

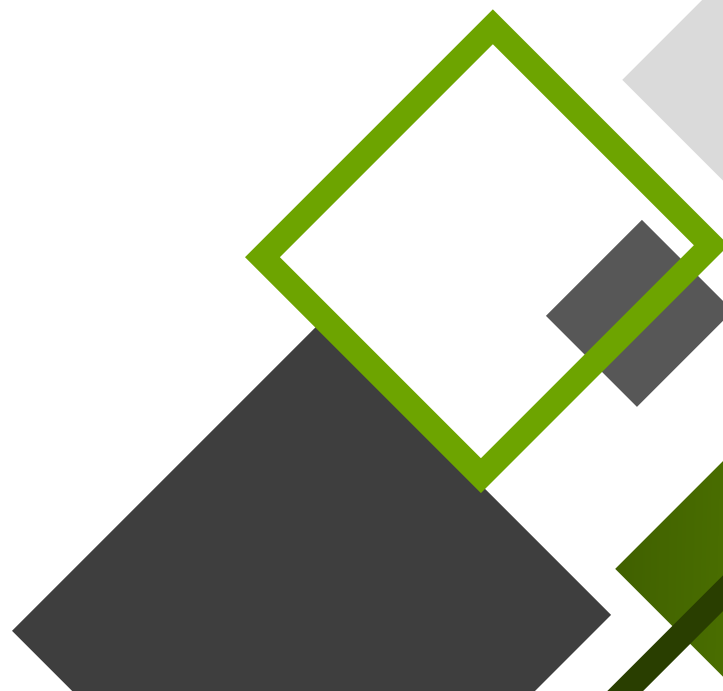
GPS

An **Unmanned aerial vehicle** (UAV) is a Unmanned Aerial Vehicle. UAVs include both autonomous (means they can do it alone) drones and remotely piloted vehicles (RPVs). A UAV is capable of controlled, sustained level flight and is powered by a jet, reciprocating, or electric engine.





GPS 개요



GPS 란?

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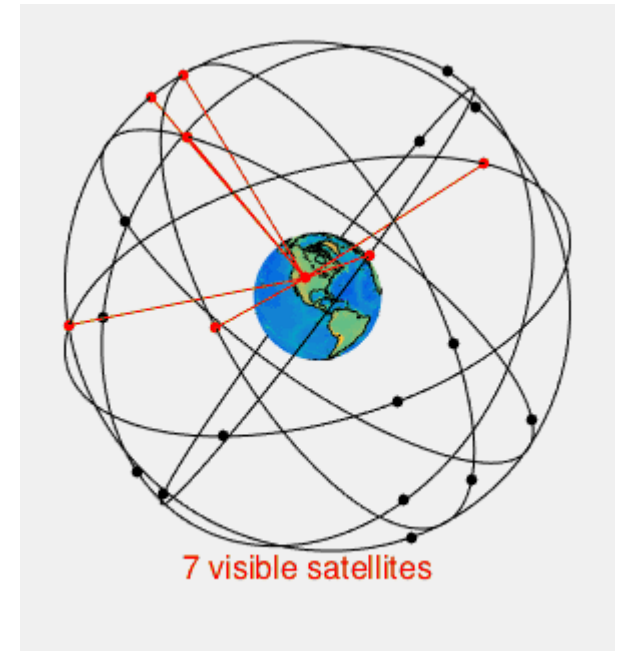
■ GPS(Global Positioning System)

- 인공위성을 이용하여 지구상의 절대 위치를 알아내는 시스템

■ 역사

- 1970년대 DoD가 제안 NAVSTAR(NAVigation Satellite Timing And Ranging)이라 부름
- 1978년 군사용 첫 위성 발사
- 1980년대 민간 용도로 확대
- 1994년 위성단 구축 완료
 - 지구상의 어떤 위치에서도 언제나 4개 이상의 위성이 보이도록 배치
 - 전체 24개의 6 궤도(21 active, 3 spare)

<https://commons.wikimedia.org/wiki/File:GPS24goldenSML.gif>



GPS의 특징

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■ NAVSTAR 서비스의 특징

- 24시간 365 무료 서비스
- 전지구적인 3차원 서비스 (극점 제외)
- 공통의 좌표사용 (WGS84 World Geodetic System 1984)
- 날씨에 무관

■ NAVSTAR외 시스템

- NAVSTAR 동등
 - GALILEO (EU), GLONASS(Russia)
- WAAS(Wide Area Augmentation System) 대응
 - EGNOS(EU), MSAS(Japan)

GPS의 구성

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■ Space segment

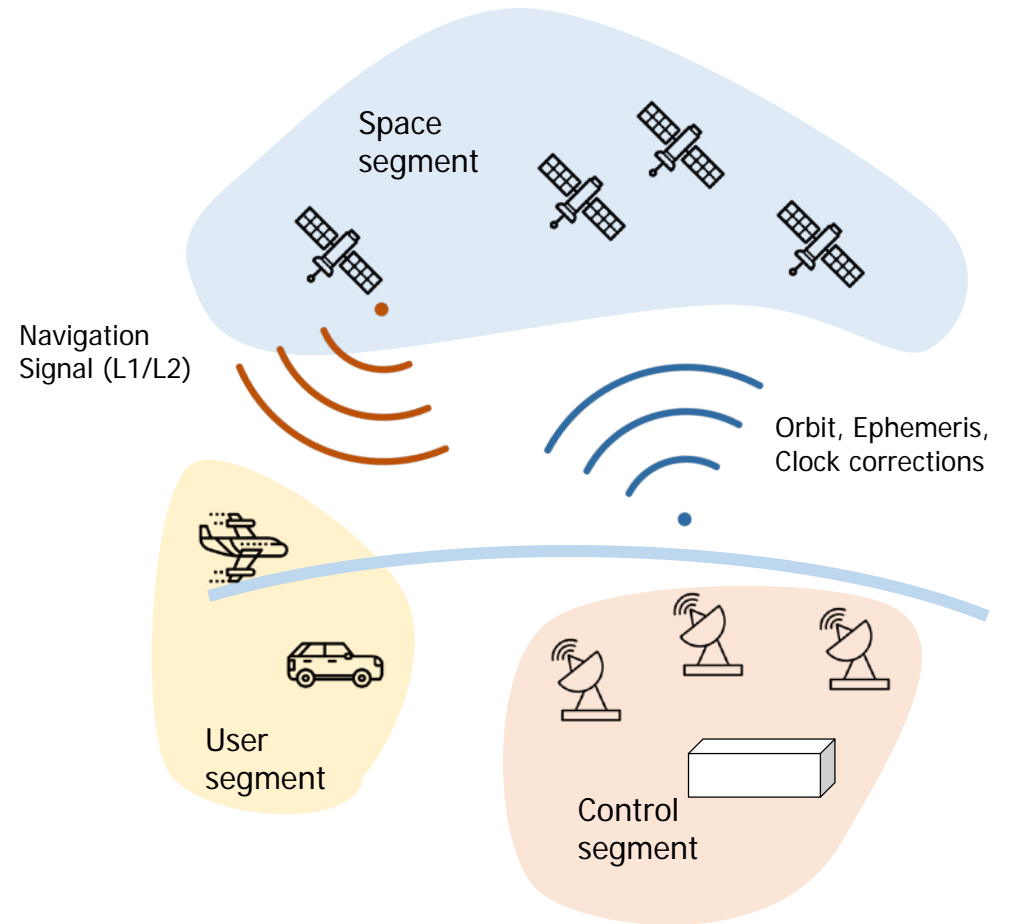
- 인공위성 24개로 구성된 성단
- 1궤도에 인공위성 4개
- 12시간마다 공전 (20,000 km)

■ Control segment

- 위성: 위치, 시간 보정
- 세계적으로 5군대 위치

■ User segment

- 사용자 위성 신호 분석
- $Distance = Velocity \times Time$



2차원 문제

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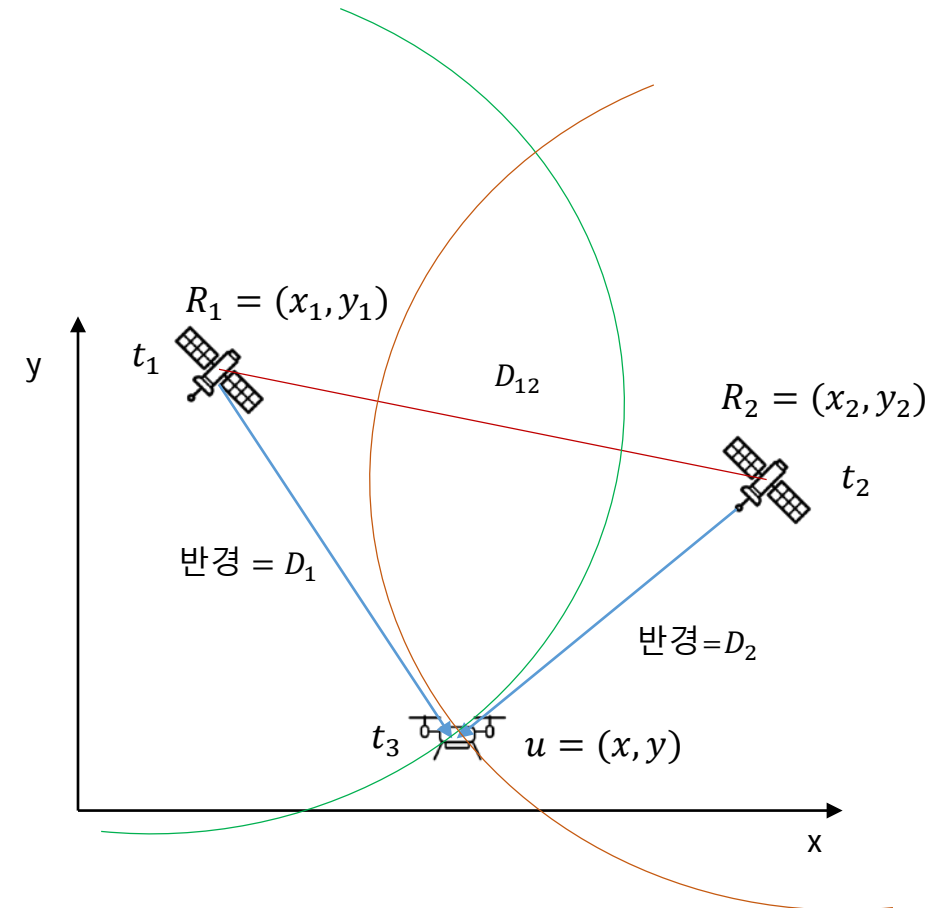
■ 2차원 평면에서 2개의 인공위성

• 가정

- S_1, S_2 의 위치 $(x_1, y_1), (x_2, y_2)$ 는 알고 있음
- S_1 은 t_1 시간에 S_2 는 t_2 시간에 자기 위치와 발신 시각을 전파로 전송

• triangulation 절차

- 수신장치 u 는 S_1, S_2 의 전파로부터 수신 시각 t_3 과 발신 시각 t_1, t_2 의 차이로 각각의 거리 R_1, R_2 를 계산
- 다음 2개의 식을 풀어 x, y 를 구함
 - $(x - x_1)^2 + (y - y_1)^2 = R_1^2$
 - $(x - x_2)^2 + (y - y_2)^2 = R_2^2$

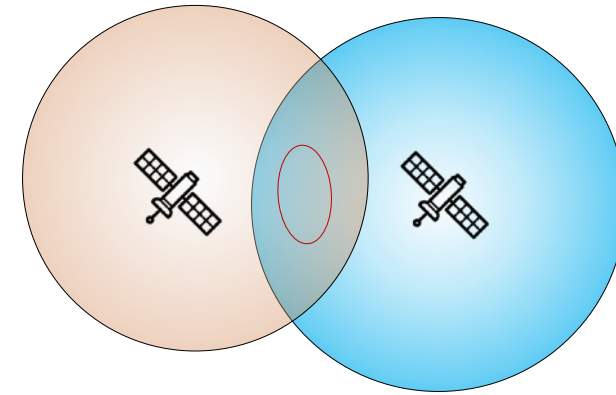


3차원 공간 문제

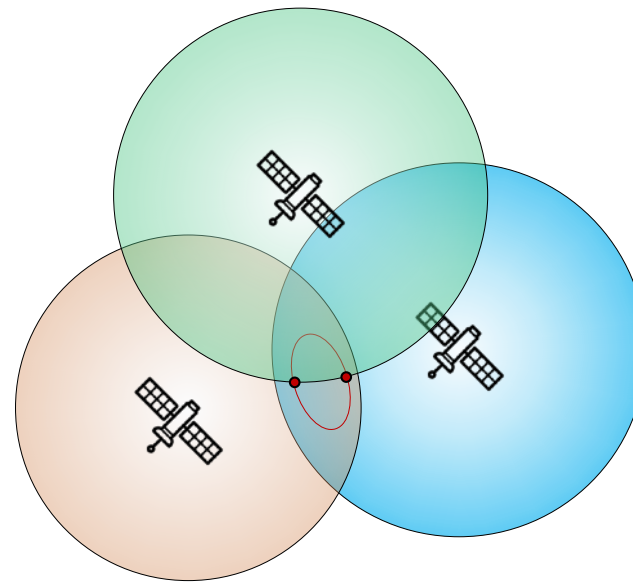
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■ 3차원 공간에서 n개의 인공위성

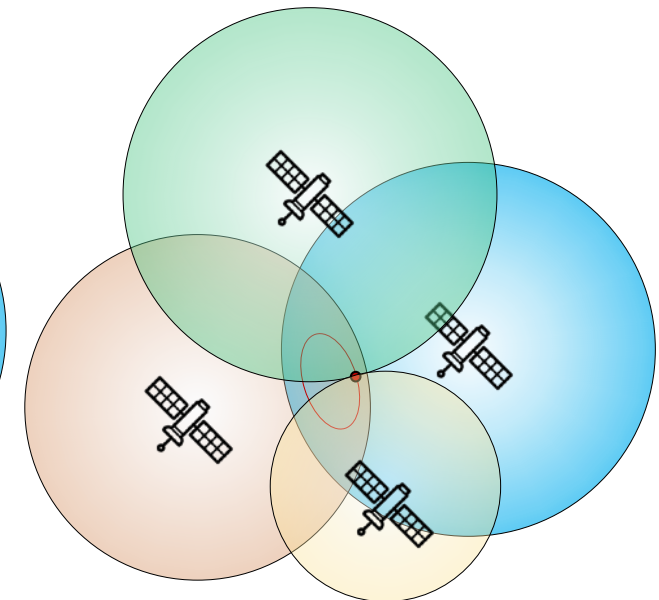
- 2개 구의 교점: 원
- 3개 구의 교점: 2개의 점
- 4개 구의 교점: 1개의 점
- 식 4개 미지수 3개
- 다음 식을 풀어 x, y, z 를 구함
 - $(x - x_i)^2 + (y - y_i)^2 + (z - z_i)^2 = R_i^2$
 $i = 1, 2, 3, 4$



2개의 위성 교점 : 원



3개의 위성 교점 : 두 점



4개의 위성 교점 : 한 점

인공위성의 주파수

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■ 기본 주파수

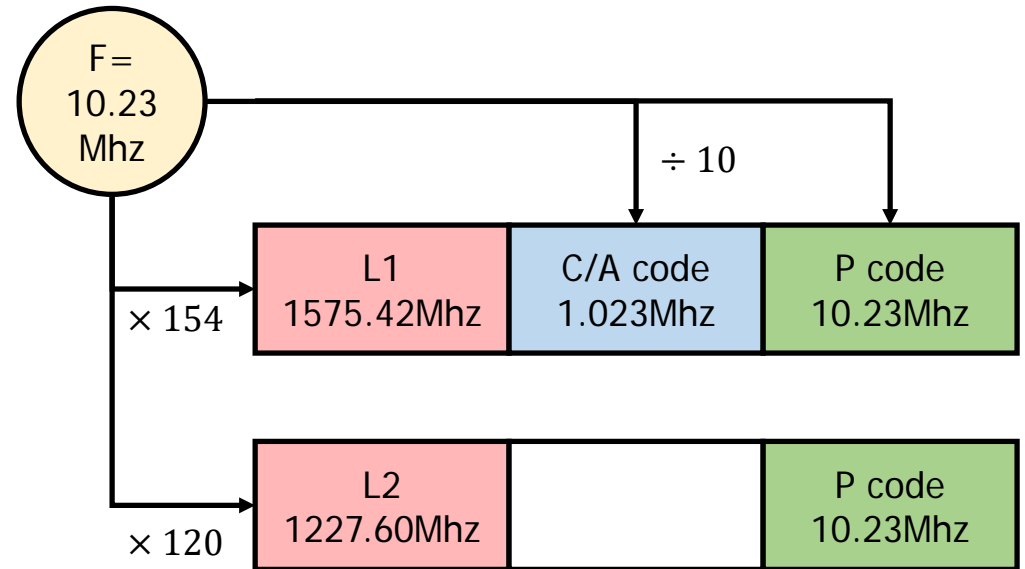
- 10.23Mhz

■ L1 주파수: 1575.42Mhz

- Coarse Acquisition (C/A) code
- Precision (P) code

■ L2 주파수: 1227.60Mhz

- Precision (P) code



GPS의 오차

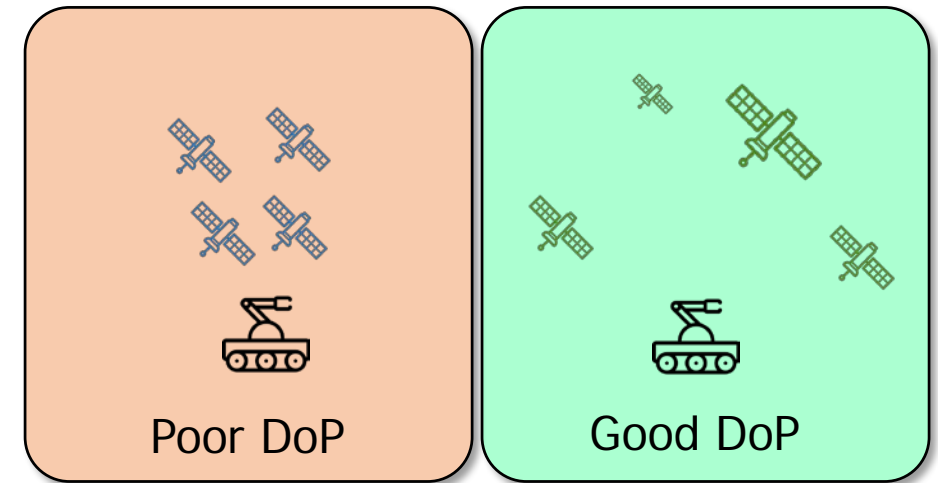
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■ DoP (Dilution of Precision)

- 위성의 기하학적 배치 때문에 나타나는 척도
 - 값이 작을 수록 좋음
 - HDOP - Horizontal Only
 - VDOP - Vertical Only
 - PDOP - Positional in 3D
 - GDOP - Geometric in 3D and Time

■ 오차 원인

- 위성: DOP (기하학적 배치, 가림)
 - DoD의 의도적 정밀도 저하. (2002년 이후 중지f)
- 수신기:
 - Clock 오차, 잡음
- 환경:
 - 대기의 전달 지연, 전리층(ionospheric)반사, Multi-path

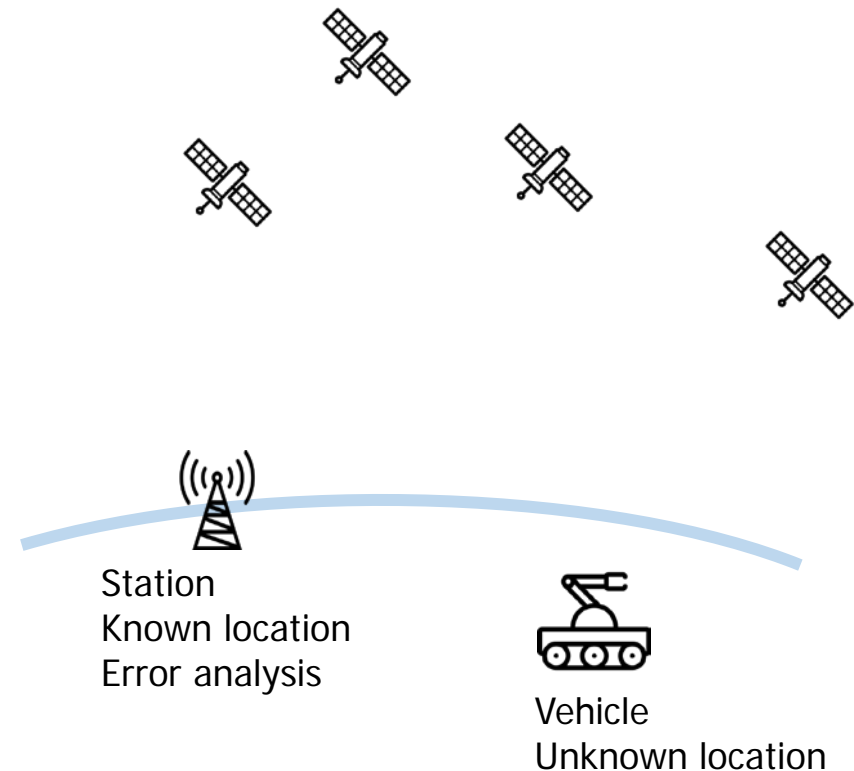


DGPS

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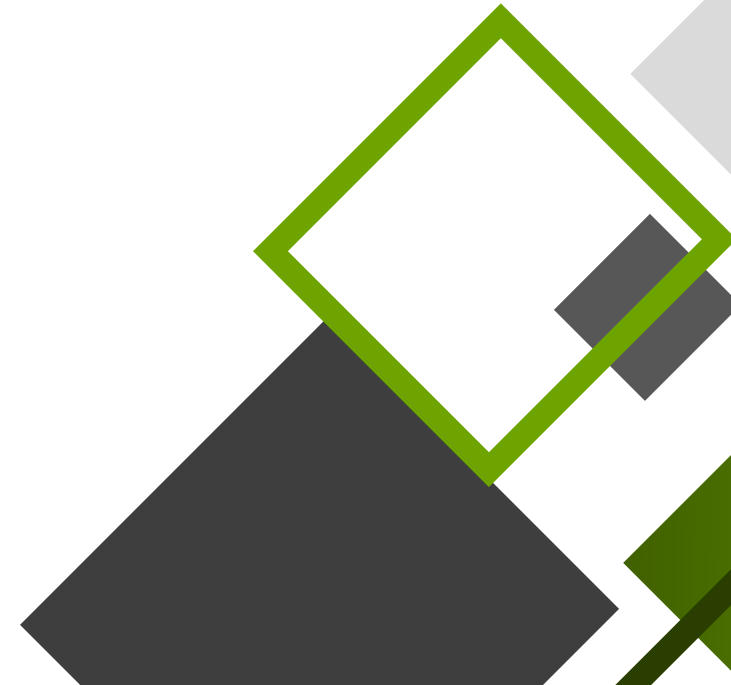
■ Differently Corrected GPS

- 위치를 알고있는 station 을 이용하여 오차 보정 데이터 계산
- 이 보정 데이터를 전송하여 이동체의 위치를 보정
- 정지궤도 위성(WAAS) 사용하는 경우도 있음.
- 정밀도 1m 이내까지





NMEA 프로토콜

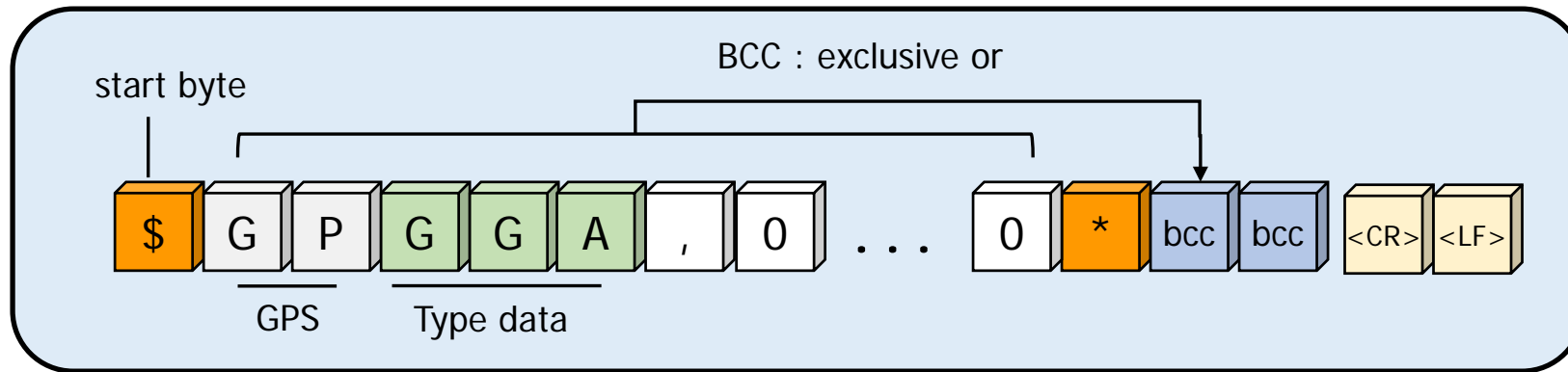


Protocol

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■ NMEA 0183

- National Marine Electronics Association에서 정의한 GPS, INS 용 프로토콜
 - '\$' 시작하고 BCC의 앞에는 '*' 를 붙임.
 - 항목들은 ','로 구분 하고 맨 뒤에는 <CR><LF>로 끝남



- 예

\$GPGGA,114455.532,3735.0079,N,12701.6446,E,1,03,7.9,48.8,M,19.6,M,0.0,0000*48

Protocol

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■ GGA Type 해석 예

- GGA: 시간, 경도, 위도, 고도 등
 - 시각: 113849.00 → 11:38:49.00
 - 위도: 3737.87564,N → 북위 37도37.87564분
 - 경도: 12704.56710,E → 동경127도 4.56710분
 - Fix의 종류: 0/위성 없음, 1/기본 위성, 2/DGPS
 - 사용 위성 개수: 11개
 - Horizontal DoP: 2.04
 - 해수면 고도: 72.8m
 - 지구를 구체와 타원체로 본경 우의 오차: 18.6m
 - DGPS 사용 시각과 기지국 ID: „0000
 - BCC: 0x60

GGA Type data

\$GPGGA,113849.00,

시간

3737.87564,N,12704.56710,E,2,

위도(latitude)

경도(longitude)

11,2.04,72.8,M,18.6,M,,0000*60

위성수

고도

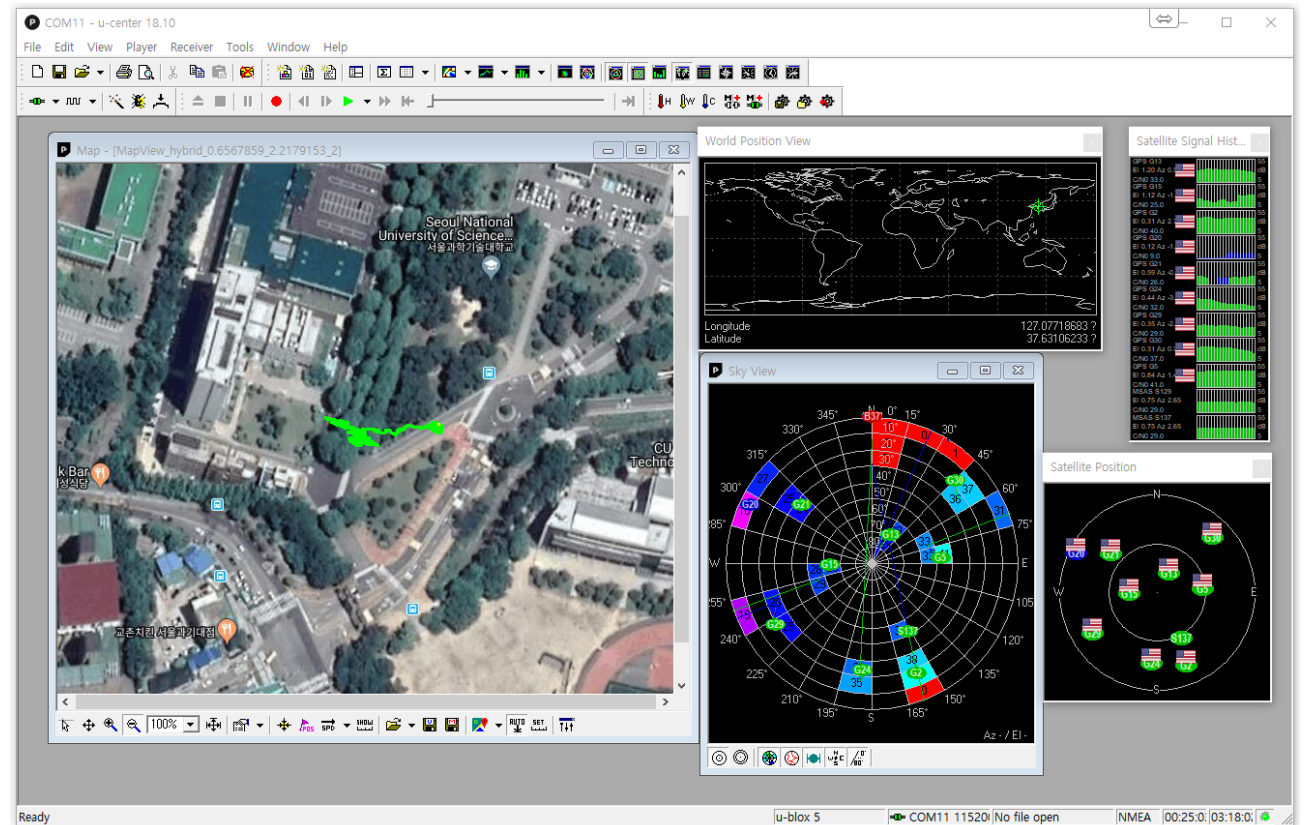
BCC

GPS 평가 소프트웨어

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■ u-center 프로그램

- GNSS 평가용
- NMEA 프로토콜
- 다양한 정보 확인가능
 - <https://www.u-blox.com/>



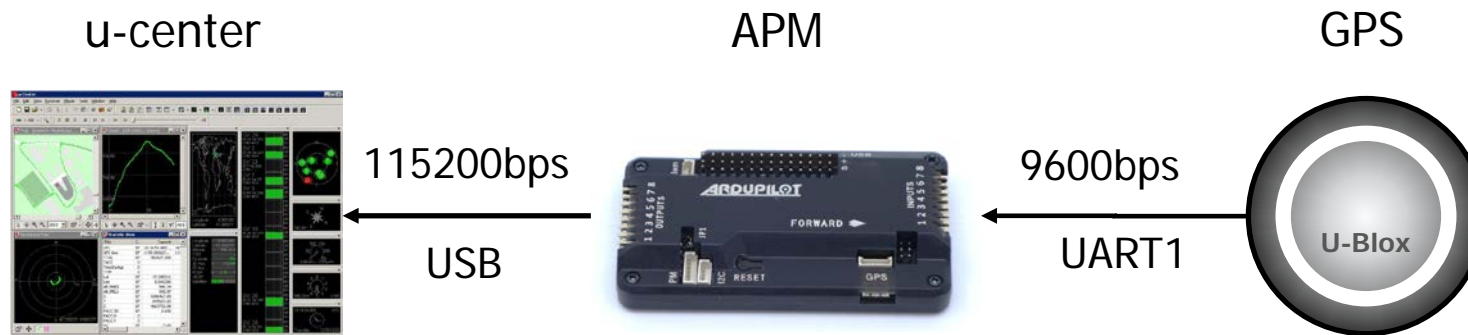
Test code

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■ u-center 용 Bridge code 이용

- baud rate 변환

```
void setup(void){  
  Serial.begin(115200);  
  Serial1.begin(9600);  
}  
void loop(void){  
  while(Serial1.available()) {  
    Serial.print((char)Serial1.read());  
  }  
}
```

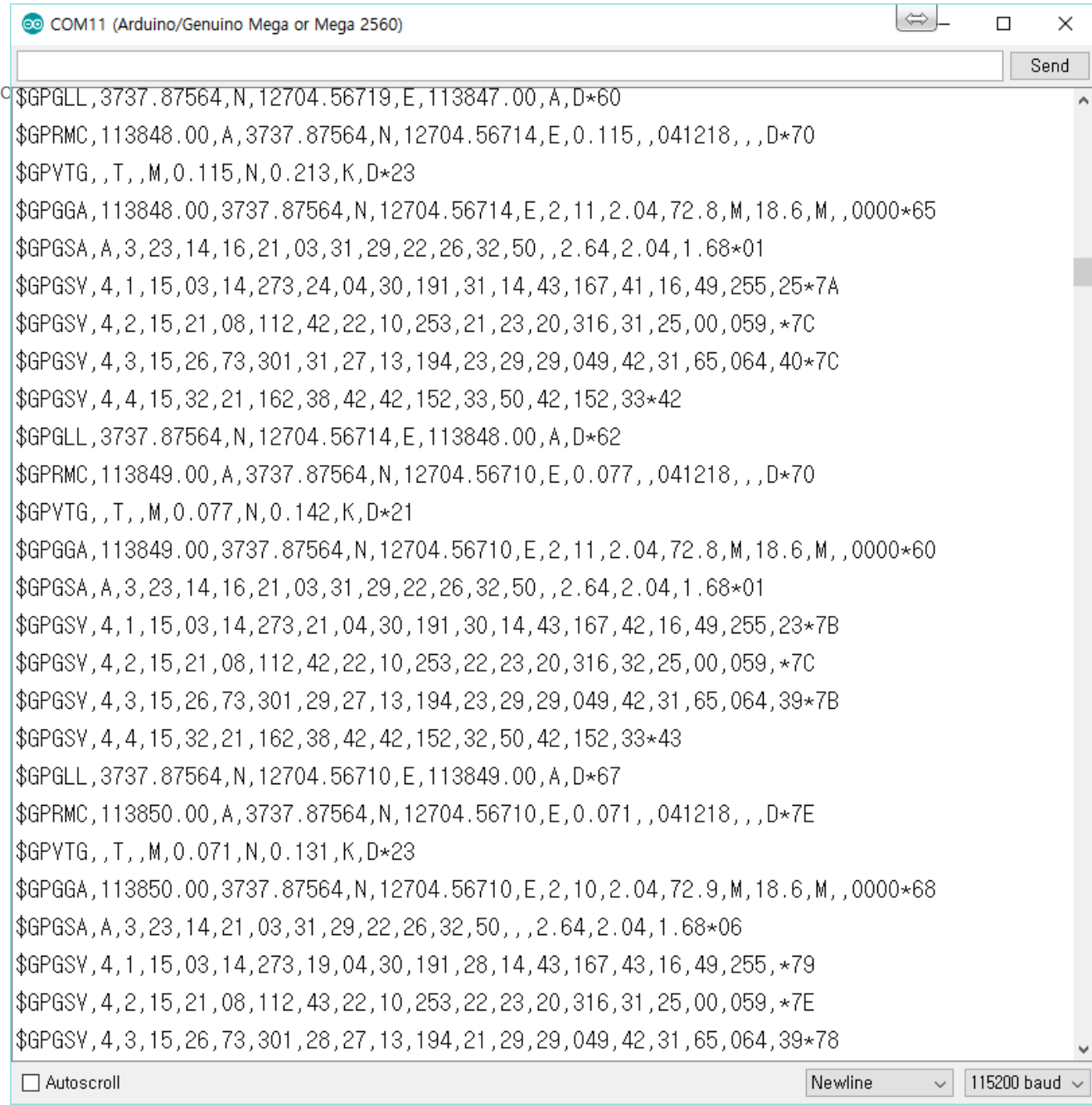


Packet 출력

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DATA Type

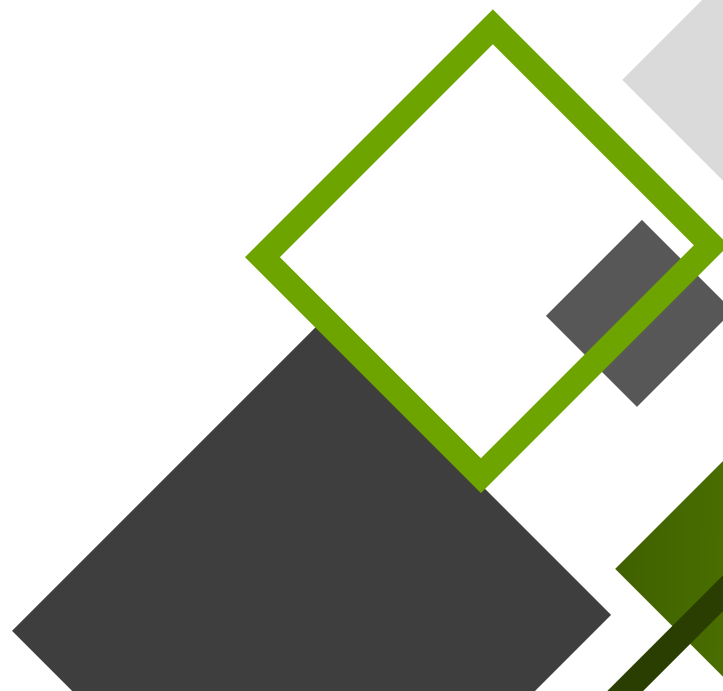
- GGA: Fix data
- GSA: DoP and active satellite
- GSV: 위성의 정보
- GLL: 경도, 위도, 시간
- RMC: 최소의 데이터
- VTG: Tracking 과 speed



```
COM11 (Arduino/Genuino Mega or Mega 2560)
$GPGLL,3737.87564,N,12704.56719,E,113847.00,A,D*60
$GPRMC,113848.00,A,3737.87564,N,12704.56714,E,0.115,,041218,,D*70
$GPVTG,,T,,M,0.115,N,0.213,K,D*23
$GPGGA,113848.00,3737.87564,N,12704.56714,E,2,11,2.04,72.8,M,18.6,M,,0000*65
$GPGSA,A,3,23,14,16,21,03,31,29,22,26,32,50,,2.64,2.04,1.68*01
$GPGSV,4,1,15,03,14,273,24,04,30,191,31,14,43,167,41,16,49,255,25*7A
$GPGSV,4,2,15,21,08,112,42,22,10,253,21,23,20,316,31,25,00,059,*7C
$GPGSV,4,3,15,26,73,301,31,27,13,194,23,29,29,049,42,31,65,064,40*7C
$GPGSV,4,4,15,32,21,162,38,42,42,152,33,50,42,152,33*42
$GPGLL,3737.87564,N,12704.56714,E,113848.00,A,D*62
$GPRMC,113849.00,A,3737.87564,N,12704.56710,E,0.077,,041218,,D*70
$GPVTG,,T,,M,0.077,N,0.142,K,D*21
$GPGGA,113849.00,3737.87564,N,12704.56710,E,2,11,2.04,72.8,M,18.6,M,,0000*60
$GPGSA,A,3,23,14,16,21,03,31,29,22,26,32,50,,2.64,2.04,1.68*01
$GPGSV,4,1,15,03,14,273,21,04,30,191,30,14,43,167,42,16,49,255,23*7B
$GPGSV,4,2,15,21,08,112,42,22,10,253,22,23,20,316,32,25,00,059,*7C
$GPGSV,4,3,15,26,73,301,29,27,13,194,23,29,29,049,42,31,65,064,39*7B
$GPGSV,4,4,15,32,21,162,38,42,42,152,32,50,42,152,33*43
$GPGLL,3737.87564,N,12704.56710,E,113849.00,A,D*67
$GPRMC,113850.00,A,3737.87564,N,12704.56710,E,0.071,,041218,,D*7E
$GPVTG,,T,,M,0.071,N,0.131,K,D*23
$GPGGA,113850.00,3737.87564,N,12704.56710,E,2,10,2.04,72.9,M,18.6,M,,0000*68
$GPGSA,A,3,23,14,21,03,31,29,22,26,32,50,,2.64,2.04,1.68*06
$GPGSV,4,1,15,03,14,273,19,04,30,191,28,14,43,167,43,16,49,255,*79
$GPGSV,4,2,15,21,08,112,43,22,10,253,22,23,20,316,31,25,00,059,*7E
$GPGSV,4,3,15,26,73,301,28,27,13,194,21,29,29,049,42,31,65,064,39*78
```




GPS 프로그래밍



TinyGPSPlus library

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■ 아두이노용 NMEA 해석 라이브러리

- download
 - <https://github.com/mikalhart/TinyGPSPlus>
- install
 - C:\Users\user\Documents\Arduino\libraries
 - TinyGPSPlus 디렉토리 아래 그림 파일들 복사
 - 아두이노 IDE를 다시 시작

Branch: master ▼ New pull request

Find file Clone or download ▼

Mikal Hart Support for HDOP in its true decimal form: ddd.xx Latest commit b4c8e29 on 4 Feb

| | | |
|--------------------|--|---------------|
| examples | Support for HDOP in its true decimal form: ddd.xx | 10 months ago |
| src | Support for HDOP in its true decimal form: ddd.xx | 10 months ago |
| keywords.txt | Version 1.0.0: reorganize per new Arduino library standard, fix bug w... | a year ago |
| library.json | Update library.json | a year ago |
| library.properties | Version 1.0.0: reorganize per new Arduino library standard, fix bug w... | a year ago |

TinyGPSPlus 사용법

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■ TinyGPSPlus 라이브러리 사용

- 라이브러리 사용

```
#include <TinyGPS++.h>
```

- 라이브러리 include

- 수신 데이터 처리

```
bool encode(char c);
```

- *c*: 수신된 1개의 문자 처리

- 유효성 확인

```
bool isValid()
```

- 해당 구조체의 데이터가 유효한지 확인

- 새로운 데이터 확인

```
bool isUpdated()
```

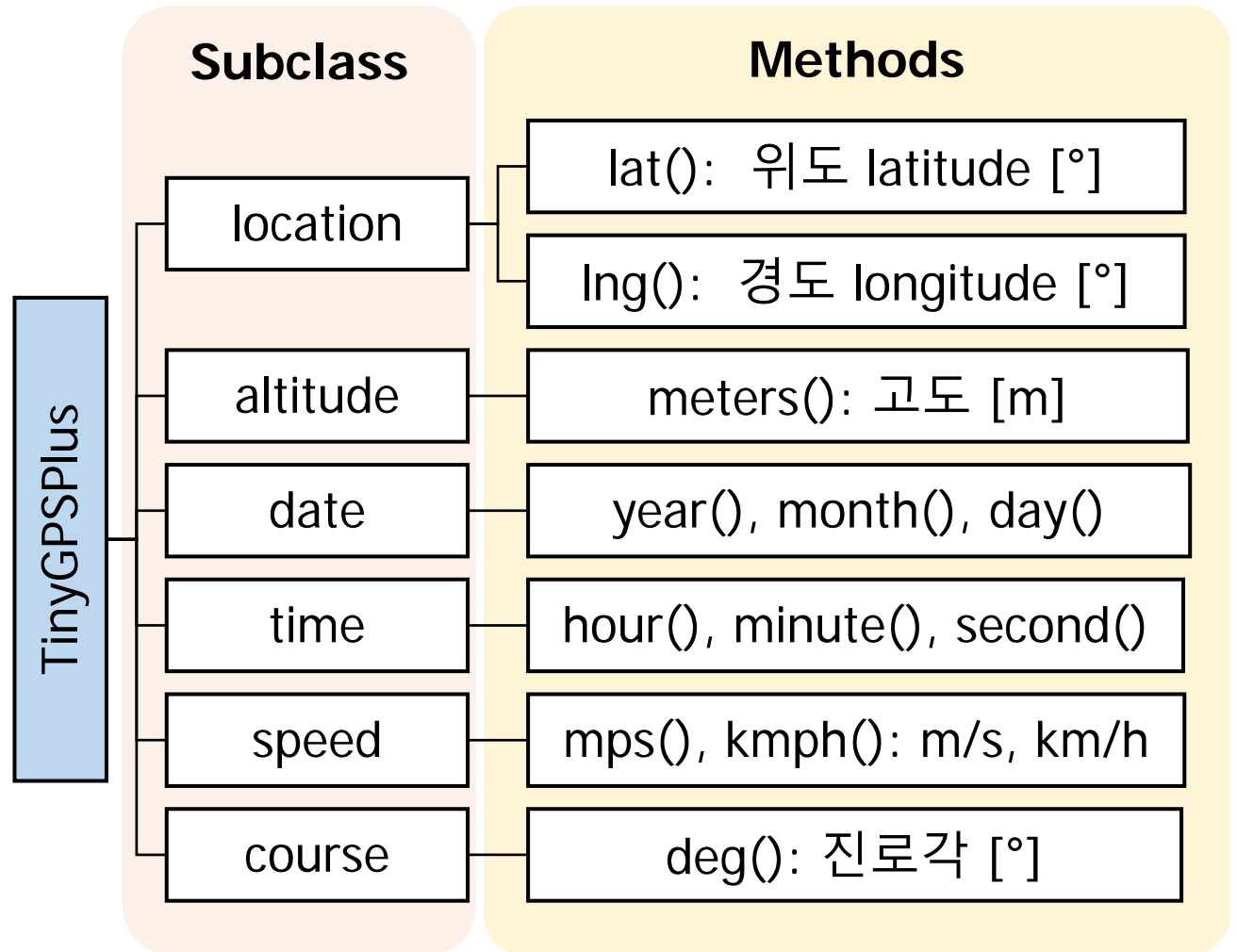
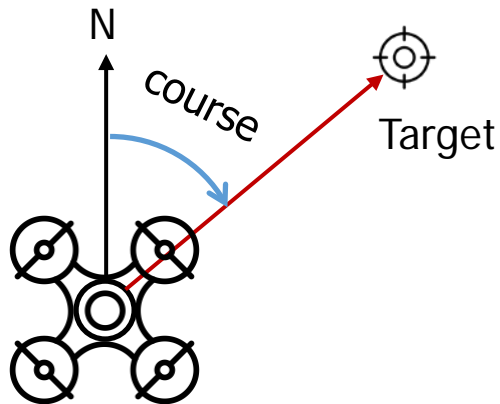
- 해당 정보가 새로운 정보인지 확인

Class 내의 subclass

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■ TinyGPSPlus 부클래스

- location
- altitude
- date
- time
- speed
- course : 진로각



적용예제

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■ NeoSerial library이용

- UART0: NeoSerial, UART1: NeoSerial1

```
#include <NeoHWSerial.h>
#include <TinyGPS++.h>
#define GPSPBaud 9600
#define PCBaud 115200
TinyGPSPlus gps;
void setup() {
  NeoSerial.begin(PCBaud);
  NeoSerial1.begin(GPSPBaud);
  NeoSerial1.attachInterrupt( recvData );
  delay(1000);
}
void loop(){
  if( gps.altitude.isValid() && gps.altitude.isUpdated() ){
    NeoSerial.print("Alt= "); NeoSerial.println(gps.altitude.meters());
  }
}
```

적용예제

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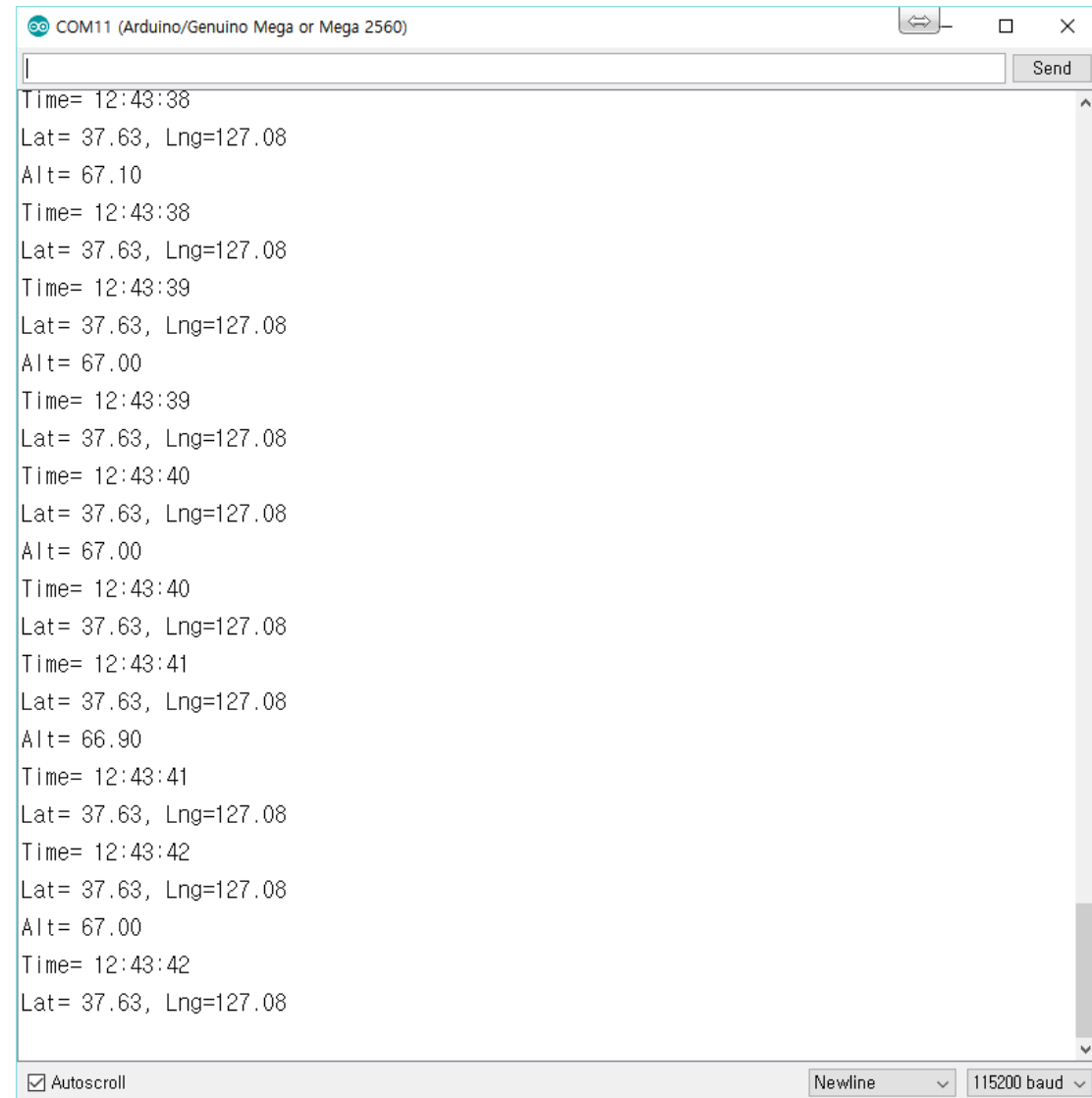
■ 주요 내용

- isValid(), isUpdate()
- recvData() : UART1 ISR

```
if( gps.time.isValid() && gps.time.isUpdated() ){
    NeoSerial.print("Time= "); NeoSerial.print((gps.time.hour()+9)%24);
    NeoSerial.print(":"); NeoSerial.print(gps.time.minute());
    NeoSerial.print(":"); NeoSerial.println(gps.time.second());
}
if( gps.location.isValid() && gps.location.isUpdated() ){
    NeoSerial.print("Lat= "); NeoSerial.print(gps.location.lat());
    NeoSerial.print(", Lng="); NeoSerial.println(gps.location.lng());
}
}
void recvData(uint8_t c){
    gps.encode((char)c);
}
```

실행결과

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The screenshot shows a serial monitor window titled "COM11 (Arduino/Genuino Mega or Mega 2560)". The window contains a text area with the following data being received from the Arduino:

```
Time= 12:43:38  
Lat= 37.63, Lng=127.08  
Alt= 67.10  
Time= 12:43:38  
Lat= 37.63, Lng=127.08  
Time= 12:43:39  
Lat= 37.63, Lng=127.08  
Alt= 67.00  
Time= 12:43:39  
Lat= 37.63, Lng=127.08  
Time= 12:43:40  
Lat= 37.63, Lng=127.08  
Alt= 67.00  
Time= 12:43:40  
Lat= 37.63, Lng=127.08  
Time= 12:43:41  
Lat= 37.63, Lng=127.08  
Alt= 66.90  
Time= 12:43:41  
Lat= 37.63, Lng=127.08  
Time= 12:43:42  
Lat= 37.63, Lng=127.08  
Alt= 67.00  
Time= 12:43:42  
Lat= 37.63, Lng=127.08
```

At the bottom of the window, there are three controls: a checkbox for "Autoscroll" which is checked, a dropdown menu for "Newline" set to "Newline", and a dropdown menu for the baud rate set to "115200 baud".

GPS class 화

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■ GPS class 정의

▶ Property

- ▶ time: 시간 구조체 변수
- ▶ date: 날짜 구조체 변수
- ▶ loca: 위치 구조체 변수 (위도,경도,고도)

▶ Method

- ▶ init(): 초기화 함수
- ▶ available(): 데이터가 유효성 및 갱신 여부
- ▶ update(): 데이터 읽기
- ▶ distanceBetween(): 두 지점의 거리
- ▶ courseTo(): 1에서 2로 가기 위한 방향각

GPS Class

property

```
struct TIME{hour,min,sec;}
struct DATE{year,month,day;}
struct LOCA{lat,lng,alt;}
```

public:

```
TIME time
DATE date
LOCA loca
```

method

```
init()
available()
update()
distanceBetween
    (lat1,long1,lat2,long2)
courseTo
    (lat1,long1,lat2,long2)
```


헤더파일

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■ 주요내용

GPS.h

```
#ifndef __GPS_h
#define __GPS_h
#define GPSBaud 9600
#include <NeoHWSerial.h>
#include <TinyGPS++.h>
#include <Arduino.h>
void recvData(uint8_t c);
class GPS{
    struct TIME{uint8_t hour,min,sec;};
    struct DATE{uint8_t year,month,day;};
    struct LOCA{float lat,lng,alt;};
public:
    void init();
    bool available();
    void update();
    float distanceBetween(float lat1,float long1,float lat2, float long2);
    float courseTo(float lat1,float long1, float lat2,float long2);
    TIME time;
    DATE date;
    LOCA loca;
};
#endif
```

C++ 파일

Dept. of Mechanical System Design, Seoul National University of Science and Technology.

■ 주요내용

GPS.cpp [1/2]

```
#include "GPS.h"
TinyGPSPlus g;
void GPS::init(){
    NeoSerial1.begin(GPSBaud);
    NeoSerial1.attachInterrupt( recvData );
    delay(1000);
}
bool GPS::available(){
    bool a=g.altitude.isValid() && g.altitude.isUpdated();
    bool b=g.location.isValid() && g.location.isUpdated();
    return (a||b)? 1:0;
}
void GPS::update(){
    loca.alt=g.altitude.meters();
    loca.lat=g.location.lat();
    loca.lng=g.location.lng();
    time.hour=(g.time.hour()+9)%24; // UMT +9 hour
    time.min=g.time.minute();
    time.sec=g.time.second();
}
```

C++ 파일

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■ 주요내용

GPS.cpp [2/2]

```
float GPS::distanceBetween(float lat1, float long1, float lat2, float long2){  
    return g.distanceBetween(lat1, long1, lat2, long2);  
}  
float GPS::courseTo(float lat1, float long1, float lat2, float long2){  
    float ang = g.courseTo(lat1, long1, lat2, long2);  
    return (ang > 180)? ang - 360 : ang;    //+- 180 degree  
}  
void recvData(uint8_t c){  
    g.encode((char)c);  
}
```

C++ 파일

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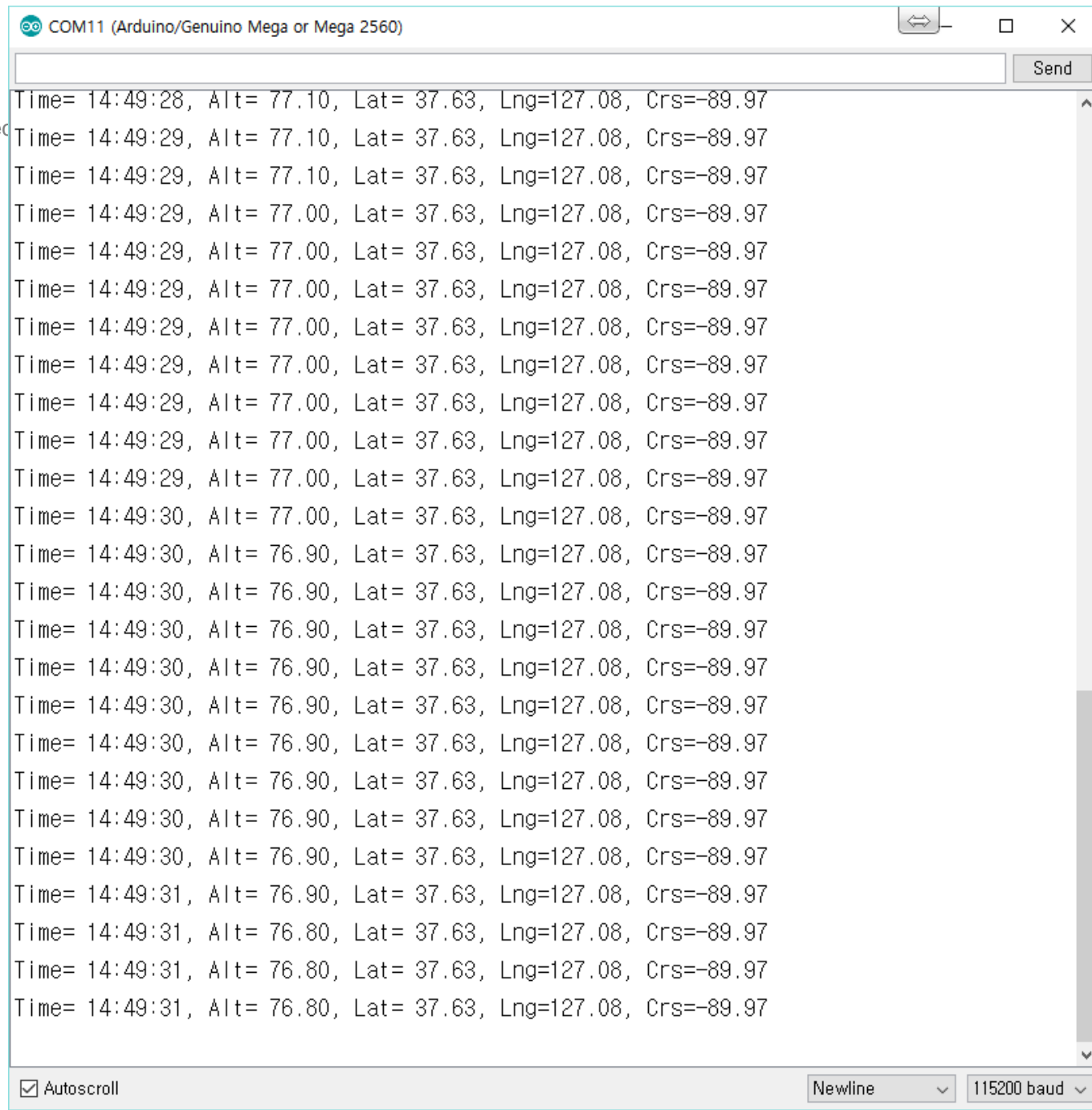
■ 주요내용

tinyGPS_Class.ino

```
#include <NeoHWSerial.h>
#include "GPS.h"
#define PCBaud 115200
GPS gps;
void setup() {
    NeoSerial.begin(PCBaud);
    gps.init();
}
void loop(){
    if(gps.available()) gps.update();
    NeoSerial.print("Time= ");NeoSerial.print(gps.time.hour);
    NeoSerial.print(":");NeoSerial.print(gps.time.min);
    NeoSerial.print(":");NeoSerial.print(gps.time.sec);
    NeoSerial.print(", Alt= "); NeoSerial.print(gps.localt.alt);
    NeoSerial.print(", Lat= "); NeoSerial.print(gps.localt.lat);
    NeoSerial.print(", Lng=");NeoSerial.print(gps.localt.lng);
    NeoSerial.print(", Crs=");
    NeoSerial.println(gps.courseTo(37.63,127.08,37.63,126.99));
    delay(100);
}
```

실행결과

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The screenshot shows a serial monitor window titled "COM11 (Arduino/Genuino Mega or Mega 2560)". The window contains a list of sensor data readings. Each line represents a single data point, showing time, altitude, latitude, longitude, and a course value. The data is as follows:

| Time | Alt | Lat | Lng | Crs |
|----------|-------|-------|--------|--------|
| 14:49:28 | 77.10 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.10 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.10 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:29 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 77.00 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:30 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:31 | 76.90 | 37.63 | 127.08 | -89.97 |
| 14:49:31 | 76.80 | 37.63 | 127.08 | -89.97 |
| 14:49:31 | 76.80 | 37.63 | 127.08 | -89.97 |
| 14:49:31 | 76.80 | 37.63 | 127.08 | -89.97 |

The window also features a "Send" button at the top right, an "Autoscroll" checkbox at the bottom left, and dropdown menus for "Newline" and "115200 baud" at the bottom right.

The slide features a minimalist design with abstract geometric shapes in various shades of green, grey, and dark grey. These shapes, including squares, diamonds, and lines, are positioned in the corners and along the sides, creating a modern, architectural feel. The central text is clean and professional, with a horizontal line separating the title from the subtitle.

THANK YOU

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