# Question #3

## DT Nonlinear Model

We simulate the nonlinear model using the ‘ode45()’ function on MATLAB. We define the nonlinear dynamics model function in the code provided in Appendix C ‘NL\_DynModel’. The resulting NL state dynamics simulation assuming no process and measurement noise is shown in Figure 1. Here we set the initial state equal to the specification provided:

|  |  |  |
| --- | --- | --- |
|  |  | ( 1 ) |

This represents the nominal state trajectory.

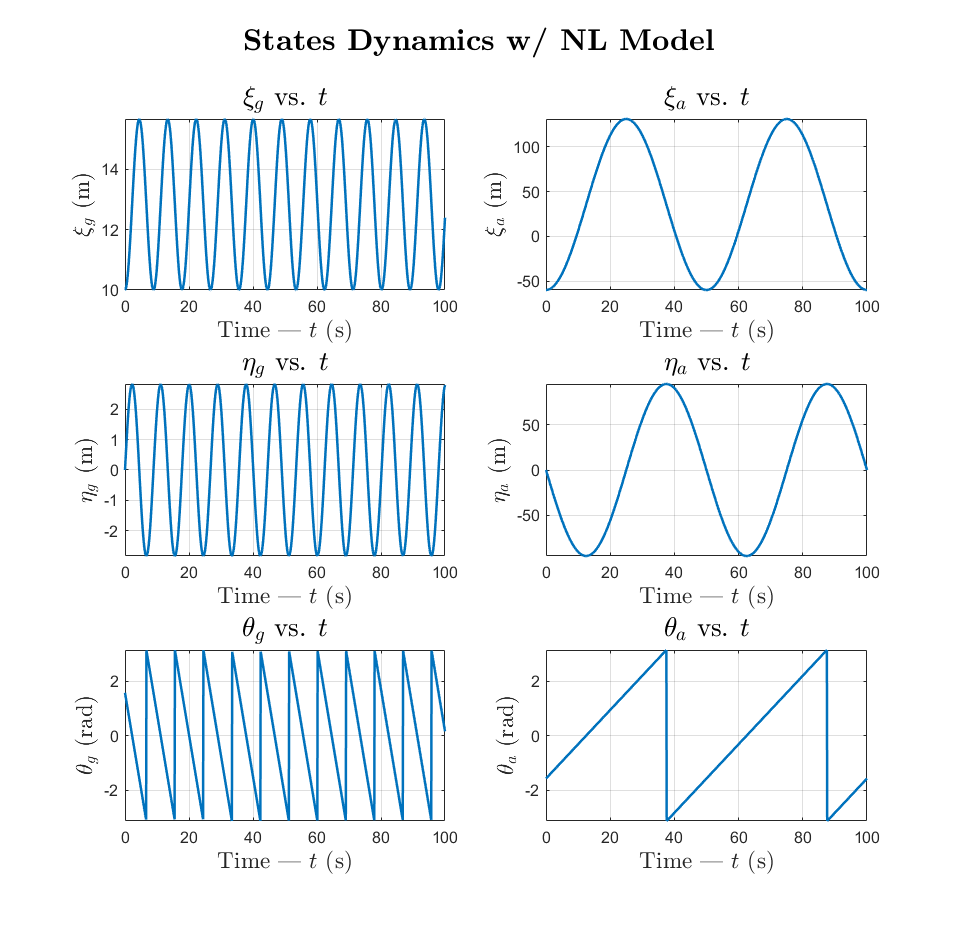


Figure 1 – State dynamics simulation with nonlinear model (using ode45)

Note here that the angles and have been wrapped to within .

The nonlinear measurement model function is defined in Appendix C ‘NL\_MeasModel’. This function takes in the states at step and outputs the sensor readings.

The resulting NL measurement dynamics without process and measurement noise is shown in Figure 2. This represents the nominal measurements trajectory.

Again the angles and have been wrapped within .

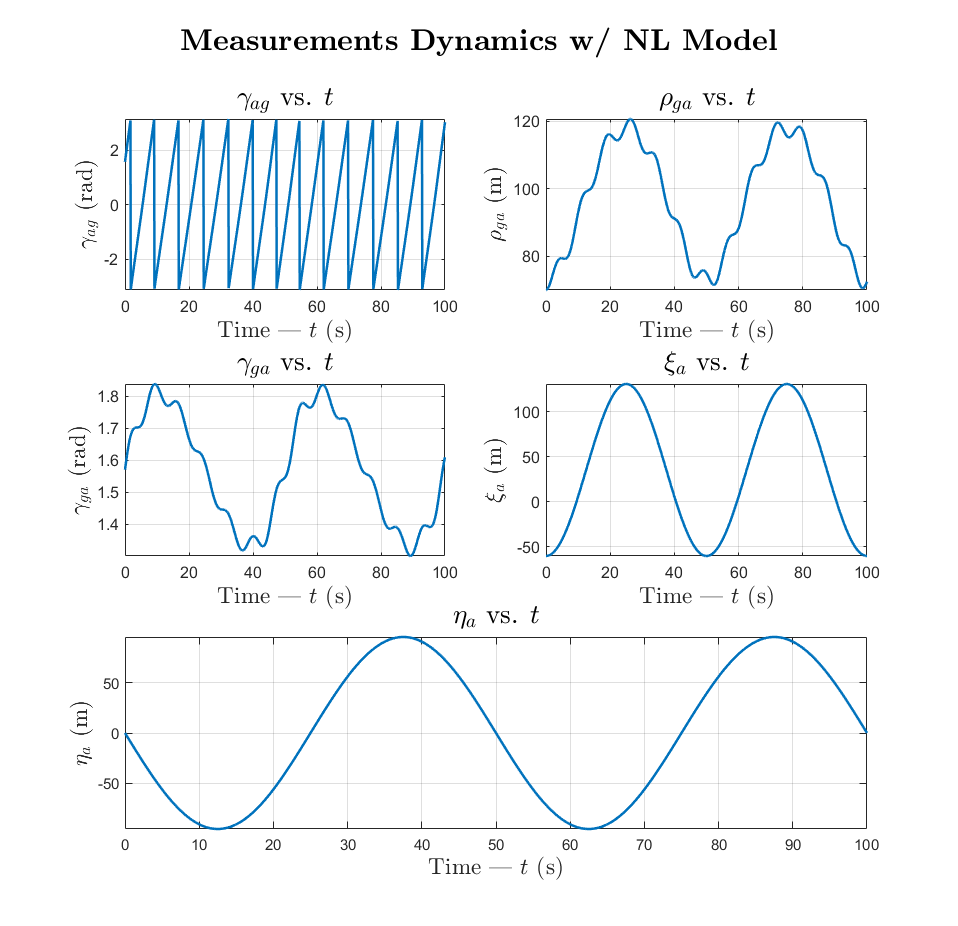


Figure 2 – Measurement dynamics simulation with nonlinear model

## DT Linearized Model

We simulate the linearized DT model using the methodology prescribed in Question #1 and Question #2. To perform the linearization, we define the following from specification:

|  |  |  |
| --- | --- | --- |
|  |  | ( 2 ) |
|  |  | ( 3 ) |
|  |  | ( 4 ) |

The transition matrices for the DT linearization model at step ‘’ are calculated in Appendix C ‘Linearize’ using and . The linearized state and measurement dynamics and perturbations are calculated in Appendix C ‘DT\_L\_Model’. in Equation ( 4 ) was selected because its small enough to ensure the linearization does not deviate from nominal trajectory

The graph in Figure 3 plots the state evolution of the linearized DT model. Although the state evolution closely matches the NL model’s nominal trajectory, there is in fact a perturbation from the nominal trajectory shown in Figure 5. The graph in Figure 4 plots the measurement dynamics of the linearized DT model and the sensor readings perturbations are shown in Figure 6.

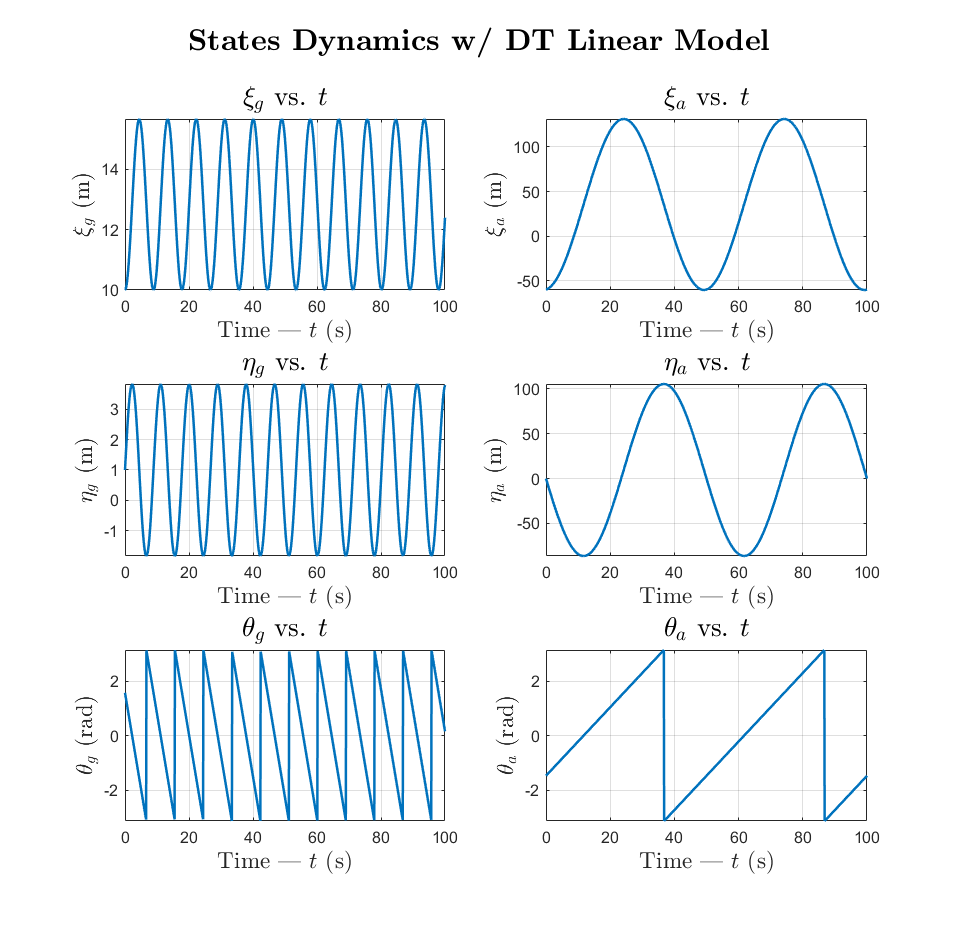


Figure 3 – State dynamics simulation with DT linearized model

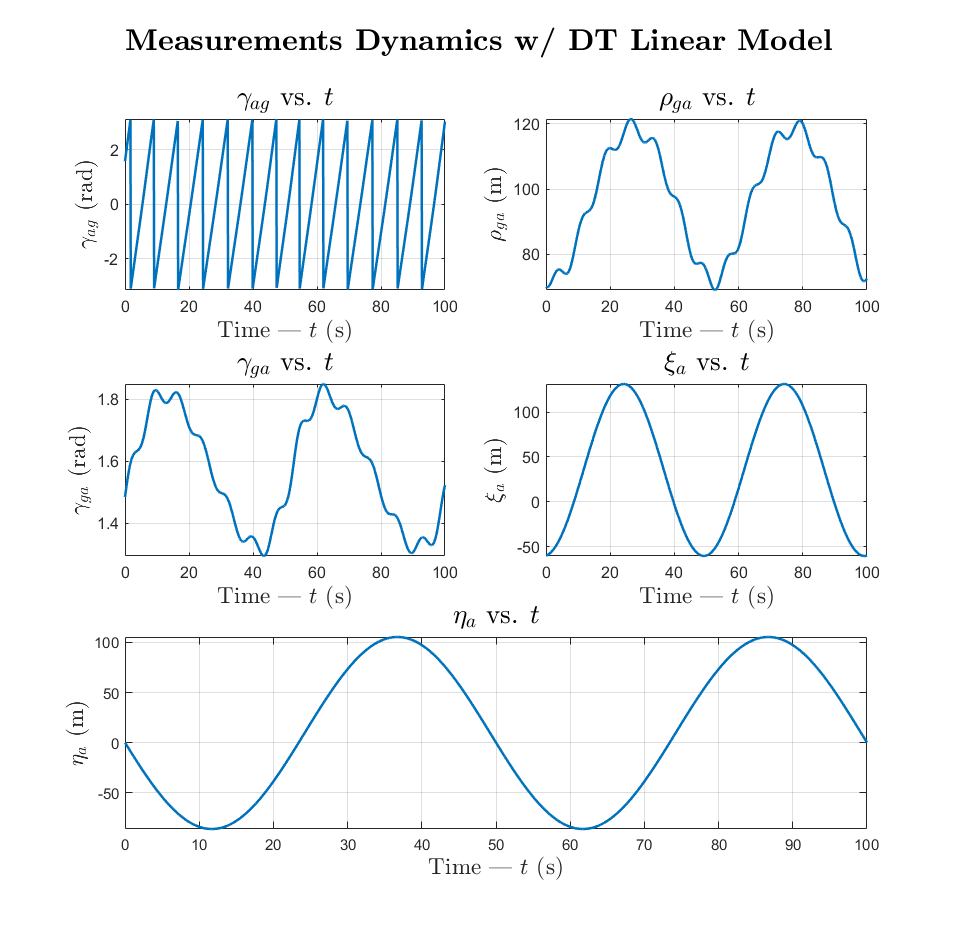


Figure 4 –Measurement dynamics simulation with DT linearized model

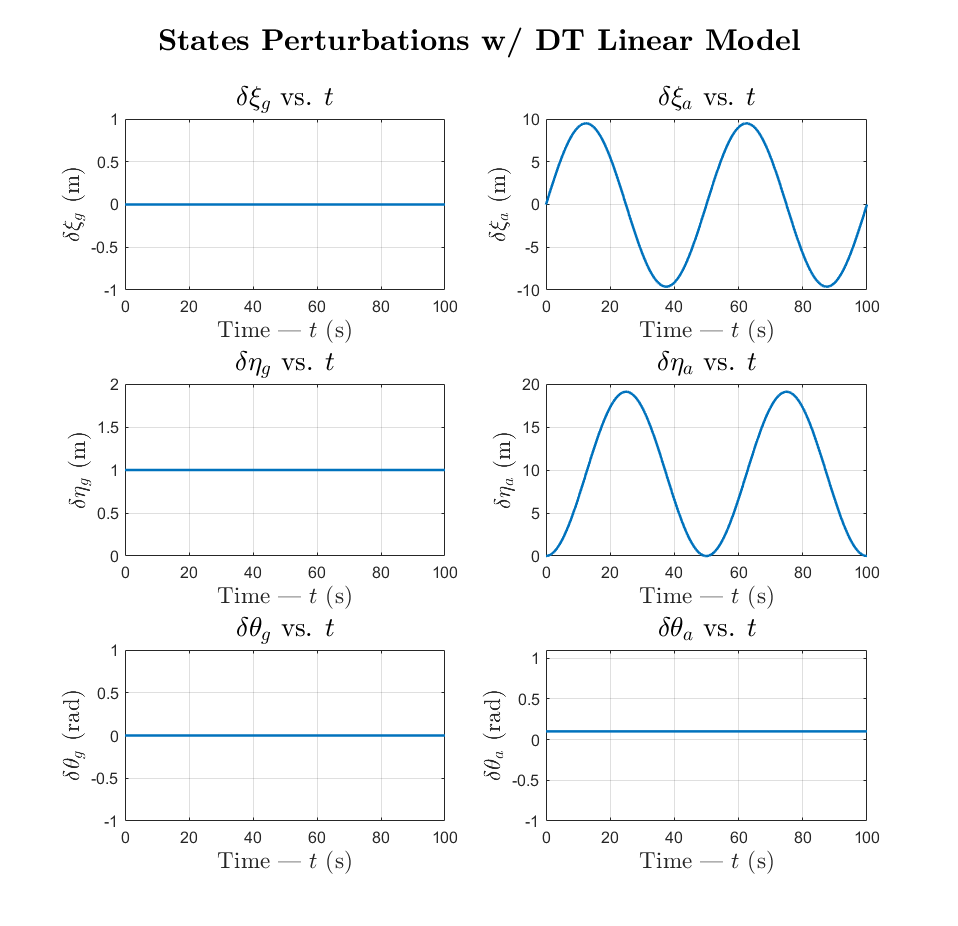


Figure 5 – State dynamics perturbations with DT linearized model

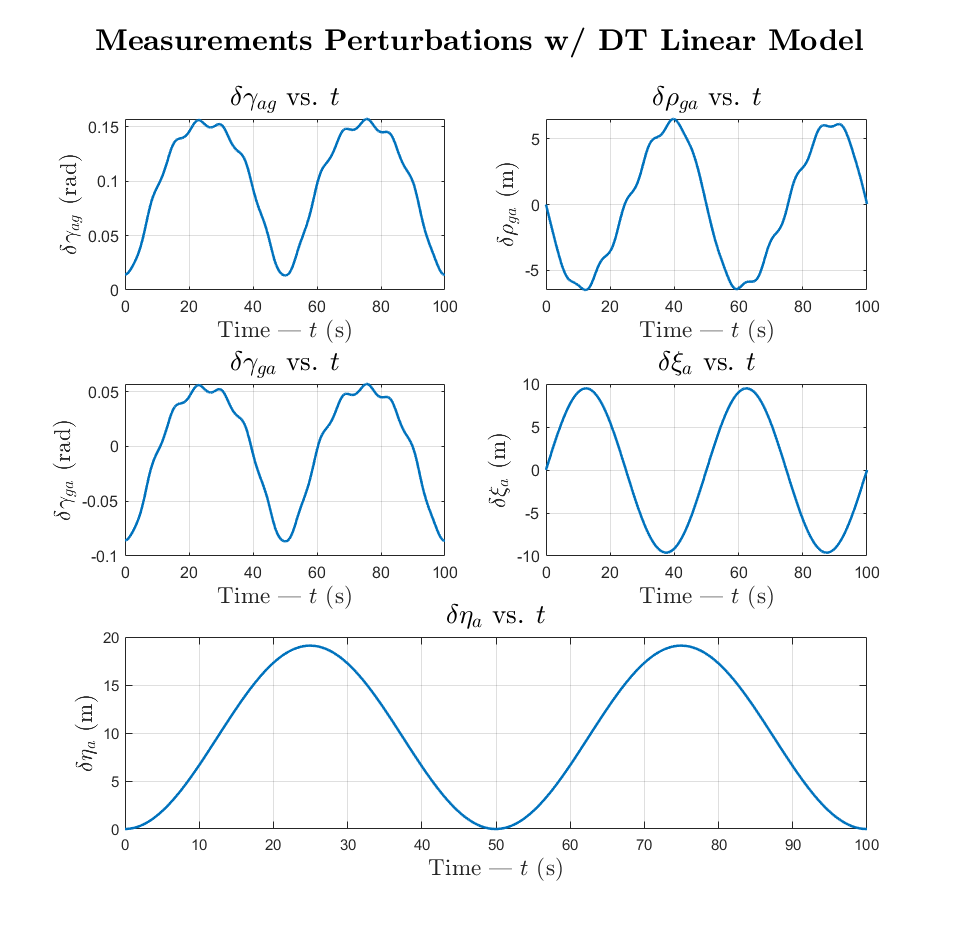


Figure 6 - Measurement dynamics perturbations with DT linearized model\

The state perturbation graphs show that and are constant and unchanging while and are varying in an oscillatory manner. This perturbation is transferred through to the sensor readings as well as all the sensor outputs are calculated using and/or .

We can conclude that the linearization only results in varying degrees of perturbation in the UAV’s states from their nominal trajectory while the UGV’s states deviate by a constant value equal to the initial perturbation. And as a result, the sensor readings relating to UAV’s states contain major perturbations, while the relative sensor readings have a lower amplitude in their variation.