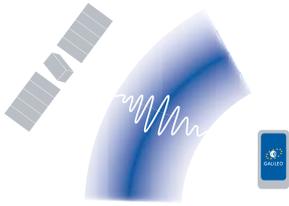


Ionosphere Modelling for Galileo Single Frequency Users



Benoît Bidaine
FNRS / University of Liège
Geomatics Unit

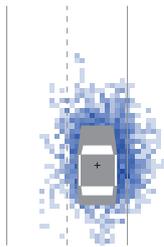
PhD defence
October 25th, 2012



Turn around as soon as possible



Propagation through the atmosphere
affects satellite **positioning**



GNSS broadcast appropriate information
to **mitigate** the ionospheric error



Receiver computing correction
New strategy for Galileo

PhD objective: **Performances?**

(Bidaine, 2012)

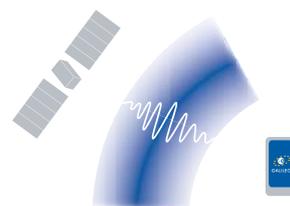
The Galileo correction improves
the positioning accuracy **less than expected**

Specifications met in terms of propagation delay
About 70% decrease

Delay and **positioning** performances
not directly related
Only 14% decrease in horizontal positioning errors

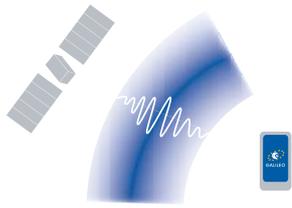
Potential **variants**
Up to 25% decrease in horizontal positioning errors

Ionosphere Modelling for Galileo



- 1 Algorithm
- 2 Performances
- 3 Variants

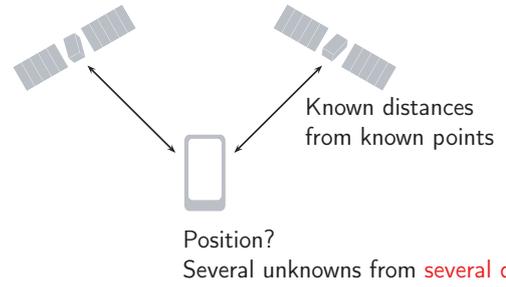
Ionosphere Modelling for Galileo



1 Algorithm
 Performances
 Variants

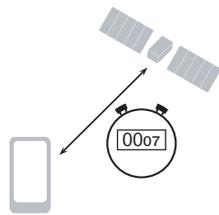
1 Algorithm

Satellite positioning is based on trilateration



1 Algorithm

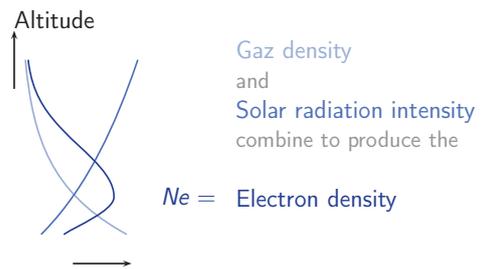
The receiver measures the signal time-of-arrival



Delays induce positioning errors

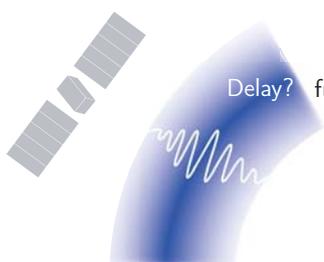
1 Algorithm

The atmosphere is ionised by solar radiation



1 Algorithm

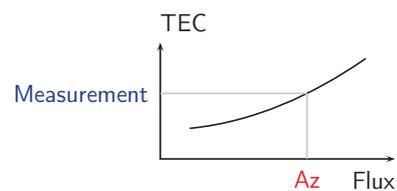
The ionospheric delay depends on the Total Electron Content



$$\text{Delay? function of } TEC = \int_{\text{Satellite}}^{\text{Receiver}} Ne$$

1 Algorithm

NeQuick models TEC in function of the solar flux



Data ingestion:
 Effective ionisation level Az minimising the difference with measurements

1 Algorithm

The Galileo ionospheric correction proceeds from **three steps**



Measure
TEC



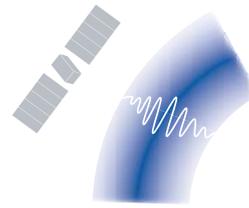
Optimise
Az



Run
NeQuick

1 Algorithm

Ionosphere Modelling for Galileo



Algorithm
2 Performances
Variants

The Galileo correction has been assessed in a **global** research framework

(Bidaine, 2012)

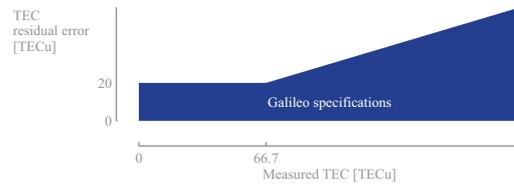
8 stations globally distributed



The whole year 2002

2 Performances

Do TEC residual errors meet the Galileo algorithm **specifications**?

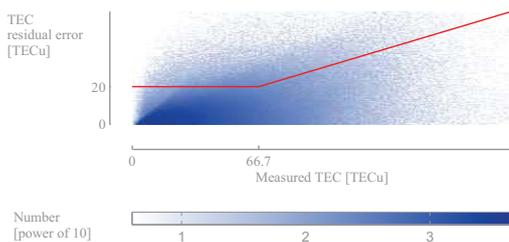


Errors smaller than 20 TECu or **30%**

2 Performances

93% of TEC residual errors meet the Galileo algorithm specifications

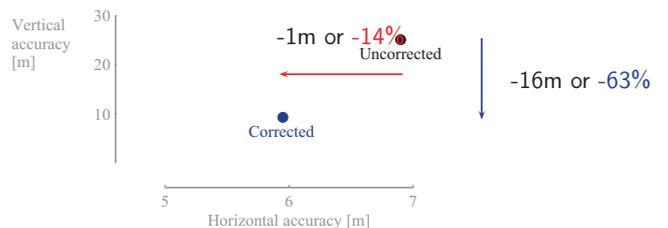
(Bidaine, 2012)



2 Performances

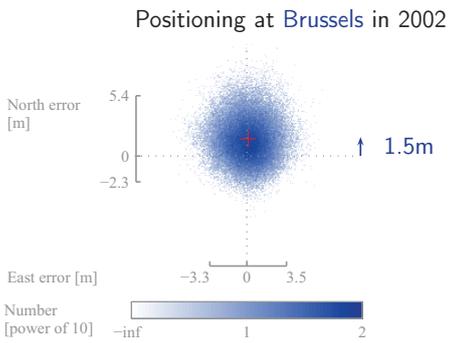
The Galileo correction only **improves partially** the horizontal accuracy

(Bidaine, 2012)



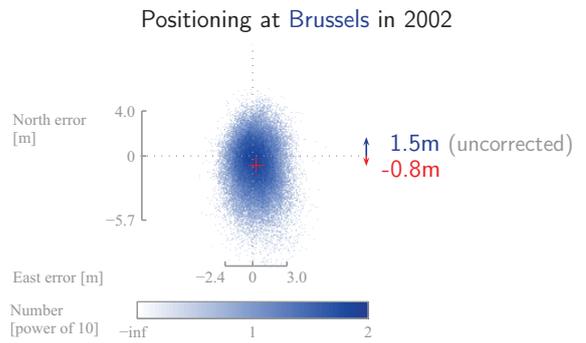
2 Performances

Without correction,
the mean north error



2 Performances

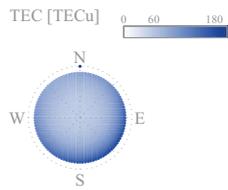
The Galileo correction **reverses**
the mean north error



2 Performances

TEC **directional** variability
influences positioning

From Brussels on March 21st, 2002

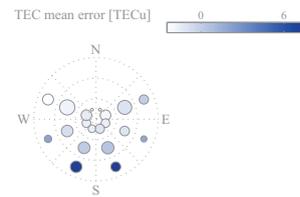


Following **sun direction**

2 Performances

TEC **directional mismodelling** explains
the limited horizontal accuracy improvement

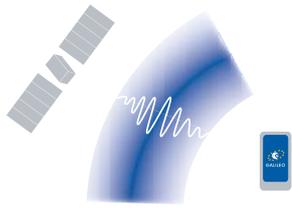
From Brussels in 2002



Receiver Az globally the most effective
but inducing a TEC **overestimation** southwards

2 Performances

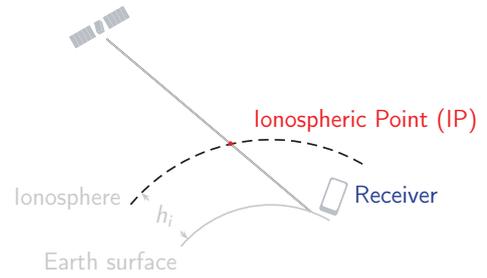
Ionosphere Modelling for Galileo



Algorithm
Performances
3 Variants

(Bidaine, 2012)

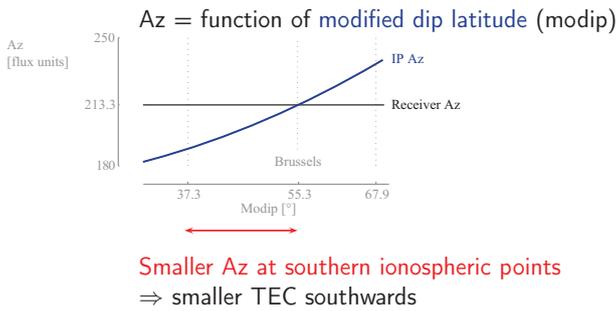
Broadcast information can be processed in different scopes



3 Variants

An adaptative Az scope copes with TEC directional mismodelling

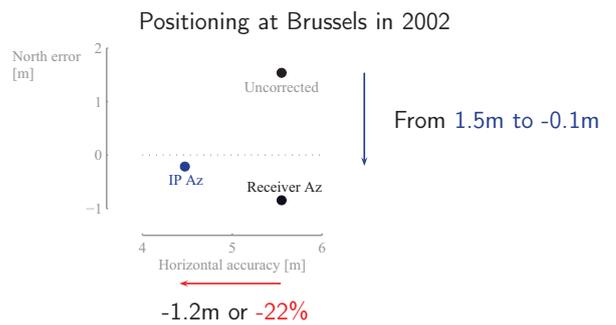
(Bidaine, 2012)



3 Variants

An adaptative Az scope neutralises properly the mean north error

(Bidaine, 2012)

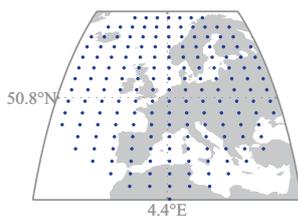


3 Variants

Broadcast information can be synthesised from TEC map ingestion

(Bidaine, 2012)

Measurements at grid points in sight of Brussels



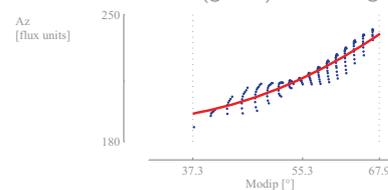
Az values for corresponding positions

3 Variants

TEC map ingestion increases the spatial flexibility of broadcast information

(Bidaine, 2012)

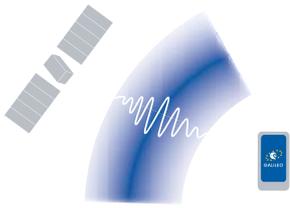
Modip dependence characterised regionally unlike (global) Galileo algorithm



Compatible with adaptative Az scope

3 Variants

Ionosphere Modelling for Galileo



- 1 Algorithm
- 2 Performances
- 3 Variants

(Bidaine, 2012)

Regional correction procedures could improve Galileo positioning

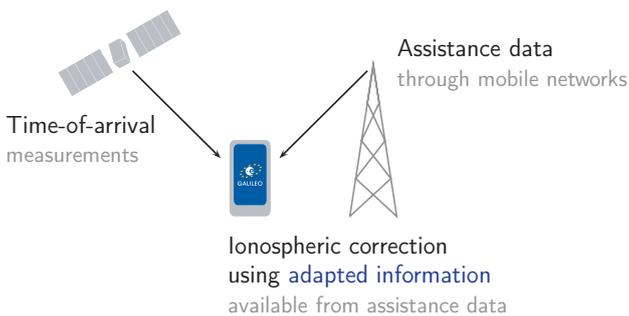
Specifications met in terms of TEC
Thanks to data ingestion

TEC and positioning performances
not directly related
Influence of TEC directional differences

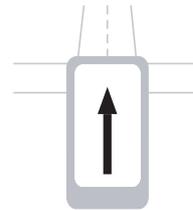
Potential variants
Adaptative effective ionisation level

Regional correction procedures could be implemented through assisted GNSS

(Bidaine, 2012)



At the next junction, go straight



Ionosphere Modelling for Galileo Single Frequency Users

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Geomatics Unit

