IFST

Make things run Internet

GNSS IN ADVANCE VEHICLE APPLICATIONS

Raksit Thitipatanapong
Co-Founder, GNSS system
Infinite Sora Technology, Co., Ltd.
Bangkok, Thailand

CONTENTS
2012-2015 (NECTEC-JAXA)

- R. THITIPATANAPONG, S. KLONGNAIVAI, N. NOOMWONGS and S. CHATRANUWATHANA, "Study of Driver Behavior Detection on Vehicle with Satellite Navigation System (in Thai)," in GEOINFOTECH, GISTDA, Nonthaburi, Thailand, 2013.
- Phondeenana, P., Thitipatanapong, R., Klongnaivai, S., Noomwongs, N. et al., "Driver Behavior Detection based On PPP-GNSS Technology," SAE Technical Paper 2014-01-2006, 2014, doi:10.4271/2014-01-2006.
- Peerapat Phondeenana, Raksit Thitipatanapong, Sanya Klongnaivai, Nuksit Noomwongs, Sunhapos Chantranuwathana: DRIVER BEHAVIOR DETECTION BASED ON MULTI GNSS TECHNOLOGY. FISITA: World Automotive Congress, Maastricht, The Netherland; 06/2014
- N. Noomwongs, R. Thitipatanapong, S. Chantranuwathana, S. Klongnaivai, "Driver Behavior Detection Based on Multi-GNSS Precise Point Positioning Technology", Applied Mechanics and Materials, Vol 619, pp. 327-331, Aug. 2014

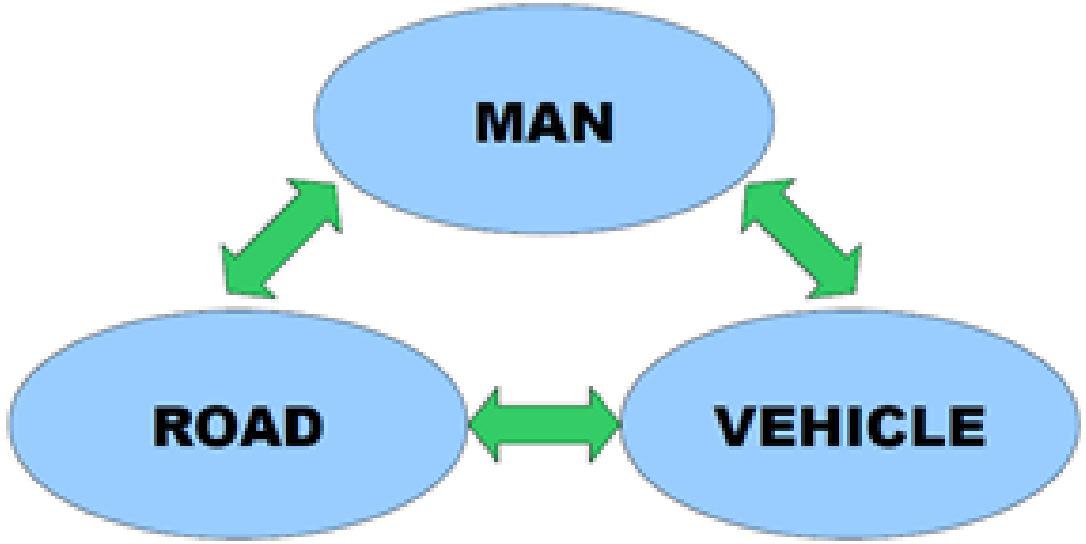
STUDY OF DRIVER BEHAVIOR DETECTION ON VEHICLE WITH SATELLITE NAVIGATION SYSTEM

Raksit THITIPATANAPONG, M.Sc., & Sanya KLONGNAVAI, M.Eng
National Electronic & Computer Technology Center, THAILAND
Nuksit NOOMWONGS, D.Eng., & Sunhapos CHATRANUWATHANA. Ph.D.
Smart Mobility Research Center, Faculty of Engineering, Chulalongkorn Univ.

Presented at Geoinfotech 2013, Thailand

ROAD ACCIDENT

In road accident, there usually are three main mistake which are man, vehicle or road combine together. Missing a link the accident would become incident.
The person or driver is important key to avoid an accident so that the monitoring system will play important role.

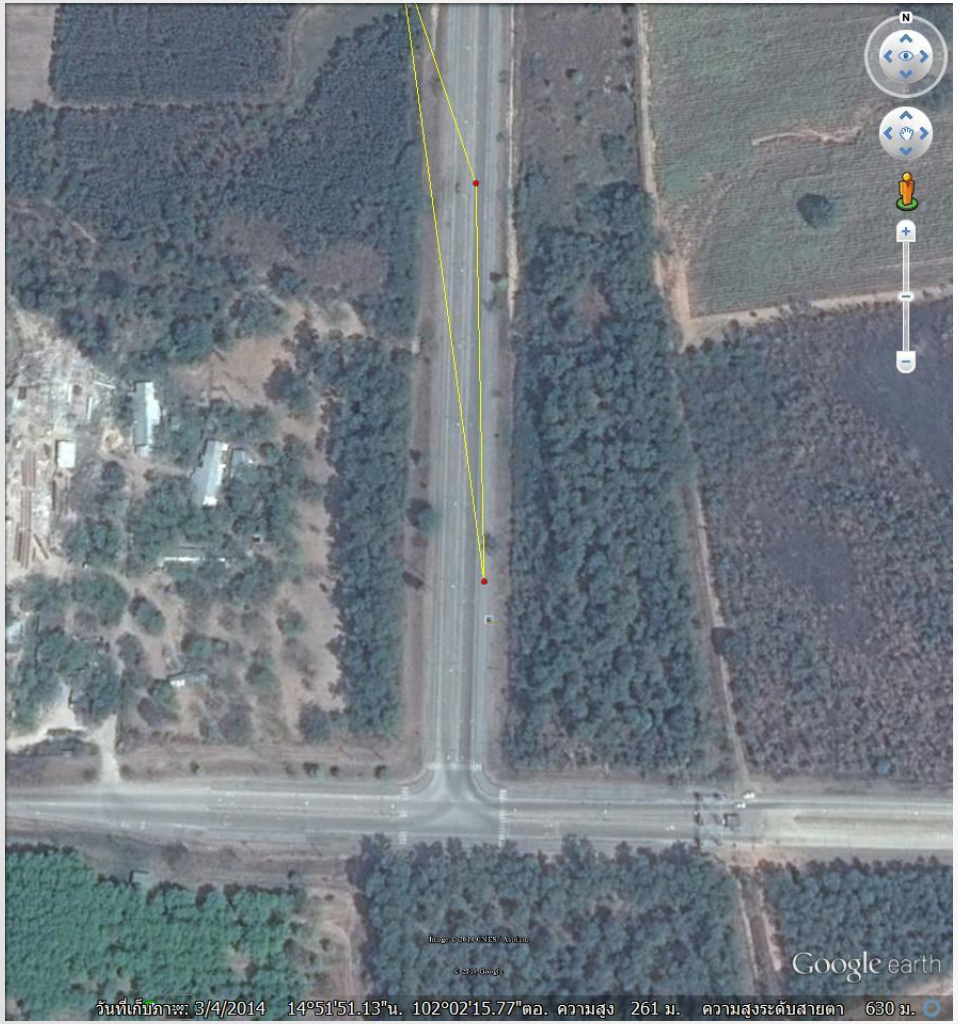


DRIVER'S BEHAVIOR

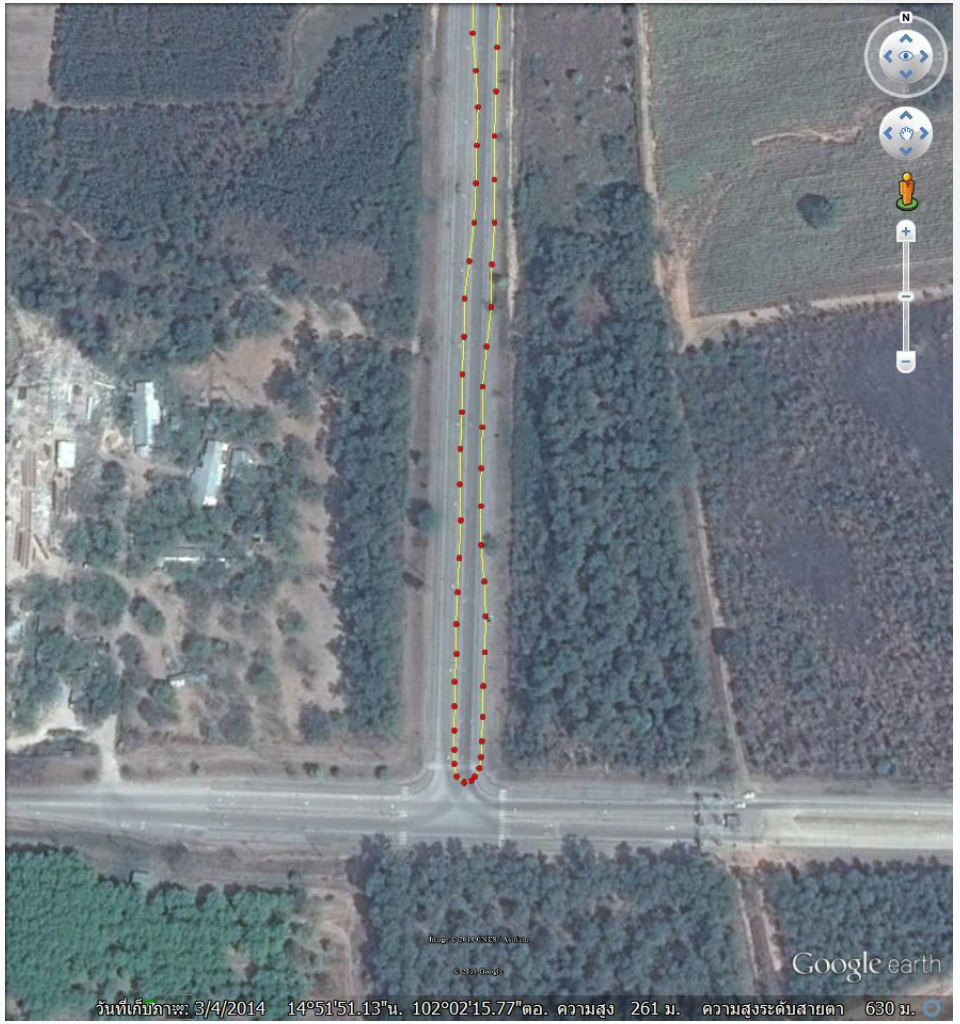
Behavior	Physical Parameter
Accelerating	Longitudinal Acceleration
Braking	
Turning	Lateral Acceleration
Lane Changing	

LIMITATION WITH GPS

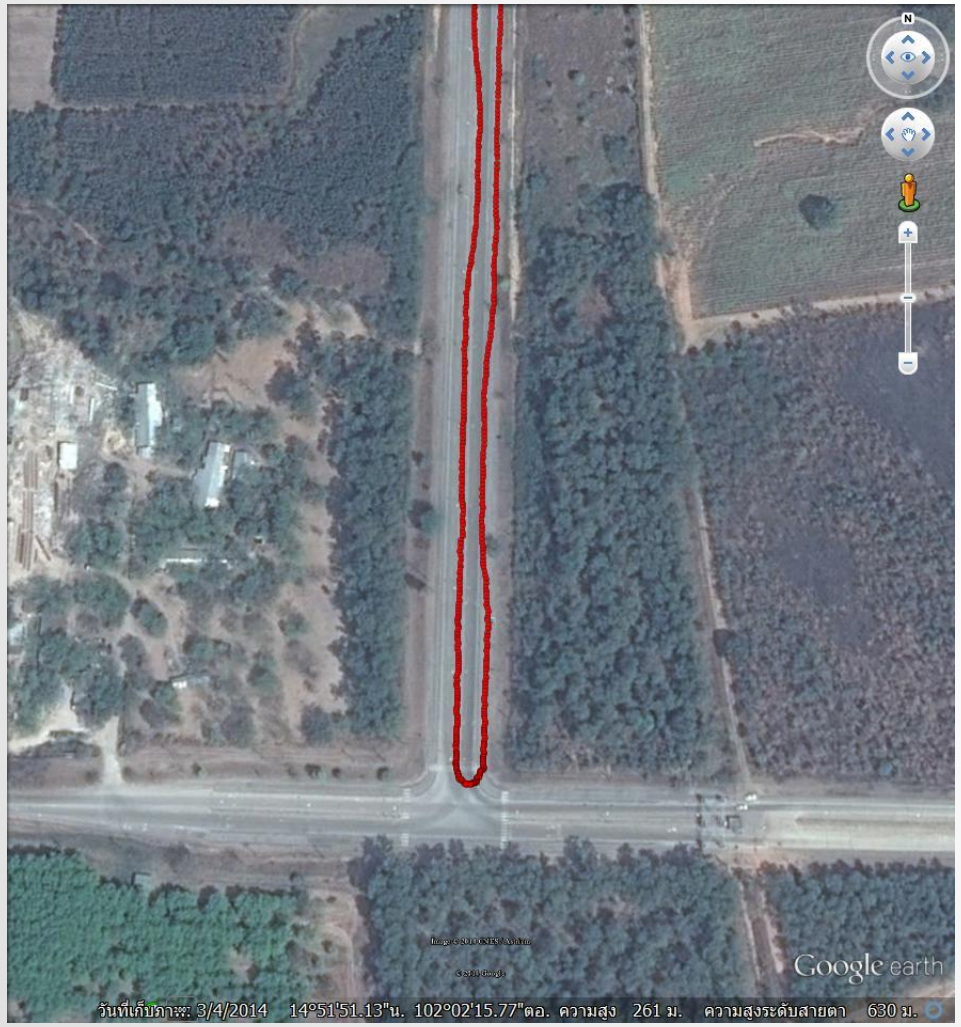
	Current 1-Hz conventional GPS receiver
Longitudinal Acceleration	enough accuracy and update rate for estimate.
Lateral Acceleration	For turning, applicable in cases with large displacement and duration.
	For lane change, cannot estimate, not enough accuracy and update rate.



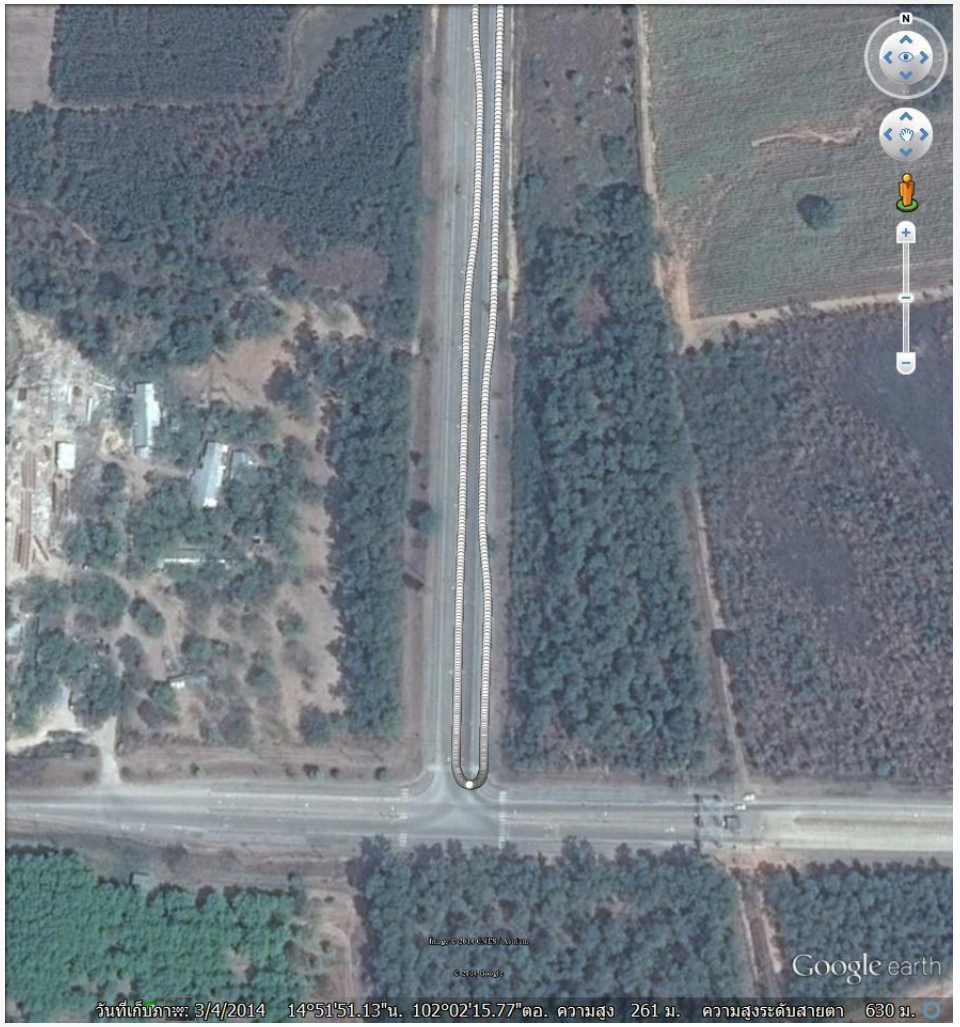
ก. ข้อมูลจาก GNSS ปัจจุบัน



ข. ข้อมูลจาก GNSS 1 วินาที



ค. ข้อมูลจาก GNSS 100 มิลลิวินาที



ง. ข้อมูลจาก PPP GNSS

OBJECTIVES

- To Evaluate the Multi-GNSS Technology for Vehicle's Lateral Acceleration Estimation

- Scopes
  - 10-Hz Resolution
  - To Compare the Output with Single Solutions and RTK Solutions

Compare the Multi-GNSS estimate lateral acceleration with Inertia Measurement Unit

EXPERIMENTAL

TEST VEHICLE

TEST EQUIPMENT

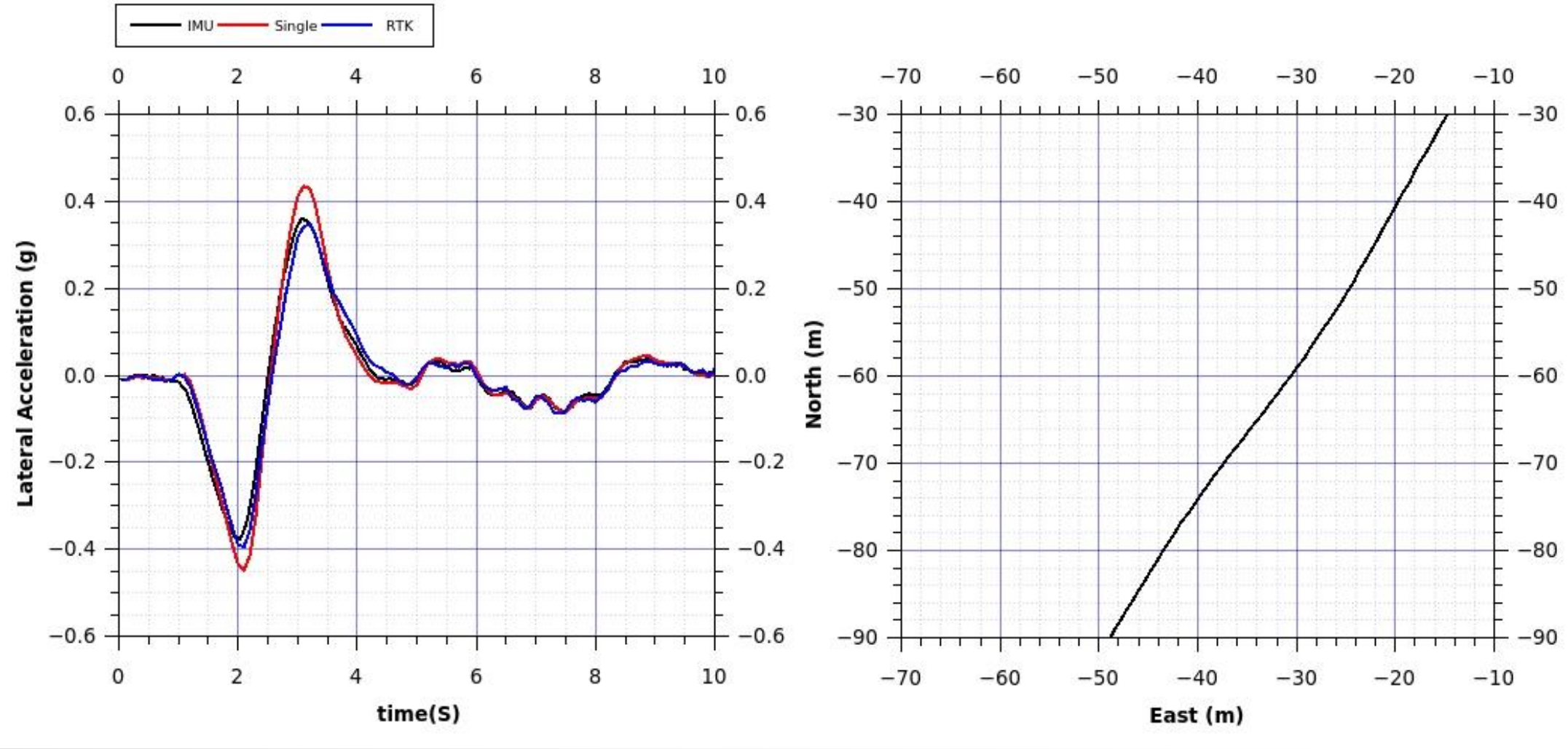
RECEIVER

JAVAD DELTA-G3T	FW: TRE-G3TH Dual-Frequency, Carrier Phase
Signal Tracked	GPS: C/A, P1, P2, L2C, L5 GLONASS: C/A, L2C, P1, P2, L3 QZSS: C/A, L1C, L2C, L5 SBAS:
Raw Data Recording	1 second/point

LANE CHANGING CLIP

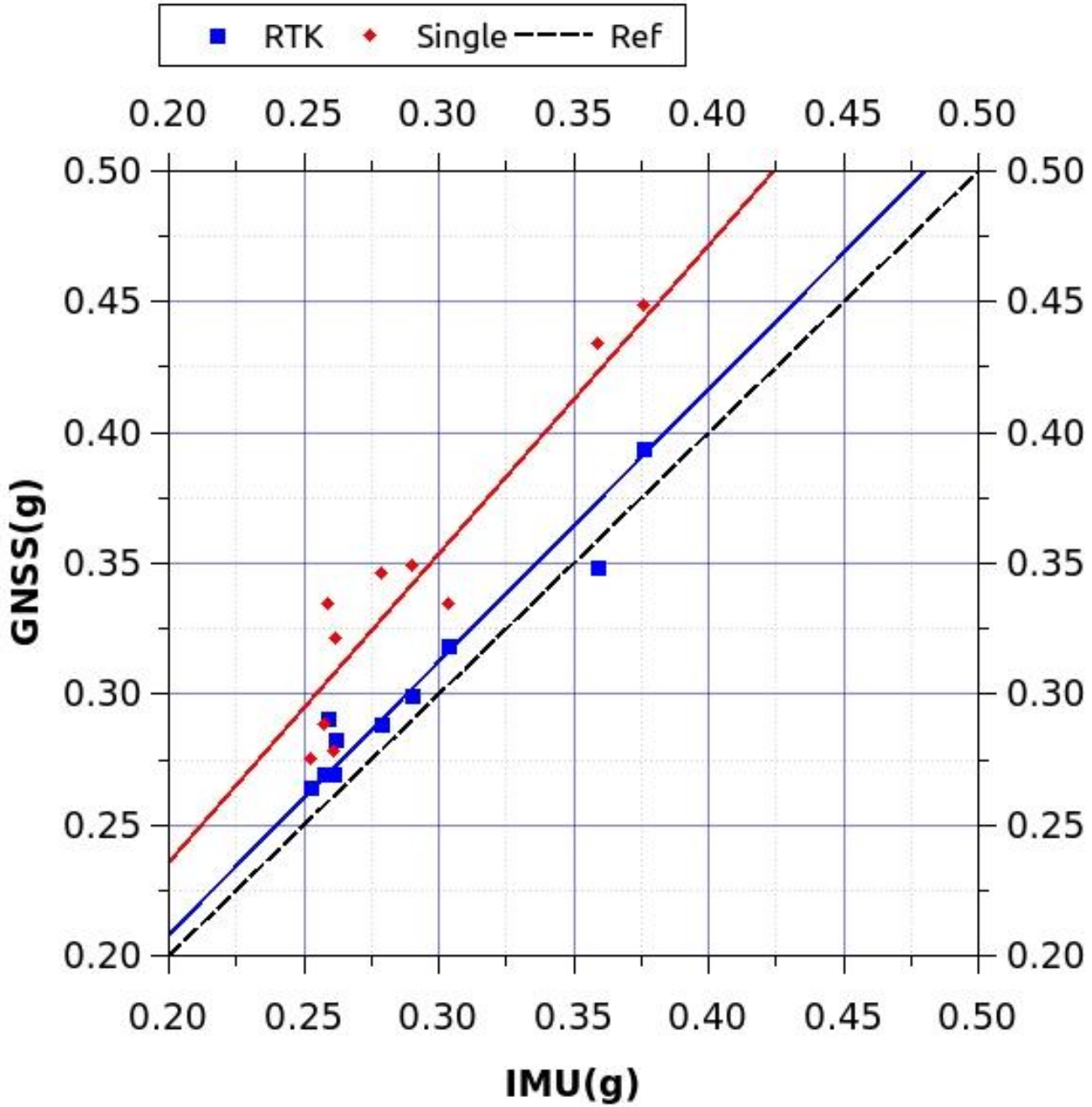
http://youtu.be/kwXfIBxs69A

LANE CHANGING TEST



LANE CHANGING TEST

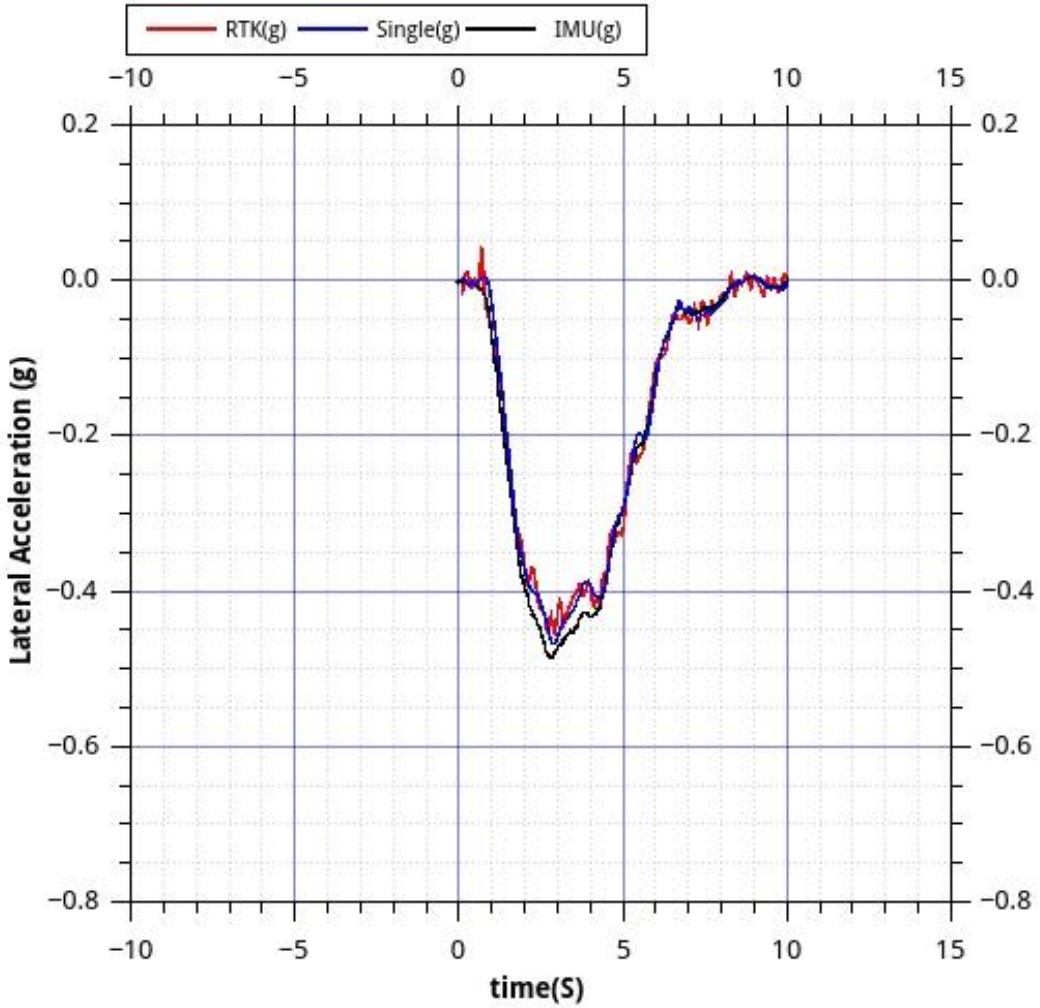
With series of tests, the peak point from estimation and IMU were compared. The RTK Solution was necessary for estimating the lateral acceleration in lane change behavior because the small lateral displacement change.

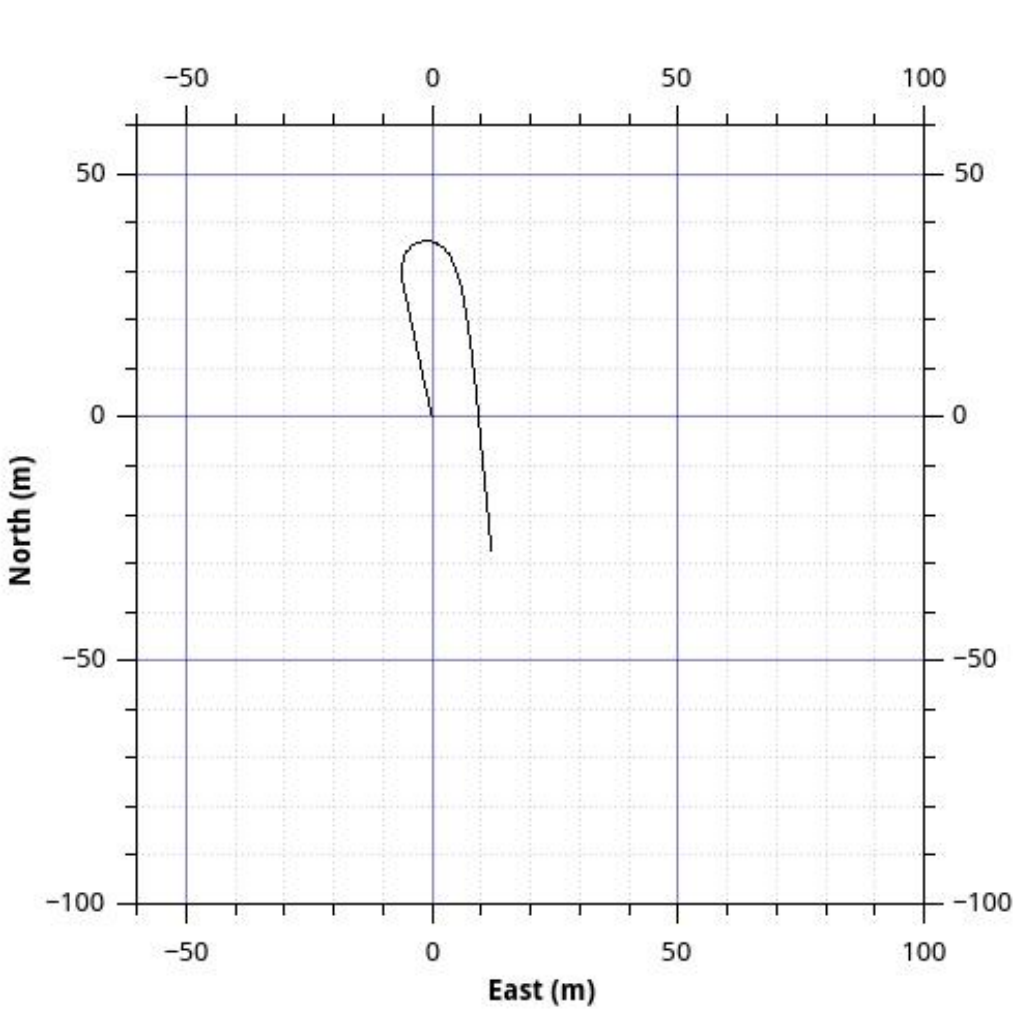


TURNING TEST CLIP

http://youtu.be/PgaUap4KjFc

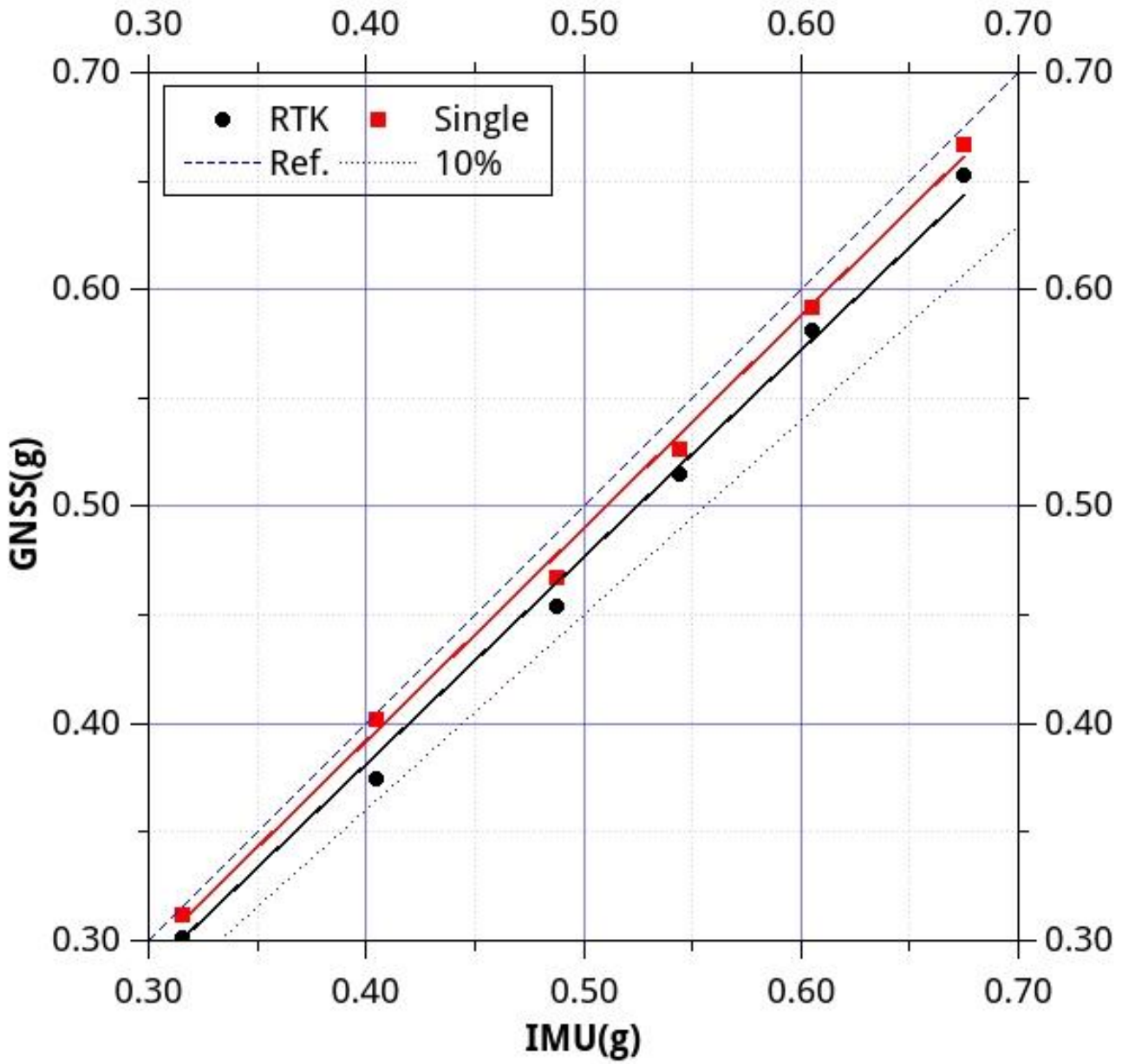
TURNING TEST





TURNING TEST

With series of tests, the peak point from estimation and IMU were compared. There were insignificant different in results between Single and RTK solutions because the maneuver was larger than an accuracy limit of Single solution.



CONCLUSIONS

CONCLUSION

- The precision from Multi-GNSS is the key to detect the risk incident in vehicle driver's behavior.
  - Single solution was enough for turning analysis.
  - RTK solution was required for lane changing analysis.

FUTURE WORKS

- The data will re-processing in precise point positioning (PPP) technique.
- LEX correction message will be considered.

DRIVER BEHAVIOR DETECTION BASED ON PPP-GNSS TECHNOLOGY

Raksit THITIPATANAPONG
Space Technologies Applications
Information, Communication & Computing Research Unit
NATIONAL ELECTRONIC & COMPUTER TECHNOLOGY CENTER, THAILAND

Presented at 10th International Conference on Automotive Engineering, Thailand

IN 2013, THAILAND IS 3RD RANK ROAD ACCIDENT FATALITIES BY WHO.

The most important parts is driver.

IN-VEHICLE DATA-LOGGER

DRIVER'S BEHAVIOR

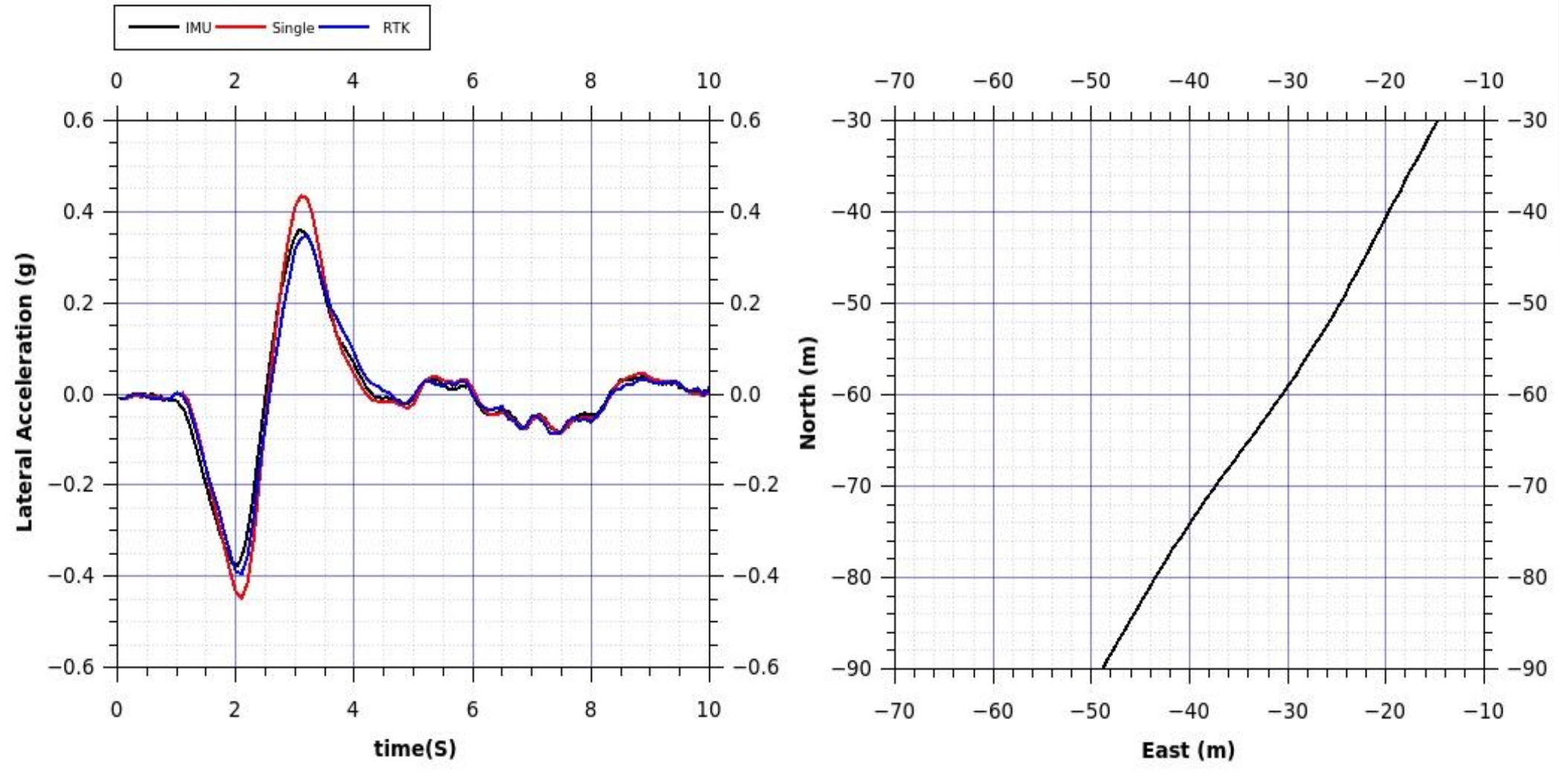
Behavior	Physical Parameter
Accelerating	Longitudinal Acceleration
Braking	
Turning	Lateral Acceleration
Lane Changing	

LIMITATION WITH GPS

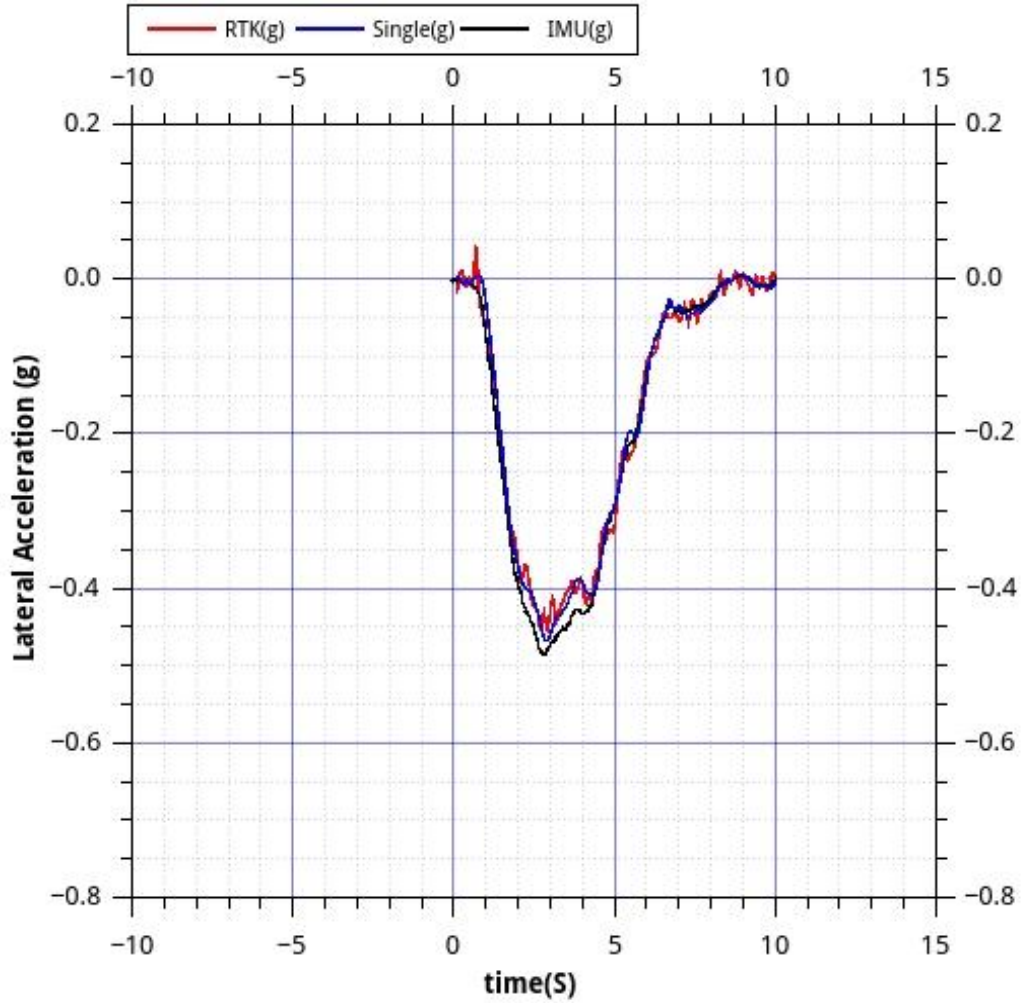
	Current 1-Hz conventional GPS receiver
Longitudinal Acceleration	enough accuracy and update rate for estimate.
Lateral Acceleration	For turning, applicable in cases with large displacement and duration.
	For lane change, cannot estimate, not enough accuracy and update rate.

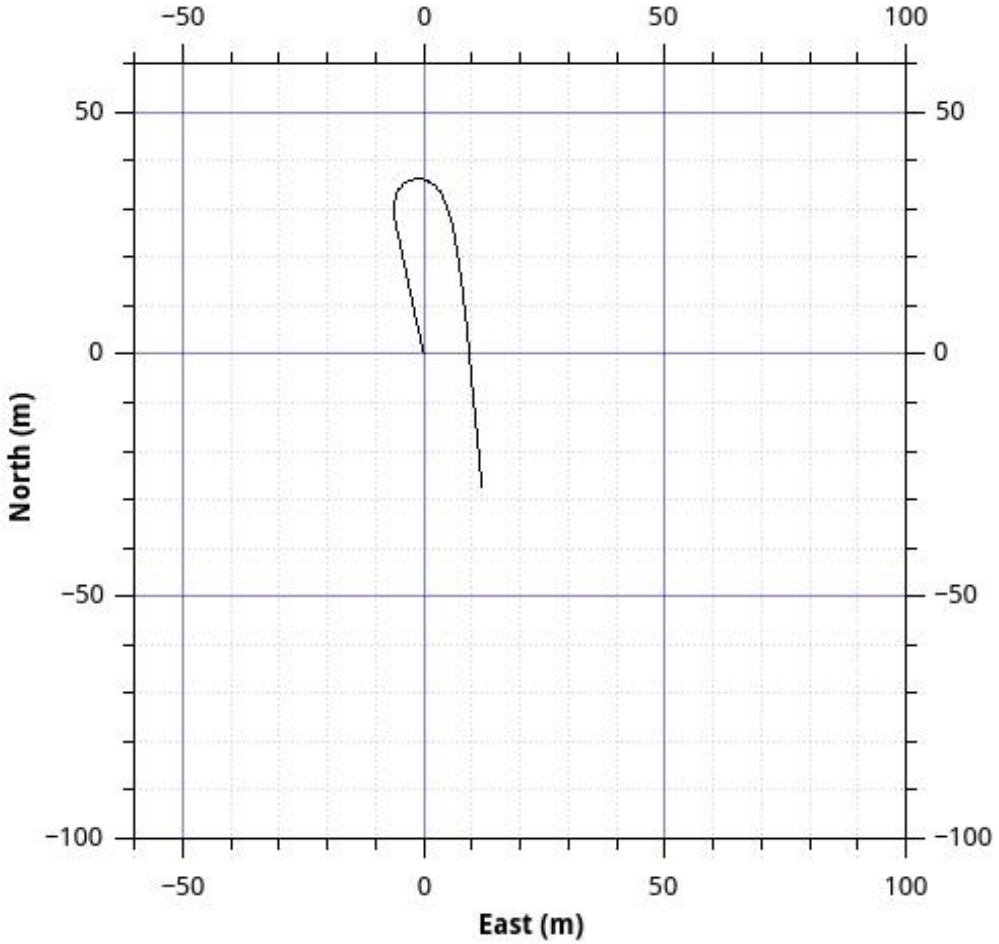
2012 TEST EQUIPMENT

LANE CHANGING TEST



TURNING TEST





http://youtu.be/kwXflBxs69A

LANE CHANGING CLIP

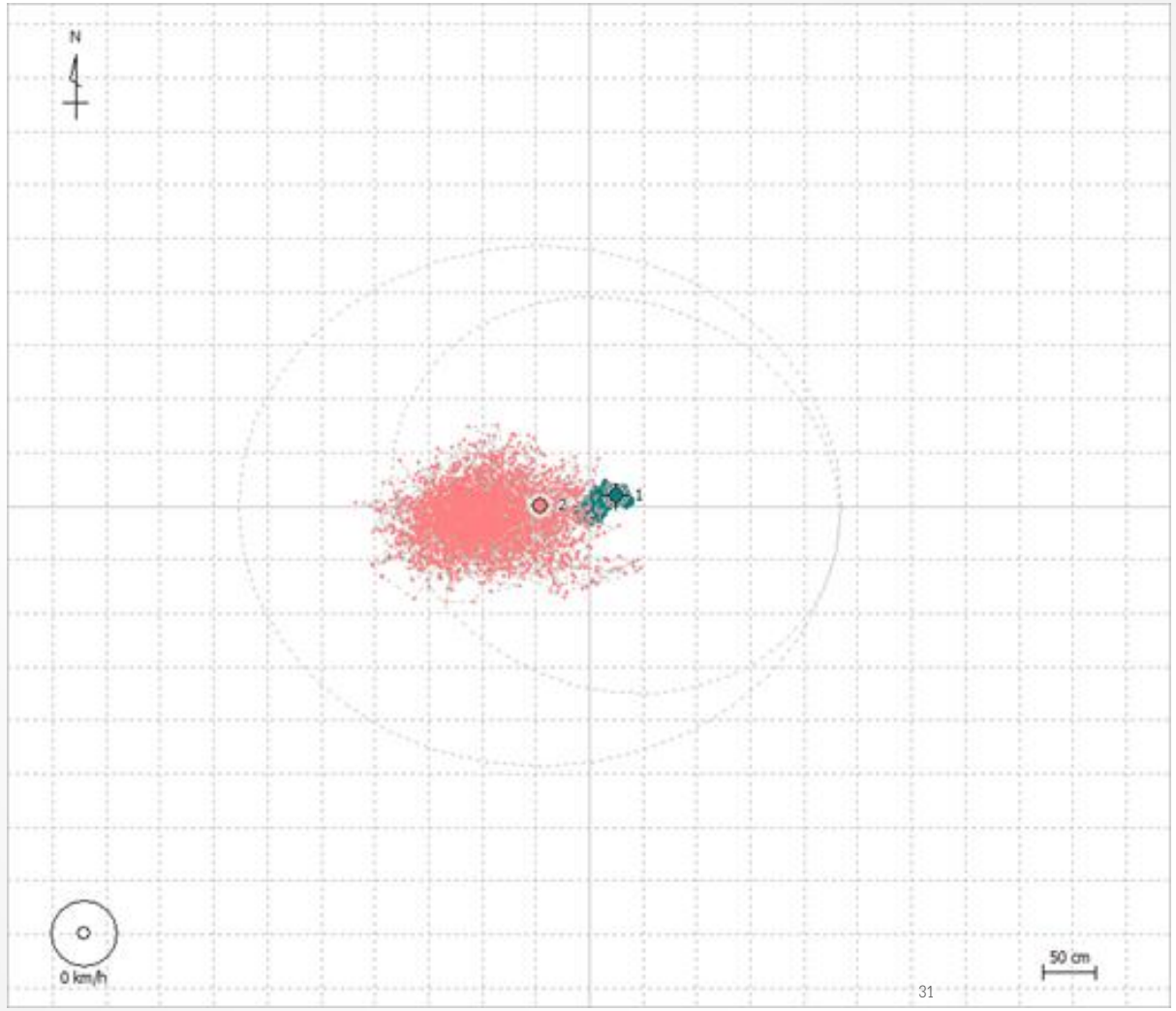
RTK SOLUTIONS

- The precision from Multi-GNSS is the key to detect the risk incident in vehicle driver's behavior.
  - Single solution was enough for turning analysis.
  - RTK solution was required for lane changing analysis.
- Accuracy from RTK solution was less than actual lateral motion from lane changing.
  - Sub-meter class with high update rate capable for it.
  - PPP was considered

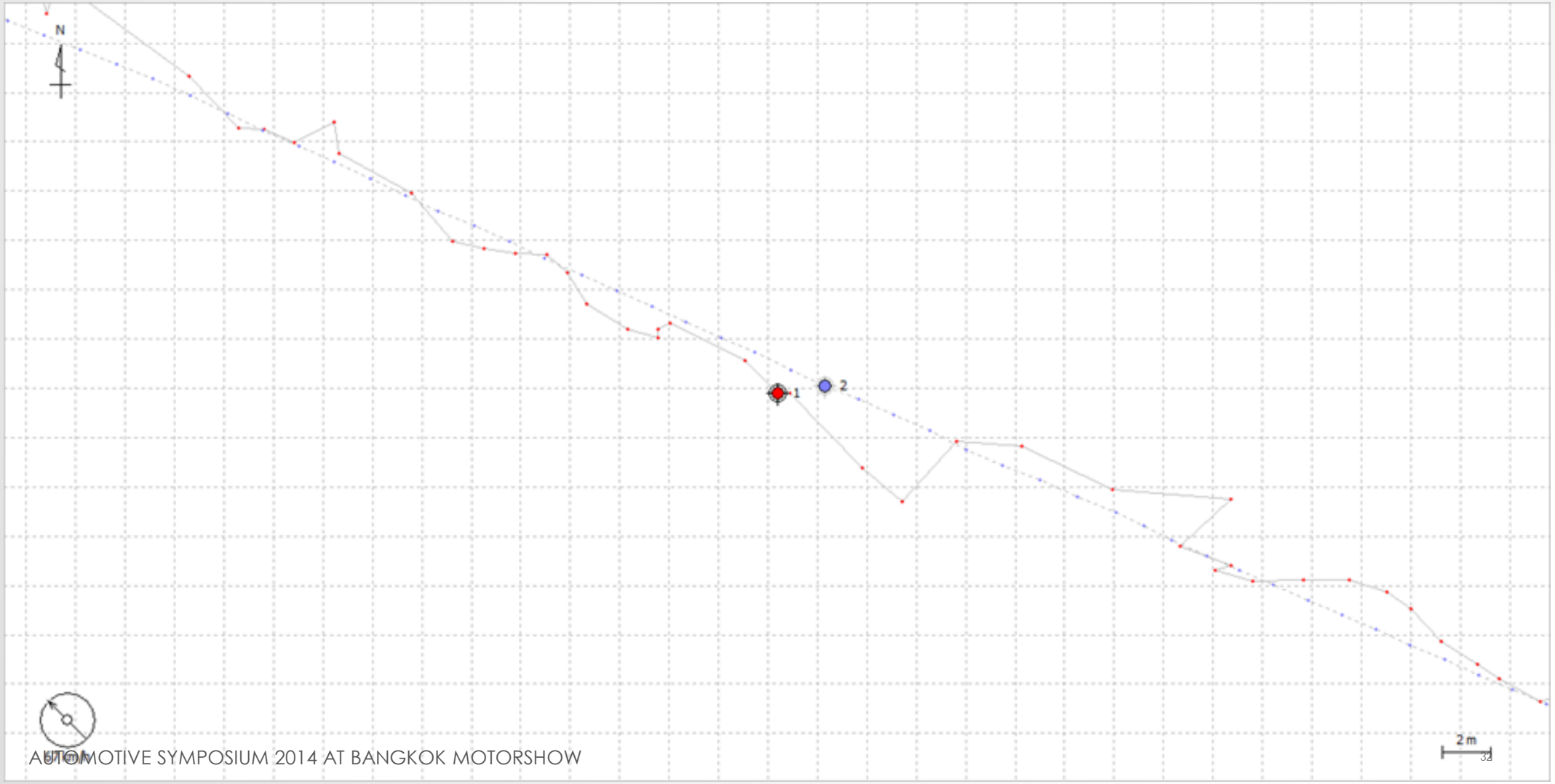
R. THITIPATANAPONG, S. KLONGNAIVAI, N. NOOMWONGS and S. CHATRANUWATHANA, "Study of Driver Behavior Detection on Vehicle with Satellite Navigation System (in Thai)," in GEOINFOTECH, GISTDA, Nonthaburi, Thailand, 2013.

IMPROVEMENTS WITH PPP

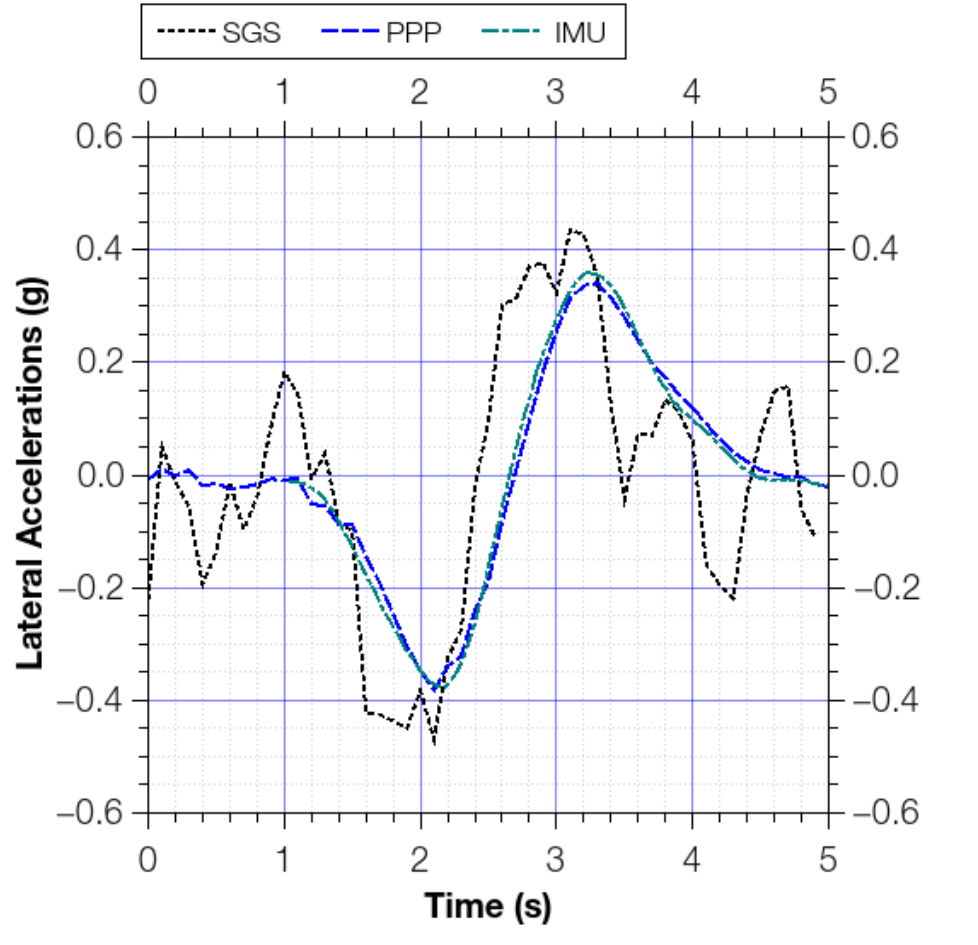
Setting	SGS	PPP
Positioning Mode	Single	PPP Kinematic
Frequencies/Filter Type	L1/Forward	L1/Forward
Elevations Mask	5°	5°
Ionosphere Correction	Broadcast	Iono-Free LC
Troposphere Correction	Saastamoinen	Estimate ZTD
Satellite Clock	Broadcast	Broadcast
Navigation System	GPS	GPS, GLONASS, QZSS

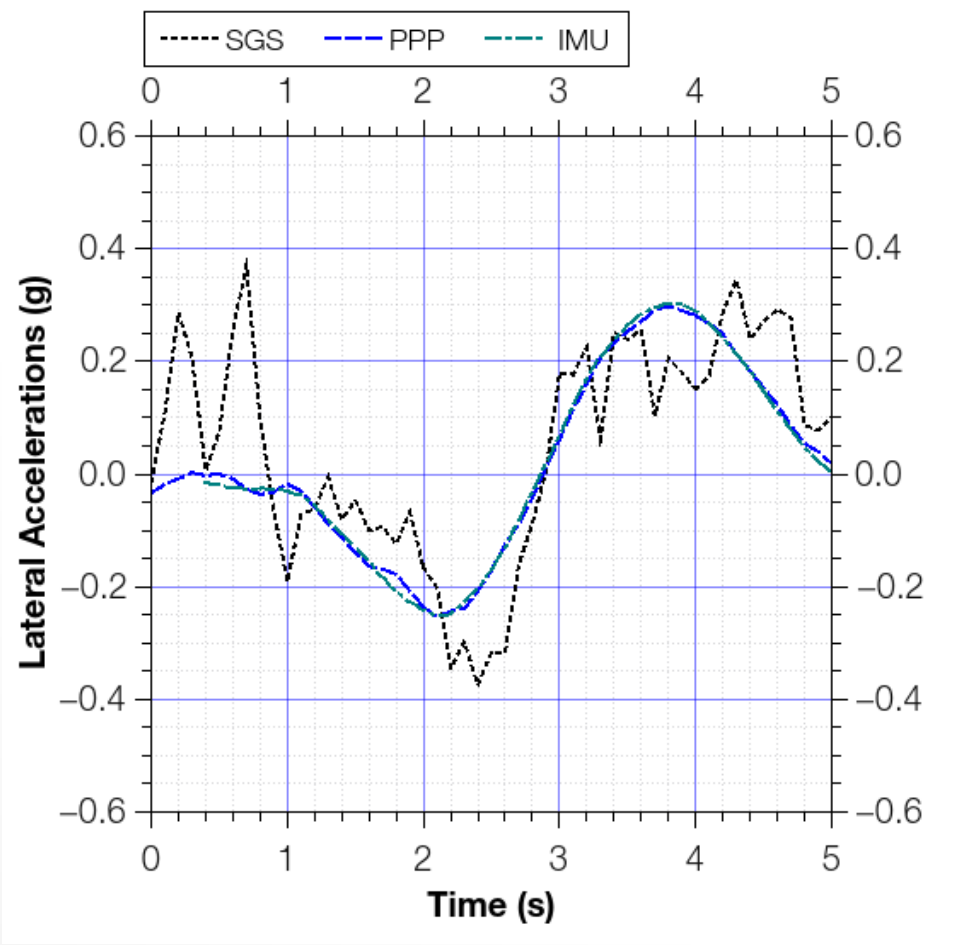


IMPROVEMENTS WITH PPP DYNAMIC

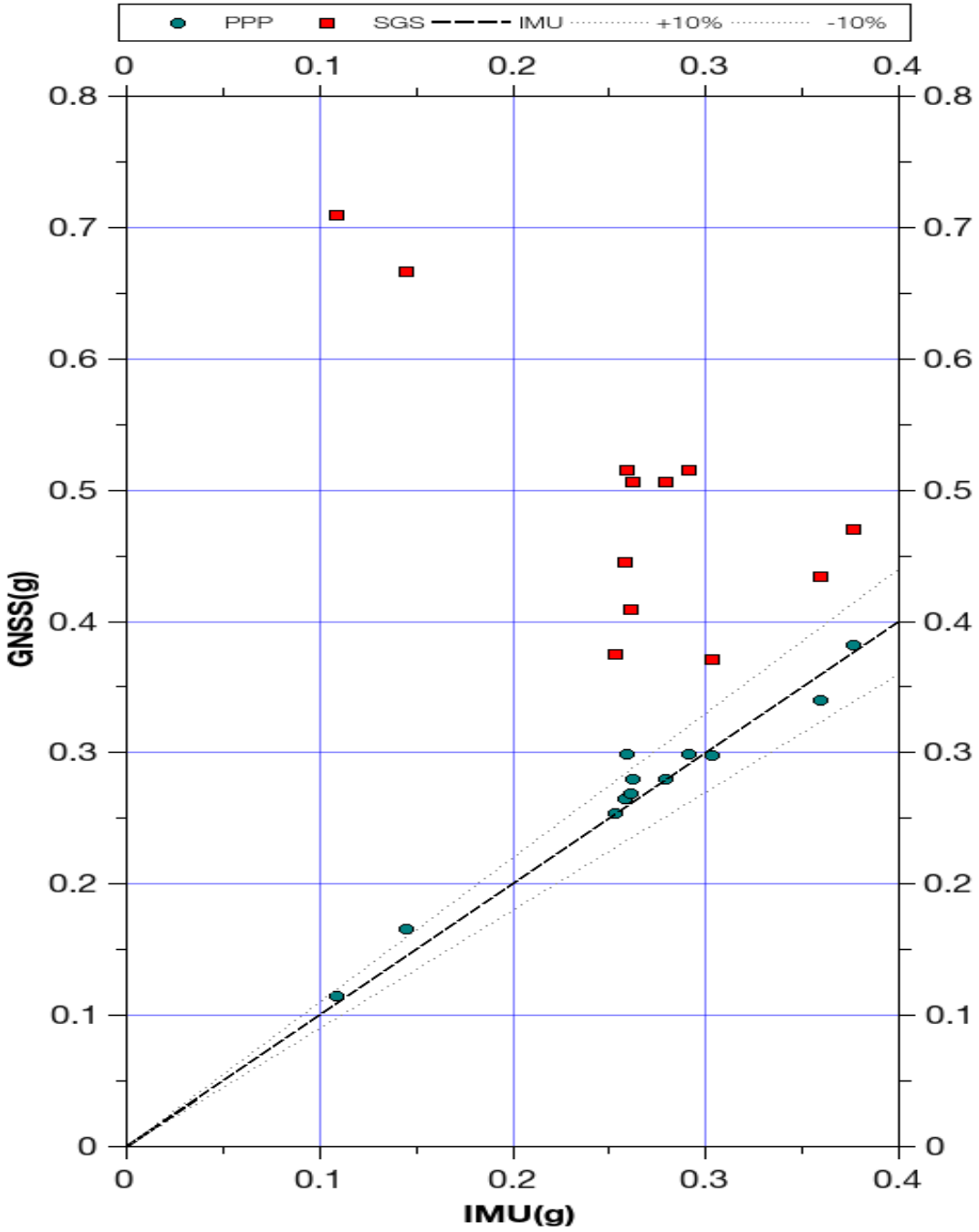


LATERAL ACCELERATION FROM PPP SOLUTIONS





PEAK LATERAL ACCELERATIONS



CONCLUSIONS

http://papers.sae.org/2014-01-2006/

- PPP solutions the lane change maneuver can be detected
  - Detected all vehicle maneuver
- Sub-meter class GNSS receiver should be evaluated.
  - L1-SAIF
  - U-blox Multi GNSS
  - LEX

DRIVER BEHAVIOR DETECTION BASED ON MULTI GNSS TECHNOLOGY

Peerapat PHONDEENANA
Smart Mobility Research Center,
Department of Mechanical Engineering, Faculty of Engineering,
Chulalongkron University, Bangkok. Thailand

Presented at 2014 FISITA World Automotive Congress, The Netherland

IN 2013, THAILAND IS 3RD RANK ROAD ACCIDENT FATALITIES BY WHO.

The most important parts is driver.

IN-VEHICLE DATA-LOGGER

F2014-AHF-021

DRIVER'S BEHAVIOR

Behavior	Physical Parameter
Accelerating	Longitudinal Acceleration
Braking	
Turning	Lateral Acceleration
Lane Changing	

LIMITATION WITH GPS

	Current 1-Hz conventional GPS receiver
Longitudinal Acceleration	enough accuracy and update rate for estimate.
Lateral Acceleration	For turning, applicable in cases with large displacement and duration.
	For lane change, cannot estimate, not enough accuracy and update rate.

http://youtu.be/kwXflBxs69A

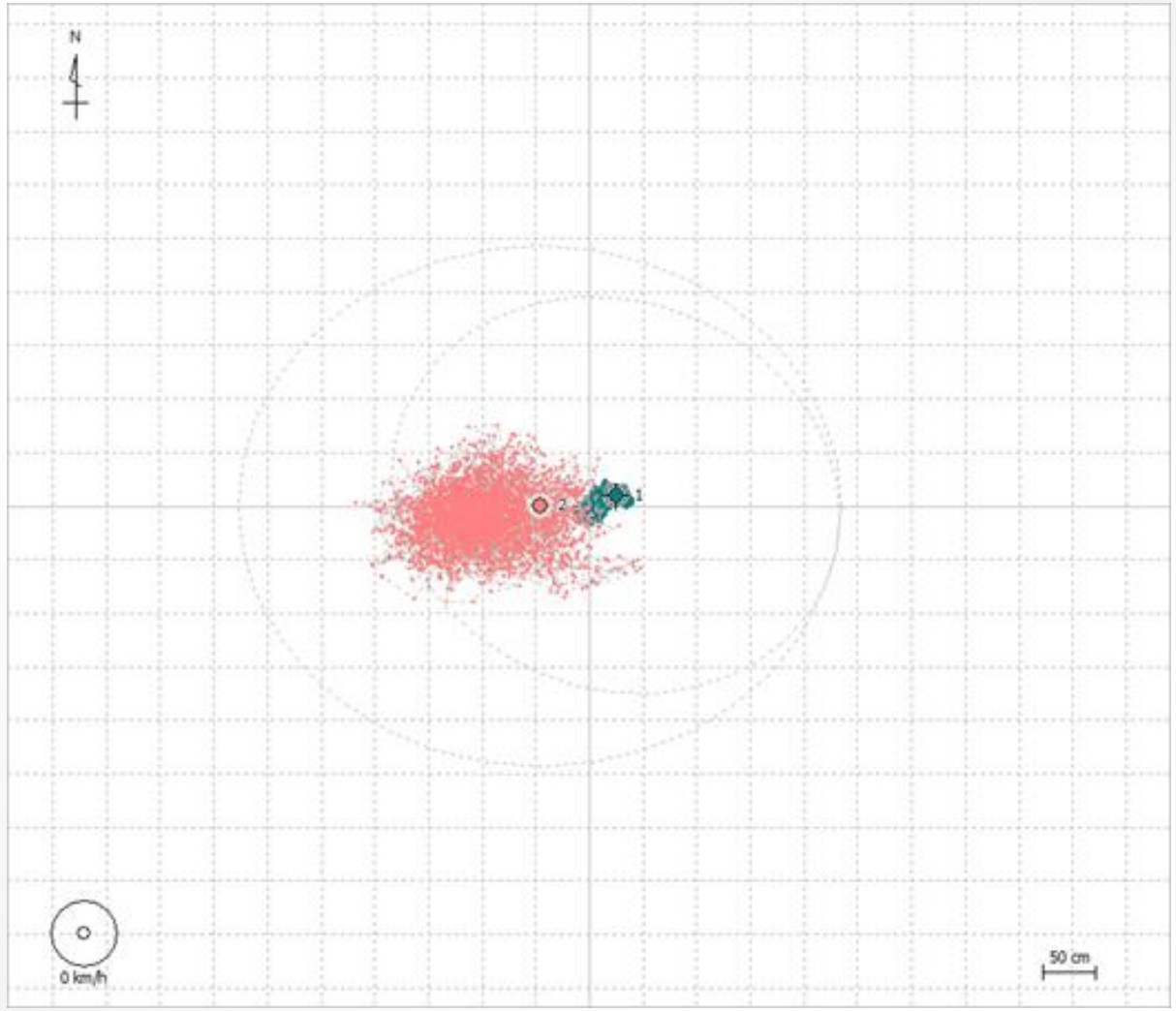
LANE CHANGING CLIP

F2014-AHF-021

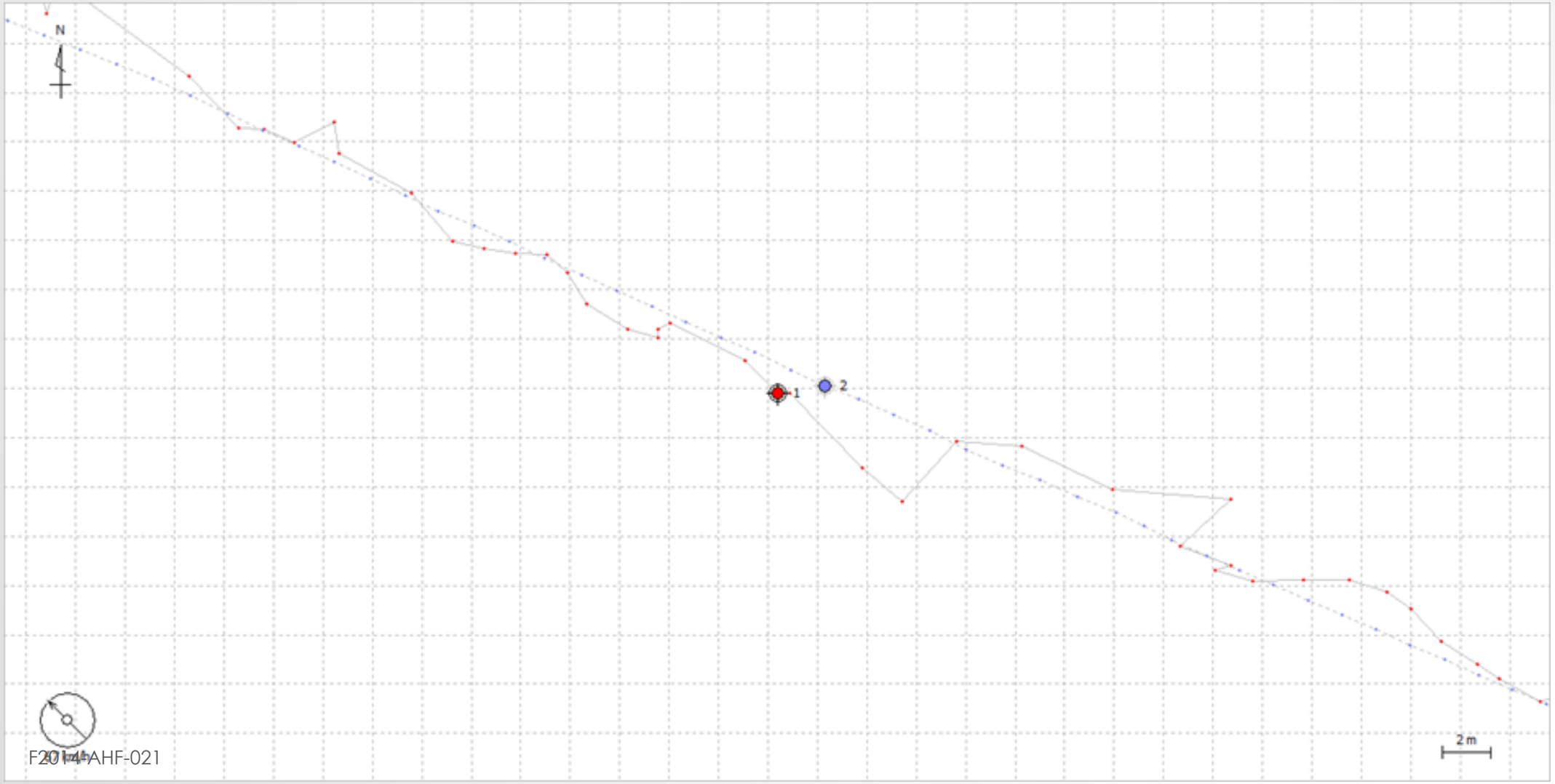
PREVIOUS WORK

IMPROVEMENTS WITH PPP

Setting	SGS	PPP
Positioning Mode	Single	PPP Kinematic
Frequencies/Filter Type	L1/Forward	L1/Forward
Elevations Mask	5°	5°
Ionosphere Correction	Broadcast	Iono-Free LC
Troposphere Correction	Saastamoinen	Estimate ZTD
Satellite Clock	Broadcast	Broadcast
Navigation System	GPS	GPS, GLONASS, QZSS

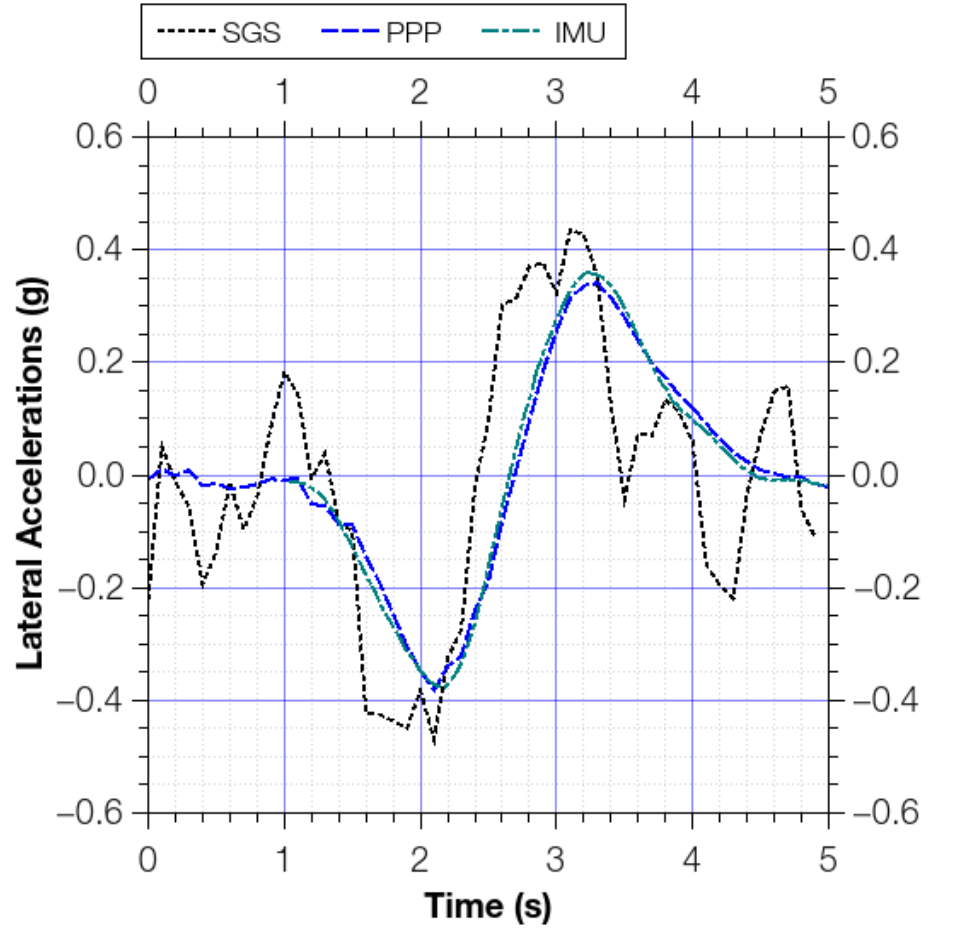


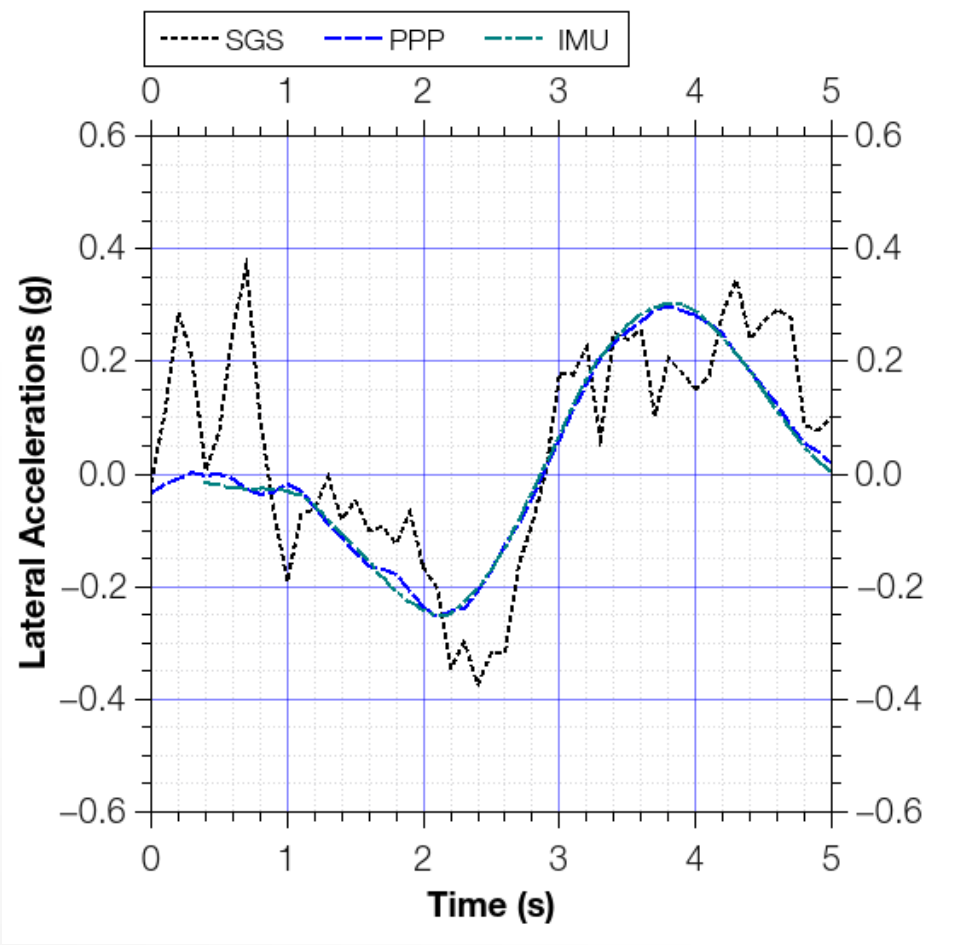
IMPROVEMENTS WITH PPP DYNAMIC



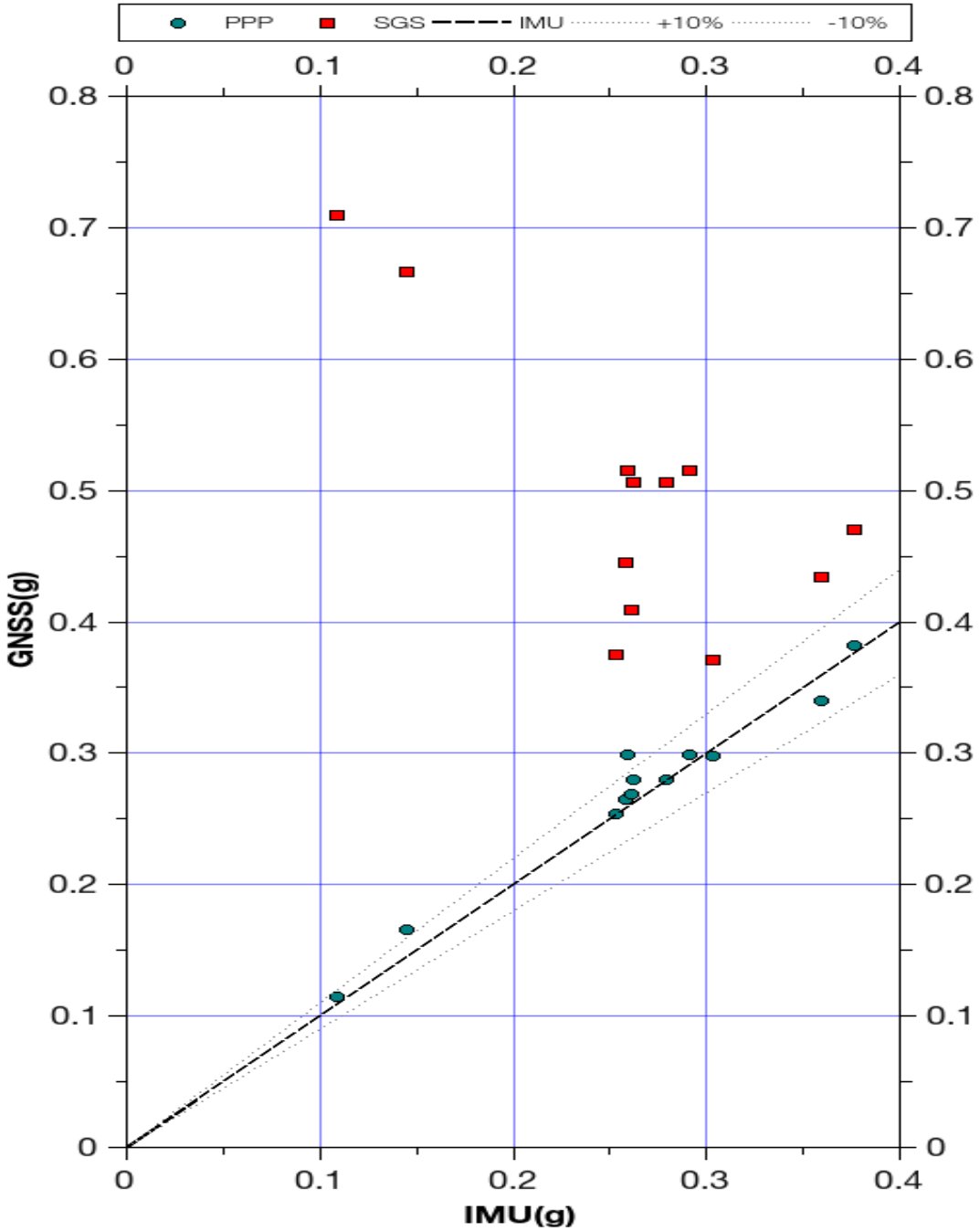
F2014-AHF-021

LATERAL ACCELERATION FROM PPP SOLUTIONS



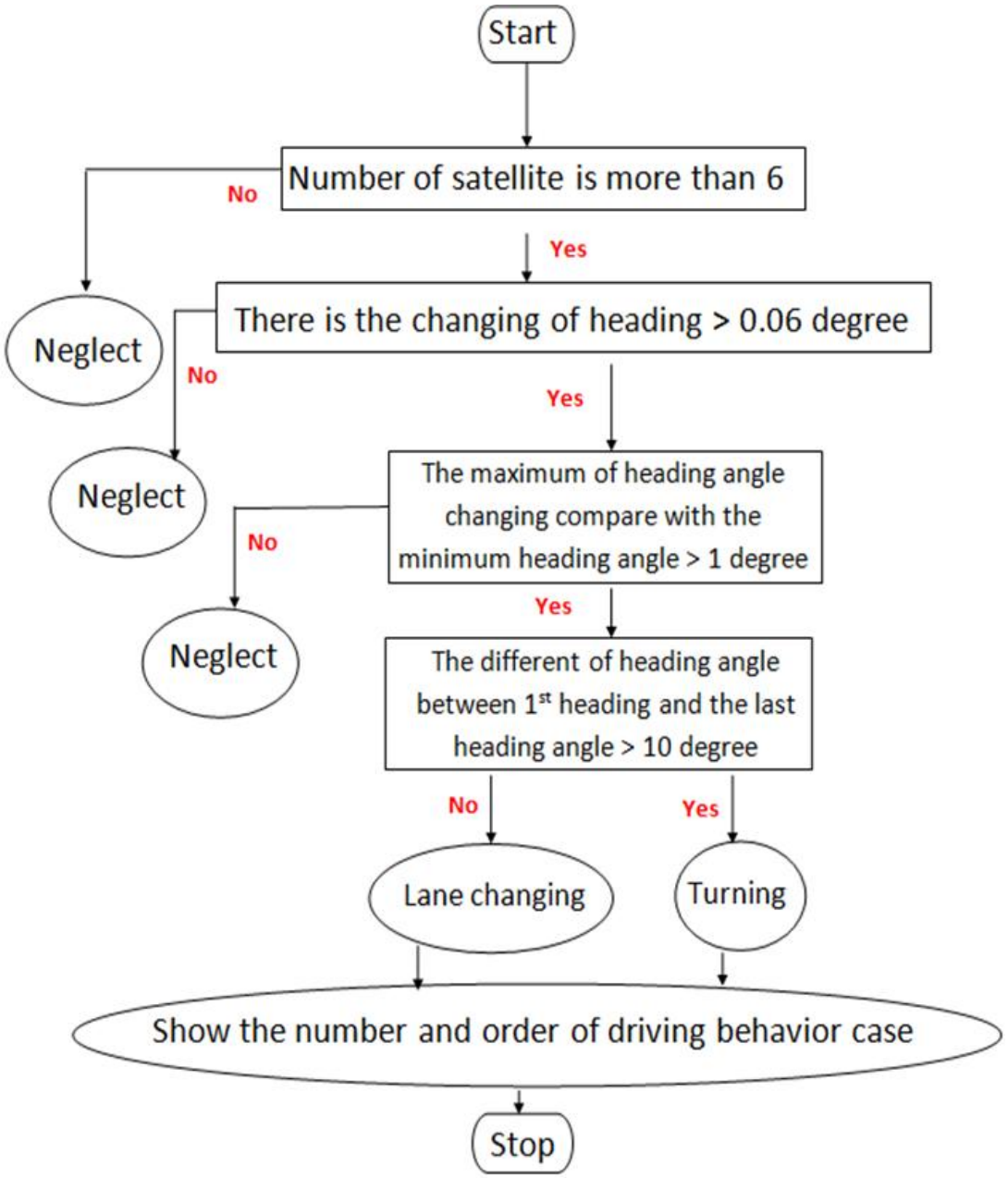


PEAK LATERAL ACCELERATIONS



PROPOSED DETECTION ALGORITHM

P. Phondeenana, N. NOOMWONGS, S. CHATRANUWATHANA and R. THITIPATANAPONG, "Driving Maneuver Detection System Based on GPS Data," in *Future Active Safety Technology Toward Zero Traffic Accidents*, Nagoya, 2013.



PROPOSED DETECTION ALGORITHM

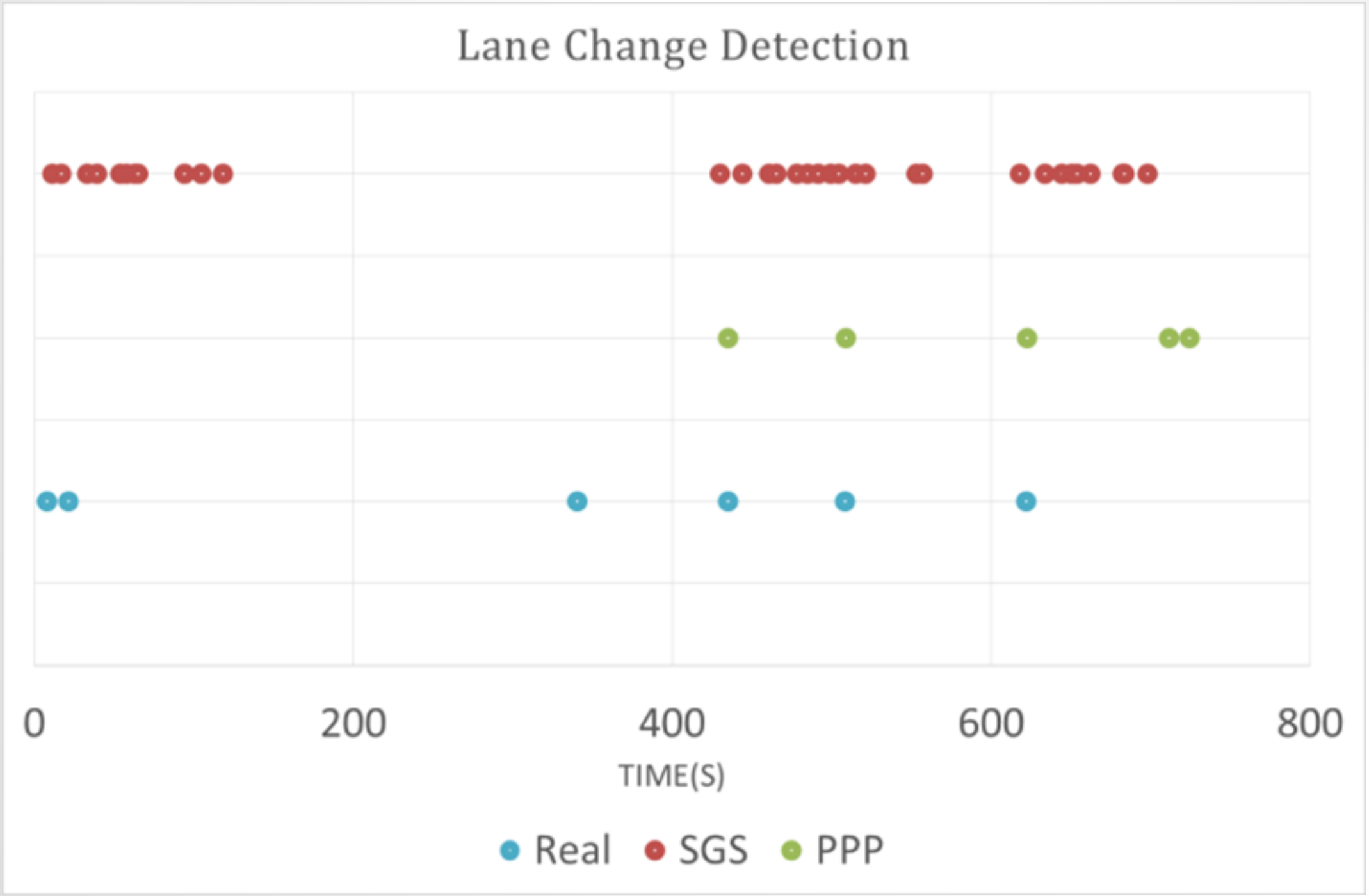
P. Phondeenana, N. NOOMWONGS, S. CHATRANUWATHANA and R. THITIPATANAPONG, "Driving Maneuver Detection System Based on GPS Data," in *Future Active Safety Technology Toward Zero Traffic Accidents*, Nagoya, 2013.

- In previous work, with conventional GPS navigation system (10-Hz)
- There were no problem with longitudinal movement.
- Many difficulties over lateral maneuver:
  - 66% over fault detection on turning.
  - Too small sample event over lane change.

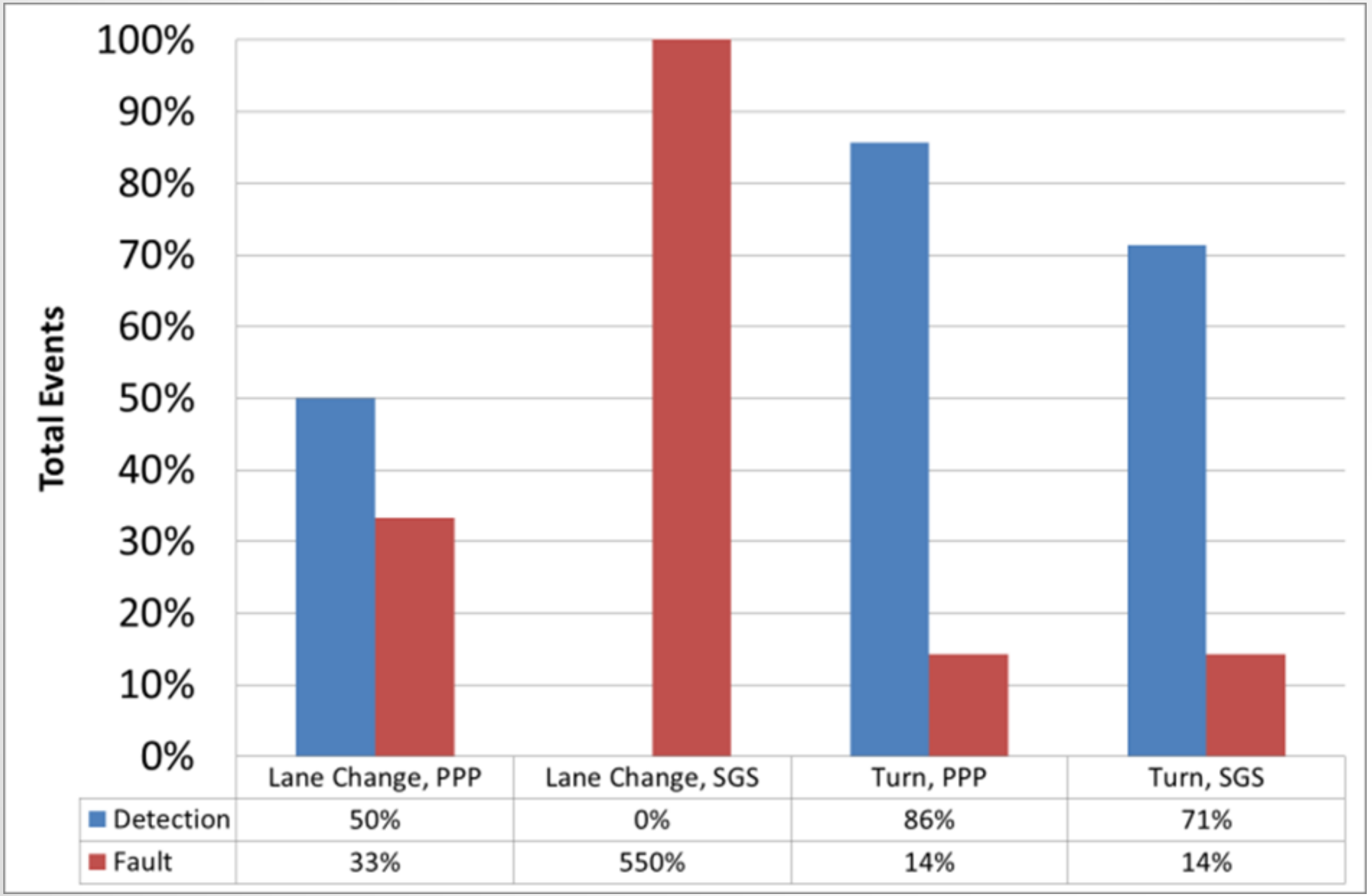
TESTED ROUTE

TESTED

- Real
  - Review the video footage (V-box)
- SGS – single solution
  - Conventional GPS
  - With 10-Hz update rate
- PPP – precise point positioning
  - Dual frequencies, ionospheric correction
  - With 10-Hz update rate


Lane Change Detection
0
200
400
600
800
TIME(S)
Real
SGS
PPP


Turn Detection
0
200
400
600
800
TIME(S)
Real
SGS
PPP



	Lane Change, PPP	Lane Change, SGS	Turn, PPP	Turn, SGS
Detection	50%	0%	86%	71%
Fault	33%	550%	14%	14%

CONCLUSIONS

- The advance multi-GNSS precise point navigation solution was investigated under driving behavior detection algorithm.
- The PPP navigation output combine with algorithm can improve:
  - Lane-change from nothing to half of total incidents.
  - Turning same as SGS.
- There still fault detection that needs to further investigated.

RECOMMENDATIONS

- This work had tested with a ten-thousand dollars receivers with decimeter accuracy.
- To feasible in real application, sub-meter accuracy, hundred dollars will further investigate.

DRIVER BEHAVIOR DETECTION BASED ON MULTI-GNSS PRECISE POINT POSITIONING TECHNOLOGY

Nuksit Noomwongs
Smart Mobility Research Center,
Department of Mechanical Engineering, Faculty of Engineering,
Chulalongkorn University, Bangkok. Thailand

Published in Applied Mechanics and Materials 08/2014; 619:327. DOI: 10.4028/www.scientific.net/AMM.619.327

IN 2013, THAILAND IS 3RD RANK ROAD ACCIDENT FATALITIES BY WHO.

The most important parts is driver.

IN-VEHICLE DATA-LOGGER

F2014-AHF-021

DRIVER'S BEHAVIOR

Behavior	Physical Parameter
Accelerating	Longitudinal Acceleration
Braking	
Turning	Lateral Acceleration
Lane Changing	

LIMITATION WITH GPS

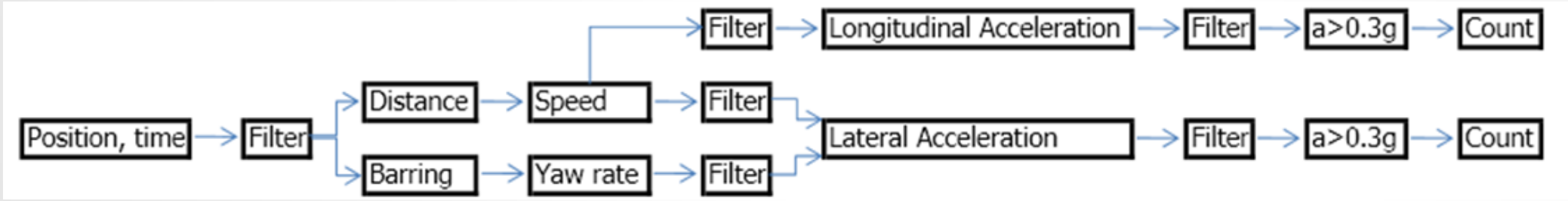
	Current 1-Hz conventional GPS receiver
Longitudinal Acceleration	enough accuracy and update rate for estimate.
Lateral Acceleration	For turning, applicable in cases with large displacement and duration.
	For lane change, cannot estimate, not enough accuracy and update rate.

OBJECTIVES

- To improve a simple vehicle maneuver detection algorithm is investigated.
  - Multi-GNSS with precise point positioning (PPP)
- Furthermore, the PPP in this study consisting of 2 method,
  - (1) Dual Frequencies estimation
  - (2) QZSS broadcast.

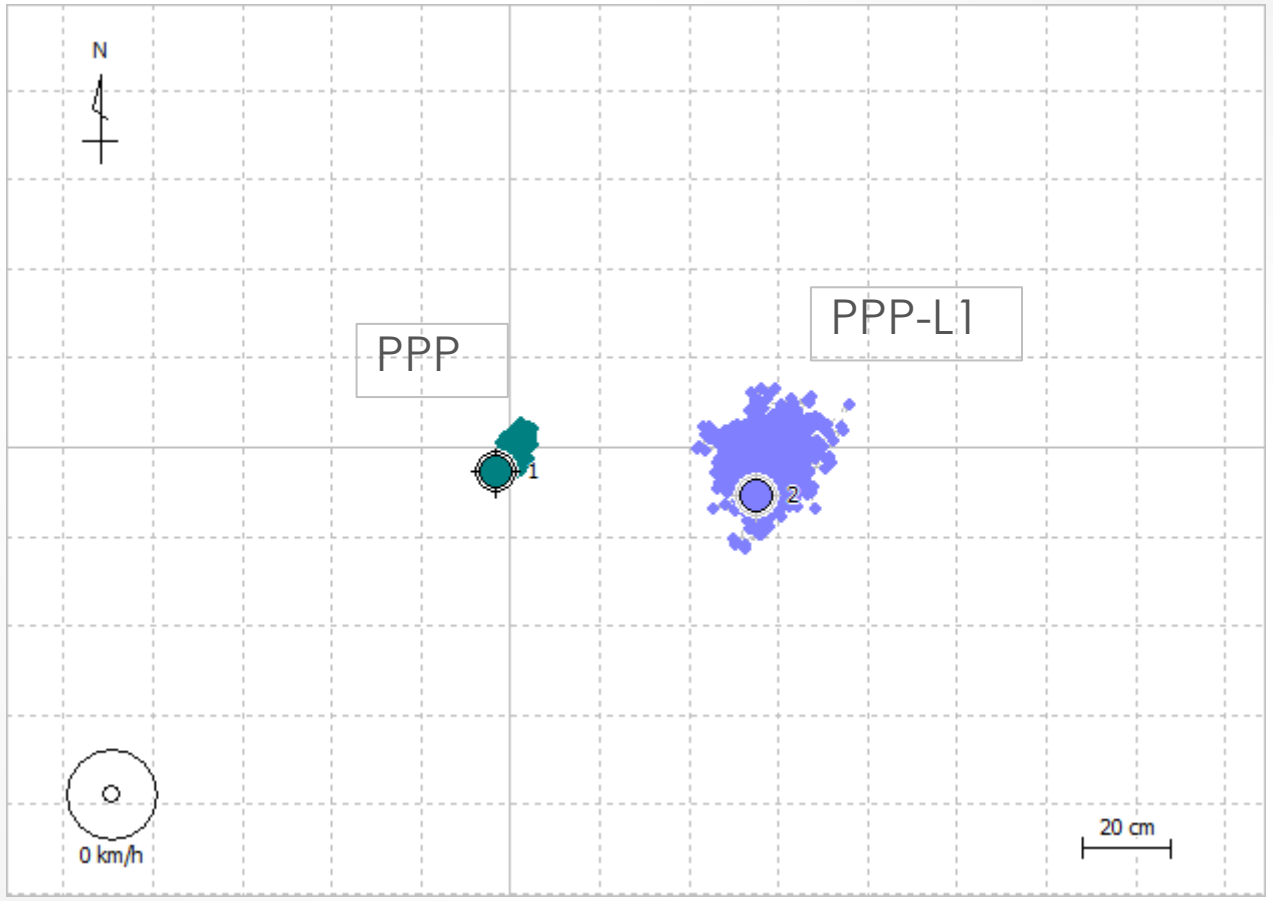
EXPERIMENTAL & RESULTS

DETECTION ALGORITHM



GNSS PROCESSING
PPP VS PPP L1

- PPP
  - Survey class receiver
    - Dual frequencies ionosphere correction
    - Precision ~0.2m
    - $15,000
- PPP-L1
  - Sub-meter class receiver
    - Broadcast Ionosphere correction from QZSS
    - Precision ~0.6m
    - $400 (prototype)



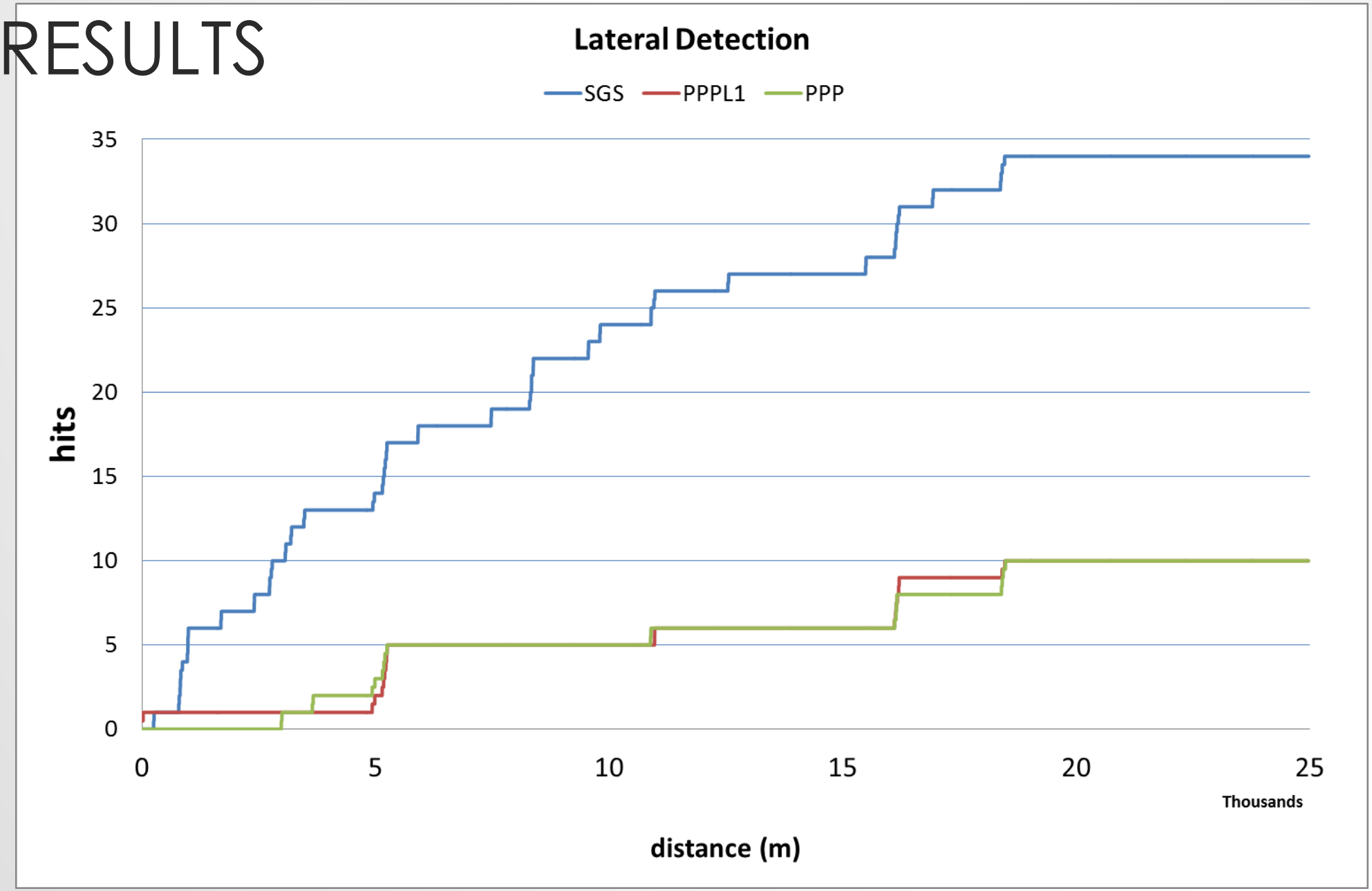
EQUIPMENT

- Visual: V-box Pro
- GNSS: JAVAD G3T
  - Post Processing with RTKlib
    - Single Solution
    - PPP
    - PPP L1
  - Vehicle: ISUZU Dmax V-cross 4Dr

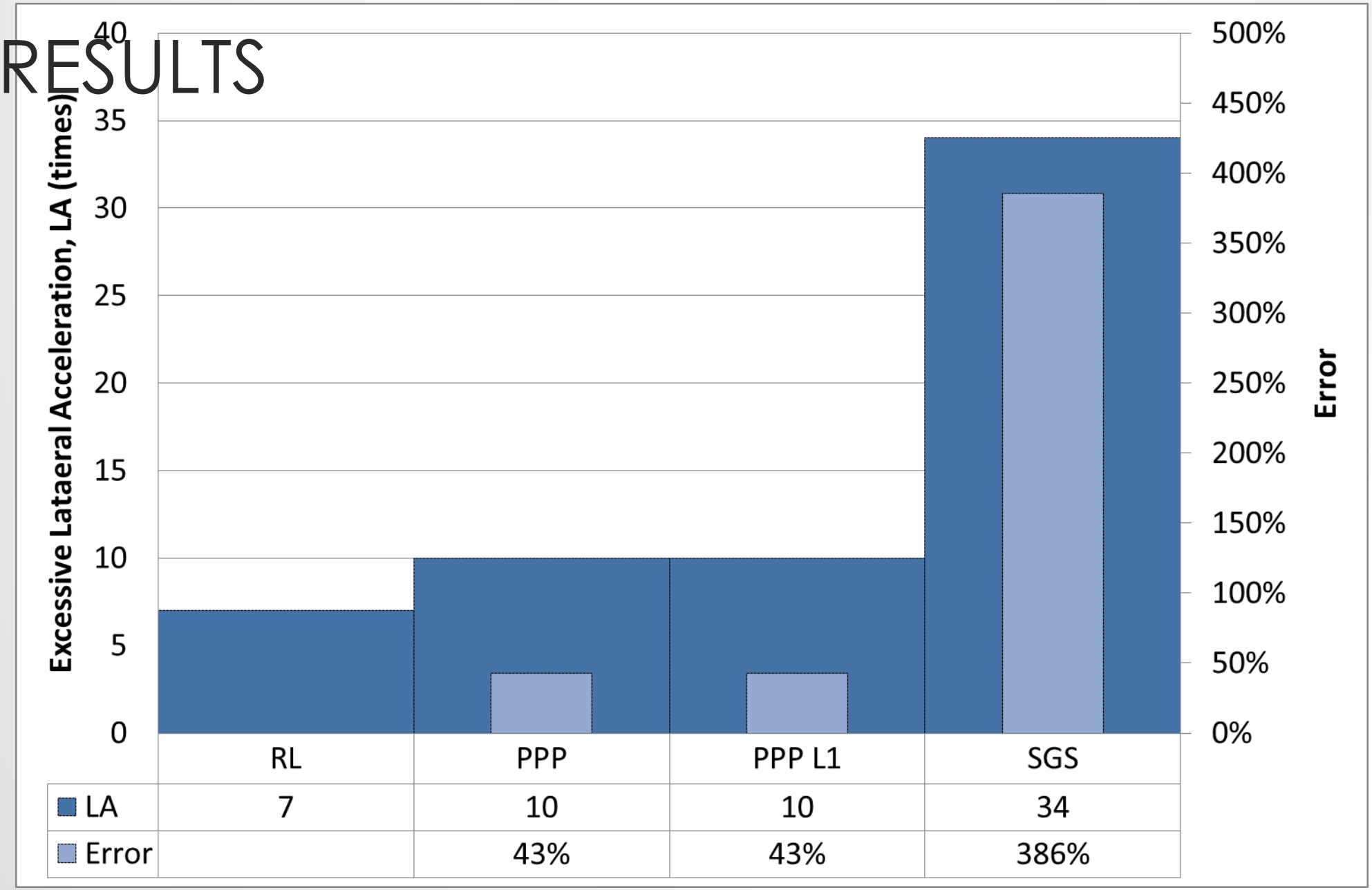
TESTED ROUTE

HW 304 in Nakhon Ratchasima

RESULTS


Lateral Detection
SGS
PPPL1
PPP
35
30
25
20
15
10
5
0
hits
0
5
10
15
20
25
Thousands
distance (m)

RESULTS


Excessive Lataeral Acceleration, LA (times)
40
35
30
25
20
15
10
5
0
500%
450%
400%
350%
300%
250%
200%
150%
100%
50%
0%
Error
RL
PPP
PPP L1
SGS
LA
7
10
10
34
Error
43%
43%
386%

CONCLUSIONS

- Both PPP on Multi-GNSS techniques can improve the detection performance in lateral motion detection.
  - 386% overestimate form conventional GPS positioning technique.
  - 43% overestimate in PPP and PPP-L1 techniques
  - 9 times improvements
- PPP-L1 indicated that low cost sub-meter class might apply to vehicle detection.

TECHNOLOGIES CONCLUSIONS

MULTI-GNSS ON ADVANCE AUTOMOTIVE

- จากประสบการณ์ที่ได้ทำการทดสอบกับระบบความแม่นยำสูงระดับเซนติเมตร
  - เครื่องมือที่ใช้ราคาหลายหมื่นเหรียญสหรัฐ
- การประยุกต์ใช้ระบบดาวเทียมนำร่องในยานพาหนะในยุคต่อไป
  - ต้องการระบบที่มีความแม่นยำระดับเมตร
  - ความถี่ในการปรับปรุงข้อมูลที่ ๕ ครั้งต่อวินาที ก็มีความเพียงพอ
- ซึ่งในปัจจุบันระบบที่กล่าวถึงนั้นสามารถหาซื้อได้ในระดับราคาหลักร้อยเหรียญสหรัฐ
- แต่ยังคงต้องพัฒนาวิธีการบริหารจัดการข้อมูลให้มีต้นทุนที่ยอมรับได้

ผู้สนับสนุน


MGA


JAXA


Quasi-Zenith Satellite System
JAXA
QZSS
みちびき


NECTEC
a member of NSTDA


สวทช
NSTDA


SAE
THAILAND


SMART MOBILITY
RESEARCH CENTER
FACULTY OF ENGINEERING, CHULALONGKORN UNIVERSITY


MSIG


Growing
Gnavis


TOYOTA
TSUSHO
ELECTRONICS
(THAILAND) Co.,Ltd.


บริษัท ตรีเพชรอีซูซุเซลส์ จำกัด
TRI PETCH ISUZU SALES CO.,LTD.