nurjanatech
THINKING HIGHER

A simulation tool
to evaluate trajectories for test range missions

nurjanatech.com

Who we are
Profile

Nurjana Technologies (NT) is a small company providing Systems and Software Solutions for System Integration and Sensor Data Fusion & Tracking based on a strong System Engineering approach to complex system design.

Nurjana was established in 2012 on the initiative of the founding partners who have more than 18 years of experience in the fields of defense and aerospace technologies.

Who we are
Business Areas

AEROSPACE

- ✓ Command&Control Systems for Test and Evaluation
- ✓ Systems for Trajectory Tracking and Orbits Determination
- ✓ Remote Sensing Data Exploitation Systems
- ✓ Subsystems for Payload Data Ground Segment

INFORMATION TECHNOLOGIES

- ✓ Applications for Real Time Expert Systems
- ✓ Image Processing and Scenario Analysis
- ✓ Tools for Sensors Modelling and Simulation
- ✓ Mathematical Optimizations Tools for Test Data Processing

ENGINEERING and R&D

- ✓ Algorithms for Multi Sensor Data Fusion and Tracking
- ✓ Trajectory Simulations and Test Data Analysis
- ✓ Design and Development of Systems of Systems
- ✓ Project Management and Engineering Support

The Ballistic Predictor
Introduction

The Ballistic Predictor is a very flexible tool able to accommodate a very general, user-defined dynamic model, and to use it for ballistic simulations.

It can be easily adopted to analyze scenarios involving:

- Test-Range Ballistic Scenarios
- Test-Range Satellite Earth Orbiting Scenarios

Each one of this scenarios can be seen in a Mission Analysis perspective or in Real-Time Applications

The Ballistic Predictor

Typical Scenario descriptions: test range Ballistic Scenarios

The Ballistic Predictor is born to solve some real case problems in the following contexts:

Mission planning Sensor positioning and evaluation problems

- Maximum sensor coverage evaluation
- Minimum triangulation error in case of optical sensors
- Find a useful distance for object detection

The Ballistic Predictor

Typical Scenario descriptions: test range Ballistic Scenarios

The Ballistic Predictor is born to solve some real case problems in the following contexts:

Nominal Trajectory for Sensor Tracking reliability

- Master Radar sensor malfunction or not available
- Improve algorithms for multi-sensor data fusion and data validation

The Ballistic Predictor

Typical Scenario descriptions: test range Ballistic scenarios

The Ballistic Predictor is made to solve some real case problems in the following contexts:

Real-time target trajectory prediction for splash detection

- Estimation of an accurate Impact point
- Test range Security

The Ballistic Predictor

Typical Scenario descriptions: space missions scenario

The Ballistic Predictor is born to solve some real case problems in the following contexts:

Satellite trajectory evaluation satellite tracking

- Estimation of a satellite nominal trajectory useful for collision avoidance
- Optical sensor calibration using satellites
- Visibility Windows calculating to evaluate sensor positions

The Ballistic Predictor
Typical Scenarios descriptions: summary

The Ballistic Predictor is born to solve some real case problems in the following contexts:

Pre-Mission Analysis

- Mission planning Sensor positioning and evaluations problems
- Nominal Trajectory for Sensor Tracking reliability
- Satellite trajectory evaluation satellite tracking

Real-time Scenario

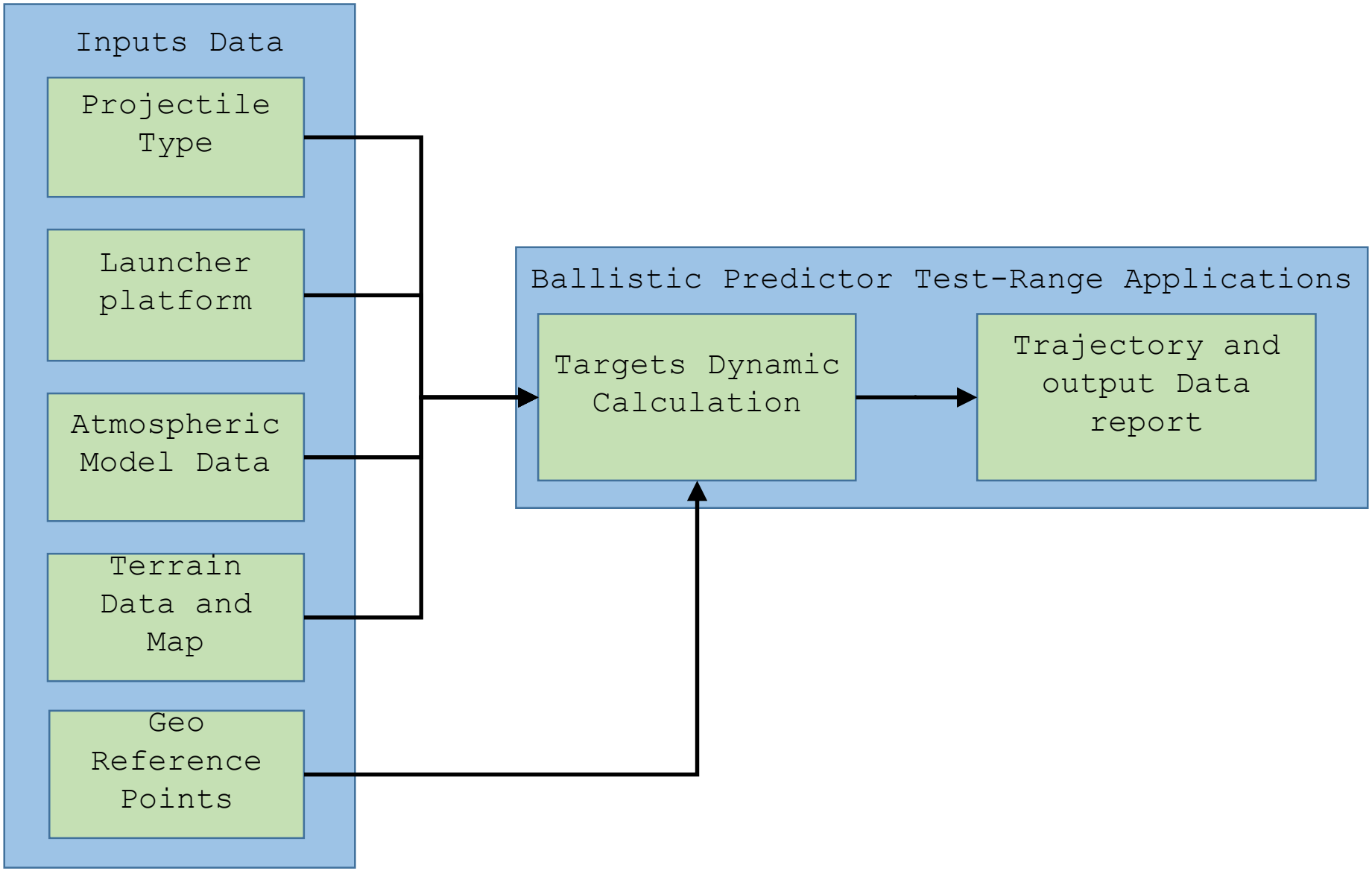
- Target trajectory prediction for security and splash detection




The Ballistic Predictor

Ballistic Predictor Test Range application and How it works

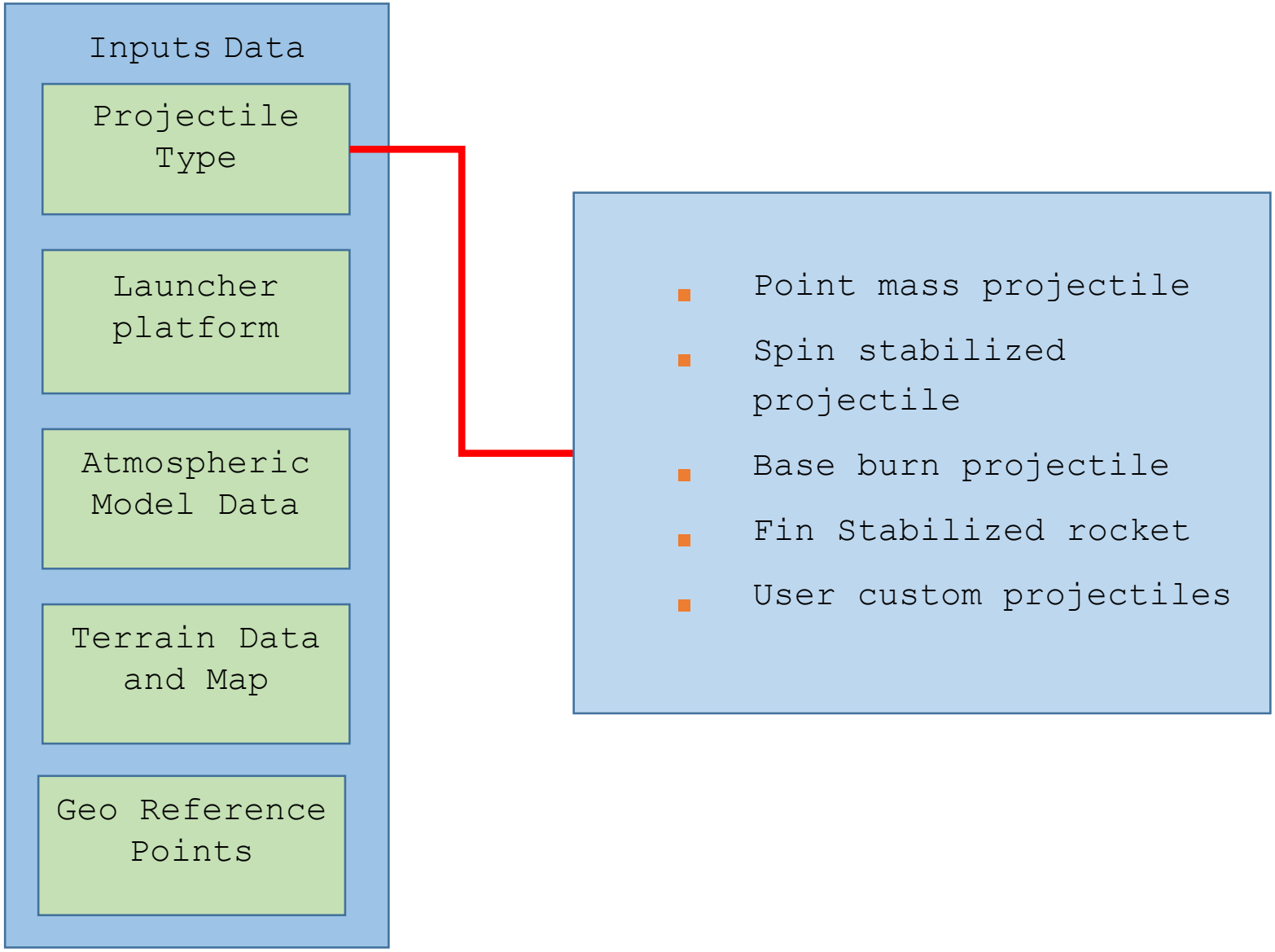
The Ballistic predictor to estimate trajectory in the test range scenario need many data to estimate an accurate trajectory:



The Ballistic Predictor

Inputs parameters- Projectile supported for test range applications

The Ballistic predictor has implemented some Projectile types, it is even possible to implement custom projectiles:



Projectile types: Types of Dynamics

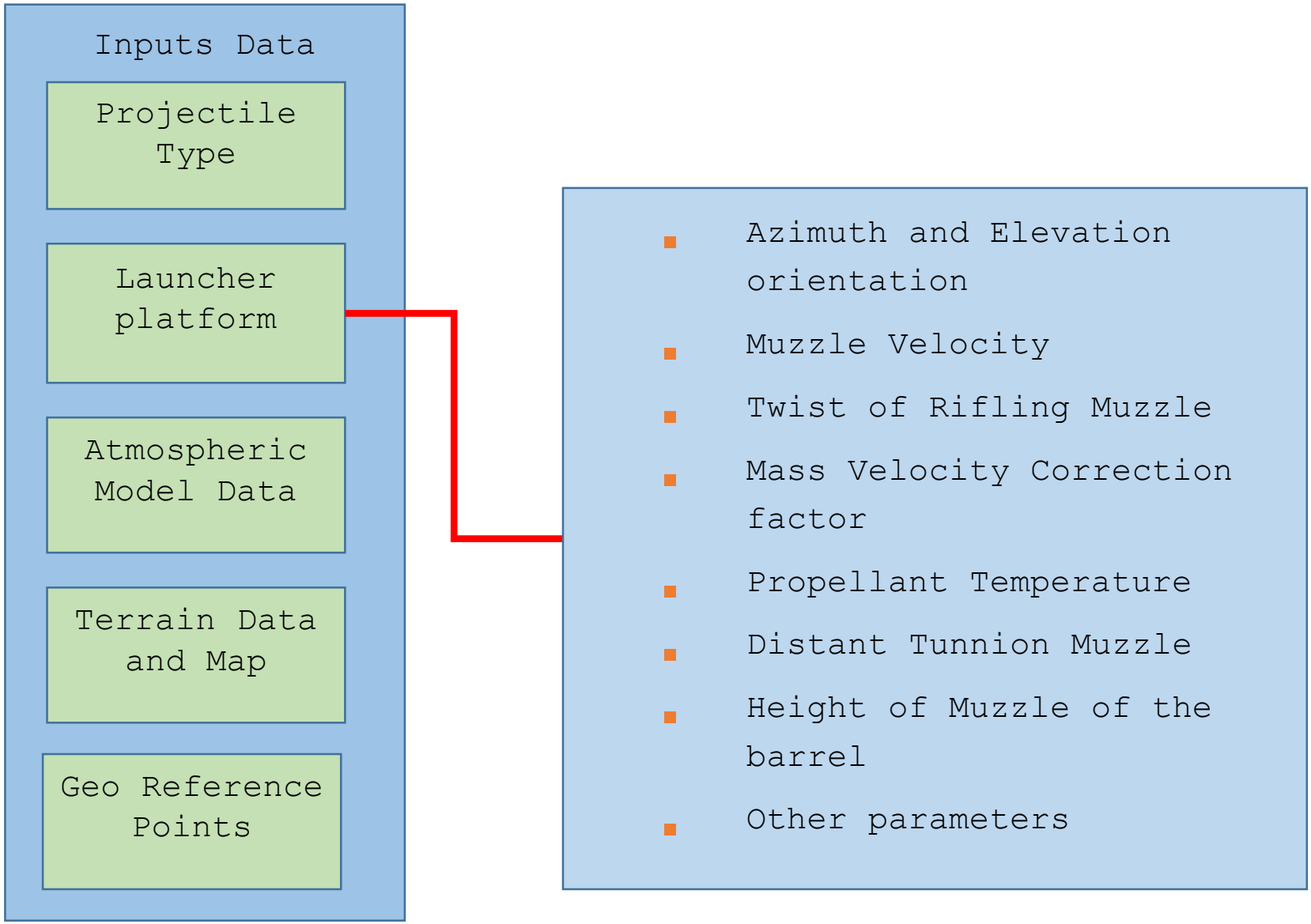
The Ballistic predictor has implemented different types of dynamics:

1. **Base point mass**
   - Launcher parameters (muzzle velocity, rifling twist, etc.)
   - Total Drag force coefficient
   - Spin damping moment coefficient (optional)
2. **Modified point mass**
   - Launcher parameters
   - 10 aerodynamics projectile parameters
   - Base burn unit data (fuel mass, density of fuel, etc.), and additional parameters
3. **5 Degrees of freedom**
   - Launcher parameters
   - 26 aerodynamics projectile parameters (Fin opened and closed)
   - Motor and others additional parameters
4. **User Custom Dynamics**

The Ballistic Predictor

Inputs parameters- Launch platforms model parameters

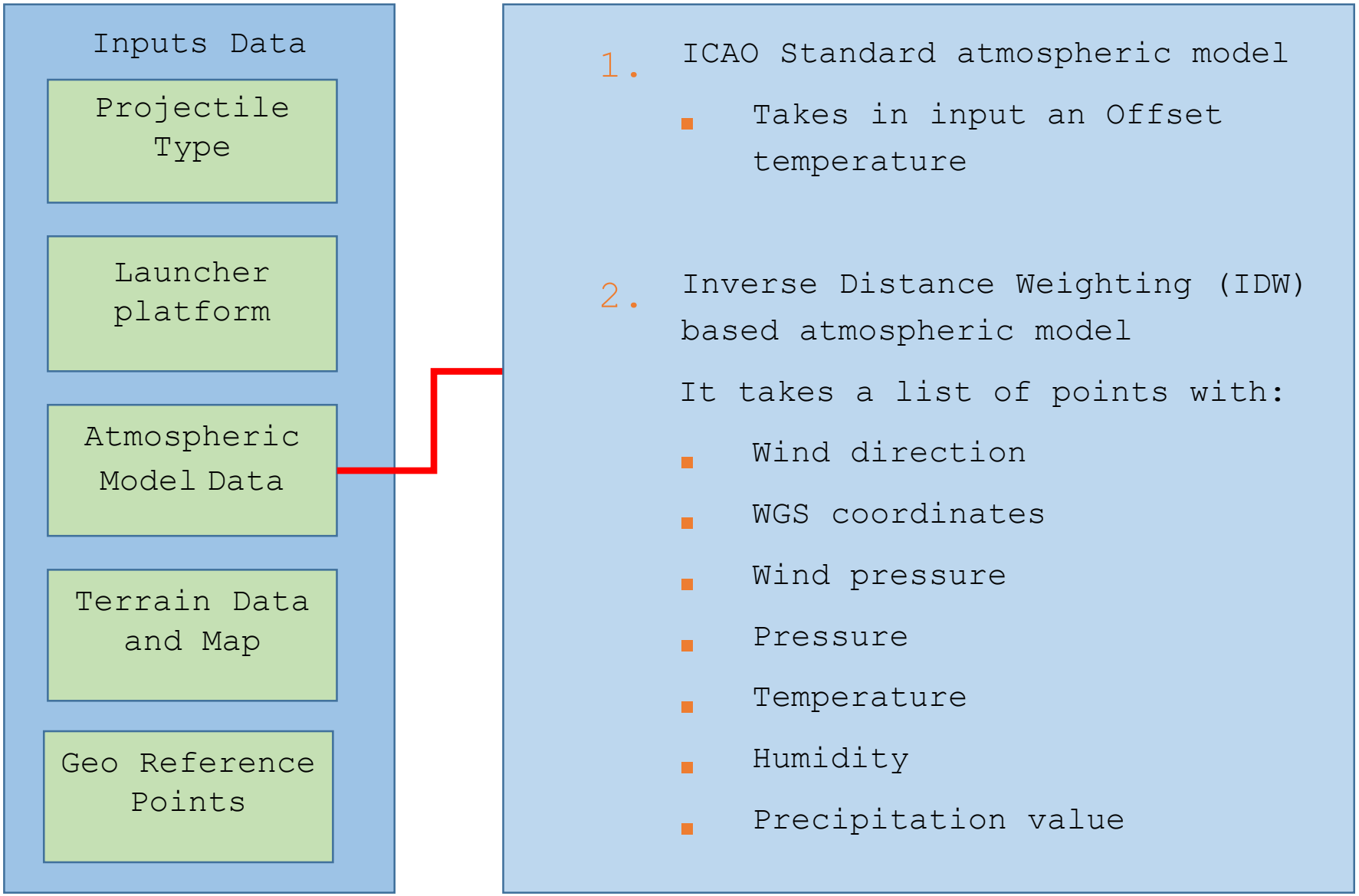
The Ballistic predictor has implemented a launcher platform model. Some of the parameters defined in this model are in the list below:



The Ballistic Predictor

Inputs parameters- Atmospheric models and their parameters

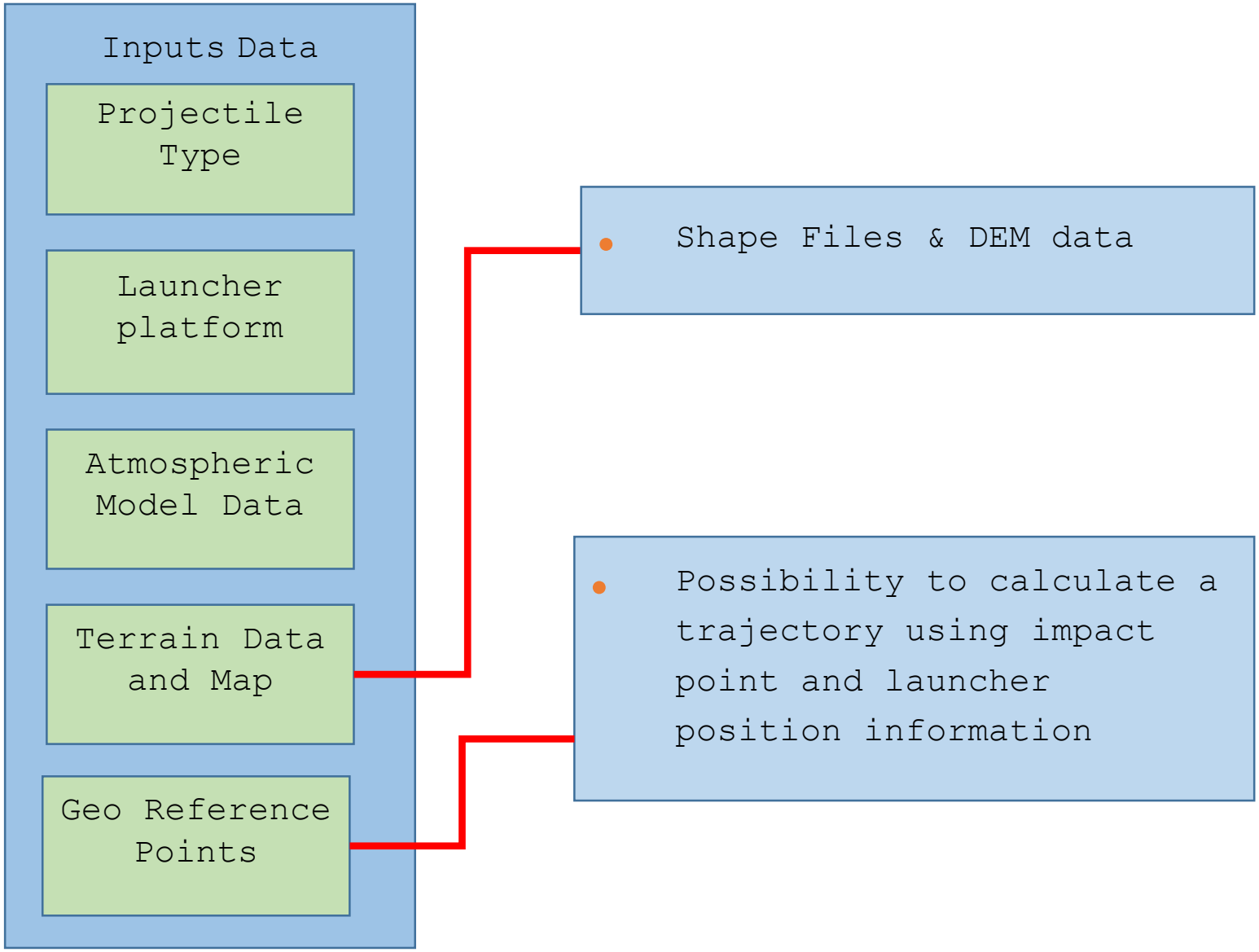
The Ballistic predictor has implemented two types of Atmospheric model :



The Ballistic Predictor

Inputs parameters- Atmospheric models and their parameters

The Ballistic predictor can take as input Terrain information and Geo Reference points:



Ballistic Predictor Output

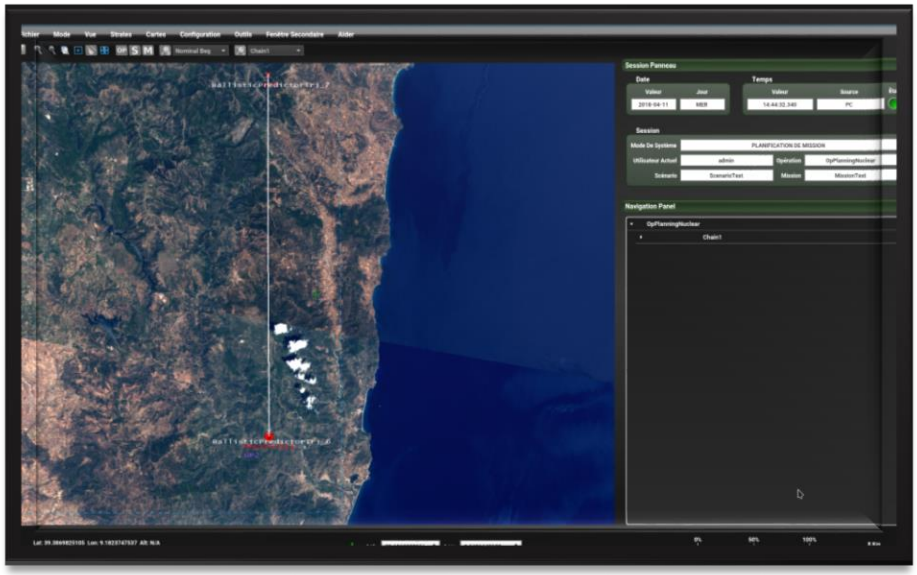
The Ballistic predictor gives as output a mission customizable report with the following information:

- Trajectory position data in different coordinates system (WGS, UTM, WRS etc.)
- Velocity data in m/s
- Impact point position info
- Time of impact Height max
- Drift at impact
- Angle of Fall
- Velocity at Gaze
- Other customizable output data

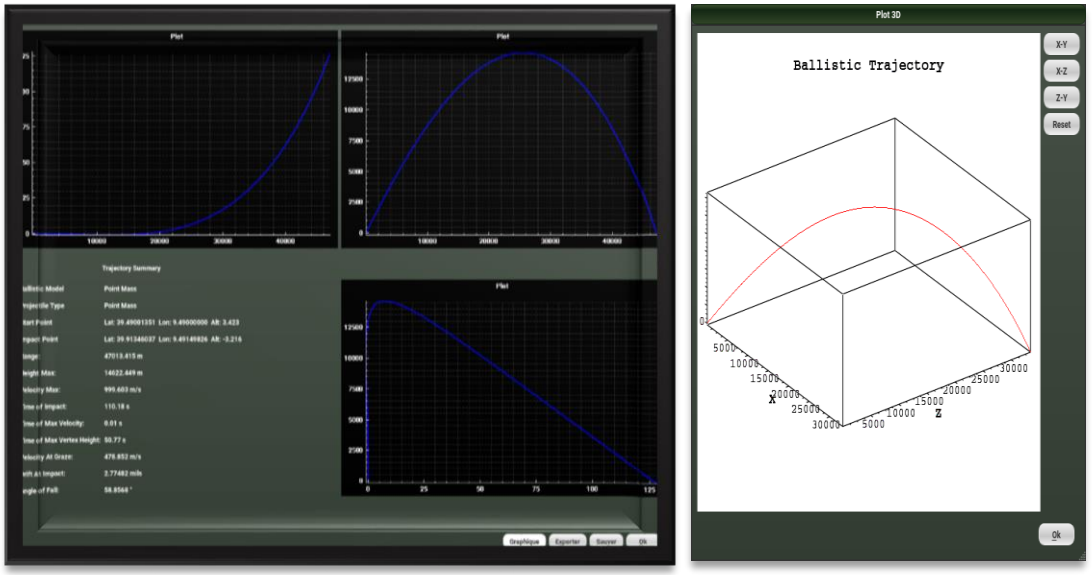
The Ballistic Predictor

Inputs parameters- Atmospheric models and their parameters

Ballistic Predictor Output



Ballistic Predictor - Trajectory Estimated



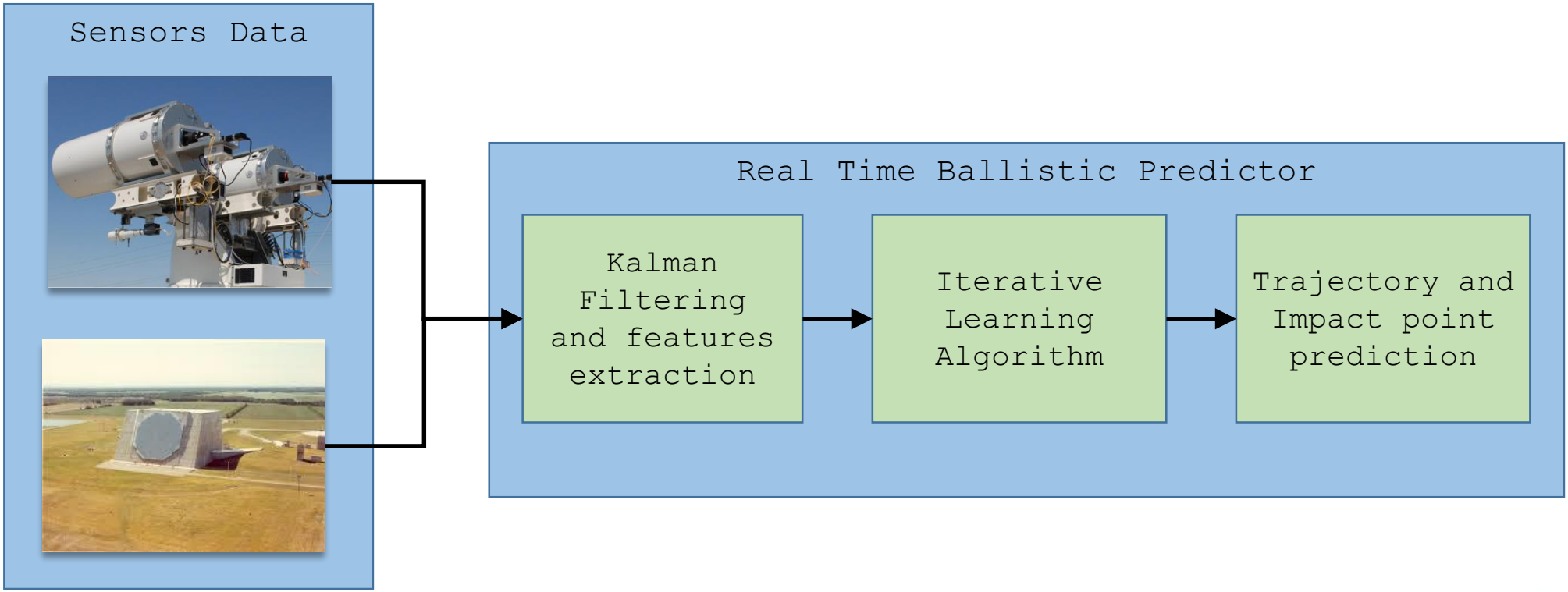
Ballistic Predictor - Output Data

The Ballistic Predictor

Ballistic Predictor mode: Real-time test range applications

Real-Time Ballistic Predictor

The Ballistic Predictor in a realt-time application use the sensors data to calculate a more accurate ballistic trajectory, using a proper dynamic model and an iterative learning algorithm.



The Ballistic Predictor

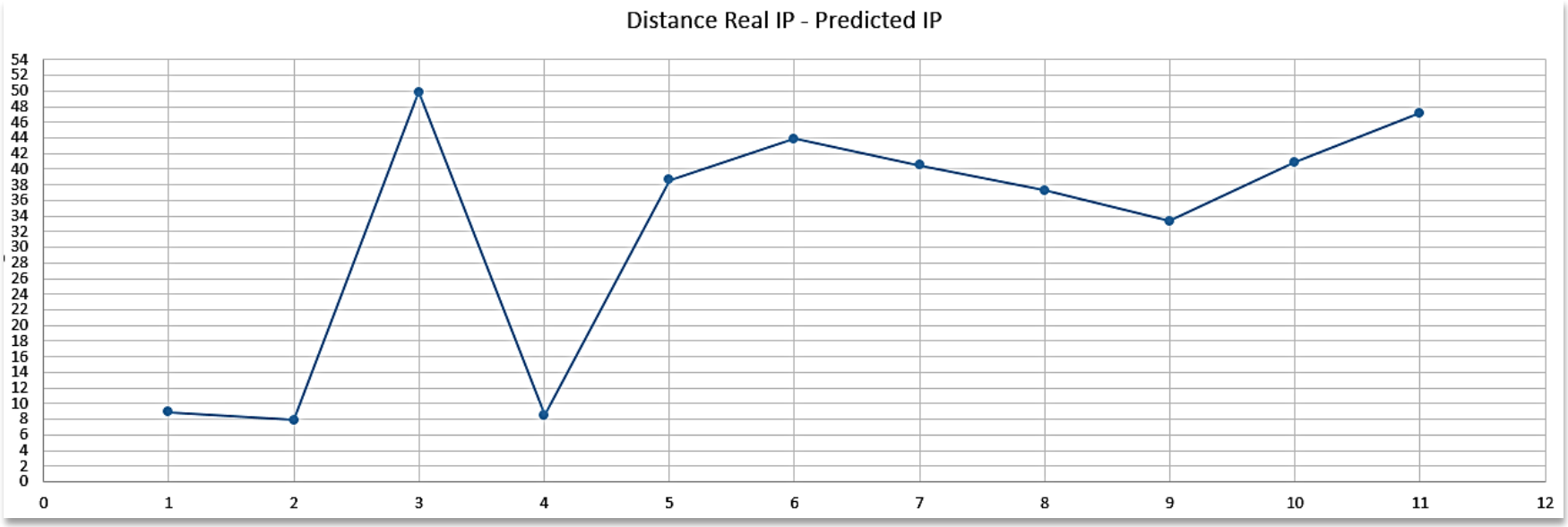
Ballistic Predictor mode: Real-time test range applications

Real-Time Ballistic Predictor

Real-Time Ballistic Predictor for splash detection

Real-Time Ballistic Predictor

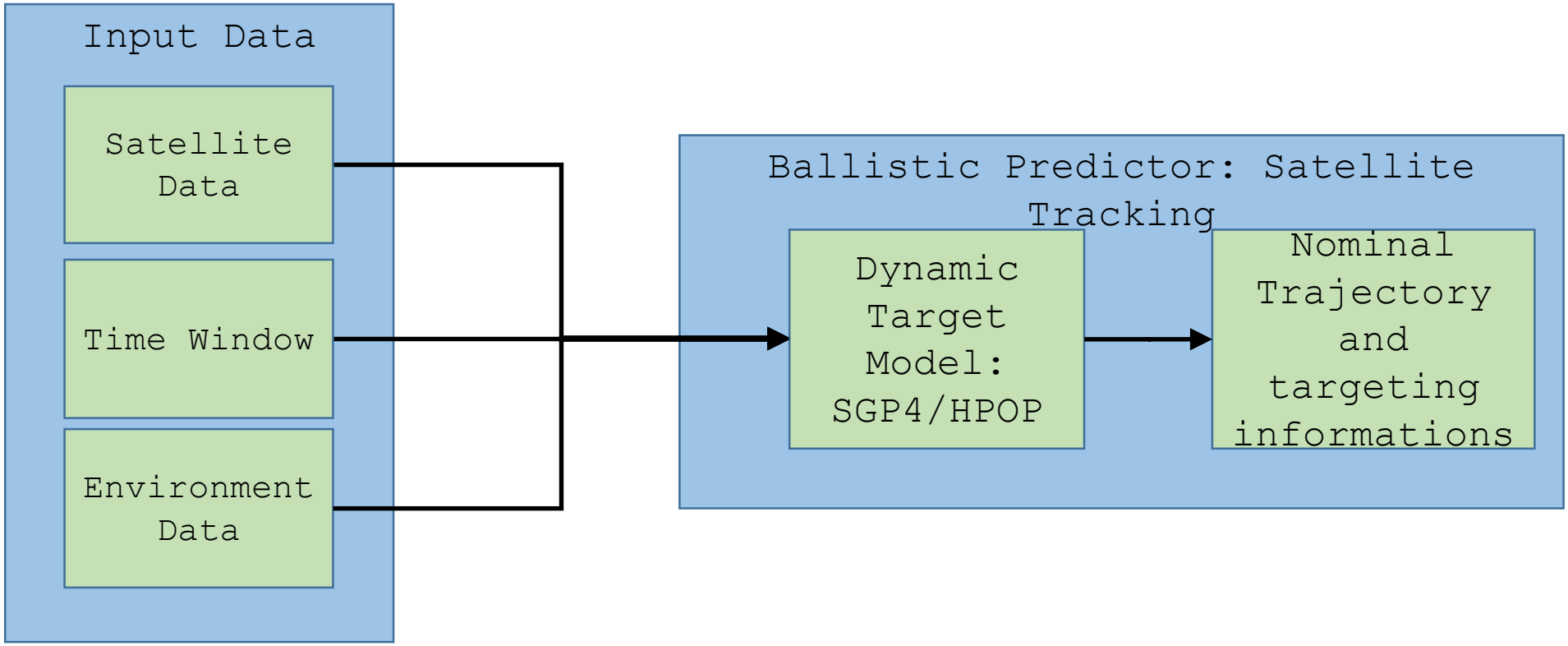
The Ballistic Predictor in a real-time application commits a mean discrepancy around 30 meters (predicted 10 sec before impact) as can be seen in the image below. The data shown are from a real Ballistic test-range campaign.



Discrepancy distance in meters

Ballistic Predictor for satellite tracking

The Ballistic Predictor has implemented all the dynamic model to calculate the trajectory of an object orbiting around the Earth



Ballistic Predictor for satellite tracking: Input Data and Orbit Propagators

The inputs and the perturbation evaluated depends on what Orbit Propagator is choosen by the user.

✓**The Simplified General Perturbations model**(SGP4) use as input:

- Two Lines Elements (TLE) [Data Input]

And takes in account inside the algorithm models about:

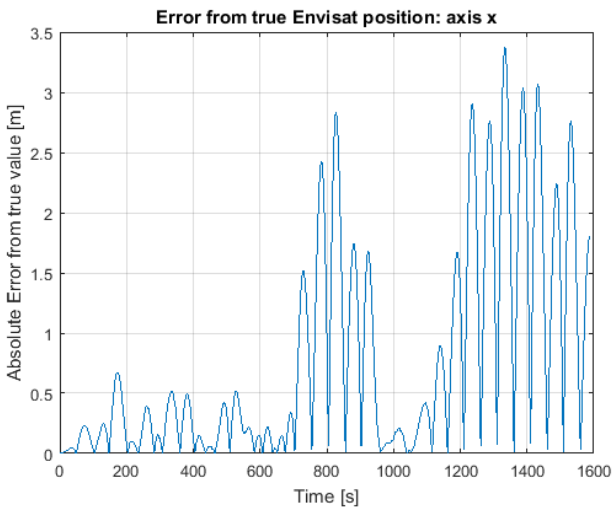
- gravitational effects
- Solar radiation
- Earth shape

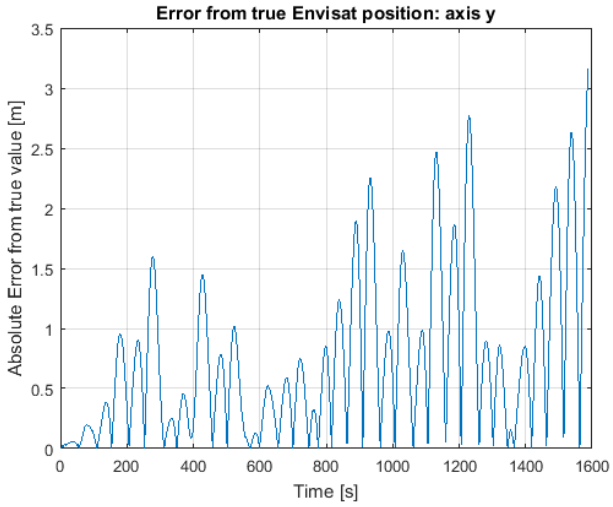
✓**High Precision Orbit Propagator** (HPOP) use as input:

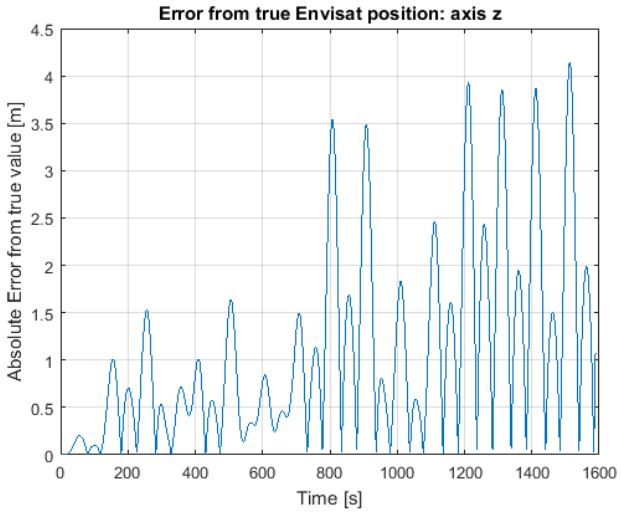
- Satellite Ephemeris data (From Orbit Determination Tool)
- Earth gravity Fields coefficient and orientation parameters
- Space weather data
- Solar radiation
- Earth shape informations
- gravitational effects from the solar systems bodies

Ballistic Predictor for satellite tracking: HPOP Errors

The HPOP errors are calculated using Envisat real positioning data and are all below 5 meters:





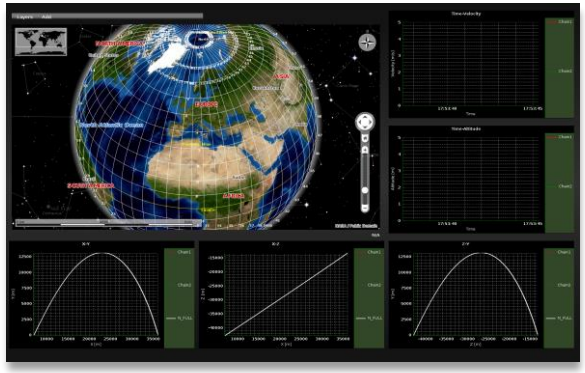


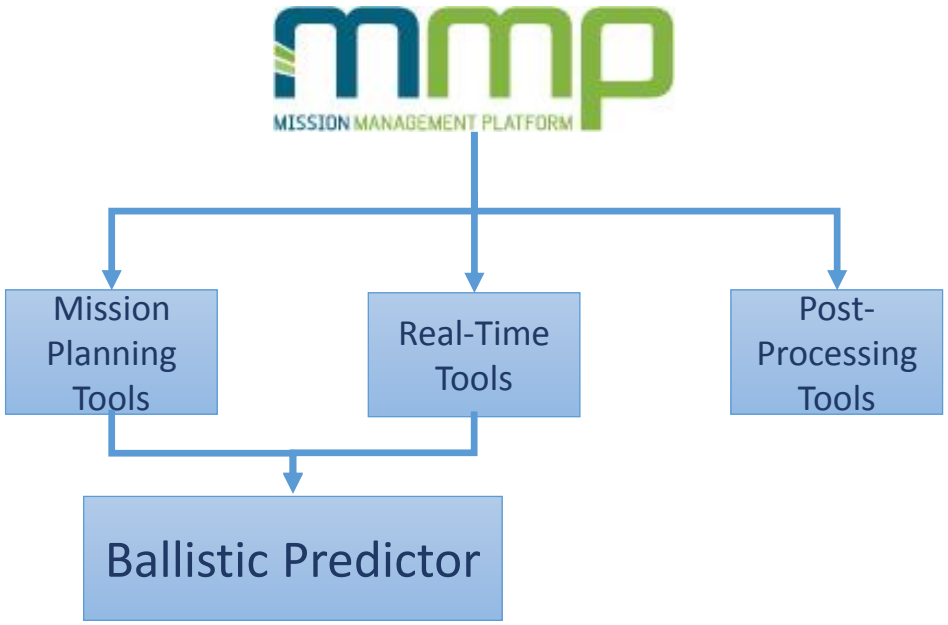
Mission Management Platform (MMP)
Tools areas Descriptions- Ballistic Predictor

The Ballistic predictor is a tool present in the NT Mission Management Platform (MMP):

Mission Management Platform (MPP)

The NT Mission Management Platform (MMP) is **a complete suite providing all the software packages for managing, configuring and launching missions.** The NT MMP is a framework that **can be installed in a modular multi sensor control system configuration** (MSCCS), without limitations regarding the number of Controller Working Position (CWP)





Contacts
Facilities

NT is located in a 1,500 sq m building in Cagliari, Sardinia (Italy), in one of the most beautiful places in the Mediterranean sea.

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