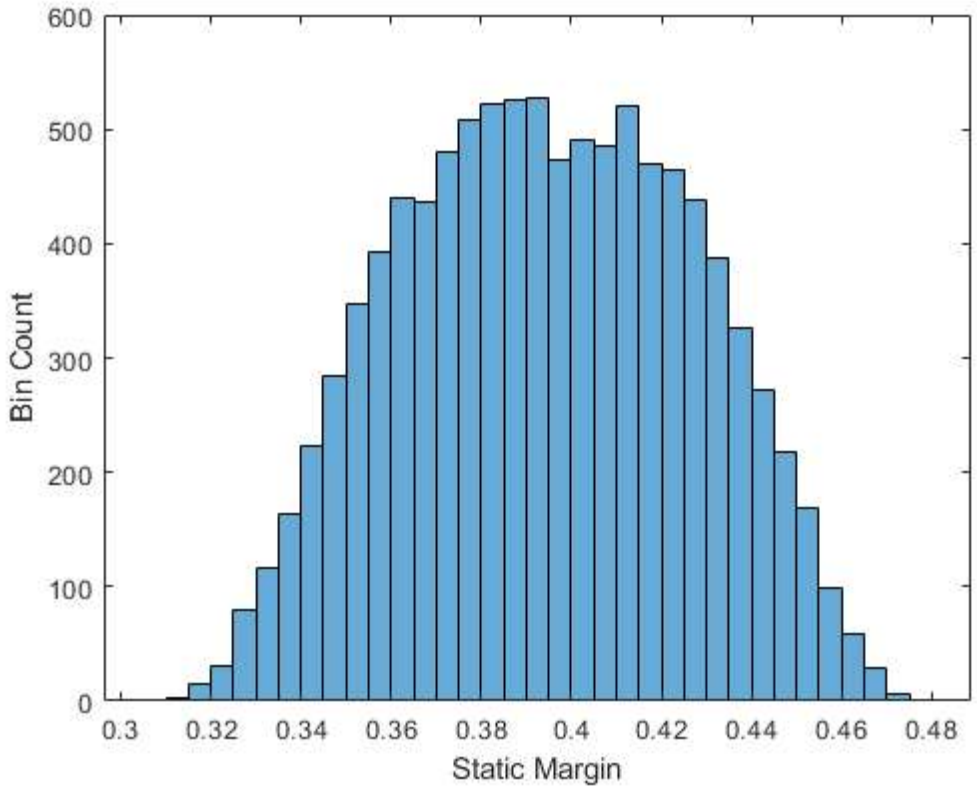
Contents


```
close all; clear all; clc
```

Determine CG and CP

```
N_sample = 10000;
static_margins = zeros([N_sample,1]);
for i = 1:N_sample
    [cg, mass_total, moment] = cg_sample();
    [cp, C_N_alpha, S_ref, cp_moment] = cp_sample();
    static_margins(i) = (cg-cp)/0.4;
    %derived properties
    C_N_q = C_N_alpha*(cg-cp);
    C_M_alpha = -C_N_alpha*(cg-cp);
    C_M_q = -(C_N_alpha*cp_moment +2*C_N_alpha*cp*cg-C_N_alpha*cg.^2);
end

figure(1)
clf
mean(static_margins)
std(static_margins)
histogram(static_margins)
xlabel('Static Margin')
ylabel('Bin Count')
```

```
ans =

    0.3945


ans =

    0.0323
```

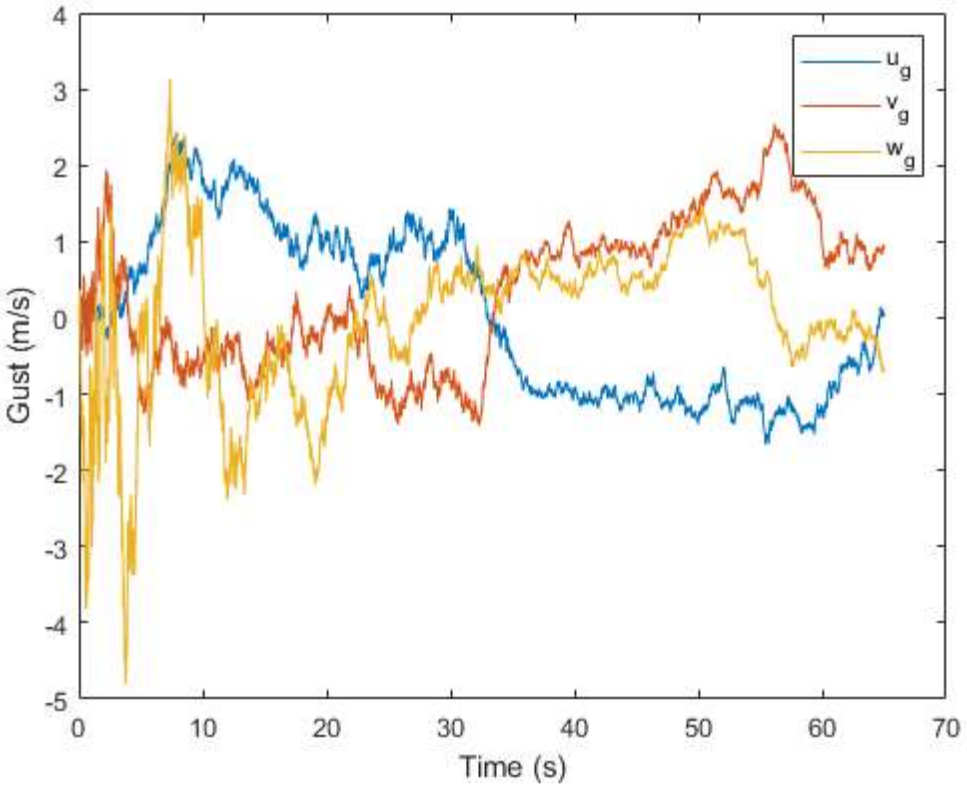


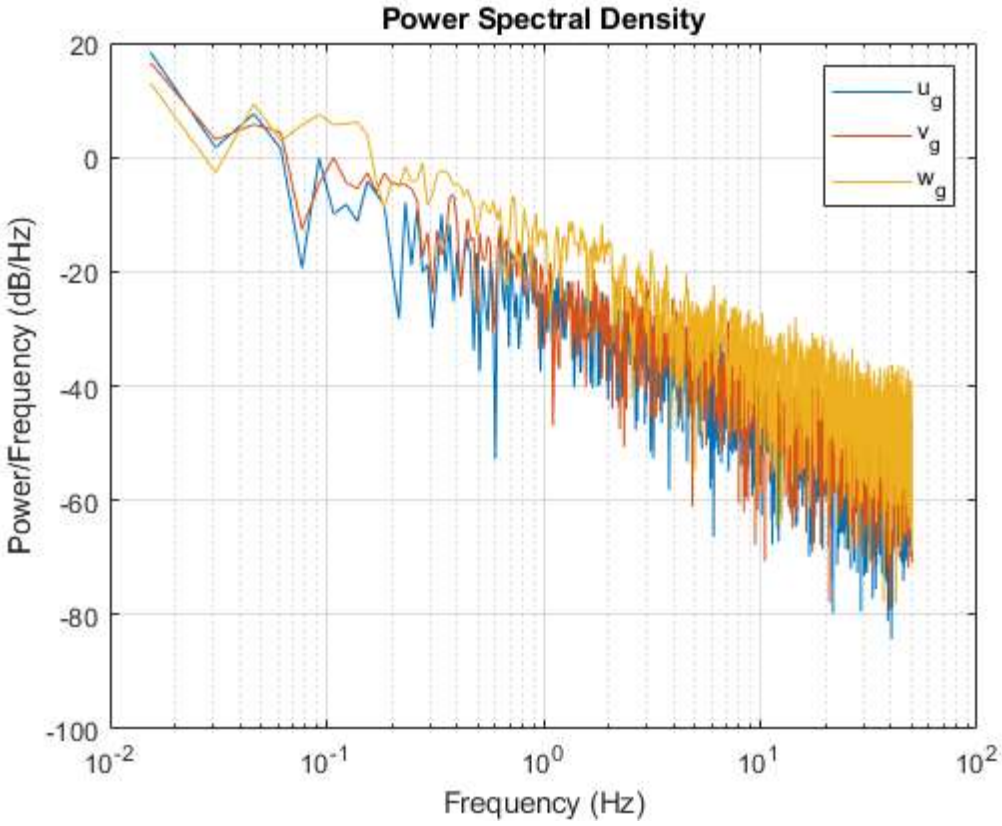
Wind Model

```
%simple gust sampling example with a vertically accelerating vehicle
N_timestep = 6500;
dt = 0.01;
accel = 1;
gust_state = [0,0,0]';
gustintensity = 1;
gustdata = zeros(3,N_timestep);
V = 0;
h = 0;
for t = 1:N_timestep
    gust_state = dryden_gust_sample(gust_state,V,h,gustintensity,dt);
    gustdata(:,t) = gust_state;
    V = V + accel*dt;
    h = h + V*dt + 0.5*accel*dt.^2;
end

%plot time series
figure(2)
clf
plot((1:N_timestep)*dt, gustdata(1:3,:)' )
legend('u_g','v_g','w_g')
xlabel('Time (s)')
ylabel('Gust (m/s)')

%plot Power Spectral Densities
fs = 1/(dt);
xdft = fft(gustdata(1,:)');
xdft = xdft(1:N_timestep/2+1);
psdx = (1/(fs*N_timestep)) * abs(xdft).^2;
```

```
psdx(2:end-1) = 2*psdx(2:end-1);
freq = 0:fs/N_timestep:fs/2;
figure(3)
clf
semilogx(freq,10*log10(psdx) )
grid on
hold on
title("Power Spectral Density")
xlabel("Frequency (Hz)")
ylabel("Power/Frequency (dB/Hz)")
legend('u_g','v_g','w_g')
xdft = fft(gustdata(2,:)');
xdft = xdft(1:N_timestep/2+1);
psdx = (1/(fs*N_timestep)) * abs(xdft).^2;
psdx(2:end-1) = 2*psdx(2:end-1);
freq = 0:fs/N_timestep:fs/2;
semilogx(freq,10*log10(psdx) )
xdft = fft(gustdata(3,:)');
xdft = xdft(1:N_timestep/2+1);
psdx = (1/(fs*N_timestep)) * abs(xdft).^2;
psdx(2:end-1) = 2*psdx(2:end-1);
freq = 0:fs/N_timestep:fs/2;
semilogx(freq,10*log10(psdx) )
legend('u_g','v_g','w_g')
```

```
Warning: Ignoring extra legend entries.
```

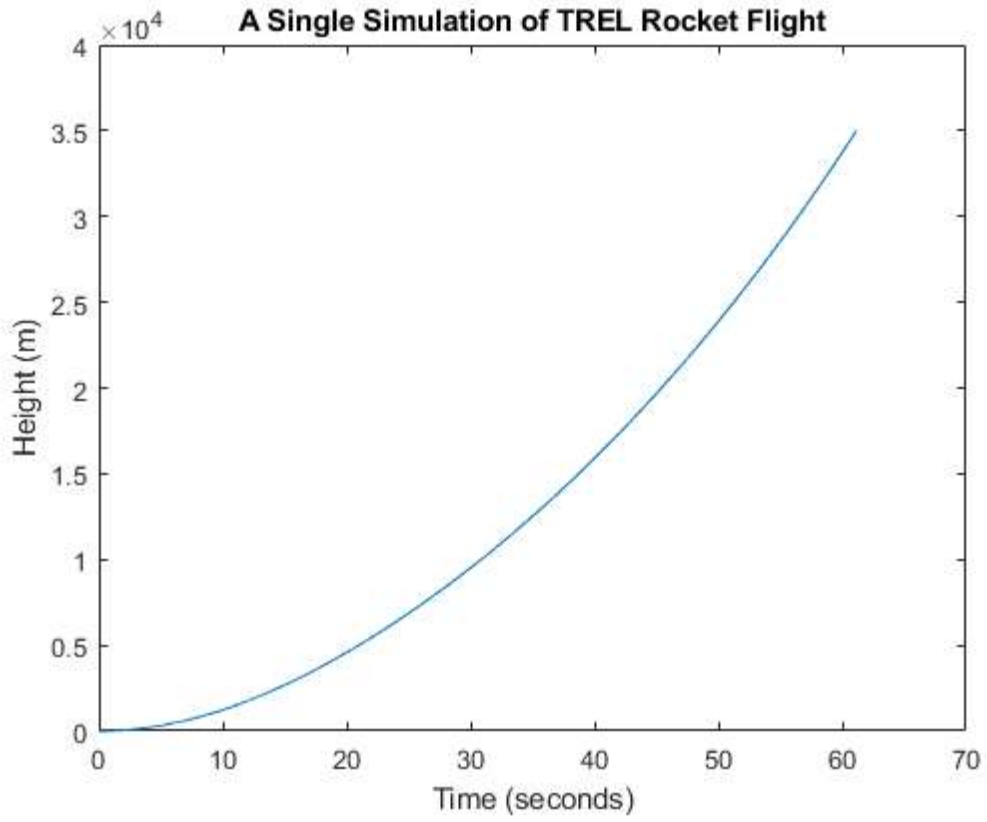




Simulate Flight

```
%---- Set Up
state  = zeros(N_timestep,9);
params = zeros(1,10);
```

```
% RocketParameters
params(1) = mass_total;    % Mass
params(2) = moment;   % Ixx
params(3) = S_ref;    % Area
params(4) = C_N_alpha;    % CNa
params(5) = C_N_q;    % CN_q
params(6) = C_M_alpha;    % CM_a
params(7) = C_M_q;    % CM_q
params(8) = 0.5;    % CD_
params(9) = 4.5;    % Gust Intensity
params(10) = cg;   % Gimbal CG
% Initial Conditions
stateInit  = zeros(1,size(state,2));
statek     = stateInit;


for k = 1:N_sample
    [statek,~]=vehicle_dynamics(statek,params,dt);
    state(k,:) = statek;
    if statek(2) >= 35000
        break
    end
end
figure,
plot((1:k)*dt,state((1:k),2))
title('A Single Simulation of TREL Rocket Flight')
xlabel('Time (seconds)')
ylabel('Height (m)')
```

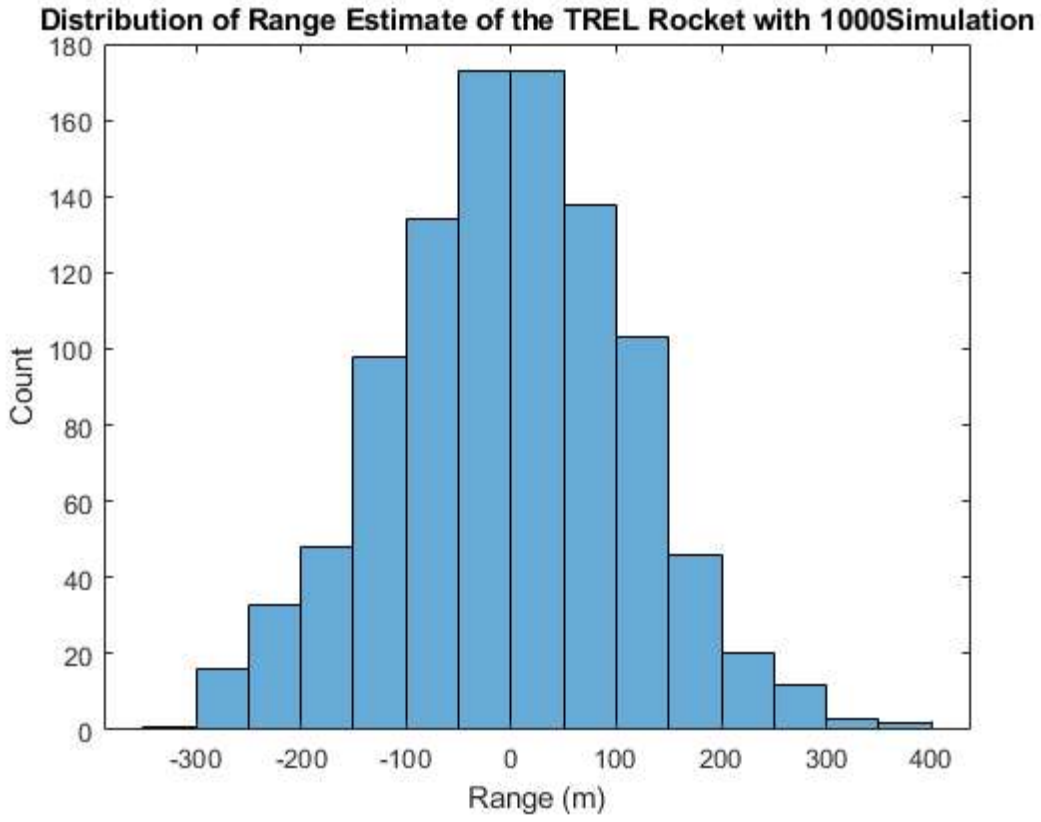


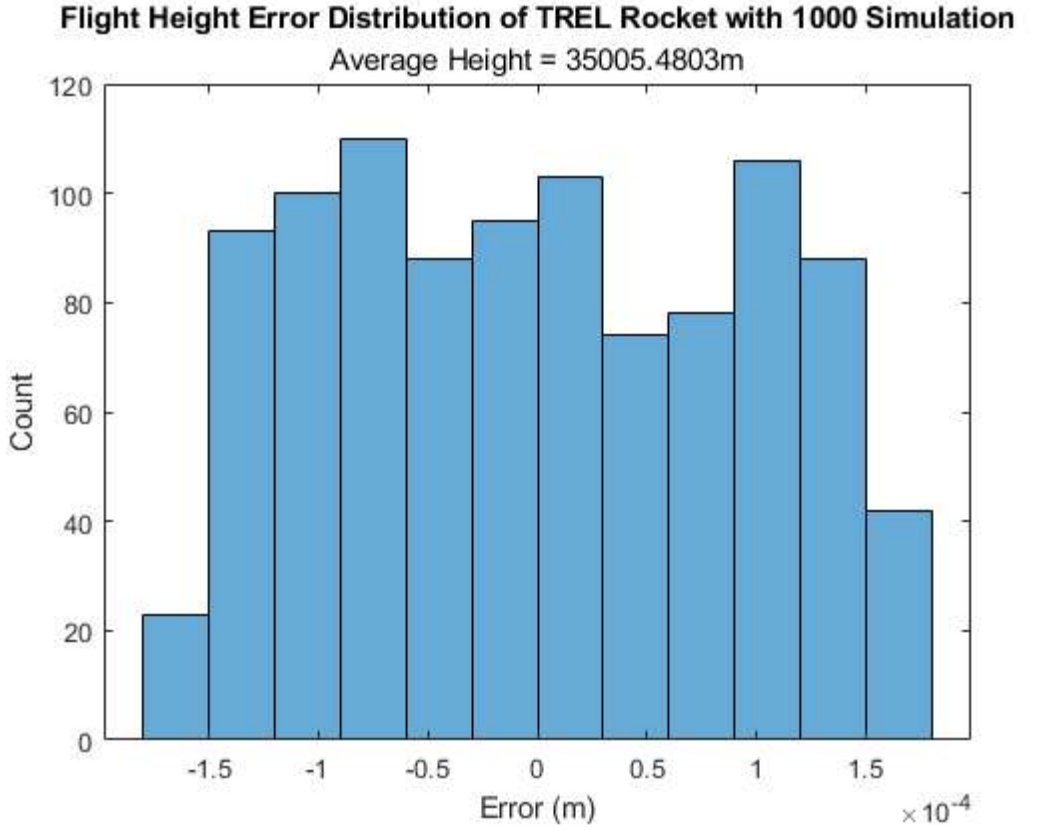
Monte Carlo Sim

```
ensemble= 1000;
X = zeros(ensemble,1);
Z = zeros(ensemble,1);
for m = 1:ensemble
    %---- GET CG AND CP
    [cg, mass_total, moment] = cg_sample();
    [cp, C_N_alpha, S_ref, cp_moment] = cp_sample();
    static_margins(i) = (cg-cp)/0.4;
    %derived properties
    C_N_q = C_N_alpha*(cg-cp);
    C_M_alpha = -C_N_alpha*(cg-cp);
    C_M_q = -(C_N_alpha*cp_moment +2*C_N_alpha*cp*cg-C_N_alpha*cg.^2);
    %---- Get Gust Parameter
    gust_state = dryden_gust_sample(gust_state,V,h,gustintensity,dt);
    gustdata(:,t) = gust_state;
    V = V + accel*dt;
    h = h + V*dt + 0.5*accel*dt.^2;
    %---- Set Up
    state  = zeros(N_timestep,9);
    params = zeros(1,10);
    % RocketParameters
    params(1) = mass_total;    % Mass
    params(2) = moment;   % Ixx
    params(3) = S_ref;    % Area
    params(4) = C_N_alpha;    % CNa
    params(5) = C_N_q;    % CN_q
    params(6) = C_M_alpha;    % CM_a
    params(7) = C_M_q;    % CM_q
    params(8) = 0.5;    % CD_
    params(9) = 4.5;    % Gust Intensity
    params(10) = cg;   % Gimbal CG
    % Initial Conditions
    stateInit  = zeros(1,size(state,2));
    statek     = stateInit;

    for k = 1:N_timestep
        [statek,~]=vehicle_dynamics(statek,params,dt);
        if statek(2) >= 35000
            X(m) = statek(1);
            Z(m) = statek(2);
            break
        end
    end
end

histogram(X)
title(['Distribution of Range Estimate of the TREL Rocket with ',num2str(ensemble), 'Simulation'])
xlabel('Range (m)');
ylabel('Count')
avgZ=mean(Z);

figure
histogram((Z-avgZ)/avgZ)
title(['Flight Height Error Distribution of TREL Rocket with ',num2str(ensemble), ' Simulation' ])
subtitle(['Average Height = ', num2str(avgZ), 'm'])
xlabel('Error (m)')
ylabel('Count')
```

```
fprintf(['The rocket is stable\n'])
```

```
The rocket is stable
```





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