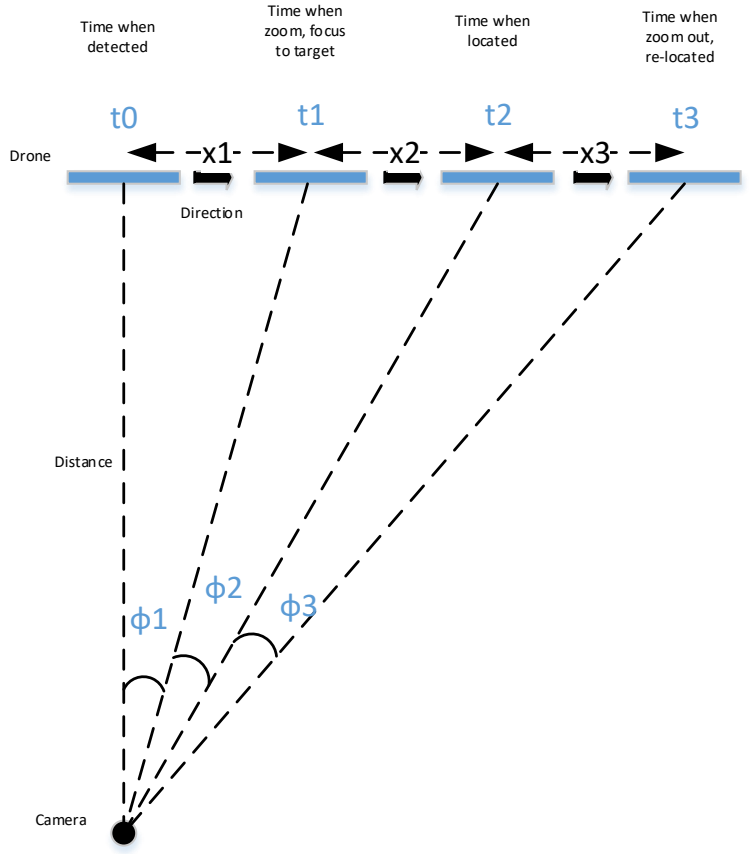
Analysis Drone System

Detection and Localization Schedule

- Detection and Localization Schedule (ideal, doesn't have loss tracking issue):
  - State 1: Scan and Detect at minimum Zoom
  - State 2: Keep Track, Zoom in and Focus to Target
  - State 3: Keep Track, Geo-localize
  - State 4: Keep Track, Zoom Out to minimum Zoom
  - State 5: Keep Track, Scan new target

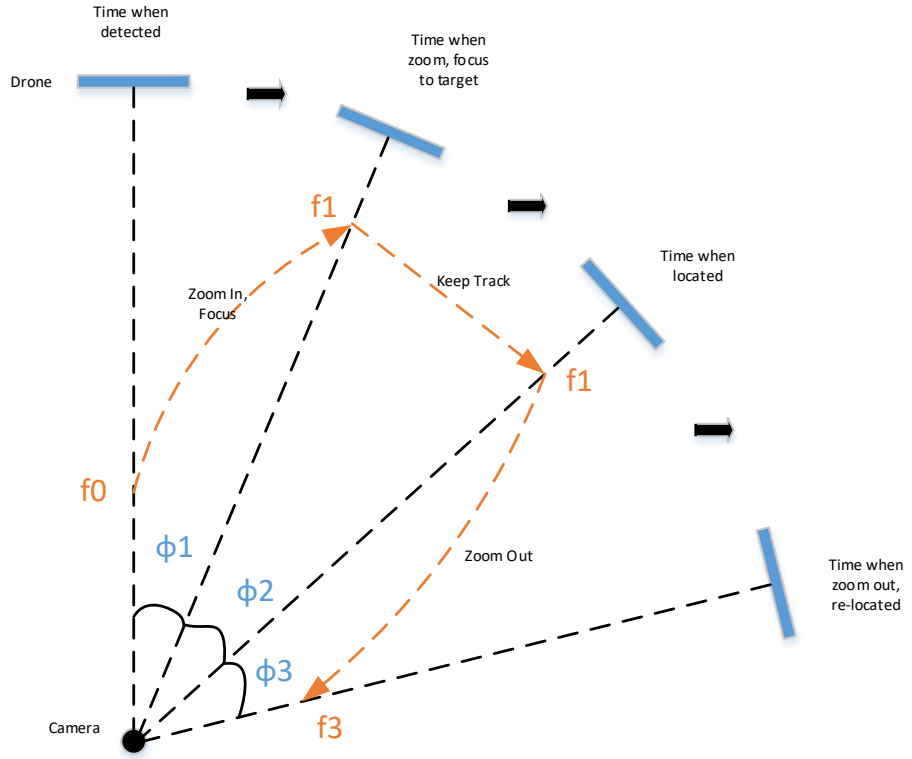
Assumptions

- Assumption for object:
  - Drone speed is constant
  - Drone moves constantly
- Assumption for system:
  - Always keep tracking, doesn't have loss
  - Zoom Speed fast enough
  - Focus Speed fast enough
  - Geo-localize fast enough
  - No control delay



Formulate problem

- From previous assumptions:
  - t1, t2, t3 will small
  - d1 = d2 = d3 (= 1km)



- $t_1 = \frac{x1}{Vdrone} \geq \frac{f_{z2} - f_{z1}}{Zoom\ speed} + \frac{f_{f2} - f_{f1}}{Focus\ speed} \geq \frac{\emptyset_1}{PTZ\ speed}$ (1)
- $t_2 = \frac{x2}{Vdrone} \geq \frac{\emptyset_2}{PTZ\ speed}$ (2)
- $t_3 = \frac{x3}{Vdrone} \geq \frac{f_{z2} - f_{z3}}{Zoom\ speed} + \frac{f_{f2} - f_{f3}}{Focus\ speed} \geq \frac{\emptyset_3}{PTZ\ speed}$ (3)

System Specifications:

- PTZ Specification:
  - Resolution: 0.003°/pos
  - Speed:

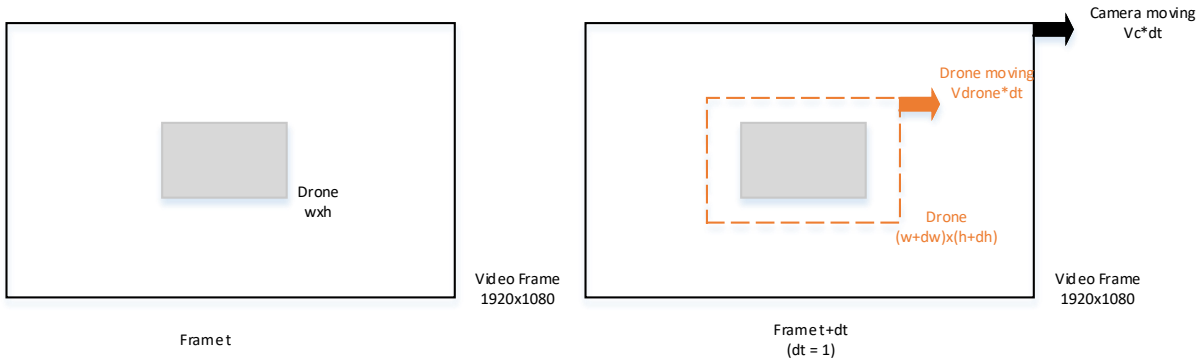
	Min Speed	**Max Speed**
Position/second	2 pos/sec	1965 pos/sec
Degree/second	0.006°	5.895°
Meter/second at 1km	0.105 m/s	102.978 m/s

- (2) → PTZ will satisfy with keep tracking with drone speed < 103 m/s
- Lens Controller Specification:
  - Range: Zoom 32x (10-320mm) (position: 40–970)
  - Resolution: 1/3 mm/pos
  - Speed: 0-255 pos/sec
  - Minimum time for Zoom: (970-40)/255=3.647 sec

Estimation

- Combine all together…
  - t1 = 3.647 sec (assume no need focus time, approximate 2x3.647 for both)
  - x1 = t1xVdrone = 3.647 x 20 = 72.94 m
  - $\phi 1 = 2*\text{artan}(72.94/2/1000) = 13.123^0$ (too big for the previous assumption)
  - PTZ min speed = $\phi 1/t1 = 3.6\ ^o$/sec (satisfied)
- Conclusion:
  - State 2 (keep track and zoom in) will be possible if drone moving constantly in 3.647 sec (in 2x3.647 if need focus)
  - State 3 (keep track and geo-localize) will be possible if drone moving constantly in time for geo-localize (0.5s - 15 frames)
  - State 4 (keep track and zoom out) similar to State 2

What happen if drone not moving constantly?



- In case of state 3 (keep track and geo-localize):
  - Size of drone 0.5 m equal to 300 pixels
  - Field of View 1920x1080 pixels equal to 3.2x1.8 m
  - Speed of drone is 20 m/s equal to 2/3=0.67 m/frame
- When drone change direction:
  - Time for loss:
    - In vertical: 1.8/2/0.67 = 1.35 frame (it mean 1 frame = 1/30 sec)
    - In horizontal: 3.2/2/0.67 = 2.39 frame (it mean 2 frames = 2/30 sec)
  - Because always have delay in motor and system (almost > 1/30 sec) then if cannot predict the path drone will change to, it seem to be 100% loss ☹. We need to zoom out, re-detect, zoom in then loss again ☹

Solutions:

- Super fast Geo-localization (in 1 frame)
- Refine desired performance:
  - If drone speed 5 m/s (18 km/h) and size for localize change to 100 pixels
  - Time for loss:
    - In vertical: 1.35*12 frame (it mean 16 frame = 16/30 sec)
    - In horizontal: 2.39*12 frame (it mean 28 frames = 28/30 sec)
- Accept loss and predict track