An aerial photograph of an airport runway and taxiway. The runway is a long, straight asphalt strip with white dashed center lines and solid white edge lines. It is flanked by taxiways and aprons. In the background, there are airport buildings, parking lots, and other aircraft. The bottom portion of the image is overlaid with a semi-transparent yellow rectangle.

Geometric Design : Part 2

Ramps and Tight Spaces

Dr. Antonio Trani

Department of Civil and Environmental Engineering
Virginia Tech



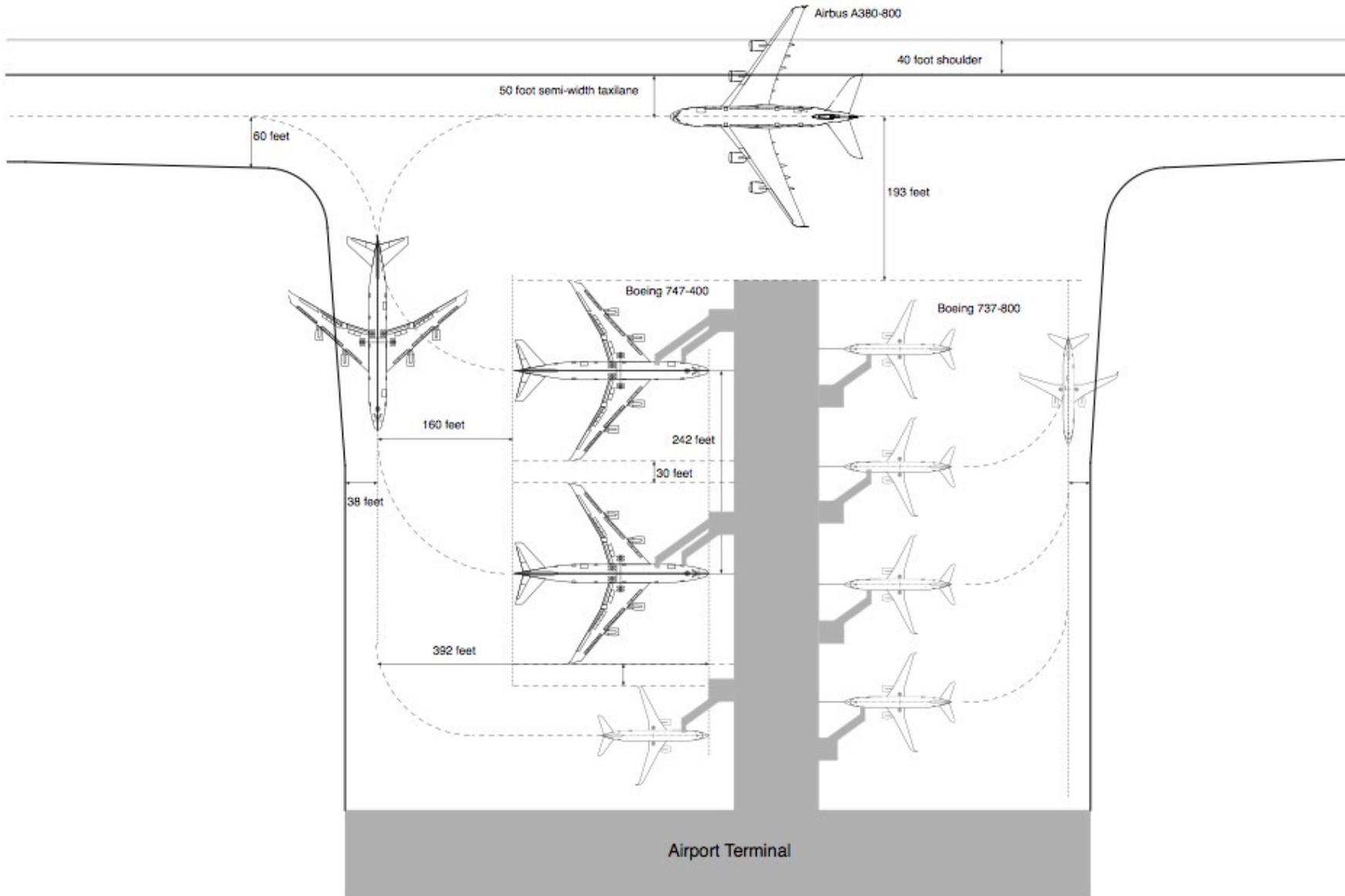
Consider the Vehicle

- Aircraft have limited capabilities to maneuver on the ground
- Tricycle landing gears
- Steering capabilities
- Limited space near gates and parking aprons



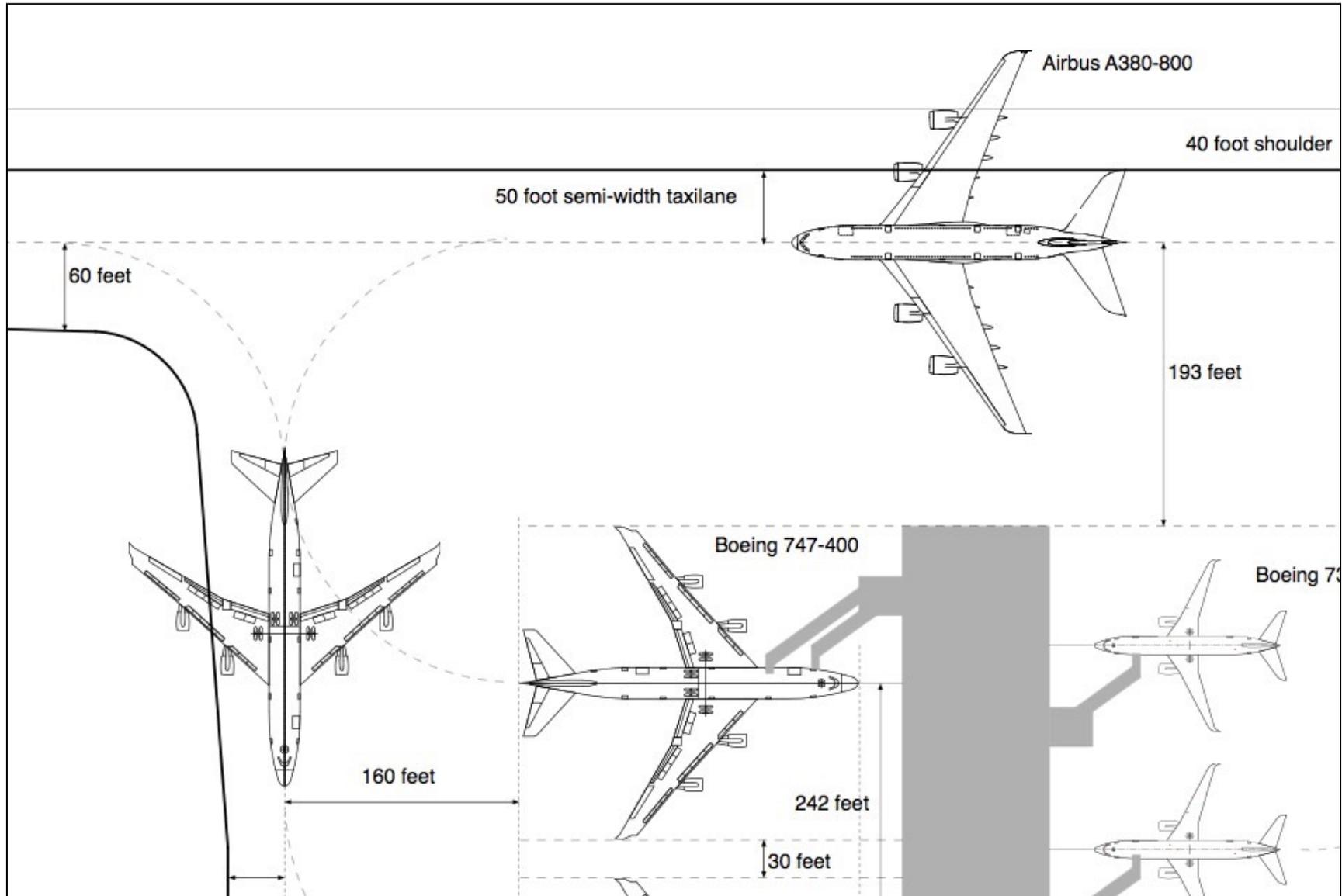


Sample Design





Sample Design

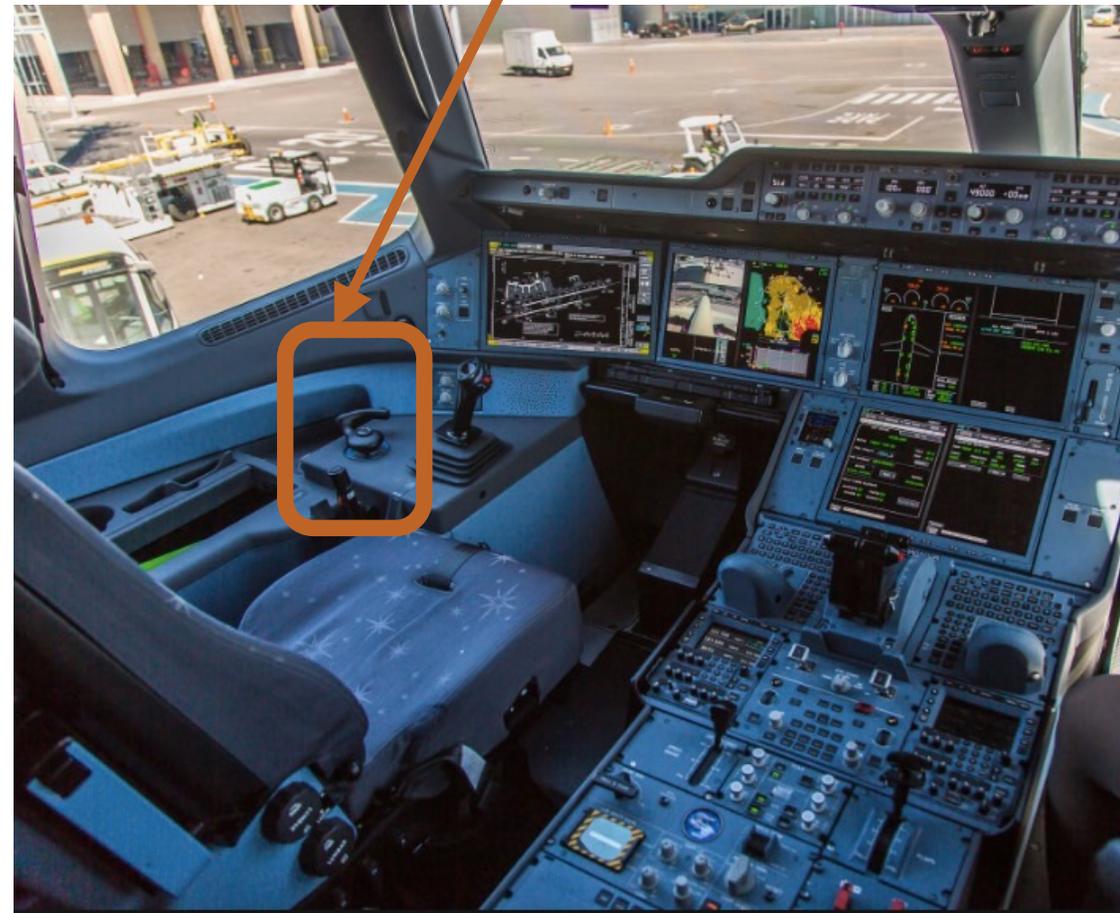




Turning Aircraft in Tight Spaces

- Pilots use two forms of steering control:
- Rudder pedals (provide limited turning capability)
- “Tiller” control for ground maneuvering

Nose gear “tiller”

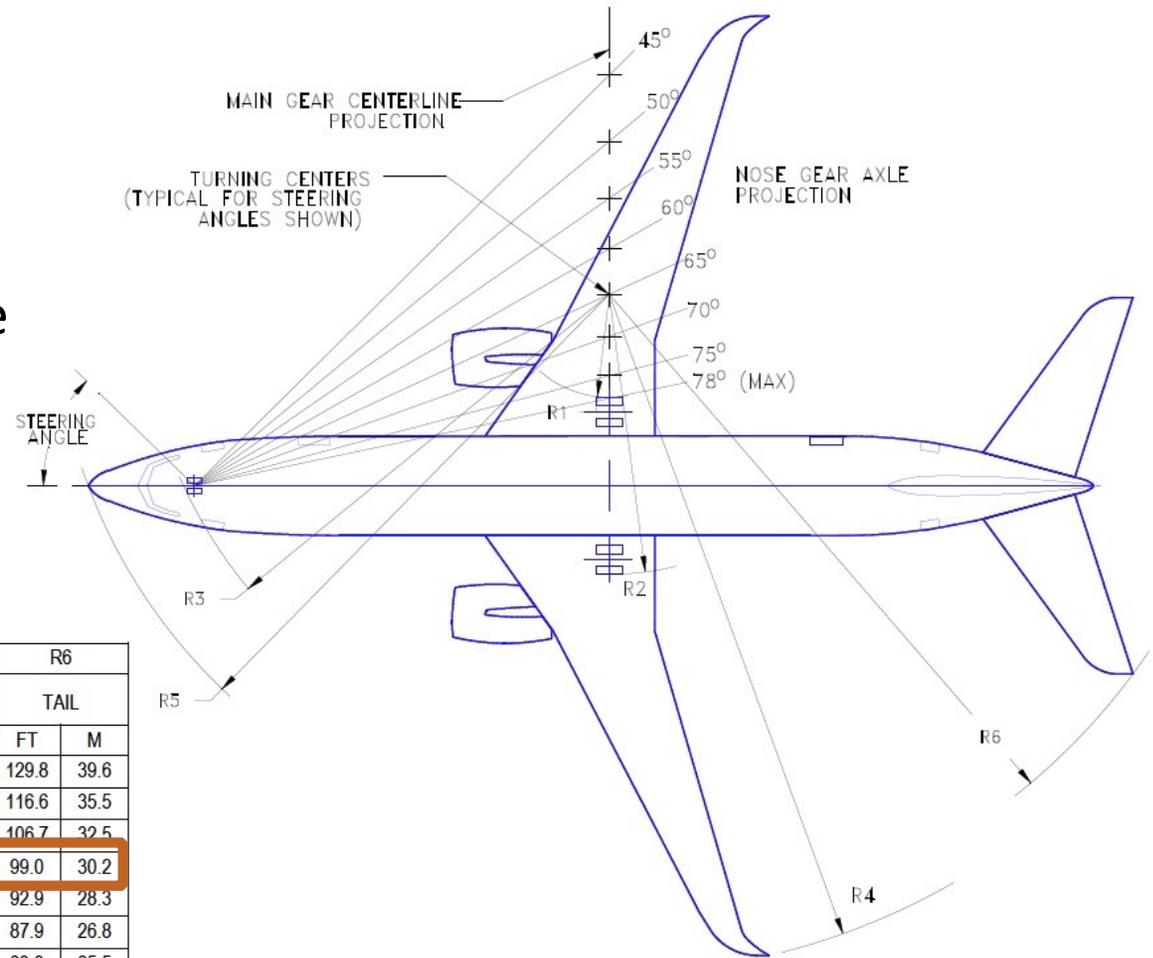


source: http://www.reddit.com/r/aviation/comments/2tq7pi/airbus_a350_xwb_cockpit/



Example Aircraft Turning Envelopes

Example: Boeing 737-800
Nose wheel turning radius (R3)
is 73.6 feet when steering angle
is 45 degrees



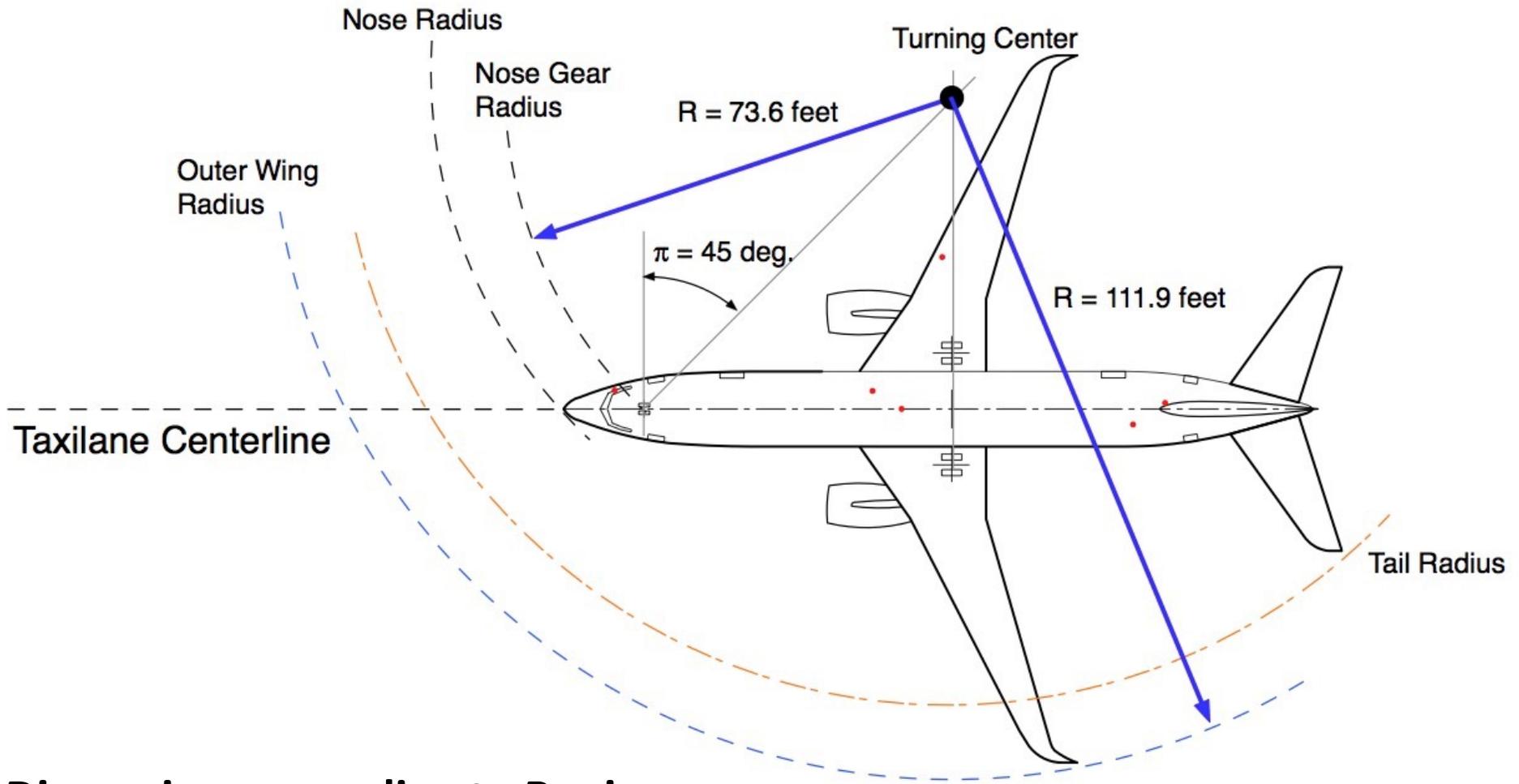
STEERING ANGLE (DEGREES)	R1		R2		R3		R4		R5		R6	
	INNER GEAR		OUTER GEAR		NOSE GEAR		WING TIP		NOSE		TAIL	
	FT	M	FT	M	FT	M	FT	M	FT	M	FT	M
30	77.5	23.6	100.6	30.7	103.7	31.6	149.1	45.4	110.1	33.6	129.8	39.6
35	61.9	18.9	85.0	25.9	90.6	27.6	133.6	4.07	97.9	29.8	116.6	35.5
40	49.7	15.2	72.8	22.2	80.9	24.7	121.6	37.1	89.2	27.2	106.7	32.5
45	39.8	12.1	62.9	19.2	73.6	22.4	111.9	34.1	82.7	25.2	99.0	30.2
50	31.6	9.6	54.7	16.7	68.0	20.7	103.8	31.6	77.8	23.7	92.9	28.3
55	24.4	7.4	47.5	14.5	63.7	19.43	96.8	29.5	74.1	22.6	87.9	26.8
60	18.1	5.5	41.2	12.6	60.3	18.4	90.6	27.6	71.3	21.7	83.8	25.5
65	12.4	3.8	35.8	10.8	57.7	17.6	85.1	25.9	69.1	21.1	80.3	24.5
70	7.2	2.2	30.3	9.2	55.6	17.0	80.0	24.4	67.4	20.6	77.3	23.6
78 (MAX)	-0.6	-0.2	22.5	6.9	53.5	16.3	72.5	22.1	65.7	20.0	73.3	22.3

source: Boeing



Example Aircraft Turning Envelopes

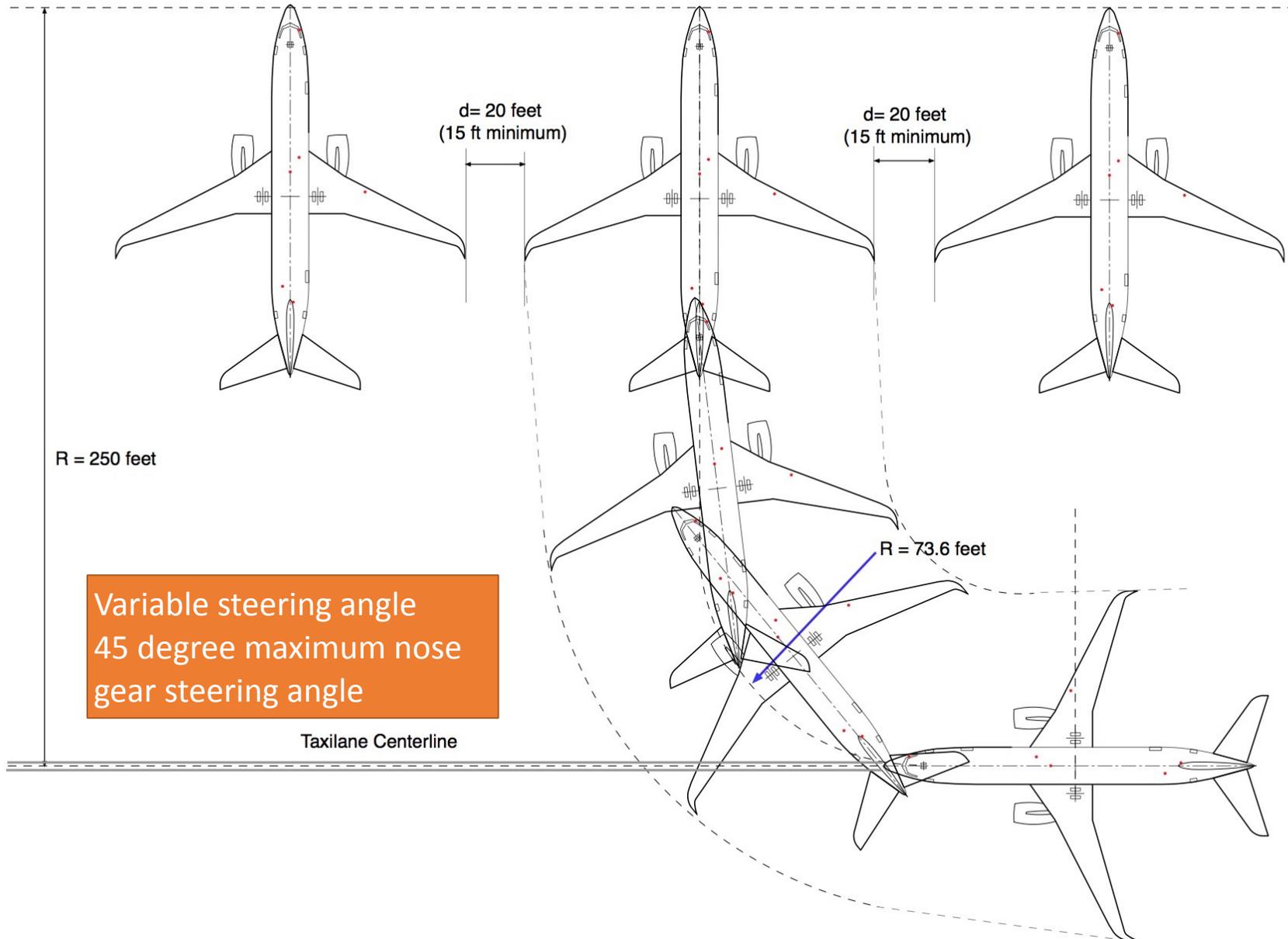
Boeing 737-800 (winglets) using 45 degree steering angle



Dimensions according to Boeing



Example Aircraft Turning Envelopes

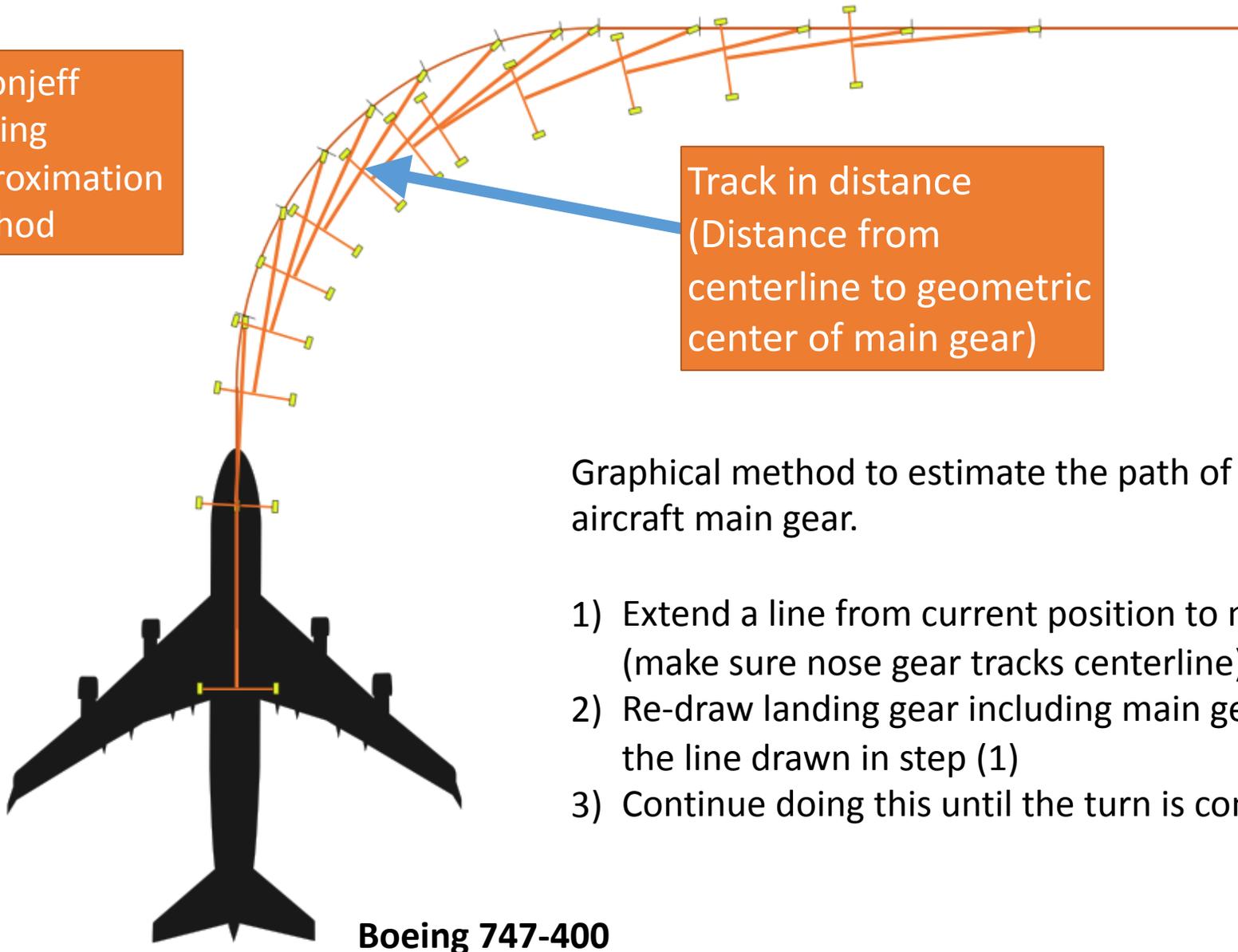




Aircraft Turning Envelopes

Horonjeff
Turning
Approximation
Method

Track in distance
(Distance from
centerline to geometric
center of main gear)

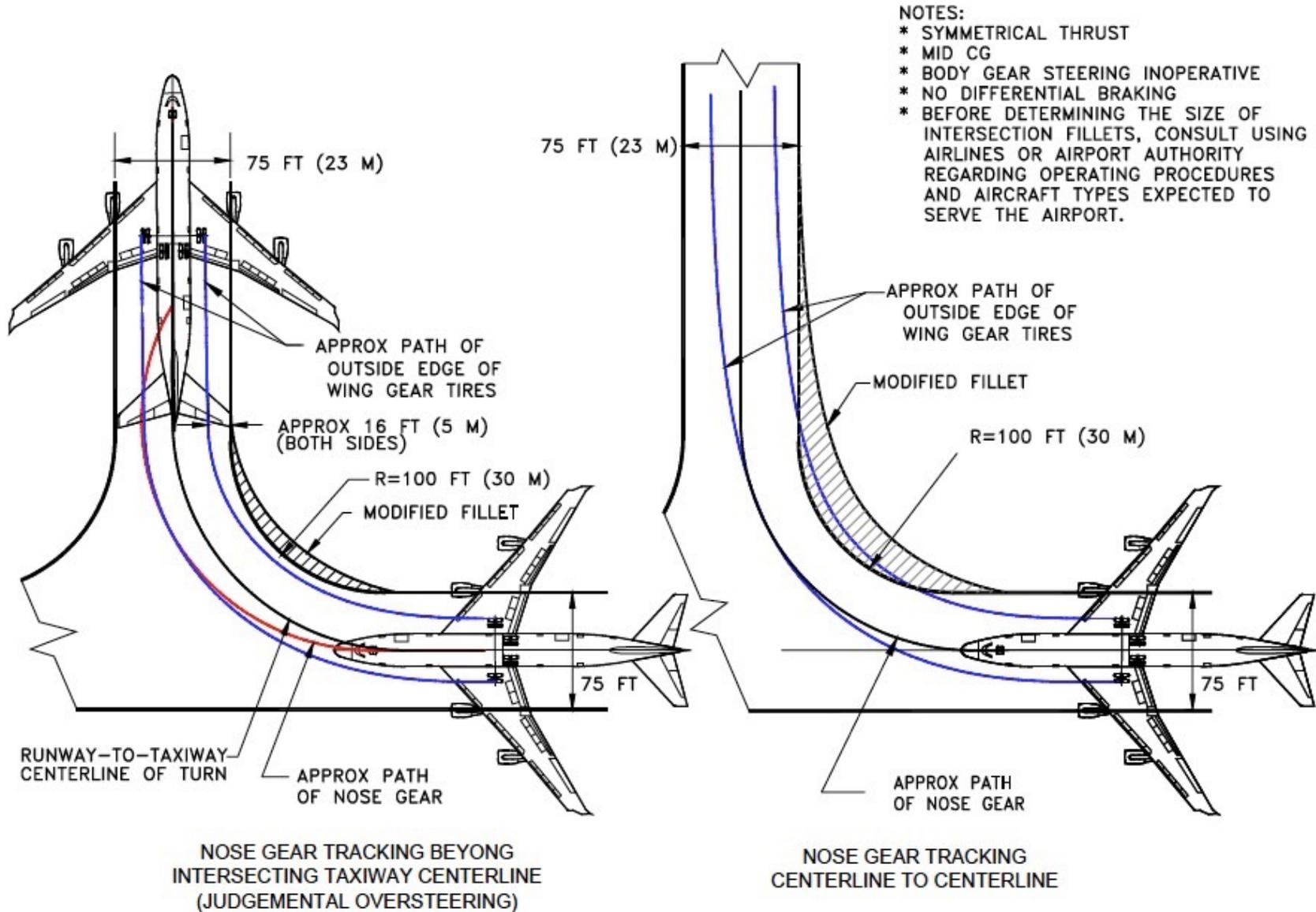


Graphical method to estimate the path of aircraft main gear.

- 1) Extend a line from current position to new position (make sure nose gear tracks centerline)
- 2) Re-draw landing gear including main gears along the line drawn in step (1)
- 3) Continue doing this until the turn is completed



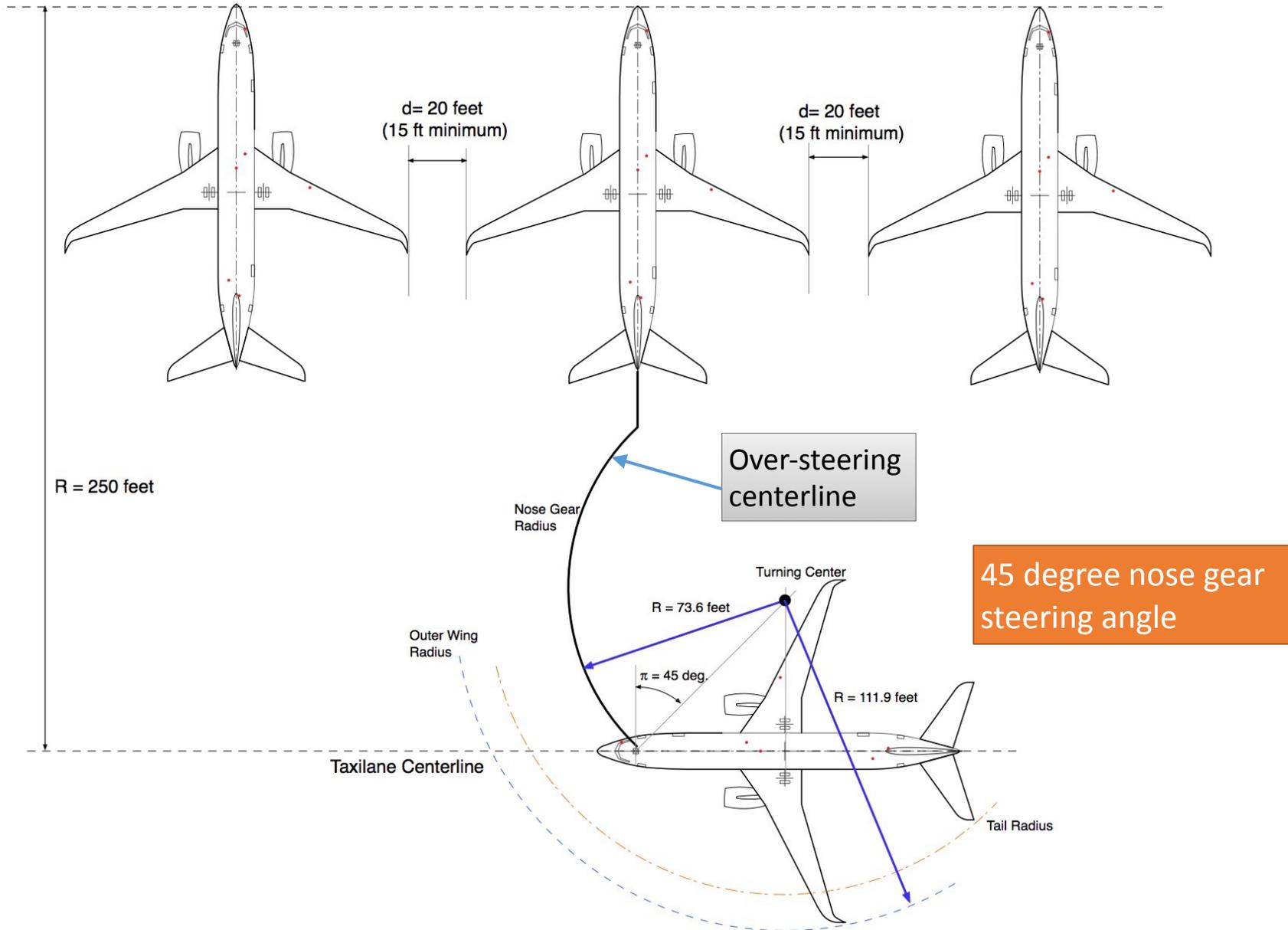
Aircraft Turning Envelopes



source: Boeing

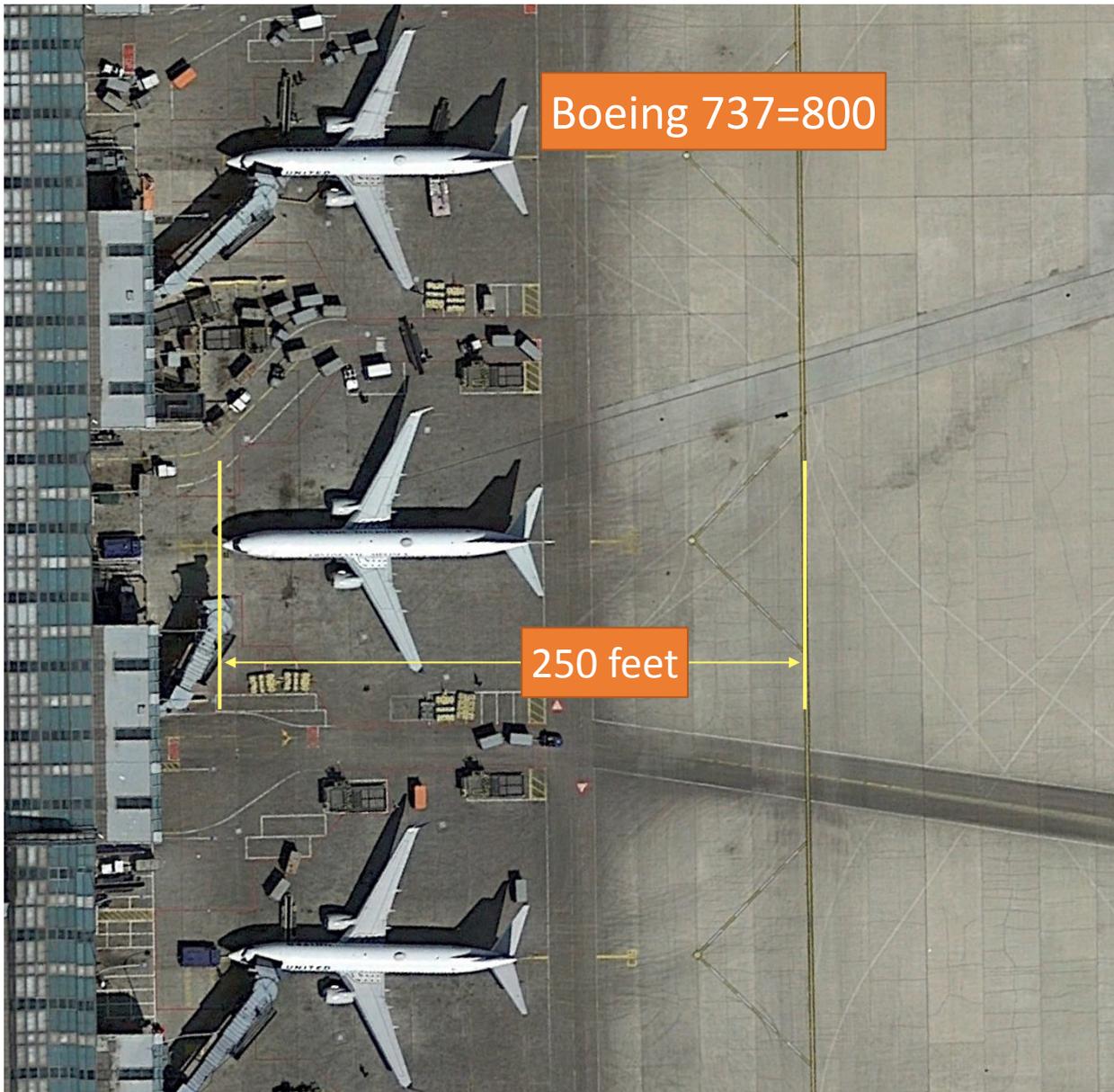


Example Aircraft Turning Envelopes





Example Aircraft Turning Envelopes



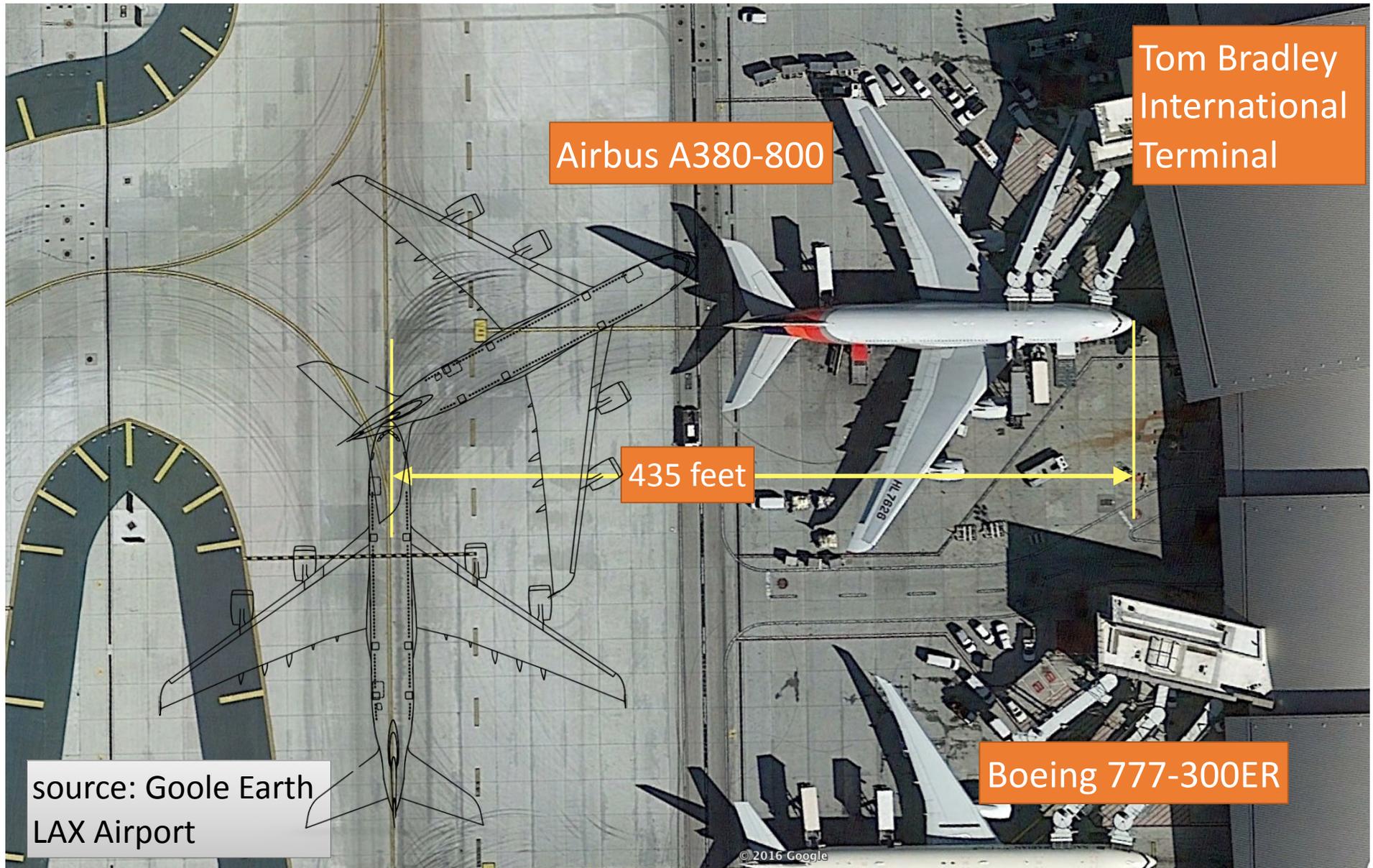
Notes:

- 1) Generous space for aircraft to taxi into the gate (without over-steering)
- 2) Aircraft shown (Boeing 737-800) are not the critical aircraft for the gate positions shown

source: Goole Earth
ORD Airport

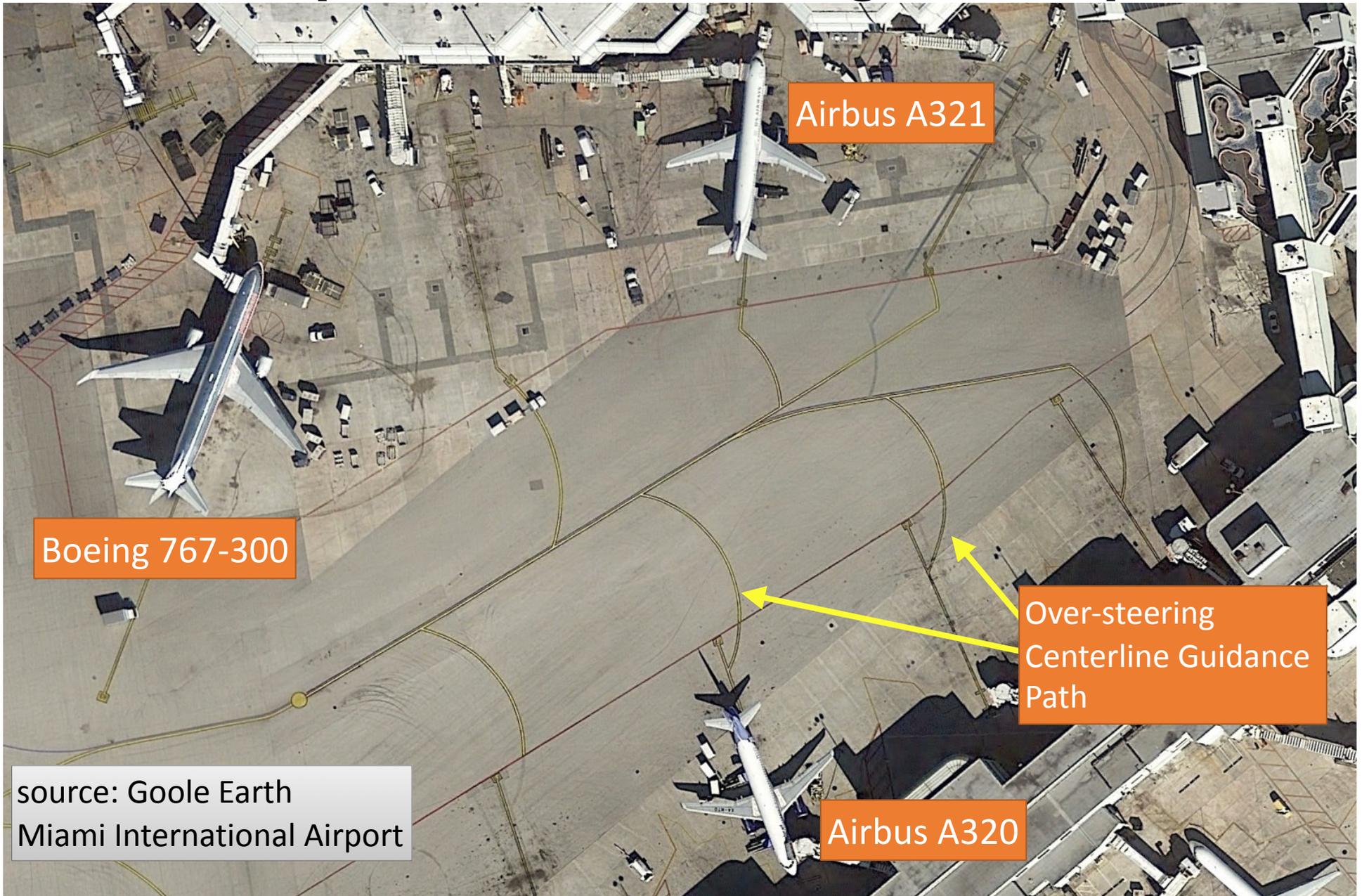


Example Aircraft Turning Envelopes





Example Aircraft Turning Envelopes



Boeing 767-300

Airbus A321

Over-steering
Centerline Guidance
Path

source: Goole Earth
Miami International Airport

Airbus A320



Limited Spaces Near Gates (ORD)



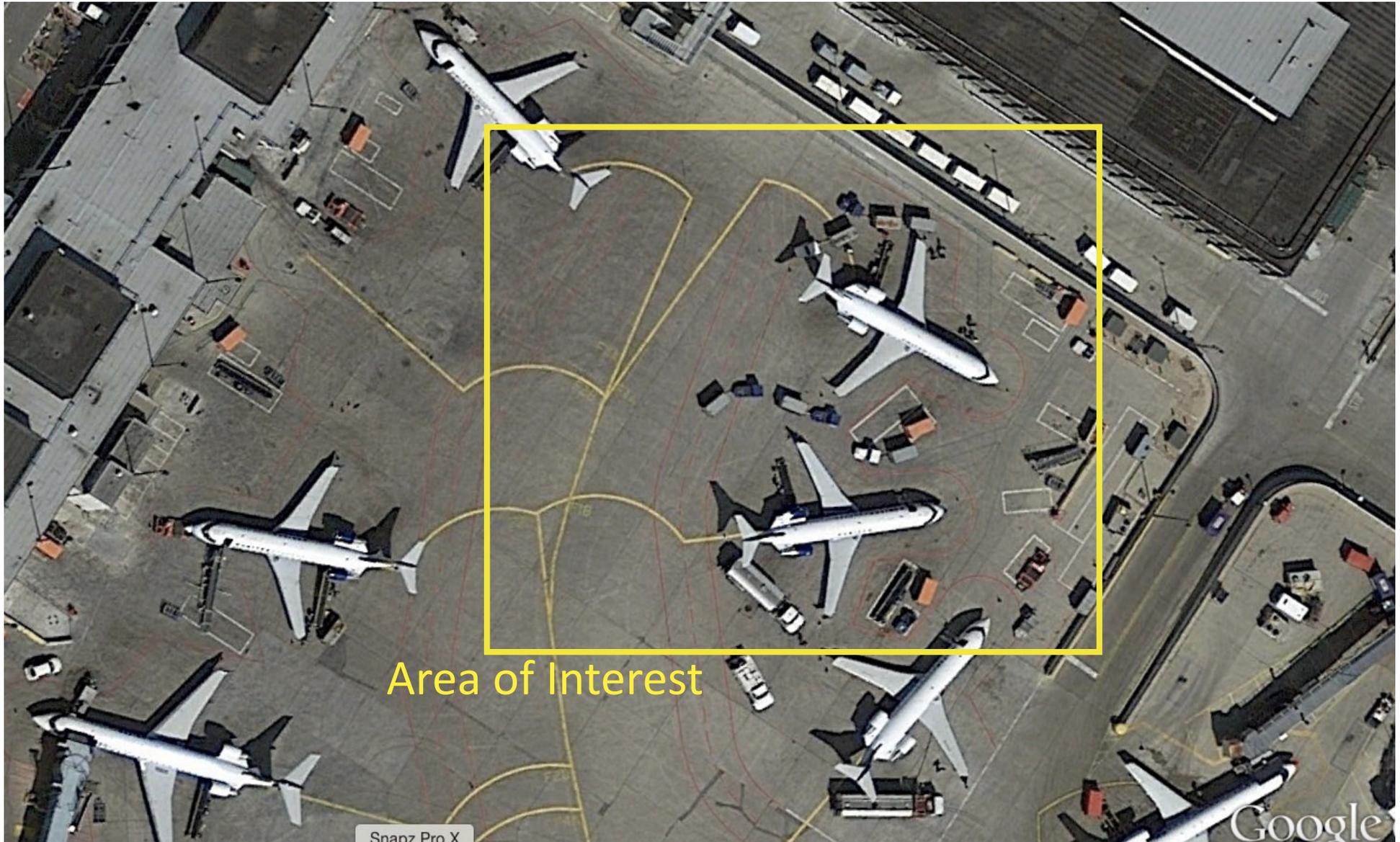


Detail: Centerline Marks to Gates (ORD)





Limited Spaces Near Gates





Limited Spaces Near Gates

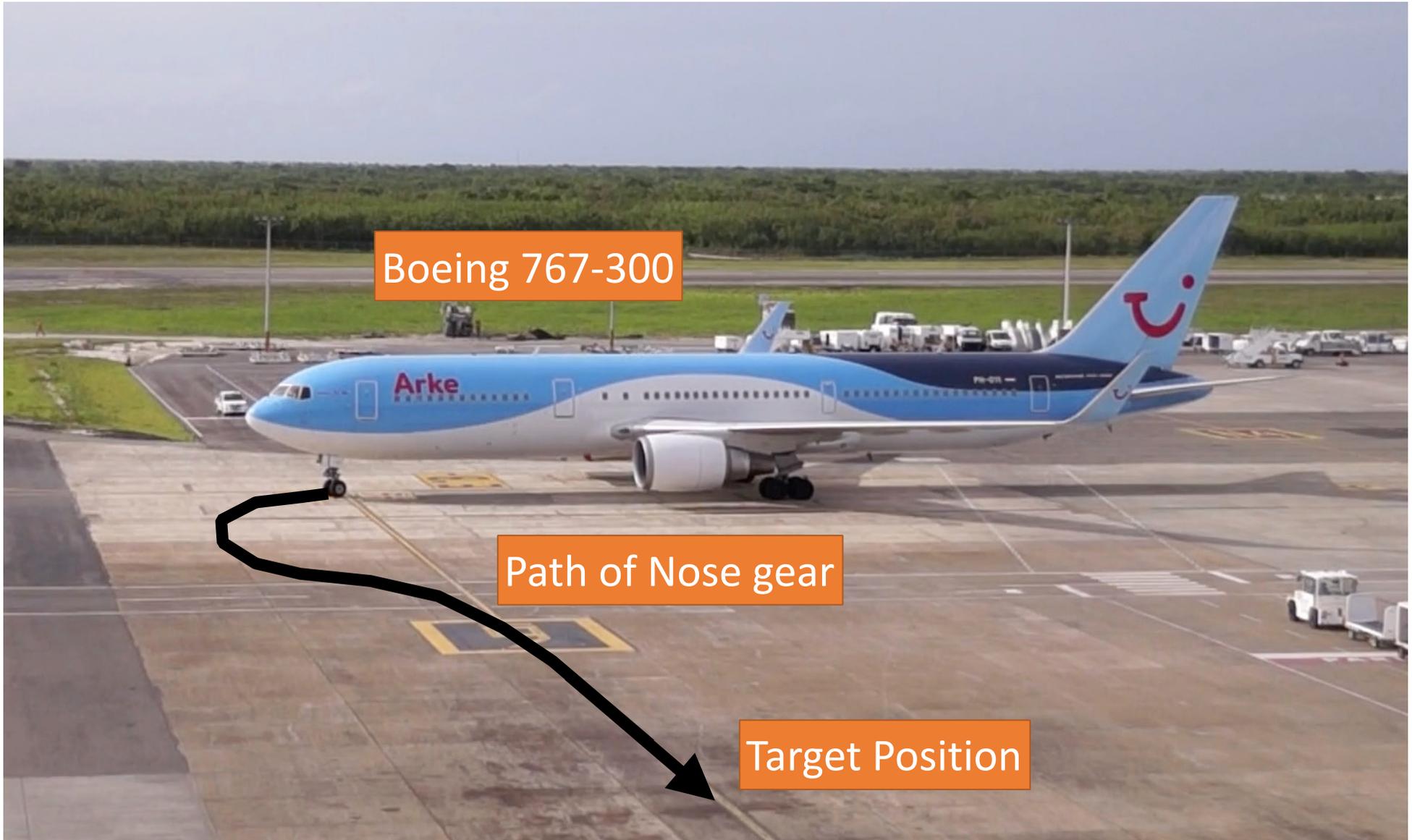




Parking a Heavy Jet to an Apron Position

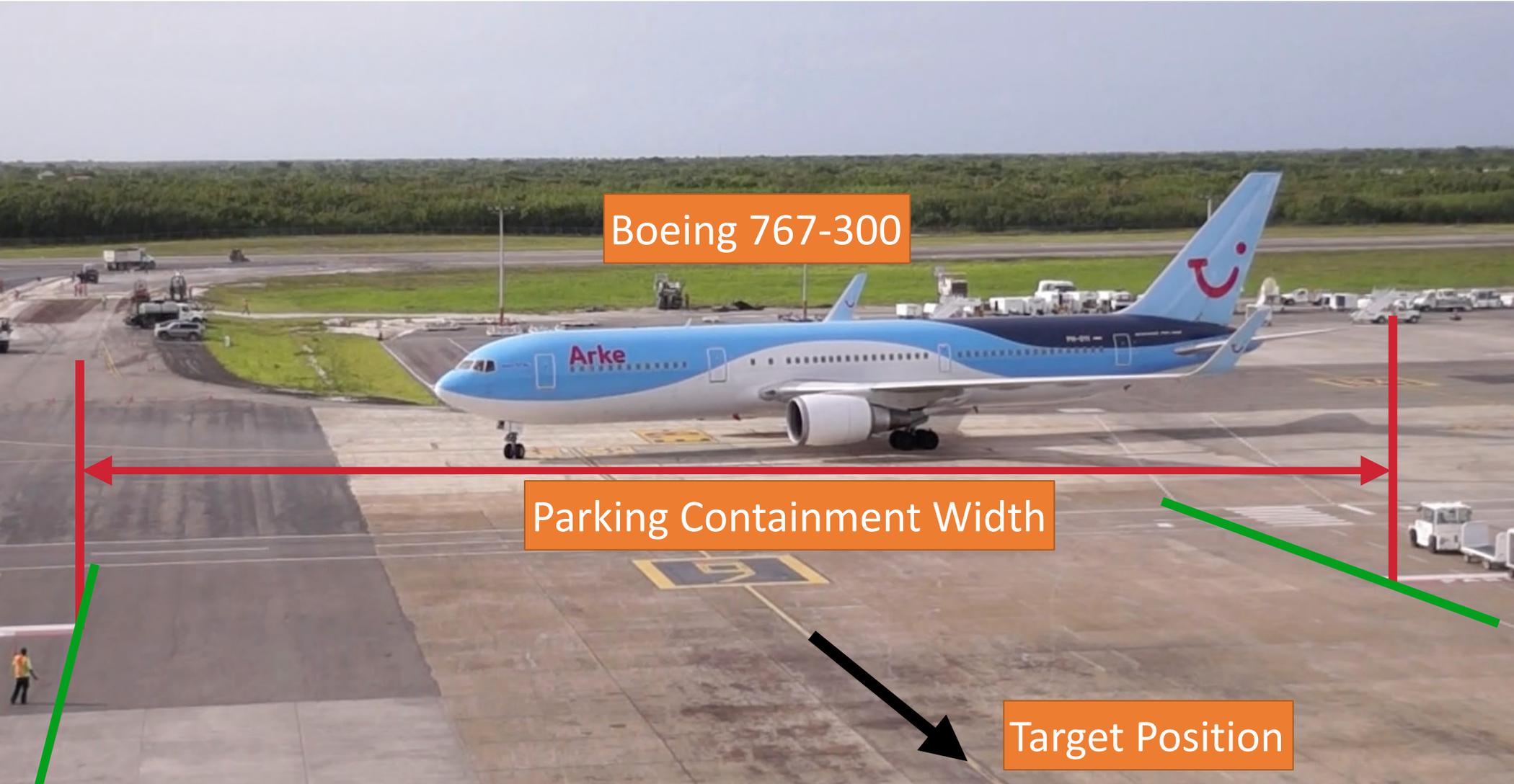


Parking a Heavy Jet with Over-steering



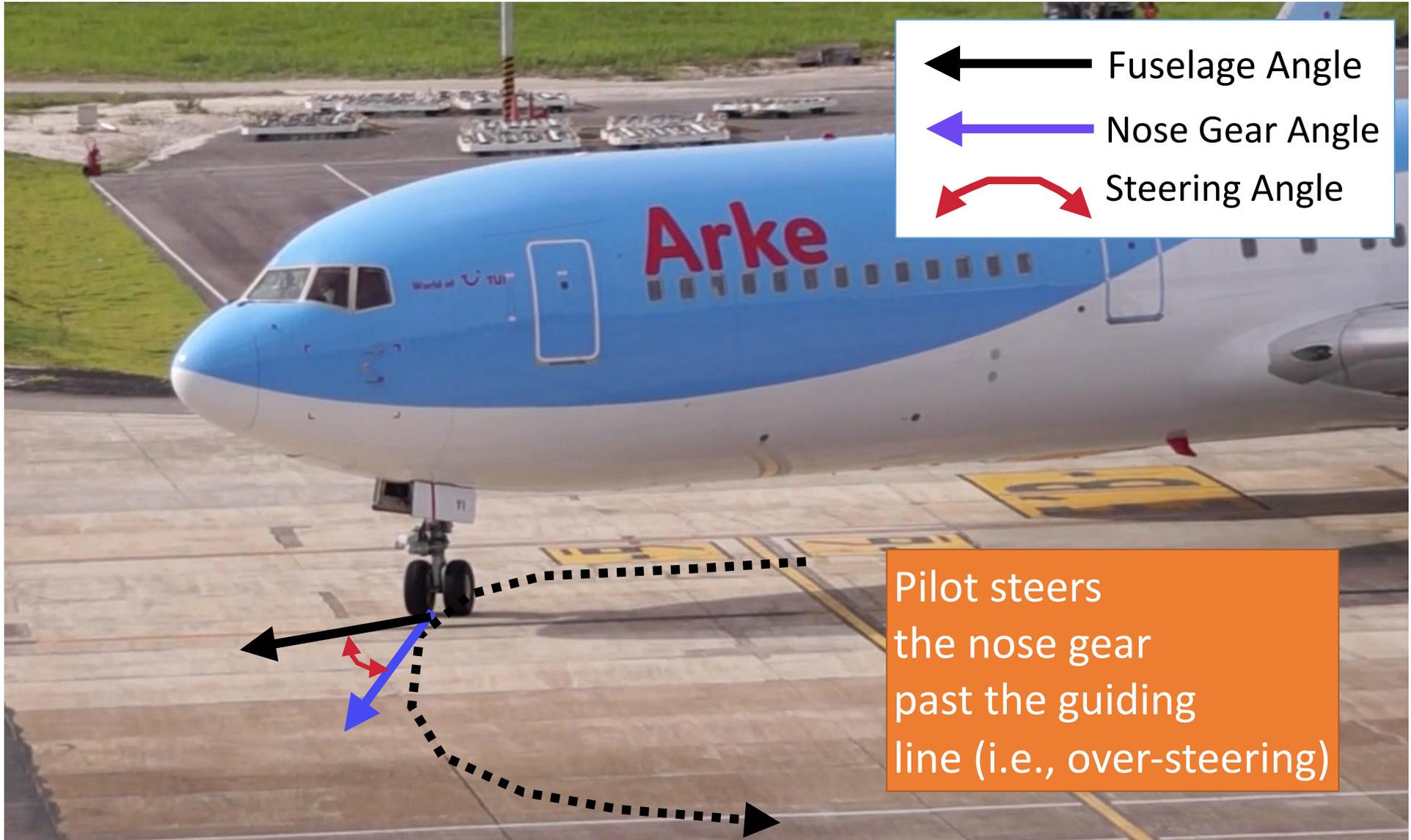


Parking a Heavy Jet with Over-steering



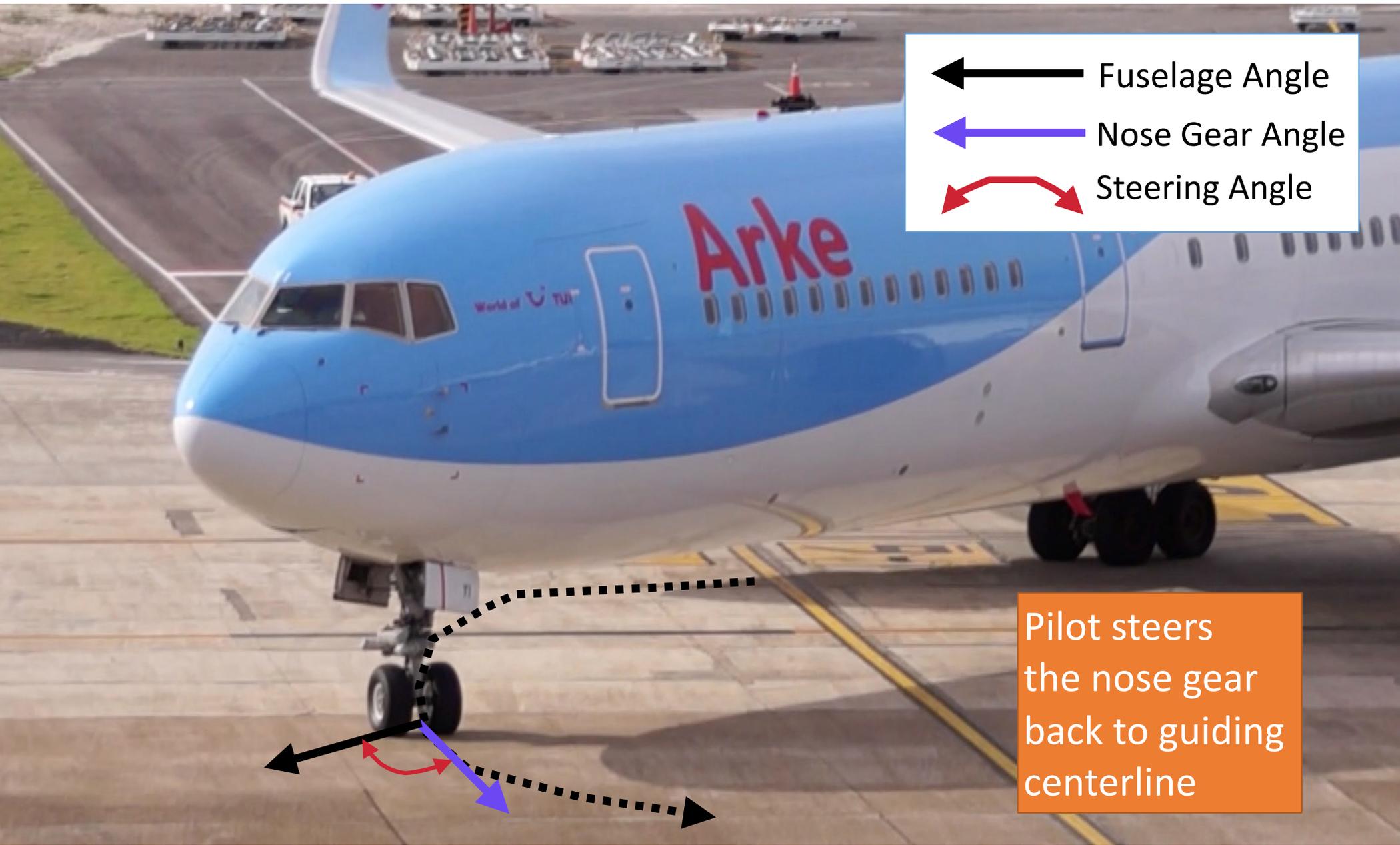


Observe the Nose Gear





Observe the Nose Gear

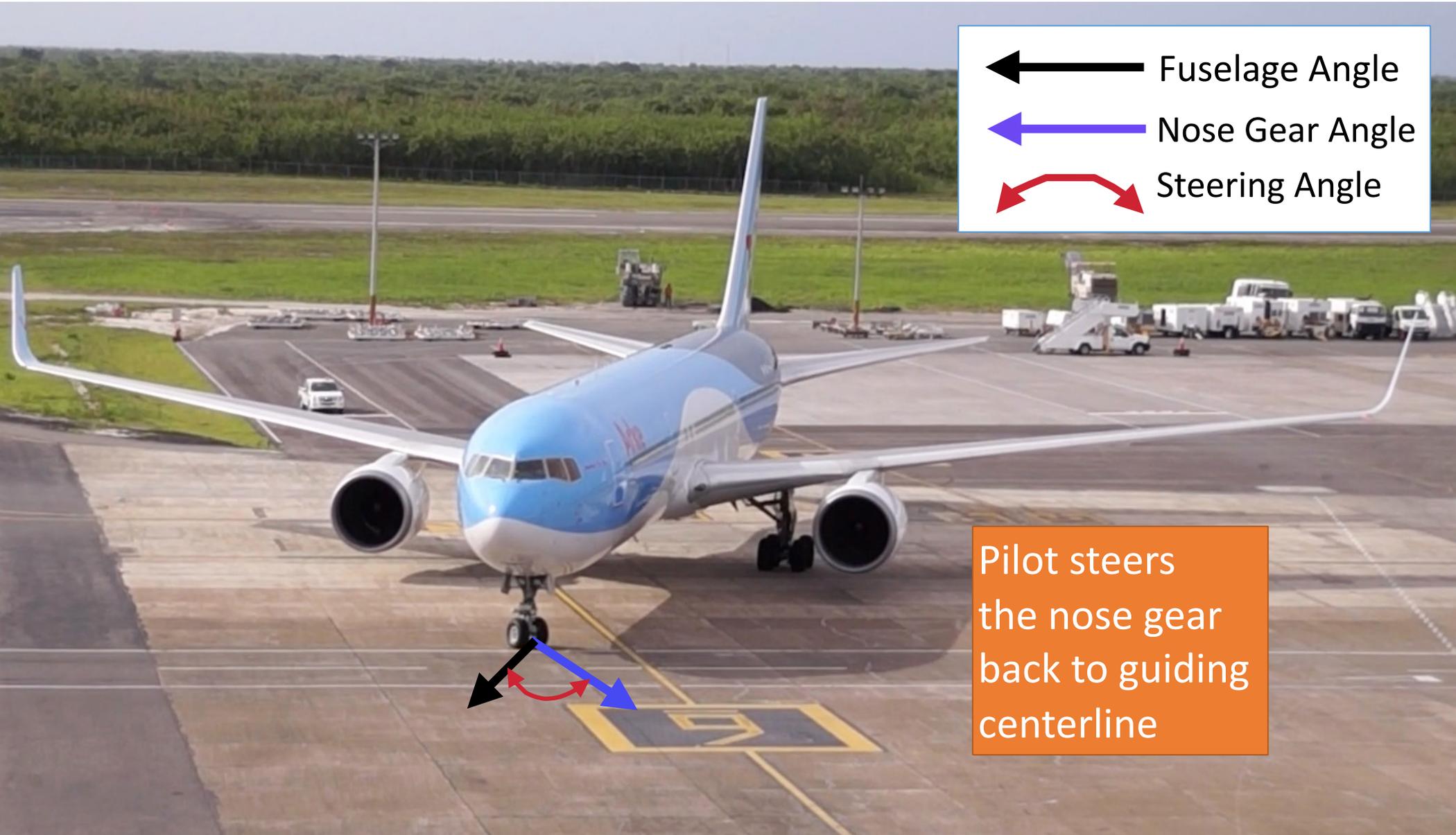


- ← Fuselage Angle
- ← Nose Gear Angle
- ↪ Steering Angle

Pilot steers the nose gear back to guiding centerline



Observe the Nose Gear

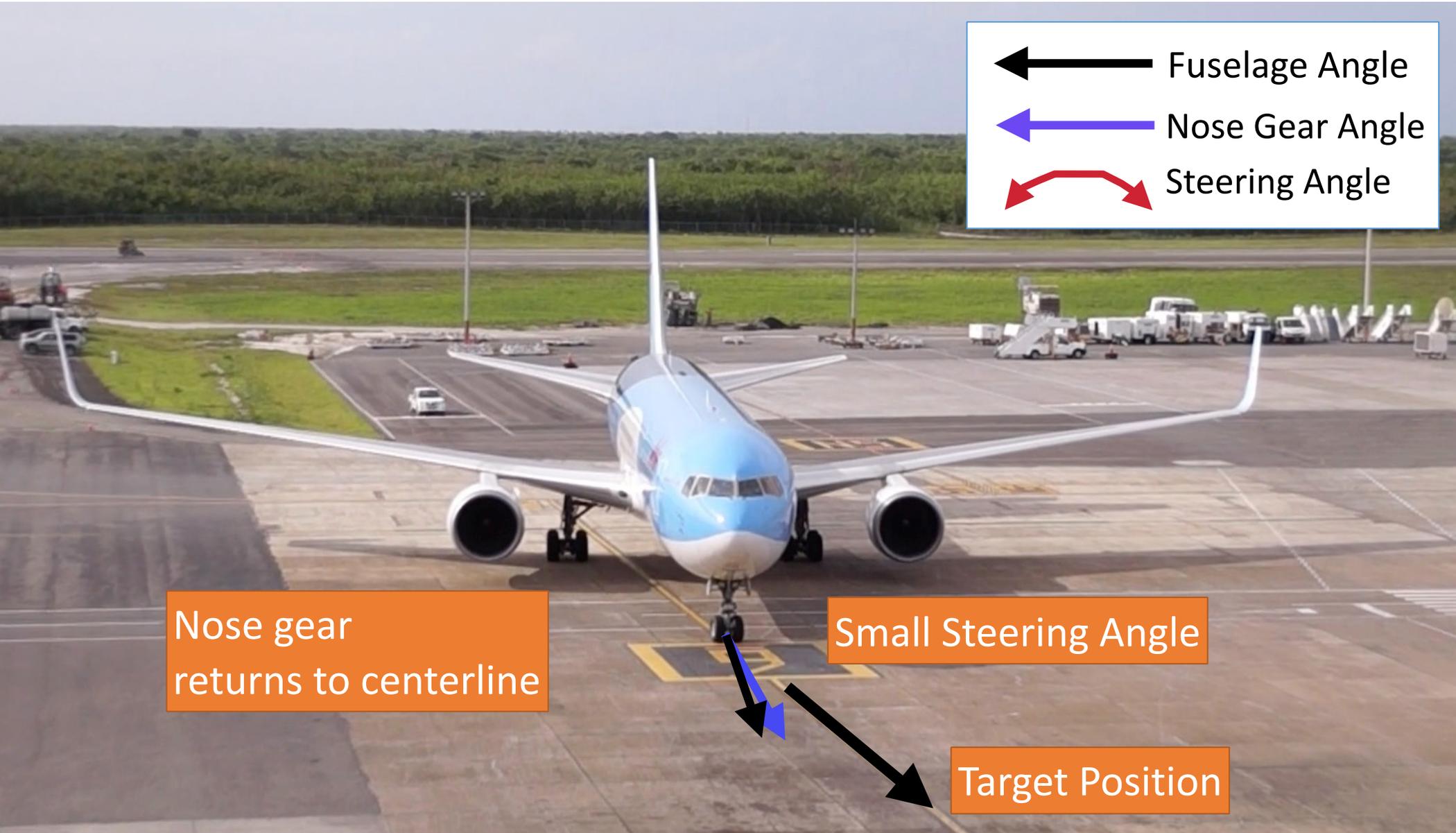


- ← Fuselage Angle
- ← Nose Gear Angle
- ↔ Steering Angle

Pilot steers the nose gear back to guiding centerline



Observe the Nose Gear



← Fuselage Angle
← Nose Gear Angle
↔ Steering Angle

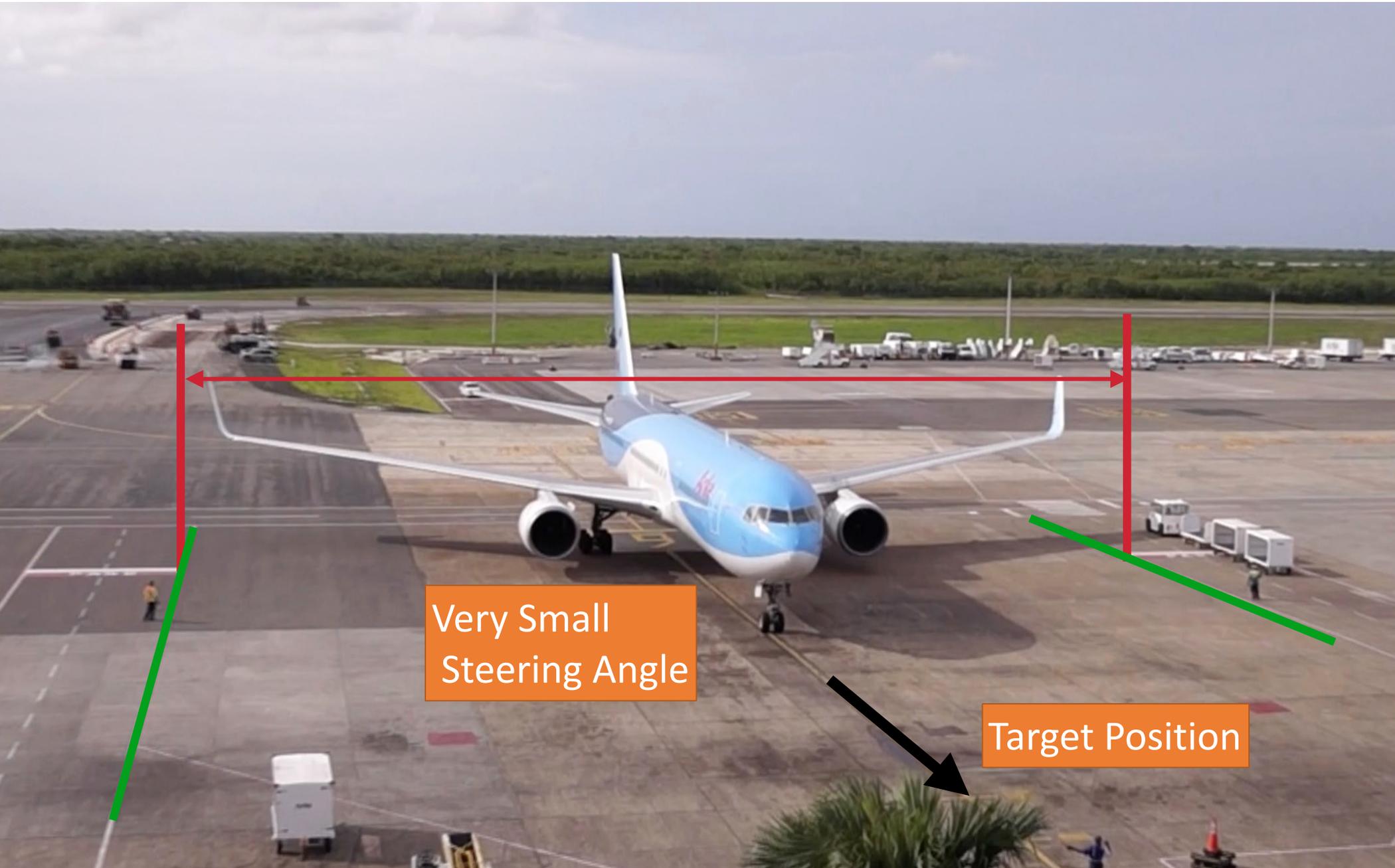
Nose gear returns to centerline

Small Steering Angle

Target Position



Observe the Nose Gear

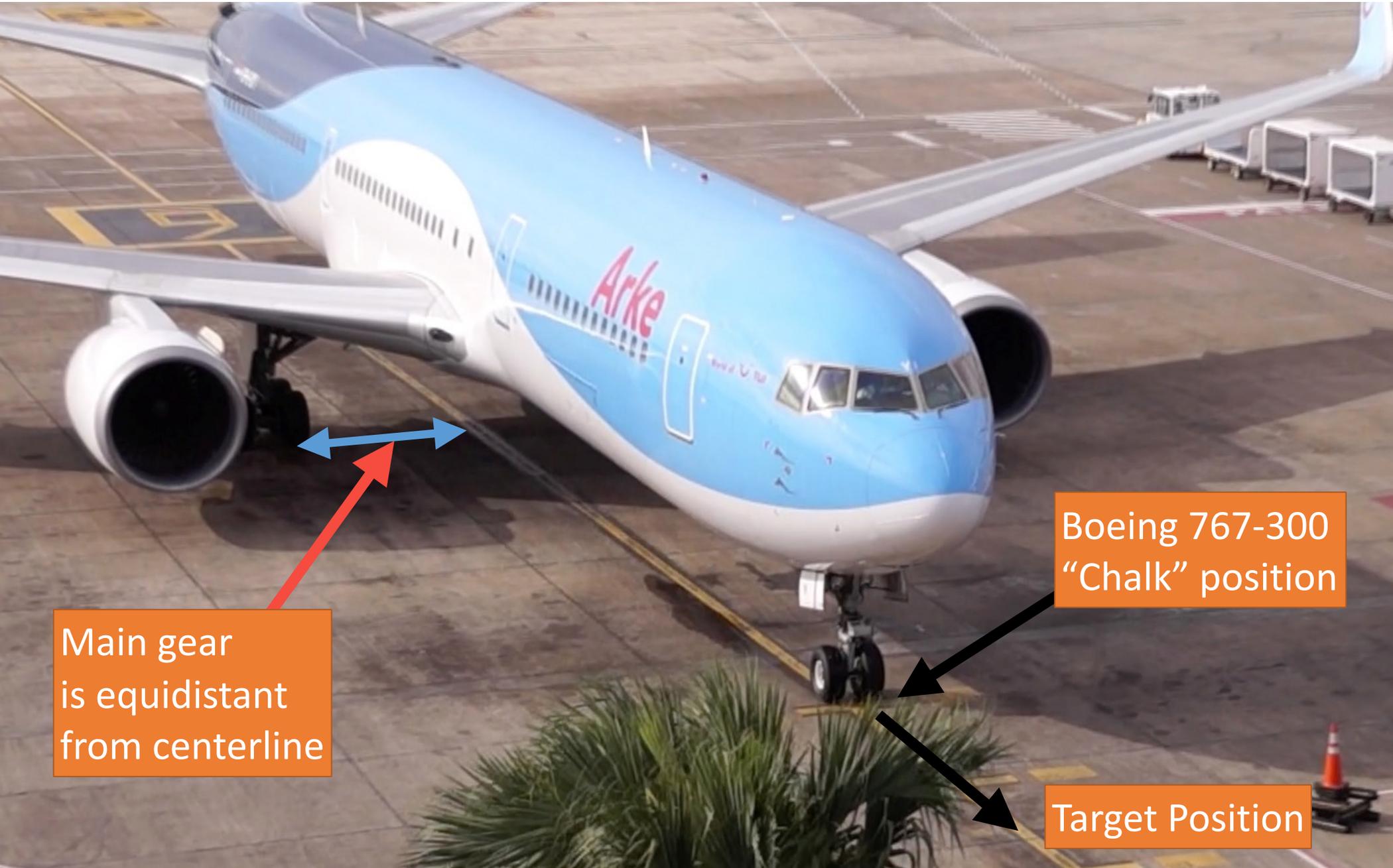


Very Small
Steering Angle

Target Position



Observe the Nose Gear



Main gear
is equidistant
from centerline

Boeing 767-300
"Chalk" position

Target Position