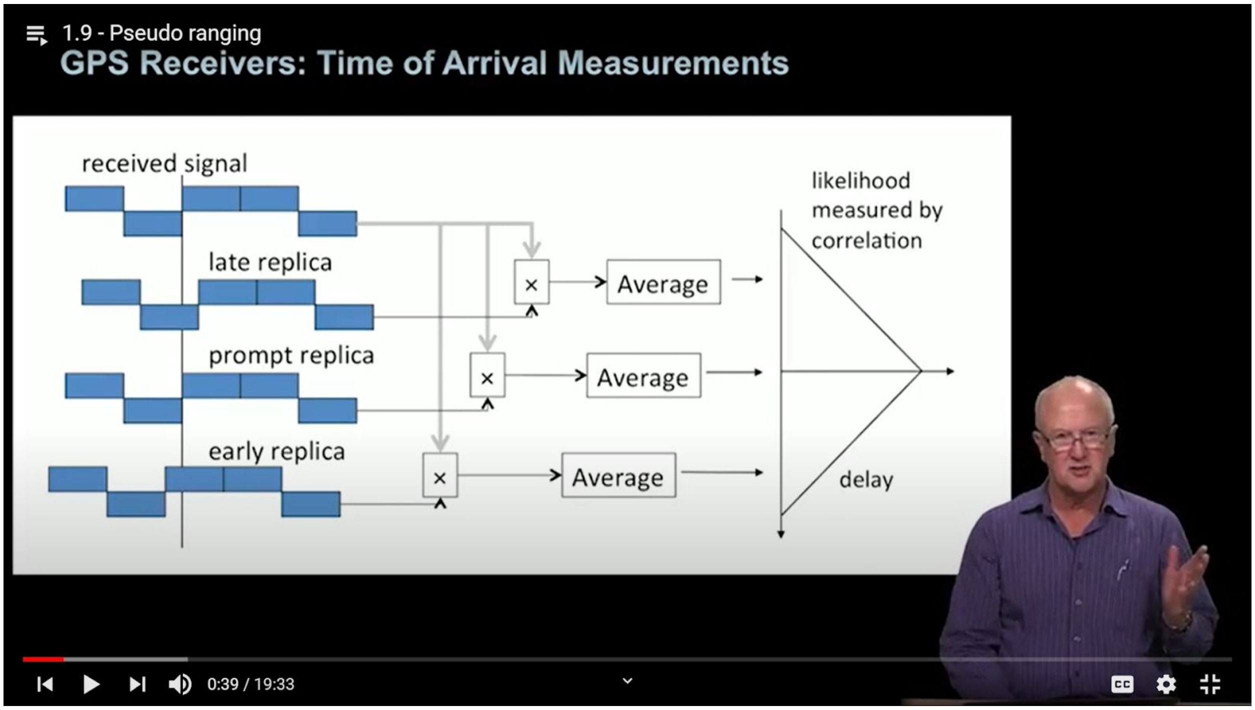
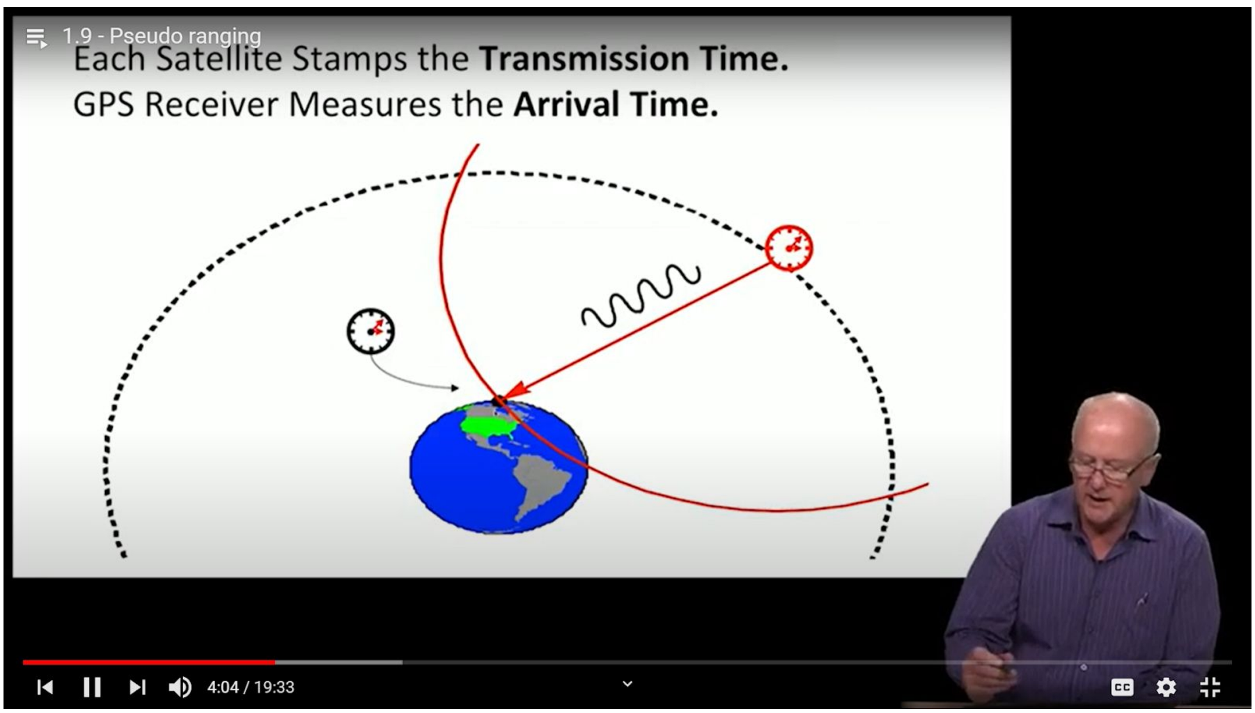
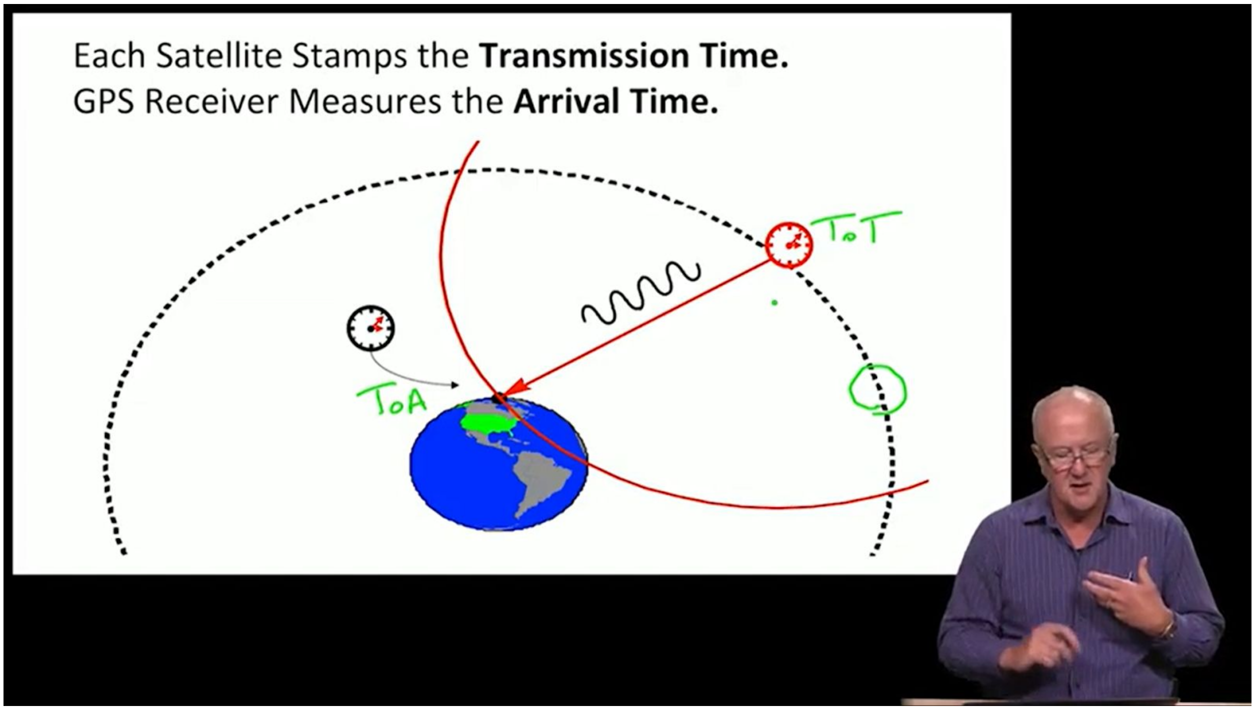
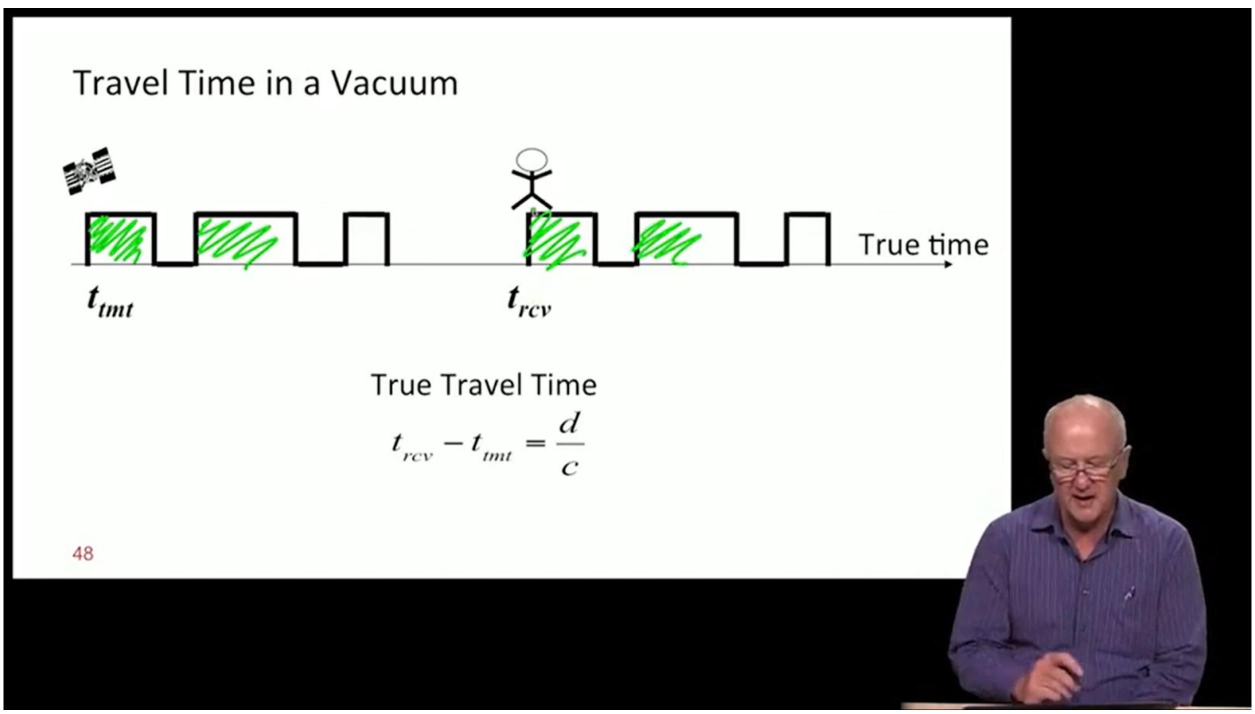
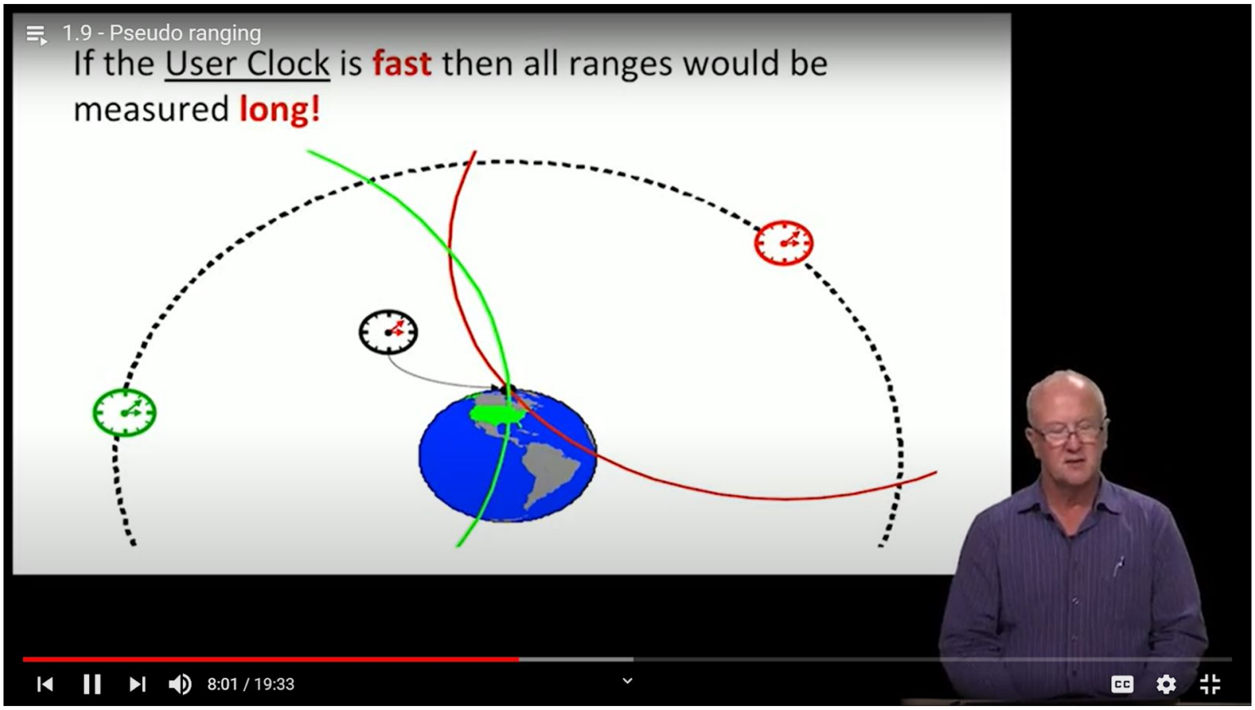
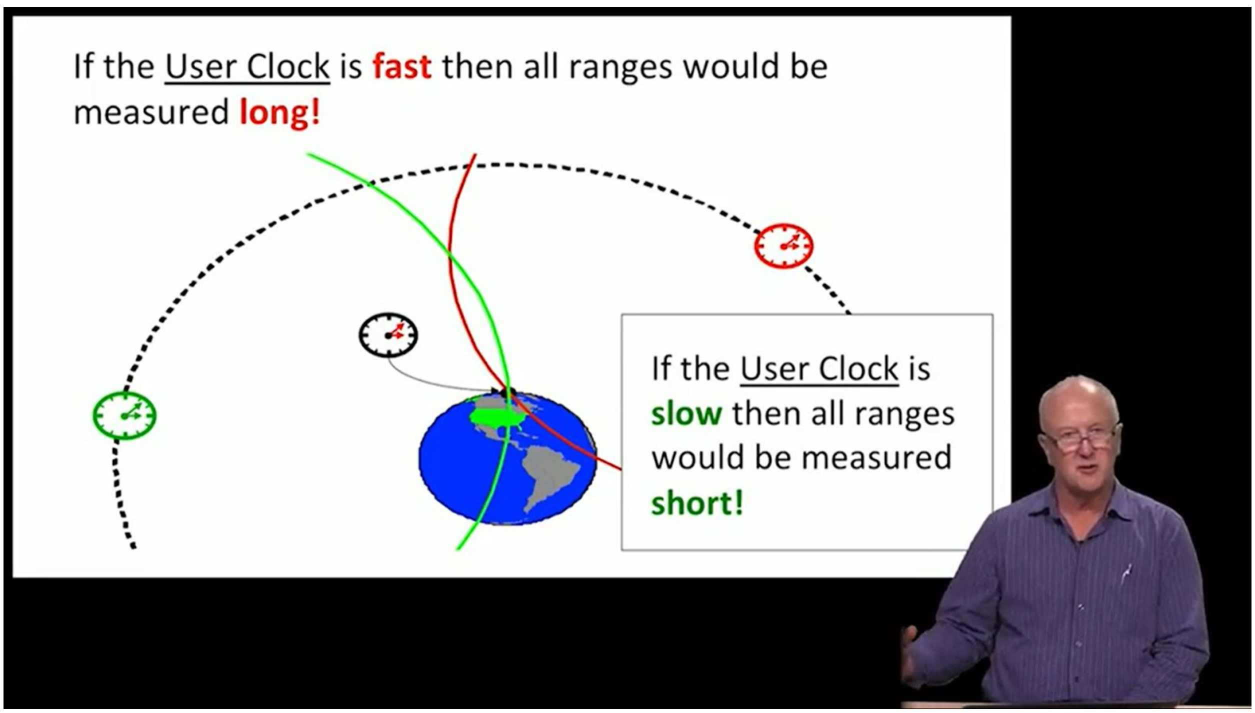

1.9 - Pseudo ranging
GPS Receivers: Time of Arrival Measurements
received signal
late replica
prompt replica
early replica
Average
Average
Average
likelihood
measured by
correlation
delay
0:39 / 19:33

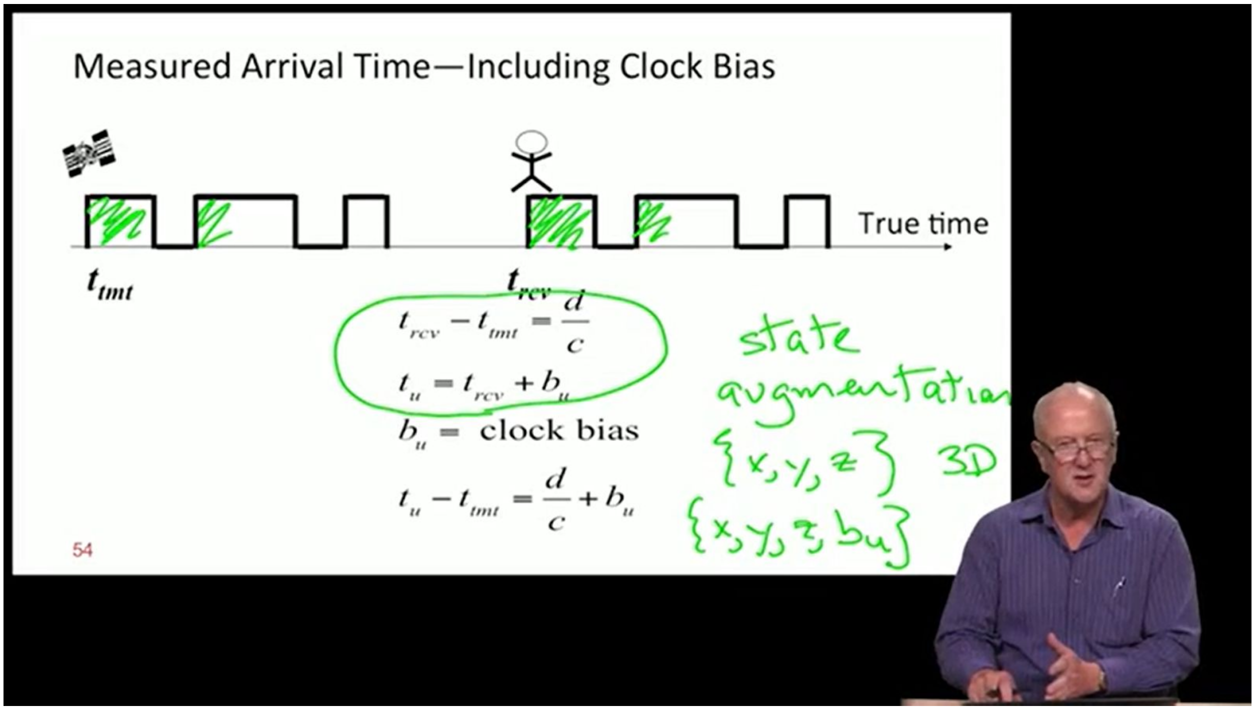

1.9 - Pseudo ranging
Each Satellite Stamps the **Transmission Time.**
GPS Receiver Measures the **Arrival Time.**
4:04 / 19:33

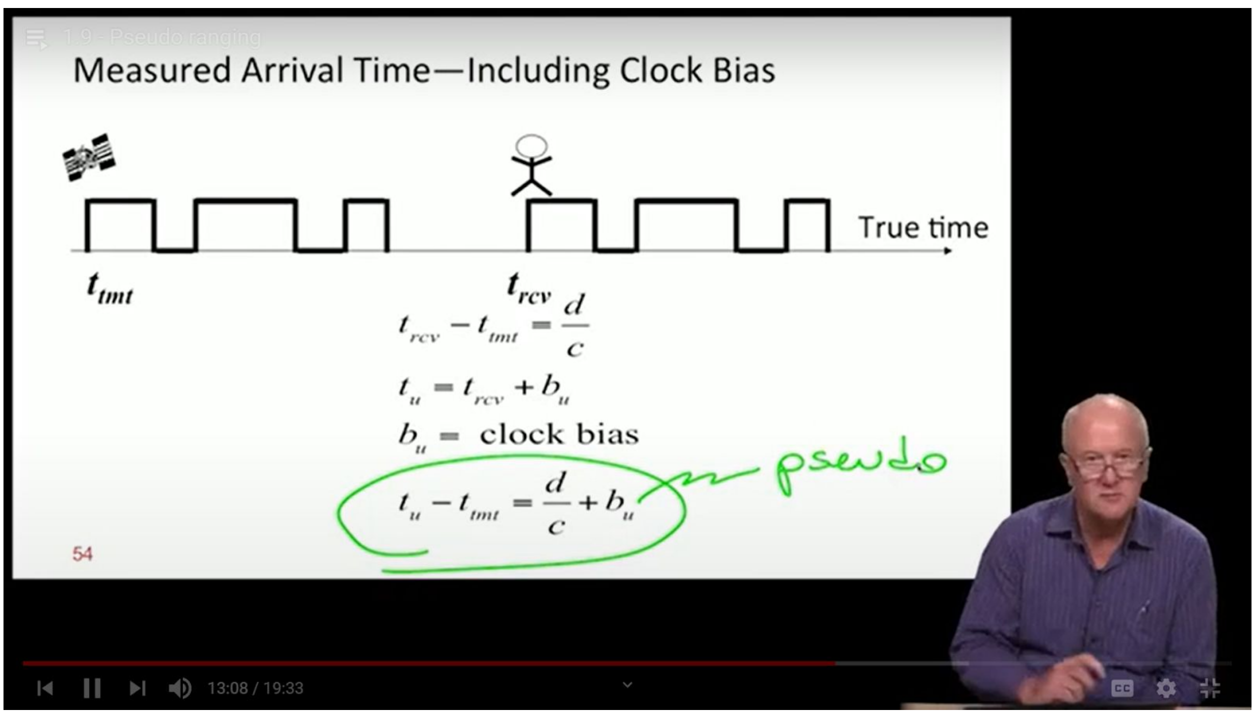

Each Satellite Stamps the **Transmission Time.**
GPS Receiver Measures the **Arrival Time.**
ToT
ToA

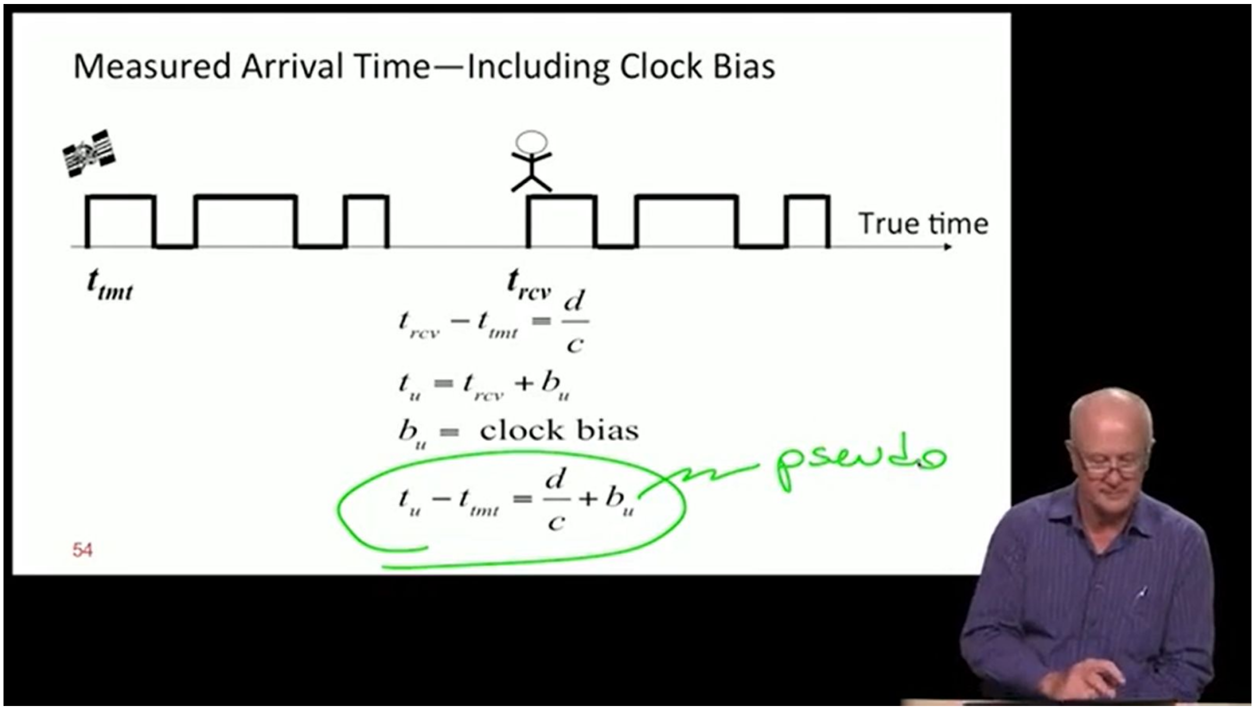

Travel Time in a Vacuum
True time
t_{tmt}
t_{rcv}
True Travel Time
$t_{rcv} - t_{tmt} = \frac{d}{c}$
48

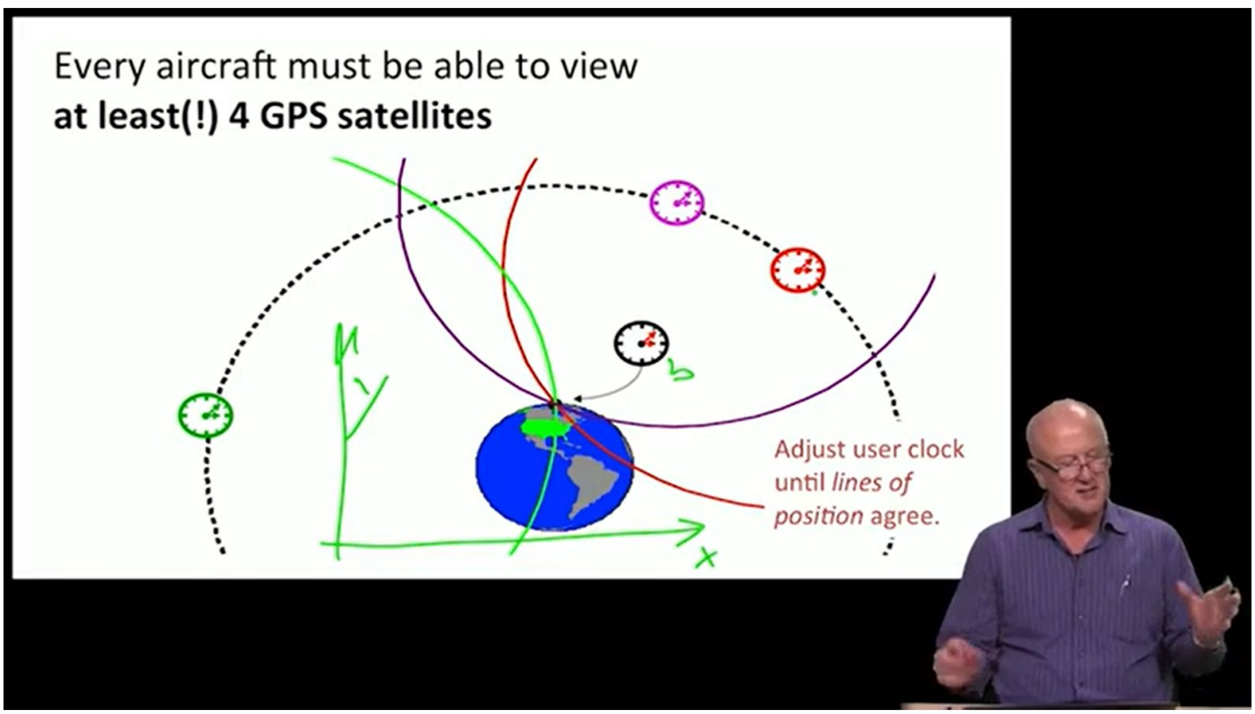

1.9 - Pseudo ranging
If the User Clock is fast then all ranges would be measured long!
8:01 / 19:33

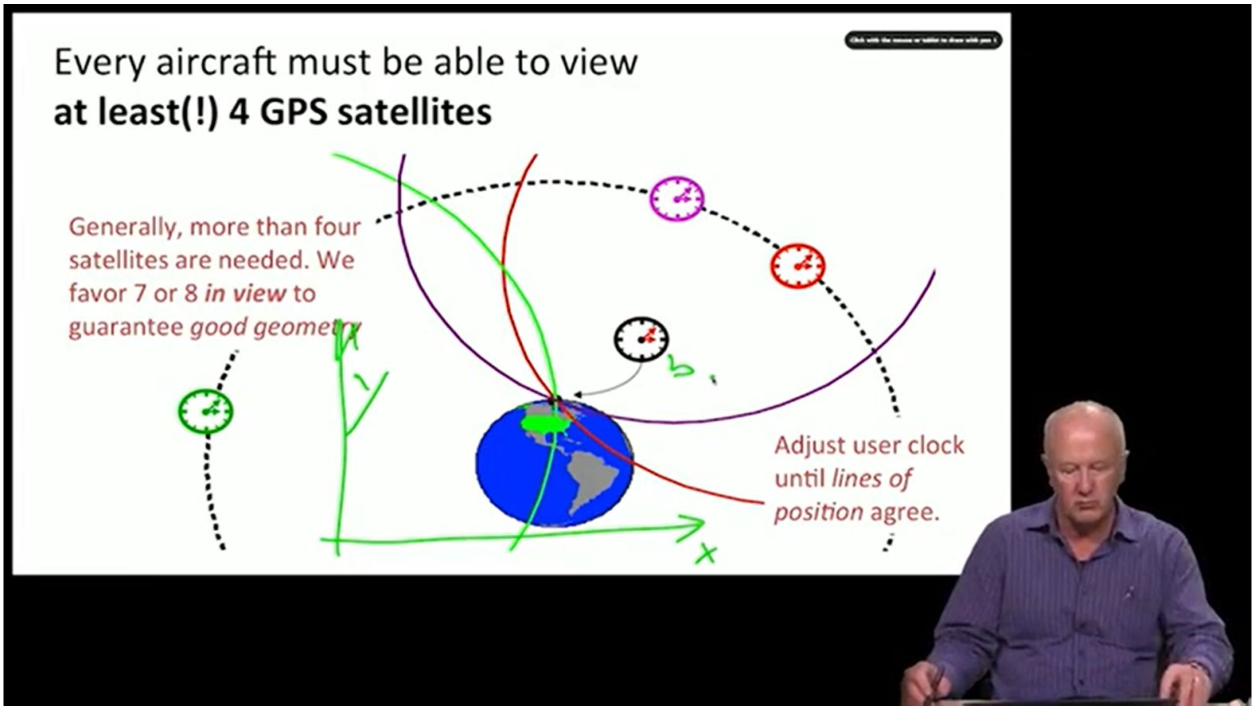

If the User Clock is fast then all ranges would be measured long!
If the User Clock is slow then all ranges would be measured short!

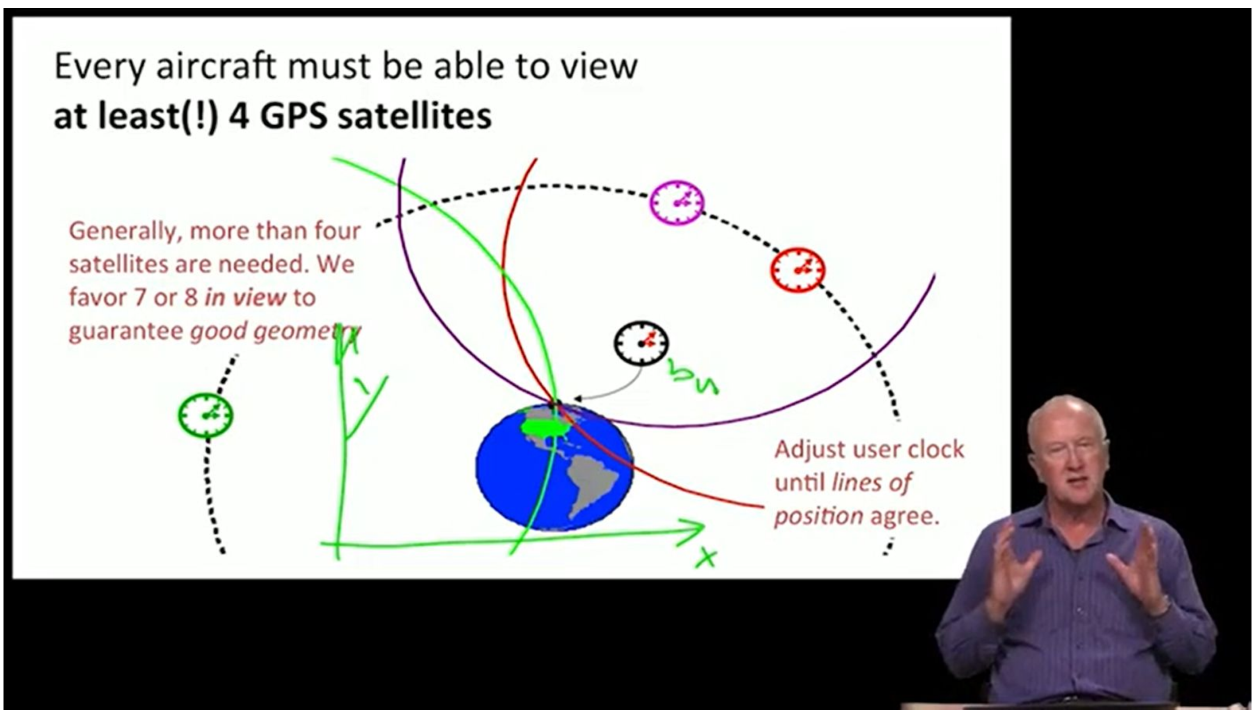

Measured Arrival Time—Including Clock Bias
True time
t_{tmt}
t_{rcv}
$t_{rcv} - t_{tmt} = \frac{d}{c}$
$t_u = t_{rcv} + b_u$
$b_u =$ clock bias
$t_u - t_{tmt} = \frac{d}{c} + b_u$
54
state
augmentation
{x, y, z} 3D
{x, y, z, b_u}

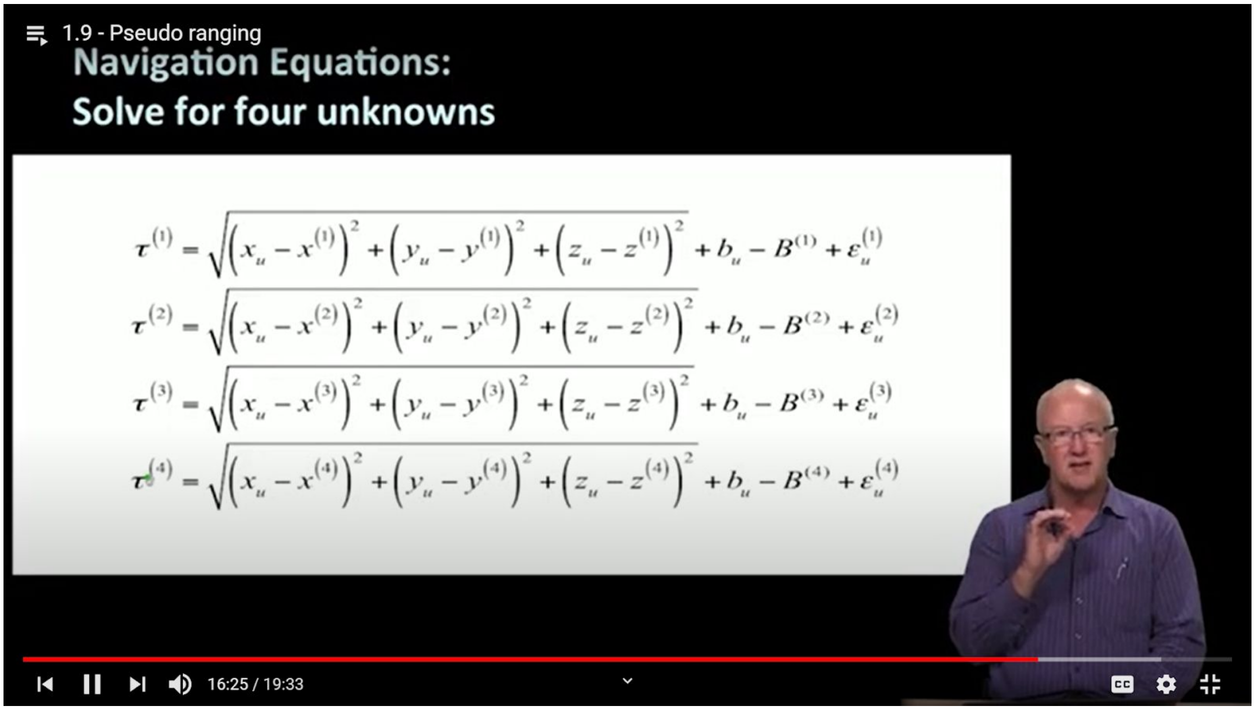

1.9 - Pseudo ranging
Measured Arrival Time—Including Clock Bias
True time
t_{tmt}
t_{rcv}
$t_{rcv} - t_{tmt} = \frac{d}{c}$
$t_u = t_{rcv} + b_u$
$b_u =$ clock bias
$t_u - t_{tmt} = \frac{d}{c} + b_u$
pseudo
54
13:08 / 19:33

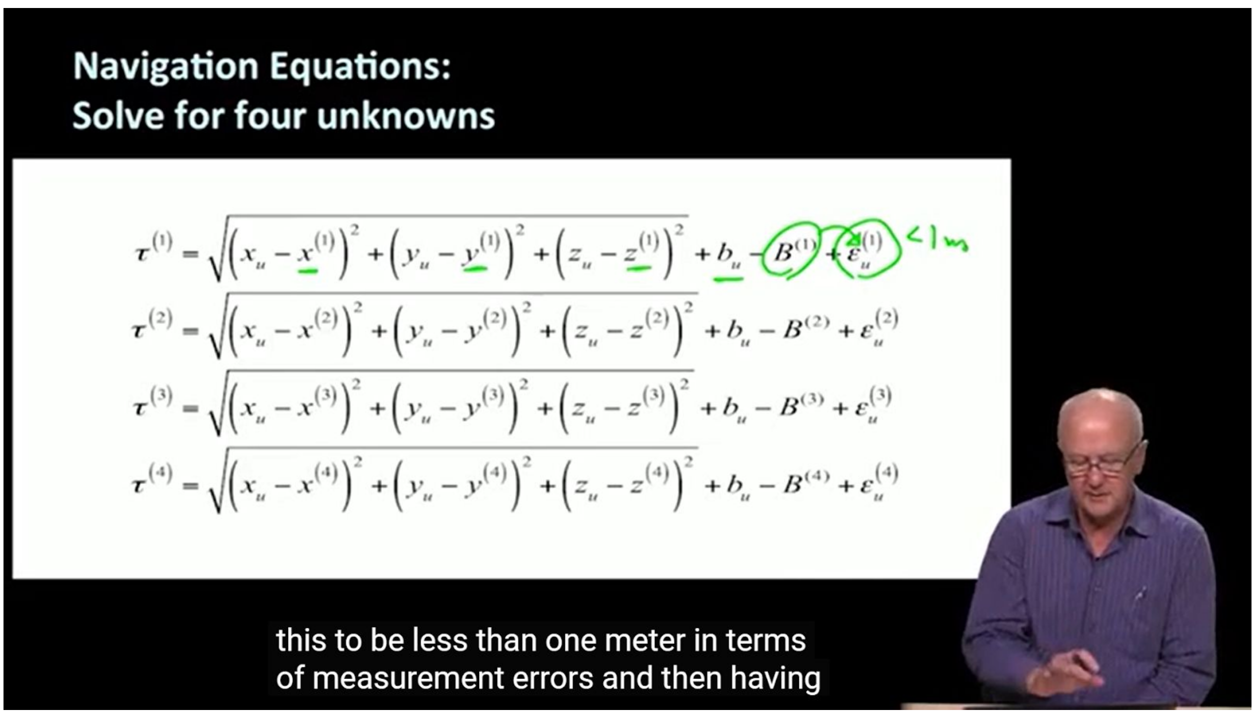

Measured Arrival Time—Including Clock Bias
True time
t_{tmt}
t_{rcv}
$t_{rcv} - t_{tmt} = \frac{d}{c}$
$t_u = t_{rcv} + b_u$
$b_u =$ clock bias
$t_u - t_{tmt} = \frac{d}{c} + b_u$
pseudo
54


Every aircraft must be able to view
at least(!) 4 GPS satellites
y
b
x
Adjust user clock until lines of position agree.


Every aircraft must be able to view
at least(!) 4 GPS satellites
Generally, more than four satellites are needed. We favor 7 or 8 in view to guarantee good geometry
y
x
Adjust user clock until lines of position agree.


Every aircraft must be able to view
at least(!) 4 GPS satellites
Generally, more than four satellites are needed. We favor 7 or 8 in view to guarantee good geometry
y
b_u
x
Adjust user clock until lines of position agree.


1.9 - Pseudo ranging
Navigation Equations:
Solve for four unknowns
$\tau^{(1)} = \sqrt{(x_u - x^{(1)})^2 + (y_u - y^{(1)})^2 + (z_u - z^{(1)})^2} + b_u - B^{(1)} + \varepsilon_u^{(1)}$
$\tau^{(2)} = \sqrt{(x_u - x^{(2)})^2 + (y_u - y^{(2)})^2 + (z_u - z^{(2)})^2} + b_u - B^{(2)} + \varepsilon_u^{(2)}$
$\tau^{(3)} = \sqrt{(x_u - x^{(3)})^2 + (y_u - y^{(3)})^2 + (z_u - z^{(3)})^2} + b_u - B^{(3)} + \varepsilon_u^{(3)}$
$\tau^{(4)} = \sqrt{(x_u - x^{(4)})^2 + (y_u - y^{(4)})^2 + (z_u - z^{(4)})^2} + b_u - B^{(4)} + \varepsilon_u^{(4)}$
16:25 / 19:33


Navigation Equations:
Solve for four unknowns
$\tau^{(1)} = \sqrt{(x_u - x^{(1)})^2 + (y_u - y^{(1)})^2 + (z_u - z^{(1)})^2} + b_u - B^{(1)} + \varepsilon_u^{(1)}$ <1m
$\tau^{(2)} = \sqrt{(x_u - x^{(2)})^2 + (y_u - y^{(2)})^2 + (z_u - z^{(2)})^2} + b_u - B^{(2)} + \varepsilon_u^{(2)}$
$\tau^{(3)} = \sqrt{(x_u - x^{(3)})^2 + (y_u - y^{(3)})^2 + (z_u - z^{(3)})^2} + b_u - B^{(3)} + \varepsilon_u^{(3)}$
$\tau^{(4)} = \sqrt{(x_u - x^{(4)})^2 + (y_u - y^{(4)})^2 + (z_u - z^{(4)})^2} + b_u - B^{(4)} + \varepsilon_u^{(4)}$
this to be less than one meter in terms
of measurement errors and then having

Navigation Equations:
Solve for four unknowns

$$\tau^{(1)} = \sqrt{\left(x_u - x^{(1)}\right)^2 + \left(y_u - y^{(1)}\right)^2 + \left(z_u - z^{(1)}\right)^2} + b_u - B^{(1)} + \varepsilon_u^{(1)}$$

$$\tau^{(2)} = \sqrt{\left(x_u - x^{(2)}\right)^2 + \left(y_u - y^{(2)}\right)^2 + \left(z_u - z^{(2)}\right)^2} + b_u - B^{(2)} + \varepsilon_u^{(2)}$$

$$\tau^{(3)} = \sqrt{\left(x_u - x^{(3)}\right)^2 + \left(y_u - y^{(3)}\right)^2 + \left(z_u - z^{(3)}\right)^2} + b_u - B^{(3)} + \varepsilon_u^{(3)}$$

$$\tau^{(4)} = \sqrt{\left(x_u - x^{(4)}\right)^2 + \left(y_u - y^{(4)}\right)^2 + \left(z_u - z^{(4)}\right)^2} + b_u - B^{(4)} + \varepsilon_u^{(4)}$$