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Course Name Engineering and the Law - New Product Creation and Business Plan (2019-20)

Assignment Number/Name PRD Assignment

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Signed ZHANG LICHENG SUN BINGHUI

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***Ethical Consideration - Declaration (ECD)***

**Project Title:** PRD Assignment

**Student Name:** ZHANG LICHENG  
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**Student ID:** 2357767Z(UoG) 2017200602011(UESTC)  
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**Tutor Name:** Julien Le Kernec

**Ethical Gateway Questions** (Please answer the following questions.)

Does the study involve vulnerable participants or those unable to give informed consent? <i>(e.g. children, people with learning disabilities, your own students)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Does the study require permission of a gatekeeper for access to participants? <i>(e.g. schools, self-help groups, residential homes, hospitals)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Is it necessary for participants to be involved without consent? <i>(e.g. covert observation in non-public places)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Does the study involve sensitive topics? <i>(e.g. obtaining information about sexual activity, substance abuse)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Is blood, tissue samples or any other substances be taken from participants? <i>(e.g. blood, urine, stools, skin)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Does the study involve intrusive interventions? <i>(e.g. The administration of drugs, hypnosis, physical exercise)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Are financial or other inducements be offered to participants? <i>(With the exception reasonable expenses or small tokens of appreciation)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Does the study investigate any aspect of illegal activity? <i>(e.g. drugs, crime, underage alcohol consumption or sexual activity)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Will work reveal personally-attributable confidential information (written, audio or video), or cause undue distress, degrade personal dignity or infringe human rights? <i>(eg. Show characteristics of someone's personality, cause distressful emotions, participant will need to be stressed beyond what is considered normal for them, contacting people under threatening circumstances)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Does the work involve, environmental issues?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>

<i>(e.g. Relates to real life environmental judgements, such as climate change, species and habitat loss, and pollution.)</i>	
Does the work encompass the reviews of military conduct including the use of military weapons? <i>(e.g. Use of military force under a given set of political circumstances, raises issues regarding conduct of military forces in combat.)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Will the work present ethical problems for tutors, or the university, or participating companies or organisations? <i>(eg Will the work infringe intellectual property rights.)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Are (non-human) animals involved with the work? <i>(e.g. Might the work inflict physical or psychological cruelty, pain, disfigurement or unnecessary restraint)</i>	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>

If the answer to any of the ethical gateway questions above is "Yes", or if there are any other significant ethical issues, then further ethical consideration is required.

**In any proposal involving human participants clear explanation of how informed consent will be obtained, how confidentiality will be observed, how the nature of research and the means of dissemination of the outcomes will be communicated to the participants must be provided.**

Summarise below the ethical issues involved in the proposal and how these will be addressed.

**Summary of Ethical Issues**

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Signed (student): ZHANG LICHENG SUN BINGHUI	Date: 6/12/2019
Signed (Tutor):	Date:

## Overview

To apply what we have learnt in Engineering and the Law lecture and combine with our own scientific research in Ultra-wide Bandwidth Communication, our group came up with a product-A High-accuracy positioning system for autonomous vehicles. This preliminary investigate report includes a Products Requirements Document, a Market Analysis and a brief Preliminary Technical Assessment. It shows what our product is and how creative and competitive it is.

## Products Requirements Document

### Background

Recent several years, much has been discussed about autonomous driving. However, existing technology is not perfect enough to be used widely in real situations, due to GPS or computer vision are affected by environment, so that cannot provide accurate position fulltime. A high-accuracy and high reliability positioning system is needed. And that is exactly what our product aims to do.

### Product introduction

Our product is a positioning system which is able to provide a centimeter-level accuracy and millisecond-level delay localization, which is good enough to support autonomous driving in real situations. It constitutes three parts: base station, reference station, and mobile station. Base stations are installed on the roadside. They continuously transmit Ultra-wide Bandwidth (UWB) pulses to the mobile station which is installed on the car. The mobile station collects the UWB pulses from different base stations. By counting the Time Difference of Arrival (TDOA) of different pulses, the base station uses designated algorithm can compute the location and transmits the location to the car.

The simplified structure and working principle of our product are shown in *Figure1* and *Figure2*.

- Base station: the basic localization unit
  - settled on roads sides (for example, on streetlamps and communication base stations);
  - send UWB signals to reference station and mobile stations.
- Reference station: the manager of the system
  - one in each localization region;
  - responsible for the synchronization of base station and mobile station.
- Mobile station: the positioned target
  - installed on each car;
  - receive UWB signals from base stations, derive its location accordingly, and send position information back to server.

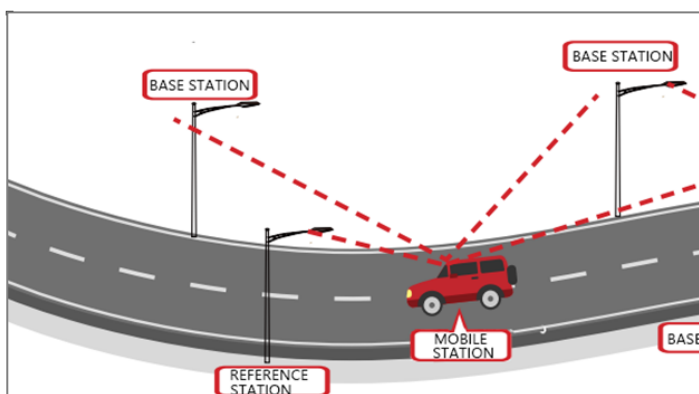


Figure1

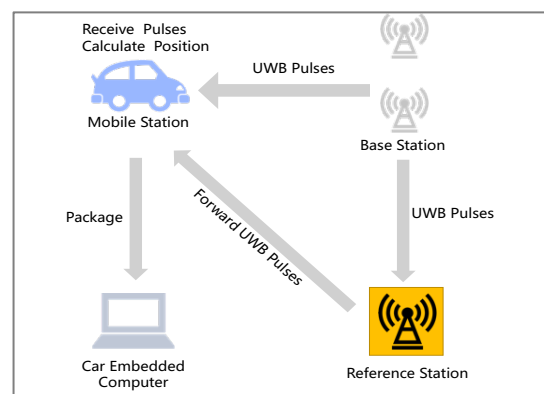


Figure2

## Main Performance Requirement

### ➤ Accuracy & Precision :

Autonomous vehicles should drive in its own lane and not on or across the lane divider. It is assumed that the width of common line divider is 10 centimeters. Therefore, the standard deviation ( $\sigma$ ) should be less than 5 centimeters.

### ➤ Refresh rate (Latency) :

The dynamic response of the car is controlled by constantly updated positioning data. The faster the car runs, the higher the refresh rate is required. Therefore, the refresh rate should be high enough with corresponding low latency to avoid accidents. The maximum car speed in the city is assumed to be 100 kilometers per hour. Combining the 10 centimeters assumption we have a lowest refresh rate of 280Hz.

### ➤ Capacity: unlimited receivers

## Product Feature

- Low cost
- Centimeter-level Accuracy
- Millisecond-level time delay
- High flexibility
- Full-time capabilities
- Infinite load capacity
- Strong anti-jamming capability

## Application Scenario

- Self-driving on urban roads

Based on reliable technology, autonomous driving on urban roads improves traffic efficiency.

- Logistics distribution

In large-scale warehouse and supermarket and other scenes, the autonomous driving robot can carry out goods accurately and efficiently.

- Shared transportation

Bus, airport bus and other modes of travel, where route is single, and road condition is simple, are suitable for driverless driving.

- Dangerous work situation

Many dangerous work situations are not suitable for drivers to enter, such as fire fighting, inflammable and explosive transportation, high pollution, high radiation areas, etc.

## Market Analysis

### PEST Analysis

**P(Political):** In recent years, Chinese government has attached great importance to the development of traffic situation. A government file called 'Medium- and long-term planning outline for 2020 in the 11th Five Year Plan for the development of information industry science and technology' pointed out that Intelligent transportation system should be a key development project. It is reported that Shanghai, Beijing there are already test zones for intelligent vehicles to verify.

**E(Economic):** As the second largest economy in the world, the rapid development of China's economy not only improves the living standards of the people, but also improves the people's requirements for the quality of life. And vehicle ownership continues to grow rapidly in China. That also means the demand for autonomous vehicles and positioning technology is huge.

**S(Social):** The technology of autonomous driving under accurate positioning can effectively

alleviate urban traffic accidents. A recent study by RAND Corporation found that compared with human driving, if self-driving cars increased by 10%, then there will be thousands of lives be saved every year. And according to a researcher at Rutgers University Camden, even if autonomous vehicles account for only 5% of traffic, it can improve traffic flow.

**T(Technological):** The existing technology solutions is not perfect enough, and the result of comparison to the technology of our product as shown in *Figure3* indicates many advantages.

Index Solution	Accuracy	Real-time refresh	Reliability	Cost
UWB	5cm	2000Hz	Full-time	4,000 \$ per machine
Laser slam	5cm	20-30 Hz	Affected by weather	100,000 \$ per machine
Computer vision	50cm	10 Hz	Affected by weather	4,000 \$ per machine
G N S S (Global navigation satellite system)	50cm	50-100 Hz	Affected by obstacles	2,000-3,000 \$ per machine (the cost of satellites is not included )

*Figure3*

## STP Model of Marketing

**S(Segmentation) → T(Targeting) → P(Positioning)**

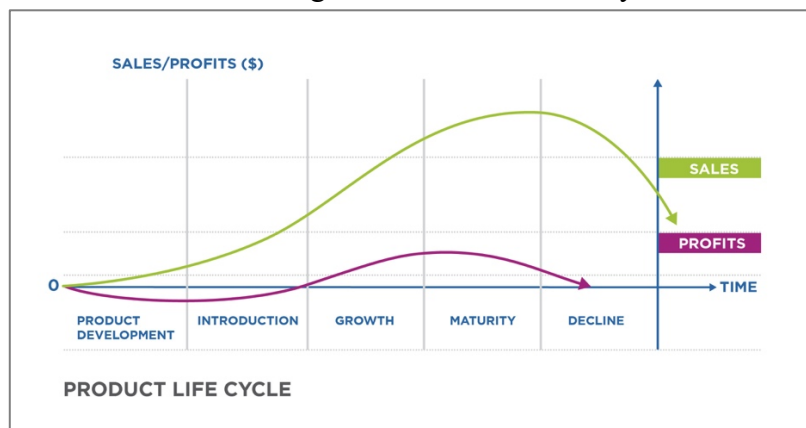
**Market Segmentation:** Combined with two main indexes of positioning system: positioning accuracy and access capability. The market is mainly divided into four categories: high accuracy and high access capability market, high accuracy and low access capability market, low accuracy and high access capability market, and low accuracy and low access capability market.

**Target Market:** The target market of our product is mainly the market with high positioning accuracy and high access ability, which can meet the accuracy requirements of the market for its positioning system and further promote the market.

And Target customer can be classified as below:

- Car Manufacturer (Volkswagen AG, Toyota, etc.)
- Mobile Network Provider (China Mobile, AT&T, etc.)
- Some Manufacturer in specific area (warehouse, airport, etc.)

**Market Positioning:** In the target market of high accuracy and high access ability, our product is aimed to provide the optimal solution for the accurate positioning of autonomous driving with high refresh rate, smooth continuation and strong anti-interference ability.



*Figure4*

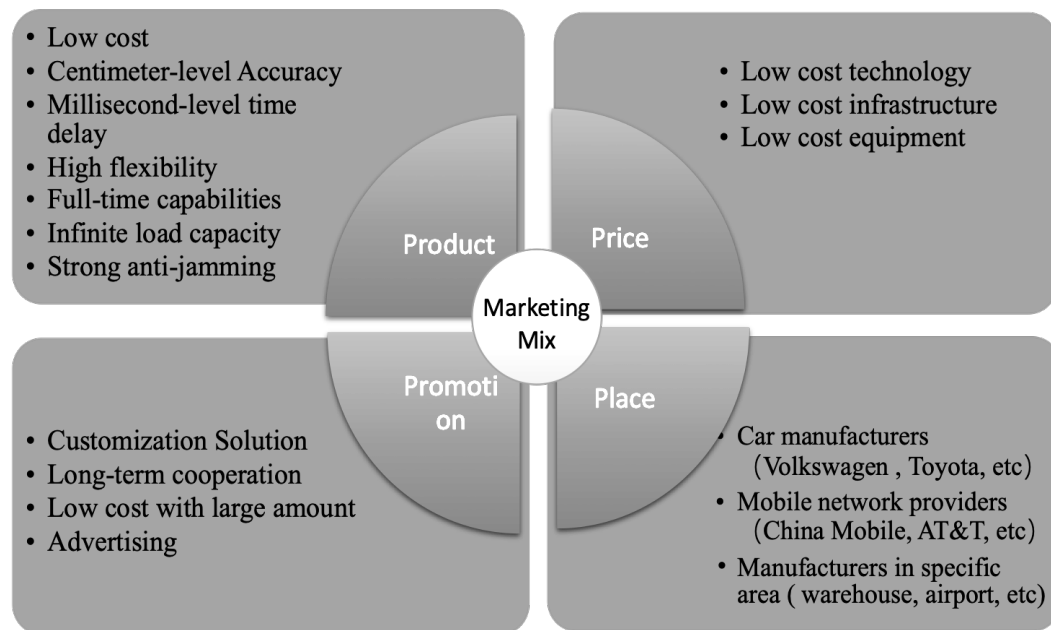


**Market Size:** By the end of 2016, China's total highway mileage was 4.577 million kilometers, according to the ministry of transport's statistical bulletin on the development of the transportation industry. In 2017, China sold 29.12 million vehicles.

With consideration of product lifetime and product life cycle (as shown in *Figure4*), it is easy to calculate the prospective earnings. If our base station product can be settled on roads every kilometer as required, and it occupies 10% market, we can obtain more than 10 billion revenue. Additionally, if our product holds 10% of vehicle market and in terms of price of mobile station product 2000 yuan per, the annual revenue is estimated to be over 10 billion yuan.

## 4Ps Marketing Mix

We analyzed the marketing mix among Product, Price, Promotion, and Place, and summarized it as below:



## SWOT Analysis

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>• High-accuracy and low-delay achieve the first-class level in the industry;</li> <li>• Vehicle can obtain its location information in real time and full-time work;</li> <li>• Under the same level of positioning accuracy, the price of the product much lower.</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>• Brand is not popular enough;</li> <li>• The capital chain may be broken due to insufficient capital;</li> <li>• The future technology iteration in autonomous driving is likely to be squeezed by enterprises with huge resources.</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>• The existing positioning system is difficult to achieve the requirements of high-accuracy and low-delay for positioning;</li> <li>• With the increasing attention in the field of automatic driving, the realization of automatic driving is just around the corner.</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>• Many large enterprises invest in technology research, which is easy to be imitated or even replaced by new technology with rapid iteration;</li> <li>• The public's acceptance of autonomous driving is still not enough.</li> </ul>



## Competitor Comparison

We studied some competitors in similar positioning filed, and made a comparison table as below, where we concluded that our product is competitive comparing to existing competitors.

Index Competitor	Technology	Real-time refresh	Continuation	Anti-interference
<b>Our product</b>	<b>UWB</b>	<b>2000Hz</b>	<b>Smooth</b>	<b>Strong</b>
Timedomain	UWB	500Hz	Smooth	Weak
ubisense	UWB	200 Hz	None	Weak
Baidu IDG	Radar SLAM	/	/	Weak

## Brief Preliminary Technical Assessment

Our product combines Ultra-Wide Band (UWB) technique and Time Difference of Arrival (TDOA) algorithm for positioning.

The Ultra-Wide Band (UWB) signal has a wide bandwidth in frequency domain and is therefore a short impulse in time domain. Unlike spread spectrum technologies, UWB signals transmit in a manner that do not interfere with other conventional narrowband signals, including WIFI, LTE and et... It can share spectrum with other users both in theory and in practical.

The Time Difference of Arrival (TDOA) algorithm is applied to calculate the car's position. As different base stations are at different distances to the car, the UWB signal arrive at the receiver i.e. the car, at different time. Based on the TDOA and the priori position knowledge of all base stations, the position of the car can be derived.

## Reference

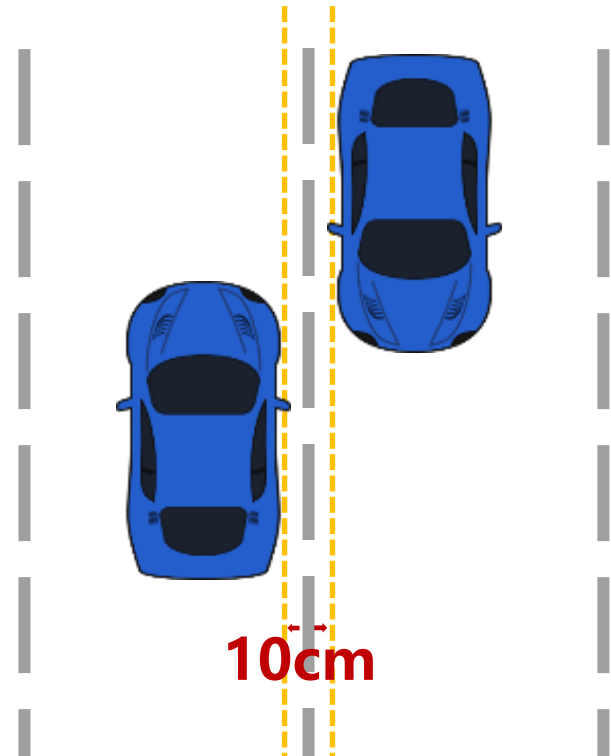
- [1] I. Oppermann, UWB Theory and Application. John Wiley & Sons, Ltd.,2004;
- [2]C. Carbonelli and U. Mengali, "Synchronization algorithms for UWB singals," IEEE Trans. Commun., vol. 54, pp. 329-337, Feb. 2006;
- [3] Asif Iqbal Mohammad Faisal, Tan Yigitcanlar, Md. Kamruzzaman, Graham Currie, Understanding autonomous vehicles: A systematic literature review on capability, impact, planning and policy,Journal of Transport and Land Use 12(1) · January 2019;
- [4] Gonzalo De La Torre, Paul Rad, Kim-Kwang Raymond Choo, Driverless vehicle security: Challenges and future research opportunities, Elsevier, 2018;
- [5]<https://www.mma-fl.com/how-will-self-driving-vehicle-technology-affect-congestion-and-accidents/>;
- [6]<https://courses.lumenlearning.com/ivytech-introbusiness/chapter/reading-stages-of-the-product-life-cycle/>;
- [7] <http://usa.baidu.com/adu/>;
- [8]<https://www.idtechex.com/en/research-report/multifunctional-composites-2019-2029-technology-players-market-forecasts/630>;
- [9]<https://www.ubisense.net>.

# Pain Point

Autonomous vehicles are not applied widely in real situations, due to existing solutions cannot provide accurate and fulltime positioning.

A high-accuracy and high reliability positioning system is needed. And that is exactly what our product aims to solve.

- Traffic intersection 10cm
- Time resolution 5ms  
(80KM/H speed)
- Complex condition High-reliability



# Comparison

Index Solution	Accuracy	Real-time refresh	Reliability	Cost
<b>UWB</b>	<b>5cm</b>	<b>2000Hz</b>	<b>Full-time</b>	<b>4,000 \$ per machine</b>
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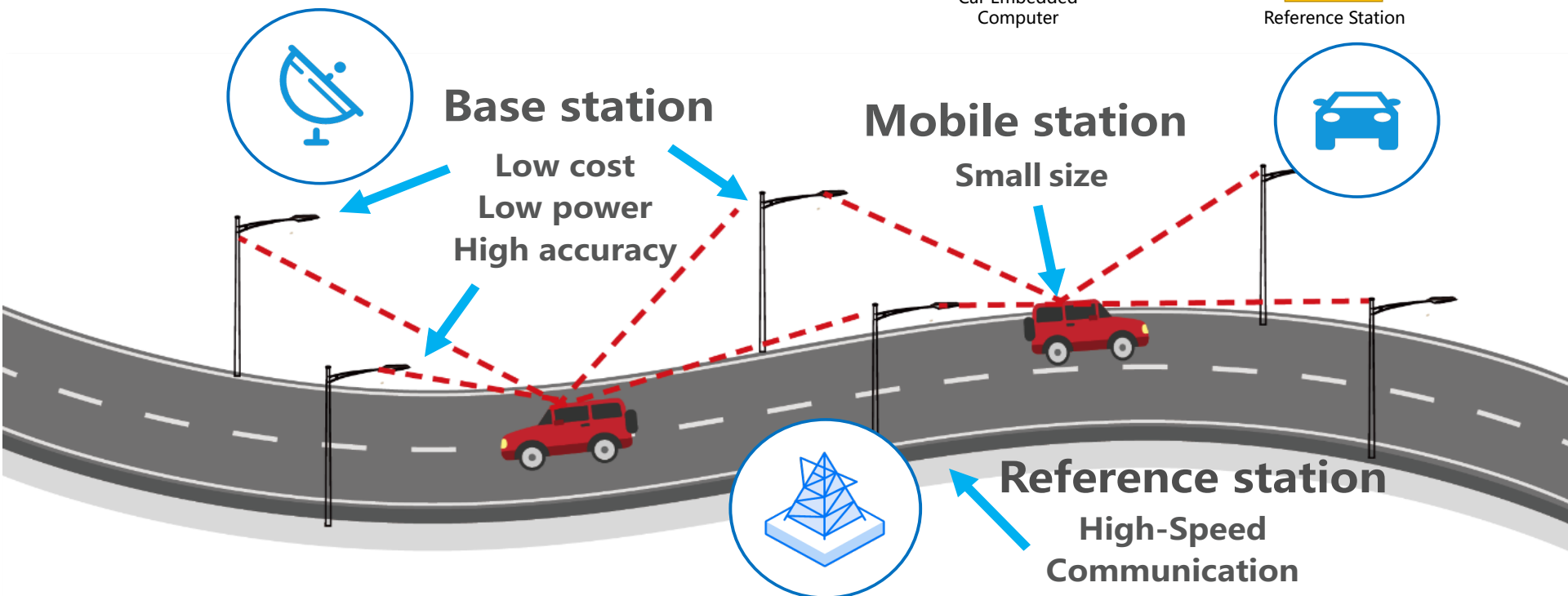
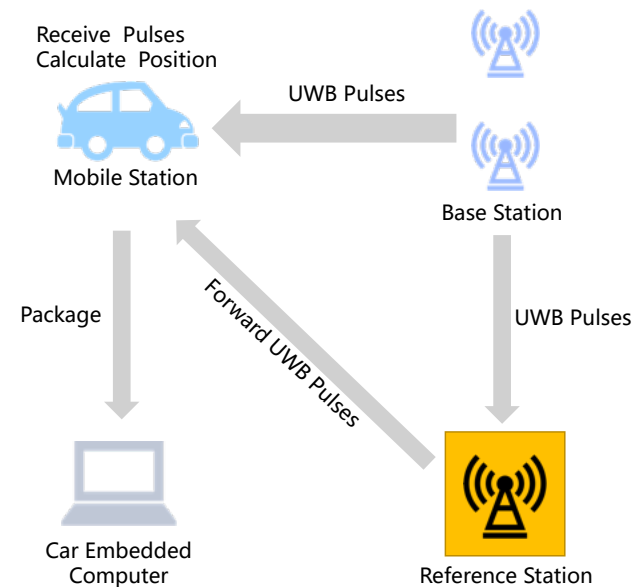
## Comparison with existing solutions

Index Competitor	Technology	Real-time refresh	Continuation	Anti-interference
<b>Our product</b>	<b>UWB</b>	<b>2000Hz</b>	<b>Smooth</b>	<b>Strong</b>
Timedomain	UWB	500Hz	Smooth	Weak
ubisense	UWB	200 Hz	None	Weak
Baidu IDG	Radar SLAM	/	/	Weak

## Comparison with existing companies

# Our Solution-A High-accuracy Positioning System for Autonomous Vehicles by Ultra Wide Band

- Centimeter-level Accuracy
- Millisecond-level time delay
- Low cost
- Full-time capability
- Infinite load capacity
- Strong anti-jamming capability



# Why it will win?

## Strengths

- High-accuracy and low-delay achieve the first-class level in the industry;
- Vehicle can obtain its location information in real time and full-time work;
- Under the same level of positioning accuracy, the price of the product much lower.

## Weaknesses

- Brand is not popular enough;
- The capital chain may be broken due to insufficient capital;
- The future technology iteration in autonomous driving is likely to be squeezed by enterprises with huge resources.

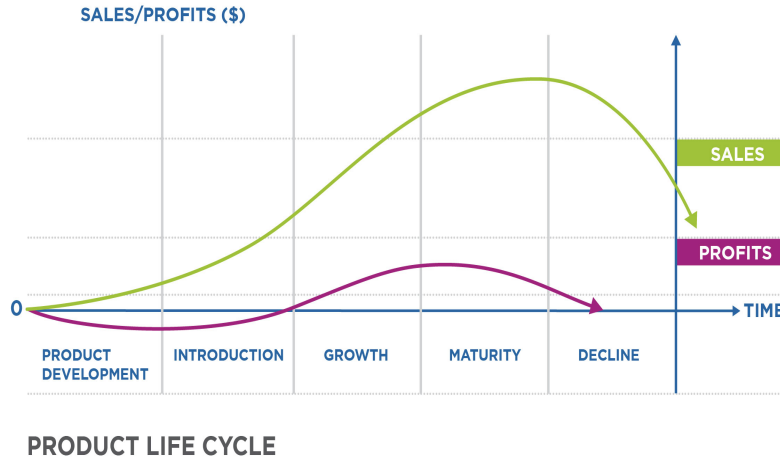
## Opportunities

- The existing positioning system is difficult to achieve the requirements of high-accuracy and low-delay for positioning;
- With the increasing attention in the field of automatic driving, the realization of automatic driving is just around the corner.

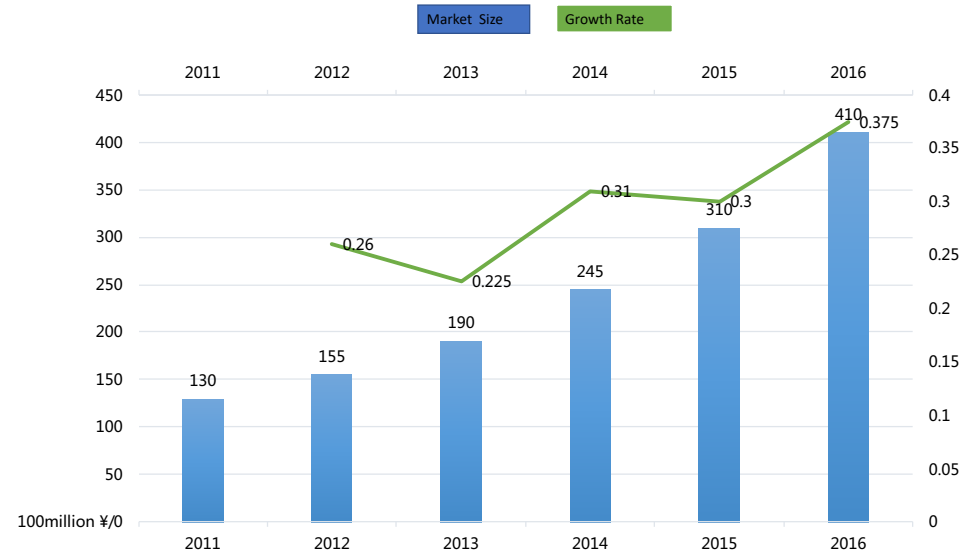
## Threats

- Many large enterprises invest in technology research, which is easy to be imitated or even replaced by new technology with rapid iteration;
- The public's acceptance of autonomous driving is still not enough.

# Market Size



2011-2016 Urban land Transportation Market Size



**Year 1**

**Some special places**(shuttle bus in the campus and airport, warehouse logistics in the industrial park.....)

The viral engine of growth.  
**Market size:** Orders in the millions (to provide enough fund guarantee for next step)

**Year 2~3**

**RSU** (Road side unit):cooperate with Unicom and mobile operator  
**OBU**(On board unit):cooperate with vehicle manufacture (SAIC,BAIDU)

The viral engine of growth  
**Market size:**10,million

**Year 4~8**

Cooperate with unicom and mobile in the first-tier in china, and try to establish network and cooperate continuously  
 The sticky engine of growth

