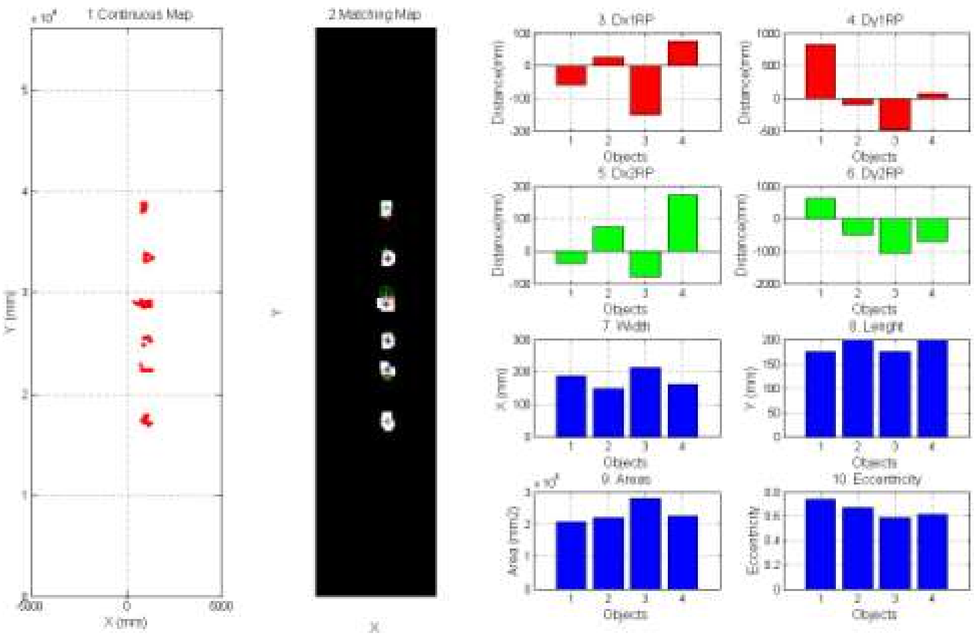


Final results of the tests File name: NSSTTS4NSS-T.png

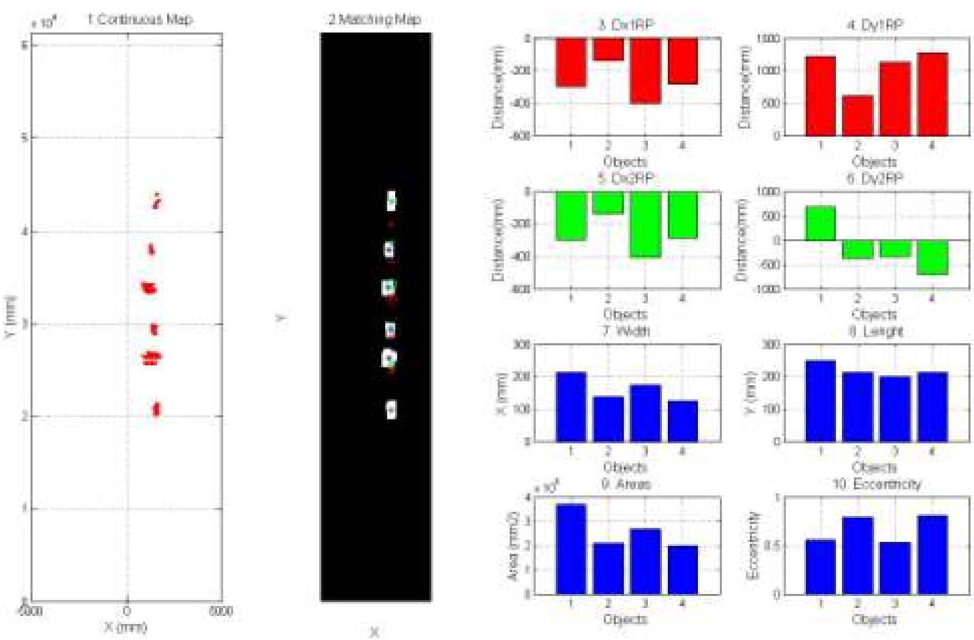


27. Test Name: **SRTTS4NSS**

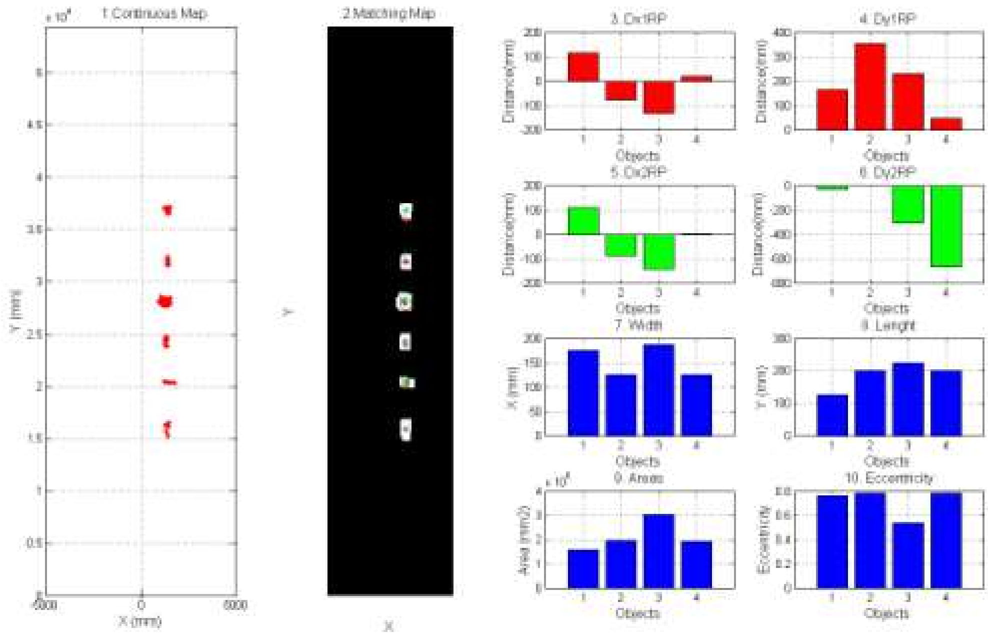
Results of trial number: 1 File name: SRTTS4NSS-1.png



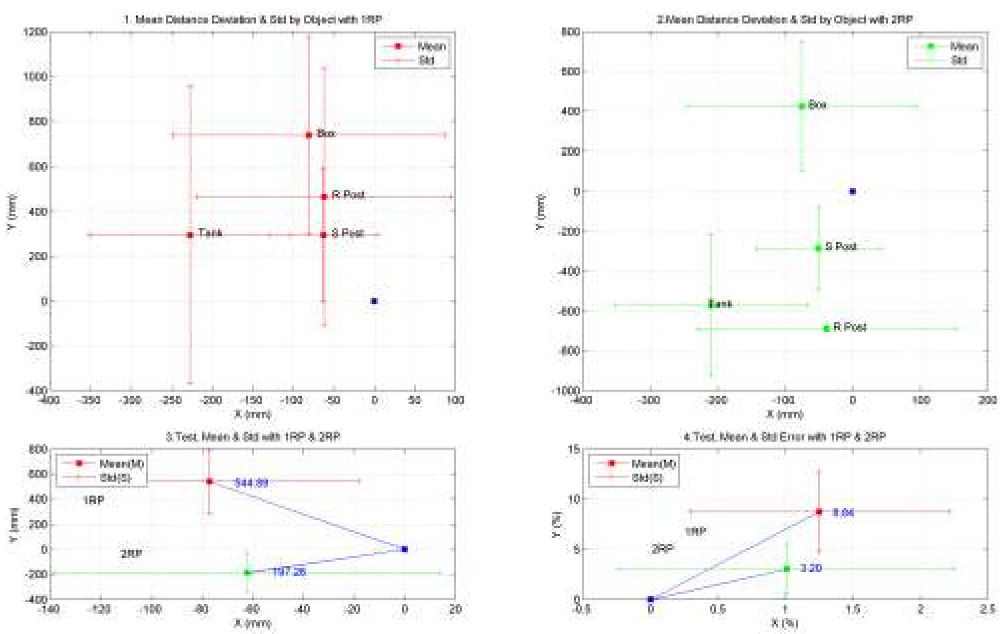
Results of trial number: 2 File name: SRTTS4NSS-2.png



Results of trial number: 3 File name: SRTTS4NSS-3.png

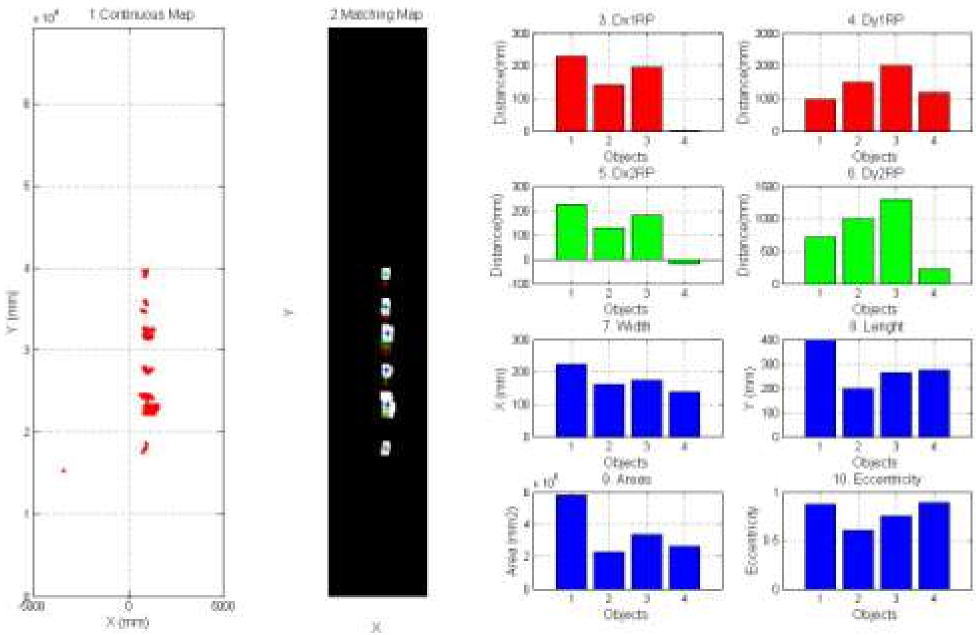


Final results of the tests File name: SRTTS4NSS-T.png

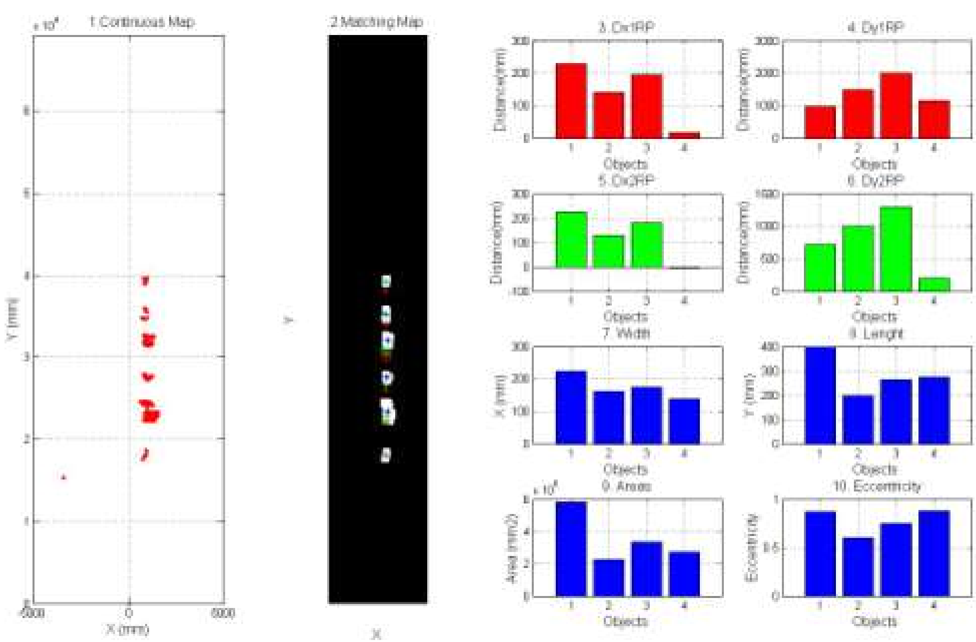


28. Test Name: **NSRTTS4NSS**

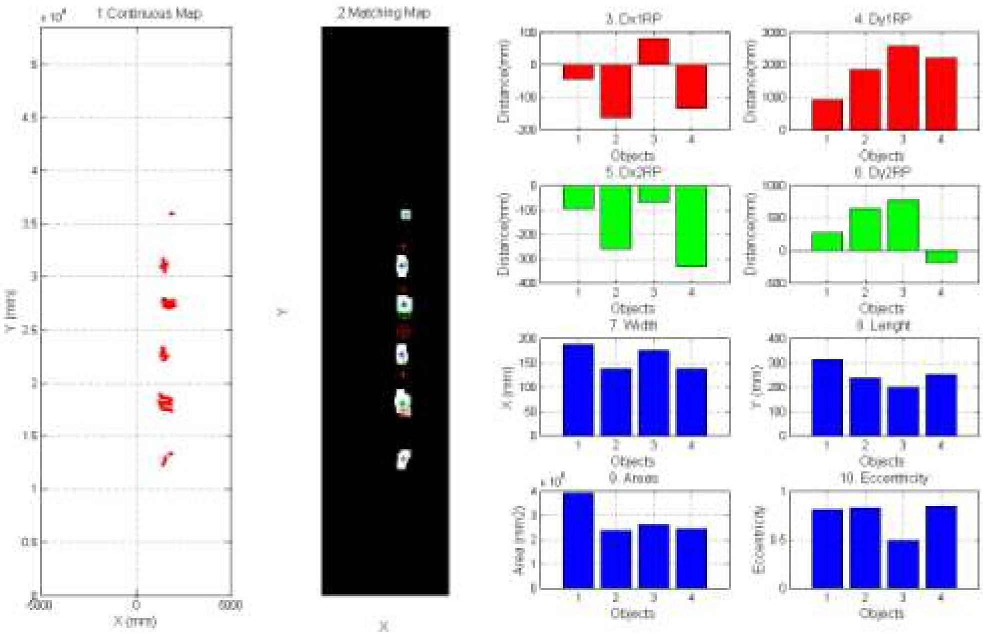
Results of trial number: 1 File name: NSRTTS4NSS-1.png



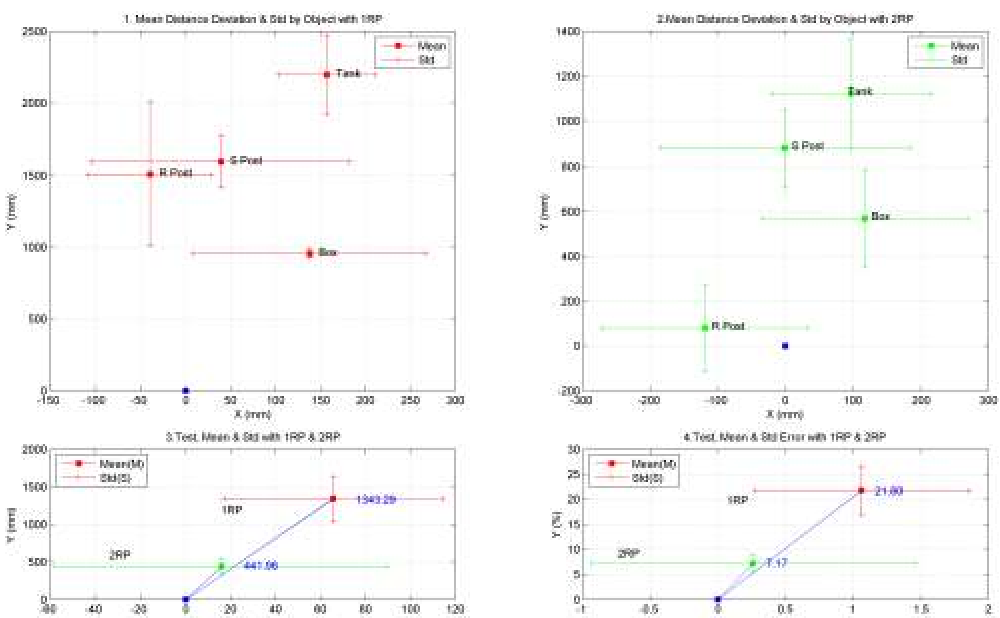
Results of trial number: 2 File name: NSRTTS4NSS-2.png



Results of trial number: 3 File name: NSRTTS4NSS-3.png

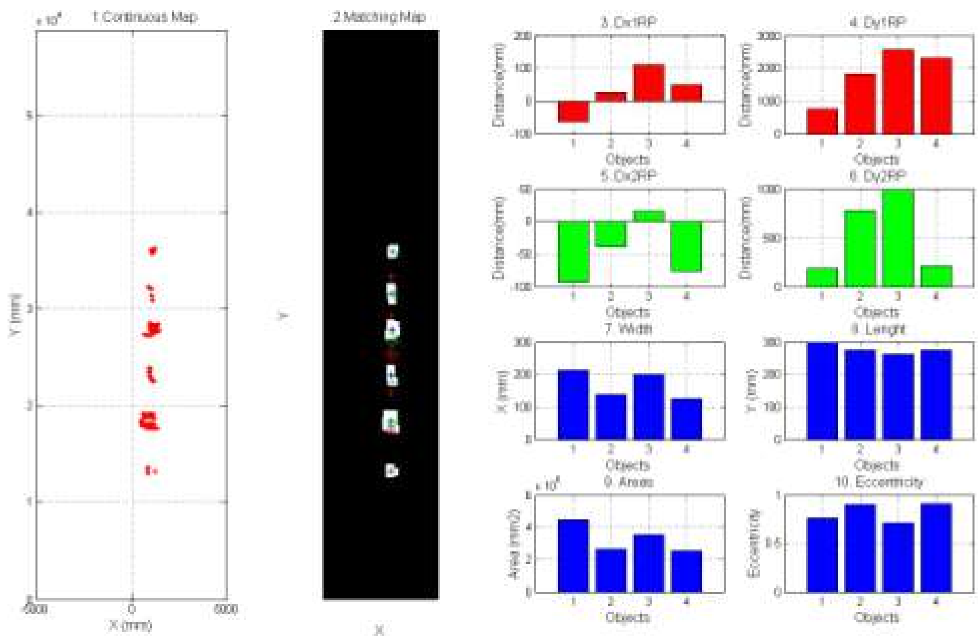


Final results of the tests File name: NSRTTS4NSS-T.png

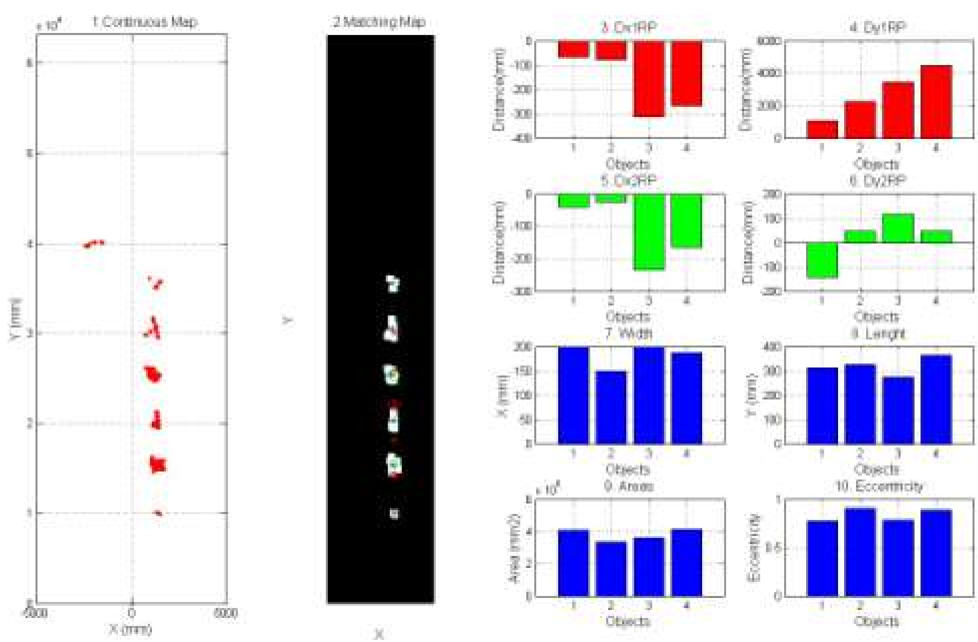


29. Test Name: **SPTTS4NSS**

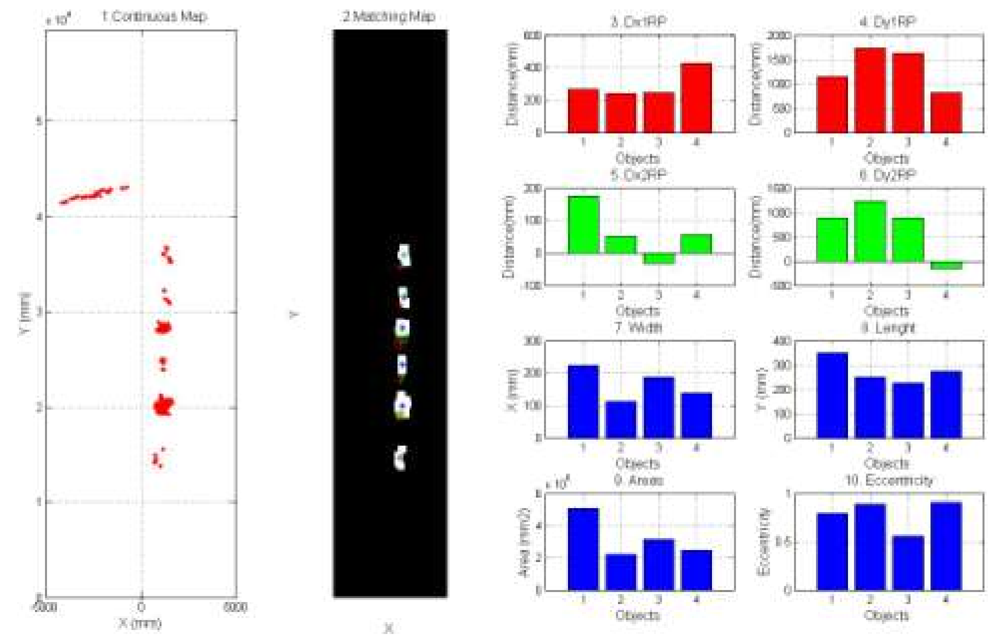
Results of trial number: 1 File name: SPTTS4NSS-1.png



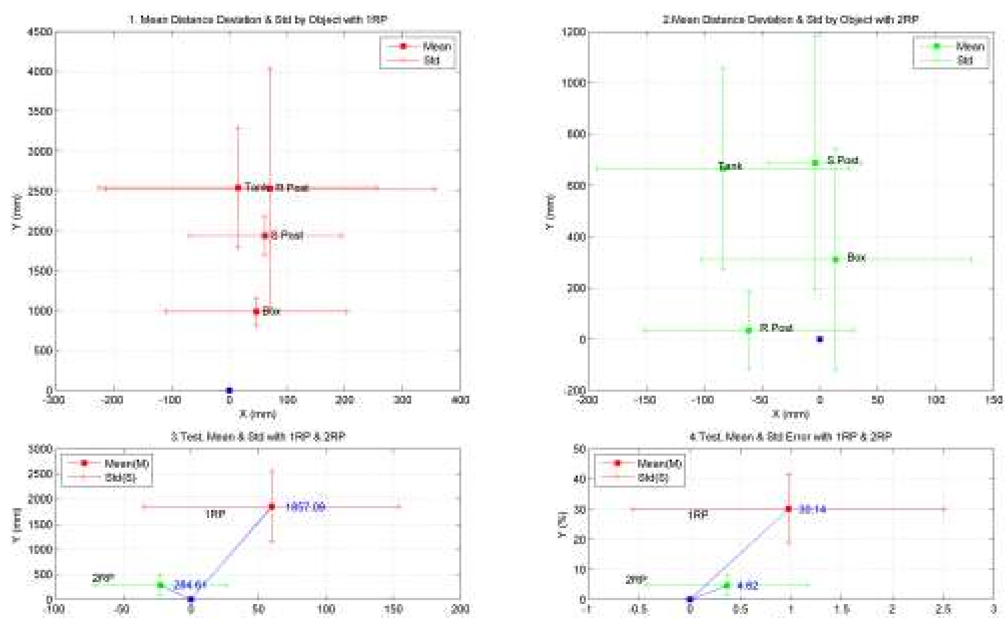
Results of trial number: 2 File name: SPTTS4NSS-2.png



Results of trial number: 3 File name: SPTTS4NSS-3.png



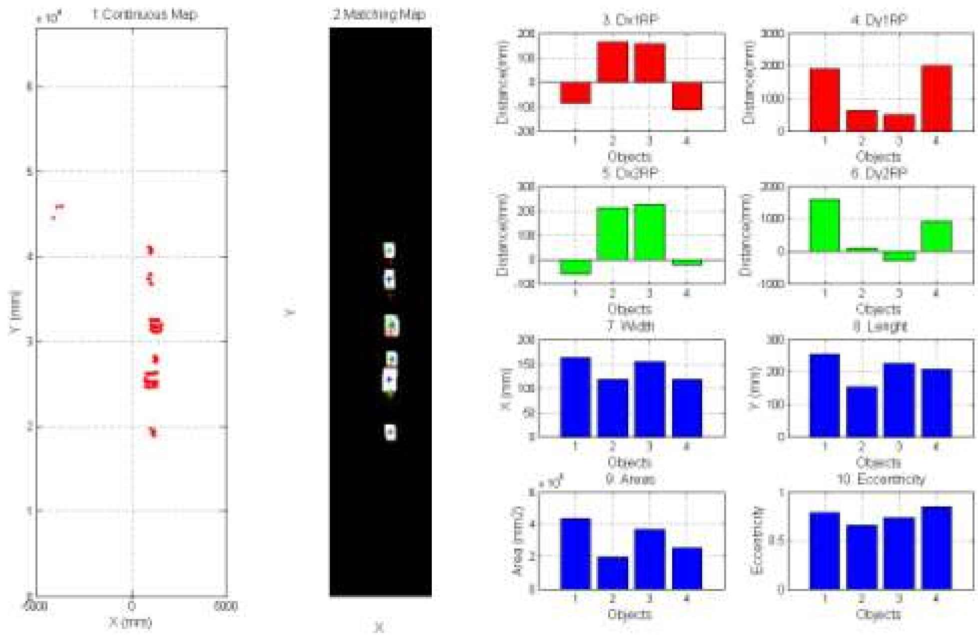
Final results of the tests File name: SPTTS4NSS-T.png



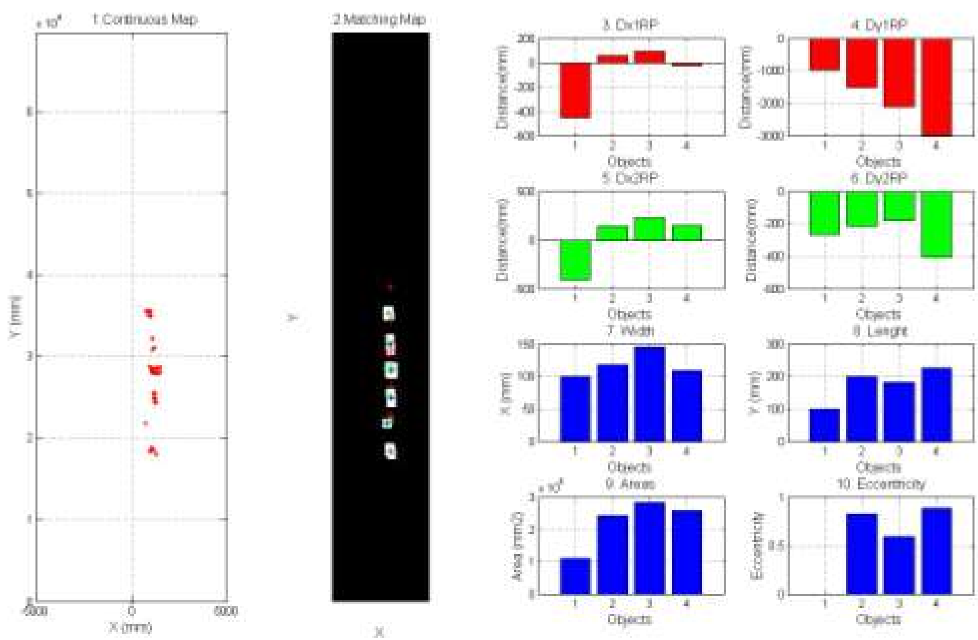
30. Test Name: **NSPTTS4NSS** **This test was not possible to do**

31. Test Name: **SSTTS7NSS**

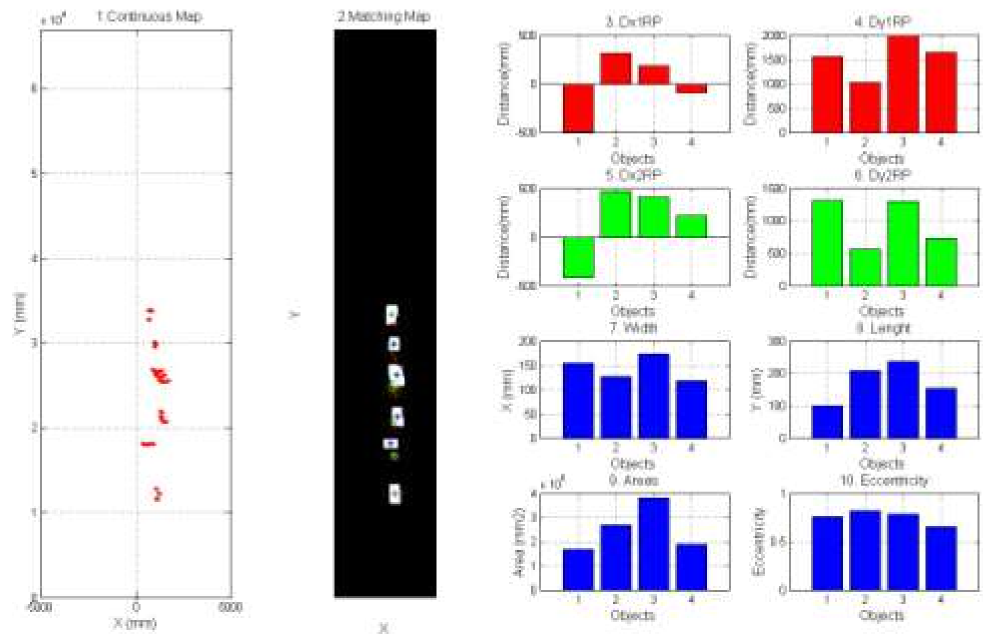
Results of trial number: 1 File name: SSTTS7NSS-1.png



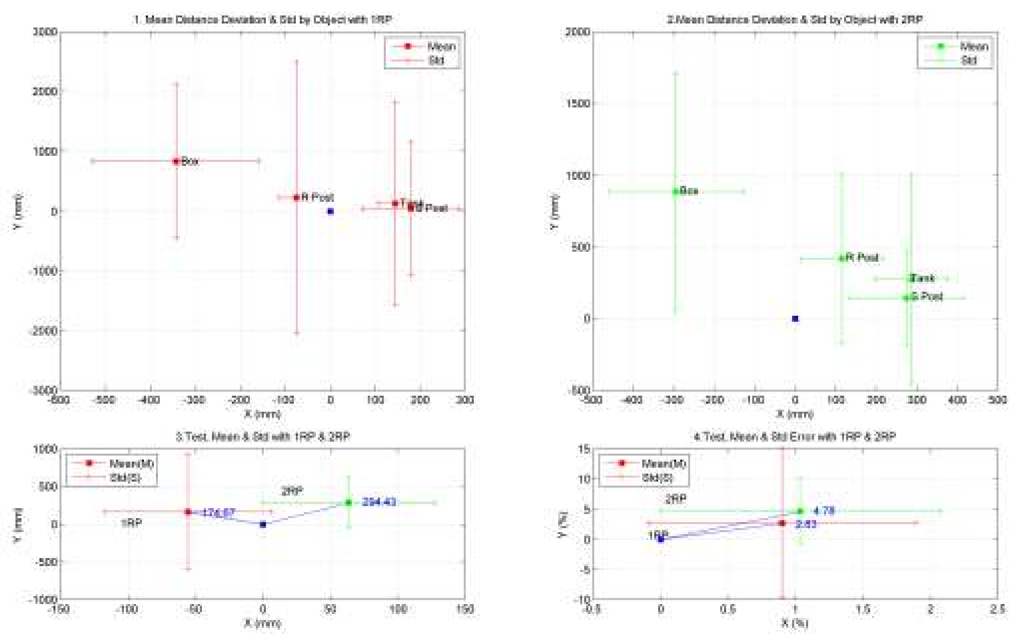
Results of trial number: 2 File name: SSTTS7NSS-2.png



Results of trial number: 3 File name: SSTTS7NSS-3.png

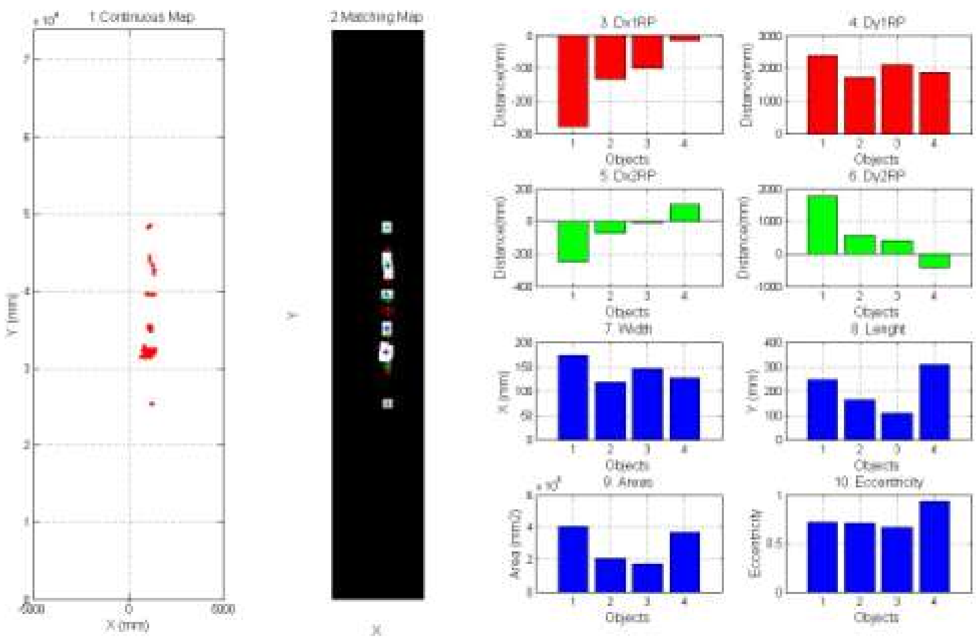


Final results of the tests File name: SSTTS7NSS-T.png

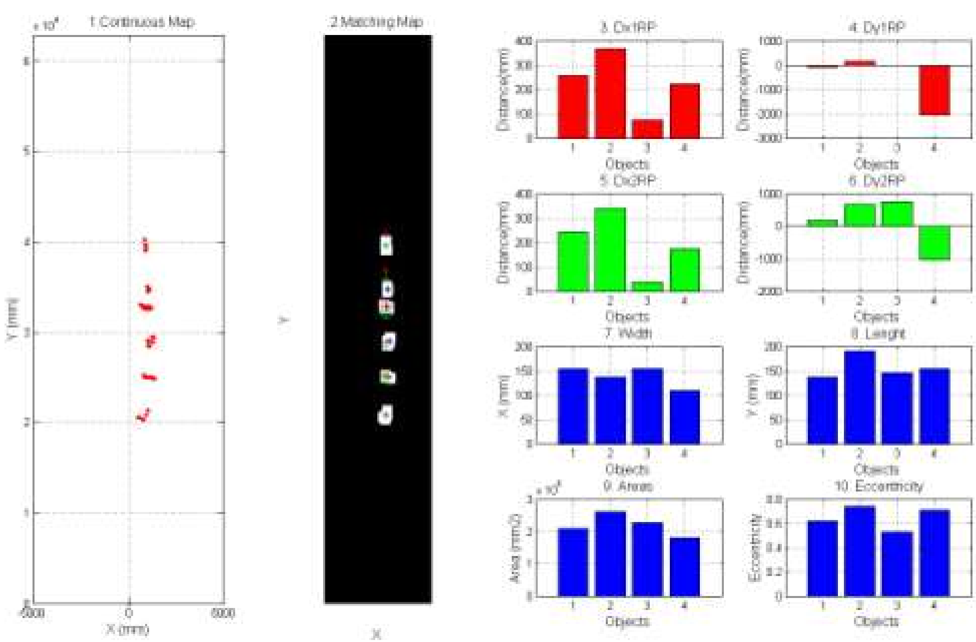


32. Test Name: **NSSTTS7NSS**

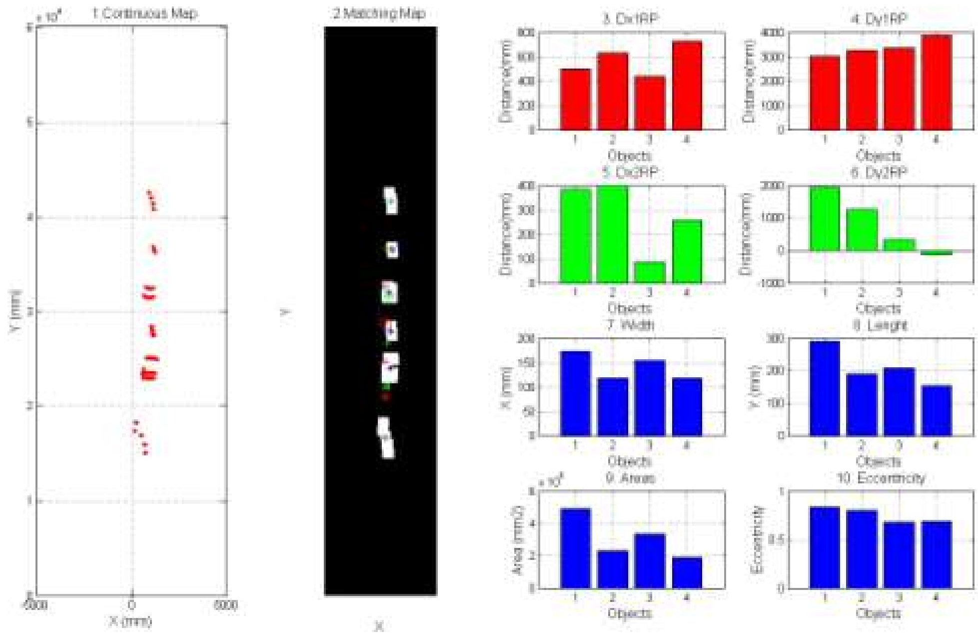
Results of trial number: 1 File name: NSSTTS7NSS-1.png



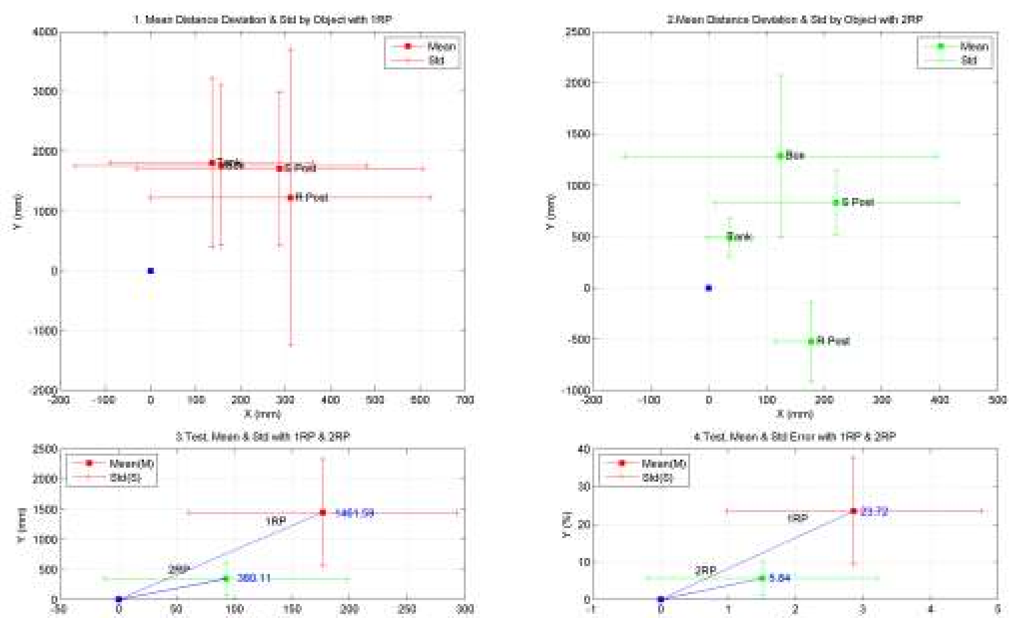
Results of trial number: 2 File name: NSSTTS7NSS-2.png



Results of trial number: 3 File name: NSSTTS7NSS-3.png

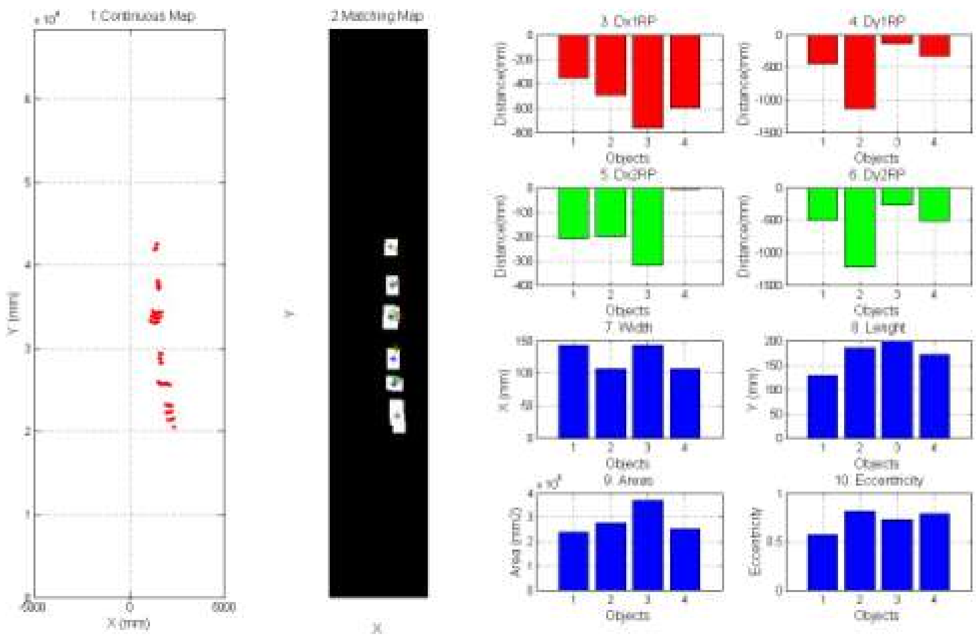


Final results of the tests File name: NSSTTS7NSS-T.png

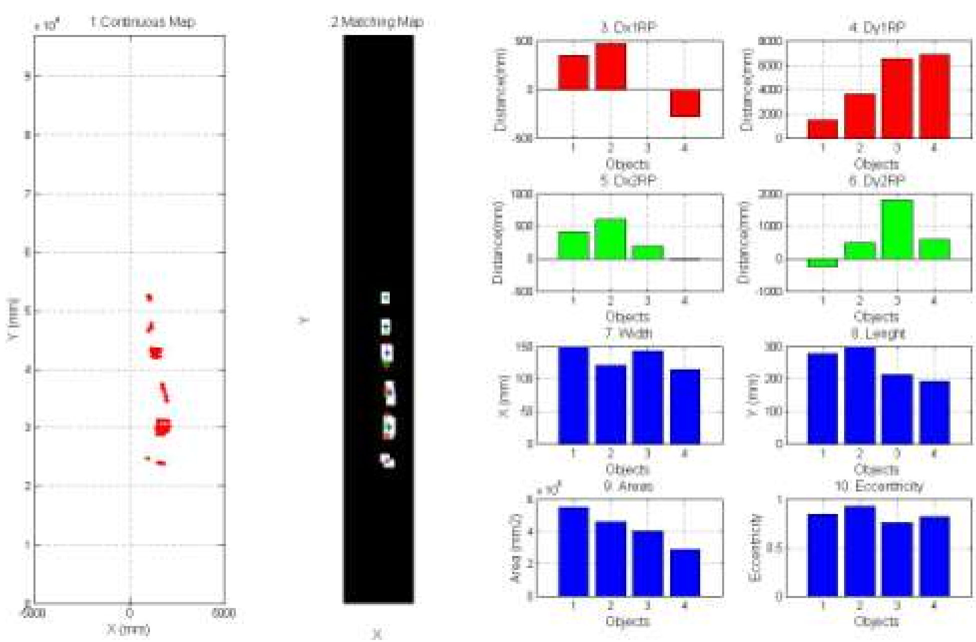


33. Test Name: **SRTTS7NSS**

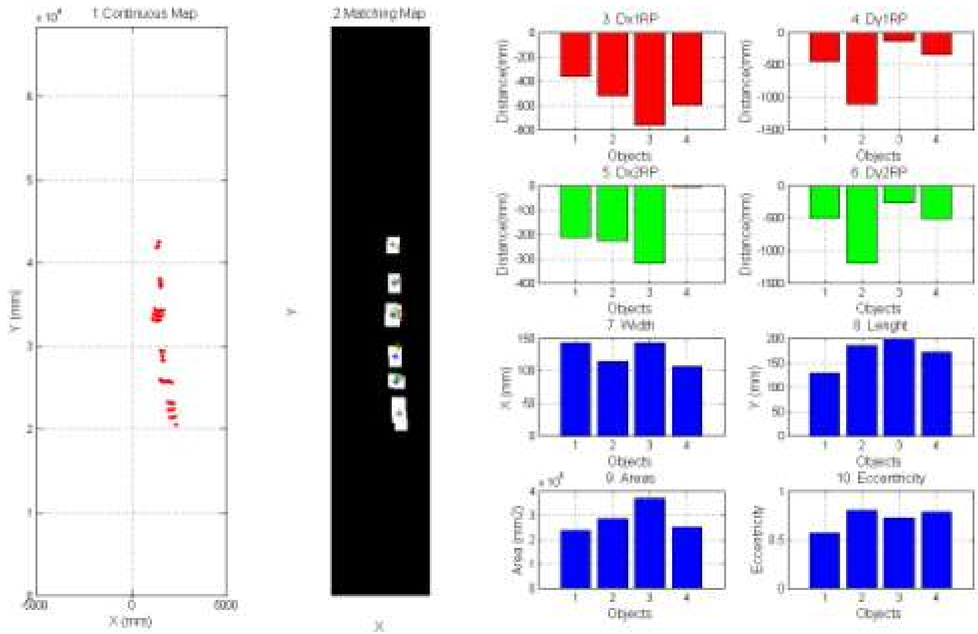
Results of trial number: 1 File name: SRTTS7NSS-1.png



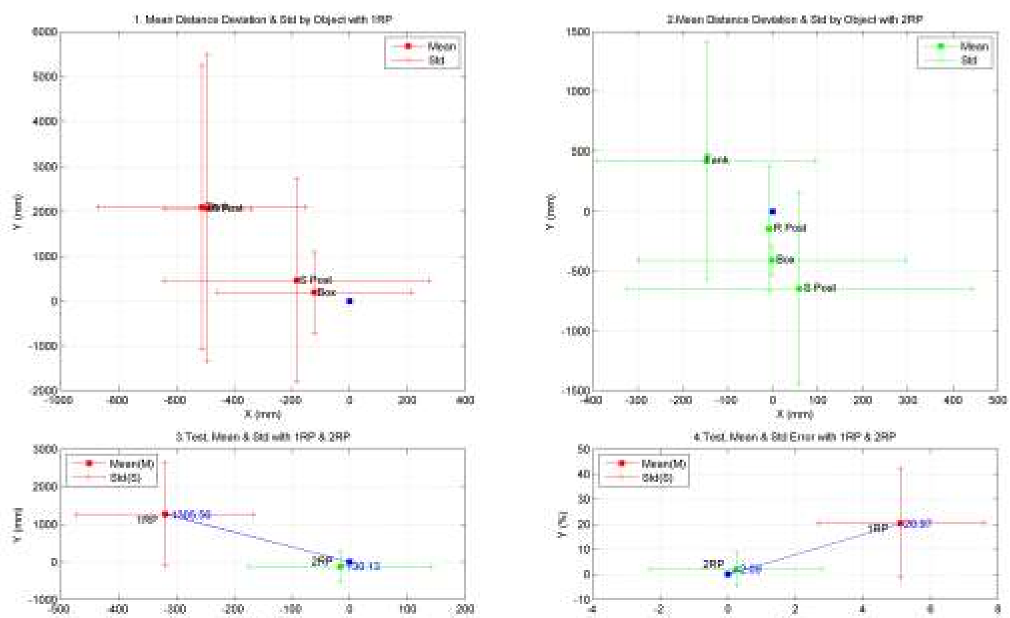
Results of trial number: 2 File name: SRTTS7NSS-2.png



Results of trial number: 3 File name: SRTTS7NSS-3.png

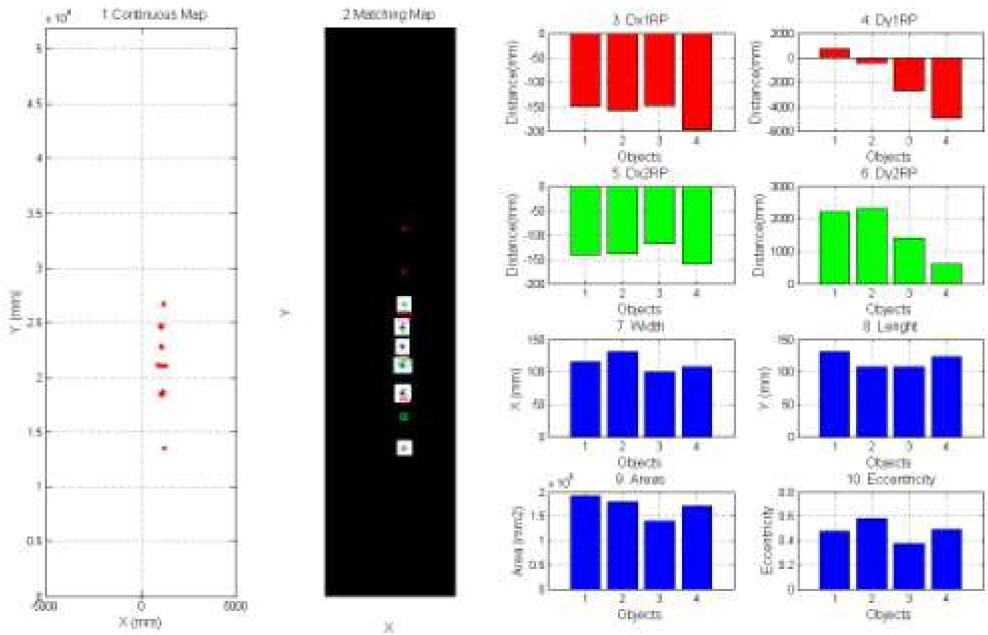


Final results of the tests File name: SRTTS7NSS-T.png

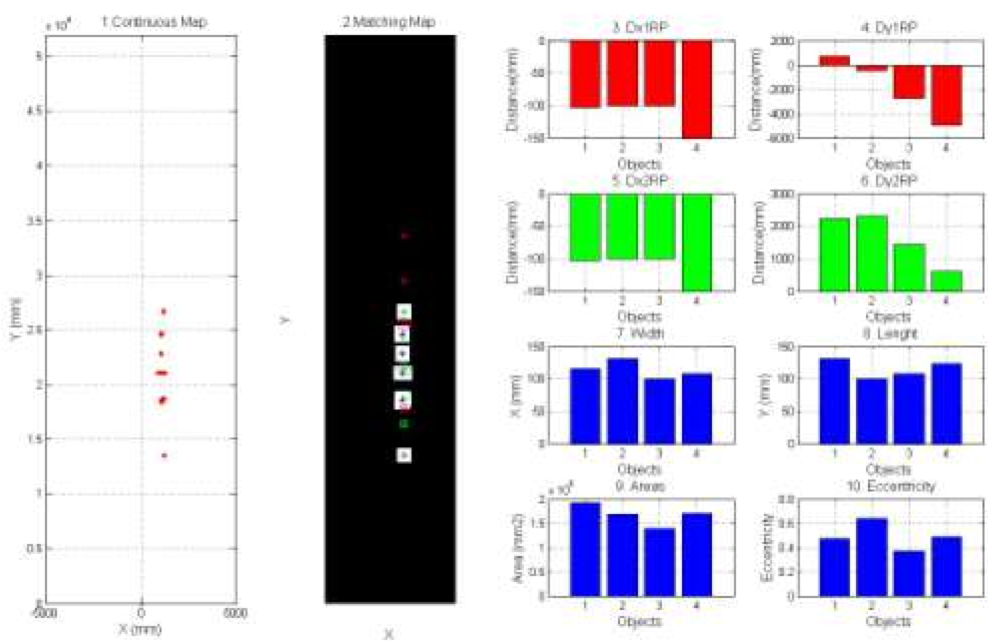


34. Test Name: **NSRTTS7NSS**

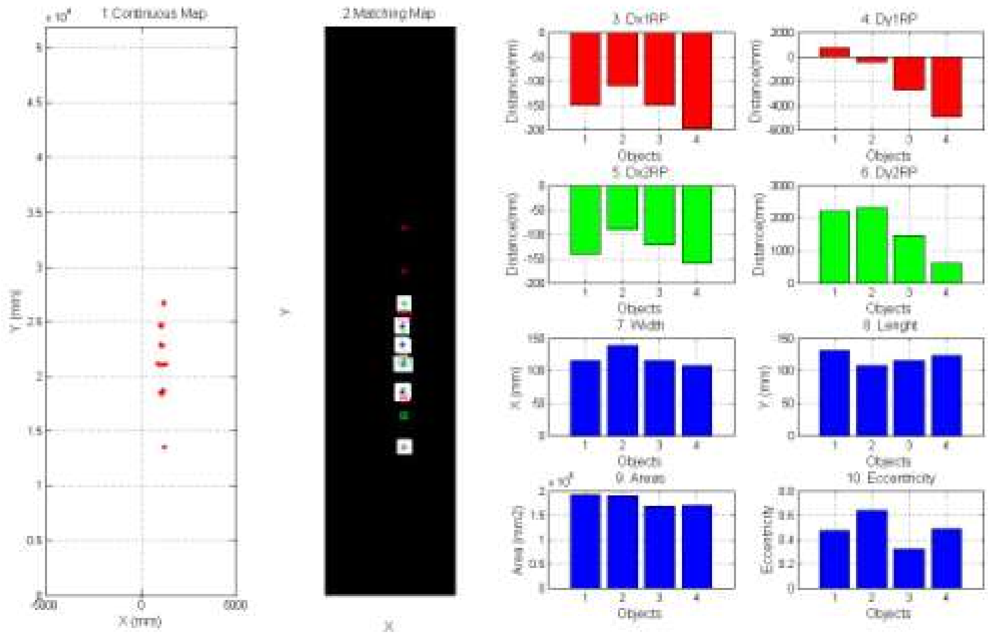
Results of trial number: 1 File name: NSRTTS7NSS-1.png



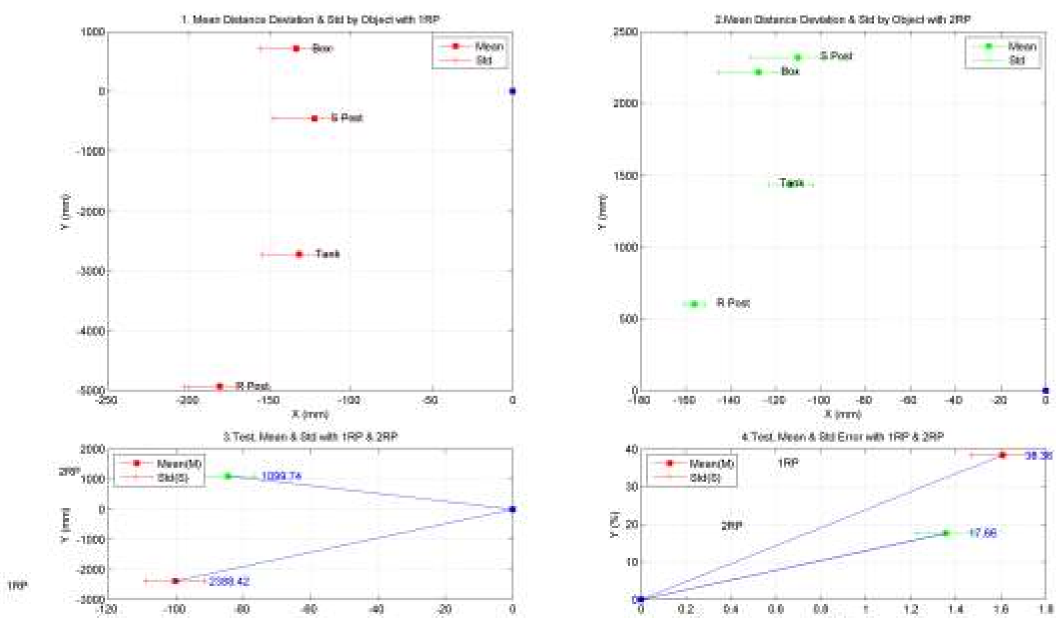
Results of trial number: 2 File name: NSRTTS7NSS-2.png



Results of trial number: 3 File name: NSRTTS7NSS-3.png



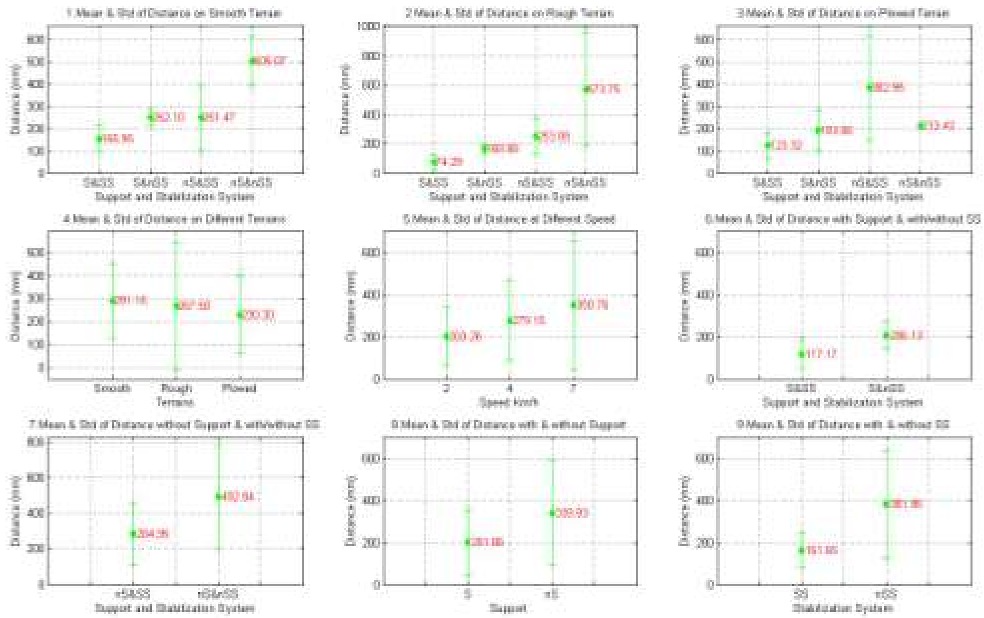
Final results of the tests File name: NSRTTS7NSS-T.png



35. Test Name: **SPTTS7NSS** **This test was not possible to do**

36. Test Name: **NSPTTS7NSS** **This test was not possible to do**

Final results of this study File name: **Final Results.png**



Results CSV files

The results of the tests are shown in the same order of the table A-3.

1. Summary of trials 1, 2, and 3 tests SSTTS2SS

File name: **SSTTS2SS-1.csv**		Test name: **SSTTS2SS**				Trial number: **1**								
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.309	353.43	72.309	353.43	72.309	353.43	0	0	0	0	1.94E+05	0.65073	200	240
Box	70.674	310.73	72.309	309.93	71.445	307.15	-163.56	-79.923	-77.161	-358.64	4.78E+05	0.64315	320	360
SP	73.508	268.65	72.309	272.93	70.581	267.78	119.89	428.54	292.7	-87.242	2.44E+05	0.88884	220	320
Tank	72.315	226.48	72.309	232.93	69.717	225.21	0.52378	645.72	259.73	-126.36	2.48E+05	0.45548	220	240
RP	71.978	190.57	72.309	192.93	68.853	182.65	-33.126	236.16	312.49	-792.21	1.82E+05	0.87289	140	280
2F	67.989	139.55	72.309	152.43	67.989	139.55	-432.01	1287.9	0	0	1.84E+05	0.682	180	240

File name: **SSTTS2SS-2.csv**		Test name: **SSTTS2SS**				Trial number: **2**								
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	76.122	320.16	76.122	320.16	76.122	320.16	0	0	0	0	1.48E+05	0.78172	140	220
Box	80.201	276.32	76.122	276.66	75.949	276.07	407.95	33.814	425.2	-25.346	3.58E+05	0.57664	280	320
SP	75.912	240.61	76.122	239.66	75.777	238.57	-20.912	-95.034	13.596	-204.51	1.60E+05	0.56362	180	200
Tank	74.522	197.9	76.122	199.66	75.604	198.02	-159.92	175.92	-108.16	12.038	2.68E+05	0.64707	220	280
RP	74.943	159.4	76.122	159.66	75.431	157.48	-117.84	26.443	-48.829	-191.84	1.76E+05	0.87357	140	280
2F	75.259	116.43	76.122	119.16	75.259	116.43	-86.269	273.36	0	1.42E-12	2.24E+05	0.91651	160	360

File name: **SSTTS2SS-3.csv**		Test name: **SSTTS2SS**				Trial number: **3**								
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	77.819	332.81	77.819	332.81	77.819	332.81	0	0	0	0	1.66E+05	0.81167	160	240
Box	78.114	290.25	77.819	289.31	77.335	289.24	29.45	-93.828	77.89	-100.63	3.34E+05	0.69905	240	320
SP	79.512	254.69	77.819	252.31	76.85	252.18	169.24	-237.88	266.12	-250.46	1.72E+05	0.75601	160	240
Tank	77.113	215.17	77.819	212.31	76.366	212.12	-70.628	-286.23	74.693	-305.06	3.54E+05	0.77127	240	360
RP	76.013	179.54	77.819	172.31	75.882	172.06	-180.61	-723.22	13.149	-748.3	1.52E+05	0.83677	140	240
2F	75.397	131.49	77.819	131.81	75.397	131.49	-242.2	31.408	0	0	1.46E+05	0.75647	160	220

Summary of test SSTTS2SS

File name: **SSTTS2SS-T.csv**				Test name: **SSTTS2SS**										
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	75.417	335.47	75.417	335.47	75.417	335.47	0	0	0	0	1.69E+05	0.74804	166.67	233.33
Box	76.33	292.43	75.417	291.97	74.91	290.82	91.278	-46.646	141.98	-161.54	3.90E+05	0.63961	280	333.33
SP	76.311	254.65	75.417	254.97	74.403	252.84	89.405	31.876	190.8	-180.74	1.92E+05	0.73616	186.67	253.33
Tank	74.65	213.18	75.417	214.97	73.896	211.78	-76.676	178.47	75.421	-139.79	2.90E+05	0.62461	226.67	293.33
RP	74.311	176.5	75.417	174.97	73.389	170.73	-110.53	-153.54	92.269	-577.45	1.70E+05	0.86108	140	266.67
2F	72.882	129.16	75.417	134.47	72.882	129.16	-253.5	530.88	0	4.74E-13	1.85E+05	0.78499	166.67	273.33
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	74.983	233.57	75.417	234.47	74.149	231.8	-43.336	90.173	83.412	-176.59	2.33E+05	0.73241	194.44	275.56
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	2.304	13.712	2.304	13.712	2.304	13.712	0	0	0	0	18927	0.069889	24.944	9.4281
Box	4.0891	14.132	2.304	13.712	2.5142	12.735	237.38	57.176	210.04	142.72	62992	0.050039	32.66	18.856
SP	2.467	11.445	2.304	13.712	2.7376	11.933	80.565	286.49	125.77	68.722	37094	0.13351	24.944	49.889
Tank	1.961	11.749	2.304	13.712	2.971	11.102	65.642	380.47	150.19	129.8	45986	0.1299	9.4281	49.889
RP	1.7068	12.906	2.304	13.712	3.2124	10.318	60.433	411.82	157.76	273.26	12961	0.017188	0	18.856
2F	3.4601	9.5843	2.304	13.712	3.4601	9.5843	141.38	544.31	0	6.70E-13	31847	0.09784	9.4281	61.824
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.84096	1.5338	0	1.03E-15	0.39582	1.4029	74.915	193.83	79.905	94.583	16646	0.041953	11.366	19.739

2. Summary of trials 1, 2, and 3 tests NSSTTS2SS

File name: **NSSTTS2SS-1.csv**	Test name: **NSSTTS2SS**			Trial number: **1**										
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	68.088	313	68.088	313	68.088	313	0	0	0	0	1.14E+05	0.66359	140	180
Box	71.247	275.69	68.088	269.5	68.47	269.74	315.93	-619.41	277.69	-595.1	1.70E+05	0.72611	220	180
SP	71.512	239.99	68.088	232.5	68.853	232.95	342.42	-748.81	265.93	-703.82	1.68E+05	0.45027	200	180
Tank	68.549	200.96	68.088	192.5	69.235	193.17	46.095	-845.58	-68.642	-778.23	2.26E+05	0.60991	240	220
RP	72.048	162.01	68.088	152.5	69.618	153.4	395.99	-951.19	243.01	-861.5	1.68E+05	0.85402	140	260
2F	70	113.12	68.088	112	70	113.12	191.23	-112.33	0	0	1.46E+05	0.77272	140	220

File name: **NSSTTS2SS-2.csv**	Test name: **NSSTTS2SS**			Trial number: **2**										
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	74.553	389.43	74.553	389.43	74.553	389.43	0	0	0	0	94000	0.66315	120	160
Box	74.718	340.83	74.553	345.93	74.726	344.73	16.512	509.45	-0.81143	389.59	1.42E+05	0.79466	220	140
SP	79.071	311.69	74.553	308.93	74.9	306.71	451.82	-276.49	417.18	-498.31	1.68E+05	0.75995	160	240
Tank	77.5	274	74.553	268.93	75.073	265.61	294.68	-507.45	242.71	-839.48	2.16E+05	0.43668	200	220
RP	78.381	231.94	74.553	228.93	75.246	224.5	382.78	-301.1	313.48	-743.35	1.26E+05	0.83858	120	220
2F	75.419	182.89	74.553	188.43	75.419	182.89	86.616	553.84	0	0	1.24E+05	0.60521	160	180

File name: **NSSTTS2SS-3.csv**	Test name: **NSSTTS2SS**			Trial number: **3**										
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	73.941	315.45	73.941	315.45	73.941	315.45	0	0	0	0	1.02E+05	0.50314	140	160
Box	73	266	73.941	271.95	73.612	271.09	-94.118	595.1	-61.21	509.13	1.10E+05	0.89072	220	100
SP	73.798	242.9	73.941	234.95	73.283	233.36	-14.32	-794.8	51.496	-953.88	1.98E+05	0.78149	180	260
Tank	69.239	203.91	73.941	194.95	72.954	192.57	-470.22	-896.05	-371.5	-1134.2	2.26E+05	0.47787	220	240
RP	73.329	166.16	73.941	154.95	72.625	151.78	-61.241	-1121.3	70.391	-1438.5	1.46E+05	0.89226	120	260
2F	72.296	110.48	73.941	114.45	72.296	110.48	-164.54	397.21	0	0	1.42E+05	0.62524	160	200

Summary of test NSSTTS2SS

File name: NSSTTS2SS-T.csv					Test name: NSSTTS2SS									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.194	339.29	72.194	339.29	72.194	339.29	0	0	0	0	1.03E+05	0.60996	133.33	166.67
Box	72.988	294.18	72.194	295.79	72.27	295.19	79.443	161.71	71.889	101.21	1.41E+05	0.80383	220	140
SP	74.794	264.86	72.194	258.79	72.345	257.67	259.97	-606.7	244.87	-718.67	1.78E+05	0.6639	180	226.67
Tank	71.763	226.29	72.194	218.79	72.421	217.12	-43.149	-749.69	-65.81	-917.3	2.23E+05	0.50815	220	226.67
RP	74.586	186.7	72.194	178.79	72.496	176.56	239.18	-791.21	208.96	-1014.5	1.47E+05	0.86162	126.67	246.67
2F	72.572	135.5	72.194	138.29	72.572	135.5	37.768	279.58	0	0	1.37E+05	0.66773	153.33	200
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	73.149	241.14	72.194	238.29	72.383	236.89	95.535	-284.39	76.651	-424.87	1.55E+05	0.68587	172.22	201.11
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	2.9143	35.464	2.9143	35.464	2.9143	35.464	0	0	0	0	8219.2	0.075531	9.4281	9.4281
Box	1.4172	33.227	2.9143	35.464	2.7248	35.034	173.22	553.44	147.6	494.78	24513	0.067515	0	32.66
SP	3.1655	33.136	2.9143	35.464	2.5562	34.673	199.03	234.25	150.03	186.28	14142	0.15131	16.33	33.993
Tank	4.0668	33.758	2.9143	35.464	2.4129	34.288	318.58	172.53	250.76	155.38	4714	0.073893	16.33	9.4281
RP	2.7341	32.029	2.9143	35.464	2.2997	33.907	212.49	353.45	102.12	303.71	17153	0.022563	9.4281	18.856
2F	2.221	33.528	2.9143	35.464	2.221	33.528	149.29	284.4	0	0	9568.5	0.074692	9.4281	16.33
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.81547	1.024	0	0	0.24088	0.65625	94.769	168.87	88.578	172.84	6511.2	0.03784	5.4919	9.9525

3. Summary of trials 1, 2, and 3 tests SRTTS2SS

File name: **SRTTS2SS-1.csv**		Test name: **SRTTS2SS**					Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	$A(mm^2)$	*E*	*W(mm)*	*L(mm)*
1F	71.898	349.17	71.898	349.17	71.898	349.17	0	0	0	0	1.76E+05	0.84672	140	260
Box	73.218	302.21	71.898	305.67	73.58	304.42	132	345.96	-36.203	220.74	2.94E+05	0.74718	280	260
SP	75.011	266.83	71.898	268.67	75.262	266.35	311.35	183.9	-25.048	-47.822	1.78E+05	0.60556	180	220
Tank	78.247	223.05	71.898	228.67	76.944	225.2	634.88	561.57	130.29	214.7	2.92E+05	0.66067	240	300
RP	78.347	187.6	71.898	188.67	78.626	184.05	644.95	107.32	-27.848	-354.68	1.44E+05	0.58797	160	200
2F	80.308	142.38	71.898	148.17	80.308	142.38	841	578.58	0	0	1.56E+05	0.5227	180	200
File name: **SRTTS2SS-2.csv**		Test name: **SRTTS2SS**					Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	$A(mm^2)$	*E*	*W(mm)*	*L(mm)*
1F	71.174	362.09	71.174	362.09	71.174	362.09	0	0	0	0	1.38E+05	0.81871	140	220
Box	69.995	317.8	71.174	318.59	71.061	315.15	-117.86	78.231	-106.55	-265.45	4.30E+05	0.70669	260	360
SP	71.316	272.93	71.174	281.59	70.948	275.23	14.241	865.84	36.85	229.83	1.96E+05	0.76537	180	260
Tank	71.529	229.43	71.174	241.59	70.835	232.07	35.501	1215.7	69.414	263.68	2.42E+05	0.26226	240	240
RP	71.418	193.18	71.174	201.59	70.722	188.91	24.381	840.97	69.598	-427.09	1.58E+05	0.73694	160	220
2F	70.609	145.21	71.174	161.09	70.609	145.21	-56.522	1588	0	0	1.84E+05	0.82511	160	260
File name: **SRTTS2SS-3.csv**		Test name: **SRTTS2SS**					Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	$A(mm^2)$	*E*	*W(mm)*	*L(mm)*
1F	75.031	370.36	75.031	370.36	75.031	370.36	0	0	0	0	3.24E+05	0.96213	160	500
Box	74.172	314.91	75.031	326.86	75.605	319.08	-85.873	1195.4	-143.28	417.49	4.88E+05	0.73369	280	400
SP	77.377	274.13	75.031	289.86	76.179	275.47	234.58	1573.4	119.77	133.78	1.54E+05	0.71457	160	220
Tank	79.478	227.64	75.031	249.86	76.753	228.31	444.69	2222	272.48	66.967	3.60E+05	0.81674	240	360
RP	77.646	183.11	75.031	209.86	77.327	181.16	261.47	2675	31.852	-195.34	1.58E+05	0.72069	160	220
2F	77.901	133.42	75.031	169.36	77.901	133.42	287.02	3594.7	0	0	1.82E+05	0.86925	140	280

Summary of test SRTTS2SS

File name: **SRTTS2SS-T.csv**					Test name: **SRTTS2SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.701	360.54	72.701	360.54	72.701	360.54	0	0	0	0	2.13E+05	0.87585	146.67	326.67
Box	72.462	311.64	72.701	317.04	73.415	312.88	-23.911	539.87	-95.344	124.26	4.04E+05	0.72919	273.33	340
SP	74.568	271.3	72.701	280.04	74.129	272.35	186.72	874.39	43.856	105.26	1.76E+05	0.69516	173.33	233.33
Tank	76.418	226.71	72.701	240.04	74.844	228.53	371.69	1333.1	157.39	181.78	2.98E+05	0.57989	240	300
RP	75.804	187.96	72.701	200.04	75.558	184.71	310.27	1207.8	24.534	-325.7	1.53E+05	0.68187	160	213.33
2F	76.272	140.34	72.701	159.54	76.272	140.34	357.17	1920.4	0	0	1.74E+05	0.73902	160	246.67
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	74.704	249.75	72.701	259.54	74.487	249.89	200.32	979.26	21.74	14.267	2.36E+05	0.71683	192.22	276.67
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	1.6739	8.7211	1.6739	8.7211	1.6739	8.7211	0	0	0	0	80239	0.062067	9.4281	123.65
Box	1.787	6.7726	1.6739	8.7211	1.8587	6.1982	111.01	476.26	44.426	287.03	81306	0.016834	9.4281	58.878
SP	2.4939	3.1952	1.6739	8.7211	2.2807	4.241	125.93	567.31	59.327	115.13	17205	0.066668	9.4281	18.856
Tank	3.4933	2.6852	1.6739	8.7211	2.8359	2.8066	250.08	682.92	85.087	83.615	48360	0.23346	0	48.99
RP	3.1144	4.1164	1.6739	8.7211	3.4607	3.196	255.68	1079.9	40.117	96.806	6599.7	0.066726	0	9.4281
2F	4.1237	5.026	1.6739	8.7211	4.1237	5.026	369.75	1253.5	0	0	12754	0.15402	16.33	33.993
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.88671	2.0953	2.22E-16	0	0.8718	1.9966	120.11	409.35	30.566	96.124	30999	0.07223	5.7965	37.349

4. Summary of trials 1, 2, and 3 tests NSRTTS2SS

File name: **NSRTTS2SS-1.csv**			Test name: **NSRTTS2SS**			Trial number: **1**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	70.824	332.8	70.824	332.8	70.824	332.8	0	0	0	0	2.04E+05	0.51433	200	220
Box	68.428	284.08	70.824	289.3	70.792	289.65	-239.58	521.96	-236.44	556.17	3.32E+05	0.54868	240	300
SP	70.247	244.35	70.824	252.3	70.761	252.94	-57.634	795.56	-51.359	858.87	1.78E+05	0.75236	160	240
Tank	68.571	206.35	70.824	212.3	70.729	213.25	-225.21	595.23	-215.8	689.99	3.64E+05	0.74563	280	320
RP	73.6	172.58	70.824	172.3	70.698	173.57	277.65	-27.79	290.2	98.43	2.20E+05	0.83097	180	300
2F	70.667	133.38	70.824	131.8	70.667	133.38	-15.686	-158.07	0	0	1.56E+05	0.50409	180	200

File name: **NSRTTS2SS-2.csv**			Test name: **NSRTTS2SS**			Trial number: **2**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	82.479	342.91	82.479	342.91	82.479	342.91	0	0	0	0	1.92E+05	0.78535	160	260
Box	75.675	294.34	82.479	299.41	82.583	296.3	-680.37	506.85	-690.78	196.71	3.02E+05	0.48223	260	260
SP	77.248	256.07	82.479	262.41	82.688	256.67	-523.15	633.96	-543.99	60.026	2.10E+05	0.6757	200	260
Tank	78.687	211.75	82.479	222.41	82.792	213.82	-379.21	1065.8	-410.46	206.66	3.26E+05	0.72197	260	320
RP	80.393	173.58	82.479	182.41	82.896	170.96	-208.59	882.2	-250.26	-262.1	1.78E+05	0.82466	160	260
2F	83	127.58	82.479	141.91	83	127.58	52.083	1433	0	-1.42E-12	1.32E+05	0.49079	180	160

File name: **NSRTTS2SS-3.csv**			Test name: **NSRTTS2SS**			Trial number: **3**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	86.326	350.59	86.326	350.59	86.326	350.59	0	0	0	0	2.70E+05	0.85497	240	320
Box	87.364	305.97	86.326	307.09	85.927	302.29	103.77	112.76	143.69	-367.53	2.86E+05	0.66034	240	280
SP	86.214	267.77	86.326	270.09	85.528	261.2	-11.164	231.88	68.673	-656.93	1.68E+05	0.80146	160	240
Tank	81.006	223.85	86.326	230.09	85.128	216.79	-531.95	624.1	-412.19	-706.35	3.10E+05	0.65812	240	320
RP	84.533	181.86	86.326	190.09	84.729	172.37	-179.26	823.54	-19.585	-948.55	2.10E+05	0.54859	220	240
2F	84.33	127.4	86.326	149.59	84.33	127.4	-199.59	2219.3	0	0	2.00E+05	0.68882	200	260

Summary of test NSRTTS2SS

File name: **NSRTTS2SS-T.csv**					Test name: **NSRTTS2SS**								
	Mean values of this properties by objects												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	79.876	342.1	79.876	342.1	79.876	342.1	0	0	0	0	2.22E+05	0.71822	200	266.67
Box	77.156	294.8	79.876	298.6	79.767	296.08	-272.06	380.52	-261.18	128.45	3.07E+05	0.56375	246.67	280
SP	77.903	256.06	79.876	261.6	79.659	256.94	-197.32	553.8	-175.56	87.321	1.85E+05	0.74317	173.33	246.67
Tank	76.088	213.98	79.876	221.6	79.55	214.62	-378.79	761.7	-346.15	63.433	3.33E+05	0.70857	260	320
RP	79.509	176.01	79.876	181.6	79.441	172.3	-36.734	559.32	6.7845	-370.74	2.03E+05	0.73474	186.67	266.67
2F	79.332	129.45	79.876	141.1	79.332	129.45	-54.399	1164.7	0	-4.74E-13	1.63E+05	0.56123	186.67	206.67
	Total Mean values of this properties												
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	78.311	235.4	79.876	241.1	79.604	235.25	-156.55	570.01	-129.35	-15.256	2.35E+05	0.67161	208.89	264.44
	Standard Deviation values of this properties by objects												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	6.591	7.2845	6.591	7.2845	6.591	7.2845	0	0	0	0	34293	0.14695	32.66	41.096
Box	7.8011	8.9386	6.591	7.2845	6.4916	5.1642	320.95	189.44	341.12	380.18	19067	0.073487	9.4281	16.33
SP	6.535	9.5634	6.591	7.2845	6.3977	3.3806	231.18	237	265.09	619.12	17913	0.051754	18.856	9.4281
Tank	5.3989	7.3171	6.591	7.2845	6.3095	1.5515	125.23	215.34	92.174	578.98	22647	0.036957	16.33	0
RP	4.5071	4.1563	6.591	7.2845	6.2274	1.0638	222.62	415.84	221.43	434.28	17913	0.13165	24.944	24.944
2F	6.1515	2.7807	6.591	7.2845	6.1515	2.7807	106.33	988.91	0	6.70E-13	28158	0.090382	9.4281	41.096
	Total Standard Deviation values of this properties												
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	1.0272	2.4413	0	8.88E-16	0.1504	2.1349	103.46	313.91	131.12	250.53	6066.5	0.03982	8.2805	15.341

5. Summary of trials 1, 2, and 3 tests SPTTS2SS

File name: **SPTTS2SS-1.csv**			Test name: **SPTTS2SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	73.128	327	73.128	327	73.128	327	0	0	0	0	94000	0.064888	140	140
Box	70.584	273.35	73.128	283.5	72.891	283.19	-254.35	1015	-230.67	983.92	4.28E+05	0.784	280	380
SP	70.5	232.21	73.128	246.5	72.654	245.93	-262.77	1429.2	-215.4	1371.7	2.40E+05	0.63798	260	240
Tank	68.994	194.59	73.128	206.5	72.417	205.64	-413.36	1190.8	-342.3	1104.9	3.38E+05	0.58533	260	300
RP	70.958	164.46	73.128	166.5	72.18	165.35	-216.93	204.17	-122.19	89.664	2.40E+05	0.91205	200	360
2F	71.943	124.57	73.128	126	71.943	124.57	-118.43	143.4	0	0	1.06E+05	0.49168	140	160

File name: **SPTTS2SS-2.csv**			Test name: **SPTTS2SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	69.439	368.43	69.439	368.43	69.439	368.43	0	0	0	0	1.96E+05	0.47104	200	220
Box	72.864	324.27	69.439	324.93	69.83	322.36	342.53	66.158	303.42	-190.93	4.12E+05	0.26699	320	340
SP	73.092	285.02	69.439	287.93	70.221	283.17	365.32	290.56	287.09	-185.2	1.74E+05	0.61134	180	220
Tank	71.818	243.25	69.439	247.93	70.612	240.81	237.88	467.7	120.55	-244.47	3.18E+05	0.65432	260	300
RP	72.031	203.42	69.439	207.93	71.003	198.44	259.25	451.19	102.8	-497.38	1.92E+05	0.56207	200	240
2F	71.394	155.55	69.439	167.43	71.394	155.55	195.56	1187.9	0	0	1.42E+05	0.64988	160	200

File name: **SPTTS2SS-3.csv**			Test name: **SPTTS2SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	75	327.95	75	327.95	75	327.95	0	0	0	0	1.88E+05	0.71618	240	180
Box	72.487	295.82	75	284.45	74.937	288.38	-251.28	-1136.9	-244.94	-743.25	3.90E+05	0.36833	300	300
SP	74.319	258.6	75	247.45	74.873	254.73	-68.056	-1115	-55.373	-386.64	1.44E+05	0.62036	160	200
Tank	73.304	217.88	75	207.45	74.81	218.35	-169.63	-1043.5	-150.61	46.868	2.70E+05	0.50662	240	260
RP	74.441	185.02	75	167.45	74.746	181.97	-55.882	-1757.3	-30.516	-305.01	2.04E+05	0.69002	200	260
2F	74.683	145.13	75	126.95	74.683	145.13	-31.707	-1818.7	0	0	1.64E+05	0.85739	140	260

Summary of test SPTTS2SS

File name: **SPTTS2SS-T.csv**					Test name: **SPTTS2SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.522	341.13	72.522	341.13	72.522	341.13	0	0	0	0	1.59E+05	0.41737	193.33	180
Box	71.978	297.81	72.522	297.63	72.552	297.98	-54.369	-18.582	-57.397	16.579	4.10E+05	0.47311	300	340
SP	72.637	258.61	72.522	260.63	72.583	261.28	11.499	201.56	5.4421	266.63	1.86E+05	0.62323	200	220
Tank	71.372	218.57	72.522	220.63	72.613	221.6	-115.03	205.02	-124.12	302.42	3.09E+05	0.58209	253.33	286.67
RP	72.477	184.3	72.522	180.63	72.643	181.92	-4.5225	-367.31	-16.636	-237.57	2.12E+05	0.72138	200	286.67
2F	72.674	141.75	72.522	140.13	72.674	141.75	15.142	-162.47	0	0	1.37E+05	0.66632	146.67	206.67
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	72.277	240.36	72.522	240.13	72.598	240.94	-24.548	-23.63	-32.118	58.009	2.36E+05	0.58058	215.56	253.33
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	2.3104	19.31	2.3104	19.31	2.3104	19.31	0	0	0	0	46313	0.26859	41.096	32.66
Box	0.99788	20.834	2.3104	19.31	2.0985	17.37	280.65	880.51	255.2	720.22	15578	0.22369	16.33	32.66
SP	1.5921	21.561	2.3104	19.31	1.8999	15.894	262.51	1040.6	209.6	785.74	40100	0.011063	43.205	16.33
Tank	1.7874	19.871	2.3104	19.31	1.7193	14.539	268.66	930.87	189.88	579.74	28535	0.060341	9.4281	18.856
RP	1.4564	15.913	2.3104	19.31	1.5628	13.508	197.76	988.02	92.375	244.36	20396	0.14459	0	52.493
2F	1.4384	12.873	2.3104	19.31	1.4384	12.873	132.4	1246.4	0	0	23907	0.14975	9.4281	41.096
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.39771	3.0454	0	0	0.3012	2.2331	99.281	396.32	100.53	323.28	10826	0.088101	16.434	12.391

6. Summary of trials 1, 2, and 3 tests NSPTTS2SS

File name: **NSPTTS2SS-1.csv**			Test name: **NSPTTS2SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	68.449	396.13	68.449	396.13	68.449	396.13	0	0	0	0	2.54E+05	0.85453	260	320
Box	67.472	344.03	68.449	352.63	69.5	342.08	-97.66	860.05	-202.79	-195.18	3.60E+05	0.76673	300	340
SP	71.305	300.03	68.449	315.63	70.551	296.11	285.58	1560.7	75.32	-392.04	3.02E+05	0.18298	280	280
Tank	69.69	254.49	68.449	275.63	71.603	246.4	124.13	2114.1	-191.26	-809.02	2.84E+05	0.59324	240	300
RP	72.949	205.6	68.449	235.63	72.654	196.7	450.05	3003.2	29.523	-890.19	2.76E+05	0.91041	200	400
2F	73.705	146.38	68.449	195.13	73.705	146.38	525.65	4875.9	0	0	2.24E+05	0.91753	180	340

File name: **NSPTTS2SS-2.csv**			Test name: **NSPTTS2SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	69.99	394.7	69.99	394.7	69.99	394.7	0	0	0	0	1.96E+05	0.81031	180	280
Box	71.429	344.32	69.99	351.2	71.077	342.56	143.96	688.2	35.218	-175.81	3.54E+05	0.53063	280	300
SP	72.98	301.14	69.99	314.2	72.165	298.21	298.99	1306.9	81.512	-292.04	2.96E+05	0.76716	220	320
Tank	74.394	252.04	69.99	274.2	73.252	250.27	440.38	2216.2	114.16	-177.28	3.76E+05	0.69196	280	340
RP	74.1	204.19	69.99	234.2	74.339	202.32	411.02	3001.7	-23.942	-186.27	1.60E+05	0.7688	180	220
2F	75.427	153.78	69.99	193.7	75.427	153.78	543.7	3992.4	0	0	1.64E+05	0.79927	160	240

File name: **NSPTTS2SS-3.csv**			Test name: **NSPTTS2SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	71.01	366.36	71.01	366.36	71.01	366.36	0	0	0	0	1.94E+05	0.86069	180	280
Box	72.122	312.21	71.01	322.86	72.588	317.87	111.15	1065.6	-46.623	566.32	3.12E+05	0.68763	240	320
SP	74.704	277.36	71.01	285.86	74.166	276.62	369.38	850.37	53.835	-73.527	1.96E+05	0.75275	180	260
Tank	77.197	230.54	71.01	245.86	75.743	232.03	618.63	1531.6	145.32	148.61	3.56E+05	0.85319	240	400
RP	79.339	189.63	71.01	205.86	77.321	187.44	832.87	1623.4	201.78	-218.68	1.18E+05	0.53692	160	160
2F	78.899	142.29	71.01	165.36	78.899	142.29	788.86	2306.9	0	0	1.78E+05	0.73324	180	240

Summary of test NSPTTS2SS

File name: **NSPTTS2SS-T.csv**					Test name: **NSPTTS2SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
1F	69.816	385.73	69.816	385.73	69.816	385.73	0	0	0	0	2.15E+05	0.84184	206.67	293.33
Box	70.341	333.52	69.816	342.23	71.055	334.17	52.482	871.28	-71.399	65.111	3.42E+05	0.66166	273.33	320
SP	72.996	292.84	69.816	305.23	72.294	290.31	317.98	1239.3	70.222	-252.54	2.65E+05	0.56763	226.67	286.67
Tank	73.76	245.69	69.816	265.23	73.533	242.9	394.38	1953.9	22.739	-279.23	3.39E+05	0.7128	253.33	346.67
RP	75.463	199.81	69.816	225.23	74.772	195.49	564.64	2542.8	69.121	-431.71	1.85E+05	0.73871	180	260
2F	76.01	147.48	69.816	184.73	76.01	147.48	619.4	3725	0	0	1.89E+05	0.81668	173.33	273.33
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
Total	73.064	267.51	69.816	284.73	72.913	266.02	324.82	1722.1	15.114	-149.73	2.56E+05	0.72322	218.89	296.67
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
1F	1.0529	13.711	1.0529	13.711	1.0529	13.711	0	0	0	0	27825	0.022438	37.712	18.856
Box	2.0482	15.072	1.0529	13.711	1.2607	11.53	107.01	154.26	98.733	354.5	21354	0.098123	24.944	16.33
SP	1.3879	10.957	1.0529	13.711	1.4784	9.7202	36.751	293.92	11.86	133	48616	0.27205	41.096	24.944
Tank	3.0971	10.758	1.0529	13.711	1.7021	7.8468	204.48	301.54	151.85	397.54	39508	0.10714	18.856	41.096
RP	2.7809	7.2202	1.0529	13.711	1.9297	6.1366	190.33	650.1	96.312	324.46	66820	0.15395	16.33	101.98
2F	2.16	4.755	1.0529	13.711	2.16	4.755	120.05	1065.7	0	0	25630	0.076236	9.4281	47.14
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
Total	0.71493	3.5404	0	0	0.37901	3.0725	74.111	352.69	58.84	164.75	15699	0.077817	11.37	29.183

7. Summary of trials 1, 2, and 3 tests SSTTS4SS

File name: **SSTTS4SS-1.csv**			Test name: **SSTTS4SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	78.1	379.11	78.1	379.11	78.1	379.11	0	0	0	0	2.61E+05	0.86291	162.5	262.5
Box	78.166	334.71	78.1	335.61	78.251	335.34	6.5375	89.307	-8.5514	63.144	2.56E+05	0.8011	237.5	162.5
SP	77.446	296.81	78.1	298.61	78.402	298.12	-65.465	179.28	-95.642	130.86	3.00E+05	0.71202	187.5	250
Tank	76.611	258.51	78.1	258.61	78.553	257.88	-148.91	9.3415	-194.18	-63.132	2.64E+05	0.50522	175	200
RP	77.777	218.64	78.1	218.61	78.704	217.64	-32.321	-3.11	-92.676	-99.641	2.75E+05	0.79068	175	250
2F	78.855	176.9	78.1	178.11	78.855	176.9	75.444	120.89	0	0	2.41E+05	0.87915	200	237.5
File name: **SSTTS4SS-2.csv**			Test name: **SSTTS4SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	78.32	378.44	78.32	378.44	78.32	378.44	0	0	0	0	2.81E+05	0.87485	162.5	275
Box	78.166	334.71	78.32	334.94	78.455	334.84	-15.415	22.78	-28.908	12.332	2.56E+05	0.8011	237.5	162.5
SP	77.446	296.81	78.32	297.94	78.59	297.75	-87.417	112.75	-114.4	93.415	3.00E+05	0.71202	187.5	250
Tank	76.611	258.51	78.32	257.94	78.725	257.65	-170.86	-57.185	-211.34	-86.128	2.64E+05	0.50522	175	200
RP	77.76	218.61	78.32	217.94	78.86	217.55	-55.982	-67.086	-109.95	-105.64	2.76E+05	0.78889	175	250
2F	78.995	176.96	78.32	177.44	78.995	176.96	67.465	48.278	0	0	2.34E+05	0.89042	200	237.5
File name: **SSTTS4SS-3.csv**			Test name: **SSTTS4SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	78.1	379.11	78.1	379.11	78.1	379.11	0	0	0	0	2.61E+05	0.86291	162.5	262.5
Box	78.206	334.75	78.1	335.61	78.279	335.36	10.54	86.017	-7.3431	61.171	2.55E+05	0.799	237.5	162.5
SP	77.446	296.81	78.1	298.61	78.458	298.15	-65.465	179.28	-101.23	133.3	3.00E+05	0.71202	187.5	250
Tank	76.611	258.51	78.1	258.61	78.637	257.92	-148.91	9.3415	-202.56	-59.484	2.64E+05	0.50522	175	200
RP	77.381	219.56	78.1	218.61	78.816	217.69	-71.977	-95.819	-143.51	-187.49	2.46E+05	0.72445	162.5	225
2F	78.995	176.96	78.1	178.11	78.995	176.96	89.417	114.8	0	0	2.34E+05	0.89042	200	237.5

Summary of test SSTTS4SS

File name: **SSTTS4SS-T.csv**					Test name: **SSTTS4SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
1F	78.174	378.88	78.174	378.88	78.174	378.88	0	0	0	0	2.68E+05	0.867	163	267
Box	78.179	334.72	78.174	335.38	78.329	335.18	0.5544	66.035	-14.93	45.549	2.56E+05	0.8	238	163
SP	77.446	296.81	78.174	298.38	78.483	298	-72.78	157.1	-103.8	119.19	3.00E+05	0.712	188	250
Tank	76.611	258.51	78.174	258.38	78.638	257.82	-156.2	-12.83	-202.7	-69.58	2.64E+05	0.505	175	200
RP	77.639	218.94	78.174	218.38	78.793	217.63	-53.43	-55.34	-115.4	-130.9	2.66E+05	0.768	171	242
2F	78.948	176.94	78.174	177.88	78.948	176.94	77.442	94.657	0	0	2.36E+05	0.887	200	238
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
Total	77.833	277.47	78.174	277.88	78.561	277.41	-34.07	41.603	-72.79	-5.961	2.65E+05	0.757	189	226
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
1F	0.10348	0.31361	0.10348	0.31361	0.1035	0.3136	0	0	0	0	9428.1	0.006	0	5.89
Box	0.01887	0.015511	0.10348	0.31361	0.0901	0.2427	11.409	30.615	9.8932	23.502	589.26	1E-03	0	0
SP	0	0	0.10348	0.31361	0.0786	0.1825	10.348	31.361	7.8647	18.254	0	0	0	0
Tank	0	0	0.10348	0.31361	0.0701	0.118	10.348	31.361	7.0081	11.795	0	0	0	0
RP	0.18305	0.44317	0.10348	0.31361	0.0655	0.0554	16.29	38.749	21.105	40.075	13857	0.031	5.9	11.8
2F	0.065869	0.028683	0.10348	0.31361	0.0659	0.0287	9.0726	32.889	0	0	3535.5	0.005	0	0
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
Total	0.065747	0.17743	0	0	0.0139	0.1007	4.8578	12.592	7.113	13.962	5299.9	0.011	2.2	4.5

8. Summary of trials 1, 2, and 3 test NSSTTS4SS

File name: **NSSTTS4SS-1.csv**	Test name: **NSSTTS4SS**		Trial number: **1**											
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.05	395.95	74.05	395.95	74.05	395.95	0	0	0	0	1.00E+05	0.24345	112.5	112.5
Box	70.971	343.34	74.05	352.45	73.508	351.13	-307.89	911.47	-253.66	779.54	2.16E+05	0.8103	200	187.5
SP	72.638	316.18	74.05	315.45	72.965	313.01	-141.2	-73.405	-32.735	-317.55	2.04E+05	0.81452	125	212.5
Tank	70.821	274.54	74.05	275.45	72.423	271.8	-322.92	90.665	-160.23	-274.8	2.16E+05	0.33844	162.5	175
RP	74.231	235.73	74.05	235.45	71.881	230.58	18.121	-27.832	235.04	-514.61	2.16E+05	0.83611	137.5	225
2F	71.338	188.85	74.05	194.95	71.338	188.85	-271.15	609.62	0	0	1.63E+05	0.81108	125	187.5

File name: **NSSTTS4SS-2.csv**	Test name: **NSSTTS4SS**		Trial number: **2**											
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.5	408.43	72.5	408.43	72.5	408.43	0	0	0	0	1.40E+05	0.61328	125	150
Box	73.724	368.4	72.5	364.93	72.624	367.4	122.39	-347.63	109.95	-100.84	2.04E+05	0.68937	187.5	162.5
SP	73.655	331.43	72.5	327.93	72.749	332.5	115.52	-350.25	90.632	106.46	1.45E+05	0.56886	125	150
Tank	72.425	295.51	72.5	287.93	72.873	294.76	-7.4627	-757.89	-44.791	-74.247	1.68E+05	0.7051	175	125
RP	74.684	263.08	72.5	247.93	72.998	257.03	218.42	-1515.4	168.65	-604.84	1.66E+05	0.52263	137.5	162.5
2F	73.122	218.83	72.5	207.43	73.122	218.83	62.214	-1140.3	0	0	1.64E+05	0.80689	112.5	187.5

File name: **NSSTTS4SS-3.csv**	Test name: **NSSTTS4SS**		Trial number: **3**											
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.15	395.85	74.05	395.95	74.05	395.95	0	0	0	0	1.00E+05	0.24345	112.5	112.5
Box	70.971	343.34	74.05	352.45	73.508	351.13	-307.89	911.47	-253.66	779.54	2.16E+05	0.8103	200	187.5
SP	72.638	316.18	74.05	315.45	72.965	313.01	-141.2	-73.405	-32.735	-317.55	2.04E+05	0.81452	125	212.5
Tank	70.811	274.54	74.05	275.45	72.423	271.8	-322.92	90.665	-160.23	-274.8	2.16E+05	0.33844	162.5	175
RP	74.131	235.73	74.05	235.45	71.881	230.58	18.121	-27.832	235.04	-514.61	2.16E+05	0.83611	137.5	225
2F	71.138	188.85	74.05	194.95	71.338	188.85	-271.15	609.62	0	0	1.63E+05	0.81108	125	187.5

Summary of test NSSTTS4SS

File name: NSSTTS4SS-T.csv					**Test name: NSSTTS4SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	73.533	400.11	73.533	400.11	73.533	400.11	0	0	0	0	1.13E+05	0.36673	116.67	125
Box	71.889	351.69	73.533	356.61	73.213	356.55	-164.46	491.77	-132.46	486.08	2.12E+05	0.76999	195.83	179.17
SP	72.977	321.27	73.533	319.61	72.893	319.5	-55.625	-165.69	8.3874	-176.22	1.84E+05	0.73264	125	191.67
Tank	71.356	281.53	73.533	279.61	72.573	279.45	-217.77	-192.19	-121.75	-207.95	2.00E+05	0.46066	166.67	158.33
RP	74.382	244.85	73.533	239.61	72.253	239.4	84.888	-523.69	212.91	-544.69	2.00E+05	0.73162	137.5	204.17
2F	71.933	198.85	73.533	199.11	71.933	198.85	-160.03	26.294	0	0	1.63E+05	0.80968	120.83	187.5
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	72.678	299.72	73.533	299.11	72.733	298.98	-85.5	-60.583	-5.484	-73.796	1.79E+05	0.64522	143.75	174.31
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	0.73068	5.8825	0.73068	5.8825	0.73068	5.8825	0	0	0	0	18856	0.17434	5.8926	17.678
Box	1.2977	11.818	0.73068	5.8825	0.41638	7.6678	202.84	593.55	171.41	415.02	5892.6	0.057009	5.8926	11.785
SP	0.47948	7.1875	0.73068	5.8825	0.10207	9.1863	121.02	130.5	58.156	199.88	27695	0.11581	0	29.463
Tank	0.7564	9.8826	0.73068	5.8825	0.21223	10.828	148.71	400.01	54.417	94.542	22981	0.17285	5.8926	23.57
RP	0.21354	12.895	0.73068	5.8825	0.52653	12.47	94.422	701.25	31.299	42.531	23570	0.14778	0	29.463
2F	0.84083	14.132	0.73068	5.8825	0.84083	14.132	157.15	824.94	0	0	589.26	0.001975	5.8926	0
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.3327	2.9748	1.11E-16	0	0.26247	2.7961	63.402	297.48	57.932	146.46	9903.6	0.063261	2.7778	10.44

9. Summary of trials 1, 2, and 3 test SRTTS4SS

File name: **SRTTS4SS-1.csv**	Test name: **SRTTS4SS**					Trial number: **1**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	70.444	413.67	70.444	413.67	70.444	413.67	0	0	0	0	1.58E+05	0.50771	150	150
Box	69.354	372.7	70.444	370.17	70.456	367.54	-109	-252.79	-110.11	-516.27	1.98E+05	0.72816	187.5	162.5
SP	71.44	333.14	70.444	333.17	70.467	328.3	99.517	3.4507	97.295	-484.14	2.59E+05	0.87875	125	262.5
Tank	71.288	287.61	70.444	293.17	70.478	285.88	84.314	556.68	80.98	-173.19	1.91E+05	0.52879	175	150
RP	72.708	240.12	70.444	253.17	70.489	243.45	226.34	1305.1	221.9	332.95	2.23E+05	0.55959	162.5	187.5
2F	70.5	200.5	70.444	212.67	70.5	200.5	5.5556	1217.5	0	0	1.65E+05	0.85935	125	200

File name: **SRTTS4SS-2.csv**	Test name: **SRTTS4SS**					Trial number: **2**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	66.786	391.38	66.786	391.38	66.786	391.38	0	0	0	0	1.46E+05	0.57423	137.5	150
Box	70.703	342.89	66.786	347.88	68.177	347.41	391.67	499.37	252.56	451.6	2.06E+05	0.68183	187.5	150
SP	73.907	304.68	66.786	310.88	69.569	310	712.08	620.32	433.85	531.92	2.83E+05	0.83658	150	262.5
Tank	76.818	258.16	66.786	270.88	70.96	269.56	1003.2	1272.7	585.85	1140.4	2.61E+05	0.68311	212.5	187.5
RP	73.2	228.95	66.786	230.88	72.351	229.12	641.37	193.13	84.919	16.882	1.88E+05	0.71246	137.5	187.5
2F	73.742	188.18	66.786	190.38	73.742	188.18	695.56	220.72	0	0	1.55E+05	0.66307	137.5	162.5

File name: **SRTTS4SS-3.csv**	Test name: **SRTTS4SS**					Trial number: **3**							
	Properties												
Objects	Ix	Iy	x1RP	y1RP	x2RP	y2RP	Dx1RP	Dy1RP	Dx2RP	Dy2RP	A	E	W	L
1F	79.5	417.5	79.5	417.5	79.5	417.5	0	0	0	0	1.20E+05	0.41719	125	125
Box	77.557	383.3	79.5	374	78.727	370.38	-194.26	-930.21	-116.93	-1291.9	2.94E+05	0.47009	187.5	212.5
SP	79.53	336.52	79.5	337	77.953	330.31	2.9801	47.682	157.64	-621.7	1.89E+05	0.80071	125	200
Tank	78.765	295.31	79.5	297	77.18	286.98	-73.494	169.28	158.49	-832.72	2.08E+05	0.71877	187.5	162.5
RP	80.077	241.64	79.5	257	76.407	243.65	57.719	1536.5	367.03	201.89	3.56E+05	0.41865	212.5	250
2F	75.634	199.79	79.5	216.5	75.634	199.79	-386.64	1671.4	0	0	1.64E+05	0.84678	150	187.5

Summary of test SRTTS4SS

File name: **SRTTS4SS-T.csv**						Test name: **SRTTS4SS**								
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.244	407.52	72.244	407.52	72.244	407.52	0	0	0	0	1.41 E+05	0.49971	137.5	141.67
Box	72.538	366.3	72.244	364.02	72.453	361.78	29.471	-227.88	8.5062	-452.2	2.33 E+05	0.62669	187.5	175
SP	74.959	324.78	72.244	327.02	72.663	322.87	271.52	223.82	229.59	-191.31	2.43 E+05	0.83868	133.33	241.67
Tank	75.624	280.36	72.244	287.02	72.873	280.81	338	666.21	275.11	44.813	2.20 E+05	0.64356	191.67	166.67
RP	75.328	236.9	72.244	247.02	73.082	238.74	308.48	1011.6	224.62	183.91	2.55 E+05	0.56357	170.83	208.33
2F	73.292	196.15	72.244	206.52	73.292	196.15	104.83	1036.5	0	0	1.61 E+05	0.78973	137.5	183.33
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	73.997	302	72.244	306.52	72.768	301.31	175.38	451.71	122.97	-69.131	2.09 E+05	0.66032	159.72	186.11
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	5.344	11.516	5.344	11.516	5.344	11.516	0	0	0	0	15712	0.064361	10.206	11.785
Box	3.5915	17.108	5.344	11.516	4.5325	10.227	258.47	583.89	172.59	713.23	43457	0.11234	0	27.003
SP	3.3855	14.28	5.344	11.516	3.7589	9.1358	314	280.95	146.52	514.47	39795	0.031895	11.785	29.463
Tank	3.1674	16.009	5.344	11.516	3.0523	7.9638	474.75	457.07	221.99	820.12	29913	0.082448	15.59	15.59
RP	3.3639	5.6557	5.344	11.516	2.4707	6.8035	245.25	586.39	115.19	129.66	72718	0.11998	31.18	29.463
2F	2.1198	5.6482	5.344	11.516	2.1198	5.6482	447.35	605.89	0	0	4448.8	0.089709	10.206	15.59
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.95356	4.6127	0	1.03 E-15	1.1317	1.9902	156.29	218.4	83.685	334.8	21778	0.029528	9.3378	7.3181

10. Summary of trials 1, 2, and 3 test NSRTTS4SS

File name: **NSRTTS4SS-1.csv**			Test name: **NSRTTS4SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	73.948	418.51	73.948	418.51	73.948	418.51	0	0	0	0	2.89E+05	0.8612	162.5	275
Box	70.206	367.35	73.948	375.01	72.86	368.36	-374.24	765.9	-265.43	100.91	1.76E+05	0.69243	175	137.5
SP	72.815	320.82	73.948	338.01	71.772	325.7	-113.3	1718.4	104.32	487.78	3.31E+05	0.90329	150	325
Tank	70.953	277.23	73.948	298.01	70.684	279.59	-299.52	2077.7	26.899	235.6	3.98E+05	0.77306	187.5	287.5
RP	72	240	73.948	258.01	69.596	233.47	-194.81	1800.6	240.42	-652.93	2.58E+05	0.78138	150	237.5
2F	68.508	186.78	73.948	217.51	68.508	186.78	-544.04	3072.7	0	0	2.44E+05	0.81551	162.5	250

File name: **NSRTTS4SS-2.csv**			Test name: **NSRTTS4SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	80.358	405.74	80.358	405.74	80.358	405.74	0	0	0	0	2.38E+05	0.83749	137.5	237.5
Box	79.543	372.41	80.358	362.24	80.564	363.84	-81.452	-1016.9	-102.02	-856.8	2.74E+05	0.72512	175	237.5
SP	77.606	340.31	80.358	325.24	80.769	328.2	-275.16	-1506.4	-316.29	-1210.2	2.00E+05	0.75561	137.5	200
Tank	73.929	294.96	80.358	285.24	80.975	289.68	-642.88	-972.24	-704.57	-528.78	3.53E+05	0.72934	187.5	262.5
RP	75.085	252.74	80.358	245.24	81.18	251.15	-527.29	-749.47	-609.54	-158.81	3.09E+05	0.8477	212.5	262.5
2F	81.386	212.14	80.358	204.74	81.386	212.14	102.82	-739.71	0	0	1.98E+05	0.64136	150	187.5

File name: **NSRTTS4SS-3.csv**			Test name: **NSRTTS4SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	93.338	376.03	93.338	376.03	93.338	376.03	0	0	0	0	2.44E+05	0.89013	125	262.5
Box	89.863	326.89	93.338	332.53	91.217	338.03	-347.57	563.84	-135.39	1114.1	2.55E+05	0.68111	175	212.5
SP	85.45	302.08	93.338	295.53	89.095	305.71	-788.85	-655.29	-364.48	362.99	1.75E+05	0.76331	125	187.5
Tank	85.782	280.53	93.338	255.53	86.973	270.77	-755.69	-2500.4	-119.15	-976.11	1.49E+05	0.67376	162.5	125
RP	86.099	246.11	93.338	215.53	84.851	235.83	-723.91	-3058.6	124.82	-1028.4	2.01E+05	0.89019	112.5	237.5
2F	82.729	200.45	93.338	175.03	82.729	200.45	-1060.9	-2542.5	0	0	1.66E+05	0.70866	125	175

Summary of test NSRTTS4SS

File name: **NSRTTS4SS-T.csv**					Test name: **NSRTTS4SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	82.548	400.09	82.548	400.09	82.548	400.09	0	0	0	0	2.57E+05	0.86294	141.67	258.33
Box	79.871	355.55	82.548	356.59	81.547	356.74	-267.75	104.28	-167.61	119.4	2.35E+05	0.69955	175	195.83
SP	78.624	321.07	82.548	319.59	80.545	319.87	-392.44	-147.77	-192.15	-119.8	2.35E+05	0.8074	137.5	237.5
Tank	76.888	284.24	82.548	279.59	79.544	280.01	-566.03	-464.98	-265.61	-423.1	3.00E+05	0.72539	179.17	225
RP	77.728	246.28	82.548	239.59	78.542	240.15	-482	-669.15	-81.432	-613.37	2.56E+05	0.83976	158.33	245.83
2F	77.541	199.79	82.548	199.09	77.541	199.79	-500.71	-69.854	0	0	2.03E+05	0.72184	145.83	204.17
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	78.867	301.17	82.548	299.09	80.045	299.44	-368.16	-207.91	-117.8	-172.81	2.48E+05	0.77615	156.25	227.78
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	8.0662	17.797	8.0662	17.797	8.0662	17.797	0	0	0	0	22829	0.021525	15.59	15.59
Box	8.0283	20.372	8.0662	17.797	7.5263	13.361	132.18	797.07	70.498	804.72	42242	0.018658	0	42.492
SP	5.2081	15.607	8.0662	17.797	7.0738	10.067	287.99	1364.6	210.56	772.68	68529	0.067874	10.206	62.082
Tank	6.4051	7.7013	8.0662	17.797	6.7266	7.7252	194	1903.1	316.07	500.29	1.08E+05	0.040637	11.785	71.443
RP	6.0519	5.2012	8.0662	17.797	6.5013	7.8372	218.37	1984.6	376.4	356.1	43903	0.044776	41.248	11.785
2F	6.411	10.364	8.0662	17.797	6.411	10.364	476.08	2340.8	0	0	31836	0.071704	15.59	32.808
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	1.0366	5.4749	0	2.90E-15	0.58793	3.5014	145.47	796.33	148.84	325.19	28424	0.020398	12.548	22.075

11. Summary of trials 1, 2, and 3 test SPTTS4SS

File name: **SPTTS4SS-1.csv**			Test name: **SPTTS4SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	69.884	442.01	69.884	442.01	69.884	442.01	0	0	0	0	2.15E+05	0.64213	162.5	200
Box	69.109	395.23	69.884	398.51	69.897	389.21	-77.511	327.94	-78.836	-601.82	3.34E+05	0.62666	187.5	237.5
SP	74.639	344.56	69.884	361.51	69.91	344.31	475.54	1694.8	472.89	-25.831	3.33E+05	0.82147	187.5	275
Tank	66.656	299.25	69.884	321.51	69.923	295.76	-322.76	2225.8	-326.74	-349.74	2.76E+05	0.66337	225	175
RP	71.401	244.25	69.884	281.51	69.937	247.21	151.77	3726	146.47	295.46	3.43E+05	0.86032	187.5	312.5
2F	69.95	198.05	69.884	241.01	69.95	198.05	6.6279	4296.2	0	0	1.00E+05	0.24345	112.5	112.5

File name: **SPTTS4SS-2.csv**			Test name: **SPTTS4SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	75.5	424	75.5	424	75.5	424	0	0	0	0	1.10E+05	0.46016	125	112.5
Box	70.353	383.17	75.5	380.5	75.706	391.4	-514.71	-266.81	-535.26	822.86	1.49E+05	0.78919	175	112.5
SP	77.518	359.17	75.5	343.5	75.911	363.67	201.81	-1566.6	160.7	449.93	2.41E+05	0.7876	162.5	225
Tank	74.639	344.56	75.5	303.5	76.117	333.69	-86.09	-4106.4	-147.77	-1087.9	3.33E+05	0.82147	187.5	275
RP	77.838	317.31	75.5	263.5	76.322	303.71	233.77	-5381.4	151.54	-1360.9	2.39E+05	0.67689	187.5	187.5
2F	76.528	273.35	75.5	223	76.528	273.35	6.6279	4296.2	0	0	2.46E+05	0.85266	137.5	250

File name: **SPTTS4SS-3.csv**			Test name: **SPTTS4SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	73.636	402.89	73.636	402.89	73.636	402.89	0	0	0	0	2.61E+05	0.8166	162.5	250
Box	71.715	345.01	73.636	359.39	73.209	354.33	-192.14	1439	-149.41	932.67	2.50E+05	0.56131	187.5	200
SP	76.245	296.57	73.636	322.39	72.782	313.03	260.87	2582.6	346.33	1645.7	2.55E+05	0.83873	150	250
Tank	74.168	250.65	73.636	282.39	72.355	268.37	53.206	3174.9	181.39	1772.4	3.56E+05	0.81406	200	275
RP	75.447	216.7	73.636	242.39	71.927	223.71	181.07	2569.5	351.98	701.39	2.13E+05	0.87122	125	237.5
2F	71.5	178.5	73.636	201.89	71.5	178.5	-213.64	2339.5	0	0	80000	0	100	100

Summary of test SPTTS4SS

File name: **SPTTS4SS-T.csv**						Test name: **SPTTS4SS**								
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	73.007	422.97	73.007	422.97	73.007	422.97	0	0	0	0	1.95E+05	0.63963	150	187.5
Box	70.392	374.47	73.007	379.47	72.937	378.31	-261.45	500.04	-254.5	384.57	2.44E+05	0.65905	183.33	183.33
SP	76.134	333.43	73.007	342.47	72.868	340.33	312.74	903.6	326.64	689.92	2.76E+05	0.81593	166.67	250
Tank	71.821	298.15	73.007	302.47	72.798	299.27	-118.55	431.45	-97.705	111.59	3.22E+05	0.7663	204.17	241.67
RP	74.895	259.42	73.007	262.47	72.729	258.21	188.87	304.68	216.66	-121.35	2.65E+05	0.80281	166.67	245.83
2F	72.659	216.63	73.007	221.97	72.659	216.63	-66.794	3643.9	0	0	1.42E+05	0.36537	116.67	154.17
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	73.151	317.51	73.007	321.97	72.833	319.29	9.1366	963.95	31.848	177.45	2.41E+05	0.67485	164.58	210.42
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	2.3357	15.986	2.3357	15.986	2.3357	15.986	0	0	0	0	63281	0.14553	17.678	56.826
Box	1.0644	21.408	2.3357	15.986	2.3791	16.982	185.09	706.93	200.61	698.93	75638	0.095808	5.8926	52.374
SP	1.178	26.74	2.3357	15.986	2.4506	20.864	117.61	1783.9	128.21	703.17	40169	0.021238	15.59	20.412
Tank	3.6573	38.35	2.3357	15.986	2.5478	26.781	155.19	3232	210.44	1212.4	33546	0.072848	15.59	47.14
RP	2.6564	42.453	2.3357	15.986	2.6678	33.57	33.926	4048.3	95.706	892.03	56128	0.089151	29.463	51.37
2F	2.8078	40.891	2.3357	15.986	2.8078	40.891	103.83	922.39	0	0	74108	0.35861	15.59	67.956
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.914	10.154	0	0	0.16496	9.014	64.517	1432.3	84.587	447.08	15883	0.10835	6.8837	14.477

12. Summary of trials 1, 2, and 3 test NSPTTS4SS

File name: **NSPTTS4SS-1.csv**			Test name: **NSPTTS4SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.954	415.46	74.954	415.46	74.954	415.46	0	0	0	0	1.09E+05	0.48887	112.5	125
Box	75.046	376.04	74.954	371.96	75.474	369.06	9.2273	-408.19	-42.803	-697.68	2.70E+05	0.23845	187.5	187.5
SP	76.225	342.88	74.954	334.96	75.995	329.6	127.1	-791.52	23.036	-1327.2	2.00E+05	0.82448	125	212.5
Tank	75.923	297.13	74.954	294.96	76.515	286.94	96.929	-216.91	-59.163	-1018.8	4.08E+05	0.86553	200	337.5
RP	76.598	250.89	74.954	254.96	77.035	244.28	164.35	406.95	-43.769	-661.17	2.05E+05	0.59516	162.5	175
2F	77.556	201.08	74.954	214.46	77.556	201.08	260.15	1337.6	0	0	1.80E+05	0.74669	125	187.5
File name: **NSPTTS4SS-2.csv**			Test name: **NSPTTS4SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.954	415.46	74.954	415.46	74.954	415.46	0	0	0	0	1.09E+05	0.48887	112.5	125
Box	75.905	375.83	74.954	371.96	75.536	369.03	95.094	-387.49	36.919	-680.06	3.03E+05	0.4408	212.5	187.5
SP	76.271	341.98	74.954	334.96	76.118	329.55	131.72	-702.33	15.367	-1243.7	2.21E+05	0.8629	125	237.5
Tank	75.86	297.32	74.954	294.96	76.699	286.86	90.604	-236.38	-83.92	-1046.8	4.29E+05	0.84068	212.5	337.5
RP	76.618	250.85	74.954	254.96	77.281	244.17	166.42	410.52	-66.282	-668.95	2.06E+05	0.58573	162.5	175
2F	77.863	200.94	74.954	214.46	77.863	200.94	290.87	1351.9	0	0	1.91E+05	0.72394	137.5	187.5
File name: **NSPTTS4SS-3.csv**			Test name: **NSPTTS4SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.954	415.46	74.954	415.46	74.954	415.46	0	0	0	0	1.09E+05	0.48887	112.5	125
Box	75.078	376.07	74.954	371.96	75.474	369.06	12.432	-411.4	-39.599	-700.89	2.71E+05	0.28175	187.5	187.5
SP	76.225	342.88	74.954	334.96	75.995	329.6	127.1	-791.52	23.036	-1327.2	2.00E+05	0.82448	125	212.5
Tank	75.86	297.32	74.954	294.96	76.515	286.94	90.604	-236.38	-65.488	-1038.3	4.29E+05	0.84068	212.5	337.5
RP	76.598	250.89	74.954	254.96	77.035	244.28	164.35	406.95	-43.769	-661.17	2.05E+05	0.59516	162.5	175
2F	77.556	201.08	74.954	214.46	77.556	201.08	260.15	1337.6	0	0	1.80E+05	0.74669	125	187.5

Summary of test NSPTTS4SS

File name: **NSPTTS4SS-T.csv**						Test name: **NSPTTS4SS**								
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.954	415.46	74.954	415.46	74.954	415.46	0	0	0	0	1.09E+05	0.5	113	125
Box	75.343	375.98	74.954	371.96	75.495	369.05	38.918	-402	-15.16	-692.9	2.81E+05	0.3	196	188
SP	76.24	342.58	74.954	334.96	76.036	329.58	128.64	-762	20.48	-1299	2.07E+05	0.8	125	221
Tank	75.881	297.26	74.954	294.96	76.576	286.91	92.712	-230	-69.52	-1035	4.22E+05	0.8	208	338
RP	76.604	250.88	74.954	254.96	77.117	244.24	165.04	408.1	-51.27	-663.8	2.05E+05	0.6	163	175
2F	77.658	201.04	74.954	214.46	77.658	201.04	270.39	1342	0	0	1.84E+05	0.7	129	188
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	76.114	313.87	74.954	314.46	76.306	307.71	115.95	59.41	-19.25	-615.1	2.35E+05	0.6	156	206
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Box	0.3974	0.10593	0	0	0.029	0.0145	39.744	10.59	36.849	9.1556	15035	0.1	11.8	0
SP	0.0218	0.42047	0	0	0.0579	0.0268	2.1772	42.05	3.6152	39.363	10017	0	0	11.8
Tank	0.0298	0.09182	0	0	0.0869	0.0402	2.9818	9.182	10.502	11.719	10017	0	5.89	0
RP	0.0097	0.01683	0	2.84E-14	0.1159	0.0535	0.9721	1.683	10.613	3.6682	589.26	0	0	0
2F	0.1448	0.06701	0	2.84E-14	0.1448	0.067	14.481	6.701	0	0	5303.3	0	5.89	0
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.1412	0.14087	0	1.34E-14	0.0495	0.0227	14.123	14.09	12.661	13.561	5409.3	0	4.39	4.39

13. Summary of trials 1, 2, and 3 test SSTTS7SS

File name: **SSTTS7SS-1.csv**			Test name: **SSTTS7SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	70.686	484.31	70.686	484.31	70.686	484.31	0	0	0	0	1.75E+05	0.73007	120	160
Box	75.383	427.12	70.686	440.81	70.849	438.69	469.71	1369.5	453.42	1157.1	2.09E+05	0.6713	160	150
SP	74.621	402.58	70.686	403.81	71.011	399.88	393.54	123.72	360.97	-269.34	2.27E+05	0.8198	120	200
Tank	73.46	368.36	70.686	363.81	71.174	357.93	277.42	-454.4	228.56	-1042.8	1.87E+05	0.66216	160	120
RP	72.979	324.54	70.686	323.81	71.337	315.98	229.35	-72.928	164.21	-856.61	2.41E+05	0.8659	110	220
2F	71.5	273.5	70.686	283.31	71.5	273.5	81.429	981.43	0	0	1.00E+05	0	100	100

File name: **SSTTS7SS-2.csv**			Test name: **SSTTS7SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.655	518.33	72.655	518.33	72.655	518.33	0	0	0	0	1.74E+05	0.73605	120	160
Box	71.697	469.3	72.655	474.83	72.959	467.33	-95.834	552.44	-126.26	-197.47	2.21E+05	0.62222	160	160
SP	74.321	404.83	72.655	437.83	73.264	423.95	166.56	3299.7	105.71	1912	2.65E+05	0.82601	130	220
Tank	75.957	359.04	72.655	397.83	73.568	377.05	330.13	3879.1	238.86	1801.8	2.76E+05	0.60739	150	190
RP	75.773	323.77	72.655	357.83	73.872	330.16	311.83	3405.4	190.13	638.49	1.81E+05	0.58832	130	150
2F	74.176	282.68	72.655	317.33	74.176	282.68	152.13	3465.1	0	0	1.70E+05	0.74358	110	160

File name: **SSTTS7SS-3.csv**			Test name: **SSTTS7SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	70.686	484.31	70.686	484.31	70.686	484.31	0	0	0	0	1.75E+05	0.73007	120	160
Box	75.383	427.12	70.686	440.81	70.849	438.69	469.71	1369.5	453.42	1157.1	2.09E+05	0.6713	160	150
SP	74.621	402.58	70.686	403.81	71.011	399.88	393.54	123.72	360.97	-269.34	2.27E+05	0.8198	120	200
Tank	73.46	368.36	70.686	363.81	71.174	357.93	277.42	-454.4	228.56	-1042.8	1.87E+05	0.66216	160	120
RP	72.979	324.54	70.686	323.81	71.337	315.98	229.35	-72.928	164.21	-856.61	2.41E+05	0.8659	110	220
2F	71.5	273.5	70.686	283.31	71.5	273.5	81.429	981.43	0	0	1.00E+05	0	100	100

Summary of test SSTTS7SS

File name: **SSTTS7SS-T.csv**					Test name: **SSTTS7SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	71.342	495.65	71.342	495.65	71.342	495.65	0	0	0	0	1.75E+05	0.73207	120	160
Box	74.154	441.18	71.342	452.15	71.552	448.24	281.19	1097.1	260.19	705.56	2.13E+05	0.65494	160	153.33
SP	74.521	403.33	71.342	415.15	71.762	407.91	317.88	1182.4	275.88	457.76	2.40E+05	0.82187	123.33	206.67
Tank	74.292	365.25	71.342	375.15	71.972	364.31	294.99	990.11	231.99	-94.582	2.17E+05	0.64391	156.67	143.33
RP	73.911	324.29	71.342	335.15	72.182	320.7	256.85	1086.5	172.85	-358.24	2.21E+05	0.77338	116.67	196.67
2F	72.392	276.56	71.342	294.65	72.392	276.56	105	1809.3	0	0	1.23E+05	0.24786	103.33	120
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	73.435	384.38	71.342	394.65	71.867	385.56	209.32	1027.6	156.82	118.42	1.98E+05	0.64567	130	163.33
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	0.92841	16.034	0.92841	16.034	0.92841	16.034	0	0	0	0	471.4	0.002816	0	0
Box	1.7376	19.886	0.92841	16.034	0.99507	13.5	266.6	385.15	273.26	638.54	5656.9	0.023136	0	4.714
SP	0.14161	1.0621	0.92841	16.034	1.0617	11.345	107	1497.2	120.33	1028.3	17913	0.002925	4.714	9.4281
Tank	1.1769	4.3945	0.92841	16.034	1.1284	9.0149	24.851	2042.8	4.8537	1340.9	41955	0.025819	4.714	32.998
RP	1.3172	0.36302	0.92841	16.034	1.195	6.6849	38.88	1639.7	12.217	704.8	28284	0.13085	9.4281	32.998
2F	1.2617	4.3258	0.92841	16.034	1.2617	4.3258	33.329	1170.8	0	0	32998	0.35053	4.714	28.284
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.48879	7.5072	0	0	0.11384	3.9684	90.226	714.26	101.01	493.76	14732	0.12471	3.2394	13.721

14. Summary of trials 1, 2, and 3 test NSSTTS7SS

File name: **NSSTTS7SS-1**.csv			Test name: **NSSTTS7SS**				Trial number: **1**						
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	75.529	456.11	75.529	456.11	75.529	456.11	0	0	0	0	2.08E+05	0.67246	140	170
Box	73.958	397.04	75.529	412.61	74.827	420.17	-157.05	1556.4	-86.909	2312.5	1.20E+05	0.20329	110	110
SP	72	385.5	75.529	375.61	74.126	389.6	-352.88	-989.42	-212.6	409.82	1.10E+05	0.4166	110	100
Tank	74.54	349.71	75.529	335.61	73.425	356.55	-98.921	-1410.8	111.51	683.76	3.28E+05	0.73852	160	230
RP	73.963	329.04	75.529	295.61	72.723	323.5	-156.63	-3343.2	123.93	-553.37	1.60E+05	0.42256	130	130
2F	72.022	290.04	75.529	255.11	72.022	290.04	-350.71	-3493.8	0	0	2.30E+05	0.85171	110	210

File name: **NSSTTS7SS-2.csv**			Test name: **NSSTTS7SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	78.392	462.43	78.392	462.43	78.392	462.43	0	0	0	0	2.55E+05	0.84305	120	220
Box	78.5	413.5	78.392	418.93	76.888	416.9	10.784	543.14	161.18	340.41	1.80E+05	0.71209	160	120
SP	74.219	380.78	78.392	381.93	75.384	378.18	-417.3	115.05	-116.51	-260.12	2.51E+05	0.85344	120	220
Tank	74.023	333.43	78.392	341.93	73.88	336.32	-436.96	850.36	14.225	288.77	5.33E+05	0.90678	170	360
RP	72.399	294.96	78.392	301.93	72.376	294.45	-599.32	696.86	2.2632	-51.145	1.88E+05	0.73775	120	170
2F	70.872	252.06	78.392	261.43	70.872	252.06	-751.98	936.75	0	0	2.35E+05	0.84969	130	210

File name: **NSSTTS7SS-3.csv**			Test name**:** **NSSTTS7SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	79.5	486	79.5	486	79.5	486	0	0	0	0	1.70E+05	0.80869	100	170
Box	76.563	451.25	79.5	442.5	78.523	448.32	-293.72	-875.13	-196.06	-292.64	1.99E+05	0.59333	160	130
SP	73.482	420.17	79.5	405.5	77.547	416.28	-601.77	-1466.7	-406.45	-388.79	3.11E+05	0.90184	120	270
Tank	75.082	371.7	79.5	365.5	76.57	381.64	-441.85	-619.91	-148.87	993.65	3.19E+05	0.73005	150	220
RP	74	338	79.5	325.5	75.594	346.99	-550	-1250	-159.36	899.17	1.65E+05	0.67987	110	150
2F	74.617	311.91	79.5	285	74.617	311.91	-488.3	-2691.5	0	0	2.35E+05	0.83746	120	210

Summary of test NSSTTS7SS

File name: **NSSTTS7SS-T.csv**					Test name: **NSSTTS7SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	77.807	468.18	77.807	468.18	77.807	468.18	0	0	0	0	2.11E+05	0.77473	120	186.67
Box	76.34	420.6	77.807	424.68	76.746	428.47	-146.66	408.14	-40.596	786.76	1.66E+05	0.5029	143.33	120
SP	73.234	395.48	77.807	387.68	75.686	394.69	-457.32	-780.36	-245.19	-79.693	2.24E+05	0.72396	116.67	196.67
Tank	74.548	351.61	77.807	347.68	74.625	358.17	-325.91	-393.44	-7.7136	655.39	3.93E+05	0.79178	160	270
RP	73.454	320.67	77.807	307.68	73.564	321.65	-435.32	-1298.8	-11.055	98.22	1.71E+05	0.61339	120	150
2F	72.504	284.67	77.807	267.18	72.504	284.67	-530.33	-1749.5	0	0	2.33E+05	0.84628	120	210
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	74.648	373.54	77.807	367.18	75.155	375.97	-315.92	-635.66	-50.759	243.45	2.33E+05	0.70884	130	188.89
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	1.6732	12.863	1.6732	12.863	1.6732	12.863	0	0	0	0	34766	0.073667	16.33	23.57
Box	1.8608	22.693	1.6732	12.863	1.5122	14.106	124.53	997.25	149.47	1109.4	33668	0.21734	23.57	8.165
SP	0.92284	17.561	1.6732	12.863	1.4127	15.965	105.47	662.46	120.59	350.1	84250	0.21823	4.714	71.336
Tank	0.43237	15.682	1.6732	12.863	1.388	18.537	160.52	936.89	107.42	288.46	98828	0.081388	8.165	63.77
RP	0.74607	18.54	1.6732	12.863	1.4419	21.49	198.09	1649.7	116.04	602.33	12193	0.13699	8.165	16.33
2F	1.5663	24.727	1.6732	12.863	1.5663	24.727	166.49	1927.5	0	0	2357	0.006296	8.165	0
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.52707	4.016	0	1.78E-15	0.098384	4.1513	63.675	631.83	59.574	382.69	35504	0.077402	6.4347	27.241

15. Summary of trials 1, 2, and 3 test SRTTS7SS

File name: **SRTTS7SS-1.csv**			Test name: **SRTTS7SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	89	499.5	89	499.5	89	499.5	0	0	0	0	1.50E+05	0.35901	107.14	100
Box	87.408	458.78	89	456	88.6	454.74	-159.21	-277.63	-119.21	-403.86	3.80E+05	0.70165	164.29	192.86
SP	85.391	429.97	89	419	88.2	416.66	-360.92	-1096.8	-280.92	-1330.4	2.94E+05	0.74401	128.57	178.57
Tank	87.5	373.5	89	379	87.8	375.5	-150	550	-30	200.34	1.40E+05	0	100	100
RP	86.212	343.79	89	339	87.4	334.34	-278.85	-478.85	-118.85	-944.58	2.60E+05	0.8115	107.14	178.57
2F	87	292.67	89	298.5	87	292.67	-200	583.25	0	0	2.99E+05	0.7782	121.43	185.71
File name: **SRTTS7SS-2.csv**			Test name: **SRTTS7SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	80.03	434.07	80.03	434.07	80.03	434.07	0	0	0	0	2.15E+05	0.57453	121.43	135.71
Box	85.623	385.5	80.03	390.57	79.238	393.6	559.31	506.23	638.45	809.47	3.49E+05	0.63273	157.14	178.57
SP	86.358	347.24	80.03	353.57	78.447	359.18	632.81	633.09	791.11	1194.2	3.09E+05	0.66655	164.29	157.14
Tank	79.527	307.22	80.03	313.57	77.655	321.97	-50.29	635.04	187.16	1475	4.36E+05	0.85102	150	250
RP	79	277	80.03	273.57	76.864	284.75	-102.99	-343.36	213.61	775.48	1.59E+05	0.21555	107.14	107.14
2F	76.072	247.08	80.03	233.07	76.072	247.08	-395.75	-1401.2	0	0	2.56E+05	0.62192	150	135.71
File name: **SRTTS7SS-3.csv**			Test name: **SRTTS7SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	89	499.5	89	499.5	89	499.5	0	0	0	0	1.50E+05	0.35901	107.14	100
Box	87.408	458.78	89	456	88.6	454.74	-159.21	-277.63	-119.21	-403.86	3.80E+05	0.70165	164.29	192.86
SP	85.088	430.13	89	419	88.2	416.66	-391.21	-1112.6	-311.21	-1346.2	2.84E+05	0.76372	121.43	178.57
Tank	87.5	373.5	89	379	87.8	375.5	-150	550	-30	200.34	1.40E+05	0	100	100
RP	86.212	343.79	89	339	87.4	334.34	-278.85	-478.85	-118.85	-944.58	2.60E+05	0.8115	107.14	178.57
2F	87	292.67	89	298.5	87	292.67	-200	583.25	0	0	2.99E+05	0.7782	121.43	185.71

Summary of test SRTTS7SS

File name: **SRTTS7SS-T.csv**					Test name: **SRTTS7SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	86.01	477.69	86.01	477.69	86.01	477.69	0	0	0	0	1.72E+05	0.43085	111.9	111.9
Box	86.813	434.35	86.01	434.19	85.479	434.36	80.295	-16.343	133.34	0.5845	3.70E+05	0.67868	161.9	188.1
SP	85.612	402.44	86.01	397.19	84.949	397.5	-39.774	-525.44	66.326	-494.11	2.96E+05	0.72476	138.1	171.43
Tank	84.842	351.41	86.01	357.19	84.418	357.66	-116.76	578.35	42.386	625.24	2.39E+05	0.28367	116.67	150
RP	83.808	321.53	86.01	317.19	83.888	317.81	-220.23	-433.68	-8.0281	-371.23	2.26E+05	0.61285	107.14	154.76
2F	83.357	277.47	86.01	276.69	83.357	277.47	-265.25	-78.216	0	0	2.85E+05	0.72611	130.95	169.05
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	85.074	377.48	86.01	376.69	84.684	377.08	-93.62	-79.222	39.005	-39.92	2.64E+05	0.57615	127.78	157.54
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	4.2285	30.846	4.2285	30.846	4.2285	30.846	0	0	0	0	30641	0.1016	6.7344	16.836
Box	0.84143	34.541	4.2285	30.846	4.4131	28.821	338.71	369.52	357.17	571.97	14816	0.032491	3.3672	6.7344
SP	0.54162	39.038	4.2285	30.846	4.5977	27.099	475.75	819.23	512.65	1193.9	10274	0.041941	18.748	10.102
Tank	3.7585	31.247	4.2285	30.846	4.7822	25.238	47.004	40.089	102.37	600.9	1.40E+05	0.40117	23.57	70.711
RP	3.3996	31.484	4.2285	30.846	4.9668	23.376	82.899	63.871	156.72	810.84	47477	0.28094	1.42E-14	33.672
2F	5.1513	21.491	4.2285	30.846	5.1513	21.491	92.276	935.46	0	0	19866	0.073673	13.469	23.57
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	1.7115	5.2712	0	0	0.31518	3.1707	172.99	378.81	188.42	425.87	44586	0.13767	8.3824	21.473

16. Summary of trials 1, 2, and 3 test NSRTTS7SS

File name: **NSRTTS7SS-1.csv**			Test name: **NSRTTS7SS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	73.079	466.05	73.079	466.05	73.079	466.05	0	0	0	0	3.80E+05	0.9163	130.77	269.23
Box	69.669	425.46	73.079	422.55	72.46	418.4	-340.99	-290.75	-279.13	-705.55	3.28E+05	0.54759	161.54	176.92
SP	71.751	379.89	73.079	385.55	71.842	377.88	-132.76	566.31	-9.0289	-201.3	2.78E+05	0.80929	115.38	192.31
Tank	70.117	322.58	73.079	345.55	71.223	334.06	-296.2	2297.4	-110.6	1148.4	4.80E+05	0.83754	161.54	261.54
RP	71.024	294.39	73.079	305.55	70.604	290.25	-205.46	1116.2	42	-414.23	2.21E+05	0.68374	115.38	153.85
2F	69.986	245.89	73.079	265.05	69.986	245.89	-309.32	1916.7	0	0	2.70E+05	0.73224	130.77	176.92

File name: **NSRTTS7SS-2.csv**			Test name: **NSRTTS7SS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	75.5	483	75.5	483	75.5	483	0	0	0	0	1.40E+05	0.37115	107.69	100
Box	74.28	457.72	75.5	439.5	75.9	444.69	-122	-1822	-162	-1302.6	2.50E+05	0.56059	146.15	146.15
SP	76.479	426.4	75.5	402.5	76.3	412.11	97.869	-2390.3	17.869	-1429.1	2.35E+05	0.62849	123.08	153.85
Tank	75.762	378.07	75.5	362.5	76.7	376.89	26.24	-1557	-93.76	-118.24	2.95E+05	0.54435	161.54	161.54
RP	76.426	349.74	75.5	322.5	77.1	341.66	92.572	-2723.6	-67.428	-807.2	3.47E+05	0.85232	130.77	230.77
2F	77.5	306	75.5	282	77.5	306	200	-2400	0	0	1.40E+05	0.37115	107.69	100

File name: **NSRTTS7SS-3.csv**			Test name: **NSRTTS7SS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	75.5	483	75.5	483	75.5	483	0	0	0	0	1.40E+05	0.37115	107.69	100
Box	74.28	457.72	75.5	439.5	75.9	444.69	-122	-1822	-162	-1302.6	2.50E+05	0.56059	146.15	146.15
SP	76.414	426.48	75.5	402.5	76.3	412.11	91.391	-2397.7	11.391	-1436.5	2.32E+05	0.63596	123.08	153.85
Tank	75.762	378.07	75.5	362.5	76.7	376.89	26.24	-1557	-93.76	-118.24	2.95E+05	0.54435	161.54	161.54
RP	76.426	349.74	75.5	322.5	77.1	341.66	92.572	-2723.6	-67.428	-807.2	3.47E+05	0.85232	130.77	230.77
2F	77.5	306	75.5	282	77.5	306	200	-2400	0	0	1.40E+05	0.37115	107.69	100

Summary of test NSRTTS7SS

File name: **NSRTTS7SS-T.csv**					Test name: **NSRTTS7SS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.693	477.35	74.693	477.35	74.693	477.35	0	0	0	0	2.20E+05	0.55287	115.38	156.41
Box	72.743	446.97	74.693	433.85	74.753	435.93	-195	-1311.6	-201.04	-1103.6	2.76E+05	0.55626	151.28	156.41
SP	74.881	410.92	74.693	396.85	74.814	400.7	18.834	-1407.2	6.7436	-1022.3	2.48E+05	0.69125	120.51	166.67
Tank	73.881	359.57	74.693	356.85	74.874	362.61	-81.239	-272.23	-99.375	303.96	3.56E+05	0.64208	161.54	194.87
RP	74.625	331.29	74.693	316.85	74.935	324.53	-6.7705	-1443.7	-30.952	-676.21	3.05E+05	0.79613	125.64	205.13
2F	74.995	285.96	74.693	276.35	74.995	285.96	30.227	-961.11	0	0	1.83E+05	0.49152	115.38	125.64
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	74.303	385.34	74.693	376.35	74.844	381.18	-38.991	-899.3	-54.104	-416.36	2.65E+05	0.62168	131.62	167.52
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	1.1413	7.9891	1.1413	7.9891	1.1413	7.9891	0	0	0	0	1.13E+05	0.25699	10.879	79.776
Box	2.1736	15.207	1.1413	7.9891	1.6215	12.393	103.23	721.84	55.215	281.45	36625	0.00613	7.2524	14.505
SP	2.2134	21.944	1.1413	7.9891	2.1017	16.139	107.22	1395.5	11.462	580.55	21234	0.083526	3.6262	18.131
Tank	2.6613	26.159	1.1413	7.9891	2.5819	20.188	152	1817	7.9407	597.09	87391	0.13821	0	47.14
RP	2.5462	26.09	1.1413	7.9891	3.0621	24.238	140.49	1810.1	51.585	185.25	59469	0.079473	7.2524	36.262
2F	3.5422	28.338	1.1413	7.9891	3.5422	28.338	240.1	2034.9	0	0	61283	0.17022	10.879	36.262
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.71441	7.189	2.22E-16	8.88E-16	0.82008	6.8971	71.441	718.9	23.272	243.73	30452	0.079081	3.8698	21.521

17. Summary of trials 1, 2, and 3 test SPTTS7SS, these trials were not possible to do

18. Summary of trials 1, 2, and 3 test NSPTTS7SS, these trials were not possible to do

19. Summary of trials 1, 2, and 3 test SSTTS2NSS

File name: **SSTTS2NSS-1.csv**		Test name: **SSTTS2NSS**					Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	69.081	320.18	69.081	320.18	69.081	320.18	0	0	0	0	2.98E+05	0.94154	280	400
Box	71.142	287.85	69.081	276.68	69.464	280.43	206.13	-1117	167.74	-742.18	2.82E+05	0.42307	260	300
SP	73.753	250.64	69.081	239.68	69.848	246.62	467.24	-1095.4	390.46	-401.8	1.70E+05	0.75423	160	240
Tank	73.891	211.95	69.081	199.68	70.232	210.06	481	-1226.8	365.83	-188.5	2.74E+05	0.58352	220	280
RP	72.8	176.31	69.081	159.68	70.616	173.51	371.95	-1662.5	218.39	-279.55	1.70E+05	0.85445	140	260
2F	71	136.5	69.081	119.18	71	136.5	191.95	-1731.9	0	0	1.32E+05	0.73605	140	200
File name: **SSTTS2NSS-2.csv**		Test name: **SSTTS2NSS**					Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	68	308.17	68	308.17	68	308.17	0	0	0	0	1.96E+05	0.76669	180	260
Box	71.899	269.76	68	264.67	68.076	265.94	389.86	-509	382.25	-382.52	2.96E+05	0.58766	220	280
SP	74.231	227.39	68	227.67	68.152	230.01	623.08	27.924	607.86	261.98	2.08E+05	0.70069	240	220
Tank	71.167	183.91	68	187.67	68.228	191.18	316.67	376.51	293.83	726.88	2.40E+05	0.6586	240	240
RP	71.684	149.37	68	147.67	68.304	152.34	368.42	-169.5	337.98	297.17	1.90E+05	0.68559	180	240
2F	68.381	113.02	68	107.17	68.381	113.02	38.053	-584.42	0	0	2.26E+05	0.87402	180	320
File name: **SSTTS2NSS-3.csv**		Test name: **SSTTS2NSS**					Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	68.536	296.64	68.536	296.64	68.536	296.64	0	0	0	0	1.38E+05	0.64051	160	200
Box	72.348	255.01	68.536	253.14	68.81	256.18	381.16	-186.96	353.76	117.11	2.76E+05	0.59564	240	280
SP	75.099	220.04	68.536	216.14	69.084	221.76	656.27	-390.63	601.47	172.06	1.82E+05	0.608	180	220
Tank	73.652	183.22	68.536	176.14	69.358	184.56	511.59	-707.97	429.39	134.32	2.76E+05	0.42192	260	240
RP	71.329	151.95	68.536	136.14	69.632	147.36	279.25	-1580.8	169.65	-458.86	1.46E+05	0.88973	120	260
2F	69.906	109.69	68.536	95.638	69.906	109.69	137	-1405	0	0	1.92E+05	0.76427	180	260

Summary of test SSTTS2NSS

File name: **SSTTS2NSS-T.csv**					Test name: **SSTTS2NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	68.54	308.33	68.539	308.33	68.54	308.33	0	0	0	0	2.11E+05	0.78	206.67	286.67
Box	71.8	270.87	68.539	264.83	68.78	267.52	325.72	-604.3	301.25	-335.9	2.85E+05	0.54	240	286.67
SP	74.36	232.69	68.539	227.83	69.03	232.8	582.19	-486	533.26	10.751	1.87E+05	0.69	193.33	226.67
Tank	72.9	193.02	68.539	187.83	69.27	195.27	436.42	-519.4	363.02	224.23	2.63E+05	0.55	240	253.33
RP	71.94	159.21	68.539	147.83	69.52	157.74	339.87	-1138	242.01	-147.1	1.69E+05	0.81	146.67	253.33
2F	69.76	119.74	68.539	107.33	69.76	119.74	122.33	-1240	0	0	1.83E+05	0.79	166.67	260
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	71.55	213.98	68.539	207.33	69.15	213.56	301.09	-664.6	239.92	-41.33	2.16E+05	0.69	198.89	261.11
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	0.441	9.6122	0.44113	9.6122	0.441	9.6122	0	0	0	0	66138	0.12	52.493	83.799
Box	0.498	13.431	0.44113	9.6122	0.567	9.963	84.636	385.62	95.12	352.35	8379.9	0.08	16.33	9.4281
SP	0.557	13.038	0.44113	9.6122	0.694	10.335	82.407	463.53	101.01	294.01	15861	0.06	33.993	9.4281
Tank	1.232	13.384	0.44113	9.6122	0.82	10.806	85.594	667.98	55.377	379.07	16519	0.1	16.33	18.856
RP	0.627	12.137	0.44113	9.6122	0.947	11.338	42.889	685.35	70.719	322.55	17988	0.09	24.944	9.4281
2F	1.074	11.932	0.44113	9.6122	1.074	11.932	63.677	482.68	0	0	38862	0.06	18.856	48.99
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.302	1.315	5.55E-17	1.78E-15	0.216	0.7947	30.742	227.58	40.852	160.98	19722	0.02	12.89	27.835

20. Summary of trials 1, 2, and 3 test NSSTTS2NSS

File name: **NSSTTS2NSS-1.csv**			Test name: **NSSTTS2NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	65.872	336.99	65.872	336.99	65.872	336.99	0	0	0	0	1.88E+05	0.71	200	240
Box	69.773	293.04	65.872	293.49	66.686	290.33	390.04	45.148	308.69	-271.02	2.64E+05	0.56	260	240
SP	72.733	260.67	65.872	256.49	67.499	250.64	686.1	-417.73	523.39	-1002.8	1.50E+05	0.66	160	200
Tank	73.276	217.48	65.872	216.49	68.313	207.73	740.32	-99.023	496.26	-974.86	3.92E+05	0.73	280	360
RP	72.351	175.23	65.872	176.49	69.126	164.82	647.83	125.56	322.42	-1041	1.54E+05	0.71	160	220
2F	69.94	121.38	65.872	135.99	69.94	121.38	406.77	1460.9	0	0	2.00E+05	0.83	180	280

File name: **NSSTTS2NSS-2.csv**			Test name: **NSSTTS2NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	67.903	327.18	67.903	327.18	67.903	327.18	0	0	0	0	1.44E+05	0.78	140	220
Box	71.847	283.38	67.903	283.68	68.76	281.77	394.43	29.82	308.69	-160.92	3.40E+05	0.36	280	280
SP	72.899	249.67	67.903	246.68	69.618	243.15	499.6	-299.03	328.11	-652.01	1.58E+05	0.82	140	240
Tank	72.664	210.79	67.903	206.68	70.475	201.4	476.12	-411.14	218.9	-939.51	2.50E+05	0.64	260	240
RP	72.761	171.42	67.903	166.68	71.332	159.64	485.81	-474.34	142.84	-1178.1	1.84E+05	0.9	140	300
2F	72.19	117.37	67.903	126.18	72.19	117.37	428.71	881.35	0	0	1.58E+05	0.82	140	240

File name: **NSSTTS2NSS-3.csv**			Test name: **NSSTTS2NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	73.5	348.16	73.5	348.16	73.5	348.16	0	0	0	0	1.28E+05	0.58	160	180
Box	75.511	306.24	73.5	304.66	73.639	301.65	201.08	-158.84	187.22	-459.89	2.78E+05	0.59	240	260
SP	74.899	269.28	73.5	267.66	73.777	262.09	139.89	-162.46	112.17	-719.58	1.78E+05	0.49	200	220
Tank	75.777	224.07	73.5	227.66	73.916	219.32	227.69	358.7	186.11	-475.24	2.60E+05	0.5	220	260
RP	77.882	184.78	73.5	187.66	74.054	176.55	438.16	287.99	382.72	-822.78	1.52E+05	0.73	160	220
2F	74.193	133.25	73.5	147.16	74.193	133.25	69.298	1391.1	0	0	2.28E+05	0.89	180	320

Summary of test NSSTTS2NSS

File name: **NSSTTS2NSS-T.csv**					Test name: **NSSTTS2NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	69.09	337.44	69.092	337.44	69.09	337.44	0	0	0	0	1.53E+05	0.69	166.67	213.33
Box	72.38	294.22	69.092	293.94	69.7	291.25	328.52	-27.96	268.2	-297.28	2.94E+05	0.5	260	260
SP	73.51	259.87	69.092	256.94	70.3	251.96	441.86	-293.1	321.22	-791.47	1.62E+05	0.66	166.67	220
Tank	73.91	217.45	69.092	216.94	70.9	209.48	481.38	-50.49	300.42	-796.54	3.01E+05	0.62	253.33	286.67
RP	74.33	177.14	69.092	176.94	71.5	167.01	523.93	-20.26	282.66	-1014	1.63E+05	0.78	153.33	246.67
2F	72.11	124	69.092	136.44	72.11	124	301.59	1244	0	4.74E-13	1.95E+05	0.85	166.67	280
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	72.55	235.02	69.092	236.44	70.6	230.19	346.21	142.1	195.42	-483.21	2.11E+05	0.68	194.44	251.11
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	3.226	8.5693	3.2255	8.5693	3.226	8.5693	0	0	0	0	25368	0.08	24.944	24.944
Box	2.372	9.3709	3.2255	8.5693	2.914	8.1391	90.129	92.76	57.26	123.46	33025	0.1	16.33	16.33
SP	0.984	8.0254	3.2255	8.5693	2.608	7.786	226.7	104.3	167.95	151.98	11776	0.14	24.944	16.33
Tank	1.347	5.4205	3.2255	8.5693	2.307	7.4198	209.31	316.2	139.12	227.65	64711	0.09	24.944	52.493
RP	2.516	5.6161	3.2255	8.5693	2.016	7.0719	89.743	327.9	101.89	146.31	14636	0.09	9.4281	37.712
2F	1.737	6.7414	3.2255	8.5693	1.737	6.7414	164.5	258.3	0	6.70E-13	28767	0.03	18.856	32.66
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	0.756	1.4779	4.44E-16	0	0.509	0.62054	78.465	124	64.544	82.95	17343	0.03	5.7711	12.726

21. Summary of trials 1, 2, and 3 test SRTTS2NSS

File name: **SRTTS2NSS-1.csv**			Test name: **SRTTS2NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	74.96	353.23	74.96	353.23	74.957	353.23	0	0	0	0	2.32E+05	0.851	220	300
Box	75.57	304.18	74.96	309.73	76.254	305.49	61.635	555.44	-68.04	130.97	3.14E+05	0.673	240	300
SP	82.07	273.1	74.96	272.73	77.55	264.88	711.17	-36.528	451.83	-822.05	2.04E+05	0.673	220	240
Tank	80.52	227.89	74.96	232.73	78.847	220.97	556.05	484.32	167.04	-691.52	3.44E+05	0.719	260	320
RP	79.34	183.18	74.96	192.73	80.144	177.07	438.43	955.63	-80.26	-610.54	1.70E+05	0.778	160	240
2F	81.44	132.62	74.96	152.23	81.44	132.62	648.36	1961.4	0	0	1.68E+05	0.811	160	240

File name: **SRTTS2NSS-2.csv**			Test name: **SRTTS2NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	81.33	342.43	81.33	342.43	81.331	342.43	0	0	0	0	2.36E+05	0.704	200	280
Box	78.65	291.8	81.33	298.93	78.813	294.98	-268.3	713.01	-16.59	317.53	3.74E+05	0.629	260	320
SP	73.18	254.21	81.33	261.93	76.295	254.61	-815.6	771.86	-312.1	40	2.06E+05	0.872	160	300
Tank	70.93	213.28	81.33	221.93	73.778	210.98	-1040	865.02	-284.8	-230.5	3.12E+05	0.446	260	280
RP	71.61	171.93	81.33	181.93	71.26	167.34	-972.3	1000.1	34.768	-459.09	2.04E+05	0.866	160	300
2F	68.74	123.16	81.33	141.43	68.743	123.16	-1259	1827.4	0	0	2.02E+05	0.849	160	280

File name: **SRTTS2NSS-3.csv**			Test name: **SRTTS2NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	86.56	331.65	86.56	331.65	86.564	331.65	0	0	0	0	2.20E+05	0.762	240	240
Box	84.92	286.7	86.56	288.15	86.813	286.27	-164	145.8	-188.9	-42.484	2.90E+05	0.699	280	260
SP	92.68	251.08	86.56	251.15	87.062	247.67	611.24	7.0038	561.42	-341.43	2.84E+05	0.903	320	320
Tank	88.89	205.77	86.56	211.15	87.311	205.94	232.92	538.31	158.19	16.745	2.80E+05	0.758	240	300
RP	90.25	168.8	86.56	171.15	87.56	164.21	368.64	235.45	269	-459.25	1.60E+05	0.746	200	200
2F	87.81	121.95	86.56	130.65	87.809	121.95	124.55	870	0	0	2.20E+05	0.859	300	200

Summary of test SRTTS2NSS

File name: **SRTTS2NSS-T.csv**					Test name: **SRTTS2NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	80.95	342.4	80.95	342.44	80.95	342.44	0	0	0	0	2.29E+05	0.77	220	273
Box	79.715	294.2	80.95	298.94	80.63	295.58	-124	471.42	-91.16	135.34	3.26E+05	0.67	260	293
SP	82.64	259.5	80.95	261.94	80.3	255.72	169	247.45	233.73	-374.49	2.31E+05	0.82	233	287
Tank	80.113	215.7	80.95	221.94	79.98	212.63	-83.7	629.22	13.469	-301.76	3.12E+05	0.64	253	300
RP	80.4	174.6	80.95	181.94	79.66	169.54	-55.1	730.39	74.503	-509.63	1.78E+05	0.8	173	247
2F	79.331	125.9	80.95	141.44	79.33	125.91	-162	1552.9	0	0.00E+00	1.97E+05	0.84	207	240
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	80.525	235.4	80.95	241.44	80.14	233.64	-42.6	605.23	38.424	-175.09	2.46E+05	0.76	224	273
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	4.7461	8.809	4.7461	8.8093	4.746	8.8093	0	0	0	0	6798.7	0.06	16.3	24.9
Box	3.8914	7.34	4.7461	8.8093	4.497	7.8565	137.7	239.06	72.206	147.01	35327	0.03	16.3	24.9
SP	7.9716	9.724	4.7461	8.8093	4.807	7.0683	697.4	371.24	388.52	352.71	37250	0.1	66	34
Tank	7.3391	9.183	4.7461	8.8093	5.583	6.2485	689	168.19	210.96	293.51	26128	0.14	9.43	16.3
RP	7.6473	6.173	4.7461	8.8093	6.663	5.4769	649.2	350.44	145.33	71.357	18833	0.05	18.9	41.1
2F	7.9255	4.769	4.7461	8.8093	7.926	4.7689	804.5	485.98	0	0.00E+00	21561	0.02	66	32.7
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	1.6357	1.759	0	1.78E-15	1.228	1.3754	308.5	156.84	135.73	137.03	10298	0.04	24.1	7.94

22. Summary of trials 1, 2, and 3 test NSRTTS2NSS

File name: **NSRTTS2NSS-1.csv**			Test name: **NSRTTS2NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	72.943	341.43	72.94	341.43	72.943	341.43	0	0	0	0	1.06E+05	0.49	140	160
Box	72.871	296.2	72.94	297.93	73.198	295.51	-7.2231	173.76	-32.73	-68.62	3.26E+05	0.61	260	300
SP	75.64	260.79	72.94	260.93	73.454	256.45	269.66	14.396	218.65	-434.1	2.00E+05	0.62	200	240
Tank	73.348	215.07	72.94	220.93	73.709	214.22	40.416	586.08	-36.11	-85.34	3.28E+05	0.79	240	360
RP	74.372	171.11	72.94	180.93	73.964	171.99	142.89	982.76	40.866	88.46	1.88E+05	0.85	160	280
2F	74.219	129.23	72.94	140.43	74.219	129.23	127.54	1120	0	0	1.28E+05	0.65	160	180

File name: **NSRTTS2NSS-2.csv**			Test name: **NSRTTS2NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	82.453	357.92	82.45	357.92	82.453	357.92	0	0	0	0	1.06E+05	0.75	120	180
Box	75.248	314.49	82.45	314.42	82.452	313.95	-720.5	-6.2197	-720.4	-53.57	2.26E+05	0.83	280	220
SP	78.594	280.44	82.45	277.42	82.451	276.55	-385.91	-301.3	-385.7	-388.9	1.92E+05	0.41	200	200
Tank	81.333	239.98	82.45	237.42	82.45	236.11	-111.95	-255.75	-111.6	-386.9	2.22E+05	0.52	240	220
RP	79.02	200.98	82.45	197.42	82.448	195.68	-343.24	-355.51	-342.8	-530.2	1.96E+05	0.74	200	240
2F	82.447	154.74	82.45	156.92	82.447	154.74	-0.54618	218.77	0	0	1.52E+05	0.84	160	240

File name: **NSRTTS2NSS-3.csv**			Test name: **NSRTTS2NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	71.462	268.92	71.46	268.92	71.462	268.92	0	0	0	0	1.30E+05	0.84	120	220
Box	69.357	237.14	71.46	225.42	70.869	235.07	-210.44	-1172	-151.2	-207.3	1.40E+05	0.8	220	160
SP	72.595	211.94	71.46	188.42	70.277	206.28	113.35	-2351.9	231.81	-566.6	2.42E+05	0.91	200	340
Tank	70.248	175.26	71.46	148.42	69.685	175.15	-121.39	-2683.4	56.3	-11.01	2.10E+05	0.72	240	220
RP	69.969	147.91	71.46	108.42	69.092	144.02	-149.28	-3948.3	87.644	-388.8	1.92E+05	0.89	140	300
2F	68.5	112.5	71.46	67.923	68.5	112.5	-296.15	-4457.7	0	0	92000	0.67	120	160

Summary of test NSRTTS2NSS

File name: **NSRTTS2NSS-T.csv**					Test name: **NSRTTS2NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	75.62	322.76	75.62	322.76	75.619	322.8	0	0	0	0	1.14E+05	0.69	126.67	186.7
Box	72.49	282.61	75.62	279.26	75.506	281.5	-312.72	-334.81	-301.44	-109.81	2.31E+05	0.75	253.33	226.7
SP	75.61	251.06	75.62	242.26	75.394	246.4	-0.96579	-879.6	21.59	-463.22	2.11E+05	0.65	200	260
Tank	74.98	210.1	75.62	202.26	75.281	208.5	-64.308	-784.36	-30.475	-161.08	2.53E+05	0.68	240	266.7
RP	74.45	173.33	75.62	162.26	75.168	170.6	-116.54	-1107	-71.432	-276.85	1.92E+05	0.83	166.67	273.3
2F	75.06	132.16	75.62	121.76	75.055	132.2	-56.388	-1039.7	0	0	1.24E+05	0.72	146.67	193.3
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
Total	74.7	228.67	75.62	221.76	75.337	227	-91.821	-690.91	-63.627	-168.49	1.88E+05	0.72	188.89	234.4
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	4.87	38.66	4.87	38.66	4.8698	38.66	0	0	0	0	11314	0.15	9.4281	24.94
Box	2.42	33.005	4.87	38.66	5.0023	33.69	300.04	596.51	300.17	69.176	76006	0.1	24.944	57.35
SP	2.449	28.798	4.87	38.66	5.1558	29.55	279.58	1049	288.04	75.403	21929	0.21	0	58.88
Tank	4.67	26.656	4.87	38.66	5.3285	25.22	74.152	1386.1	68.669	162.53	53024	0.12	0	66
RP	3.696	21.724	4.87	38.66	5.5187	21.11	199.81	2082.1	192.84	264.68	3266	0.06	24.944	24.94
2F	5.725	17.367	4.87	38.66	5.7246	17.37	177.42	2444.8	0	0	24658	0.08	18.856	33.99
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP(mm)*	*Dy1RP(mm)*	*Dx2RP(mm)*	*Dy2RP(mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
Total	1.236	6.9886	0	0	0.2935	7.254	106.4	833.43	125.59	93.5	25123	0.05	10.57	16.88

23. Summary of trials 1, 2, and 3 test SPTTS2NSS

File name: **SPTTS2NSS-1.csv**		Test name: **SPTTS2NSS**					Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.808	332.96	72.808	332.96	72.808	332.96	0	0	0	0	1.56E+05	0.7	160	220
Box	71.095	295.27	72.808	289.46	72.571	289.58	-171.3	-581.21	-147.6	-569	1.90E+05	0.81	260	200
SP	75.086	256.97	72.808	252.46	72.334	252.69	227.84	-450.53	275.23	-428	3.02E+05	0.92	200	400
Tank	73.328	209.22	72.808	212.46	72.097	212.8	52.043	324.28	123.13	358	2.56E+05	0.25	240	240
RP	73.733	172.33	72.808	172.46	71.86	172.91	92.564	12.821	187.34	57.78	1.50E+05	0.66	160	200
2F	71.623	132.52	72.808	131.96	71.623	132.52	-118.5	-56.305	0	0	1.22E+05	0.57	160	180

File name: **SPTTS2NSS-2.csv**		Test name: **SPTTS2NSS**					Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.248	368.49	72.248	368.49	72.248	368.49	0	0	0	0	2.26E+05	0.81	200	300
Box	70.344	316.71	72.248	324.99	71.567	318.47	-190.4	827.63	-122.26	175.5	3.66E+05	0.63	240	320
SP	74.481	273.24	72.248	287.99	70.886	275.92	223.37	1474.2	359.56	267.4	2.70E+05	0.92	160	380
Tank	73.843	224.65	72.248	247.99	70.205	229.92	159.55	2333.7	363.83	527.2	2.68E+05	0.63	220	280
RP	71.447	181.96	72.248	207.99	69.524	183.92	-80.1	2602.9	192.27	196.7	1.88E+05	0.68	200	220
2F	68.843	137.35	72.248	167.49	68.843	137.35	-340.5	3013.4	0	0	1.02E+05	0.62	140	160

File name: **SPTTS2NSS-3.csv**		Test name: **SPTTS2NSS**					Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	75.048	386.37	75.048	386.37	75.048	386.37	0	0	0	0	1.26E+05	0.47	180	160
Box	76.277	342.65	75.048	342.87	75.418	337.51	122.9	21.969	85.85	-514	2.82E+05	0.72	260	280
SP	78.248	295.74	75.048	305.87	75.789	295.95	320.02	1013	245.93	21.17	2.34E+05	0.88	180	320
Tank	78.5	247.48	75.048	265.87	76.159	251.02	345.24	1838.7	234.1	354	2.72E+05	0.74	300	240
RP	76	205.12	75.048	225.87	76.53	206.09	95.238	2074.2	-52.952	96.67	1.46E+05	0.77	140	220
2F	76.9	160.6	75.048	185.37	76.9	160.6	185.24	2476.5	0	0	1.00E+05	0.66	140	160

Summary of test SPTTS2NSS

File name: **SPTTS2NSS-T.csv**					Test name: **SPTTS2NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	73.368	362.6	73.368	362.6	73.368	362.6	0	0	0	0	1.69E+05	0.66	180	227
Box	72.572	318.21	73.368	319.1	73.185	315.18	-79.58	89.463	-61.337	-302.5	2.79E+05	0.72	253	267
SP	75.938	275.32	73.368	282.1	73.003	274.85	257.08	678.9	293.57	-46.48	2.69E+05	0.9	180	367
Tank	75.224	227.12	73.368	242.1	72.82	231.25	185.61	1498.9	240.35	413.1	2.65E+05	0.54	253	253
RP	73.727	186.47	73.368	202.1	72.638	187.64	35.901	1563.3	108.89	117.06	1.61E+05	0.71	167	213
2F	72.455	143.49	73.368	161.6	72.455	143.49	-91.23	1811.2	0	0	1.08E+05	0.62	147	167
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	73.881	252.2	73.368	261.6	72.912	252.5	51.295	940.3	96.912	30.194	2.09E+05	0.69	197	249
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	1.2097	22.195	1.2097	22.195	1.2097	22.195	0	0	0	0	41899	0.14	16.3	57.3
Box	2.6375	19.368	1.2097	22.195	1.6312	19.701	143.39	577.14	104.59	338.74	71876	0.07	9.43	49.9
SP	1.6515	15.895	1.2097	22.195	2.0566	17.677	44.547	820.53	48.167	287.88	27777	0.02	16.3	34
Tank	2.3261	15.716	1.2097	22.195	2.484	15.631	121.11	854.83	98.365	80.712	6798.7	0.21	34	18.9
RP	1.8588	13.762	1.2097	22.195	2.9124	13.798	82.031	1117.4	114.46	58.526	18927	0.05	24.9	9.43
2F	3.3415	12.256	1.2097	22.195	3.3415	12.256	215.48	1338.6	0	0	9933.1	0.03	9.43	9.43
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.6956	3.3452	0	0	0.7285	3.3981	69.587	424.76	47.89	135.28	22220	0.07	8.71	18.8

24. Summary of trials 1, 2, and 3 test NSPTTS2NSS

File name: **NSPTTS2NSS-1.csv**	Test name: **NSPTTS2NSS**					Trial number: **1**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.041	370.1	74.04	370	74.04	370.1	0	0	0	0	98000	0.82	180	140
Box	73.835	315.4	74.04	327	74.14	318.3	-20.6	1120.2	-30.45	289.84	2.30E+05	0.63	240	240
SP	76.497	269.89	74.04	290	74.24	274.24	245.6	1971.4	225.87	434.74	2.86E+05	0.91	200	380
Tank	72.631	217.48	74.04	250	74.34	226.6	-141	3212.1	-170.5	911.86	3.74E+05	0.79	240	380
RP	74.871	174.91	74.04	210	74.44	178.96	83.06	3468.8	43.66	405.01	1.40E+05	0.79	140	220
2F	74.533	130.73	74.04	169	74.53	130.73	49.25	3836.9	0	0	1.50E+05	0.76	160	220

File name: **NSPTTS2NSS-2.csv**	Test name: **NSPTTS2NSS**					Trial number: **2**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	77.625	383.13	77.63	383	77.63	383.13	0	0	0	0	80000	0.57	120	140
Box	73.681	337.86	77.63	340	77.34	336.58	-394.4	176.79	-365.7	-127.51	3.64E+05	0.52	300	260
SP	77.412	294.1	77.63	303	77.05	296.99	-21.32	852.21	35.935	289.09	1.36E+05	0.54	160	180
Tank	74.051	252.32	77.63	263	76.77	254.2	-357.4	1030.9	-271.5	187.95	2.34E+05	0.61	260	200
RP	76.287	217.61	77.63	223	76.48	211.4	-133.8	501.25	-19.23	-621.49	1.60E+05	0.81	160	240
2F	76.194	168.06	77.63	182	76.19	168.06	-143.2	1406	0	0	1.86E+05	0.77	240	220

File name: **NSPTTS2NSS-3.csv**	Test name: **NSPTTS2NSS**					Trial number: **3**							
	Properties												
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74.041	370.1	74.04	370	74.04	370.1	0	0	0	0	98000	0.82	180	140
Box	73.835	315.4	74.04	327	74.14	318.3	-20.6	1120.2	-30.45	289.84	2.30E+05	0.63	240	240
SP	76.497	269.89	74.04	290	74.24	274.24	245.6	1971.4	225.87	434.74	2.86E+05	0.91	200	380
Tank	72.631	217.48	74.04	250	74.34	226.6	-141	3212.1	-170.5	911.86	3.74E+05	0.79	240	380
RP	74.871	174.91	74.04	210	74.44	178.96	83.06	3468.8	43.66	405.01	1.40E+05	0.79	140	220
2F	74.533	130.73	74.04	169	74.53	130.73	49.25	3836.9	0	0	1.50E+05	0.76	160	220

Summary of test NSPTTS2NSS

File name: **NSPTTS2NSS-T.csv**						Test name: **NSPTTS2NSS**								
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	75.236	374.44	75.236	374.44	75.236	374.44	0	0	0	0	92000	0.74	160	140
Box	73.784	322.89	75.236	330.94	75.206	324.39	-145.2	805.73	-142.22	150.72	2.75E+05	0.59	260	247
SP	76.802	277.96	75.236	293.94	75.176	281.82	156.6	1598.3	162.56	386.19	2.36E+05	0.79	186.7	313
Tank	73.104	229.09	75.236	253.94	75.146	235.8	-213.1	2485	-204.18	670.56	3.27E+05	0.73	246.7	320
RP	75.343	189.15	75.236	213.94	75.116	189.78	10.791	2479.6	22.695	62.84	1.47E+05	0.79	146.7	227
2F	75.087	143.18	75.236	173.44	75.087	143.18	-14.88	3026.6	0	0	1.62E+05	0.76	186.7	220
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	74.893	256.12	75.236	273.44	75.161	258.23	-34.3	1732.5	-26.858	211.72	2.06E+05	0.73	197.8	244
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	1.6896	6.1391	1.6896	6.1391	1.6896	6.1391	0	0	0	0	8485.3	0.12	28.28	0
Box	0.072344	10.586	1.6896	6.1391	1.5082	8.619	176.19	444.73	158.06	196.74	63168	0.05	28.28	9.43
SP	0.43146	11.415	1.6896	6.1391	1.3268	10.728	125.81	527.59	89.536	68.659	70711	0.18	18.86	94.3
Tank	0.66952	16.421	1.6896	6.1391	1.1454	13.009	102.01	1028.2	47.59	341.26	65997	0.09	9.428	84.9
RP	0.66754	20.128	1.6896	6.1391	0.964	15.289	102.21	1398.9	29.648	483.89	9428.1	0.01	9.428	9.43
2F	0.78263	17.598	1.6896	6.1391	0.7826	17.598	90.697	1145.9	0	0	16971	0	37.71	0
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.49194	4.761	0	0	0.3098	3.8839	52.545	476.1	55.612	180.65	27717	0.06	10.42	40.3

25. Summary of trials 1, 2, and 3 test SSTTS4NSS

File name: **SSTTS4NSS-1.csv**			Test name: **SSTTS4NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	68.289	396.29	68.289	396.3	68.289	396.29	0	0	0	0	2.90E+05	0.91	175	300
Box	70.754	360.96	68.289	352.8	68.612	357.84	246.55	-817.1	214.26	-311.7	2.19E+05	0.55	187.5	162.5
SP	72.879	329.92	68.289	315.8	68.935	325.14	458.98	-1413	394.41	-477.7	2.16E+05	0.79	137.5	212.5
Tank	73.056	289.8	68.289	275.8	69.257	289.79	476.71	-1401	379.85	-0.927	2.24E+05	0.38	175	175
RP	72.748	259.64	68.289	235.8	69.58	254.44	445.87	-2386	316.73	-520.6	2.53E+05	0.8	162.5	237.5
2F	69.903	218.64	68.289	195.3	69.903	218.64	161.43	-2335	0	0	2.45E+05	0.85	137.5	250

File name: **SSTTS4NSS-2.csv**			Test name: **SSTTS4NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	68.927	439.1	68.927	439.1	68.927	439.1	0	0	0	0	2.41E+05	0.79	150	225
Box	68.636	398.11	68.927	395.6	68.792	397.75	-29.11	-251.5	-15.59	-36.14	2.20E+05	0.29	175	187.5
SP	74.5	369	68.927	358.6	68.657	362.58	557.25	-1040	584.29	-641.6	2.08E+05	0.81	125	212.5
Tank	73.731	322.36	68.927	318.6	68.522	324.56	480.35	-376.6	520.91	220.05	4.60E+05	0.84	212.5	337.5
RP	71.616	282.42	68.927	278.6	68.387	286.55	268.9	-381.9	322.97	412.73	1.83E+05	0.82	125	200
2F	68.252	248.05	68.927	238.1	68.252	248.05	-67.589	-995.2	0	0	1.99E+05	0.76	137.5	200

File name: **SSTTS4NSS-3.csv**			Test name: **SSTTS4NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	68.082	395.14	68.082	395.1	68.082	395.14	0	0	0	0	2.29E+05	0.86	137.5	237.5
Box	70.006	355.36	68.082	351.6	68.186	355.49	192.4	-372.3	182.04	13.463	2.09E+05	0.52	175	162.5
SP	73.123	318.4	68.082	314.6	68.289	321.77	504.1	-376.5	483.38	337.38	2.34E+05	0.8	137.5	225
Tank	71.892	272.74	68.082	274.6	68.393	285.32	381.05	189.56	349.96	1258.1	3.14E+05	0.68	187.5	250
RP	69.979	246.95	68.082	234.6	68.496	248.87	189.68	-1231	148.23	192.19	2.35E+05	0.9	112.5	262.5
2F	68.6	211.96	68.082	194.1	68.6	211.96	51.803	-1782	0	0	1.56E+05	0.64	125	162.5

Summary of test SSTTS4NSS

File name: **SSTTS4NSS-T.csv**					Test name: **SSTTS4NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	68.433	410.17	68.433	410.17	68.433	410.17	0	0	0	0	2.53E+05	0.85	154	254
Box	69.799	371.48	68.433	366.67	68.53	370.36	136.6	-480.3	126.9	-111.5	2.16E+05	0.45	179	171
SP	73.501	339.11	68.433	329.67	68.627	336.5	506.8	-943.2	487.36	-260.6	2.19E+05	0.8	133	217
Tank	72.893	294.97	68.433	289.67	68.724	299.89	446	-529.3	416.91	492.4	3.33E+05	0.64	192	254
RP	71.448	263	68.433	249.67	68.821	263.28	301.5	-1333	262.64	28.094	2.23E+05	0.84	133	233
2F	68.918	226.22	68.433	209.17	68.918	226.22	48.55	-1704	0	0	2.00E+05	0.75	133	204
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	70.832	317.49	68.433	309.17	68.675	317.74	239.9	-831.7	215.64	24.733	2.41E+05	0.72	154	222
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	0.35987	20.458	0.35987	20.458	0.3599	20.458	0	0	0	0	26425	0.05	15.6	32.8
Box	0.87695	18.973	0.35987	20.458	0.2544	19.391	119.3	243.21	101.62	143.03	5034.6	0.12	5.89	11.8
SP	0.71374	21.654	0.35987	20.458	0.2643	18.495	40.16	428.7	77.569	428.12	10913	0.01	5.89	5.89
Tank	0.75936	20.586	0.35987	20.458	0.3808	17.541	45.98	658.27	74.543	548.88	97356	0.19	15.6	66.4
RP	1.1366	14.674	0.35987	20.458	0.5386	16.605	107.1	821.1	80.941	398.32	29744	0.04	21.2	25.7
2F	0.71077	15.677	0.35987	20.458	0.7108	15.677	93.52	549.92	0	0	36243	0.09	5.89	35.8
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	0.23102	2.6072	5.55E-17	0	0.161	1.6211	42.21	269.81	40.381	215.81	30183	0.06	6.09	19.6

26. Summary of trials 1, 2, and 3 test NSSTTS4NSS

File name: **NSSTTS4NSS-1.csv**			Test name: **NSSTTS4NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	63.37	417.35	63.37	417.35	63.37	417.35	0	0	0	0	1.35E+05	0.68	125	150
Box	73.109	382.78	63.37	373.85	65.13	370.75	973.82	-892.64	797.82	-1202.5	2.76E+05	0.43	188	200
SP	75.358	342.81	63.37	336.85	66.89	331.12	1198.7	-596.2	846.71	-1169.5	3.43E+05	0.92	138	337.5
Tank	73.178	291.04	63.37	296.85	68.65	288.27	980.79	581.56	452.77	-276.64	4.14E+05	0.84	188	312.5
RP	73.869	252.84	63.37	256.85	70.41	245.42	1049.8	401.58	345.82	-741.51	2.29E+05	0.91	113	262.5
2F	72.171	202.04	63.37	216.35	72.17	202.04	880.04	1431.5	0	0	2.05E+05	0.88	113	237.5

File name: **NSSTTS4NSS-2.csv**			Test name: **NSSTTS4NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	71.646	409.24	71.646	409.24	71.65	409.24	0	0	0	0	1.84E+05	0.62	175	150
Box	78.439	368.67	71.646	365.74	72.27	364.31	679.3	-292.33	617.35	-435.37	2.68E+05	0.59	188	212.5
SP	77.98	335.6	71.646	328.74	72.89	326.1	633.33	-685.71	509.43	-950.42	2.45E+05	0.87	138	250
Tank	76.698	290.67	71.646	288.74	73.51	284.78	505.17	-192.96	319.31	-589.2	4.26E+05	0.88	188	350
RP	75.098	250.17	71.646	248.74	74.12	243.47	345.22	-142.18	97.416	-669.94	1.65E+05	0.6	138	162.5
2F	74.744	201.64	71.646	208.24	74.74	201.64	309.76	660.94	0	0	2.54E+05	0.91	125	275

File name: **NSSTTS4NSS-3.csv**			Test name: **NSSTTS4NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	63.37	417.35	63.37	417.35	63.37	417.35	0	0	0	0	1.35E+05	0.68	125	150
Box	73.109	382.78	63.37	373.85	65.13	370.75	973.82	-892.64	797.82	-1202.5	2.76E+05	0.43	188	200
SP	75.358	342.81	63.37	336.85	66.89	331.12	1198.7	-596.2	846.71	-1169.5	3.43E+05	0.92	138	337.5
Tank	73.178	291.04	63.37	296.85	68.65	288.27	980.79	581.56	452.77	-276.64	4.14E+05	0.84	188	312.5
RP	73.869	252.84	63.37	256.85	70.41	245.42	1049.8	401.58	345.82	-741.51	2.29E+05	0.91	113	262.5
2F	72.171	202.04	63.37	216.35	72.17	202.04	880.04	1431.5	0	0	2.05E+05	0.88	113	237.5

Summary of test NSSTTS4NSS

File name: **NSSTTS4NSS-T.csv**					Test name: **NSSTTS4NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	66.129	414.65	66.129	414.65	66.13	414.65	0	0	0	0	1.51E+05	0.66	142	150
Box	74.885	378.07	66.129	371.15	67.51	368.61	875.65	-692.54	737.66	-946.8	2.73E+05	0.49	188	204
SP	76.232	340.41	66.129	334.15	68.89	329.45	1010.3	-626.04	734.29	-1097	3.10E+05	0.9	138	308
Tank	74.351	290.92	66.129	294.15	70.27	287.11	822.25	323.39	408.28	-380.8	4.18E+05	0.85	188	325
RP	74.279	251.95	66.129	254.15	71.65	244.77	814.97	220.33	263.02	-717.7	2.08E+05	0.81	121	229
2F	73.028	201.9	66.129	213.65	73.03	201.9	689.94	1174.7	0	0	2.21E+05	0.89	117	250
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	73.151	312.98	66.129	313.65	69.58	307.75	702.18	66.633	357.21	-523.6	2.64E+05	0.77	149	244
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	3.9013	3.8217	3.9013	3.8217	3.901	3.8217	0	0	0	0	22981	0.03	23.6	0
Box	2.5129	6.6515	3.9013	3.8217	3.364	3.0355	138.84	282.99	85.073	361.6	4124.8	0.07	0	5.89
SP	1.236	3.3997	3.9013	3.8217	2.826	2.3668	266.53	42.197	159	103.29	45962	0.02	0	41.2
Tank	1.6592	0.17054	3.9013	3.8217	2.288	1.6439	224.21	365.11	62.91	147.34	5892.6	0.02	0	17.7
RP	0.57965	1.2584	3.9013	3.8217	1.751	0.921	332.16	256.33	117.1	33.734	30052	0.14	11.8	47.1
2F	1.213	0.18909	3.9013	3.8217	1.213	0.1891	268.83	363.26	0	0	22981	0.01	5.89	17.7
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	1.0863	2.3116	0	0	0.918	1.2312	108.63	145.41	58.042	125.65	14259	0.05	8.62	17.2

27. Summary of trials 1, 2, and 3 test SRTTS4NSS

File name: **SRTTS4NSS-1.csv**			Test name: **SRTTS4NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	71.913	390	71.913	390.02	71.91	390	0	0	0	0	2.60E+05	0.8	163	237.5
Box	71.313	338.3	71.913	346.52	71.67	344.4	-60.02	827.22	-36.09	615.08	2.08E+05	0.7	188	175
SP	72.176	310.4	71.913	309.52	71.44	305.6	26.267	-91.26	74.131	-483.8	2.20E+05	0.7	150	200
Tank	70.42	274.3	71.913	269.52	71.2	263.6	-149.4	-479.3	-77.59	-1067	2.80E+05	0.6	213	175
RP	72.68	228.7	71.913	229.52	70.96	221.7	76.61	78.995	172.34	-703.7	2.26E+05	0.6	163	200
2F	70.717	179.2	71.913	189.02	70.72	179.2	-119.7	980.24	0	0	2.08E+05	0.8	138	200

File name: **SRTTS4NSS-2.csv**			Test name: **SRTTS4NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	77.31	408.4	77.31	408.41	77.31	408.4	0	0	0	0	2.54E+05	0.8	138	250
Box	74.338	352.7	77.31	364.91	77.33	359.6	-297.3	1221.1	-299.2	688.55	3.70E+05	0.6	213	250
SP	75.958	321.7	77.31	327.91	77.35	318.1	-135.2	620.12	-139.1	-365.4	2.09E+05	0.8	138	212.5
Tank	73.288	276.6	77.31	287.91	77.37	273.2	-402.2	1133.7	-408.1	-341.5	2.69E+05	0.5	175	200
RP	74.5	235.2	77.31	247.91	77.39	228.3	-281	1268.9	-288.9	-696.1	2.00E+05	0.8	125	212.5
2F	77.408	182.8	77.31	207.41	77.41	182.8	9.7818	2460.8	0	0	2.45E+05	0.9	125	275

File name: **SRTTS4NSS-3.csv**			Test name: **SRTTS4NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	75.408	386.6	75.408	386.6	75.41	386.6	0	0	0	0	2.45E+05	0.9	125	262.5
Box	76.551	341.5	75.408	343.1	75.45	341.2	114.3	162.96	110.24	-31.09	1.59E+05	0.8	175	125
SP	74.615	302.6	75.408	306.1	75.49	302.5	-79.28	352.51	-87.4	-6.584	1.95E+05	0.8	125	200
Tank	74.086	263.8	75.408	266.1	75.53	260.7	-132.2	228.72	-144.4	-308.8	3.04E+05	0.5	188	225
RP	75.587	225.6	75.408	226.1	75.57	218.9	17.893	47.623	1.6575	-668.3	1.94E+05	0.8	125	200
2F	75.611	176.6	75.408	185.6	75.61	176.6	20.295	896.62	0	0	2.03E+05	0.7	150	187.5

Summary of test SRTTS4NSS

File name: **SRTTS4NSS-T.csv**					Test name: **SRTTS4NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	74.877	395.01	74.877	395.01	74.877	395.01	0	0	0	0	2.53E+05	0.84	142	250
Box	74.067	344.14	74.877	351.51	74.818	348.38	-80.99	737.1	-75.02	424.2	2.45E+05	0.69	192	183.3
SP	74.25	311.57	74.877	314.51	74.758	308.72	-62.75	293.79	-50.8	-285	2.08E+05	0.75	138	204.2
Tank	72.598	271.57	74.877	274.51	74.698	265.84	-227.9	294.37	-210	-572	2.84E+05	0.55	192	200
RP	74.256	229.86	74.877	234.51	74.638	222.97	-62.18	465.17	-38.29	-689	2.07E+05	0.74	138	204.2
2F	74.579	179.55	74.877	194.01	74.579	179.55	-29.86	1445.9	0	0	2.18E+05	0.77	138	220.8
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	74.105	288.62	74.877	294.01	74.728	286.75	-77.28	539.38	-62.35	-187	2.36E+05	0.72	156	210.4
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
1F	2.235	9.5789	2.235	9.5789	2.235	9.5789	0	0	0	0	6152	0.05	15.6	10.21
Box	2.1469	6.1958	2.235	9.5789	2.3517	8.033	168.67	436.66	169.41	323.3	90314	0.09	15.6	51.37
SP	1.5655	7.8537	2.235	9.5789	2.4694	6.7214	66.958	293.37	90.831	202.9	10223	0.06	10.2	5.893
Tank	1.5745	5.5597	2.235	9.5789	2.5881	5.3096	123.43	660.15	142.68	350	14589	0.02	15.6	20.41
RP	1.1995	3.9996	2.235	9.5789	2.7075	3.9109	156.6	568.46	190.39	15.2	14081	0.09	17.7	5.893
2F	2.8276	2.5302	2.235	9.5789	2.8276	2.5302	63.642	718.45	0	0	18966	0.11	10.2	38.64
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm ^{2})*	*E*	*W(mm)*	*L(mm)*
Total	0.53827	2.3275	0	1.78E-15	0.2024	2.3924	58.893	244.06	76.252	150.5	29156	0.03	2.88	17.32

28. Summary of trials 1, 2, and 3 test NSRTTS4NSS

File name: **NSRTTS4NSS-1.csv**			Test name: **NSRTTS4NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1 RP*	*y1 RP*	*x2 RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	70.095	513.74	70.1	513.7	70.1	513.74	0	0	0	0	2.10E+05	0.85	137.5	225
Box	72.39	460.47	70.1	470.2	70.15	467.67	229.5	977.04	225	720	5.80E+05	0.88	225	400
SP	71.494	418.49	70.1	433.2	70.19	428.48	139.9	1474.4	130	999	2.25E+05	0.61	162.5	200
Tank	72.044	373.18	70.1	393.2	70.24	386.12	194.9	2006.1	180	1294	3.39E+05	0.75	175	263
RP	70.1	341.53	70.1	353.2	70.29	343.75	0.429	1171.2	-19.4	223	2.64E+05	0.89	137.5	275
2F	70.343	300.86	70.1	312.7	70.34	300.86	24.74	1187.8	0	0	1.79E+05	0.77	125	188
File name: **NSRTTS4NSS-2.csv**			Test name: **NSRTTS4NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1 RP*	*y1 RP*	*x2 RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	70.095	513.74	70.1	513.7	70.1	513.74	0	0	0	0	2.10E+05	0.85	137.5	225
Box	72.39	460.47	70.1	470.2	70.15	467.67	229.5	977.04	225	720	5.80E+05	0.88	225	400
SP	71.494	418.49	70.1	433.2	70.19	428.48	139.9	1474.4	130	999	2.25E+05	0.61	162.5	200
Tank	72.044	373.18	70.1	393.2	70.24	386.12	194.9	2006.1	180	1294	3.39E+05	0.75	175	263
RP	70.257	341.7	70.1	353.2	70.29	343.75	16.16	1153.6	-3.63	205	2.73E+05	0.88	137.5	275
2F	70.343	300.86	70.1	312.7	70.34	300.86	24.74	1187.8	0	0	1.79E+05	0.77	125	188
File name: **NSRTTS4NSS-3.csv**			Test name: **NSRTTS4NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1 RP*	*y1 RP*	*x2 RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	77.514	408.98	77.51	409	77.51	408.98	0	0	0	0	2.24E+05	0.85	162.5	225
Box	77.067	356.34	77.51	365.5	78.01	358.99	-44.7	914.22	-94.4	265	3.91E+05	0.82	187.5	313
SP	75.895	310.07	77.51	328.5	78.51	316.47	-162	1840.4	-261	640	2.39E+05	0.83	137.5	238
Tank	78.329	262.7	77.51	288.5	79.01	270.51	81.46	2577.3	-67.7	780	2.63E+05	0.49	175	200
RP	76.164	226.43	77.51	248.5	79.5	224.54	-135	2205.2	-334	-189	2.44E+05	0.85	137.5	250
2F	80	178	77.51	208	80	178	248.6	2997.8	0	0	98750	0.34	112.5	113

Summary of test NSRTTS4NSS

File name: **NSRTTS4NSS-T.csv**					Test name: **NSRTTS4NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.568	478.82	72.568	478.82	72.568	478.82	0	0	0	0	2.15E+05	0.84592	146	225
Box	73.949	425.76	72.568	435.32	72.767	431.44	138.09	956.1	118.22	568.5	5.17E+05	0.85753	213	371
SP	72.961	382.35	72.568	398.32	72.966	391.14	39.324	1596.4	-0.42	879.1	2.30E+05	0.68154	154	213
Tank	74.139	336.35	72.568	358.32	73.164	347.58	157.09	2196.5	97.472	1123	3.13E+05	0.66378	175	242
RP	72.174	303.22	72.568	318.32	73.363	304.02	-39.46	1510	-119	79.79	2.60E+05	0.87262	138	267
2F	73.562	259.91	72.568	277.82	73.562	259.91	99.362	1791.1	0	0	1.52E+05	0.62498	121	163
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	73.225	364.4	72.568	377.82	73.065	368.82	65.734	1341.7	16.053	441.7	2.81E+05	0.75773	158	247
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	3.4972	49.385	3.4972	49.385	3.4972	49.385	0	0	0	0	6481.8	4.93E-05	11.8	0
Box	2.2048	49.088	3.4972	49.385	3.7083	51.231	129.25	29.615	150.35	214.3	88978	0.02847	17.7	41.2
SP	2.0746	51.11	3.4972	49.385	3.9193	52.802	142.26	172.57	184.48	169.2	6481.8	0.1071	11.8	17.7
Tank	2.9624	52.077	3.4972	49.385	4.1304	54.5	53.478	269.26	116.8	242.3	35945	0.12412	0	29.5
RP	2.8225	54.3	3.4972	49.385	4.3415	56.198	67.849	491.63	152.1	189.9	12033	0.01671	0	11.8
2F	4.5525	57.917	3.4972	49.385	4.5525	57.917	105.53	853.23	0	0	37712	0.19996	5.89	35.4
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.83437	3.0504	0	7.11E-15	0.3605	2.8919	48.56	295.25	73.786	98.66	28846	0.07086	6.51	14.2

29. Summary of trials 1, 2, and 3 test SPTTS4NSS

File name: **SPTTS4NSS-1.csv**	Test name: **SPTTS4NSS**	Trial number: **1**												
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	71.316	456.7	71.32	456.7	71.32	456.7	0	0	0	0	1.98E+05	0.4	163	175
Box	70.699	405.63	71.32	413.2	71.63	407.5	-61.702	757.05	-93.25	187.14	4.45E+05	0.8	213	300
SP	71.565	357.86	71.32	376.2	71.95	365.66	24.814	1834.6	-38.27	779.95	2.61E+05	0.9	138	275
Tank	72.423	310.47	71.32	336.2	72.26	320.42	110.7	2572.9	16.074	994.21	3.51E+05	0.7	200	263
RP	71.811	273.09	71.32	296.2	72.58	275.17	49.449	2311.3	-76.72	208.53	2.51E+05	0.9	125	275
2F	72.894	229.37	71.32	255.7	72.89	229.37	157.72	2633.4	0	0	1.76E+05	0.7	138	175

File name: **SPTTS4NSS-2.csv**	Test name: **SPTTS4NSS**	Trial number: **2**												
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	75.667	533.33	75.67	533.33	75.67	533.33	0	0	0	0	1.20E+05	0.4	125	125
Box	75	479.29	75.67	489.83	75.41	477.87	-66.667	1054.3	-40.93	-142.4	4.09E+05	0.8	200	313
SP	74.896	430.21	75.67	452.83	75.15	430.69	-77.037	2262.6	-25.57	48.108	3.38E+05	0.9	150	325
Tank	72.543	378.53	75.67	412.83	74.9	379.68	-312.37	3430.8	-235.2	115.91	3.64E+05	0.8	200	275
RP	73.006	328.22	75.67	372.83	74.64	328.68	-266.06	4461.3	-163.1	46.065	4.14E+05	0.9	188	363
2F	74.38	277.04	75.67	332.33	74.38	277.04	-128.67	5529.3	0	0	2.50E+05	0.8	175	238

File name: **SPTTS4NSS-3.csv**	Test name: **SPTTS4NSS**	Trial number: **3**												
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	70.593	451.35	70.59	451.35	70.59	451.35	0	0	0	0	3.08E+05	0.9	163	325
Box	73.281	396.31	70.59	407.85	71.53	405.2	268.77	1154.3	175.47	889.2	5.11E+05	0.8	225	350
SP	72.978	353.55	70.59	370.85	72.46	365.95	238.42	1730.1	51.811	1239.4	2.24E+05	0.9	113	250
Tank	73.076	314.59	70.59	330.85	73.39	323.51	248.22	1626	-31.69	891.6	3.14E+05	0.6	188	225
RP	74.879	282.58	70.59	290.85	74.33	281.07	428.53	827.29	55.319	-150.9	2.48E+05	0.9	138	275
2F	75.259	238.1	70.59	250.35	75.26	238.1	466.51	1225	0	0	2.90E+05	0.9	163	288

Summary of test SPTTS4NSS

File name: **SPTTS4NSS-T.csv**							Test name: **SPTTS4NSS**							
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.526	480.46	72.526	480.46	72.526	480.46	0	0	0	0	2.08E+05	0.6	150	208
Box	72.994	427.08	72.526	436.96	72.856	430.19	46.8	988.55	13.762	311.32	4.55E+05	0.8	213	321
SP	73.146	380.54	72.526	399.96	73.186	387.43	62.064	1942.4	-4.0108	689.17	2.74E+05	0.9	133	283
Tank	72.681	334.53	72.526	359.96	73.517	341.2	15.517	2543.2	-83.595	667.24	3.43E+05	0.7	196	254
RP	73.232	294.63	72.526	319.96	73.847	294.98	70.639	2533.3	-61.511	34.564	3.04E+05	0.9	150	304
2F	74.177	248.17	72.526	279.46	74.177	248.17	165.19	3129.2	0	0	2.39E+05	0.8	158	233
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	73.126	360.9	72.526	379.46	73.351	363.74	60.035	1856.1	-22.559	283.72	3.04E+05	0.8	167	267
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	2.2406	37.449	2.2406	37.449	2.2406	37.449	0	0	0	0	76929	0.2	17.7	85
Box	1.7674	37.116	2.2406	37.449	1.8061	33.725	156.97	168.71	116.32	430.19	42439	0	10.2	21.2
SP	1.3654	35.165	2.2406	37.449	1.4056	30.588	131.45	230.38	39.811	490.58	47328	0	15.6	31.2
Tank	0.28352	31.155	2.2406	37.449	1.0781	27.24	238.55	737.09	108.94	392.09	21246	0.1	5.89	21.2
RP	1.2626	24.066	2.2406	37.449	0.9062	23.954	283.96	1491.9	89.828	146.96	77502	0	27	41.2
2F	0.97608	20.723	2.2406	37.449	0.97608	20.723	243.04	1791.9	0	0	47115	0.1	15.6	46
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.61177	6.4555	0	0	0.48283	5.6756	94.326	683.78	48.408	202.44	19810	0.1	6.55	21.7

30. Summary of trials 1, 2, and 3 test NSPTTS4NSS, these trials were not possible to do

31. Summary of trials 1, 2, and 3 test SSTTS7NSS

File name: **SSTTS7NSS-1.csv**			Test name: **SSTTS7NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1 RP*	*y1RP*	*x2 RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	72.16	477.88	72.16	477.88	72.16	477.88	0	0	0	0	2.12E+05	0.8	118	173
Box	71.31	415.37	72.16	434.38	71.92	431.46	-84.423	1901.1	-61.33	1608.2	4.34E+05	0.8	164	255
SP	73.81	391.09	72.16	397.38	71.69	391.96	165.39	629.53	211.6	87.495	1.95E+05	0.7	118	155
Tank	73.73	352.23	72.16	357.38	71.46	349.27	157.75	515.58	227	-295.8	3.66E+05	0.7	155	227
RP	71.02	297.24	72.16	317.38	71.23	306.58	-113.28	2014.5	-20.92	933.79	2.51E+05	0.8	118	209
2F	71	263.35	72.16	276.88	71	263.35	-115.45	1353.4	0	0	2.00E+05	0.7	118	164
File name: **SSTTS7NSS-2.csv**			Test name: **SSTTS7NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1 RP*	*y1RP*	*x2 RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	72.54	514.87	72.54	514.87	72.54	514.87	0	0	0	0	2.23E+05	0.7	127	173
Box	68	481	72.54	471.37	72.1	478.35	-453.88	-962.7	-410.3	-265	1.10E+05	0	100	100
SP	73.11	449.45	72.54	434.37	71.67	447.28	57.275	-1508	144.5	-217	2.45E+05	0.8	118	200
Tank	73.47	415.5	72.54	394.37	71.23	413.7	93.542	-2113	224.3	-180.5	2.82E+05	0.6	145	182
RP	72.29	384.19	72.54	354.37	70.8	380.11	-25.106	-2982	149.3	-408	2.59E+05	0.9	109	227
2F	70.36	346.11	72.54	313.87	70.36	346.11	-217.95	-3224	0	0	2.10E+05	0.6	127	155
File name: **SSTTS7NSS-3.csv**			Test name: **SSTTS7NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1 RP*	*y1RP*	*x2 RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	71.91	549.1	71.91	549.1	71.91	549.1	0	0	0	0	2.65E+05	0.8	118	209
Box	67	490	71.91	505.6	71.15	503.13	-491.41	1560	-414.7	1312.7	1.70E+05	0.8	155	100
SP	75.07	458.37	71.91	468.6	70.38	464.02	316	1022.9	469.5	565.26	2.70E+05	0.8	127	209
Tank	73.74	408.77	71.91	428.6	69.61	421.75	182.99	1983.2	413.2	1298.1	3.80E+05	0.8	173	236
RP	71.03	372.13	71.91	388.6	68.84	379.47	-88.552	1646.6	218.4	734.14	1.91E+05	0.7	118	155
2F	68.08	336.67	71.91	348.1	68.08	336.67	-383.72	1142.7	0	0	2.72E+05	0.8	127	209

Summary of test SSTTS7NSS

File name: **SSTTS7NSS-T.csv**					Test name: **SSTTS7NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	72.202	513.95	72.202	513.95	72.202	513.95	0	0	0	0	2.33E+05	0.76798	121.21	184.85
Box	68.77	462.12	72.202	470.45	71.724	470.98	-343.24	832.8	-295.43	885.27	2.38E+05	0.51748	139.39	151.52
SP	73.998	432.97	72.202	433.45	71.246	434.42	179.55	48.152	275.17	145.25	2.36E+05	0.76851	121.21	187.88
Tank	73.65	392.17	72.202	393.45	70.768	394.91	144.76	128.59	288.18	273.94	3.43E+05	0.7062	157.58	215.15
RP	71.446	351.19	72.202	353.45	70.29	355.39	-75.645	226.39	115.59	419.98	2.34E+05	0.79765	115.15	196.97
2F	69.812	315.38	72.202	312.95	69.812	315.38	-239.04	-242.44	0	0	2.27E+05	0.71056	124.24	175.76
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	71.646	411.3	72.202	412.95	71.007	414.17	-55.601	165.58	63.919	287.41	2.52E+05	0.7114	129.8	185.35
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	0.25727	29.081	0.25727	29.081	0.25727	29.081	0	0	0	0	22725	0.045115	4.2855	17.142
Box	1.842	33.262	0.25727	29.081	0.41502	29.721	183.65	1277.2	165.54	822.29	1.41E+05	0.36609	28.102	72.853
SP	0.81235	29.838	0.25727	29.081	0.61321	30.791	106.1	1112	140.11	321.96	31343	0.08212	4.2855	23.861
Tank	0.12446	28.374	0.25727	29.081	0.82313	32.436	37.656	1694.5	88.422	725.72	43428	0.081759	11.338	23.861
RP	0.59518	38.464	0.25727	29.081	1.0377	34.516	37.135	2273.6	100.57	591.11	30397	0.098652	4.2855	30.903
2F	1.2545	36.99	0.25727	29.081	1.2545	36.99	110.53	2109.7	0	0	31762	0.090327	4.2855	23.861
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.58936	3.9145	0	0	0.34514	2.7749	61.077	753.97	63.493	328.23	40938	0.10807	8.7383	18.662

32. Summary of trials 1, 2, and 3 test NSSTTS7NSS

File name: **NSSTTS7NSS-1.csv**		Test name: **NSSTTS7NSS**					Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	74	486.5	74	486.5	74	486.5	0	0	0	0	1.10E+05	0.42	110	100
Box	71.222	419.19	74	443	73.7	436.83	-277.8	2380.8	-247.8	1764	4.01E+05	0.73	180	260
SP	72.668	388.91	74	406	73.4	394.59	-133.2	1708.7	-73.16	567.26	1.96E+05	0.72	120	170
Tank	73	344.94	74	366	73.1	348.91	-100	2106.1	-10	397.55	1.63E+05	0.68	150	110
RP	73.853	307.36	74	326	72.8	303.24	-14.72	1863.6	105.28	-412.14	3.60E+05	0.94	130	330
2F	72.5	257	74	285.5	72.5	257	-150	2850	0	0	1.50E+05	0.48	120	130

File name: **NSSTTS7NSS-2.csv**		Test name: **NSSTTS7NSS**					Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	69.651	422.4	69.65	422.4	69.65	422.4	0	0	0	0	2.61E+05	0.77	150	210
Box	72.164	379.83	69.65	378.9	69.78	381.68	251.28	-92.74	238.89	184.94	2.01E+05	0.65	160	140
SP	73.276	340.34	69.65	341.9	69.9	347.04	362.42	155.59	337.65	669.46	2.54E+05	0.76	140	200
Tank	70.361	302.16	69.65	301.9	70.02	309.59	70.939	-26.14	33.769	743.07	2.19E+05	0.55	160	150
RP	71.854	282.53	69.65	261.9	70.15	272.14	220.25	-2063	170.69	-1038.8	1.71E+05	0.73	110	160
2F	70.271	234.23	69.65	221.4	70.27	234.23	61.949	-1283	0	0	2.40E+05	0.84	120	210

File name: **NSSTTS7NSS-3.csv**		Test name: **NSSTTS7NSS**					Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	66.212	436.81	66.21	436.8	66.21	436.81	0	0	0	0	4.85E+05	0.96	170	430
Box	71.203	363.29	66.21	393.3	67.39	382.45	499.06	3002	380.99	1915.9	4.78E+05	0.85	180	310
SP	72.549	323.63	66.21	356.3	68.57	336.21	633.67	3267.7	397.54	1257.9	2.24E+05	0.82	120	200
Tank	70.614	282.83	66.21	316.3	69.75	286.22	440.16	3347.3	85.958	338.89	3.29E+05	0.69	160	220
RP	73.5	237.5	66.21	276.3	70.94	236.24	728.76	3880.6	256.49	-126.48	1.80E+05	0.71	120	160
2F	72.116	185.62	66.21	235.8	72.12	185.62	590.34	5018.2	0	0	3.11E+05	0.92	130	280

Summary of test NSSTTS7NSS

File name: **NSSTTS7NSS-T.csv**					Test name: **NSSTTS7NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	69.955	448.57	69.955	448.57	69.955	448.57	0	0	0	0	2.85E+05	0.72	143	247
Box	71.53	387.43	69.955	405.07	70.289	400.32	157.51	1763	124.03	1288.3	3.60E+05	0.74	173	237
SP	72.831	350.96	69.955	368.07	70.624	359.28	287.65	1711	220.67	831.53	2.25E+05	0.77	127	190
Tank	71.325	309.98	69.955	328.07	70.959	314.91	137.03	1809	36.576	493.17	2.37E+05	0.64	157	160
RP	73.069	275.8	69.955	288.07	71.294	270.54	311.43	1227	177.49	-525.82	2.37E+05	0.79	120	217
2F	71.629	225.62	69.955	247.57	71.629	225.62	167.43	2195	0	0	2.34E+05	0.74	123	207
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	71.723	333.06	69.955	347.57	70.792	336.54	176.84	1451	93.127	347.86	2.63E+05	0.73	141	209
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	3.1865	27.459	3.1865	27.459	3.1865	27.459	0	0	0	0	1.54E+05	0.23	24.9	137
Box	0.4487	23.449	3.1865	27.459	2.6003	25.821	324.01	1337	269.25	782.65	1.17E+05	0.08	9.43	71.3
SP	0.3181	27.69	3.1865	27.459	2.0359	25.355	317.49	1271	209.21	304.35	23683	0.04	9.43	14.1
Tank	1.189	25.95	3.1865	27.459	1.5178	25.869	225.42	1393	39.225	178.32	68954	0.06	4.71	45.5
RP	0.8712	28.916	3.1865	27.459	1.1124	27.379	310.3	2468	61.92	381.04	87052	0.1	8.17	80.1
2F	0.973	29.769	3.1865	27.459	0.973	29.769	311.31	2614	0	0	65880	0.19	4.71	61.3
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	0.9522	2.0609	0	3.55E-15	0.79473	1.4929	115.84	867.7	104.6	267.83	41143	0.07	6.87	37.4

33. Summary of trials 1, 2, and 3 test SRTTS7NSS

File name: **SRTTS7NSS-1.csv**			Test name: **SRTTS7NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
1F	82.92	466.73	82.92	466.73	82.92	466.73	0	0	0	0	4.91E+05	0.9	136	293
Box	79.336	427.67	82.92	423.23	81.436	422.75	-358.37	-443.56	-210	-491.9	2.40E+05	0.6	143	129
SP	77.982	397.53	82.92	386.23	79.952	385.34	-493.81	-1129.8	-197	-1219	2.78E+05	0.8	107	186
Tank	75.276	347.6	82.92	346.23	78.468	344.89	-764.45	-136.33	-319.3	-270.3	3.71E+05	0.7	143	200
RP	76.941	309.58	82.92	306.23	76.984	304.45	-597.92	-334.63	-4.317	-513	2.54E+05	0.8	107	171
2F	75.5	263.5	82.92	265.73	75.5	263.5	-742.01	223.4	0	0	2.20E+05	0.6	114	143

File name: **SRTTS7NSS-2.csv**			Test name: **SRTTS7NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
1F	75.344	729.35	75.34	729.35	75.344	729.35	0	0	0	0	3.01E+05	0.8	171	164
Box	78.831	671.17	75.34	685.85	74.675	668.78	348.69	1467.3	415.56	-239.1	5.52E+05	0.8	150	279
SP	80.009	612.47	75.34	648.85	74.006	617.27	466.57	3637.8	600.32	480	4.59E+05	0.9	121	300
Tank	75.299	543.39	75.34	608.85	73.337	561.58	-4.5015	6545.2	196.11	1818	4.04E+05	0.8	143	214
RP	72.531	499.98	75.34	568.85	72.669	505.89	-281.3	6886.3	-13.82	590.4	2.92E+05	0.8	114	193
2F	72	449.5	75.34	528.35	72	449.5	-334.36	7884.6	0	0	2.14E+05	0.7	107	143

File name: **SRTTS7NSS-3.csv**			Test name: **SRTTS7NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A*(mm^2)	*E*	*W(mm)*	*L(mm)*
1F	82.927	466.71	82.93	466.71	82.927	466.71	0	0	0	0	4.92E+05	0.9	136	293
Box	79.336	427.67	82.93	423.21	81.442	422.73	-359.11	-446.43	-210.6	-494.2	2.40E+05	0.6	143	129
SP	77.705	397.32	82.93	386.21	79.956	385.32	-522.27	-1111.7	-225.2	-1200	2.88E+05	0.8	114	186
Tank	75.276	347.6	82.93	346.21	78.471	344.88	-765.19	-139.19	-319.5	-271.4	3.71E+05	0.7	143	200
RP	76.941	309.58	82.93	306.21	76.985	304.44	-598.66	-337.49	-4.464	-513.6	2.54E+05	0.8	107	171
2F	75.5	263.5	82.93	265.71	75.5	263.5	-742.74	220.54	0	0	2.20E+05	0.6	114	143

Summary of test SRTTS7NSS

File name: **SRTTS7NSS-T.csv**							Test name: **SRTTS7NSS**							
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	80.397	554.26	80.397	554.26	80.397	554.26	0	0	0	0	4.28E+05	0.9	148	250
Box	79.168	508.84	80.397	510.76	79.184	504.75	-122.9	192.42	-1.657	-408.4	3.44E+05	0.7	145	179
SP	78.565	469.11	80.397	473.76	77.972	462.64	-183.2	465.42	59.38	-646.4	3.42E+05	0.8	114	224
Tank	75.283	412.86	80.397	433.76	76.759	417.12	-511.4	2089.9	-147.6	425.57	3.82E+05	0.7	143	205
RP	75.471	373.05	80.397	393.76	75.546	371.59	-492.6	2071.4	-7.532	-145.4	2.66E+05	0.8	110	179
2F	74.333	325.5	80.397	353.26	74.333	325.5	-606.4	2776.2	0	0	2.18E+05	0.6	112	143
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	77.203	440.6	80.397	453.26	77.365	439.31	-319.4	1265.9	-16.23	-129.1	3.30E+05	0.8	129	196
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
1F	3.5733	123.8	3.5733	123.8	3.5733	123.8	0	0	0	0	89736	0.1	16.8	61
Box	0.23843	114.79	3.5733	123.8	3.1886	115.99	333.5	901.45	295	119.71	1.47E+05	0.1	3.37	71
SP	1.0273	101.37	3.5733	123.8	2.804	109.34	459.6	2243.2	382.7	796.57	83269	0.1	5.83	54
Tank	0.01087	92.299	3.5733	123.8	2.4193	102.15	358.4	3150.4	243	984.86	15826	0	0	6.7
RP	2.079	89.757	3.5733	123.8	2.0346	94.96	149.4	3404.7	4.444	520.29	18183	0	3.37	10
2F	1.6499	87.681	3.5733	123.8	1.6499	87.681	192.3	3612.2	0	0	2693.7	0	3.37	0
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm^2)*	*E*	*W(mm)*	*L(mm)*
Total	1.2013	13.463	4.44E-16	0	0.657	12.243	152	1346.3	158.1	389.93	51644	0	5.36	29

34. Summary of trials 1, 2, and 3 test NSRTTS7NSS

File name: **NSRTTS7NSS-1.csv**			Test name: **NSRTTS7NSS**				Trial number: **1**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	73.467	385.53	73.467	385.53	73.467	385.53	0	0	0	0	1.50E+05	0.16	108	108
Box	71.972	335.03	73.467	342.03	73.373	357.07	-149.47	700.13	-140.13	2203.5	1.92E+05	0.48	115	131
SP	71.889	309.61	73.467	305.03	73.28	332.85	-157.78	-457.78	-139.11	2324.3	1.80E+05	0.58	131	108
Tank	72	292.5	73.467	265.03	73.187	306.68	-146.67	-2746.7	-118.67	1417.9	1.40E+05	0.37	100	108
RP	71.5	274.5	73.467	225.03	73.093	280.5	-196.67	-4946.7	-159.33	600.3	1.71E+05	0.49	108	123
2F	73	254	73.467	184.53	73	254	-46.667	-6946.7	0	0	1.50E+05	0.5	100	115

File name: **NSRTTS7NSS-2.csv**			Test name: **NSRTTS7NSS**				Trial number: **2**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	73	386	73	386	73	386	0	0	0	0	1.30E+05	0	100	100
Box	71.972	335.03	73	342.5	73	357.43	-102.8	746.8	-102.8	2240.1	1.92E+05	0.48	115	131
SP	72	310	73	305.5	73	333.13	-100	-450	-100	2313.4	1.70E+05	0.64	131	100
Tank	72	292.5	73	265.5	73	306.87	-100	-2700	-100	1436.6	1.40E+05	0.37	100	108
RP	71.5	274.5	73	225.5	73	280.6	-150	-4900	-150	609.7	1.71E+05	0.49	108	123
2F	73	254	73	185	73	254	0	-6900	0	0	1.50E+05	0.5	100	115

File name: **NSRTTS7NSS-3.csv**			Test name: **NSRTTS7NSS**				Trial number: **3**							
	Properties													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	73.467	385.53	73.467	385.53	73.467	385.53	0	0	0	0	1.50E+05	0.16	108	108
Box	71.972	335.03	73.467	342.03	73.373	357.07	-149.47	700.13	-140.13	2203.5	1.92E+05	0.48	115	131
SP	72.368	309.63	73.467	305.03	73.28	332.85	-109.82	-459.82	-91.158	2322.3	1.90E+05	0.64	138	108
Tank	71.973	292.03	73.467	265.03	73.187	306.68	-149.39	-2699.8	-121.39	1464.7	1.69E+05	0.33	115	115
RP	71.5	274.5	73.467	225.03	73.093	280.5	-196.67	-4946.7	-159.33	600.3	1.71E+05	0.49	108	123
2F	73	254	73.467	184.53	73	254	-46.667	-6946.7	0	0	1.50E+05	0.5	100	115

Summary of test NSRTTS7NSS

File name: **NSRTTS7NSS-T.csv**					Test name: **NSRTTS7NSS**									
	Mean values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	73.311	385.69	73.311	385.69	73.311	385.69	0	0	0	0	1.43E+05	0.1	105.1	105
Box	71.972	335.03	73.311	342.19	73.249	357.19	-133.91	715.69	-127.69	2215.7	1.92E+05	0.5	115.4	131
SP	72.086	309.75	73.311	305.19	73.187	332.95	-122.53	-455.87	-110.09	2320	1.80E+05	0.6	133.3	105
Tank	71.991	292.34	73.311	265.19	73.124	306.74	-132.02	-2715.5	-113.35	1439.7	1.50E+05	0.4	105.1	110
RP	71.5	274.5	73.311	225.19	73.062	280.53	-181.11	-4931.1	-156.22	603.43	1.71E+05	0.5	107.7	123
2F	73	254	73.311	184.69	73	254	-31.111	-6931.1	0	0	1.50E+05	0.5	100	115
	Total Mean values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
Total	72.31	308.55	73.311	284.69	73.156	319.52	-100.11	-2386.3	-84.559	1096.5	1.64E+05	0.4	111.1	115
	Standard Deviation values of this properties by objects													
Objects	*Ix*	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
1F	0.21999	0.21999	0.22	0.21999	0.22	0.21999	0	0	0	0	9428.1	0.1	3.626	3.63
Box	0	0	0.22	0.21999	0.176	0.17238	21.999	21.999	17.599	17.238	2.91E-11	0	0	0
SP	0.20495	0.1787	0.22	0.21999	0.132	0.13188	25.242	4.2322	20.836	4.7359	8165	0	3.626	3.63
Tank	0.01286	0.2207	0.22	0.21999	0.088	0.08811	22.669	22.035	9.5078	19.242	13780	0	7.252	3.63
RP	0	0	0.22	0.21999	0.044	0.04433	21.999	21.999	4.3998	4.4326	0	0	0	0
2F	0	0	0.22	0.21999	0	0	21.999	21.999	0	0	0	0	0	0
	Total Standard Deviation values of this properties													
	Ix	*Iy*	*x1RP*	*y1RP*	*x2RP*	*y2RP*	*Dx1RP (mm)*	*Dy1RP (mm)*	*Dx2RP (mm)*	*Dy2RP (mm)*	*A(mm²)*	*E*	*W(mm)*	*L(mm)*
Total	0.09884	0.10416	0	2.78E-17	0.0751	0.07456	8.5674	9.4563	8.1343	7.7695	5498.3	0	2.703	1.81

35. Summary of trials 1, 2, and 3 test SPTTS7NSS, these trials were not possible to do

36. Summary of trials 1, 2, and 3 test NSPTTS7NSS, these trials were not possible to do

File Name: Final Results.csv

The results of the tests are shown in the same order of the table A-3.

Number	Files Name	Dx2RP	Dy2RP	MD	STDX	STDY
1	**SSTTS2SS**	83.412	-176.59	195.30	79.91	94.18
2	**NSSTTS2SS**	76.651	-424.87	431.73	88.58	172.83
3	**SRTTS2SS**	21.740	14.267	26.000	30.56	96.12
4	**NSRTTS2SS**	-129.36	-15.256	130.25	131.12	250.53
5	**SPTTS2SS**	-32.118	58.009	66.34	100.52	323.28
6	**NSPTTS2SS**	15.114	-149.73	150.49	58.84	164.75
7	**SSTTS4SS**	-72.794	-5.9606	76.03	7.11	13.96
8	**NSSTTS4SS**	-5.4840	-73.796	74.00	57.93	146.45
9	**SRTTS4SS**	122.97	-69.131	141.07	83.69	196.54
10	**NSRTTS4SS**	-117.80	-172.81	209.14	148.84	325.19
11	**SPTTS4SS**	31.848	177.45	180.29	84.59	447.09
12	**NSPTTS4SS**	-19.246	-615.12	615.42	12.66	13.56
13	**SSTTS7SS**	156.82	118.42	196.51	101.01	493.75
14	**NSSTTS7SS**	-50.759	243.45	248.69	59.57	382.69
15	**SRTTS7SS**	39.005	-39.920	55.81	188.42	425.87
16	**NSRTTS7SS**	-54.104	-416.36	419.86	23.27	243.73
17	**SPTTS7SS***	-	-	-	-	-
18	**NSPTTS7SS***	-	-	-	-	-
19	**SSTTS2NSS**	239.92	-41.327	243.45	40.86	78.32
20	**NSSTTS2NSS**	195.42	-483.21	521.23	64.55	82.95
21	**SRTTS2NSS**	38.424	175.09	179.26	135.73	137.03
22	**NSRTTS2NSS**	-63.627	-168.49	180.10	125.58	93.50
23	**SPTTS2NSS**	96.912	30.194	101.50	47.89	135.28
24	**NSPTTS2NSS**	-26.858	211.72	213.42	55.61	180.65
25	**SSTTS4NSS**	215.64	24.733	217.05	40.38	215.81
26	**NSSTTS4NSS**	357.21	-523.62	633.86	58.04	125.65
27	**SRTTS4NSS**	-62.351	-187.15	197.26	76.25	150.54
28	**NSRTTS4NSS**	16.056	441.67	441.96	73.79	98.66
29	**SPTTS4NSS**	-22.559	283.72	284.62	48.40	202.43
30	**NSPTTS4NSS***	-	-	-	-	-
31	**SSTTS7NSS**	63.919	287.41	295.79	63.49	328.23
32	**NSSTTS7NSS**	93.127	347.86	360.11	104.60	267.84
33	**SRTTS7NSS**	-16.228	-129.11	130.13	158.06	389.93
34	**NSRTTS7NSS**	-85.559	1096.5	1099.2	8.13	7.70
35	**SPTTS7NSS***	-	-	-	-	-
36	**NSPTTS7NSS***	-	-	-	-	-

* This test was not possible to do.

Appendix C. Programs

C.1 "Three_Trials_Representation.m" program

```
function [] = Three_Trials_Representation()

% HEIGHT_SCANCARLOS This function analyse data from text file using the Average Height Method
% This function compare three trial with the same parameters step by step
% File modified by Carlos Fresquet M. A. Sc. Candidate, University of Ottawa, June 14, 2011
% Data file has no units removed and follows the format provided
%% Input Data

trialn=1;
for trial=1:1:3
    if trial ==1;
     trialn=trialn+1;
     file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\sstts4nss-1.txt';
    end
    if trial ==2;
     trialn=trialn+1;
     file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\sstts4nss-2.txt';
    end
    if trial ==3;
     trialn=trialn+1;
     file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\sstts4nss-3.txt';
    end

theta = 8.9;          % in degree                              %% el valor real es 8.9
velocity = 4.65;      % in km/h                                %% 2km/h= 1.7km/h, 4km/h = 4.6km/h, 7km/h =
7.3km/h,
visualization = 1;
hough_transform = 0;
%distperscan=velocity*5/18/9*1000;                             %% in mm =216.
req=1.5;             % Hz                            %% the book and Zach use 75 Hz
distperscan=velocity*1000/3600*1000/freq;    % mm                   %% distpersacan=velocity(Km/h)*
1h/60min*1min/60seg*1000m/1Km*1000mm/1m/75Hz
distperscan5=distperscan/5;
Height = 1255;                                  %% Height of scanner [mm]
%scan_filter = 1;                                %% use every # of scans
%clipping = 0;                                   %% =1 if Yes =0 if No, gclearance in [mm]
xmax = 6750;   %%tenian 6500
xmin = 0;
xgrid = 75;                     %% tenia grid=100, la replace porque me interfiere con la funcion grid y el
valor de 75 sale de la figura 3.2 Spot Size
threshold = 0;
distribution_xlimit=6500; distribution_ylimit=8200;          %distribution_xlimit=160;
distribution_ylimit=40;
real_time(1)=0;
real_time(2)=0;
screen_width=1440;
```

```
screen_height=900;
%close all;
tic
%% Import all scans
M = dlmread(file, ';',3,0);                    % read the file after delimeter ';' beguining in row 3,
column 0 and make a matrix M
data=M;                                        % put the matrx M into data
data(:, 2) = [];                               % Deleting Scan index column -   It is better with this
data(:,2:4)=[];
data(:, 2) = [];                               % Deleting Telegram Indes column
data(:, 2) = [];                               % Deleting Interlaces Scan Number column
scan_number = max(data(:,1));                          % number of scans in file
data(:, 1) = [];                               % Deleting Scan number

%%%%%%%%%%%%%%%%%% Convert to Cartesian%%%%%%%%%%%%%%%

c=1;
for i=45:0.5:135                                % Preparing RHO (radio) matrix(row=1, columns=181),
comienza desde el angulo 45 hasta 135 con paso 0.5
   THETA(1,c)=i*pi/180;                          % para cada valor de c obtengo(desde 90 hasta
180)valores de THETHA en radianes
   c=c+1;
end                                            % obtengo una matrix con c y los valores de THETA en
radianes
var=0;
for s=1:1:scan_number                            %% Reducing number of scans used
   [X,Y] = pol2cart(THETA,data(s,:))                 % Obtengo una matrix en cartesiana con los
valores del angulo en radianes y la radio(distancia del medision del laser)
   cart_data(:,1,s)=X;                           %% [x-value, y-value, scan number]De cada una de las
lecturas de data file
   cart_data(:,2,s)=Y;
var=var+1;
end
scan_number = var;                              %% new scan_number
%% Visualize in 2D and range Data 2D
for s=1:1:scan_number
   rows = 90;
   cols = 135;
   occupancy=zeros(rows,cols) %% Initialize size of Occupancy grid--make a matrix of 0 with 135 rows and
columns
   occupancy_density=occupancy
   occupancy3=zeros(rows,cols)
   occupancy_density3=occupancy3
   clear real_time;
   clear prog_time;
   clear zvalue_array;
   clear zvalue_array2;
   for i=1:1:181

%%%%%% First Occupancy Grid with Value = # of points in 10cm xgrids %%%%%%%%%%%

      xvalue = round(cart_data(i,1,s)/xgrid)+1;                %% xvalue in 75 mm sections for occupancy
matrix address--- este valor tiene que ser +
      yvalue = round(cart_data(i,2,s)/distperscan)+1;             %% yvalue in distperscan mm sections for
occupancy matrix address
      zvalue = Height-cart_data(i,2,s)*sind(theta);
```

```
        zvalue_array(i)= zvalue;
        xvalue3 = round((cart_data(i,1,s)/xgrid)*cosd(theta))+1;
        yvalue3 = round((cart_data(i,2,s)/distperscan5)*cosd(theta))+1;                %% yvalue3 in distperscan mm
sections for occupancy matrix address
        zvalue2 = (Height*(8183-cart_data(i,2,s))/8183);
        zvalue3 = Height-(cart_data(i,2,s)*cosd(theta))*sind(theta);
        zvalue_array2(i)= zvalue2;

    %%%%%%%%%%%%%%%%%% Side clipping %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

        if (xvalue < xmax/xgrid    && xvalue > xmin/xgrid)              %% Framing xvalues //Clipping xvalues
          occupancy_density(xvalue,yvalue)=occupancy(xvalue,yvalue)+1;     %% Density Matrix
          occupancy(xvalue,yvalue)=zvalue ;                               %% Occupancy Matrix

          occupancy_density3(xvalue3,yvalue3)=occupancy3(xvalue3,yvalue3)+1;     %% Density Matrix3
          occupancy3(xvalue3,yvalue3)=zvalue3 ;                           %% Occupancy Matrix3
          occupancy2(xvalue,yvalue)=zvalue2;
          zvalue12=[zvalue zvalue2];
        end
    end

 %% %%%%%%%%%Connectivity Matrix, Cell values represent size of connected block  %%%%%%%

    occupancy;
    label=[1,0];                              %% declair label matrix
    occupancy = bwlabeln(occupancy);              %% Labels connected components 1 to n
 %% density matrix values X connectivity matrix values
    probability_matrix=occupancy;
%% Creation of map
if s==1;
    map=probability_matrix;
else
    map(1:rows,s+cols)=zeros(rows,1);
    map(1:rows,s:s+cols-1)=(map(1:rows,s:s+cols-1)+probability_matrix(1:rows,1:cols))/2;
    map(:,s+cols-1)=probability_matrix(:,cols);
end
if s==scan_number
   map(:,s+cols-1)=(probability_matrix(:,cols)+map(:,s+cols-2))/2;
end

%%%%%%%%%%%%%%%%%%%%% Visuals%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%% Visualize in 2D Range Data %%%%%%%%%%%%%

if visualization ==1;
    figure(trial),
  if trial==1
  set(trial, 'Name', 'Trial1', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica las figuras principal del
trial a toda pantalla
  end
  if trial==2
  set(trial, 'Name', 'Trial2', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica las figuras principal del
trial a toda pantalla
  end
  if trial==3
```

```
 set(trial, 'Name', 'Trial3', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica las figuras principal del
trial a toda pantalla
 end
  figure(trial),
  subplot(2,2,1);
   plot((cart_data(:,1,s)*cosd(theta)),(cart_data(:,2,s)*cosd(theta)),'x');
   axis([-7500 7500 -50 9000]);
   title('Range Data','fontsize',12);
   xlabel('X-value(mm)');
   ylabel('Y-value(mm)');
   grid on,

 %%%%%%%%%%%%%%%%%%% Occupancy Grid Visual %%%%%%%%%%%

subplot(2,2,2);
   pcolor(occupancy_density3');
   contourf(occupancy3',50);
   title('Density','fontsize',12);
   xlabel('X-value(mm)');
   ylabel('Y-value(mm)');
   legend('# Outof Range');
   set(gca, 'XTickLabel', 0:xgrid*10:xmax);
   if (velocity>=1.70 & velocity<2.5)
       ymaxaxis=135;
       k=4;
   end
   if (velocity>=4.65 & velocity<4.70)
       ymaxaxis=52;
       k=1.95;
   end
   if (velocity>=7.0 & velocity<8.0)
       ymaxaxis=35;
       k=0.95;
   end
   axis([0 90 0 ymaxaxis])
   set(gca,'YTickLabel', 0:round(distperscan*k):round(k*yvalue*distperscan))
   grid on;

  %%%%%%%%%%%%%%%%%%   Height per scan  %%%%%%%%%%%%%%%%%%%

  subplot(2,2,3);
   plot3((fliplr(45:0.5:135)),zeros(181)+s,zvalue_array,'r');
   title('Data-Height','fontsize',12);
   xlabel('Angles(*)');
   ylabel('Scan number(#)');
   zlabel('Zvalue(mm)' );
   axis([45 135 0 scan_number 0 1300]);
   set(gca,'XTickLabel',{'120','100','80','60','40','20'});
   grid on

   %%%%%%%%%%%%%%%%%%% Time Data %%%%%%%%%%%%%%%%%%%%%%%%%

   prog_time(s,1)=s;
   prog_time(s,2)=toc;
   real_time(s,1)=s;
   real_time(s,2)=s/9;
```

```
  subplot(2,2,4);
   plot(real_time(:,1),real_time(:,2),prog_time(:,1),prog_time(:,2));
   xlabel('scan #');
   ylabel('Time (s)');
   axis([0 scan_number 0 100]);
   title('Time','fontsize',12);
   legend('Real Time','Program Time');
   grid on;
   %pause();
   pause(1/(2*9)) ;
end

end
prog_time(:,2)=0;
real_time(:,1)=0;
end %% end of trial loop

end
```

C.2 "Continuous_Map.m" program

```
function [] = Continuous_Map()

% HEIGHT_SCANCARLOSContinuousMapa
%This function analyse data from text file using the Average Height Method with continuous values
% File modified by Carlos Fresquet M. A. Sc. Candidate, University of Ottawa, June 13, 2011
% Data file has no units removed and follows the format provided
%% Input Data

 clear();

theta        = 8.9;   % el valor real es 9 degree
 velocity     = 1.78; % km/h
 velocity     = velocity * 1000 / 3600; % m/s
 freq         = 1.48;   % Hz
 dist_per_scan = velocity/freq;  %% m
 dist_per_scan = dist_per_scan * 1000 ; %% mm
 max_range     = 8183; % mm;
 thresholdH    = 310;  %mm height threshold
 threshold     = thresholdH/sind(theta);  % mm;    -- declaring as part of the max distance allowed for the scan
 Height        = 1255; %mm    Height of the scanner beam according to the floor

 file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\sstts2ss-2.txt';
 M = dlmread(file, ';',3,0);                         % read the file after delimeter ';' beguining in row 3,
column 0 and make a matrix M
 data=M;                                        % put the matrx M into data
 data(:, 2:4) = [];                              % Deleting Scan index column -   It is better with this
data(:,2:4)=[];                               % Deleting Interlaces Scan Number column
 scan_number  = max(data(:,1));                            % number of scans in file
 data(:, 1)   = [];

 angle     = 45:0.5:135;
 theta_rad = angle*pi/180;
```

```
 for i = 1:1:scan_number,
      rho_i = data(i,:); %% scan per iteration i (181 depth values)
      temp  = ~(rho_i >= (max_range - threshold)); %% neg positions of the maximum allowed distances
      rho_i = temp .* rho_i;
      [X,Y] = pol2cart(theta_rad,rho_i);
      Z  = Height - rho_i*sind(theta);   %% Z value of the indentified objects
      Y = (Y + (i-1) * dist_per_scan ) .* temp; %% temp is used to remove the max permisible scan values
>=(max_range - thrshold)
      X_i(i,:) = X;     % this case the points are in the theta (8.9)plane from the horizontale
      Y_i(i,:) = Y;     % this case the points are in the theta (8.9)plane from the horizontale
      Z_i(i,:) = Z;     % this case ""
      Xr=  X_i(i,:)* cosd (theta);   % this case the points are in the horizontal plane
      Yr= Y_i(i,:)* cosd (theta);    % this case the points are in the horizontal plane

 end;


Continuous_Map=6;
figure(6),
set(Continuous_Map, 'Name', 'Continuous Map', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica
las figuras principal del trial a toda pantalla
% figure(2),

for i = 1:1:scan_number,
   %plot(X_i(i,:),Y_i(i,:),'.r');  % this case the points are in the theta (8.9)plane from the horizontale
  subplot(2,2,1)
   plot((X_i(i,:)*cosd(theta)),(Y_i(i,:)*cosd(theta)),'.r') % this case the points are in the horizontal plane X and
Y
   title('Continuous Map (X and Y Cartesian Coordinate)','fontsize',14);
   xlabel('X (mm)', 'fontsize',14);
   ylabel('Y (mm)','fontsize',14);
   axis([-6000 6000 0 ((scan_number * dist_per_scan) + max_range)]);
   hold on;
   grid on;

  subplot(2,2,2)
   plot3((X_i(i,:)*cosd(theta)),(Y_i(i,:)*cosd(theta)),(Z_i(i,:)),'.b') % this case is 3D
   title('Continuous Map 3D','fontsize',14);
   axis([-6000 6000 0 ((scan_number * dist_per_scan) + max_range) -500 Height]);
   xlabel('X (mm)', 'fontsize',14);
   ylabel('Y (mm)','fontsize',14);
   zlabel('Z (mm)', 'fontsize',14);
   hold on;
   grid on;

  subplot(2,2,3)
   plot((Y_i(i,:)*cosd(theta)),(Z_i(i,:)),'.g') % this case is the plane Y and Z
   title('Continuous Map (Y and Z Cartesian Coordinate)','fontsize',14);
   axis([0 ((scan_number * dist_per_scan) + max_range) -500 Height]);
   xlabel('Y (mm)','fontsize',14);
   ylabel('Z (mm)', 'fontsize',14);
   hold on;
   grid on;

   subplot(2,2,4)
   plot((X_i(i,:)*cosd(theta)),(Z_i(i,:)),'.y') % this case is the plane X and Z
```

```
    title('Continuous Map (X and Z Cartesian Coordinate)','fontsize',14);
    axis([-6000 6000 -500 Height]);
    xlabel('X (mm)','fontsize',14);
    ylabel('Z (mm)', 'fontsize',14);
    hold on;
    grid on;
end

hold off;
end
```

C.3 "Map_Images.m" program

```
function [] = Map_Images()

% Height ScancarlosDContXYplane
%This function analyse data from text file using the Average Height Method with continuous values
% File modified by Carlos Fresquet M. A. Sc. Candidate, University of Ottawa, June 16, 2011
% Data file has no units removed and follows the format provided
%% Input Data

 clear();

 theta      = 8.9;   % el valor real es 9 degree
 velocity      = 1.78; % km/h
 velocity      = velocity * 1000 / 3600; % m/s
 freq          = 1.48;   % Hz
 dist_per_scan = velocity/freq;  %% m
 dist_per_scan = dist_per_scan * 1000 ; %% mm
 max_range     = 8183; % mm;
 thresholdH    = 310;  %mm height threshold
 threshold     = thresholdH/sind(theta);  % mm;    -- declaring as part of the max distance allowed for the scan
 Height        = 1255; %mm    Height of the scanner beam according to the floor
 Xgrid = 100 ; %mm
 Ygrid = 100; %mm
 file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\sstts2ss-1.txt';
 M = dlmread(file, ';',3,0);                                  % read the file after delimeter ';' beguining in row 3,
column 0 and make a matrix M
 data=M;                                                   % put the matrx M into data
 data(:, 2:4) = [];                                         % Deleting Scan index column -   It is better with this
data(:,2:4)=[];                                         % Deleting Interlaces Scan Number column
 scan_number  = max(data(:,1));                                       % number of scans in file
 data(:, 1)   = [];


 angle     = 45:0.5:135;
 theta_rad = angle*pi/180;
  for i = 1:1:scan_number,
       rho_i = data(i,:); %% scan per iteration i (181 depth values)
       temp  = ~(rho_i >= (max_range - threshold)); %% neg positions of the maximum allowed distances
       rho_i = temp .* rho_i;
       [X,Y] = pol2cart(theta_rad,rho_i);
       Z  = Height - rho_i*sind(theta);   %% Z value of the indentified objects
```

```
        Y = (Y + (i-1) * dist_per_scan ) .* temp; %% temp is used to remove the max permisible scan values
>=(max_range - thrshold)
        X_i(i,:) = X;     % this case the points are in the theta (8.9)plane from the horizontale
        Y_i(i,:) = Y;     % this case the points are in the theta (8.9)plane from the horizontale
        Z_i(i,:) = Z;     % this case ""
        Xr=  X_i(i,:)* cosd (theta);   % this case the points are in the horizontal plane
        Yr= Y_i(i,:)* cosd (theta);    % this case the points are in the horizontal plane

 end;
Continuous_Map=8;
figure(8),
set(Continuous_Map, 'Name', 'Continuous Map X and Y plane', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8
0.8]))    %ubica las figuras principal del trial a toda pantalla
% figure(8),
imageYZ = zeros (round(((scan_number * dist_per_scan) + max_range)/Xgrid)+1, ...
                 round(Height/Ygrid*10)+1 );
imageXY = zeros (12000/Xgrid, round(((scan_number * dist_per_scan) + max_range)/Ygrid)+1);

for i = 1:1:scan_number,

   subplot(2,2,1)
    plot((X_i(i,:)*cosd(theta)),(Y_i(i,:)*cosd(theta)),'.r') % this case the points are in the horizontal plane X and
Y
    %plot(X_i(i,:),Y_i(i,:),'.r');  % this case the points are in the theta (8.9)plane from the horizontale
    title('Continuous Map (X and Y Cartesian Cordinate)','fontsize',14);
    xlabel('X (mm)', 'fontsize',14);
    ylabel('Y (mm)','fontsize',14);
    axis([-6000 6000 0 ((scan_number * dist_per_scan) + max_range)]);
    hold on;
    grid on;

  subplot(2,2,3)
    plot((Y_i(i,:)*cosd(theta)),(Z_i(i,:)),'.g') % this case is the plane Y and Z
    title('Continuous Map (Y and Z Cartesian Cordinate)','fontsize',14);
    axis([0 ((scan_number * dist_per_scan) + max_range) -500 Height]);
    xlabel('Y (mm)','fontsize',14);
    ylabel('Z (mm)', 'fontsize',14);
    hold on;

    Xa  = round((Y_i(i,:)*cosd(theta))/ Xgrid);
    Ya  = round((Z_i(i,:))/Ygrid*10);
    Xa1 = round (((X_i(i,:)*cosd(theta))+6000)/Xgrid);
    Ya1 = round((Y_i(i,:)*cosd(theta))/Ygrid);

    for k = 1:1:length(Xa),
        imageYZ(Xa(k)+1,Ya(k)+1) = 1;
    end;
    for k = 1:1:length(Xa1),
        if (Xa1(k)+1 > (12000/(Xgrid*2))+1) ,
            imageXY(Xa1(k)+1,Ya1(k)+1) = 1;
        end;
    end;
  end

imageYZ  = fliplr(imageYZ)';
hold off;
```

```
subplot(2,2,4)
line = strel('line',12,90);
imageYZ = imdilate(imageYZ,line);
imshow(imageYZ)
title('Density Map Y and Z','fontsize',14);

imageXY  = fliplr(imageXY)';
square = strel('square',5);
imageXY = imdilate(imageXY,square);
%imageXY = imerode(imageXY,square);
hold off;

subplot(2,2,2)
imshow(imageXY)
BW=imageXY;
s  = regionprops(bwlabel(BW), 'centroid');
centroids = cat(1, s.Centroid);
imshow(BW)
hold on;
plot(centroids(:,1), centroids(:,2), 'r*')
title('Density Map X and Y (Objects Center)','fontsize',14);
hold off;
end
```

C.4 "Trial_and_Test_Results.m" program

```
function [] = Trial_and_Test_Results()

% % HEIGHT_SCANCARLOSContinuousMapa
% % This function analyse data from text file using the Average Height Method with continuous values
% % File modified by Carlos Fresquet M. A. Sc. Candidate, University of Ottawa, December  3, 2011
% % Data file has no units removed and follows the format provided
%% Input Data

clear();

 theta         = 8.9;   % el valor real es aprox 9 degree
 velocity1     = 1.78; % km/h
 velocity      = velocity1 * 1000 / 3600; % m/s
 freq          = 1.48;   % Hz
 dist_per_scan = velocity/freq;  %% m
 dist_per_scan = dist_per_scan * 1000 ; %% mm
 max_rangeT    = 8183; % mm;
 thresholdH    = 310;  %mm height threshold
 threshold     = thresholdH/sind(theta);  % mm;    -- declaring as part of the max distance allowed for the scan
 max_range     = max_rangeT-threshold;  % mm; -- declaring as max distance allowed for the scan when is
applied a threshold
 Height        = 1255; %mm    Height of the scanner beam according to the floor
 Xgrid = 100 ; %mm
 Ygrid = 100 ; %mm
 w=3;
 vstrel=(round(velocity1)+w);
F2   = '%.2f';
```

```
 %Real position data  [Start flag, box, square post, tank, Rectangular post, End flag]
 %distance from first flag
dF1F = [ 0 , 4350.0, 8050.0, 12050.0, 16050.0, 20100 ];
%dF1F = [ 0 , 4304.8, 8000.0, 11955.55, 16000.0, 20000 ] ;
%width of objects
wO  =  [ 100, 609.6, 90, 571.5, 38.1, 100];
%height of objects
hO  =  [ 100, 609.6, 90, 571.5, 104.77, 100];
%areas of objects
AO =   [1000, 371600, 7905, 257000, 4000, 1000];
% trialn=1;
% trial==1;

for trial=1:1:3
   if trial ==1;

    file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\SRTTS2SS-1.txt';
   end
   if trial ==2;
    file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\SRTTS2SS-2.txt';
       end
   if trial ==3;
    file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\SRTTS2SS-3.txt';
   end

 M = dlmread(file, ';',3,0);  % read the file after delimeter ';' beguining in row 3, column 0 and make a matrix M
 data=M;                                                   % put the matrx M into data
 data(:, 2:4) = [];       % Deleting Scan index column -   It is better with this data(:,2:4)=[];
% Deleting Interlaces Scan Number column
 scan_number  = max(data(:,1));                                   % number of scans in file
 data(:, 1)   = [];
% data(x,:);  %%  x is the scan number
% data(x,y);  %%  x is the scan number , y is the angle (1 - 181)
                                 %% angle is 45 + (y *0.5)
 angle     = 45:0.5:135;
 theta_rad = angle*pi/180;
  for i = 1:1:scan_number,
       rho_i = data(i,:); %% scan per iteration i (181 depth values)
       temp  = ~(rho_i >= (max_rangeT - threshold)); %% neg positions of the maximum allowed distances
       rho_i = temp .* rho_i;
       [X,Y] = pol2cart(theta_rad,rho_i);
       Z  = Height - rho_i*sind(theta);   %% Z value of the indentified objects
       Y = (Y + (i-1) * dist_per_scan ) .* temp; %% temp is used to remove the max permisible scan values
>=(max_rangeT - thrshold)
       X_i(i,:) = X;     % this case the points are in the theta (8.82)plane from the horizontale
       Y_i(i,:) = Y;     % this case the points are in the theta (8.82)plane from the horizontale
       Z_i(i,:) = Z;     % this case ""
       Xr=  X_i(i,:)* cosd (theta);   % this case the points are in the horizontal plane
       Yr= Y_i(i,:)* cosd (theta);    % this case the points are in the horizontal plane
 end;

if trial==1;
```

```
Continuous_Map=11;
figure(11),
set(Continuous_Map, 'Name', 'Continuous Map', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica
las figuras principal del trial a toda pantalla
end;

if trial==2
Continuous_Map=12;
figure(12),
set(Continuous_Map, 'Name', 'Continuous Map', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica
las figuras principal del trial a toda pantalla

end;

if trial==3
Continuous_Map=13;
figure(13),
set(Continuous_Map, 'Name', 'Continuous Map', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica
las figuras principal del trial a toda pantalla
end;

imageXY = zeros (12000/Xgrid, round(((scan_number * dist_per_scan) + max_rangeT)/Ygrid)+1);

for i = 1:1:scan_number,
   subplot(4,4,[1 5 9 13])
   plot((X_i(i,:)*cosd(theta)),(Y_i(i,:)*cosd(theta)),'.r')% this case the points are in the horizontal plane X and Y

%plot(X_i(i,:),Y_i(i,:),'.r');  % this case the points are in the theta (8.9)plane from the horizontale
    title('        1.Continuous Map','fontsize',12);
    xlabel('X (mm)', 'fontsize',12);
    ylabel('Y (mm)','fontsize',12);
    axis([-5000 5000 0 ((scan_number * dist_per_scan) + max_rangeT)]);
    hold on;
    grid on;

    Xa1 = round (((X_i(i,:)*cosd(theta))+6000)/Xgrid);
    Ya1 = round((Y_i(i,:)*cosd(theta))/Ygrid);

    for k = 1:1:length(Xa1),
        if (Xa1(k)+1 > (12000/(Xgrid*2))+1) ,
            imageXY(Xa1(k)+1,Ya1(k)+1) = 1;
        end;
    end;
end

 imageXY  = imrotate(imageXY,90,'nearest');
rectangle = strel('rectangle',[vstrel vstrel]);
imageXY = imdilate(imageXY,rectangle);
 imageXY = bwareaopen(imageXY,5)
 imageXY = imerode(imageXY,square);
hold off;

subplot(4,4,[2 6 10 14]);
imshow(imageXY);
```

```
BW=imageXY;
s  = regionprops(bwlabel(BW), 'centroid');
centroids = cat(1, s.Centroid);
imshow(BW);
hold on;
plot(centroids(:,1), centroids(:,2), 'b*');

%% STATS = regionprops(bwlabel(BW), 'all');
stats = regionprops(bwlabel(BW), 'Area', 'Centroid','BoundingBox','Extrema',
'ConvexHull','Solidity','MajorAxisLength','Eccentricity');
allArea       = [stats.Area];
allCentroid   = [stats.Centroid];
allBoundingBox= [stats.BoundingBox];
allExtrema    = [stats.Extrema];
allSolidity   = [stats.Solidity];
allMajorAxisLength= [stats.MajorAxisLength];
allEccentricity=[stats.Eccentricity];

nn=length(allCentroid(1,:));
for cent=1:1:nn/2;
    centroid(cent,1:2) = stats(cent).Centroid;
end;
na=length(allArea(1,:));
for allna=1:1:na;
    centroid(allna,3)=stats(allna).Area;
end;
ns=length(allSolidity(1,:));
for allns=1:1:ns;
    centroid(allns,4)=stats(allns).Solidity;
end;
ne=length(allExtrema(1,:));
 for allne=1:1:ne/2;
     centroid(allne,5:6)=stats(allne).Extrema(5,:);
 end;
 nex=length(allEccentricity(1,:));
 for allnex=1:1:nex;
     centroid(allnex,7)=stats(allnex).Eccentricity;
 end;
 nbb=length(allBoundingBox(1,:));
 for allnbb=1:1:nbb/4
     centroid(allnbb,8:11)=stats(allnbb).BoundingBox;
 end

centroidorder= sortrows(centroid,2);
centroidorder=flipud(centroidorder);
centroidcirle= centroidorder(4,1:2);

XX = centroidorder(1,2) - centroidorder(6,2);

firstX = centroidorder(1,1);
firstY = centroidorder(1,2);
lastX = centroidorder(end,1);
lastY = centroidorder(end,2);

yi = interp1([0 (dF1F(6)/Ygrid)],[firstY lastY],dF1F/Ygrid);
```

```
xi = interp1([1 6],[firstX lastX],1:6);

% start flag
[cx,cy] = circle2(firstX,firstY - (dF1F(1)/Ygrid),wO(1)/Xgrid);
plot(cx,cy,'r');
plot(firstX, firstY - (dF1F(1)/Ygrid), 'r+');
objectscentroid(1,1:2)=[firstX , firstY - (dF1F(1)/Ygrid)];   %% red box center

[cx,cy] = circle2(xi(1), yi(1),wO(1)/Xgrid);
plot(cx,cy,'g');
objectscentroid(1,3:4)=[xi(1), yi(1)];  %% green box center

% box
[cx,cy] = square2(firstX, firstY - (dF1F(2))/Ygrid,wO(2)/Xgrid,hO(2)/Ygrid);
plot(cx,cy,'r');
plot(firstX, firstY - (dF1F(2)/Ygrid), 'r+');
objectscentroid(2,1:2)=[firstX , firstY - (dF1F(2)/Ygrid)];   %% red box center

[cx,cy] = square2(xi(2), yi(2),wO(2)/Xgrid,hO(2)/Ygrid);
plot(cx,cy,'g');
plot(xi(2), yi(2), 'g+');
objectscentroid(2,3:4)=[xi(2), yi(2)];  %% green box center

% square post
[cx,cy] = square2(firstX, firstY - (dF1F(3))/Ygrid,wO(3)/Xgrid,hO(3)/Ygrid);
plot(cx,cy,'r');
plot(firstX, firstY - (dF1F(3)/Ygrid), 'r+');
objectscentroid(3,1:2)=[firstX, firstY - (dF1F(3)/Ygrid)];    %% red box center

[cx,cy] = square2(xi(3),yi(3),wO(3)/Xgrid,hO(3)/Ygrid);
plot(cx,cy,'g');
plot(xi(3), yi(3), 'g+');
objectscentroid(3,3:4)=[xi(3), yi(3)];    %% green box center

% tank
[cx,cy] = circle2(firstX,firstY - (dF1F(4))/Ygrid,wO(4)/Xgrid);
plot(cx,cy,'r');
plot(firstX, firstY - (dF1F(4)/Ygrid), 'r+');
objectscentroid(4,1:2)=[firstX, firstY - (dF1F(4)/Ygrid)];    %% red circle center

[cx,cy] = circle2(xi(4), yi(4),wO(4)/Xgrid);
plot(cx,cy,'g');
plot(xi(4), yi(4), 'g+');
objectscentroid(4,3:4)=[xi(4), yi(4)];    %% green circle center

% rectangular post
[cx,cy] = square2(firstX, firstY - (dF1F(5))/Ygrid,wO(5)/Xgrid,hO(5)/Ygrid);
plot(cx,cy,'r');
plot(firstX, firstY - (dF1F(5)/Ygrid), 'r+');
objectscentroid(5,1:2)=[firstX, firstY - (dF1F(5)/Ygrid)];    %% red box center

[cx,cy] = square2(xi(5),yi(5),wO(5)/Xgrid,hO(5)/Ygrid);
plot(cx,cy,'g');
plot(xi(5), yi(5), 'g+');
```

```
objectscentroid(5,3:4)=[xi(5), yi(5)];    %% green box center

% end flag
[cx,cy] = circle2(firstX, firstY - (dF1F(6))/Ygrid,wO(6)/Xgrid);
plot(cx,cy,'r');
plot(firstX, firstY - (dF1F(6)/Ygrid), 'r+');
objectscentroid(6,1:2)=[firstX, firstY - (dF1F(6)/Ygrid)];    %% red box center

[cx,cy] = circle2(xi(6), yi(6),wO(6)/Xgrid);
plot(cx,cy,'g');
plot(xi(6), yi(6), 'g+');
objectscentroid(6,3:4)=[xi(6), yi(6)];    %% green box center

%%plot(centroid(:,5), centroid(:,6),'r+');
title('2.Matching Map','fontsize',12);
xlabel('X', 'fontsize',12);
ylabel('Y','fontsize',12);
hold off;

%% calculate the distances
% dist1- distance from the centroid of first flag to every other centroid objects include the last flag
% dist2- distance from the centroid between each objects
% dist3- distance from bottom-right point the first flag to every other bottom-right point objects include the last
flag
% dist4(:,1:2)-distance from the centroid of objects red(real position with one reference point) to the centroid
of real objects
% dist4(:,3:4)-distance from the centroid of objects green(real position with two reference point) to the
centroid of real objects
% dist5- Variacion of distance from the centroid of first flag to every other centroid objects include the last flag
if nn>12;
   nn=12;
end;
 for cent1=1:1:(nn/2-1);
   dist1(cent1,2) = ((centroidorder(1,2)-centroidorder(cent1+1,2))*Ygrid);      % distance Y (mm) from the first
flag to every other objects include the last flag
   dist1(cent1,1) = -((centroidorder(1,1)-centroidorder(cent1+1,1))*Xgrid);      % distance X (mm) from the
first flag to every other objects include the last flag
   dist2(cent1,2) = ((centroidorder(cent1,2)-centroidorder(cent1+1,2))*Ygrid);  % distance Y (mm) between
each objects
   dist2(cent1,1) = -((centroidorder(cent1,1)-centroidorder(cent1+1,1))*Xgrid);  % distance X (mm) between
each objects
   dist3(cent1,2) = ((centroidorder(1,6)-centroidorder(cent1+1,6))*Ygrid);      % distance Y (mm) from the first
flag to every other objects include the last flag
   dist3(cent1,1) = -((centroidorder(1,5)-centroidorder(cent1+1,5))*Xgrid);      % distance Y (mm) from the
first flag to every other objects include the last flag
   dist4(cent1,1) = -((objectscentroid(cent1+1,1)-centroidorder(cent1+1,1))*Xgrid);
   dist4(cent1,2) = ((objectscentroid(cent1+1,2)-centroidorder(cent1+1,2))*Ygrid);
   dist4(cent1,3) = -((objectscentroid(cent1+1,3)-centroidorder(cent1+1,1))*Xgrid);
   dist4(cent1,4) = ((objectscentroid(cent1+1,4)-centroidorder(cent1+1,2))*Ygrid);
   dist5(cent1,1) = dist1(cent1,1);
   dist5(cent1,2) = ((dist1(cent1,2)-dF1F(1,cent1+1)));

 end;
%%Final results
```

```
finaldist(:,1:2)=(dist1) ;                                  % dist1- distance from the centroid of first flag to every other centroid objects include the last flag
finaldist(:,3:4)=(dist2) ;                                  % dist2- distance from the centroid between each objects
finaldist(:,5:6)=(dist3) ;                                  % dist- distance from bottom-right point the first flag to every other bottom-right point objects include the last flag
finaldist(:,7:10)=(dist4);
finaldist(:,11:12)=(dist5);

finalpropieties(:,1)=(centroidorder(:,3)*Xgrid*Ygrid/vstrel)  ;          % Area*Xgrid*Ygrid/vstrel
finalpropieties(:,2)=(centroidorder(:,7));                              %Eccentricity
finalpropieties(:,3)=(centroidorder(:,10)*Xgrid/vstrel) ;               % Width*Xgrid/vstrel
finalpropieties(:,4)=(centroidorder(:,11)*Ygrid/vstrel) ;               % Lenght*Ygrid/vstrel

finalmatrix(:,1:2) = centroidorder(:,1:2);                              % centroid X and Y of image
finalmatrix(:,3:6) = objectscentroid(:,1:4);                            % centroid of objects X and Y, red and green
finalmatrix(:,7) = (centroidorder(:,3)*Xgrid*Ygrid/vstrel);             % Area*Xgrid*Ygrid/vstrel [mm]
finalmatrix(:,8:13) = centroidorder(:,4:9);                             % Solidity, Extrema X, Extrema Y, Eccentricity, BounndingBox(Upper left corner X and Y)
finalmatrix(:,14) = (centroidorder(:,10)*Xgrid/vstrel) ;                % Width*Xgrid/vstrel [mm]
finalmatrix(:,15) = (centroidorder(:,11)*Ygrid/vstrel) ;                % Lenght*Ygrid/vstrel [mm]finaldist(:,1:2)=(dist1) ;                   % dist1- distance from the centroid of first flag to every other centroid objects include the last flag
finalmatrix(1,16:27)=zeros;
finalmatrix(2:6,16:17)=(dist1) ;                            % dist1- distance from the centroid of first flag to every other centroid objects include the last flag
finalmatrix(2:6,18:19)=(dist2) ;                            % dist2- distance from the centroid between each objects
finalmatrix(2:6,20:21)=(dist3);                             % dist3- distance from bottom-right point the first flag to every other bottom-right point objects include the last flag
finalmatrix(2:6,22:25)=(dist4) ;                            % dist4(:,1:2)-distance from the image to objects red- dist4(:,3:4)-distance from the image to objects green
finalmatrix(2:6,26:27)=(dist5);
if trial==1;
;
    finalmatrix1 = finalmatrix;
end;
if trial==2;
    finalmatrix2 = finalmatrix;
end;
if trial==3;
    finalmatrix3 = finalmatrix ;
end;

subplot (4,4,3);
  bar(finaldist(1:4,7), 'group','r')
  grid on;
  title('3. Dx1RP','fontsize',12);
  xlabel('Objects', 'fontsize',12);
  ylabel('Distance(mm)','fontsize',12);

subplot (4,4,4);
  bar(finaldist(1:4,8), 'group','r')
  grid on;
  title('4. Dy1RP','fontsize',12);
```

```
    xlabel('Objects', 'fontsize',12);
    ylabel('Distance(mm)','fontsize',12);
subplot (4,4,7);
    bar(finaldist(1:4,9), 'group','g')
    grid on;
    title('5. Dx2RP','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Distance(mm)','fontsize',12);

subplot (4,4,8);
    bar(finaldist(1:4,10), 'group','g')
    grid on;
    title('6. Dy2RP','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Distance(mm)','fontsize',12);

subplot(4,4,15);
    bar(finalpropieties(2:5,1),'group','b');
    grid on;
    title('9. Areas','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Area (mm2)','fontsize',12);

 subplot(4,4,16);
    bar(centroidorder(2:5,7),'group','b');
    grid on;
    title('10. Eccentricity','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Eccentricity','fontsize',12);

 subplot(4,4,11);
    bar(finalpropieties(2:5,3),'group','b');
    grid on;
    title('7. Width','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('X (mm)','fontsize',12);

subplot(4,4,12);
    bar(finalpropieties(2:5,4),'group','b');
    grid on;
    title('8. Lenght','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Y (mm)','fontsize',12);

[token, remain] = strtok(file, '-');
Ioutput = [token '-' num2str(trial) '.png'];
%print('-dpng',Ioutput);
set(gcf, 'PaperPositionMode', 'auto');
print ('-dpng', '-r300', Ioutput);

% fileoutput = [file '.csv'];
fileoutput = [token '-' num2str(trial) '.csv'];
data = zeros(size(centroidorder(:,1)),14);
data(:,1:6) = finalmatrix(:,1:6);
```

```
data(:,7:10) = finalmatrix(:,22:25);
data(:,11) = finalmatrix(:,7);
data(:,12) = finalmatrix(:,11);
data(:,13:14) = finalmatrix(:,14:15);
dlmwrite(fileoutput,zeros(1,14));
dlmwrite(fileoutput,data,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');

end;

nsize=size(finalmatrix1);
nobjects=nsize(1,1);
nprop=nsize(1,2);

for nnobj=1:1:nobjects;

        finalmatrixobject(:,1)= finalmatrix1(nnobj,:);
        finalmatrixobject(:,2)= finalmatrix2(nnobj,:);
        finalmatrixobject(:,3)= finalmatrix3(nnobj,:);

        for nnprp=1:1:nprop;
            finalmatrixmean(nnprp,nnobj)  = mean(finalmatrixobject(nnprp,:));
            finalmatrixrange(nnprp,nnobj) = range(finalmatrixobject(nnprp,:));
            finalmatrixstd(nnprp,nnobj)   = std(finalmatrixobject(nnprp,:),1);
        end;
end;

for nnpp=1:1:nprop;
    fss(1,nnpp) = std(finalmatrixstd(nnpp,:),1);
    fmm(1,nnpp) = mean(finalmatrixmean(nnpp,:));
end;
for obj=2:1:6;
earea(1,obj-1)=abs((1-(finalmatrixmean(7,obj)/AO(1,obj)))*100);
ewidth(1,obj-1)=abs((1-(finalmatrixmean(14,obj)/wO(1,obj)))*100);
elenght(1,obj-1)=abs((1-(finalmatrixmean(15,obj)/hO(1,obj)))*100);
end ;

Xfmmr(1,1)=(fmm(1,22)-fss(1,22));
Xfmmr(2,1)= fmm(1,22);
Xfmmr(3,1)=(fmm(1,22)+fss(1,22));
Xfmmr(4,1)= fmm(1,22);
Xfmmr(5,1)= fmm(1,22);
Xfmmr(6,1)= fmm(1,22);

Yfmmr(1,1)=(fmm(1,23)-fss(1,23));
Yfmmr(1,2)= fmm(1,23);
Yfmmr(1,3)=(fmm(1,23)+fss(1,23));
Yfmmr(1,4)= fmm(1,23);
Yfmmr(1,5)= fmm(1,23);
Yfmmr(1,6)= fmm(1,23);

Xfmmg(1,1)=(fmm(1,24)-fss(1,24));
Xfmmg(2,1)= fmm(1,24);
Xfmmg(3,1)=(fmm(1,24)+fss(1,24));
```

```
Xfmmg(4,1)= fmm(1,24);
Xfmmg(5,1)= fmm(1,24);
Xfmmg(6,1)= fmm(1,24);

Yfmmg(1,1)=(fmm(1,25)-fss(1,25));
Yfmmg(1,2)= fmm(1,25);
Yfmmg(1,3)=(fmm(1,25)+fss(1,25));
Yfmmg(1,4)= fmm(1,25);
Yfmmg(1,5)= fmm(1,25);
Yfmmg(1,6)= fmm(1,25);

Xfmmrp(1,1)=(((abs(fmm(1,22))-fss(1,22))/max_range)*100);
Xfmmrp(2,1)=((abs(fmm(1,22))/max_range)*100);
Xfmmrp(3,1)=(((abs(fmm(1,22))+fss(1,22))/max_range)*100);
Xfmmrp(4,1)=((abs(fmm(1,22))/max_range)*100);
Xfmmrp(5,1)=((abs(fmm(1,22))/max_range)*100);
Xfmmrp(6,1)=((abs(fmm(1,22))/max_range)*100);

Yfmmrp(1,1)=(((abs(fmm(1,23))-fss(1,23))/max_range)*100);
Yfmmrp(1,2)= ((abs(fmm(1,23))/max_range)*100);
Yfmmrp(1,3)=(((abs(fmm(1,23))+fss(1,23))/max_range)*100);
Yfmmrp(1,4)= ((abs(fmm(1,23))/max_range)*100);
Yfmmrp(1,5)= ((abs(fmm(1,23))/max_range)*100);
Yfmmrp(1,6)= ((abs(fmm(1,23))/max_range)*100);

Xfmmgp(1,1)=(((abs(fmm(1,24))-fss(1,24))/max_range)*100);
Xfmmgp(2,1)=((abs(fmm(1,24))/max_range)*100);
Xfmmgp(3,1)=(((abs(fmm(1,24))+fss(1,24))/max_range)*100);
Xfmmgp(4,1)=((abs(fmm(1,24))/max_range)*100);
Xfmmgp(5,1)=((abs(fmm(1,24))/max_range)*100);
Xfmmgp(6,1)=((abs(fmm(1,24))/max_range)*100);

Yfmmgp(1,1)=(((abs(fmm(1,25))-fss(1,25))/max_range)*100);
Yfmmgp(1,2)= ((abs(fmm(1,25))/max_range)*100);
Yfmmgp(1,3)=(((abs(fmm(1,25))+fss(1,25))/max_range)*100);
Yfmmgp(1,4)=((abs(fmm(1,25))/max_range)*100);
Yfmmgp(1,5)=((abs(fmm(1,25))/max_range)*100);
Yfmmgp(1,6)=((abs(fmm(1,25))/max_range)*100);

finalmatrixE(1,1:3)=zeros;
finalmatrixE(2:6,1)=earea(1,1:5);
finalmatrixE(2:6,2)=ewidth(1,1:5);
finalmatrixE(2:6,3)=elenght(1,1:5);
finalmatrixE(1:6,4)=Xfmmr(1:6,1);
finalmatrixE(1:6,5)=fliplr(Yfmmr(1,1:6));
finalmatrixE(1:6,6)=Xfmmg(1:6,1);
finalmatrixE(1:6,7)=fliplr(Yfmmg(1,1:6));

finalmatrixE(1:6,8)=Xfmmrp(1:6,1);
finalmatrixE(1:6,9)=fliplr(Yfmmrp(1,1:6));
finalmatrixE(1:6,10)=Xfmmgp(1:6,1);
finalmatrixE(1:6,11)=fliplr(Yfmmgp(1,1:6));

 [token, remain] = strtok(file, '-');
```

```
new_file=strcat(token,'-TT');
new_fileR=strcat(token,'-T');
[token, remain] = strtok(file, 'direcction\');

fileoutput = [new_file '.csv'];
fileoutputR = [new_fileR '.csv'];

data1 = zeros(size(finalmatrix1(:,1)),14);
data1(:,1:6) = finalmatrix1(:,1:6);
data1(:,7:10) = finalmatrix1(:,22:25);
data1(:,11) = finalmatrix1(:,7);
data1(:,12) = finalmatrix1(:,11);
data1(:,13:14) = finalmatrix1(:,14:15);
dlmwrite(fileoutput,zeros(1,14));
dlmwrite(fileoutput,data1,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');

data2 = zeros(size(finalmatrix2(:,1)),14);
data2(:,1:6) = finalmatrix2(:,1:6);
data2(:,7:10) = finalmatrix2(:,22:25);
data2(:,11) = finalmatrix2(:,7);
data2(:,12) = finalmatrix2(:,11);
data2(:,13:14) = finalmatrix2(:,14:15);
dlmwrite(fileoutput,zeros(1,14),'-append');
dlmwrite(fileoutput,data2,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');

data3 = zeros(size(finalmatrix3(:,1)),14);
data3(:,1:6) = finalmatrix3(:,1:6);
data3(:,7:10) = finalmatrix3(:,22:25);
data3(:,11) = finalmatrix3(:,7);
data3(:,12) = finalmatrix3(:,11);
data3(:,13:14) = finalmatrix3(:,14:15);
dlmwrite(fileoutput,zeros(1,14),'-append');
dlmwrite(fileoutput,data3,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');

ndata4=size(finalmatrixmean(1,:));
data4 = zeros(ndata4(1,2),14);
data4(:,1:6) = ((finalmatrixmean(1:6,:))');
data4(:,7:10) = ((finalmatrixmean(22:25,:))');
data4(:,11) = ((finalmatrixmean(7,:))');
data4(:,12) = ((finalmatrixmean(11,:))');
data4(:,13:14) = ((finalmatrixmean(14:15,:))');
dlmwrite(fileoutput,data4,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');
dlmwrite(fileoutputR,zeros(1,14));
dlmwrite(fileoutputR,data4,'-append');
dlmwrite(fileoutputR,zeros(1,14),'-append');

ndata5=size(fmm(1,:));
data5 = zeros(ndata5(1,1),14);
data5(:,1:6) = fmm(:,1:6);
data5(:,7:10) = fmm(:,22:25);
data5(:,11) = fmm(:,7);
```

```
data5(:,12) = fmm(:,11);
data5(:,13:14) = fmm(:,14:15);
dlmwrite(fileoutput,data5,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');
dlmwrite(fileoutputR,data5,'-append');
dlmwrite(fileoutputR,zeros(1,14),'-append');

ndata6 = size(finalmatrixstd(1,:));
data6 = zeros(ndata6(1,2),14);
data6(:,1:6) = ((finalmatrixstd(1:6,:))');
data6(:,7:10) = ((finalmatrixstd(22:25,:))');
data6(:,11) = ((finalmatrixstd(7,:))');
data6(:,12) = ((finalmatrixstd(11,:))');
data6(:,13:14) = ((finalmatrixstd(14:15,:))');
dlmwrite(fileoutput,data6,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');
dlmwrite(fileoutputR,data6,'-append');
dlmwrite(fileoutputR,zeros(1,14),'-append');

ndata7=size(fss(1,:));
data7 = zeros(ndata7(1,1),14);
data7(:,1:6) = fss(:,1:6);
data7(:,7:10) = fss(:,22:25);
data7(:,11) = fss(:,7);
data7(:,12) = fss(:,11);
data7(:,13:14) = fss(:,14:15);
dlmwrite(fileoutput,data7,'-append');
dlmwrite(fileoutput,zeros(1,14),'-append');
dlmwrite(fileoutputR,data7,'-append');
dlmwrite(fileoutputR,zeros(1,14),'-append');


Continuous_Map=14;
figure(14),
set(Continuous_Map, 'Name', 'Distance Statistics', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]))    %ubica
las figuras principal del trial a toda pantalla


subplot (3,2,[1 3]);
% hold on;
for obj=2:1:5
Xdistred(obj,4)=(finalmatrixmean(22,obj)-finalmatrixstd(22,obj));
Xdistred(obj,5)=finalmatrixmean(22,obj);
Xdistred(obj,6)=(finalmatrixmean(22,obj)+finalmatrixstd(22,obj));
Xdistred(obj,7)=finalmatrixmean(22,obj);
Ydistred(obj,4)=(finalmatrixmean(23,obj)-finalmatrixstd(23,obj));
Ydistred(obj,5)=finalmatrixmean(23,obj);
Ydistred(obj,6)=(finalmatrixmean(23,obj)+finalmatrixstd(23,obj));
Ydistred(obj,7)=finalmatrixmean(23,obj);
plot (Xdistred(obj,5),Ydistred(obj,5), '-rs', 'MarkerFaceColor','r');
hold on;
plot (Xdistred(obj,[4 6]),Ydistred(obj,5), '-r+', 'MarkerFaceColor','r');
hold on;
plot (Xdistred(obj,5),Ydistred(obj,[4 6]), '-r+', 'MarkerFaceColor','r');
hold on;
```

```
end;
line(Xdistred(2,[4 6]),Ydistred(2,[5 7]),'Color','r');
line(Xdistred(2,[5 7]),Ydistred(2,[4 6]),'Color','r');
line(Xdistred(3,[4 6]),Ydistred(3,[5 7]),'Color','r');
line(Xdistred(3,[5 7]),Ydistred(3,[4 6]),'Color','r');
line(Xdistred(4,[4 6]),Ydistred(4,[5 7]),'Color','r');
line(Xdistred(4,[5 7]),Ydistred(4,[4 6]),'Color','r');
line(Xdistred(5,[4 6]),Ydistred(5,[5 7]),'Color','r');
line(Xdistred(5,[5 7]),Ydistred(5,[4 6]),'Color','r');
text((Xdistred(2,5)+10),(Ydistred(2,5)+10),'Box');
text((Xdistred(3,5)+10),(Ydistred(3,5)+10),'S Post');
text((Xdistred(4,5)+10),(Ydistred(4,5)+10),'Tank');
text((Xdistred(5,5)+10),(Ydistred(5,5)+10),'R Post');
grid on;
xlabel('X (mm)');
ylabel('Y (mm)');
plot (0,0,'-bs', 'MarkerFaceColor','b');
hold on;
title('1. Mean Distance Deviation & Std by Object with 1RP');
h = legend('Mean','Std','Location','NorthEast');
set(h,'Interpreter','none');

subplot (3,2,[2 4]);
for obj=2:1:5
Xdistgreen(obj,4)=(finalmatrixmean(24,obj)-finalmatrixstd(24,obj));
Xdistgreen(obj,5)=finalmatrixmean(24,obj);
Xdistgreen(obj,6)=(finalmatrixmean(24,obj)+finalmatrixstd(24,obj));
Xdistgreen(obj,7)=finalmatrixmean(24,obj);
Ydistgreen(obj,4)=(finalmatrixmean(25,obj)-finalmatrixstd(25,obj));
Ydistgreen(obj,5)=finalmatrixmean(25,obj);
Ydistgreen(obj,6)=(finalmatrixmean(25,obj)+finalmatrixstd(25,obj));
Ydistgreen(obj,7)=finalmatrixmean(25,obj);

plot (Xdistgreen(obj,5),Ydistgreen(obj,5), '-gs', 'MarkerFaceColor','g');
hold on;
plot (Xdistgreen(obj,[4 6]),Ydistgreen(obj,5), '-g+', 'MarkerFaceColor','g');
hold on;
plot (Xdistgreen(obj,5),Ydistgreen(obj,[4 6]), '-g+', 'MarkerFaceColor','g');
hold on;

end;
line(Xdistgreen(2,[4 6]),Ydistgreen(2,[5 7]),'Color','g');
line(Xdistgreen(2,[5 7]),Ydistgreen(2,[4 6]),'Color','g');
line(Xdistgreen(3,[4 6]),Ydistgreen(3,[5 7]),'Color','g');
line(Xdistgreen(3,[5 7]),Ydistgreen(3,[4 6]),'Color','g');
line(Xdistgreen(4,[4 6]),Ydistgreen(4,[5 7]),'Color','g');
line(Xdistgreen(4,[5 7]),Ydistgreen(4,[4 6]),'Color','g');
line(Xdistgreen(5,[4 6]),Ydistgreen(5,[5 7]),'Color','g');
line(Xdistgreen(5,[5 7]),Ydistgreen(5,[4 6]),'Color','g');

text((Xdistgreen(2,5)+10),(Ydistgreen(2,5)+10),'Box');
text((Xdistgreen(3,5)+10),(Ydistgreen(3,5)+10),'S Post');
text((Xdistgreen(4,5)-5),(Ydistgreen(4,5)+10),'Tank');
text((Xdistgreen(5,5)+10),(Ydistgreen(5,5)+10),'R Post');
```

```
grid on;
xlabel('X (mm)');
ylabel('Y (mm)');
plot (0,0,'-bs', 'MarkerFaceColor','b');
hold on;
title('2.Mean Distance Deviation & Std by Object with 2RP');
h = legend('Mean','Std','Location','NorthEast');
set(h,'Interpreter','none');

subplot (3,2,6);

Xfmmrp(5,1)=zeros;
Yfmmrp(1,5)=zeros;

plot (Xfmmrp(2,1),Yfmmrp(1,2),'-rs', 'MarkerFaceColor','r');
hold on;
plot (Xfmmrp([1 3],1),Yfmmrp(1,2),'-r+', 'MarkerFaceColor','r');
hold on;
plot (Xfmmrp(2,1),Yfmmrp(1,[1 3]),'-r+', 'MarkerFaceColor','r');
hold on;

Xfmmgp(5,1)=zeros;
Yfmmgp(1,5)=zeros;

plot (Xfmmgp(2,1),Yfmmgp(1,2),'-gs', 'MarkerFaceColor','g');
hold on;
plot (Xfmmgp([1 3],1),Yfmmgp(1,2),'-g+', 'MarkerFaceColor','g');
hold on;
plot (Xfmmgp(2,1),Yfmmgp(1,[1 3]),'-g+', 'MarkerFaceColor','g');
hold on;

text((Xfmmgp(2,1)-1),(Yfmmgp(1,2)+2),'2RP');
text((Xfmmrp(2,1)-1),(Yfmmrp(1,2)-2),'1RP');
line(Xfmmgp([1 3],1),Yfmmgp(1,[2 4]),'Color','g');
line(Xfmmgp([2 4],1),Yfmmgp(1,[1 3]),'Color','g');
line(Xfmmrp([1 3],1),Yfmmrp(1,[2 4]),'Color','r');
line(Xfmmrp([2 4],1),Yfmmrp(1,[1 3]),'Color','r');

DM10=num2str(sqrt((Xfmmrp(2,1))^2+(Yfmmrp(1,2))^2),F2);
text((Xfmmrp(2,1)+0.1),(Yfmmrp(1,2)-0.1),['\color{blue}',DM10]);
line(Xfmmrp([2,5],1),Yfmmrp(1,[2 5]),'Color','b');

DM20=num2str(sqrt((Xfmmgp(2,1))^2+(Yfmmgp(1,2))^2),F2);
text((Xfmmgp(2,1)+0.1),(Yfmmgp(1,2)+0.1),['\color{blue}',DM20]);
line(Xfmmgp([2,5],1),Yfmmgp(1,[2 5]),'Color','b');
hold on;

grid on;
xlabel('X (%)');
ylabel('Y (%)');
plot (0,0,'-bs', 'MarkerFaceColor','b');
hold on;
title('4.Test, Mean & Std Error with 1RP & 2RP');
h = legend('Mean(M)','Std(S)','Location','NorthWest');
```

```
set(h,'Interpreter','none');

subplot (3,2,5);
Xfmmr(5,1)= zeros;
Yfmmr(1,5)= zeros;

plot (Xfmmr(2,1),Yfmmr(1,2),'-rs', 'MarkerFaceColor','r');
hold on;
plot (Xfmmr([1 3],1),Yfmmr(1,2),'-r+', 'MarkerFaceColor','r');
hold on;
plot (Xfmmr(2,1),Yfmmr(1,[1 3]),'-r+', 'MarkerFaceColor','r');
hold on;

Xfmmg(5,1)= zeros;
Yfmmg(1,5)= zeros;

plot (Xfmmg(2,1),Yfmmg(1,2),'-gs', 'MarkerFaceColor','g');
hold on;
plot (Xfmmg([1 3],1),Yfmmg(1,2),'-g+', 'MarkerFaceColor','g');
hold on;
plot (Xfmmg(2,1),Yfmmg(1,[1 3]),'-g+', 'MarkerFaceColor','g');
hold on;

text((Xfmmg(2,1)-50),(Yfmmg(1,2)+150),'2RP');
text((Xfmmr(2,1)-50),(Yfmmr(1,2)-150),'1RP');
line(Xfmmg([1 3]),Yfmmg(1,[2 4]),'Color','g');
line(Xfmmg([2 4]),Yfmmg(1,[1 3]),'Color','g');
line(Xfmmr([1 3]),Yfmmr(1,[2 4]),'Color','r');
line(Xfmmr([2 4]),Yfmmr(1,[1 3]),'Color','r');

DM1=num2str(sqrt((fmm(1,22))^2+(fmm(1,23))^2),F2);
text((Xfmmr(2,1)+10),(Yfmmr(1,2)-10),['\color{blue}',DM1]);
line(Xfmmr([2,5],1),Yfmmr(1,[2 5]),'Color','b');
DM2=num2str(sqrt((fmm(1,24))^2+(fmm(1,25))^2),F2);
text((Xfmmg(2,1)+10),(Yfmmg(1,2)+10),['\color{blue}',DM2]);
line(Xfmmg([2,5],1),Yfmmg(1,[2 5]),'Color','b');
hold on;

hold on;
grid on;
xlabel('X (mm)');
ylabel('Y (mm)');
plot (0,0,'-bs', 'MarkerFaceColor','b');
hold on;
title('3.Test, Mean & Std with 1RP & 2RP');
h=legend('Mean(M)','Std(S)','Location','Northwest');
set(h,'Interpreter','none');

[token, remain] = strtok(file, '-');
Ioutput15 = [token '-' 'T' '.png'];
%print('-dpng',Ioutput);
set(gcf, 'PaperPositionMode', 'auto');
print ('-dpng', '-r300', Ioutput15);
```

```
Continuous_Map=15;
figure(15),
set(Continuous_Map, 'Name', 'Area, Width, and Lenght Statistics', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8
0.8]))    %ubica las figuras principal del trial a toda pantalla

 subplot (3,2,1);
    finalmatrixmeanAO(2:5,1)=AO(1,2:5);
    finalmatrixmeanAO(2:5,2)=finalmatrixmean(7,2:5);
    bar(finalmatrixmeanAO(2:5,1:2),'group');
    grid on;
    title('1.Objects Areas','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Area (mm2)','fontsize',12);
    h=legend('Real Area','Mean Area','Location','NorthEast');
    set(h,'Interpreter','none');
 subplot (3,2,2);
   for obj=2:1:5;
    bar(earea(1,1:4),'group','r');
    grid on;
    title('2.Areas Mean Error','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Area Error (%)','fontsize',12);
   end;
 subplot(3,2,3);
    finalmatrixmeanwO(2:5,1)= wO(1,2:5);
    finalmatrixmeanwO(2:5,2)= finalmatrixmean(14,2:5);
    bar(finalmatrixmeanwO(2:5,1:2),'group');
    grid on;
    title('3.Objects Width','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Width (mm)','fontsize',12);
    h=legend('Real Width','Mean Width','Location','NorthEast');
    set(h,'Interpreter','none');

  subplot(3,2,4);
  for obj=2:1:5;
        bar(ewidth(1,1:4),'group','r');
    grid on;
    title('4.Width Mean Error','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Width Error (%)','fontsize',12);
   end ;
 subplot(3,2,5);
    finalmatrixmeanhO(2:5,1)= hO(1,2:5);
    finalmatrixmeanhO(2:5,2)= finalmatrixmean(15,2:5);
    bar(finalmatrixmeanhO(2:5,1:2),'group');
    grid on;
    title('5.Objects Length','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Length (mm)','fontsize',12);
    h=legend('Real Lenght','Mean Lenght','Location','NorthEast');
    set(h,'Interpreter','none');

 subplot(3,2,6);
  for obj=2:1:5;
```

```
    bar(elenght(1,1:4),'group','r');
    grid on;
    title('6.Lenght Mean Error','fontsize',12);
    xlabel('Objects', 'fontsize',12);
    ylabel('Lenght Error (%)','fontsize',12);
  end ;

[token, remain] = strtok(file, '-');
Ioutput16 = [token '-' 'P' '.png'];
%print('-dpng',Ioutput);
set(gcf, 'PaperPositionMode', 'auto');
print ('-dpng', '-r300', Ioutput16);

  end
```

C.5 "Final_Results.m" program

```
function [] = Final_Results()

% Final_Results
% This function analyse final data from all text files used for Height_scanCarlos......
% File modified by Carlos Fresquet M. A. Sc. Candidate, University of Ottawa, November 3, 2011
% Data file has no units removed and follows the format provided
%% Input Data .

file = 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests normal
direcction\Final1Resumen.txt';
M = dlmread(file, ';');                          % read the file after delimeter ';' beginning in row 3,
column 0 and make a matrix M
Finalresults=M(:,1:5);

F2   = '%.2f';
nsize=size(Finalresults);
nrows=nsize(1,1);
ncolumns=nsize(1,2);

for nncolumns=1:1:ncolumns;

FinalresultsTotal(1,nncolumns)= mean(abs(Finalresults(1:12,nncolumns)));           % mean of all tests with
speed of 2 km/h
FinalresultsTotal(2,nncolumns)= mean(abs(Finalresults(13:23,nncolumns)));          % mean of all tests with
speed of 4 km/h
FinalresultsTotal(3,nncolumns)= mean(abs(Finalresults(24:31,nncolumns)));          % mean of all tests with
speed of 7 km/h

FinalresultsTotal(4,nncolumns)= mean(abs(Finalresults([1:4 13:16 24:27],nncolumns))); % mean of all tests
with  all speeds (2,4,7) on smoot terrain
FinalresultsTotal(5,nncolumns)= mean(abs(Finalresults([5:8 17:20 28:31],nncolumns))); % mean of all tests
with  all speeds (2,4,7) on rough terrain
FinalresultsTotal(6,nncolumns)= mean(abs(Finalresults([9:12 21:23],nncolumns)));     % mean of all tests with
all speeds (2,4,7) on plow terrain

FinalresultsTotal(7,nncolumns)= mean(abs(Finalresults([1 13 24],nncolumns)));        % mean of all tests with
all speeds (2,4,7) on smoot terrain, support & ss
```

```
FinalresultsTotal(8,nncolumns)= mean(abs(Finalresults([2 14 25],nncolumns)));        % mean of all tests with all speeds (2,4,7) on smoot terrain, support & nss
FinalresultsTotal(9,nncolumns)= mean(abs(Finalresults([3 15 26],nncolumns)));        % mean of all tests with all speeds (2,4,7) on smoot terrain, nsupport & ss
FinalresultsTotal(10,nncolumns)= mean(abs(Finalresults([4 16 27],nncolumns)));       % mean of all tests with all speeds (2,4,7) on smoot terrain, nsupport $ nss
FinalresultsTotal(11,nncolumns)= mean(abs(Finalresults([5 17 28],nncolumns)));       % mean of all tests with all speeds (2,4,7) on rought terrain, support & ss
FinalresultsTotal(12,nncolumns)= mean(abs(Finalresults([6 18 29],nncolumns)));       % mean of all tests with all speeds (2,4,7) on rought terrain, support & nss
FinalresultsTotal(13,nncolumns)= mean(abs(Finalresults([7 19 30],nncolumns)));       % mean of all tests with all speeds (2,4,7) on rought terrain, nsupport & ss
FinalresultsTotal(14,nncolumns)= mean(abs(Finalresults([8 20 31],nncolumns)));       % mean of all tests with all speeds (2,4,7) on rought terrain, nsupport & nss
FinalresultsTotal(15,nncolumns)= mean(abs(Finalresults([9 21],nncolumns)));          % mean of all tests with all speeds (2,4,7) on plow terrain, support & ss
FinalresultsTotal(16,nncolumns)= mean(abs(Finalresults([10 22],nncolumns)));         % mean of all tests with all speeds (2,4,7) on plow terrain, support & nss
FinalresultsTotal(17,nncolumns)= mean(abs(Finalresults([11 23],nncolumns)));         % mean of all tests with all speeds (2,4,7) on plow terrain, nsupport & ss
FinalresultsTotal(18,nncolumns)= mean(abs(Finalresults(12,nncolumns)));              % mean of all tests with all speeds (2,4,7) on plow terrain, nsupport & nss

FinalresultsTotal(19,nncolumns)= mean(abs(Finalresults([1 5 9 13 17 21 24 28],nncolumns)));  % mean of all tests with  all speeds (2,4,7) on all terrains, support & ss
FinalresultsTotal(20,nncolumns)= mean(abs(Finalresults([2 6 10 14 18 22 25 29],nncolumns))); % mean of all tests with  all speeds (2,4,7) on all terrains, support & nss
FinalresultsTotal(21,nncolumns)= mean(abs(Finalresults([3 7 11 15 19 23 26 30],nncolumns))); % mean of all tests with  all speeds (2,4,7) on all terrains, nsupport & ss
FinalresultsTotal(22,nncolumns)= mean(abs(Finalresults([4 8 12 16 20 27 31],nncolumns)));    % mean of all tests with  all speeds (2,4,7) on all terrains, nsupport & nss

FinalresultsTotal(23,nncolumns)= mean(abs(Finalresults([1 3 5 7 9 11 13 15 17 19 21 23 24 26 28 30],nncolumns))); %% mean of all tests with  all speeds (2,4,7) on all terrains, with ss
FinalresultsTotal(24,nncolumns)= mean(abs(Finalresults([2 4 6 8 10 12 14 16 18 20 22 25 27 29 31],nncolumns)));   %% mean of all tests with  all speeds (2,4,7) on all terrains, without ss
FinalresultsTotal(25,nncolumns)= mean(abs(Finalresults([1 2 5 6 9 10 13 14 17 18 21 22 24 25 28 29],nncolumns))); %% mean of all tests with  all speeds (2,4,7) on all terrains, with support
FinalresultsTotal(26,nncolumns)= mean(abs(Finalresults([3 4 7 8 11 12 15 16 19 20 23 26 27 30 31],nncolumns)));   %% mean of all tests with  all speeds (2,4,7) on all terrains, without support

end;
FinalresultsTotal(1,6)= std(Finalresults(1:12,3),1);            % std of all tests with speed of 2 km/h
FinalresultsTotal(2,6)= std(Finalresults(13:23,3),1);           % std of all tests with speed of 4 km/h
FinalresultsTotal(3,6)= std(Finalresults(24:31,3),1);           % std of all tests with speed of 7 km/h

FinalresultsTotal(4,6)= std(Finalresults([1:4 13:16 24:27],3),1);   % std of all tests with  all speeds (2,4,7) on smoot terrain
FinalresultsTotal(5,6)= std(Finalresults([5:8 17:20 28:31],3),1);   % std of all tests with  all speeds (2,4,7) on rough terrain
FinalresultsTotal(6,6)= std(Finalresults([9:12 21:23],3),1);        % std of all tests with  all speeds (2,4,7) on plow terrain

FinalresultsTotal(7,6)= std(Finalresults([1 13 24],3),1);          % std of all tests with  all speeds (2,4,7) on smoot terrain, support & ss
```

```
FinalresultsTotal(8,6)= std(Finalresults([2 14 25],3),1);          % std of all tests with  all speeds (2,4,7) on
smoot terrain, support & nss
FinalresultsTotal(9,6)= std(Finalresults([3 15 26],3),1);          % std of all tests with  all speeds (2,4,7) on
smoot terrain, nsupport & ss
FinalresultsTotal(10,6)= std(Finalresults([4 16 27],3),1);         % std of all tests with  all speeds (2,4,7) on
smoot terrain, nsupport $ nss
FinalresultsTotal(11,6)= std(Finalresults([5 17 28],3),1);         % std of all tests with  all speeds (2,4,7) on
rought terrain, support & ss
FinalresultsTotal(12,6)= std(Finalresults([6 18 29],3),1);         % std of all tests with  all speeds (2,4,7) on
rought terrain, support & nss
FinalresultsTotal(13,6)= std(Finalresults([7 19 30],3),1);         % std of all tests with  all speeds (2,4,7) on
rought terrain, nsupport & ss
FinalresultsTotal(14,6)= std(Finalresults([8 20 31],3),1);         % std of all tests with  all speeds (2,4,7) on
rought terrain, nsupport & nss
FinalresultsTotal(15,6)= std(Finalresults([9 21],3),1);            % std of all tests with  all speeds (2,4,7) on plow
terrain, support & ss
FinalresultsTotal(16,6)= std(Finalresults([10 22],3),1);           % std of all tests with  all speeds (2,4,7) on plow
terrain, support & nss
FinalresultsTotal(17,6)= std(Finalresults([11 23],3),1);           % std of all tests with  all speeds (2,4,7) on plow
terrain, nsupport & ss
FinalresultsTotal(18,6)= std(Finalresults(12,3),1);                % std of all tests with  all speeds (2,4,7) on plow
terrain, nsupport & nss

FinalresultsTotal(19,6)= std(Finalresults([1 5 9 13 17 21 24 28],3),1);  % std of all tests with  all speeds (2,4,7)
on all terrains, support & ss
FinalresultsTotal(20,6)= std(Finalresults([2 6 10 14 18 22 25 29],3),1); % std of all tests with  all speeds (2,4,7)
on all terrains, support & nss
FinalresultsTotal(21,6)= std(Finalresults([3 7 11 15 19 23 26 30],3),1); % std of all tests with  all speeds (2,4,7)
on all terrains, nsupport & ss
FinalresultsTotal(22,6)= std(Finalresults([4 8 12 16 20 27 31],3),1);    % std of all tests with  all speeds (2,4,7)
on all terrains, nsupport & nss

FinalresultsTotal(23,6)= std(Finalresults([1 3 5 7 9 11 13 15 17 19 21 23 24 26 28 30],3),1); % std of all tests
with  all speeds (2,4,7) on all terrains, with ss
FinalresultsTotal(24,6)= std(Finalresults([2 4 6 8 10 12 14 16 18 20 22 25 27 29 31],3),1);   % std of all tests
with  all speeds (2,4,7) on all terrains, without ss
FinalresultsTotal(25,6)= std(Finalresults([1 2 5 6 9 10 13 14 17 18 21 22 24 25 28 29],3),1); % std of all tests
with  all speeds (2,4,7) on all terrains, with support
FinalresultsTotal(26,6)= std(Finalresults([3 4 7 8 11 12 15 16 19 20 23 26 27 30 31],3),1);   % std of all tests
with  all speeds (2,4,7) on all terrains, without support
FinalData(28,5)=zeros
Continuous_Map=16;
figure(16),
set(Continuous_Map, 'Name','Final Results of all Tests', 'Position', ([1 1 1440 900]), 'Color', ([0.8 0.8 0.8]));
%ubica las figuras principal del trial a toda pantalla

subplot(3,3,1);
for nr=7:1:10;
nrr=nr-6;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
```

```
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));

FinalData(nrr+1,2)= FinalY(3,nrr);
FinalData(nrr+1,3)= FinalY(1,nrr);
FinalData(nrr+1,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Support and Stabilization System');
ylabel('Distance (mm)');
title('1.Mean & Std of Distance on Smooth Terrain');

axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'','S&SS', 'S&nSS', 'nS&SS', 'nS&nSS', ''});

end;

subplot(3,3,2);
for nr=11:1:14;
nrr=nr-10;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));

FinalData(nrr+5,2)= FinalY(3,nrr);
FinalData(nrr+5,3)= FinalY(1,nrr);
FinalData(nrr+5,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Support and Stabilization System');
```

```
ylabel('Distance (mm)');
title('2.Mean & Std of Distance on Rough Terrain');

axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'','S&SS', 'S&nSS', 'nS&SS', 'nS&nSS', ''});

end;

subplot(3,3,3);
for nr=15:1:18;
nrr=nr-14;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));

FinalData(nrr+9,2)= FinalY(3,nrr);
FinalData(nrr+9,3)= FinalY(1,nrr);
FinalData(nrr+9,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Support and Stabilization System');
ylabel('Distance (mm)');
title('3.Mean & Std of Distance on Plowed Terrain');

axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'','S&SS', 'S&nSS', 'nS&SS', 'nS&nSS', ''});

end;

subplot(3,3,4);
for nr=4:1:6;
nrr=nr-3;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));
```

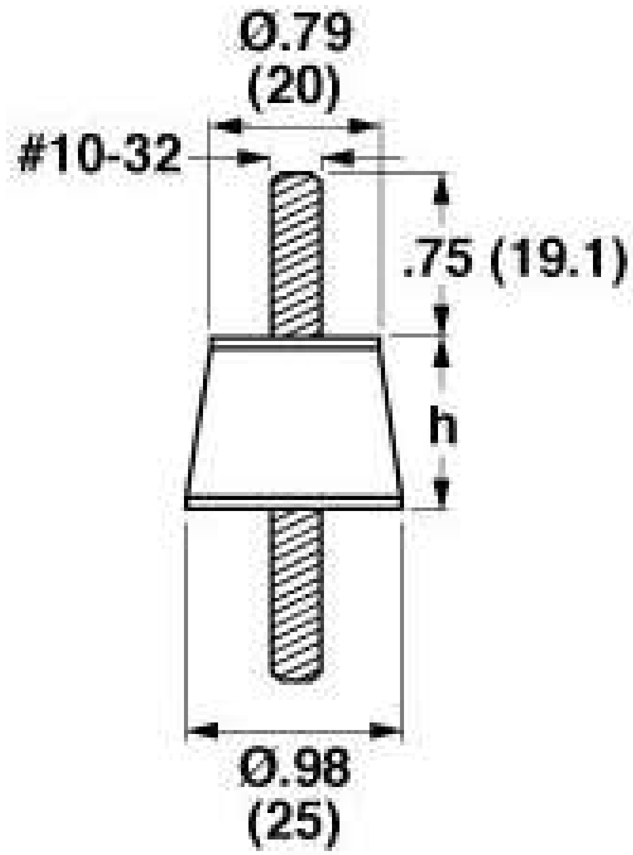
```
FinalData(nrr+13,2)= FinalY(3,nrr);
FinalData(nrr+13,3)= FinalY(1,nrr);
FinalData(nrr+13,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Terrains');
ylabel('Distance (mm)');
title('4.Mean & Std of Distance on Different Terrains');

axis([0 (nrr+1) -50 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'','Smooth', 'Rough', 'Plowed', ''});

end;

subplot(3,3,5);
for nr=1:1:3;
nrr=nr;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));

FinalData(nrr+16,2)= FinalY(3,nrr);
FinalData(nrr+16,3)= FinalY(1,nrr);
FinalData(nrr+16,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Speed Km/h');
ylabel('Distance (mm)');
```

```
title('5.Mean & Std of Distance at Different Speed');

axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'','2', '4', '7', ''});

end;

subplot(3,3,6);
for nr=19:1:20;
nrr=nr-18;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));

FinalData(nrr+19,2)= FinalY(3,nrr);
FinalData(nrr+19,3)= FinalY(1,nrr);
FinalData(nrr+19,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Support and Stabilization System');
ylabel('Distance (mm)');
title('6.Mean & Std of Distance with Support & with/without SS');

axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'','', 'S&SS','','S&nSS', '', ''});

end;

subplot(3,3,7);
for nr=21:1:22;
nrr=nr-20;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));
```

```
FinalData(nrr+21,2)= FinalY(3,nrr);
FinalData(nrr+21,3)= FinalY(1,nrr);
FinalData(nrr+21,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Support and Stabilization System');
ylabel('Distance (mm)');
title('7.Mean & Std of Distance without Support & with/without SS');

axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'','', 'nS&SS','','nS&nSS', '', ''});

end;

subplot(3,3,8);
for nr=23:1:24;
nrr=nr-22;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));

FinalData(nrr+23,2)= FinalY(3,nrr);
FinalData(nrr+23,3)= FinalY(1,nrr);
FinalData(nrr+23,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Support');
ylabel('Distance (mm)');
title('8.Mean & Std of Distance with & without Support');
```

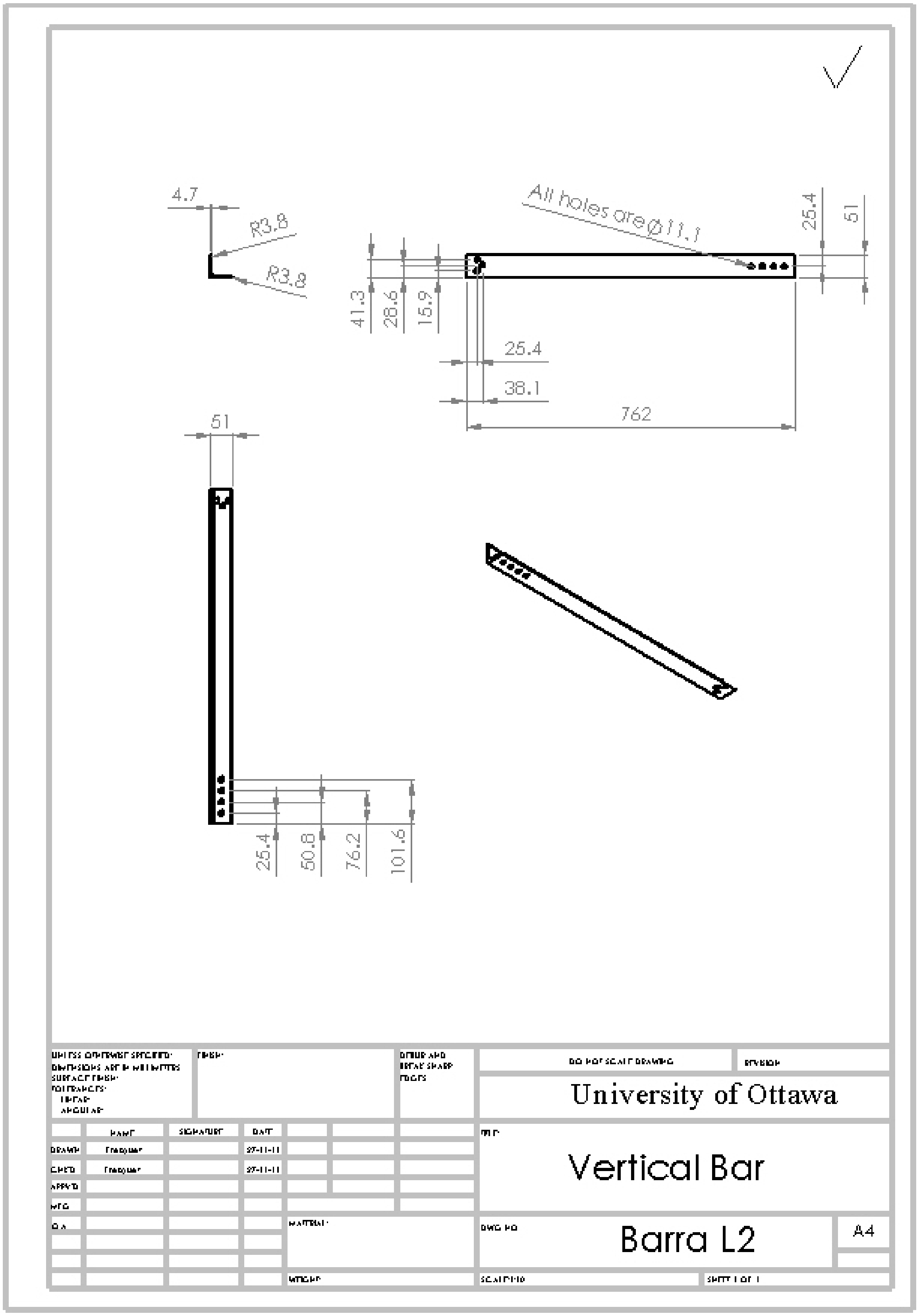
```
axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'',' ', 'S','','nS', '', ''});

end;

subplot(3,3,9);
for nr=25:1:26;
nrr=nr-24;
nrt=nrr+0.05;

FinalX(1,nrr)=nrr;
FinalX(2,nrr)=nrr;
FinalX(3,nrr)=nrr;
FinalY(1,nrr)=(FinalresultsTotal(nr,3)-FinalresultsTotal(nr,6));
FinalY(2,nrr)=FinalresultsTotal(nr,3);
FinalY(3,nrr)=(FinalresultsTotal(nr,3)+FinalresultsTotal(nr,6));

FinalData(nrr+25,2)= FinalY(3,nrr);
FinalData(nrr+25,3)= FinalY(1,nrr);
FinalData(nrr+25,4)= FinalY(2,nrr);

plot (nrr,FinalY(2,nrr),'-gd', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(1,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
plot (nrr,FinalY(3,nrr),'-g+', 'MarkerFaceColor','g');
hold on;
line(FinalX([1 3],nrr),FinalY([1 3],nrr),'Color','g');
hold on;

text(nrt,(FinalY(2,nrr)),['\color{red}',num2str(FinalresultsTotal(nr,3),F2)]);
hold on;
grid on;
xlabel('Stabilization System');
ylabel('Distance (mm)');
title('9.Mean & Std of Distance with & without SS');

axis([0 (nrr+1) 0 (round((max(max(FinalY)))+50))]);
set(gca,'XTickLabel',{'',' ', 'SS','','nSS', '', ''});

end;
FinalData;
set(gcf, 'PaperPositionMode', 'auto');
print -dpng -r300 'C:\Documents and Settings\Carlos\My Documents\Research projects\Field Test\Field tests
normal direcction\Final Results.png';
[token, remain] = strtok(file, '1');
new_file=strcat(token,' Results');
fileoutput = [new_file '.csv'];

data1 = zeros(size(FinalData(:,1)),5);
data1 = FinalData;
dlmwrite(fileoutput,data1);


end
```

Appendix D. Drawings of SS and Structure of LMS

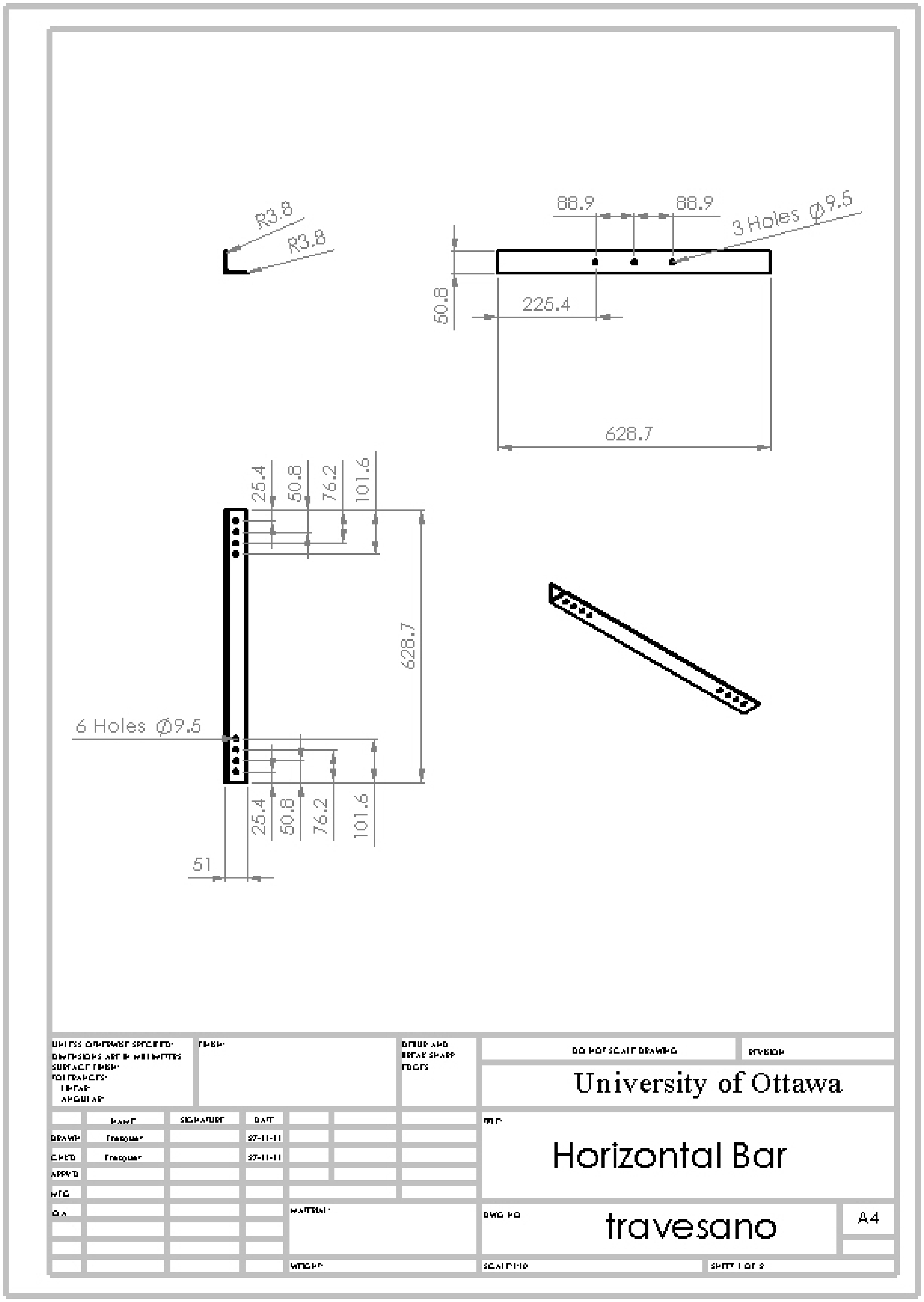


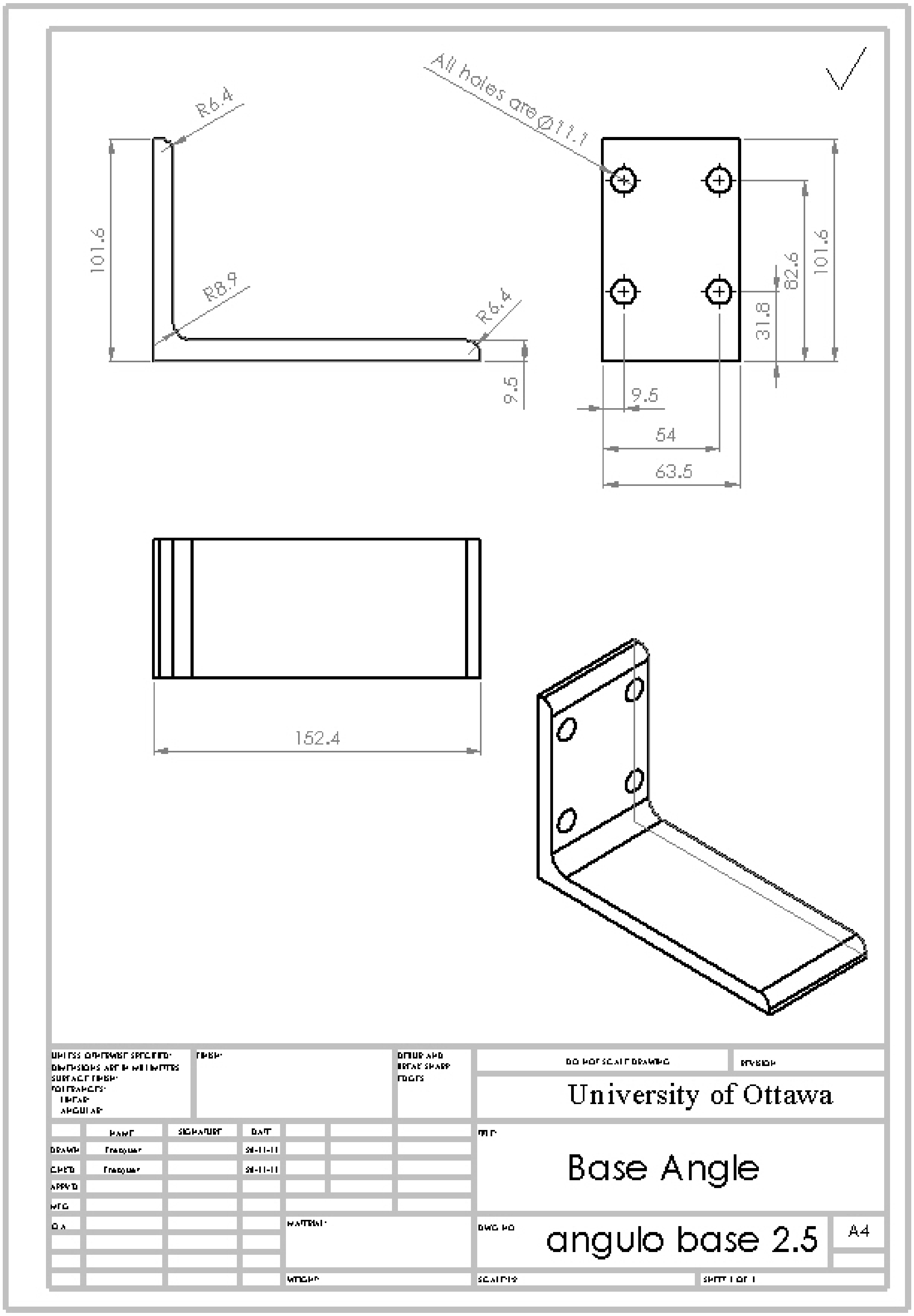
Dimensions of isolator V10Z64-MN03, (Vibrationmounts, 2010).

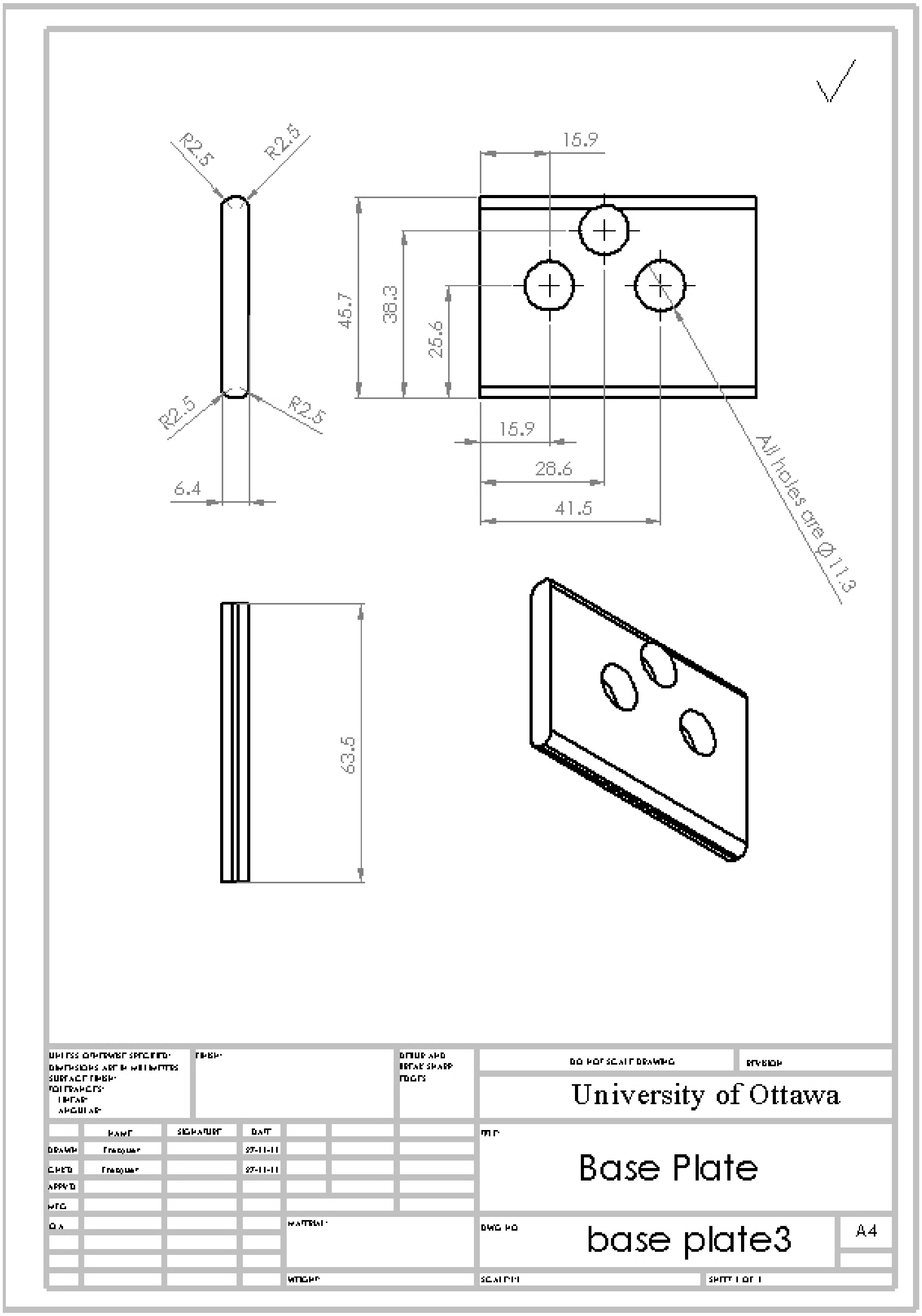
(The dimensions are in inches and the dimensions inside parentheses are in millimeters).



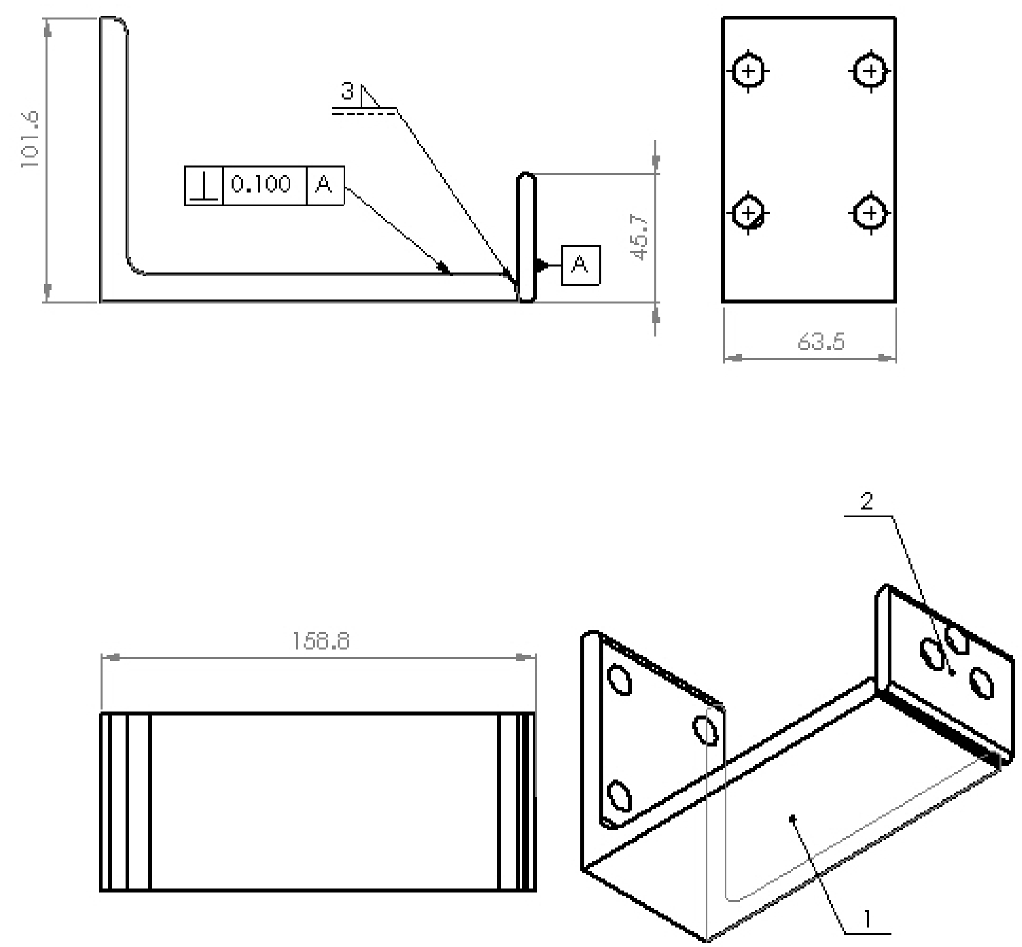
4.7
R3.8
R3.8
All holes are Ø11.1
25.4
51
41.3
28.6
15.9
25.4
38.1
762
51
25.4
50.8
76.2
101.6
University of Ottawa
Vertical Bar
Barra L2
A4


R3.8
R3.8
88.9
88.9
3 Holes Ø9.5
50.8
225.4
628.7
25.4
50.8
76.2
101.6
628.7
6 Holes Ø9.5
25.4
50.8
76.2
101.6
51
University of Ottawa
Horizontal Bar
travesano
A4


R6.4
All holes are Ø11.1
101.6
R8.9
R6.4
9.5
82.6
101.6
31.8
9.5
54
63.5
152.4
DO NOT SCALE DRAWING
REVISION
University of Ottawa
Base Angle
angulo base 2.5
A4


R2.5
R2.5
R2.5
R2.5
6.4
15.9
45.7
38.3
25.6
15.9
28.6
41.5
All holes are Ø11.3
63.5
DO NOT SCALE DRAWING
REVISION
University of Ottawa
Base Plate
base plate3
A4

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	angulo base 2.5	Base Angle	1
2	baseplate3	Base Plate	1



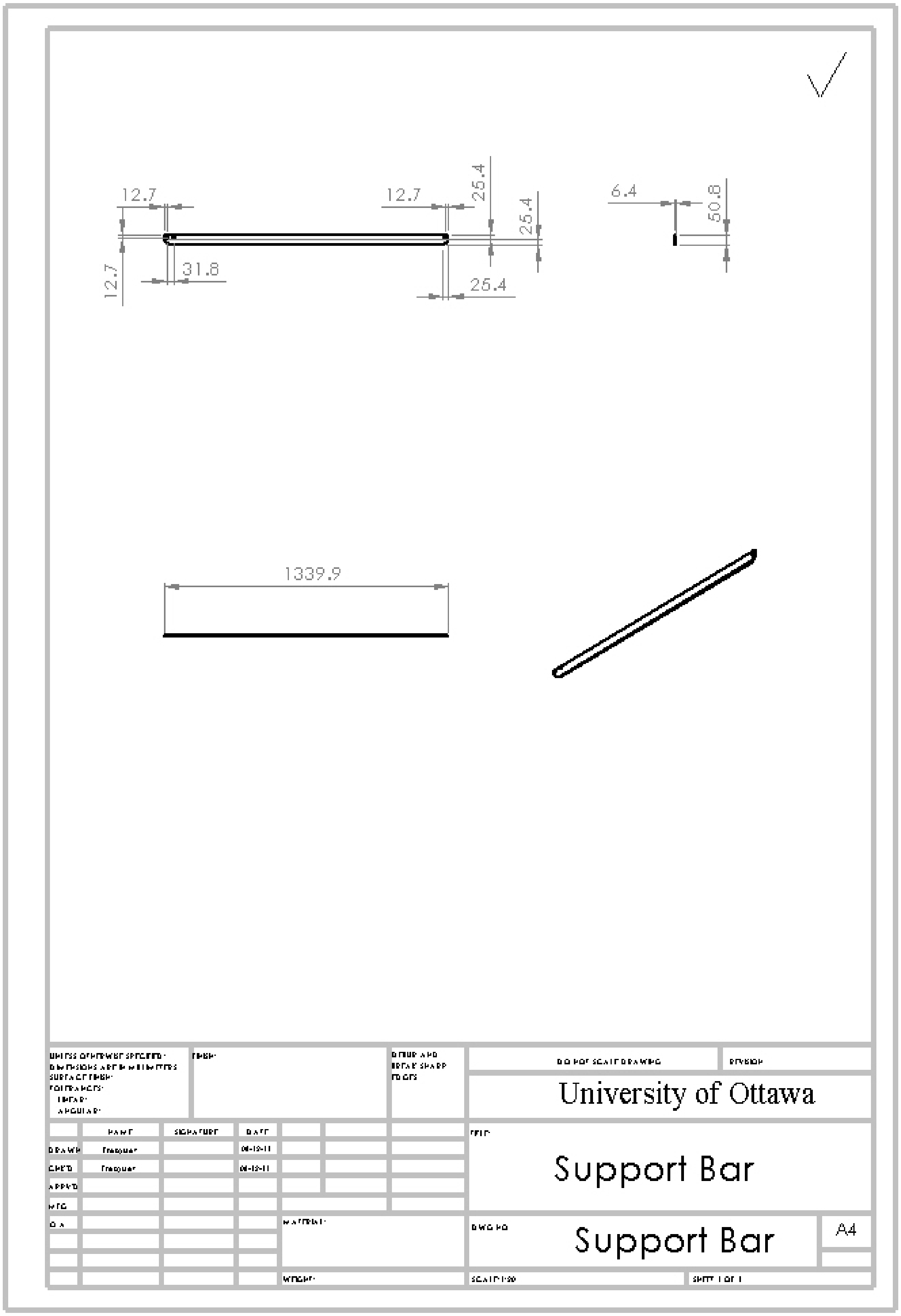
DO NOT SCALE DRAWING

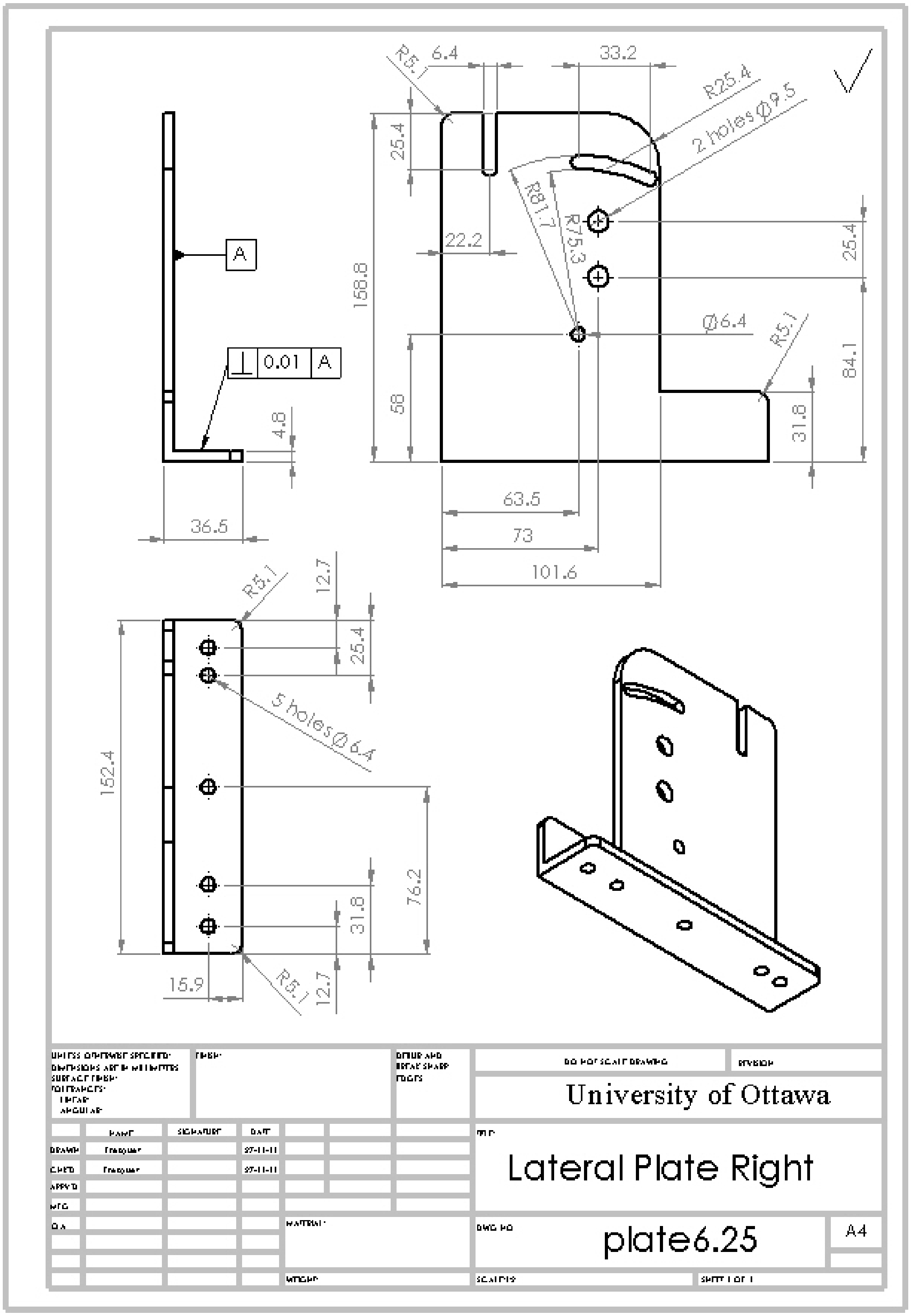
University of Ottawa

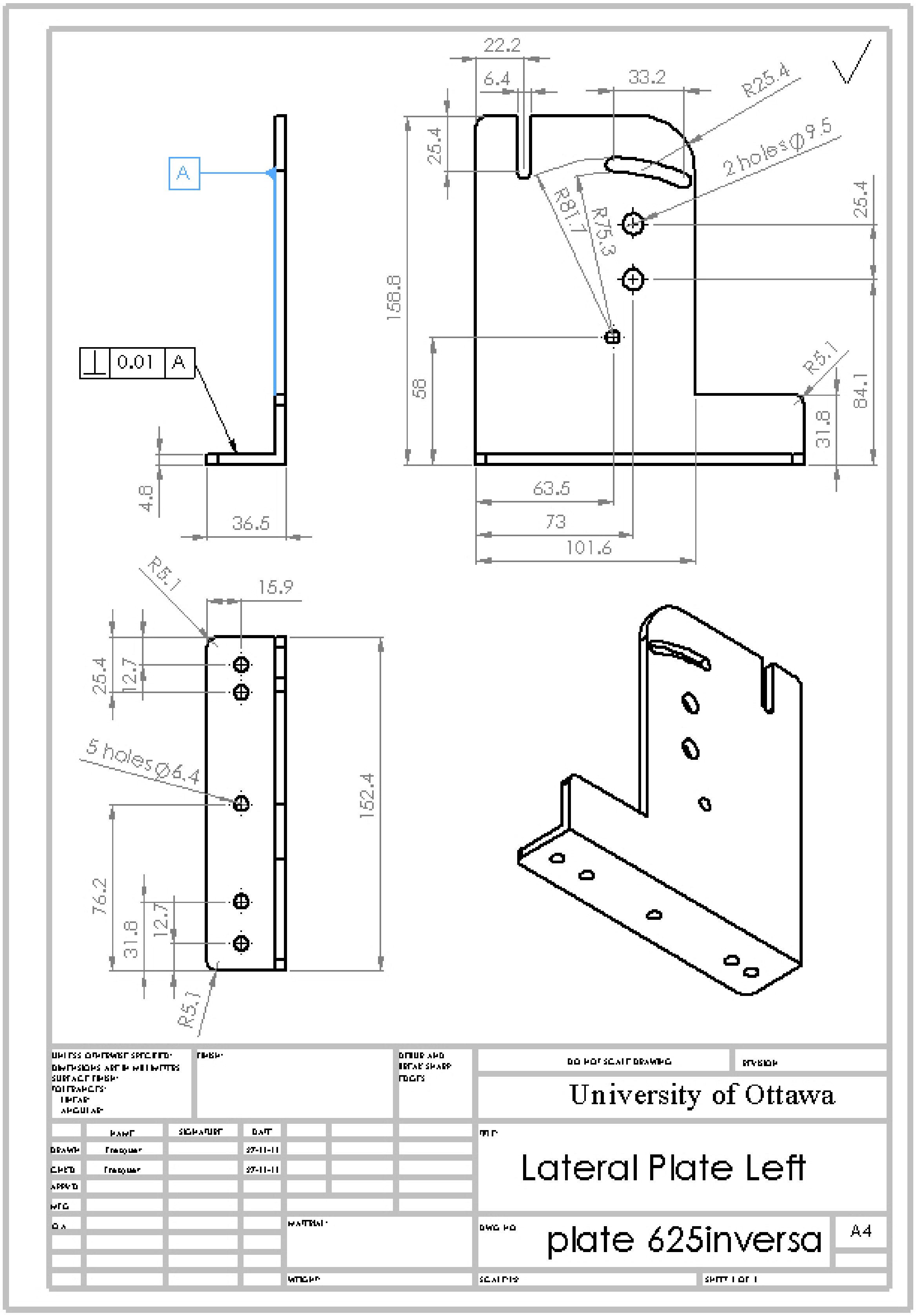
Bracket

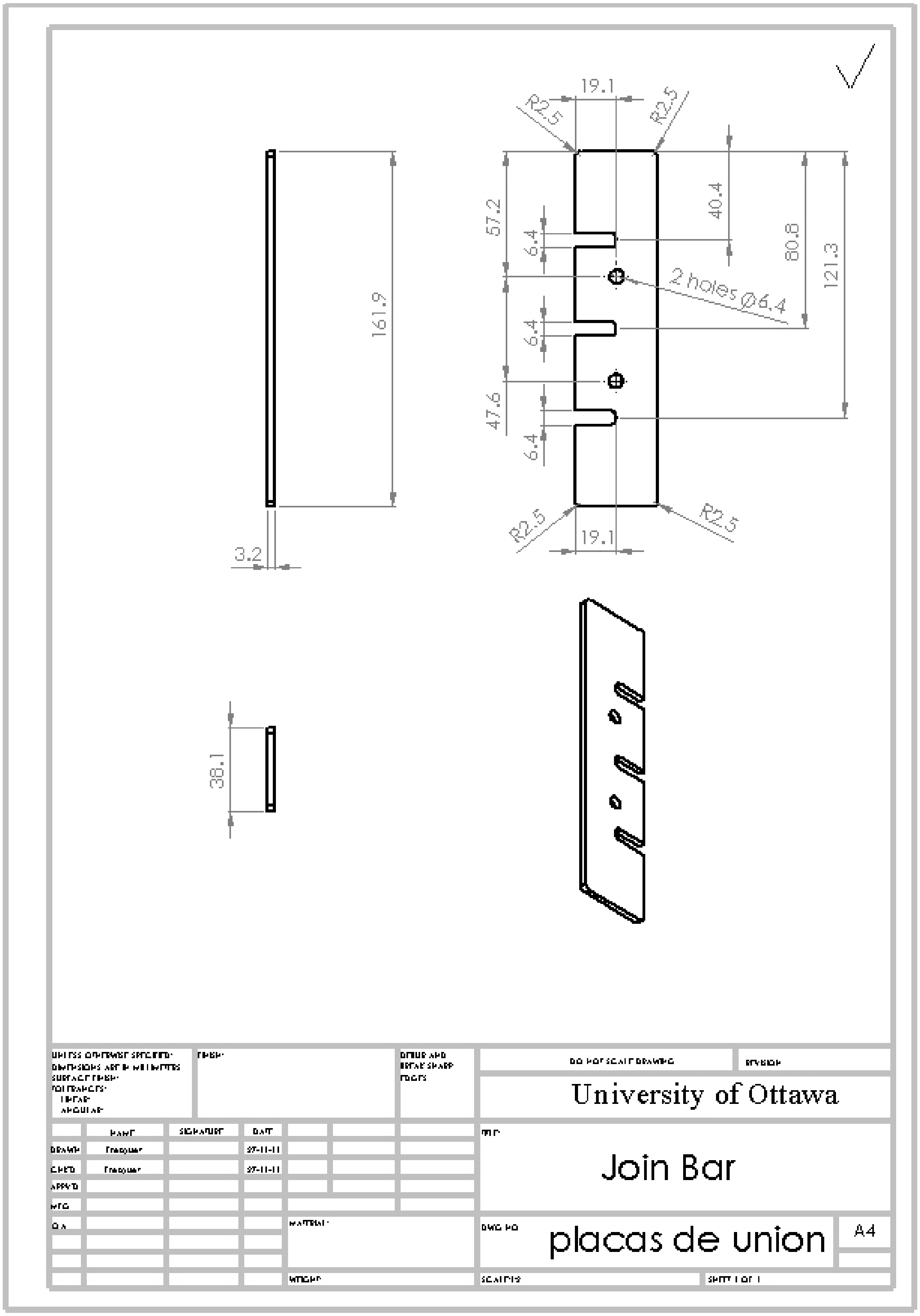
Base

A4

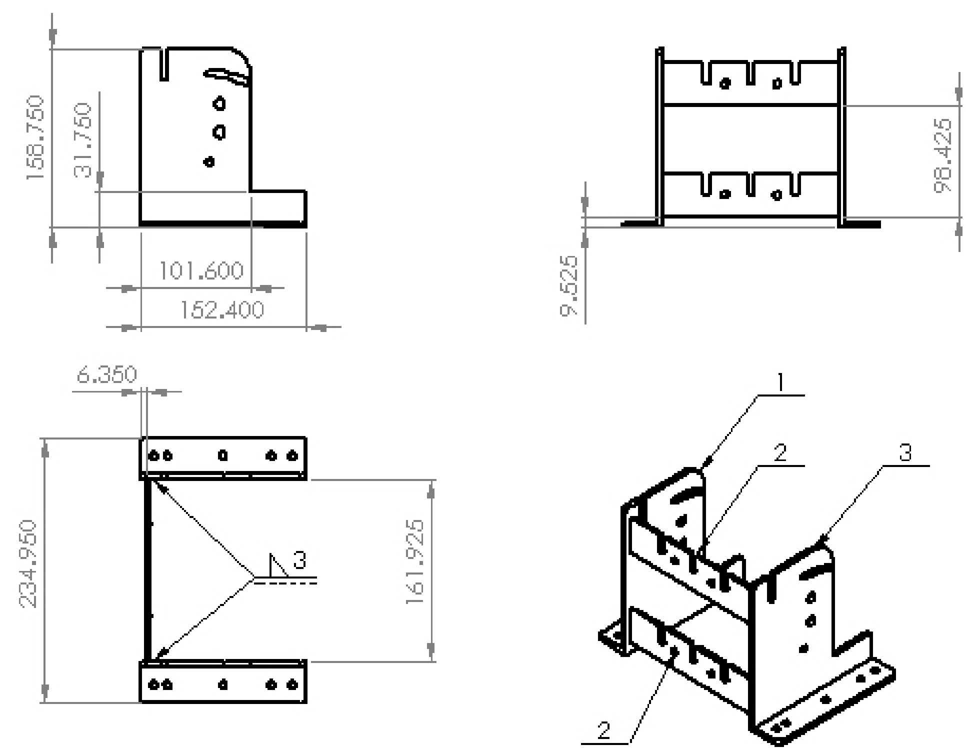

12.7
12.7
25.4
25.4
6.4
50.8
12.7
31.8
25.4
1339.9
University of Ottawa
Support Bar
Support Bar
A4


R5.1
6.4
33.2
R25.4
2 holes Ø9.5
25.4
R81.7
R75.3
22.2
158.8
A
Ø6.4
R5.1
25.4
84.1
⊥ 0.01 A
58
4.8
31.8
36.5
63.5
73
101.6
R5.1
12.7
25.4
5 holes Ø6.4
152.4
76.2
31.8
15.9
R5.1
12.7
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:
FINISH:
DEBUR AND BREAK SHARP EDGES
DO NOT SCALE DRAWING
REVISION
University of Ottawa
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
WEIGHT:
TITLE:
Lateral Plate Right
DWG NO.
plate6.25
A4
SCALE:
SHEET 1 OF 1


22.2
6.4
33.2
R25.4
2 holes∅9.5
25.4
R81.7
R75.3
158.8
58
25.4
R5.1
84.1
31.8
63.5
73
101.6
A
0.01 A
4.8
36.5
R5.1
15.9
25.4
12.7
5 holes∅6.4
152.4
76.2
31.8
12.7
R5.1
DO NOT SCALE DRAWING
REVISION
University of Ottawa
TITLE:
Lateral Plate Left
DWG NO.
plate 625inversa
A4
NAME
SIGNATURE
DATE
DRAWN
CHK'D
APPV'D
MFG
Q.A
MATERIAL:
WEIGHT:
SCALE:1:2
SHEET 1 OF 1
FINISH:
DEBUR AND BREAK SHARP EDGES
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:


19.1
R2.5
R2.5
57.2
6.4
40.4
80.8
121.3
2 holes Ø6.4
161.9
6.4
47.6
6.4
R2.5
R2.5
19.1
3.2
38.1
University of Ottawa
Join Bar
placas de union
A4

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	plate6.25	Lateral Plate Right	1
2	placas de union	Join Bar	2
3	plate 625inversa	Lateral Plate Left	1

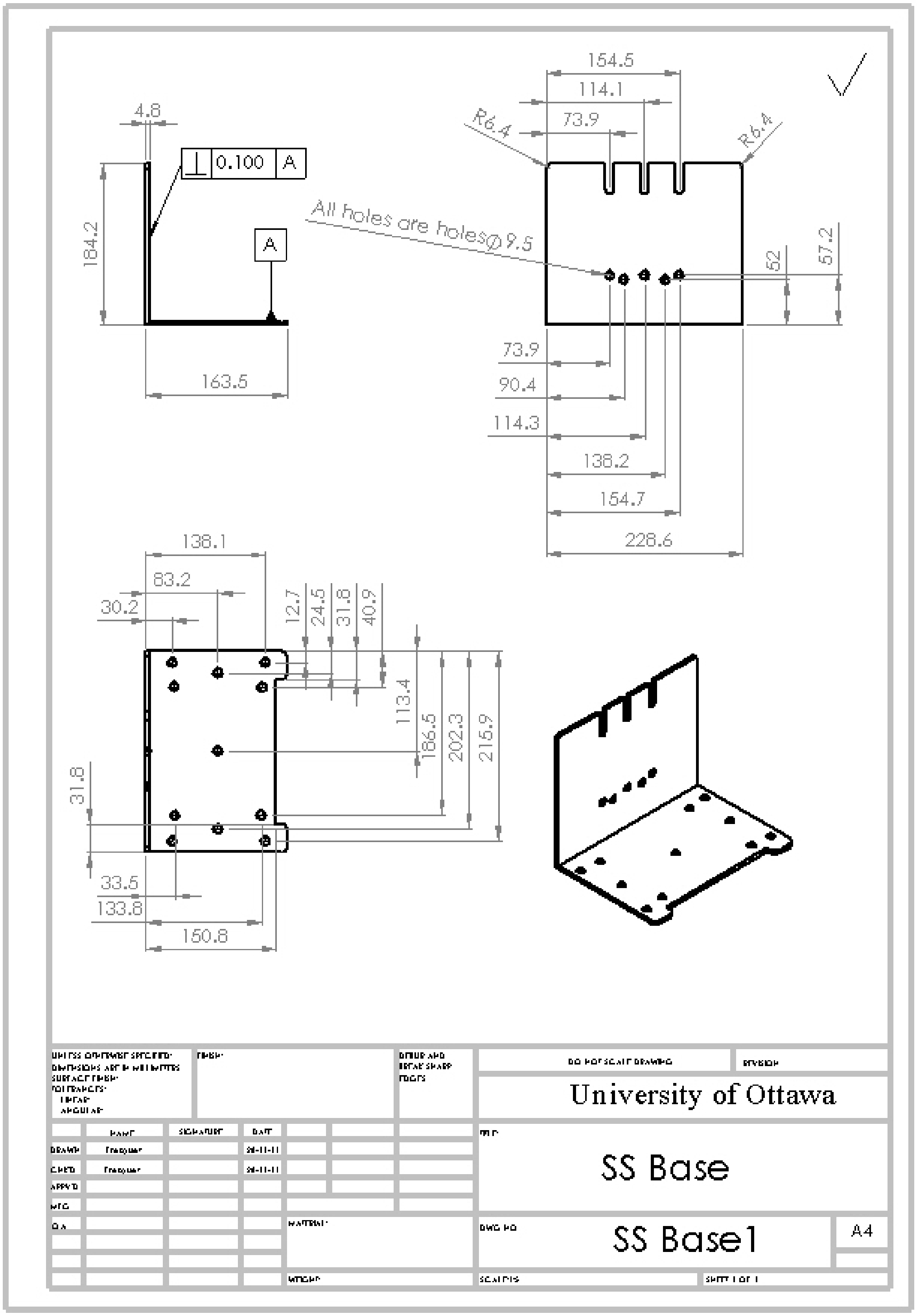


University of Ottawa

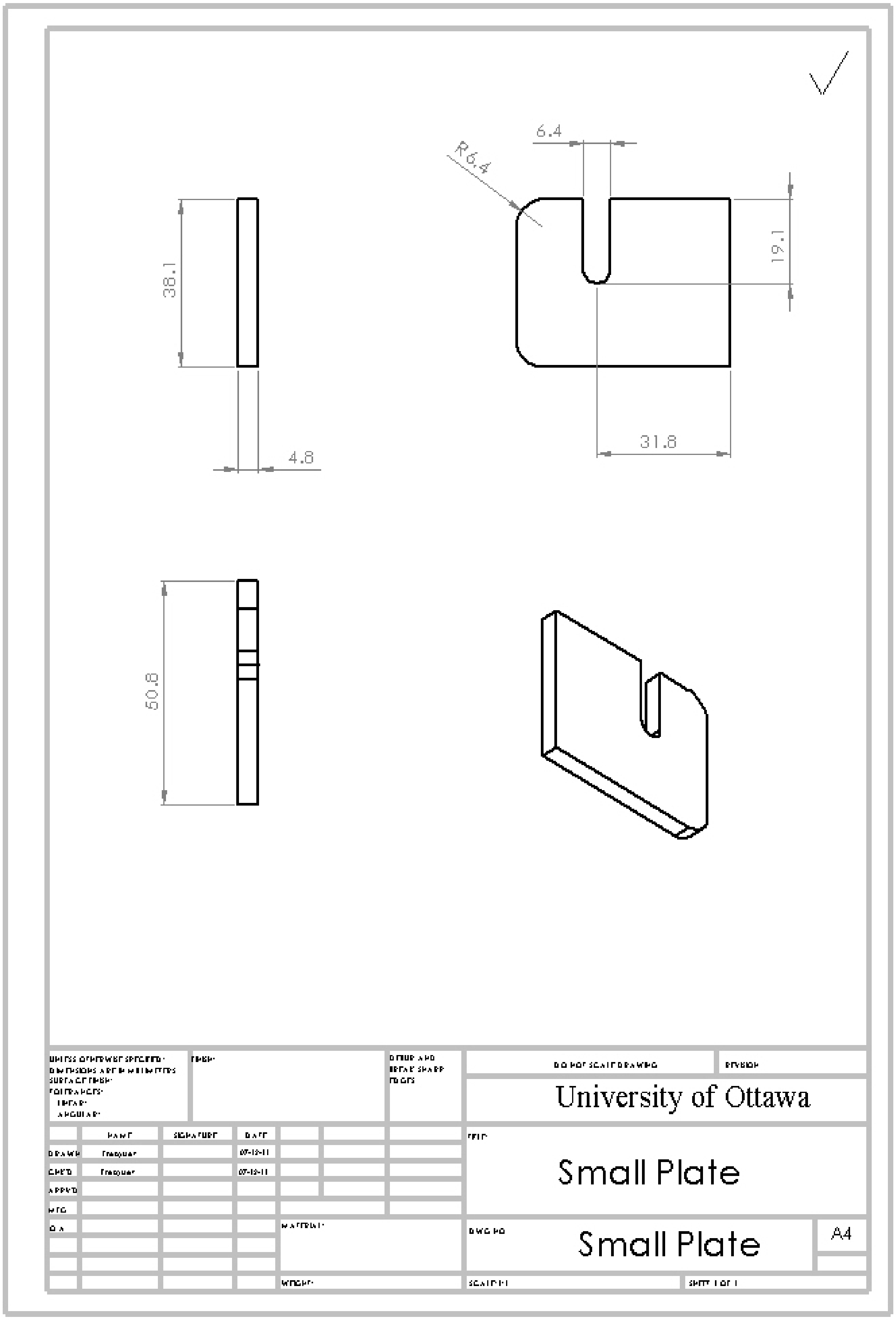
Assem. Lateral Plates

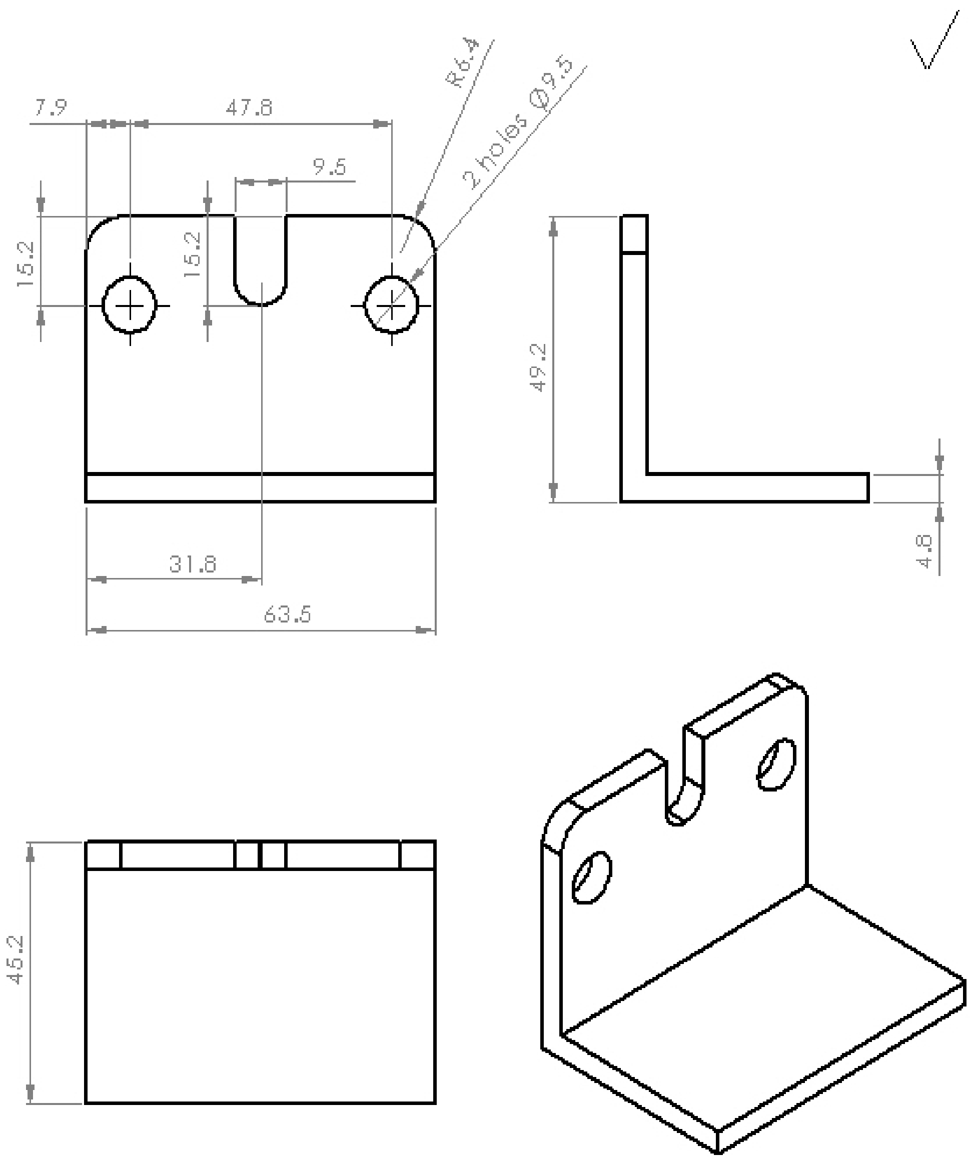
Ass Plates

A4



4.8
0.100 A
A
184.2
163.5
154.5
114.1
73.9
R6.4
R6.4
All holes are holes∅9.5
52
57.2
73.9
90.4
114.3
138.2
154.7
228.6
138.1
83.2
30.2
12.7
24.5
31.8
40.9
113.4
186.5
202.3
215.9
31.8
33.5
133.8
150.8
University of Ottawa
SS Base
SS Base1
A4


6.4
R6.4
38.1
19.1
4.8
31.8
50.8
University of Ottawa
Small Plate
Small Plate
A4



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
SURFACE FINISH:
TOLERANCES:
LINEAR:
ANGULAR:

FINISH:

DEBUR AND BREAK SHARP EDGES

DO NOT SCALE DRAWING

REVISION

University of Ottawa

	NAME	SIGNATURE	DATE
DRAWN	Fracquer		07-12-11
CHK'D	Fracquer		07-12-11
APPV'D			
MFG			
Q.A			

TITLE:

Front L Plate

MATERIAL:

DWG NO.

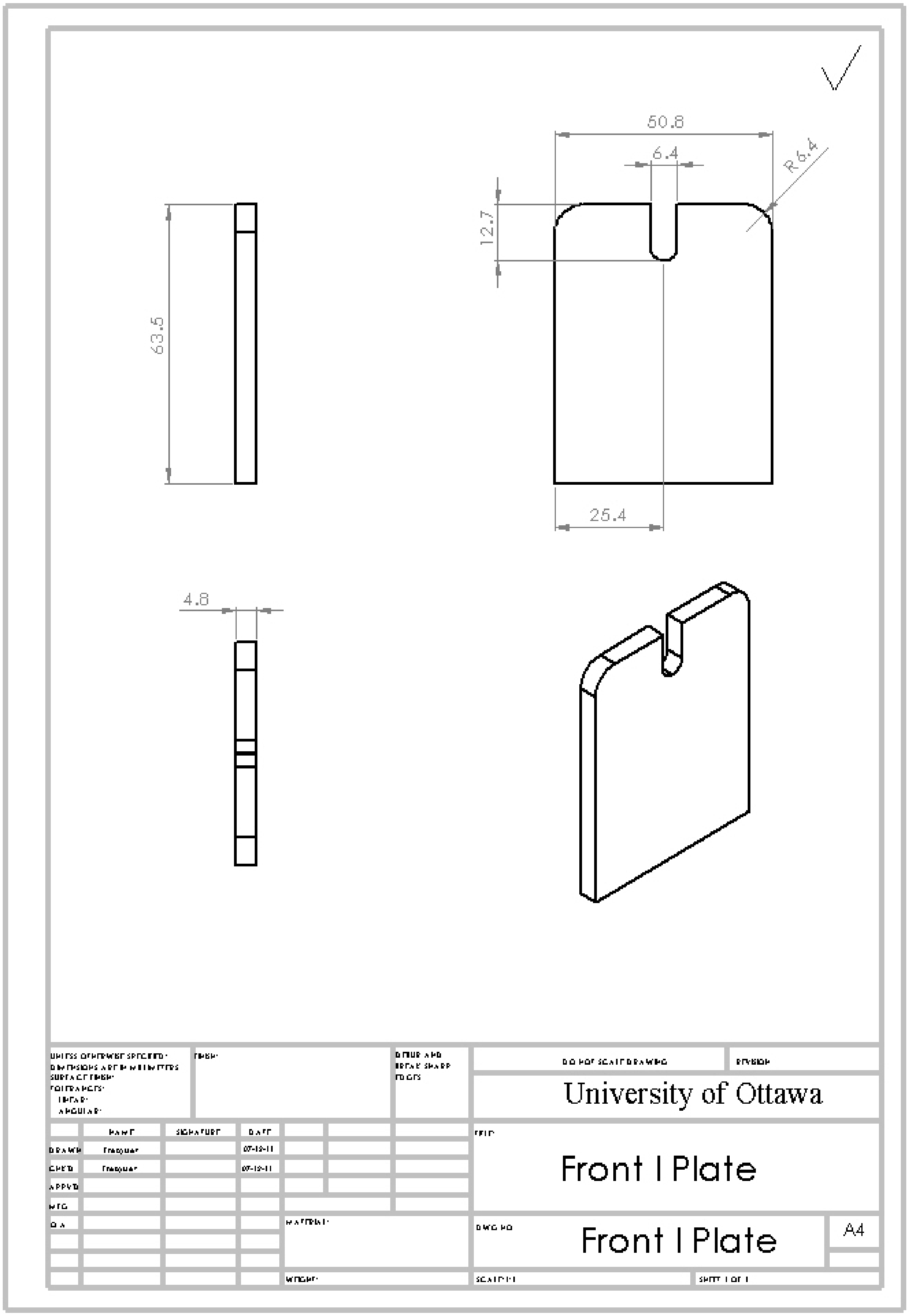
Front L Plate

A4

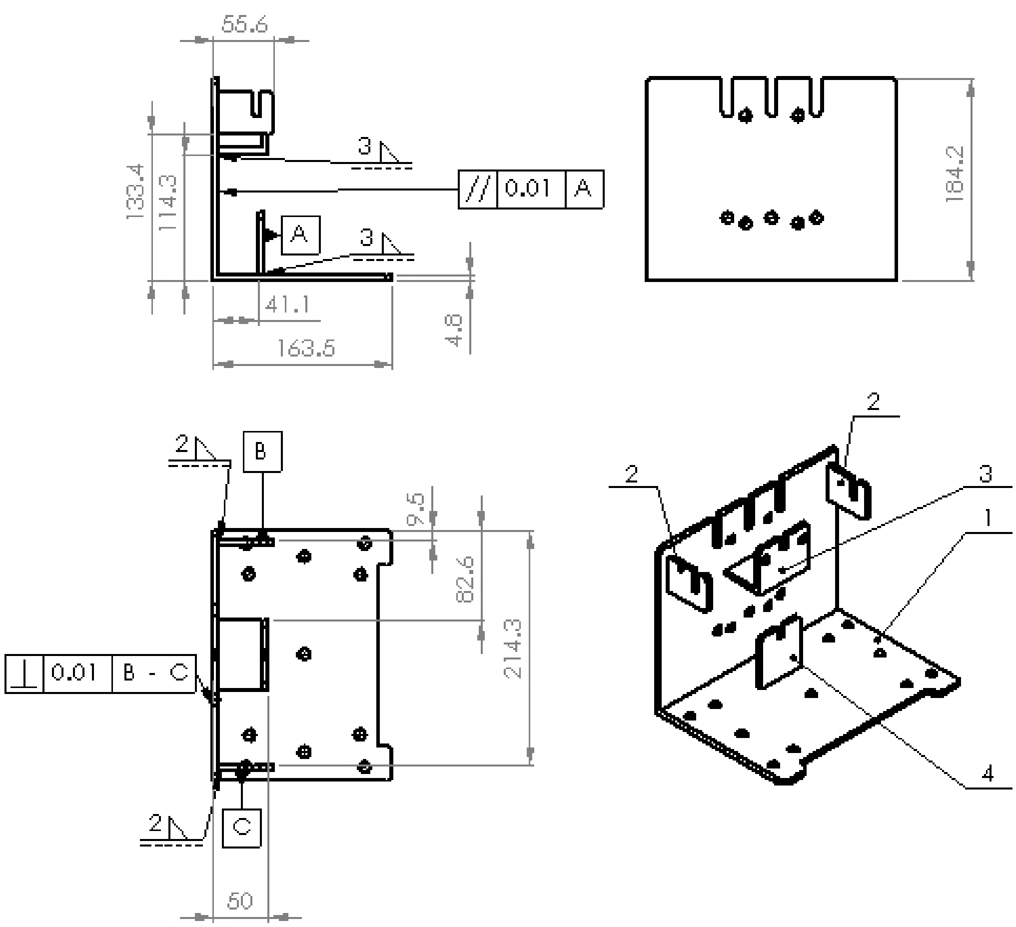
WEIGHT:

SCALE:1:1

SHEET 1 OF 1


50.8
6.4
R6.4
12.7
63.5
25.4
4.8
University of Ottawa
Front I Plate
Front I Plate
A4

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	SS Base T	SS Base	1
2	Small Plate	Small Plate	2
3	Front L Plare	Front L Plate	1
4	Front I Plate	Front I Plate	1



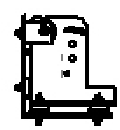
University of Ottawa

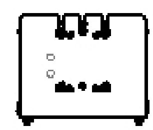
Assem. Angle Plate

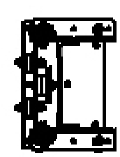
SS Base T

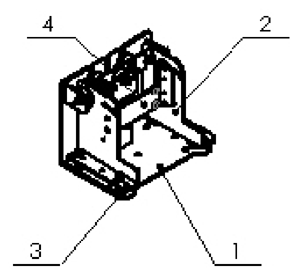
A4

Item Number	Part Number	Description	Qty
1	SS Base T	Assem. Angle Plate	1
2	Ass Plates	Assem. Lateral Plates	1
3	V10Z64-MN03	Isolator	16
4	LMS Brackect	LMS Bracket	1







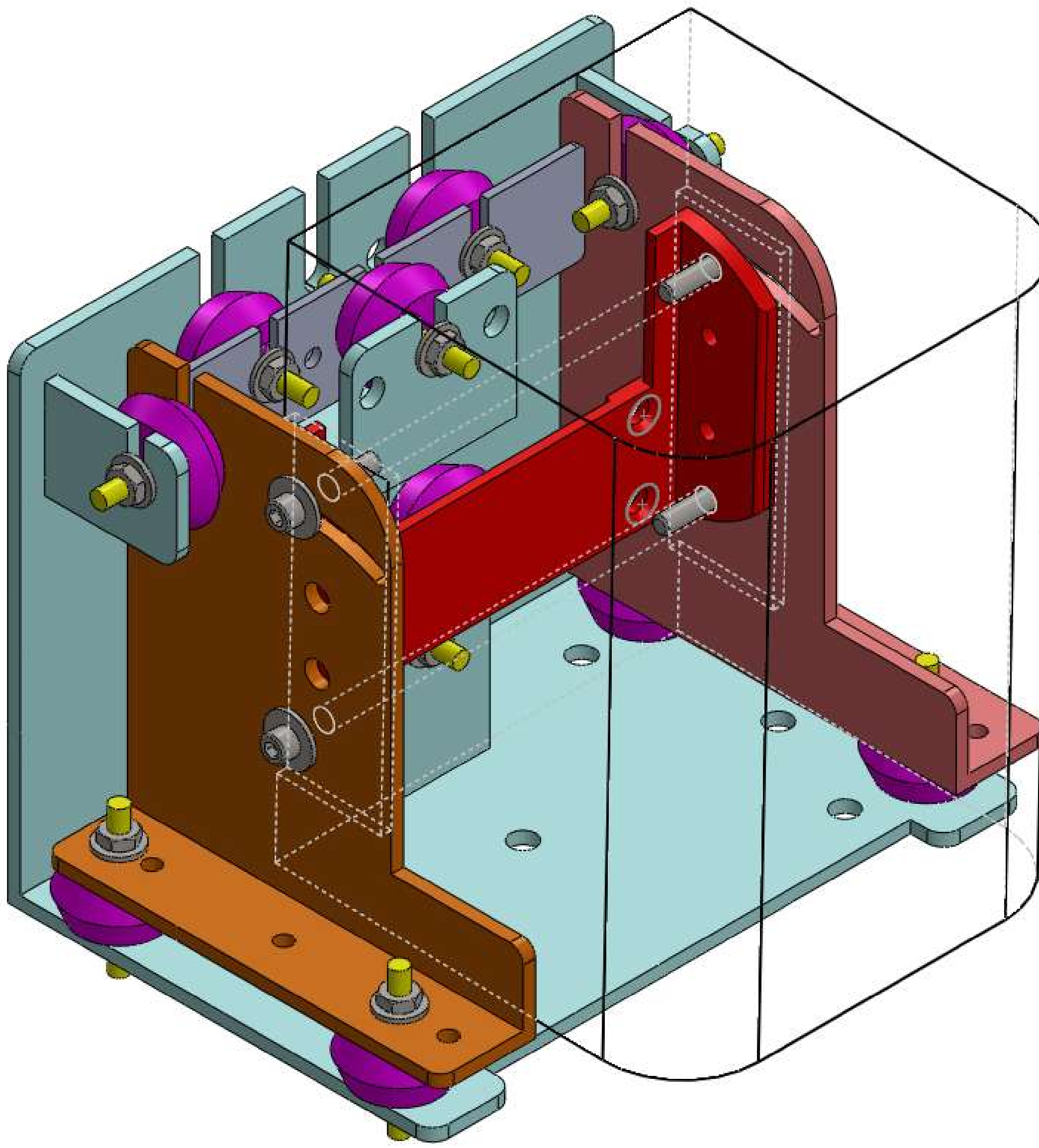


University of Ottawa

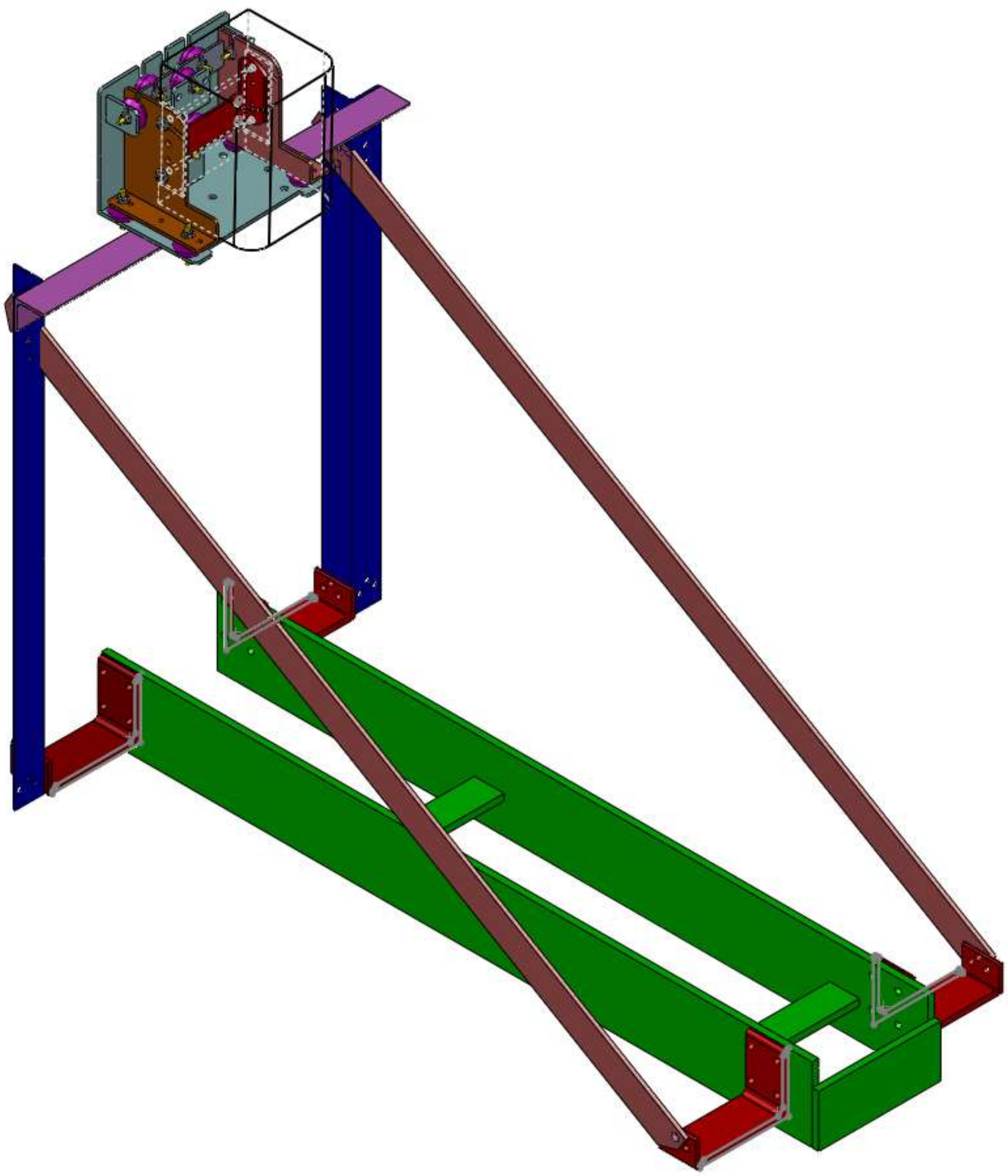
Stabilization System

Assem total final

A4



Stabilization System and LMS sensor



Structure of Stabilization System and LMS sensor