

\*\*\*\*\*

## Simulation Loop

\*\*\*\*\*

### Experiment b2 - the log is kind of messed up due to bugs in the print statements

errored out

#### load main workspace

```
end_sim = 0;
fail_count = 0;
low_soc_count = 0;
pos_err_count = 0;

% for trajectory selection whether or not to select a trajectory less than
% rul_hat
explore = false;

addpath(genpath(pwd));
load_db_params;
conn = database(datasource_name, user_name, password);

% load UAV airframe
uav_sern = 'X001';
octomodel = get_airframe(conn, uav_sern);

% load battery
battery_sern = 'B001';
battery = get_battery(conn, battery_sern);
batterytwin = get_battery(conn, battery_sern);

% load motors
[Motor1, Motor2, Motor3, Motor4, Motor5, Motor6, Motor7, Motor8] = get_motors(conn, octomodel.i
[Motortwin1, Motortwin2, Motortwin3, Motortwin4, Motortwin5, Motortwin6, Motortwin7, Motortwin8]

% initial rul estimate, used as baseline in rul updates where the minimum
% value is taken to ensure rul_hat never exceeds this value
rul_init = 18.0;
rul_hat = rul_init;

% minimum rul
rul_threshold = 10.0;

% load base directory
load_base_workspace;

%load_trajectory; % load individually
```

## Initialize some variables

```
% for poly fitting
lookback = 6;

% how far into the future to look
horizon = 2;

% number of missions (can be oversized)
n_missions = 250;

% keep track of delta over time
% number of missions, 3 degradation parameters, 2 coefficients to save
% (slope & intercept)
polys = zeros(n_missions, 3, 2);

% keep track of degradation parameter values for poly fitting
q_deg = zeros(n_missions, 1);
r_deg = zeros(n_missions, 1);
m_deg = zeros(n_missions, 1);

% variance gets tighter over time, a pseudo-hack...
r_var_vals = [.001:-.00001:.0001];
q_var_vals = [.9:-.01:.2];
m_var_vals = [.02:-.00025:.0025];

% keep track of rul
ruls = zeros(n_missions, 1);
```

## Main Loop

```
% loop
% accelerated is 80
% normal is 300
for i = 1:n_missions
    if i < 20 && i >= 11
        lookback = 8;
        horizon = 3;
    elseif i >= 21
        lookback = 10;
        horizon = 4;
    end

    ruls(i) = rul_hat;
    load_trajectory;
    if end_sim == 1
        disp("[INFO] no more valid trajectories. ending simulation.")
        break;
    end
    if explore
        fprintf("[INFO] TrueSystem selecting trajectory: <id> with path_time: %.2f to explore c
```

```

        explore = false;
    else
        fprintf("[INFO] TrueSystem selecting trajectory: <%d> with path_time: %.2f that meets c
    end
    sys = "TrueSystem";
    octomodel.sampletime = true_sample_rate;
    fprintf('[INFO] simulating true system on i: %d\n', i)
    %tic
    sim('truesystem.slx');
    %toc

```

## update degradation parameters for saving

- assign values from the current run to the arrays for saving

```

q_deg(i) = battery.Q;
r_deg(i) = battery.R0;
m_deg(i) = Motor2.Req;

```

## update variance

```

fprintf('[INFO] updating degradation parameter variance on i: %d\n', i)
if i <= length(r_var_vals)
    r_var = r_var_vals(i);
else
    r_var = .0001;
end
if i <= length(q_var_vals)
    q_var = q_var_vals(i);
else
    q_var = .25;
end
if i <= length(m_var_vals)
    m_var = m_var_vals(i);
else
    m_var = .005;
end

```

## sample the degradation parameters and update

```

fprintf('[INFO] updating degradation parameter values via random sampling on i: %d\n', i)
battery.R0 = max(abs(normrnd(rdeg(i), r_var)), .0001);
battery.Q = min(abs(normrnd(qdeg(i), q_var)), 15.5);
Motor2.Req = max(abs(normrnd(mdeg(i), m_var)), .001);

```

## write telemetry data to database

```

distance = calculatedistance([pos_actual.Data(:,1) pos_actual.Data(:,2)]);
mission_id = table2array(select(conn, 'select id from mission_tb mt order by id desc limit
if isempty(mission_id)
    mission_id = 1;
else
    mission_id = mission_id + 1;

```

```

end
start = table2array(select(conn, 'select mt.dt_stop from mission_tb mt order by dt_stop des
if isempty(start)
    start = datetime(now, 'ConvertFrom', 'datenum');
end
start = datetime(start, 'InputFormat', 'yyyy-MM-dd HH:mm:ss');
start = dateshift(start, 'start', 'second');
start = start + hours(1);
stop = start + seconds(flight_time.Data(end, 1)*60);

fprintf("[INFO] i: %d\tmission_id: %d\ttrul_hat: %.2f\tflight_time: %.2f\tdistance: %.2f\tR0

write_mission_data;
write_battery_data;
write_flight_data;

if any(stop_code.Data(:,1)) == 1 && ~any(stop_code.Data(:,3)) == 1
    fprintf('[WARN] true system low soc threshold exceeded on i: %d\tmission_id: %d\n', i,
    %break;
end

if any(stop_code.Data(:,2)) == 1
    fprintf('[WARN] true system position error threshold exceeded on i: %d\tmission_id: %d\n', i,
    %break;
end

if any(stop_code.Data(:,3)) == 1
    fprintf('[INFO] success on i: %d\tmission_id: %d\n', i, mission_id)
end

clear('trajectory', 'battery_actual', 'battery_observed', 'ctrl_err', 'current', 'current_r

```

## define placeholder variables

```

twin_ctr = 1;
twin_count = 1;
times = zeros(1, twin_count);
vs = zeros(1, twin_count);
socs = zeros(1, twin_count);
r0s = zeros(1, twin_count);
qs = zeros(1, twin_count);
ms = zeros(1, twin_count);
dist = zeros(1, twin_count);
errs = zeros(1, twin_count);
degs = zeros(3, twin_count);

```

## Update twin degradation parameters

```

if i > lookback
    x = double(((i - (lookback-1)):1:i)');
    r_poly = polyfit(x, smoothdata(r_deg(x), 'rlowess', 5), 1);
    q_poly = polyfit(x, smoothdata(q_deg(x), 'rlowess', 5), 1);

```

```

m_poly = polyfit(x, smoothdata(m_deg(x), 'rlowess', 5), 1);

polys(i, 1, :) = r_poly;
polys(i, 2, :) = q_poly;
polys(i, 3, :) = m_poly;

r_mu = polyval(r_poly, i + horizon);
q_mu = polyval(q_poly, i + horizon);
m_mu = polyval(m_poly, i + horizon);
fprintf('[INFO] forecasting degradation values: r_mu: %.6f\tq_mu: %.6f\tm_mu: %.6f', r_mu, q_mu, m_mu);
batterytwin.R0 = max(abs(normrnd(r_mu, r_var)), .0001);
batterytwin.Q = min(abs(normrnd(q_mu, q_var)), 15.5);
Motortwin2.Req = max(abs(normrnd(m_mu, m_var)), .001);
else
    batterytwin.R0 = max(abs(normrnd(rdeg(i), r_var)), .0001);
    batterytwin.Q = min(abs(normrnd(qdeg(i), q_var)), 15.5);
    Motortwin2.Req = max(abs(normrnd(mdeg(i), m_var)), .001);
end
fprintf("[INFO] digital twin degradation parameters: %.4f\t%.4f\t%.4f", batterytwin.R0, batterytwin.Q, Motortwin2.Req);
write_degradation_data;

```

## now simulate digital twin

```

load_trajectory;
sys = "DigitalTwin";
octomodel.sampletime = twin_sample_rate;
for twin_ctr=1:twin_count
    if explore
        fprintf("[INFO] DigitalTwin selecting trajectory: < %d> with path_time: %.2f to explore", twin_ctr, path_time);
        explore = false; % this never gets updated because of scope - silly error! only the first trajectory is explored
    else
        fprintf("[INFO] DigitalTwin selecting trajectory: < %d> with path_time: %.2f that meets the criteria", twin_ctr, path_time);
    end
    fprintf('[INFO] simulating digital twin on i, mission_id: %d\n', i, mission_id);
    out = sim('digitaltwin1c.slx');
    % get the output from each parallel worker
    times(twin_ctr) = flight_time.Data(end);
    vs(twin_ctr) = battery_actual.Data(end, 1);
    socs(twin_ctr) = battery_actual.Data(end, 2);
    r0s(twin_ctr) = battery_actual.Data(end, 3);
    qs(twin_ctr) = battery_actual.Data(end, 6);
    ms(twin_ctr) = motors.Data(end, 1);
    errs(twin_ctr) = mean(euclidean_pos_err);
    dist(twin_ctr) = calculatedistance([pos_actual.Data(:,1) pos_actual.Data(:,2)]);
    degs(:, twin_ctr) = [batterytwin.R0 batterytwin.Q Motortwin2.Req]';

    % resample the degradation parameters if more than one digital twin
    % simulation
    if twin_count > 1 && twin_ctr < twin_count
        fprintf('[INFO] resampling for twin run # %d', twin_ctr + 1);
        if i > lookback
            batterytwin.R0 = normrnd(r_mu, r_var);
            batterytwin.Q = normrnd(q_mu, q_var);
            Motortwin2.Req = normrnd(m_mu, m_var);
        end
    end
end

```



```

[INFO] TrueSystem selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.00
[INFO] simulating true system on i: 1
[INFO] updating degradation parameter variance on i: 1
[INFO] updating degradation parameter values via random sampling on i: 1
[INFO] i: 1 mission_id: 452 rul_hat: 18.00 flight_time: 19.63 distance: 1449.27 R0: 0.00106 Q: 15.04 Req: 0.25074
[INFO] success on i: 1 mission_id: 452
[INFO] digital twin degradation parameters: 0.0006 12.7557 0.2806
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.00
[INFO] simulating digital twin on i, mission_id: 1
[INFO] simulating digital twin on i, mission_id: 452
[INFO] digital twin degradation parameters: 0.0006 12.7557 0.2806
[INFO] digital twin mission success on i: 1 mission_id: 452
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.00
[INFO] simulating true system on i: 2
[INFO] updating degradation parameter variance on i: 2
[INFO] updating degradation parameter values via random sampling on i: 2
[INFO] i: 2 mission_id: 453 rul_hat: 18.00 flight_time: 17.84 distance: 1302.10 R0: 0.00080 Q: 14.10 Req: 0.21900
[INFO] success on i: 2 mission_id: 453
[INFO] digital twin degradation parameters: 0.0005 15.5000 0.2357
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.00
[INFO] simulating digital twin on i, mission_id: 2
[INFO] simulating digital twin on i, mission_id: 453
[INFO] digital twin degradation parameters: 0.0005 15.5000 0.2357
[INFO] digital twin mission success on i: 2 mission_id: 453
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.00
[INFO] simulating true system on i: 3
[INFO] updating degradation parameter variance on i: 3
[INFO] updating degradation parameter values via random sampling on i: 3
[INFO] i: 3 mission_id: 454 rul_hat: 18.00 flight_time: 17.83 distance: 1301.98 R0: 0.00119 Q: 14.04 Req: 0.21499
[INFO] success on i: 3 mission_id: 454
[INFO] digital twin degradation parameters: 0.0009 14.0563 0.2206
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.00
[INFO] simulating digital twin on i, mission_id: 3
[INFO] simulating digital twin on i, mission_id: 454
[INFO] digital twin degradation parameters: 0.0009 14.0563 0.2206
[INFO] digital twin mission success on i: 3 mission_id: 454
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.00
[INFO] simulating true system on i: 4
[INFO] updating degradation parameter variance on i: 4
[INFO] updating degradation parameter values via random sampling on i: 4
[INFO] i: 4 mission_id: 455 rul_hat: 18.00 flight_time: 16.36 distance: 1218.63 R0: 0.00133 Q: 15.16 Req: 0.24242
[INFO] success on i: 4 mission_id: 455
[INFO] digital twin degradation parameters: 0.0016 14.0711 0.2449
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.00
[INFO] simulating digital twin on i, mission_id: 4
[INFO] simulating digital twin on i, mission_id: 455
[INFO] digital twin degradation parameters: 0.0016 14.0711 0.2449
[INFO] digital twin mission success on i: 4 mission_id: 455
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.00
[INFO] simulating true system on i: 5
[INFO] updating degradation parameter variance on i: 5
[INFO] updating degradation parameter values via random sampling on i: 5
[INFO] i: 5 mission_id: 456 rul_hat: 18.00 flight_time: 16.36 distance: 1218.60 R0: 0.00074 Q: 15.38 Req: 0.24635
[INFO] success on i: 5 mission_id: 456
[INFO] digital twin degradation parameters: 0.0001 14.9187 0.2207
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.00
[INFO] simulating digital twin on i, mission_id: 5
[INFO] simulating digital twin on i, mission_id: 456
[INFO] digital twin degradation parameters: 0.0001 14.9187 0.2207
[INFO] digital twin mission success on i: 5 mission_id: 456
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.00
[INFO] simulating true system on i: 6
[INFO] updating degradation parameter variance on i: 6
[INFO] updating degradation parameter values via random sampling on i: 6

```

```

[INFO] i: 6 mission_id: 457 rul_hat: 18.00 flight_time: 17.63 distance: 1283.83 R0: 0.00012 Q: 14.28 Req: 0.23880
[INFO] success on i: 6 mission_id: 457
[INFO] digital twin degradation parameters: 0.0026 15.5000 0.2604
[INFO] DigitalTwin selecting trajectory: <2> with path_time: 19.92 that meets constraint: path_time < 18.00
[INFO] simulating digital twin on i, mission_id: 6
[INFO] simulating digital twin on i, mission_id: 457
[INFO] digital twin degradation parameters: 0.0026 15.5000 0.2604
[INFO] digital twin mission success on i: 6 mission_id: 457
[INFO] new RUL update is available, 18.93 replaces 18.00
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 7
[INFO] updating degradation parameter variance on i: 7
[INFO] updating degradation parameter values via random sampling on i: 7
[INFO] i: 7 mission_id: 458 rul_hat: 18.93 flight_time: 16.36 distance: 1218.63 R0: 0.00100 Q: 14.04 Req: 0.24362
[INFO] success on i: 7 mission_id: 458
[INFO] forecasting degradation values: r_mu: 0.000175 q_mu: 14.788323 m_mu: 0.242031
[INFO] digital twin degradation parameters: 0.0005 15.5000 0.2191
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 7
[INFO] simulating digital twin on i, mission_id: 458
[INFO] digital twin degradation parameters: 0.0005 15.5000 0.2191
[INFO] digital twin mission success on i: 7 mission_id: 458
[INFO] TrueSystem selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 8
[INFO] updating degradation parameter variance on i: 8
[INFO] updating degradation parameter values via random sampling on i: 8
[INFO] i: 8 mission_id: 459 rul_hat: 18.93 flight_time: 18.53 distance: 1332.08 R0: 0.00118 Q: 15.50 Req: 0.23411
[WARN] true system low soc threshold exceeded on i: 8 mission_id: 459
[INFO] forecasting degradation values: r_mu: 0.000771 q_mu: 14.519422 m_mu: 0.258049
[INFO] digital twin degradation parameters: 0.0007 14.5578 0.2529
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 8
[INFO] simulating digital twin on i, mission_id: 459
[INFO] digital twin degradation parameters: 0.0007 14.5578 0.2529
[WARN] digital twin low soc threshold exceeded on i: 8 mission_id: 459
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 9
[INFO] updating degradation parameter variance on i: 9
[INFO] updating degradation parameter values via random sampling on i: 9
[INFO] i: 9 mission_id: 460 rul_hat: 18.93 flight_time: 17.83 distance: 1301.95 R0: 0.00125 Q: 14.99 Req: 0.20387
[INFO] success on i: 9 mission_id: 460
[INFO] forecasting degradation values: r_mu: 0.001014 q_mu: 15.140167 m_mu: 0.248172
[INFO] digital twin degradation parameters: 0.0023 14.3970 0.2438
[INFO] DigitalTwin selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 9
[INFO] simulating digital twin on i, mission_id: 460
[INFO] digital twin degradation parameters: 0.0023 14.3970 0.2438
[INFO] digital twin mission success on i: 9 mission_id: 460
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 10
[INFO] updating degradation parameter variance on i: 10
[INFO] updating degradation parameter values via random sampling on i: 10
[INFO] i: 10 mission_id: 461 rul_hat: 18.93 flight_time: 17.83 distance: 1301.89 R0: 0.00123 Q: 15.50 Req: 0.23321
[INFO] success on i: 10 mission_id: 461
[INFO] forecasting degradation values: r_mu: 0.001183 q_mu: 14.798249 m_mu: 0.204188
[INFO] digital twin degradation parameters: 0.0028 14.9205 0.2109
[INFO] DigitalTwin selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 10
[INFO] simulating digital twin on i, mission_id: 461
[INFO] digital twin degradation parameters: 0.0028 14.9205 0.2109
[INFO] digital twin mission success on i: 10 mission_id: 461
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 11
[INFO] updating degradation parameter variance on i: 11
[INFO] updating degradation parameter values via random sampling on i: 11

```



```

[INFO] i: 11 mission_id: 462 rul_hat: 18.93 flight_time: 17.83 distance: 1301.90 R0: 0.00137 Q: 14.76 Req: 0.24852
[INFO] success on i: 11 mission_id: 462
[INFO] forecasting degradation values: r_mu: 0.001281 q_mu: 15.606725 m_mu: 0.240133
[INFO] digital twin degradation parameters: 0.0029 13.8874 0.2775
[INFO] DigitalTwin selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 11
[INFO] simulating digital twin on i, mission_id: 462
[INFO] digital twin degradation parameters: 0.0029 13.8874 0.2775
[WARN] digital twin low soc threshold exceeded on i: 11 mission_id: 462
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 12
[INFO] updating degradation parameter variance on i: 12
[INFO] updating degradation parameter values via random sampling on i: 12
[INFO] i: 12 mission_id: 463 rul_hat: 18.93 flight_time: 17.84 distance: 1302.09 R0: 0.00116 Q: 14.88 Req: 0.22576
[INFO] success on i: 12 mission_id: 463
[INFO] forecasting degradation values: r_mu: 0.001286 q_mu: 14.985461 m_mu: 0.237171
[INFO] digital twin degradation parameters: 0.0002 15.5000 0.2458
[INFO] DigitalTwin selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 12
[INFO] simulating digital twin on i, mission_id: 463
[INFO] digital twin degradation parameters: 0.0002 15.5000 0.2458
[INFO] digital twin mission success on i: 12 mission_id: 463
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 13
[INFO] updating degradation parameter variance on i: 13
[INFO] updating degradation parameter values via random sampling on i: 13
[INFO] i: 13 mission_id: 464 rul_hat: 18.93 flight_time: 17.64 distance: 1283.69 R0: 0.00068 Q: 14.11 Req: 0.26896
[INFO] success on i: 13 mission_id: 464
[INFO] forecasting degradation values: r_mu: 0.001480 q_mu: 15.070308 m_mu: 0.218463
[INFO] digital twin degradation parameters: 0.0018 14.6445 0.2296
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 13
[INFO] simulating digital twin on i, mission_id: 464
[INFO] digital twin degradation parameters: 0.0018 14.6445 0.2296
[INFO] digital twin mission success on i: 13 mission_id: 464
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 14
[INFO] updating degradation parameter variance on i: 14
[INFO] updating degradation parameter values via random sampling on i: 14
[INFO] i: 14 mission_id: 465 rul_hat: 18.93 flight_time: 16.36 distance: 1218.81 R0: 0.00168 Q: 14.50 Req: 0.22573
[INFO] success on i: 14 mission_id: 465
[INFO] forecasting degradation values: r_mu: 0.001403 q_mu: 14.826263 m_mu: 0.268937
[INFO] digital twin degradation parameters: 0.0022 13.6509 0.2375
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 14
[INFO] simulating digital twin on i, mission_id: 465
[INFO] digital twin degradation parameters: 0.0022 13.6509 0.2375
[WARN] digital twin low soc threshold exceeded on i: 14 mission_id: 465
[INFO] updating RUL from 18.93 to 17.34
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 15
[INFO] updating degradation parameter variance on i: 15
[INFO] updating degradation parameter values via random sampling on i: 15
[INFO] i: 15 mission_id: 466 rul_hat: 17.34 flight_time: 13.94 distance: 1048.04 R0: 0.00149 Q: 15.11 Req: 0.22798
[INFO] success on i: 15 mission_id: 466
[INFO] forecasting degradation values: r_mu: 0.001723 q_mu: 14.508845 m_mu: 0.235914
[INFO] digital twin degradation parameters: 0.0020 15.5000 0.2464
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 15
[INFO] simulating digital twin on i, mission_id: 466
[INFO] digital twin degradation parameters: 0.0020 15.5000 0.2464
[INFO] digital twin mission success on i: 15 mission_id: 466
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 16
[INFO] updating degradation parameter variance on i: 16

```

```

[INFO] updating degradation parameter values via random sampling on i: 16
[INFO] i: 16 mission_id: 467 rul_hat: 17.34 flight_time: 13.94 distance: 1048.03 R0: 0.00171 Q: 14.96 Req: 0.24900
[INFO] success on i: 16 mission_id: 467
[INFO] forecasting degradation values: r_mu: 0.001451 q_mu: 14.276584 m_mu: 0.240501
[INFO] digital twin degradation parameters: 0.0012 14.5241 0.2259
[INFO] DigitalTwin selecting trajectory: <10> with path_time: 13.57 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 16
[INFO] simulating digital twin on i, mission_id: 467
[INFO] digital twin degradation parameters: 0.0012 14.5241 0.2259
[INFO] digital twin mission success on i: 16 mission_id: 467
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 17
[INFO] updating degradation parameter variance on i: 17
[INFO] updating degradation parameter values via random sampling on i: 17
[INFO] i: 17 mission_id: 468 rul_hat: 17.34 flight_time: 17.84 distance: 1302.18 R0: 0.00276 Q: 14.90 Req: 0.23842
[INFO] success on i: 17 mission_id: 468
[INFO] forecasting degradation values: r_mu: 0.001984 q_mu: 14.613625 m_mu: 0.255833
[INFO] digital twin degradation parameters: 0.0027 15.5000 0.2737
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 17
[INFO] simulating digital twin on i, mission_id: 468
[INFO] digital twin degradation parameters: 0.0027 15.5000 0.2737
[INFO] digital twin mission success on i: 17 mission_id: 468
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 18
[INFO] updating degradation parameter variance on i: 18
[INFO] updating degradation parameter values via random sampling on i: 18
[INFO] i: 18 mission_id: 469 rul_hat: 17.34 flight_time: 13.94 distance: 1047.76 R0: 0.00116 Q: 14.61 Req: 0.23176
[INFO] success on i: 18 mission_id: 469
[INFO] forecasting degradation values: r_mu: 0.002680 q_mu: 14.647372 m_mu: 0.240175
[INFO] digital twin degradation parameters: 0.0026 14.6717 0.2435
[INFO] DigitalTwin selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 18
[INFO] simulating digital twin on i, mission_id: 469
[INFO] digital twin degradation parameters: 0.0026 14.6717 0.2435
[INFO] digital twin mission success on i: 18 mission_id: 469
[INFO] new RUL update is available, 17.78 replaces 17.34
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 19
[INFO] updating degradation parameter variance on i: 19
[INFO] updating degradation parameter values via random sampling on i: 19
[INFO] i: 19 mission_id: 470 rul_hat: 17.78 flight_time: 17.63 distance: 1283.72 R0: 0.00207 Q: 14.89 Req: 0.29869
[INFO] success on i: 19 mission_id: 470
[INFO] forecasting degradation values: r_mu: 0.001486 q_mu: 14.752501 m_mu: 0.233408
[INFO] digital twin degradation parameters: 0.0019 14.1550 0.2327
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 19
[INFO] simulating digital twin on i, mission_id: 470
[INFO] digital twin degradation parameters: 0.0019 14.1550 0.2327
[INFO] digital twin mission success on i: 19 mission_id: 470
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 20
[INFO] updating degradation parameter variance on i: 20
[INFO] updating degradation parameter values via random sampling on i: 20
[INFO] i: 20 mission_id: 471 rul_hat: 17.78 flight_time: 17.63 distance: 1284.02 R0: 0.00174 Q: 14.20 Req: 0.25637
[INFO] success on i: 20 mission_id: 471
[INFO] forecasting degradation values: r_mu: 0.002499 q_mu: 14.958200 m_mu: 0.282942
[INFO] digital twin degradation parameters: 0.0030 15.3795 0.3040
[INFO] DigitalTwin selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 20
[INFO] simulating digital twin on i, mission_id: 471
[INFO] digital twin degradation parameters: 0.0030 15.3795 0.3040
[INFO] digital twin mission success on i: 20 mission_id: 471
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 21

```

```

[INFO] updating degradation parameter variance on i: 21
[INFO] updating degradation parameter values via random sampling on i: 21
[INFO] i: 21 mission_id: 472 rul_hat: 17.78 flight_time: 14.83 distance: 1083.46 R0: 0.00127 Q: 14.60 Req: 0.27384
[INFO] success on i: 21 mission_id: 472
[INFO] forecasting degradation values: r_mu: 0.001947 q_mu: 14.531576 m_mu: 0.260272
[INFO] digital twin degradation parameters: 0.0027 14.7118 0.2356
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 21
[INFO] simulating digital twin on i, mission_id: 472
[INFO] digital twin degradation parameters: 0.0027 14.7118 0.2356
[INFO] digital twin mission success on i: 21 mission_id: 472
[INFO] TrueSystem selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 22
[INFO] updating degradation parameter variance on i: 22
[INFO] updating degradation parameter values via random sampling on i: 22
[INFO] i: 22 mission_id: 473 rul_hat: 17.78 flight_time: 18.77 distance: 1386.86 R0: 0.00168 Q: 13.86 Req: 0.25616
[INFO] success on i: 22 mission_id: 473
[INFO] forecasting degradation values: r_mu: 0.002042 q_mu: 14.579364 m_mu: 0.282404
[INFO] digital twin degradation parameters: 0.0023 15.5000 0.3035
[INFO] DigitalTwin selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 22
[INFO] simulating digital twin on i, mission_id: 473
[INFO] digital twin degradation parameters: 0.0023 15.5000 0.3035
[INFO] digital twin mission success on i: 22 mission_id: 473
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 23
[INFO] updating degradation parameter variance on i: 23
[INFO] updating degradation parameter values via random sampling on i: 23
[INFO] i: 23 mission_id: 474 rul_hat: 17.78 flight_time: 17.63 distance: 1283.75 R0: 0.00110 Q: 15.50 Req: 0.25383
[INFO] success on i: 23 mission_id: 474
[INFO] forecasting degradation values: r_mu: 0.002002 q_mu: 14.193665 m_mu: 0.270117
[INFO] digital twin degradation parameters: 0.0009 13.5439 0.2656
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 23
[INFO] simulating digital twin on i, mission_id: 474
[INFO] digital twin degradation parameters: 0.0009 13.5439 0.2656
[WARN] digital twin low soc threshold exceeded on i: 23 mission_id: 474
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 24
[INFO] updating degradation parameter variance on i: 24
[INFO] updating degradation parameter values via random sampling on i: 24
[INFO] i: 24 mission_id: 475 rul_hat: 17.78 flight_time: 16.36 distance: 1218.59 R0: 0.00240 Q: 15.50 Req: 0.23279
[INFO] success on i: 24 mission_id: 475
[INFO] forecasting degradation values: r_mu: 0.001259 q_mu: 14.947263 m_mu: 0.274656
[INFO] digital twin degradation parameters: 0.0019 14.8672 0.2988
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 24
[INFO] simulating digital twin on i, mission_id: 475
[INFO] digital twin degradation parameters: 0.0019 14.8672 0.2988
[INFO] digital twin mission success on i: 24 mission_id: 475
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 25
[INFO] updating degradation parameter variance on i: 25
[INFO] updating degradation parameter values via random sampling on i: 25
[INFO] i: 25 mission_id: 476 rul_hat: 17.78 flight_time: 17.63 distance: 1283.66 R0: 0.00043 Q: 14.67 Req: 0.24011
[INFO] success on i: 25 mission_id: 476
[INFO] forecasting degradation values: r_mu: 0.001887 q_mu: 15.308745 m_mu: 0.260469
[INFO] digital twin degradation parameters: 0.0025 14.7920 0.2706
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 25
[INFO] simulating digital twin on i, mission_id: 476
[INFO] digital twin degradation parameters: 0.0025 14.7920 0.2706
[INFO] digital twin mission success on i: 25 mission_id: 476
[INFO] new RUL update is available, 18.64 replaces 17.78
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.64

```

```

[INFO] simulating true system on i: 26
[INFO] updating degradation parameter variance on i: 26
[INFO] updating degradation parameter values via random sampling on i: 26
[INFO] i: 26 mission_id: 477 rul_hat: 18.64 flight_time: 17.84 distance: 1302.10 R0: 0.00112 Q: 15.50 Req: 0.25060
[INFO] success on i: 26 mission_id: 477
[INFO] forecasting degradation values: r_mu: 0.000365 q_mu: 14.926752 m_mu: 0.249872
[INFO] digital twin degradation parameters: 0.0016 15.5000 0.2254
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 26
[INFO] simulating digital twin on i, mission_id: 477
[INFO] digital twin degradation parameters: 0.0016 15.5000 0.2254
[INFO] digital twin mission success on i: 26 mission_id: 477
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 27
[INFO] updating degradation parameter variance on i: 27
[INFO] updating degradation parameter values via random sampling on i: 27
[INFO] i: 27 mission_id: 478 rul_hat: 18.64 flight_time: 17.63 distance: 1283.61 R0: 0.00081 Q: 14.73 Req: 0.26738
[INFO] success on i: 27 mission_id: 478
[INFO] forecasting degradation values: r_mu: 0.000311 q_mu: 15.484080 m_mu: 0.253250
[INFO] digital twin degradation parameters: 0.0009 15.5000 0.2694
[INFO] DigitalTwin selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 27
[INFO] simulating digital twin on i, mission_id: 478
[INFO] digital twin degradation parameters: 0.0009 15.5000 0.2694
[INFO] digital twin mission success on i: 27 mission_id: 478
[INFO] TrueSystem selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 28
[INFO] updating degradation parameter variance on i: 28
[INFO] updating degradation parameter values via random sampling on i: 28
[INFO] i: 28 mission_id: 479 rul_hat: 18.64 flight_time: 19.53 distance: 1442.96 R0: 0.00138 Q: 14.63 Req: 0.24900
[WARN] true system low soc threshold exceeded on i: 28 mission_id: 479
[INFO] forecasting degradation values: r_mu: 0.000210 q_mu: 15.388726 m_mu: 0.262623
[INFO] digital twin degradation parameters: 0.0005 15.1056 0.2575
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 28
[INFO] simulating digital twin on i, mission_id: 479
[INFO] digital twin degradation parameters: 0.0005 15.1056 0.2575
[INFO] digital twin mission success on i: 28 mission_id: 479
[INFO] new RUL update is available, 18.64 replaces 18.64
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 29
[INFO] updating degradation parameter variance on i: 29
[INFO] updating degradation parameter values via random sampling on i: 29
[INFO] i: 29 mission_id: 480 rul_hat: 18.64 flight_time: 17.63 distance: 1283.72 R0: 0.00131 Q: 14.81 Req: 0.26219
[INFO] success on i: 29 mission_id: 480
[INFO] forecasting degradation values: r_mu: 0.000283 q_mu: 15.161343 m_mu: 0.223839
[INFO] digital twin degradation parameters: 0.0008 14.5377 0.2243
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 29
[INFO] simulating digital twin on i, mission_id: 480
[INFO] digital twin degradation parameters: 0.0008 14.5377 0.2243
[INFO] digital twin mission success on i: 29 mission_id: 480
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 30
[INFO] updating degradation parameter variance on i: 30
[INFO] updating degradation parameter values via random sampling on i: 30
[INFO] i: 30 mission_id: 481 rul_hat: 18.64 flight_time: 16.36 distance: 1218.58 R0: 0.00222 Q: 15.09 Req: 0.22857
[INFO] success on i: 30 mission_id: 481
[INFO] forecasting degradation values: r_mu: 0.000742 q_mu: 15.104793 m_mu: 0.251594
[INFO] digital twin degradation parameters: 0.0011 14.6229 0.2328
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 30
[INFO] simulating digital twin on i, mission_id: 481
[INFO] digital twin degradation parameters: 0.0011 14.6229 0.2328
[INFO] digital twin mission success on i: 30 mission_id: 481

```

```

[INFO] TrueSystem selecting trajectory: <2> with path_time: 19.92 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 31
[INFO] updating degradation parameter variance on i: 31
[INFO] updating degradation parameter values via random sampling on i: 31
[INFO] i: 31 mission_id: 482 rul_hat: 18.64 flight_time: 19.68 distance: 1444.92 R0: 0.00161 Q: 15.35 Req: 0.25349
[WARN] true system low soc threshold exceeded on i: 31 mission_id: 482
[INFO] forecasting degradation values: r_mu: 0.001689 q_mu: 14.924783 m_mu: 0.229964
[INFO] digital twin degradation parameters: 0.0020 15.2117 0.2353
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 31
[INFO] simulating digital twin on i, mission_id: 482
[INFO] digital twin degradation parameters: 0.0020 15.2117 0.2353
[INFO] digital twin mission success on i: 31 mission_id: 482
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 32
[INFO] updating degradation parameter variance on i: 32
[INFO] updating degradation parameter values via random sampling on i: 32
[INFO] i: 32 mission_id: 483 rul_hat: 18.64 flight_time: 16.36 distance: 1218.80 R0: 0.00135 Q: 15.13 Req: 0.24907
[INFO] success on i: 32 mission_id: 483
[INFO] forecasting degradation values: r_mu: 0.001821 q_mu: 15.441525 m_mu: 0.250712
[INFO] digital twin degradation parameters: 0.0013 14.9499 0.2383
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 32
[INFO] simulating digital twin on i, mission_id: 483
[INFO] digital twin degradation parameters: 0.0013 14.9499 0.2383
[INFO] digital twin mission success on i: 32 mission_id: 483
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 33
[INFO] updating degradation parameter variance on i: 33
[INFO] updating degradation parameter values via random sampling on i: 33
[INFO] i: 33 mission_id: 484 rul_hat: 18.64 flight_time: 16.36 distance: 1218.68 R0: 0.00164 Q: 13.96 Req: 0.25536
[INFO] success on i: 33 mission_id: 484
[INFO] forecasting degradation values: r_mu: 0.002077 q_mu: 14.704619 m_mu: 0.253133
[INFO] digital twin degradation parameters: 0.0014 14.1637 0.2452
[INFO] DigitalTwin selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 33
[INFO] simulating digital twin on i, mission_id: 484
[INFO] digital twin degradation parameters: 0.0014 14.1637 0.2452
[INFO] digital twin mission success on i: 33 mission_id: 484
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 34
[INFO] updating degradation parameter variance on i: 34
[INFO] updating degradation parameter values via random sampling on i: 34
[INFO] i: 34 mission_id: 485 rul_hat: 18.64 flight_time: 16.36 distance: 1218.63 R0: 0.00083 Q: 13.63 Req: 0.26490
[INFO] success on i: 34 mission_id: 485
[INFO] forecasting degradation values: r_mu: 0.001350 q_mu: 14.236091 m_mu: 0.267303
[INFO] digital twin degradation parameters: 0.0015 14.0709 0.2690
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 34
[INFO] simulating digital twin on i, mission_id: 485
[INFO] digital twin degradation parameters: 0.0015 14.0709 0.2690
[WARN] digital twin low soc threshold exceeded on i: 34 mission_id: 485
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 35
[INFO] updating degradation parameter variance on i: 35
[INFO] updating degradation parameter values via random sampling on i: 35
[INFO] i: 35 mission_id: 486 rul_hat: 18.64 flight_time: 17.63 distance: 1283.76 R0: 0.00223 Q: 15.50 Req: 0.24109
[INFO] success on i: 35 mission_id: 486
[INFO] forecasting degradation values: r_mu: 0.001809 q_mu: 14.055007 m_mu: 0.267015
[INFO] digital twin degradation parameters: 0.0009 15.4975 0.2789
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 35
[INFO] simulating digital twin on i, mission_id: 486
[INFO] digital twin degradation parameters: 0.0009 15.4975 0.2789
[INFO] digital twin mission success on i: 35 mission_id: 486

```

```

[INFO] TrueSystem selecting trajectory: <2> with path_time: 19.92 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 36
[INFO] updating degradation parameter variance on i: 36
[INFO] updating degradation parameter values via random sampling on i: 36
[INFO] i: 36 mission_id: 487 rul_hat: 18.64 flight_time: 19.93 distance: 1464.69 R0: 0.00207 Q: 15.31 Req: 0.24576
[INFO] success on i: 36 mission_id: 487
[INFO] forecasting degradation values: r_mu: 0.002210 q_mu: 14.718610 m_mu: 0.247140
[INFO] digital twin degradation parameters: 0.0036 15.3565 0.2441
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 36
[INFO] simulating digital twin on i, mission_id: 487
[INFO] digital twin degradation parameters: 0.0036 15.3565 0.2441
[INFO] digital twin mission success on i: 36 mission_id: 487
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 37
[INFO] updating degradation parameter variance on i: 37
[INFO] updating degradation parameter values via random sampling on i: 37
[INFO] i: 37 mission_id: 488 rul_hat: 18.64 flight_time: 16.36 distance: 1218.65 R0: 0.00218 Q: 14.46 Req: 0.27197
[INFO] success on i: 37 mission_id: 488
[INFO] forecasting degradation values: r_mu: 0.002433 q_mu: 14.420103 m_mu: 0.242193
[INFO] digital twin degradation parameters: 0.0018 14.1953 0.2620
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 37
[INFO] simulating digital twin on i, mission_id: 488
[INFO] digital twin degradation parameters: 0.0018 14.1953 0.2620
[INFO] digital twin mission success on i: 37 mission_id: 488
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 38
[INFO] updating degradation parameter variance on i: 38
[INFO] updating degradation parameter values via random sampling on i: 38
[INFO] i: 38 mission_id: 489 rul_hat: 18.64 flight_time: 16.36 distance: 1218.79 R0: 0.00183 Q: 14.87 Req: 0.25330
[INFO] success on i: 38 mission_id: 489
[INFO] forecasting degradation values: r_mu: 0.002594 q_mu: 14.637389 m_mu: 0.262751
[INFO] digital twin degradation parameters: 0.0029 13.4195 0.2663
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 38
[INFO] simulating digital twin on i, mission_id: 489
[INFO] digital twin degradation parameters: 0.0029 13.4195 0.2663
[INFO] digital twin mission success on i: 38 mission_id: 489
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 39
[INFO] updating degradation parameter variance on i: 39
[INFO] updating degradation parameter values via random sampling on i: 39
[INFO] i: 39 mission_id: 490 rul_hat: 18.64 flight_time: 14.83 distance: 1083.22 R0: 0.00200 Q: 14.64 Req: 0.26854
[INFO] success on i: 39 mission_id: 490
[INFO] forecasting degradation values: r_mu: 0.002443 q_mu: 14.935164 m_mu: 0.258073
[INFO] digital twin degradation parameters: 0.0026 14.8685 0.2548
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 39
[INFO] simulating digital twin on i, mission_id: 490
[INFO] digital twin degradation parameters: 0.0026 14.8685 0.2548
[INFO] digital twin mission success on i: 39 mission_id: 490
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 40
[INFO] updating degradation parameter variance on i: 40
[INFO] updating degradation parameter values via random sampling on i: 40
[INFO] i: 40 mission_id: 491 rul_hat: 18.64 flight_time: 14.83 distance: 1083.74 R0: 0.00250 Q: 14.55 Req: 0.28073
[INFO] success on i: 40 mission_id: 491
[INFO] forecasting degradation values: r_mu: 0.002162 q_mu: 14.561258 m_mu: 0.275022
[INFO] digital twin degradation parameters: 0.0020 14.3829 0.2793
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 40
[INFO] simulating digital twin on i, mission_id: 491
[INFO] digital twin degradation parameters: 0.0020 14.3829 0.2793
[INFO] digital twin mission success on i: 40 mission_id: 491

```

```

[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 41
[INFO] updating degradation parameter variance on i: 41
[INFO] updating degradation parameter values via random sampling on i: 41
[INFO] i: 41 mission_id: 492 rul_hat: 18.64 flight_time: 16.36 distance: 1218.88 R0: 0.00201 Q: 14.46 Req: 0.27143
[INFO] success on i: 41 mission_id: 492
[INFO] forecasting degradation values: r_mu: 0.002676 q_mu: 14.559158 m_mu: 0.278790
[INFO] digital twin degradation parameters: 0.0027 14.3342 0.2742
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 41
[INFO] simulating digital twin on i, mission_id: 492
[INFO] digital twin degradation parameters: 0.0027 14.3342 0.2742
[INFO] digital twin mission success on i: 41 mission_id: 492
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.64
[INFO] simulating true system on i: 42
[INFO] updating degradation parameter variance on i: 42
[INFO] updating degradation parameter values via random sampling on i: 42
[INFO] i: 42 mission_id: 493 rul_hat: 18.64 flight_time: 17.63 distance: 1283.72 R0: 0.00306 Q: 14.27 Req: 0.24909
[INFO] success on i: 42 mission_id: 493
[INFO] forecasting degradation values: r_mu: 0.002421 q_mu: 14.615292 m_mu: 0.283807
[INFO] digital twin degradation parameters: 0.0029 15.0494 0.2852
[INFO] DigitalTwin selecting trajectory: <2> with path_time: 19.92 that meets constraint: path_time < 18.64
[INFO] simulating digital twin on i, mission_id: 42
[INFO] simulating digital twin on i, mission_id: 493
[INFO] digital twin degradation parameters: 0.0029 15.0494 0.2852
[INFO] digital twin mission success on i: 42 mission_id: 493
[INFO] new RUL update is available, 18.93 replaces 18.64
[INFO] TrueSystem selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 43
[INFO] updating degradation parameter variance on i: 43
[INFO] updating degradation parameter values via random sampling on i: 43
[INFO] i: 43 mission_id: 494 rul_hat: 18.93 flight_time: 18.77 distance: 1386.60 R0: 0.00171 Q: 13.93 Req: 0.26127
[WARN] true system low soc threshold exceeded on i: 43 mission_id: 494
[INFO] forecasting degradation values: r_mu: 0.003081 q_mu: 14.429176 m_mu: 0.270261
[INFO] digital twin degradation parameters: 0.0018 14.7579 0.2744
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 43
[INFO] simulating digital twin on i, mission_id: 494
[INFO] digital twin degradation parameters: 0.0018 14.7579 0.2744
[INFO] digital twin mission success on i: 43 mission_id: 494
[INFO] TrueSystem selecting trajectory: <2> with path_time: 19.92 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 44
[INFO] updating degradation parameter variance on i: 44
[INFO] updating degradation parameter values via random sampling on i: 44
[INFO] i: 44 mission_id: 495 rul_hat: 18.93 flight_time: 18.22 distance: 1293.90 R0: 0.00304 Q: 14.30 Req: 0.25733
[WARN] true system low soc threshold exceeded on i: 44 mission_id: 495
[INFO] forecasting degradation values: r_mu: 0.002548 q_mu: 14.263087 m_mu: 0.270068
[INFO] digital twin degradation parameters: 0.0032 13.5553 0.2557
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 44
[INFO] simulating digital twin on i, mission_id: 495
[INFO] digital twin degradation parameters: 0.0032 13.5553 0.2557
[INFO] digital twin mission success on i: 44 mission_id: 495
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 45
[INFO] updating degradation parameter variance on i: 45
[INFO] updating degradation parameter values via random sampling on i: 45
[INFO] i: 45 mission_id: 496 rul_hat: 18.93 flight_time: 17.63 distance: 1283.63 R0: 0.00202 Q: 14.55 Req: 0.25909
[INFO] success on i: 45 mission_id: 496
[INFO] forecasting degradation values: r_mu: 0.003610 q_mu: 13.517604 m_mu: 0.278881
[INFO] digital twin degradation parameters: 0.0040 13.1914 0.2734
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 45
[INFO] simulating digital twin on i, mission_id: 496
[INFO] digital twin degradation parameters: 0.0040 13.1914 0.2734

```

```

[INFO] digital twin mission success on i: 45 mission_id: 496
[INFO] TrueSystem selecting trajectory: <2> with path_time: 19.92 that meets constraint: path_time < 18.93
[INFO] simulating true system on i: 46
[INFO] updating degradation parameter variance on i: 46
[INFO] updating degradation parameter values via random sampling on i: 46
[INFO] i: 46 mission_id: 497 rul_hat: 18.93 flight_time: 19.07 distance: 1375.18 R0: 0.00302 Q: 14.56 Req: 0.26435
[WARN] true system low soc threshold exceeded on i: 46 mission_id: 497
[INFO] forecasting degradation values: r_mu: 0.002682 q_mu: 13.801004 m_mu: 0.267800
[INFO] digital twin degradation parameters: 0.0029 13.6561 0.2848
[INFO] DigitalTwin selecting trajectory: <2> with path_time: 19.92 that meets constraint: path_time < 18.93
[INFO] simulating digital twin on i, mission_id: 46
[INFO] simulating digital twin on i, mission_id: 497
[INFO] digital twin degradation parameters: 0.0029 13.6561 0.2848
[WARN] digital twin low soc threshold exceeded on i: 46 mission_id: 497
[INFO] updating RUL from 18.93 to 17.05
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.05
[INFO] simulating true system on i: 47
[INFO] updating degradation parameter variance on i: 47
[INFO] updating degradation parameter values via random sampling on i: 47
[INFO] i: 47 mission_id: 498 rul_hat: 17.05 flight_time: 13.94 distance: 1047.82 R0: 0.00238 Q: 14.07 Req: 0.24933
[INFO] success on i: 47 mission_id: 498
[INFO] forecasting degradation values: r_mu: 0.003034 q_mu: 14.314512 m_mu: 0.253822
[INFO] digital twin degradation parameters: 0.0030 14.6140 0.2520
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.05
[INFO] simulating digital twin on i, mission_id: 47
[INFO] simulating digital twin on i, mission_id: 498
[INFO] digital twin degradation parameters: 0.0030 14.6140 0.2520
[INFO] digital twin mission success on i: 47 mission_id: 498
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.05
[INFO] simulating true system on i: 48
[INFO] updating degradation parameter variance on i: 48
[INFO] updating degradation parameter values via random sampling on i: 48
[INFO] i: 48 mission_id: 499 rul_hat: 17.05 flight_time: 16.36 distance: 1218.62 R0: 0.00275 Q: 14.29 Req: 0.26731
[INFO] success on i: 48 mission_id: 499
[INFO] forecasting degradation values: r_mu: 0.002950 q_mu: 13.911109 m_mu: 0.251261
[INFO] digital twin degradation parameters: 0.0028 14.3537 0.2688
[INFO] DigitalTwin selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 17.05
[INFO] simulating digital twin on i, mission_id: 48
[INFO] simulating digital twin on i, mission_id: 499
[INFO] digital twin degradation parameters: 0.0028 14.3537 0.2688
[INFO] digital twin mission success on i: 48 mission_id: 499
[INFO] new RUL update is available, 17.78 replaces 17.05
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 49
[INFO] updating degradation parameter variance on i: 49
[INFO] updating degradation parameter values via random sampling on i: 49
[INFO] i: 49 mission_id: 500 rul_hat: 17.78 flight_time: 17.63 distance: 1283.73 R0: 0.00277 Q: 14.96 Req: 0.26539
[INFO] success on i: 49 mission_id: 500
[INFO] forecasting degradation values: r_mu: 0.002928 q_mu: 14.266380 m_mu: 0.252200
[INFO] digital twin degradation parameters: 0.0031 14.0545 0.2510
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 49
[INFO] simulating digital twin on i, mission_id: 500
[INFO] digital twin degradation parameters: 0.0031 14.0545 0.2510
[WARN] digital twin low soc threshold exceeded on i: 49 mission_id: 500
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 50
[INFO] updating degradation parameter variance on i: 50
[INFO] updating degradation parameter values via random sampling on i: 50
[INFO] i: 50 mission_id: 501 rul_hat: 17.78 flight_time: 17.63 distance: 1283.81 R0: 0.00311 Q: 14.53 Req: 0.27150
[INFO] success on i: 50 mission_id: 501
[INFO] forecasting degradation values: r_mu: 0.002906 q_mu: 14.620638 m_mu: 0.257687
[INFO] digital twin degradation parameters: 0.0030 14.7750 0.2572
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 50

```



```

[INFO] simulating digital twin on i, mission_id: 501
[INFO] digital twin degradation parameters: 0.0030 14.7750 0.2572
[INFO] digital twin mission success on i: 50 mission_id: 501
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 51
[INFO] updating degradation parameter variance on i: 51
[INFO] updating degradation parameter values via random sampling on i: 51
[INFO] i: 51 mission_id: 502 rul_hat: 17.78 flight_time: 16.36 distance: 1218.87 R0: 0.00276 Q: 14.26 Req: 0.25858
[INFO] success on i: 51 mission_id: 502
[INFO] forecasting degradation values: r_mu: 0.003234 q_mu: 14.481654 m_mu: 0.267116
[INFO] digital twin degradation parameters: 0.0037 14.3573 0.2781
[INFO] DigitalTwin selecting trajectory: <20> with path_time: 19.65 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 51
[INFO] simulating digital twin on i, mission_id: 502
[INFO] digital twin degradation parameters: 0.0037 14.3573 0.2781
[WARN] digital twin low soc threshold exceeded on i: 51 mission_id: 502
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 52
[INFO] updating degradation parameter variance on i: 52
[INFO] updating degradation parameter values via random sampling on i: 52
[INFO] i: 52 mission_id: 503 rul_hat: 17.78 flight_time: 14.83 distance: 1083.61 R0: 0.00357 Q: 14.20 Req: 0.27267
[INFO] success on i: 52 mission_id: 503
[INFO] forecasting degradation values: r_mu: 0.002860 q_mu: 14.586943 m_mu: 0.270570
[INFO] digital twin degradation parameters: 0.0030 14.5287 0.2652
[INFO] DigitalTwin selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 52
[INFO] simulating digital twin on i, mission_id: 503
[INFO] digital twin degradation parameters: 0.0030 14.5287 0.2652
[INFO] digital twin mission success on i: 52 mission_id: 503
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 53
[INFO] updating degradation parameter variance on i: 53
[INFO] updating degradation parameter values via random sampling on i: 53
[INFO] i: 53 mission_id: 504 rul_hat: 17.78 flight_time: 13.94 distance: 1047.70 R0: 0.00284 Q: 14.11 Req: 0.26274
[INFO] success on i: 53 mission_id: 504
[INFO] forecasting degradation values: r_mu: 0.003879 q_mu: 14.444943 m_mu: 0.273370
[INFO] digital twin degradation parameters: 0.0044 14.1168 0.2640
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 53
[INFO] simulating digital twin on i, mission_id: 504
[INFO] digital twin degradation parameters: 0.0044 14.1168 0.2640
[INFO] digital twin mission success on i: 53 mission_id: 504
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 54
[INFO] updating degradation parameter variance on i: 54
[INFO] updating degradation parameter values via random sampling on i: 54
[INFO] i: 54 mission_id: 505 rul_hat: 17.78 flight_time: 13.94 distance: 1047.76 R0: 0.00362 Q: 14.26 Req: 0.27556
[INFO] success on i: 54 mission_id: 505
[INFO] forecasting degradation values: r_mu: 0.003224 q_mu: 14.134205 m_mu: 0.271840
[INFO] digital twin degradation parameters: 0.0028 14.1550 0.2665
[INFO] DigitalTwin selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 54
[INFO] simulating digital twin on i, mission_id: 505
[INFO] digital twin degradation parameters: 0.0028 14.1550 0.2665
[INFO] digital twin mission success on i: 54 mission_id: 505
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 55
[INFO] updating degradation parameter variance on i: 55
[INFO] updating degradation parameter values via random sampling on i: 55
[INFO] i: 55 mission_id: 506 rul_hat: 17.78 flight_time: 16.36 distance: 1218.91 R0: 0.00273 Q: 14.30 Req: 0.26642
[INFO] success on i: 55 mission_id: 506
[INFO] forecasting degradation values: r_mu: 0.003935 q_mu: 14.033211 m_mu: 0.276718
[INFO] digital twin degradation parameters: 0.0045 14.3901 0.2753
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 55

```

```

[INFO] simulating digital twin on i, mission_id: 506
[INFO] digital twin degradation parameters: 0.0045 14.3901 0.2753
[INFO] digital twin mission success on i: 55 mission_id: 506
[INFO] TrueSystem selecting trajectory: <15> with path_time: 17.63 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 56
[INFO] updating degradation parameter variance on i: 56
[INFO] updating degradation parameter values via random sampling on i: 56
[INFO] i: 56 mission_id: 507 rul_hat: 17.78 flight_time: 17.63 distance: 1283.85 R0: 0.00404 Q: 13.30 Req: 0.26347
[INFO] success on i: 56 mission_id: 507
[INFO] forecasting degradation values: r_mu: 0.003315 q_mu: 14.121450 m_mu: 0.274573
[INFO] digital twin degradation parameters: 0.0033 13.4978 0.2685
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 56
[INFO] simulating digital twin on i, mission_id: 507
[INFO] digital twin degradation parameters: 0.0033 13.4978 0.2685
[INFO] digital twin mission success on i: 56 mission_id: 507
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.78
[INFO] simulating true system on i: 57
[INFO] updating degradation parameter variance on i: 57
[INFO] updating degradation parameter values via random sampling on i: 57
[INFO] i: 57 mission_id: 508 rul_hat: 17.78 flight_time: 13.94 distance: 1047.74 R0: 0.00420 Q: 14.00 Req: 0.26990
[INFO] success on i: 57 mission_id: 508
[INFO] forecasting degradation values: r_mu: 0.004159 q_mu: 13.490927 m_mu: 0.273400
[INFO] digital twin degradation parameters: 0.0039 13.7494 0.2694
[INFO] DigitalTwin selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 17.78
[INFO] simulating digital twin on i, mission_id: 57
[INFO] simulating digital twin on i, mission_id: 508
[INFO] digital twin degradation parameters: 0.0039 13.7494 0.2694
[WARN] digital twin low soc threshold exceeded on i: 57 mission_id: 508
[INFO] updating RUL from 17.78 to 17.34
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 58
[INFO] updating degradation parameter variance on i: 58
[INFO] updating degradation parameter values via random sampling on i: 58
[INFO] i: 58 mission_id: 509 rul_hat: 17.34 flight_time: 17.84 distance: 1302.11 R0: 0.00487 Q: 13.91 Req: 0.26534
[INFO] success on i: 58 mission_id: 509
[INFO] forecasting degradation values: r_mu: 0.004461 q_mu: 13.960612 m_mu: 0.268667
[INFO] digital twin degradation parameters: 0.0041 13.9051 0.2693
[INFO] DigitalTwin selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 58
[INFO] simulating digital twin on i, mission_id: 509
[INFO] digital twin degradation parameters: 0.0041 13.9051 0.2693
[INFO] digital twin mission success on i: 58 mission_id: 509
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 59
[INFO] updating degradation parameter variance on i: 59
[INFO] updating degradation parameter values via random sampling on i: 59
[INFO] i: 59 mission_id: 510 rul_hat: 17.34 flight_time: 14.83 distance: 1083.79 R0: 0.00402 Q: 13.82 Req: 0.27132
[INFO] success on i: 59 mission_id: 510
[INFO] forecasting degradation values: r_mu: 0.005113 q_mu: 13.575719 m_mu: 0.267352
[INFO] digital twin degradation parameters: 0.0059 13.5120 0.2716
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 59
[INFO] simulating digital twin on i, mission_id: 510
[INFO] digital twin degradation parameters: 0.0059 13.5120 0.2716
[INFO] digital twin mission success on i: 59 mission_id: 510
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 60
[INFO] updating degradation parameter variance on i: 60
[INFO] updating degradation parameter values via random sampling on i: 60
[INFO] i: 60 mission_id: 511 rul_hat: 17.34 flight_time: 16.36 distance: 1218.89 R0: 0.00309 Q: 14.23 Req: 0.27703
[INFO] success on i: 60 mission_id: 511
[INFO] forecasting degradation values: r_mu: 0.005017 q_mu: 13.623448 m_mu: 0.268354
[INFO] digital twin degradation parameters: 0.0056 14.0035 0.2593
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34

```

```

[INFO] simulating digital twin on i, mission_id: 60
[INFO] simulating digital twin on i, mission_id: 511
[INFO] digital twin degradation parameters: 0.0056 14.0035 0.2593
[INFO] digital twin mission success on i: 60 mission_id: 511
[INFO] TrueSystem selecting trajectory: <10> with path_time: 13.57 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 61
[INFO] updating degradation parameter variance on i: 61
[INFO] updating degradation parameter values via random sampling on i: 61
[INFO] i: 61 mission_id: 512 rul_hat: 17.34 flight_time: 13.58 distance: 1021.12 R0: 0.00421 Q: 14.06 Req: 0.26982
[INFO] success on i: 61 mission_id: 512
[INFO] forecasting degradation values: r_mu: 0.004471 q_mu: 13.970738 m_mu: 0.277282
[INFO] digital twin degradation parameters: 0.0037 14.4911 0.2834
[INFO] DigitalTwin selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 61
[INFO] simulating digital twin on i, mission_id: 512
[INFO] digital twin degradation parameters: 0.0037 14.4911 0.2834
[INFO] digital twin mission success on i: 61 mission_id: 512
[INFO] TrueSystem selecting trajectory: <10> with path_time: 13.57 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 62
[INFO] updating degradation parameter variance on i: 62
[INFO] updating degradation parameter values via random sampling on i: 62
[INFO] i: 62 mission_id: 513 rul_hat: 17.34 flight_time: 13.58 distance: 1021.05 R0: 0.00469 Q: 14.01 Req: 0.26873
[INFO] success on i: 62 mission_id: 513
[INFO] forecasting degradation values: r_mu: 0.004549 q_mu: 13.776283 m_mu: 0.271795
[INFO] digital twin degradation parameters: 0.0050 13.8225 0.2632
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 62
[INFO] simulating digital twin on i, mission_id: 513
[INFO] digital twin degradation parameters: 0.0050 13.8225 0.2632
[INFO] digital twin mission success on i: 62 mission_id: 513
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 63
[INFO] updating degradation parameter variance on i: 63
[INFO] updating degradation parameter values via random sampling on i: 63
[INFO] i: 63 mission_id: 514 rul_hat: 17.34 flight_time: 14.83 distance: 1083.74 R0: 0.00499 Q: 13.75 Req: 0.26854
[INFO] success on i: 63 mission_id: 514
[INFO] forecasting degradation values: r_mu: 0.005146 q_mu: 13.700680 m_mu: 0.273788
[INFO] digital twin degradation parameters: 0.0046 13.7879 0.2660
[INFO] DigitalTwin selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 63
[INFO] simulating digital twin on i, mission_id: 514
[INFO] digital twin degradation parameters: 0.0046 13.7879 0.2660
[INFO] digital twin mission success on i: 63 mission_id: 514
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 64
[INFO] updating degradation parameter variance on i: 64
[INFO] updating degradation parameter values via random sampling on i: 64
[INFO] i: 64 mission_id: 515 rul_hat: 17.34 flight_time: 17.84 distance: 1302.12 R0: 0.00509 Q: 13.95 Req: 0.27868
[INFO] success on i: 64 mission_id: 515
[INFO] forecasting degradation values: r_mu: 0.005138 q_mu: 13.684444 m_mu: 0.269693
[INFO] digital twin degradation parameters: 0.0048 13.4372 0.2750
[INFO] DigitalTwin selecting trajectory: <6> with path_time: 18.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 64
[INFO] simulating digital twin on i, mission_id: 515
[INFO] digital twin degradation parameters: 0.0048 13.4372 0.2750
[WARN] digital twin low soc threshold exceeded on i: 64 mission_id: 515
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 65
[INFO] updating degradation parameter variance on i: 65
[INFO] updating degradation parameter values via random sampling on i: 65
[INFO] i: 65 mission_id: 516 rul_hat: 17.34 flight_time: 13.94 distance: 1047.90 R0: 0.00500 Q: 13.94 Req: 0.27949
[INFO] success on i: 65 mission_id: 516
[INFO] forecasting degradation values: r_mu: 0.005922 q_mu: 13.767838 m_mu: 0.278617
[INFO] digital twin degradation parameters: 0.0057 13.8827 0.2834
[INFO] DigitalTwin selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.34

```

```

[INFO] simulating digital twin on i, mission_id: 65
[INFO] simulating digital twin on i, mission_id: 516
[INFO] digital twin degradation parameters: 0.0057 13.8827 0.2834
[INFO] digital twin mission success on i: 65 mission_id: 516
[INFO] TrueSystem selecting trajectory: <11> with path_time: 16.38 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 66
[INFO] updating degradation parameter variance on i: 66
[INFO] updating degradation parameter values via random sampling on i: 66
[INFO] i: 66 mission_id: 517 rul_hat: 17.34 flight_time: 16.36 distance: 1218.89 R0: 0.00565 Q: 13.84 Req: 0.27758
[INFO] success on i: 66 mission_id: 517
[INFO] forecasting degradation values: r_mu: 0.005513 q_mu: 14.270684 m_mu: 0.282333
[INFO] digital twin degradation parameters: 0.0055 14.1675 0.2828
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 66
[INFO] simulating digital twin on i, mission_id: 517
[INFO] digital twin degradation parameters: 0.0055 14.1675 0.2828
[INFO] digital twin mission success on i: 66 mission_id: 517
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 67
[INFO] updating degradation parameter variance on i: 67
[INFO] updating degradation parameter values via random sampling on i: 67
[INFO] i: 67 mission_id: 518 rul_hat: 17.34 flight_time: 13.94 distance: 1047.82 R0: 0.00570 Q: 13.98 Req: 0.27875
[INFO] success on i: 67 mission_id: 518
[INFO] forecasting degradation values: r_mu: 0.006182 q_mu: 13.877693 m_mu: 0.281647
[INFO] digital twin degradation parameters: 0.0063 14.2042 0.2797
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 67
[INFO] simulating digital twin on i, mission_id: 518
[INFO] digital twin degradation parameters: 0.0063 14.2042 0.2797
[INFO] digital twin mission success on i: 67 mission_id: 518
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 68
[INFO] updating degradation parameter variance on i: 68
[INFO] updating degradation parameter values via random sampling on i: 68
[INFO] i: 68 mission_id: 519 rul_hat: 17.34 flight_time: 14.83 distance: 1083.74 R0: 0.00622 Q: 13.78 Req: 0.27789
[INFO] success on i: 68 mission_id: 519
[INFO] forecasting degradation values: r_mu: 0.006037 q_mu: 13.920967 m_mu: 0.284360
[INFO] digital twin degradation parameters: 0.0061 14.0854 0.2831
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 68
[INFO] simulating digital twin on i, mission_id: 519
[INFO] digital twin degradation parameters: 0.0061 14.0854 0.2831
[INFO] digital twin mission success on i: 68 mission_id: 519
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 69
[INFO] updating degradation parameter variance on i: 69
[INFO] updating degradation parameter values via random sampling on i: 69
[INFO] i: 69 mission_id: 520 rul_hat: 17.34 flight_time: 17.84 distance: 1302.25 R0: 0.00587 Q: 13.53 Req: 0.27704
[INFO] success on i: 69 mission_id: 520
[INFO] forecasting degradation values: r_mu: 0.007127 q_mu: 13.823922 m_mu: 0.284629
[INFO] digital twin degradation parameters: 0.0069 13.7564 0.2835
[INFO] DigitalTwin selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 69
[INFO] simulating digital twin on i, mission_id: 520
[INFO] digital twin degradation parameters: 0.0069 13.7564 0.2835
[INFO] digital twin mission success on i: 69 mission_id: 520
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 70
[INFO] updating degradation parameter variance on i: 70
[INFO] updating degradation parameter values via random sampling on i: 70
[INFO] i: 70 mission_id: 521 rul_hat: 17.34 flight_time: 14.83 distance: 1083.76 R0: 0.00613 Q: 13.63 Req: 0.28049
[INFO] success on i: 70 mission_id: 521
[INFO] forecasting degradation values: r_mu: 0.007401 q_mu: 13.455767 m_mu: 0.281156
[INFO] digital twin degradation parameters: 0.0077 13.6255 0.2847
[INFO] DigitalTwin selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34

```

```

[INFO] simulating digital twin on i, mission_id: 70
[INFO] simulating digital twin on i, mission_id: 521
[INFO] digital twin degradation parameters: 0.0077 13.6255 0.2847
[INFO] digital twin mission success on i: 70 mission_id: 521
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 71
[INFO] updating degradation parameter variance on i: 71
[INFO] updating degradation parameter values via random sampling on i: 71
[INFO] i: 71 mission_id: 522 rul_hat: 17.34 flight_time: 14.83 distance: 1083.55 R0: 0.00608 Q: 13.80 Req: 0.27836
[INFO] success on i: 71 mission_id: 522
[INFO] forecasting degradation values: r_mu: 0.007076 q_mu: 13.472292 m_mu: 0.285569
[INFO] digital twin degradation parameters: 0.0073 13.2789 0.2860
[INFO] DigitalTwin selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 71
[INFO] simulating digital twin on i, mission_id: 522
[INFO] digital twin degradation parameters: 0.0073 13.2789 0.2860
[INFO] digital twin mission success on i: 71 mission_id: 522
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 72
[INFO] updating degradation parameter variance on i: 72
[INFO] updating degradation parameter values via random sampling on i: 72
[INFO] i: 72 mission_id: 523 rul_hat: 17.34 flight_time: 17.84 distance: 1302.25 R0: 0.00701 Q: 13.49 Req: 0.27605
[INFO] success on i: 72 mission_id: 523
[INFO] forecasting degradation values: r_mu: 0.006956 q_mu: 13.556941 m_mu: 0.283403
[INFO] digital twin degradation parameters: 0.0069 14.0239 0.2797
[INFO] DigitalTwin selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 72
[INFO] simulating digital twin on i, mission_id: 523
[INFO] digital twin degradation parameters: 0.0069 14.0239 0.2797
[INFO] digital twin mission success on i: 72 mission_id: 523
[INFO] TrueSystem selecting trajectory: <14> with path_time: 14.81 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 73
[INFO] updating degradation parameter variance on i: 73
[INFO] updating degradation parameter values via random sampling on i: 73
[INFO] i: 73 mission_id: 524 rul_hat: 17.34 flight_time: 14.83 distance: 1083.74 R0: 0.00686 Q: 13.47 Req: 0.27965
[INFO] success on i: 73 mission_id: 524
[INFO] forecasting degradation values: r_mu: 0.007464 q_mu: 13.445959 m_mu: 0.281543
[INFO] digital twin degradation parameters: 0.0079 13.4053 0.2878
[INFO] DigitalTwin selecting trajectory: <10> with path_time: 13.57 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 73
[INFO] simulating digital twin on i, mission_id: 524
[INFO] digital twin degradation parameters: 0.0079 13.4053 0.2878
[INFO] digital twin mission success on i: 73 mission_id: 524
[INFO] TrueSystem selecting trajectory: <3> with path_time: 17.83 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 74
[INFO] updating degradation parameter variance on i: 74
[INFO] updating degradation parameter values via random sampling on i: 74
[INFO] i: 74 mission_id: 525 rul_hat: 17.34 flight_time: 17.78 distance: 1298.84 R0: 0.00716 Q: 13.67 Req: 0.29304
[WARN] true system low soc threshold exceeded on i: 74 mission_id: 525
[INFO] forecasting degradation values: r_mu: 0.007665 q_mu: 13.237329 m_mu: 0.278337
[INFO] digital twin degradation parameters: 0.0074 13.3828 0.2792
[INFO] DigitalTwin selecting trajectory: <10> with path_time: 13.57 that meets constraint: path_time < 17.34
[INFO] simulating digital twin on i, mission_id: 74
[INFO] simulating digital twin on i, mission_id: 525
[INFO] digital twin degradation parameters: 0.0074 13.3828 0.2792
[INFO] digital twin mission success on i: 74 mission_id: 525
[INFO] TrueSystem selecting trajectory: <13> with path_time: 13.94 that meets constraint: path_time < 17.34
[INFO] simulating true system on i: 75
[INFO] updating degradation parameter variance on i: 75
[INFO] updating degradation parameter values via random sampling on i: 75
[INFO] i: 75 mission_id: 526 rul_hat: 17.34 flight_time: 13.94 distance: 1047.85 R0: 0.00752 Q: 13.33 Req: 0.28706
Error using database.odbc.connection/sqlwrite (line 158)
ODBC Error: ODBC Driver Error: server closed the connection unexpectedly
This probably means the server terminated abnormally
before or while processing the request.

```

```
;
The connection has been lost.

Error in write_flight_data (line 31)
sqlwrite(conn, 'flight_sensor_tb', flight_sensor_tb);
```

\*\*\*\*\* end of simulation code

```
sprintf("[INFO] digital twin degradation parameters: %.4f\t%.4f\t%.4f", batterytwin.R0, batterytwin.Q, batterytwin.Motortwin2.Req);
write_degradation_data;
```

## now simulate digital twin

```
load_trajectory;
sys = "DigitalTwin";
octomodel.sampletime = twin_sample_rate;
for twin_ctr=1:twin_count
    sprintf('[INFO] simulating digital twin on mission: %d', i)
    out = sim('digitaltwin1c.slx');
    % get the output from each parallel worker
    times(twin_ctr) = flight_time.Data(end);
    vs(twin_ctr) = battery_actual.Data(end, 1);
    socs(twin_ctr) = battery_actual.Data(end, 2);
    r0s(twin_ctr) = battery_actual.Data(end, 3);
    qs(twin_ctr) = battery_actual.Data(end, 6);
    ms(twin_ctr) = motors.Data(end, 1);
    errs(twin_ctr) = mean(euclidean_pos_err);
    dist(twin_ctr) = calculatedistance([pos_actual.Data(:,1) pos_actual.Data(:,2)]);
    degs(:, twin_ctr) = [batterytwin.R0 batterytwin.Q Motortwin2.Req]';

    % resample the degradation parameters if more than one digital twin
    % simulation
    if twin_count > 1
        if i > lookback
            disp('[INFO] using forecast degradation values');
            batterytwin.R0 = normrnd(r_mu, r_var);
            batterytwin.Q = normrnd(q_mu, q_var);
            Motortwin2.Req = normrnd(m_mu, m_var);
        else
            batterytwin.R0 = max(abs(normrnd(rdeg(i), r_var)), .00075);
            batterytwin.Q = min(abs(normrnd(qdeg(i), q_var)), 15.5);
            Motortwin2.Req = max(abs(normrnd(mdeg(i), m_var)), .001);
        end
    end
end
```

## do some checks on when to stop the simulation

```
if any(stop_code.Data(:,1)) == 1
    fprintf('[INFO] digital twin low soc threshold exceeded on mission %d\n', i)
    fprintf('[INFO] updating RUL from %.2f to %.2f', rul_hat, min(mean(times(:)) - 1, rul_init));
    rul_hat = min(mean(times(:)) - 1, rul_init); % rul is now 1 minute less than the digital twin
end
```

