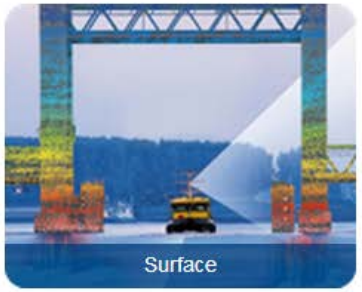
INS performance tuning through careful selection of Standard Deviations

Offshore survey and positioning, 6th June 2013, Jim Titcomb

Market Sectors

Navigation & Motion systems for Geoscience


Subsea


Surface

Navigation & Motion systems for Defense


Naval Defense


Land Defense

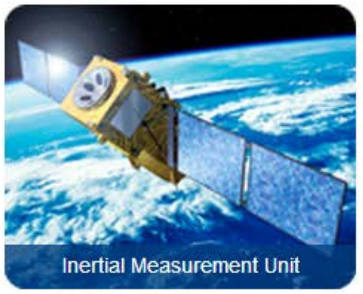
Offshore


Subsea Navigation

Land & Air

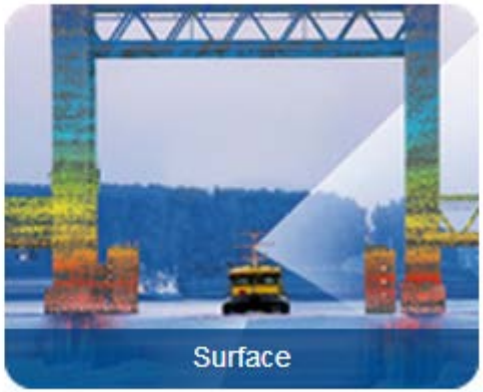

Mobile Mapping

Space


Inertial Measurement Unit

Geoscience

Navigation & Motion systems for Geoscience

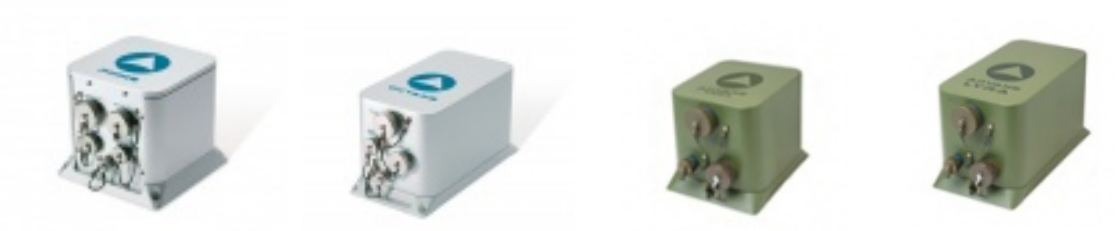


Defence

Navigation & Motion systems for Defense

Naval Defense

Land Defense



Commercial

Offshore

Land & Air

Inertial Navigation Aiding

- Generic inputs available for GPS, USBL, LBL, DVL, etc.
- Various protocols for each input type.
- Each generic input has a default error model.
- Error model based on SD
- SD set by default or read from input data.
- Designed to accept data from most systems in most circumstances.

- Standard deviation used in two different ways:-
  - Pre Filter
  - Weighting

Input Protocols with Standard Deviation fields

INS

USER GUIDE

V PART 5: LIBRARY INTERFACE

Input Protocols with Standard Deviation fields

- APOS PSMSSB
- EIVA
- GAPS STANDARD
- GPS
- HALIBURTON SAS
- USBL LBL CTD (Bluefin)
- IXSEA USBL INS 1
- POSIDONIA 6000

Quality factor sent by GPS	Message in IXREAPATER	Converted STD in INS
0 or ≥ 5	N/A	Data rejected
1	Natural	10 m
2	Differential	3 m
3	Military	10 m
4	RTK	0.3 m
5	Float RTK	1 m

$PIXSE,STDPOS,x.x,y.y,z.z*hh<CR><LF> (*)		
x.x	Latitude standard deviation in meters	USED
y.y	Longitude standard deviation in meters	USED
z.z	Altitude standard deviation in meters	USED
hh	Checksum	USED

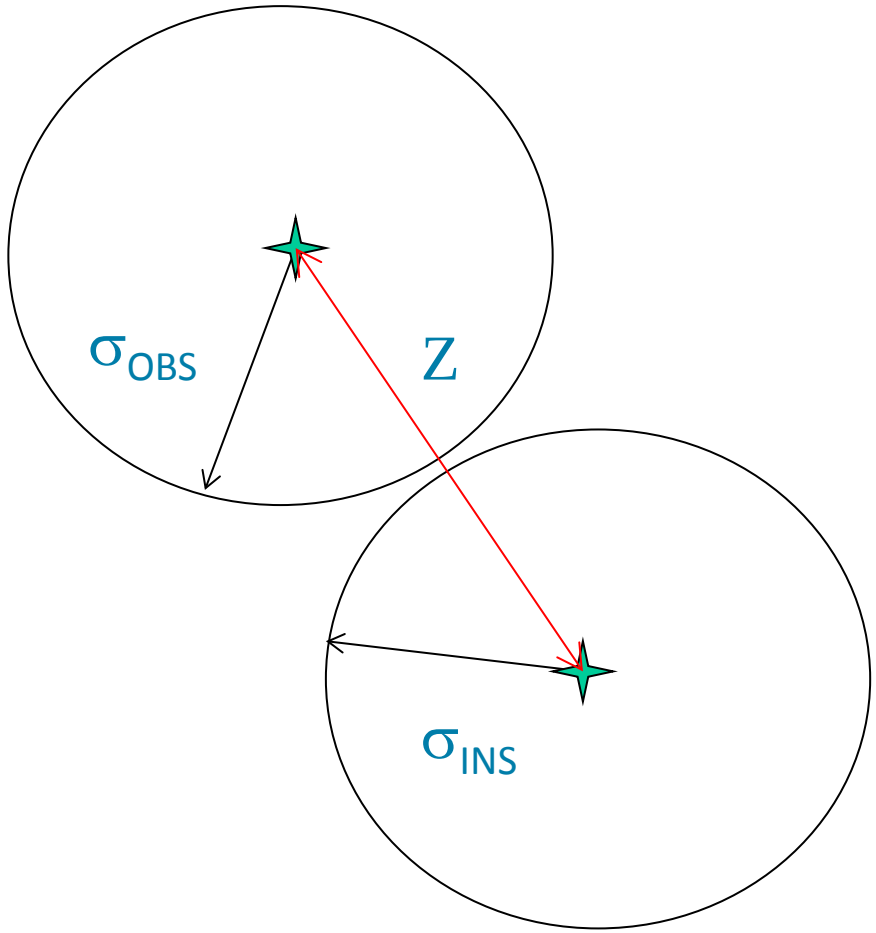
$PUSBA,hhmmss.s,llmm.m,a,LLLmm.m,b,±c.c,±c.c,±c.c,±c.c,r.r,t.t,s.s,a.a, llmm.m,a,LLLmm.m,b,d.d,c<CR><LF>		
hhmmss.s	UTC time stamp of position in hours (hh) minutes (mm) and Second(ss.ss) (taken into account if the INS is UTC time synchronized otherwise age of data is taken into account)[1]	ss.s : 40 bit float (*)
llmm.m	is the latitude in degrees (ll) and in minutes (mm.m)	mm.m : 40 bit float
a	is the hemisphere N: North S: South	char
LLLmm.m	is the longitude in degrees (LLL) and in minutes (mm.m)	mm.m : 40 bit float
b	is longitude sign E: East W: West	char
±c.c	is estimated errors in latitude, covar(Lat), in meters^2	40 bit float
±c.c	is estimated error in longitude, covar(Long), in meters^2	40 bit float
±c.c	is estimated correlated lat/long error, covar(LatLong), in meters^2	40 bit float

Pre Filter

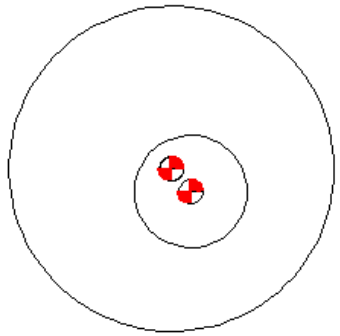
- IF $$Z = INS - OBS.\sqrt{(2.\sigma_{INS}{}^2 + \lambda.\sigma_{OBS}{}^2)}$$
- Then the aiding data is rejected. Where:-
  - INS = Position calculated by INS
  - OBS = Position observed from external sensor
  - σ_{OBS} = Standard deviation on position from external (or default, for USBL =10m)
  - σ_{INS} = Standard deviation on INS position (internally calculated)
  - λ = 3 (default value)

Pre Filter – In Simple Terms.

- If the SD circles overlap the data is accepted.
- If no aiding data is available σ_{INS} will grow, eventually circles will overlap.



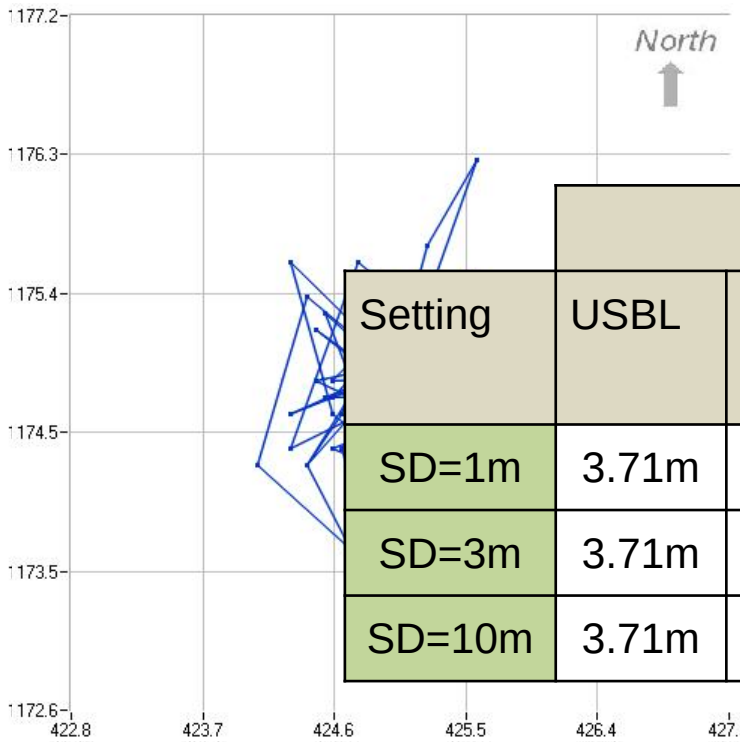
Rejection filter in practice



Weighting

- The larger the standard deviation the less effect the applied data will have on the final position.

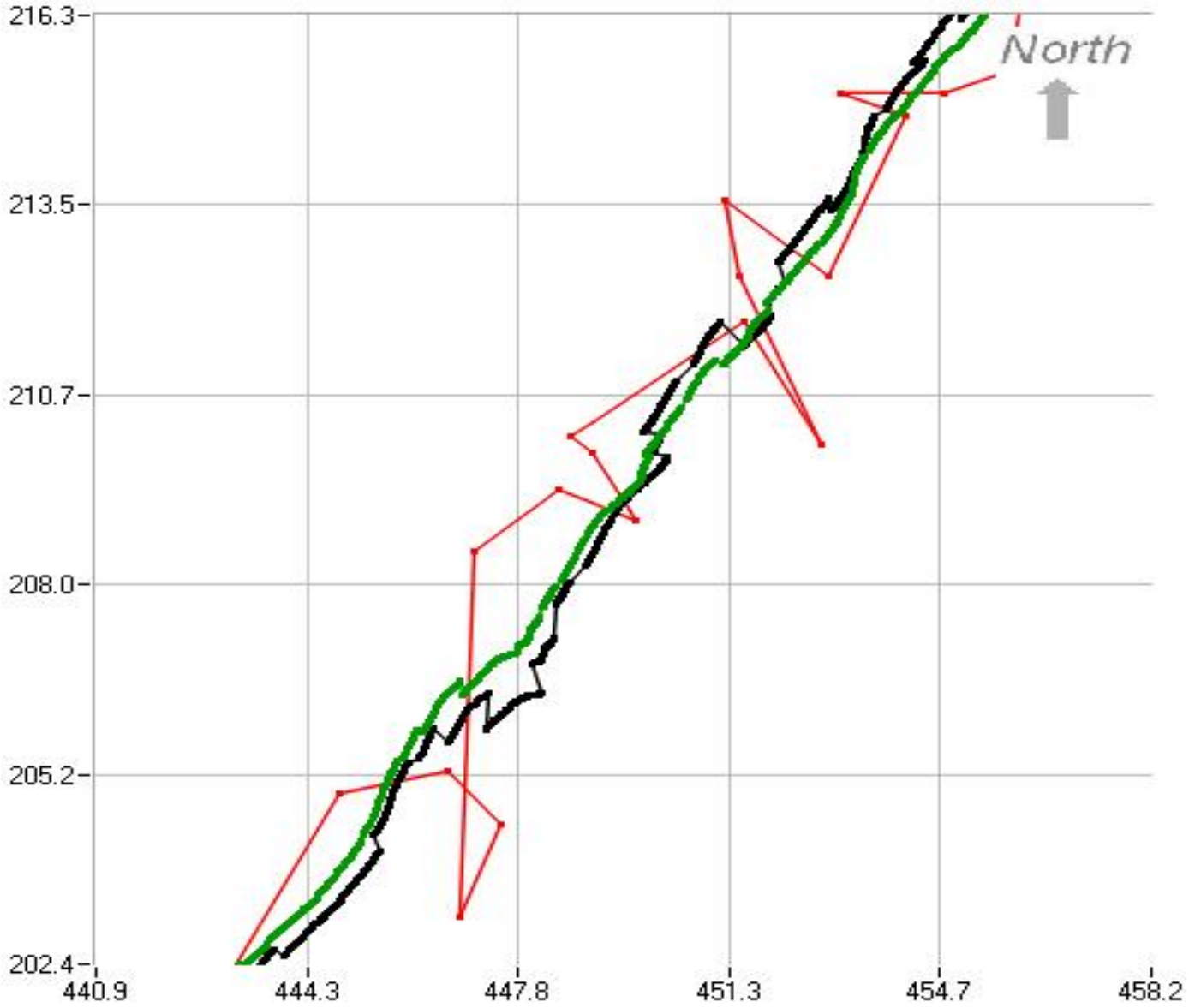
USBL SD = 3m



	Noise Reduction		
Setting	USBL	PHINS + DVL + USBL	Ratio
SD=1m	3.71m	1.58m	2.34
SD=3m	3.71m	1.00m	3.71
SD=10m	3.71m	0.69m	5.31

Weighting 2

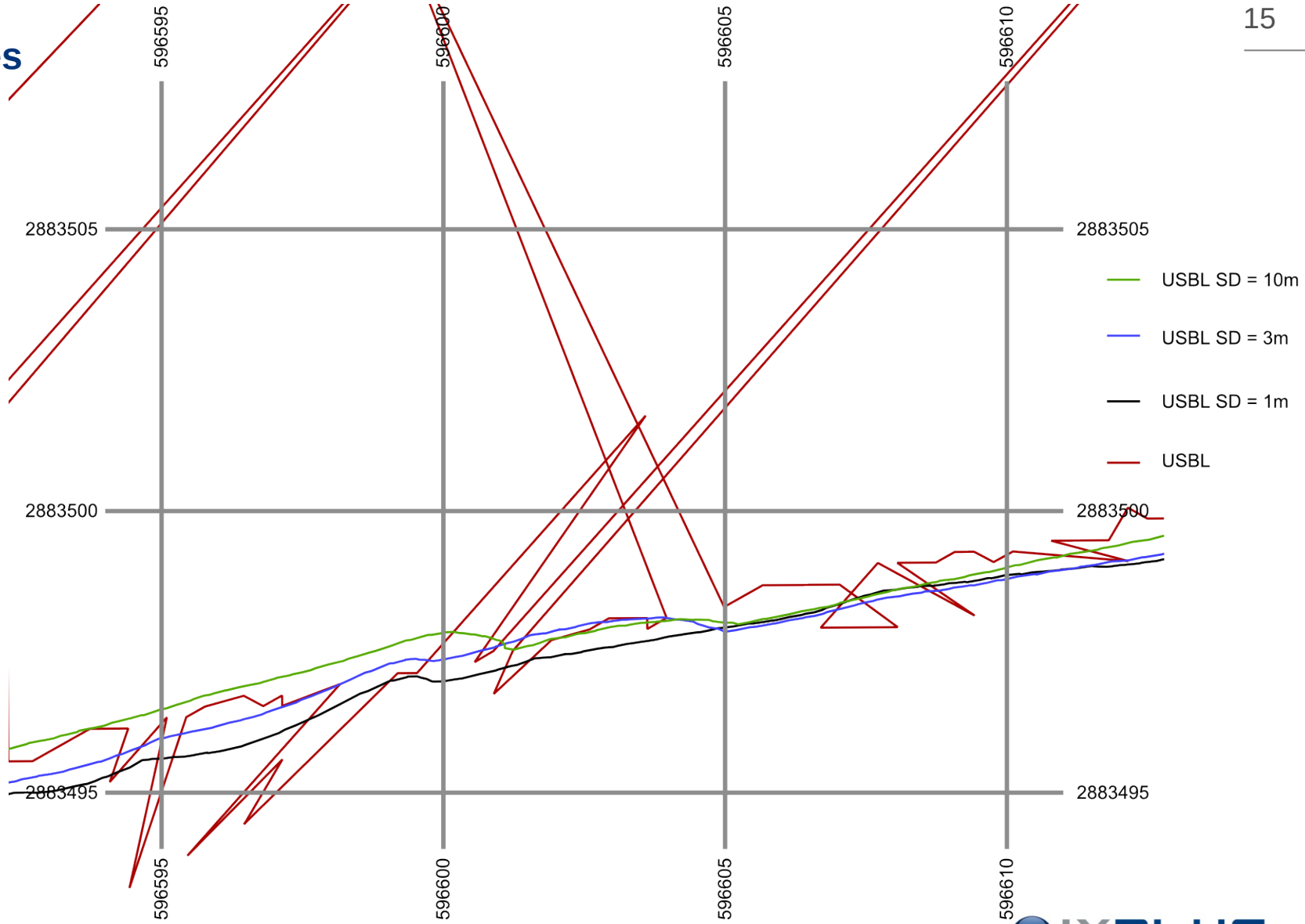
- Red = USBL
- Black SD=1m
- Green SD=10m



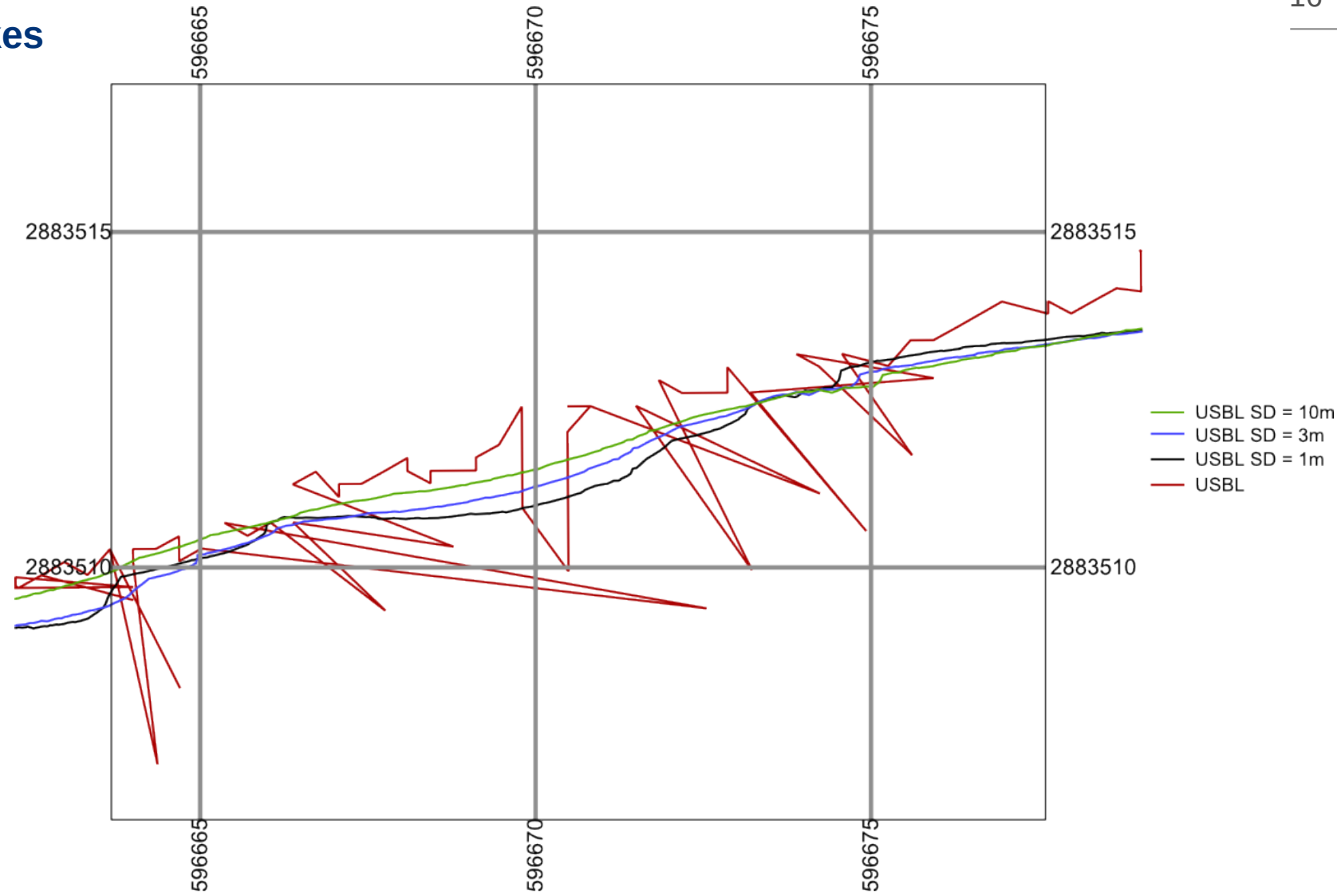
The Problem

- Large Position spikes
  - Large SD will allow large position spikes to be accepted
  - Small SD will cause these spikes to be rejected.
  - BUT a Small SD will cause small noise to have more effect.

Large Spikes



Small Spikes



Conclusions

- Reducing the USBL SD causes more low level noise to break through from the USBL data to the INS position but prevents INS taking USBL spikes as good data.

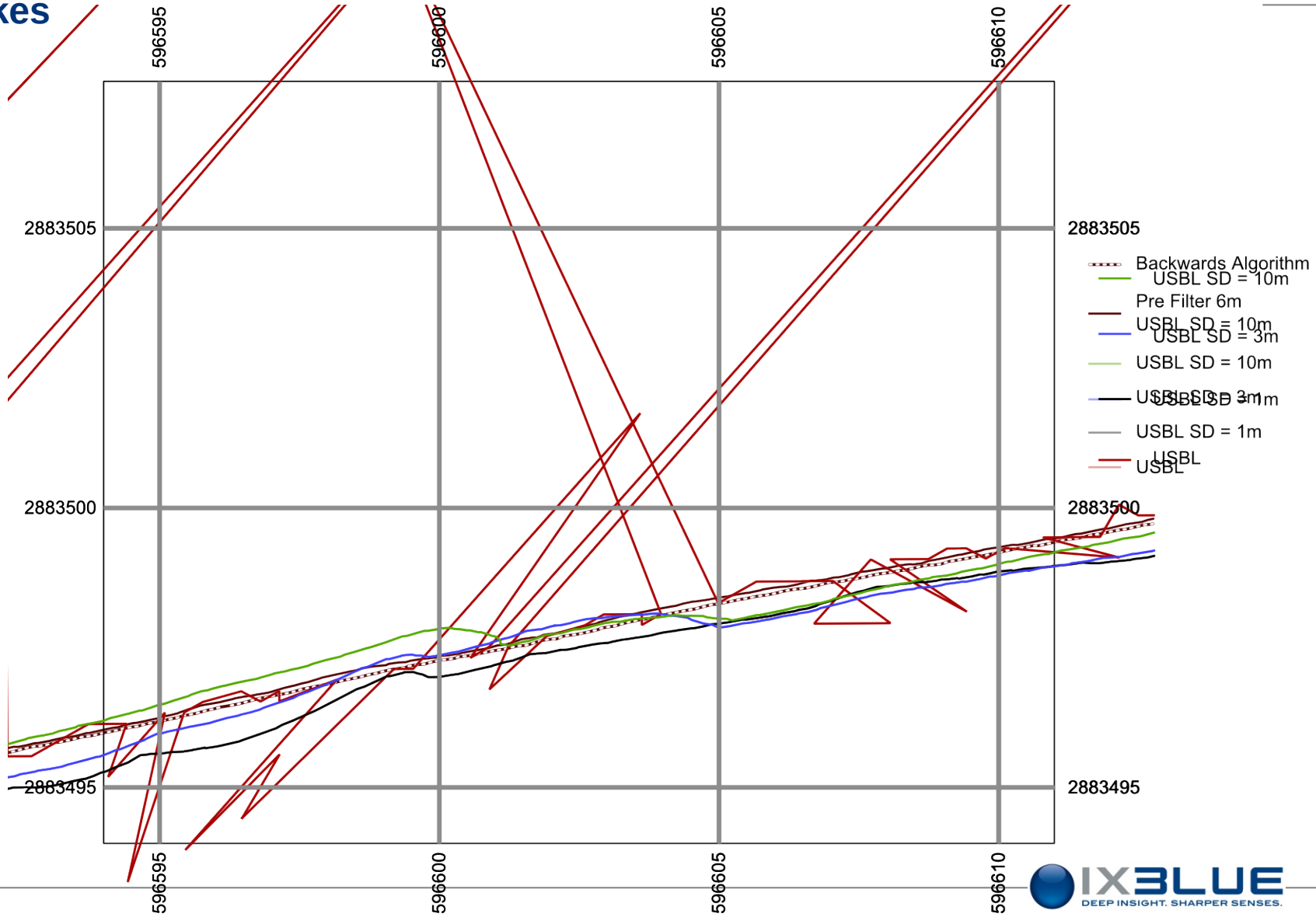
- Increasing the USBL SD can greatly improve smoothing of the navigation but USBL spikes could be more easily accepted and hence influence the absolute INS position accuracy.

- USBL standard deviation should be tuned to the actual data received, avoiding settings that are unrealistically high or low. As a rule of the thumb USBL SD can be increased by a factor 3 to 10 with respect to the observed USBL noise SD.

Going Further

- Delph INS now includes USBL Pre-Filter.
  - Distance between INS position and USBL is compared if > threshold USBL is rejected.
- This allows the use of a high SD without the danger of accepting large USBL spikes.
- Not included in real time due to the danger of excluding USBL data after an outage.

Large Spikes



Small Spikes