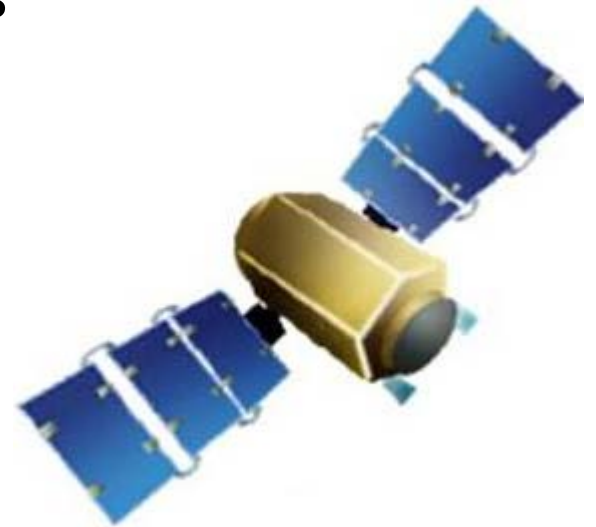




University
of Pardubice
Faculty
of Electrical Engineering
and Informatics

Detection of GNSS Horizontal Position Using 3D - Track Map

Ing. Marek Jonas



OUTLINE

- Differences between railway and aviation safety concepts
- Problems of integrity of GNSS-based position for safety-related applications on railways
- Proposed method for detection of horizontal position error based on altitude
- Test of this method by simulation
- Summary of error behaviour of investigated satellite



TRANSPORTATION SAFETY CONCEPTS

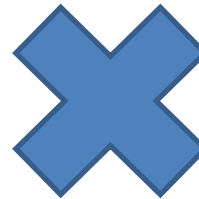
Differences between safety concepts



CENELEC standards (EN 50126, EN 50129, EN 50128 a EN 50159)

- railway RAMS - reliability, availability, maintainability and safety
- **Safety Integrity Levels (SIL)**

Big difference

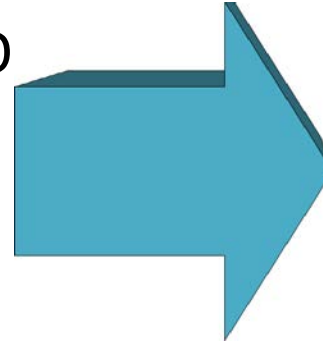


Aviation Target Level of Safety (TLS) concept defined by the International Civil Aviation Organization (ICAO)

- based on results from the statistical data of airplane accidents

MOTIVATION

- Upcoming GALILEO
- SBAS are available (EGNOS, WAAS, MSAS, GAGAN, SNAS)



Were designed according
The aviation requirements

For future use of satellite navigation systems on railways, increase of integrity of position solution is needed.

- The biggest task is satisfied of **SIL 4**

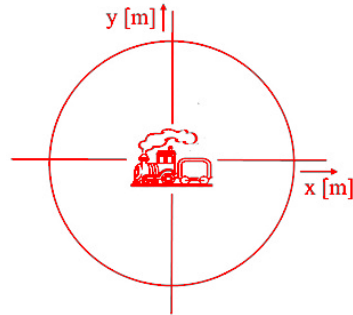


Torelable Hazard Rate

$$\text{THR} = 10^{-9}/\text{h}$$

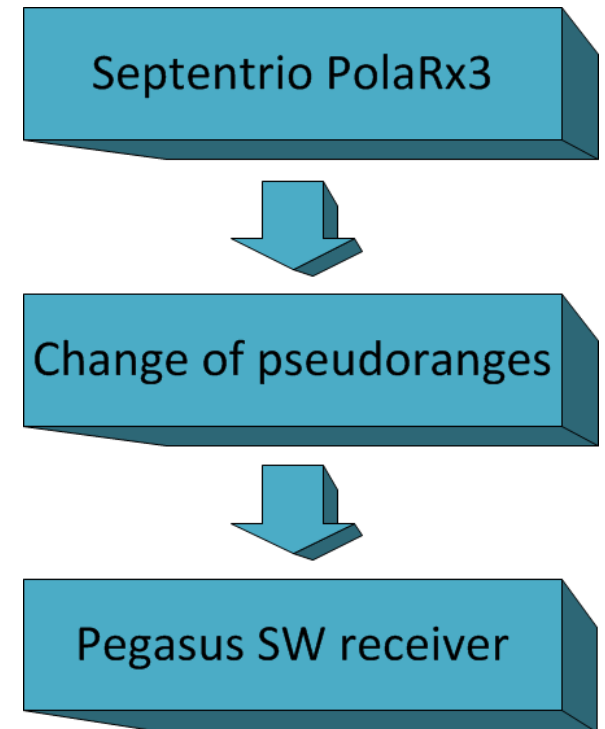
PROPOSED METHOD

- New method for improvement of integrity of the position solution is proposed



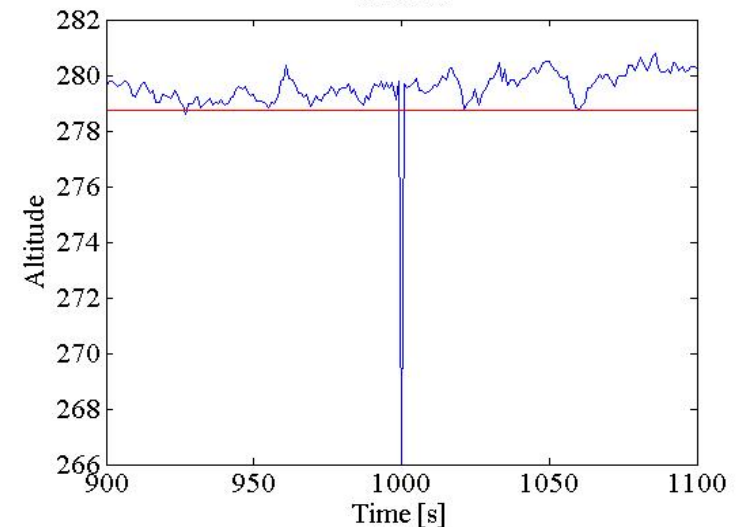
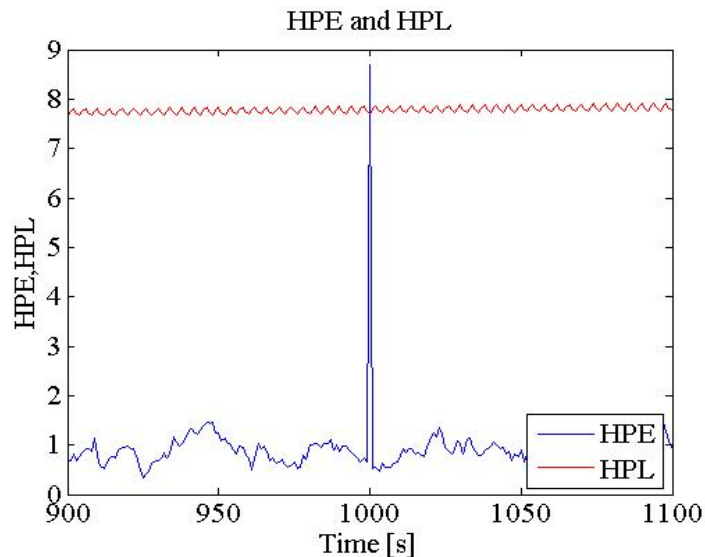
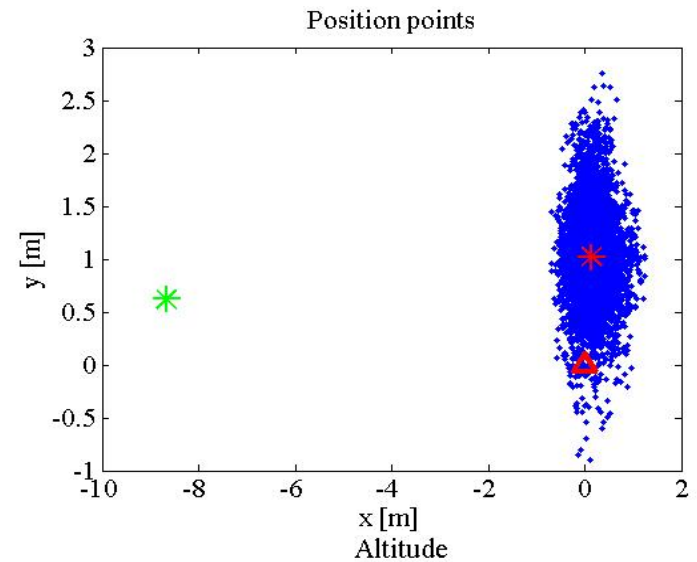
- **Horizontal position** is **crucial** in ground transportation
- Vertical position can be used for integrity check
- Possibility of **detection of GNSS errors in horizontal plane** by means of GNSS measured **altitude** was investigated by simulations

Simulation methodology



RESULTS

- Pseudorange of SVN 12; +20 m
- HPE = 8.8 m
- Difference between actual and mean value of altitude = 12.7 m
- HPE exceeds HPL, hazardous misleading information (HMI), it can be detected by altitude



SIMULATION RESULTS

From the results implies that effects of errors in horizontal plane and vertical directions are nearly the same in this case Of the satellite with elevation of about 50 degrees.

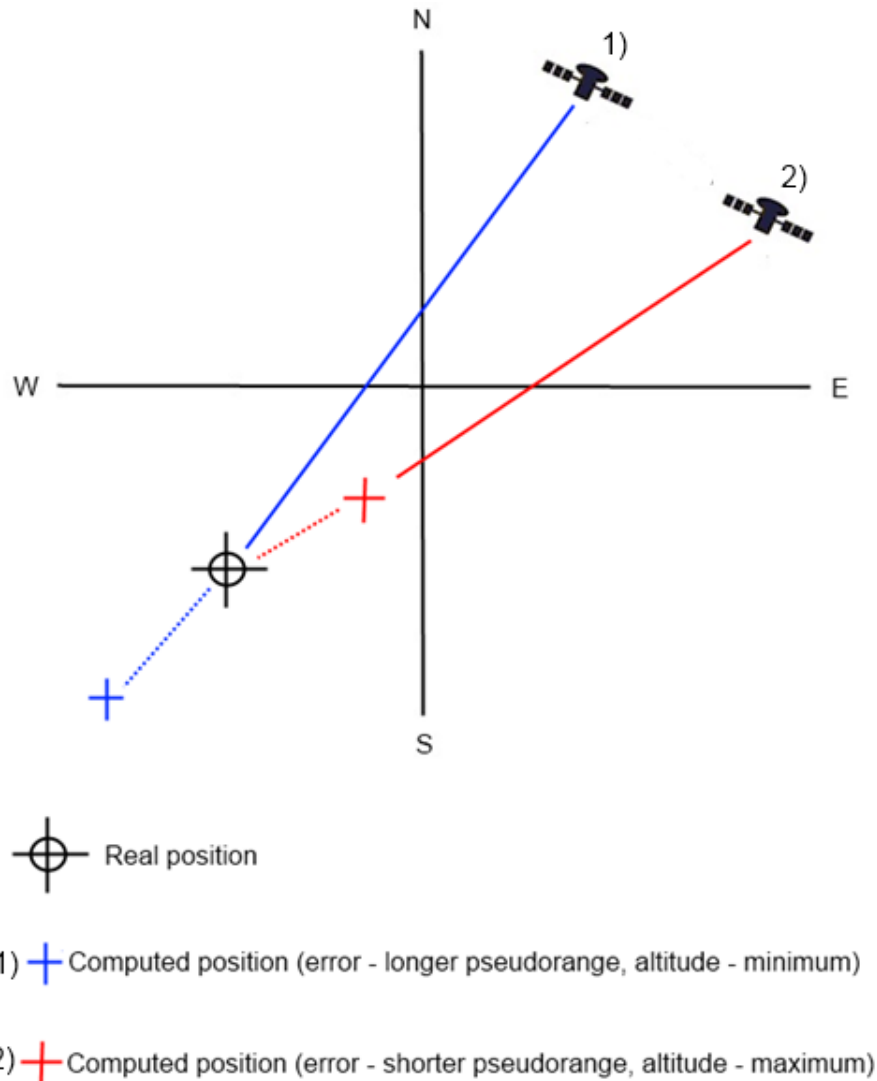
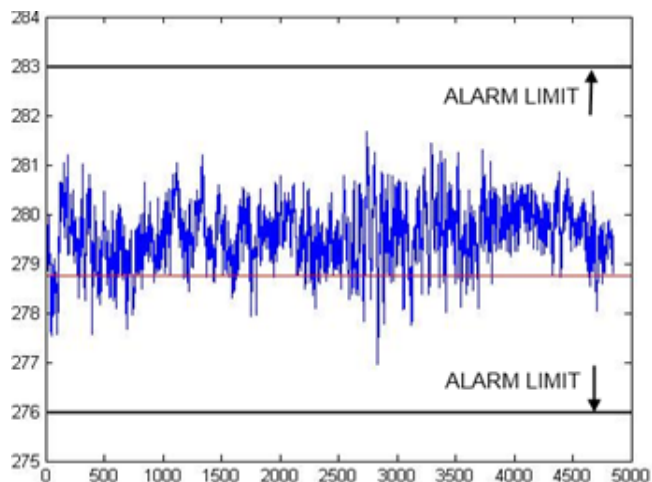
SHORTER PSEUDORANGE		
PR ERROR [M]	HPE	ALTITUDE DIFF
-3	1.5	3.4
-5	2.3	4.8
-12	5.4	9.7
-20	8.8	15.3

LONGER PSEUDORANGE		
PR ERROR [M]	HPE	ALTITUDE DIFF
+3	1.3	0.8
+5	2.2	2.2
+12	5.2	7.1
+20	8.8	12.7


- PR ERROR is error in the pseudorange
- HPE is Horizontal Position Error
- ALTITUDE DIFF is difference between measured and real position

SUMMARY OF ERROR BEHAVIOUR OF SVN 12

- Behaviour of errors in horizontal plane is in the picture on the right
- An alarm limits can be set for altitude for detection of error in horizontal plane



CONCLUSION

- 
- Method for detection of the horizontal position error based on current value of altitude was described
 - Method was tested by simulation
 - The simulation implies that we can estimate the value of HPE according to current value of measured altitude in this case of satellite with elevation about 50 degrees
 - According to results, this method is sensitive to errors caused by local effects which are not detectable by protection levels
 - This method can help increase the **integrity** of GNSS-based positioning at the earth ground
 - **integrity** is the key aspect of positioning from point of view of safety-related applications.

ACKNOWLEDGEMENT & CONTACT

Marek Jonas

marek.jonas@student.upce.cz

Department of Electrical Engineering

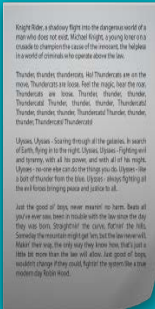
Faculty of Electrical Engineering and Informatics

University of Pardubice

Czech Republic

<http://www.upce.cz/en/fei/ke.html>

This research was supported by Internal Grant Agency of University of Pardubice SGS FEI 01/2013, by the grant GACR.



Knights Ride, a shadowy fight into the dangerous world of a
man who does not exist. Michael Knight, a young boy on a
quest to change the world for the better, the highest
in a world of criminals who operate above the law.

Thunder, thunder, thunder, All Thunderers are on the
move, Thunderers are here, feel the rage, feel the rage,
Thunderers are here, Thunder, thunder, thunder,
Thunderers, Thunder, thunder, Thunderers,
Thunder, thunder, Thunderers, Thunder,
Thunder, Thunder, Thunderers, Thunder,
Thunder, Thunder, Thunderers, Thunder,
Thunder, Thunder, Thunderers, Thunder,

Uppas, Uppas, Scaring through all the galaxies, in search
of Earth, flying in the night, Uppas, Uppas, Fighting and
screaming with all his power, and with all his might,
Uppas, no one else can do for things you do, Uppas, the
best of thunder from the blue, Uppas, always fighting
of the evil forces, always power and justice to all.

Just the good of love, when needed, no harm, because
you've ever been in trouble with the law since the day
they was born, Stay together, the cops, for the hell,
Somebody has to stand up for the law, the law will
hear of their way, the way they know how, that's just a
line of men from the world above, the good of love,
couldn't change if they could, fight for the good, like a true
modern day Robin Hood.