Determining an Aircraft Drag Polar.

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Drag Polar

- What is it?
  - A drag polar is a graph of an aircraft drag versus indicated air speed.
- What good is it?
  - Many performance parameters can be determined from the drag polar. Best Climb, Glide ratio, optimum cruise, etc.
- What is it for my airplane?
  - This presentation is to give you a procedure to measure it.

Procedure Overview

- Conduct flight test.
  - Level flight, various airspeeds and flap configurations.
  - Record density altitude of flight test.
  - Record engine MP/RPM for power determination
  - Note aircraft weight
- Plot Data
  - Determine engine power from settings
  - Convert power to thrust
- Determine Aircraft Performance Parameters

Data from PA28-236

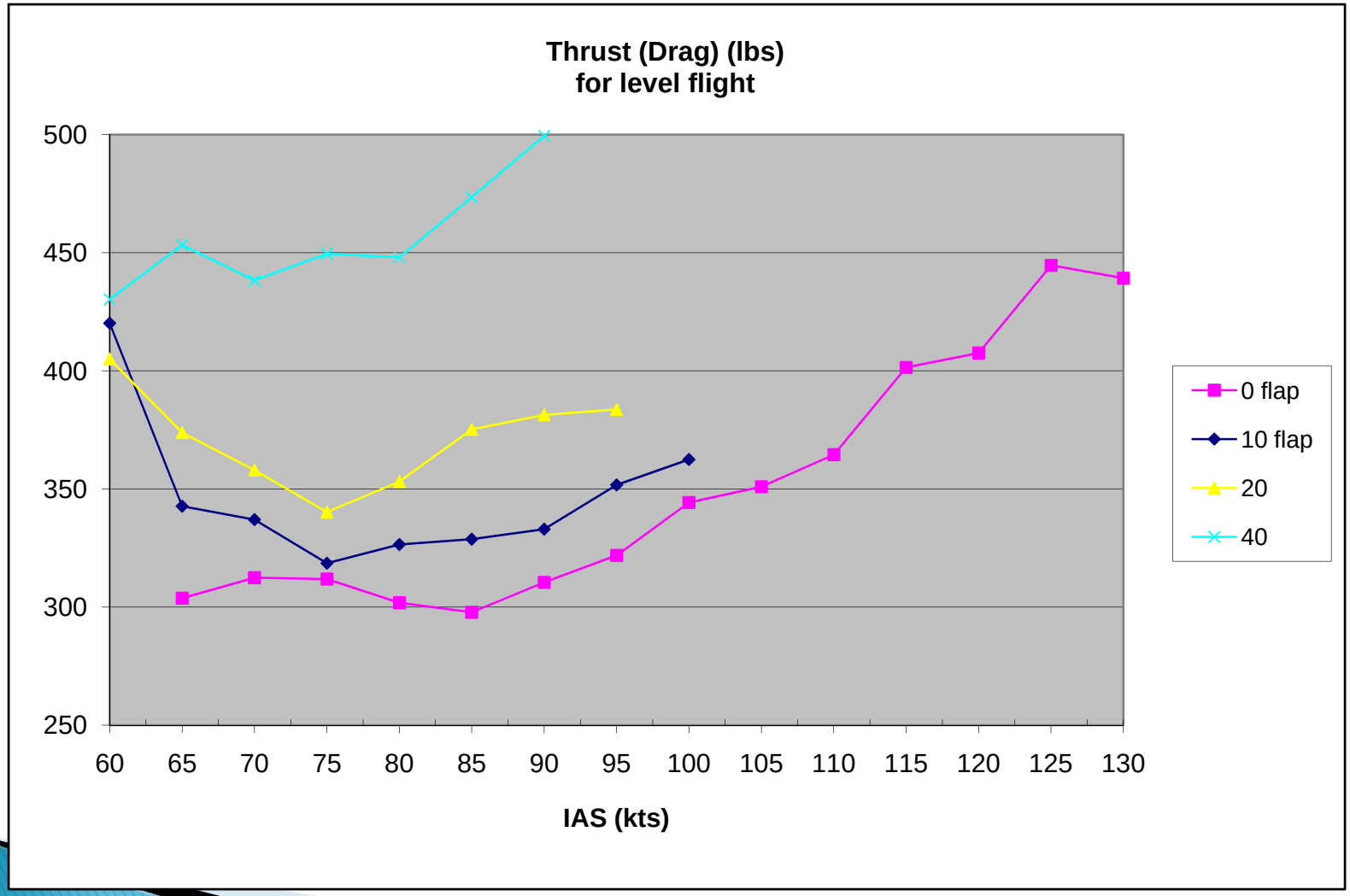
Flaps 0		Test 1			Test 2		
IAS	TAS	MP	RPM	SL Pwr	MP	RPM	SL Pwr
60	64.2						
65	69.6				15	1900	66
70	74.9				15.5	2050	78
75	80.3				15.5	2100	82
80	85.6				15.5	2150	84
85	91	15	2200	82	15.5	2200	86
90	96.3	16	2200	92	16	2200	92
95	102	16.5	2200	98	17	2200	102
100	107	18	2200	112	18	2200	114
105	112	18	2300	120	19	2200	122
110	118	20	2300	132	20	2200	132
115	123	22	2300	158	21.5	2200	146
120	128	23	2300	168	22	2250	154
125	134	25	2300	188	24	2300	178
130	139				25	2300	188

Convert Power to Thrust

- Thrust = 325 * Power / True Airspeed

Flaps 0		Test 1			Test 2			Test 3				
IAS	TAS	MP	RPM	SL Pwr	MP	RPM	SL Pwr	MP	RPM	SL Pwr	avg	Thrust
60	64.2											
65	69.6				15	1900	66	15	1850	64	65	304
70	74.9				15.5	2050	78	15	1900	66	72	312
75	80.3				15.5	2100	82	15	2000	72	77	312
80	85.6				15.5	2150	84	15	2100	75	80	302
85	91	15	2200	82	15.5	2200	86	15	2200	82	83	298
90	96.3	16	2200	92	16	2200	92	16	2200	92	92	310
95	102	16.5	2200	98	17	2200	102	17	2200	102	101	322
100	107	18	2200	112	18	2200	114	18	2200	114	113	344
105	112	18	2300	120	19	2200	122	19	2200	122	121	351
110	118	20	2300	132	20	2200	132				132	364
115	123	22	2300	158	21.5	2200	146				152	401
120	128	23	2300	168	22	2250	154				161	408
125	134	25	2300	188	24	2300	178				183	445
130	139				25	2300	188				188	439

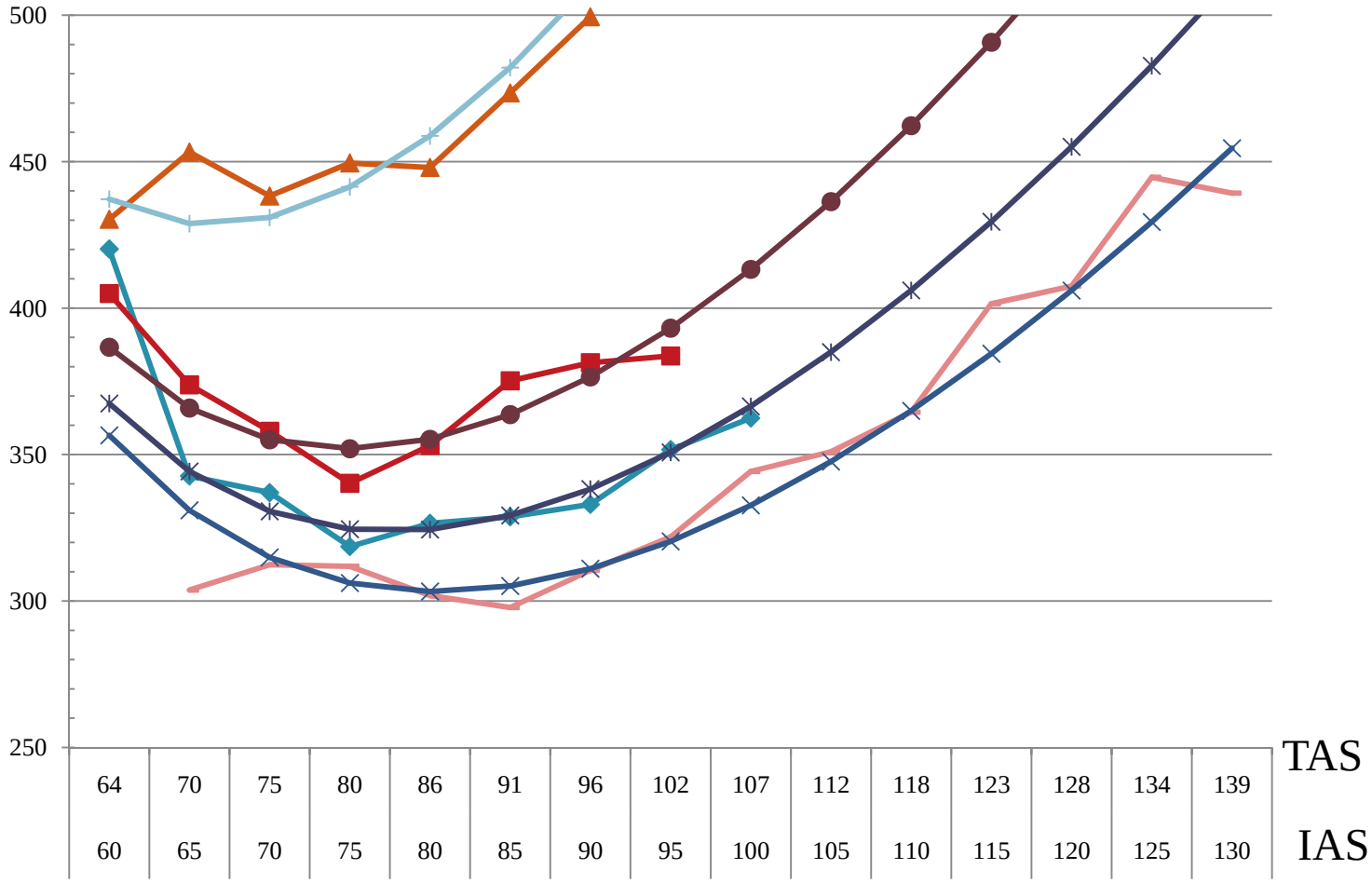
Graph of Raw Data



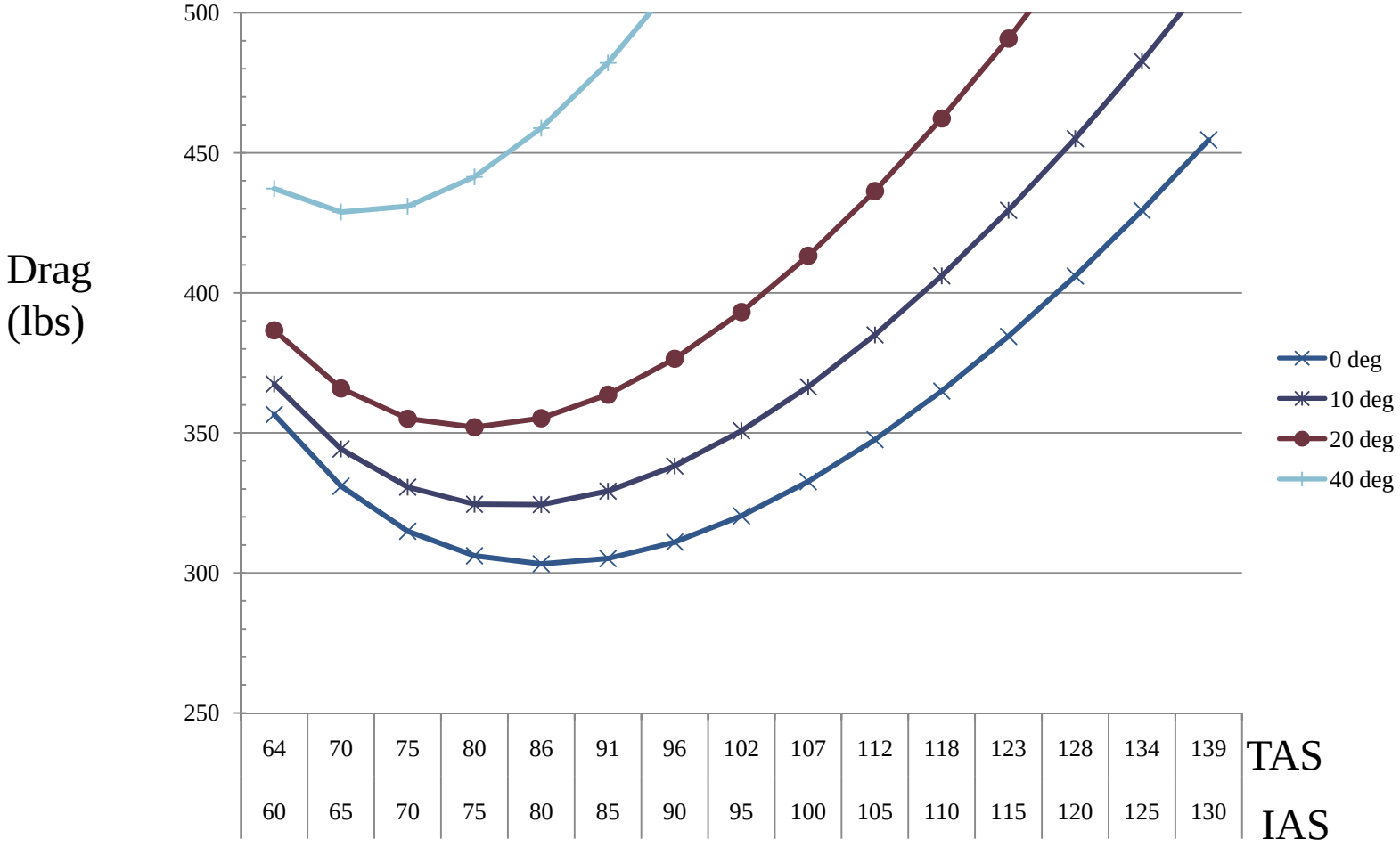
Data Smoothing

- Low end of curve dominated by induced drag
  - Proportional to $1/V^2$
- High end dominated by parasitic drag
  - Proportional to V^2
- Drag = $a/V^2 + b\,V^2$
- $b = a\,V_{gl}^{-4}$ where V_{gl} = best glide.

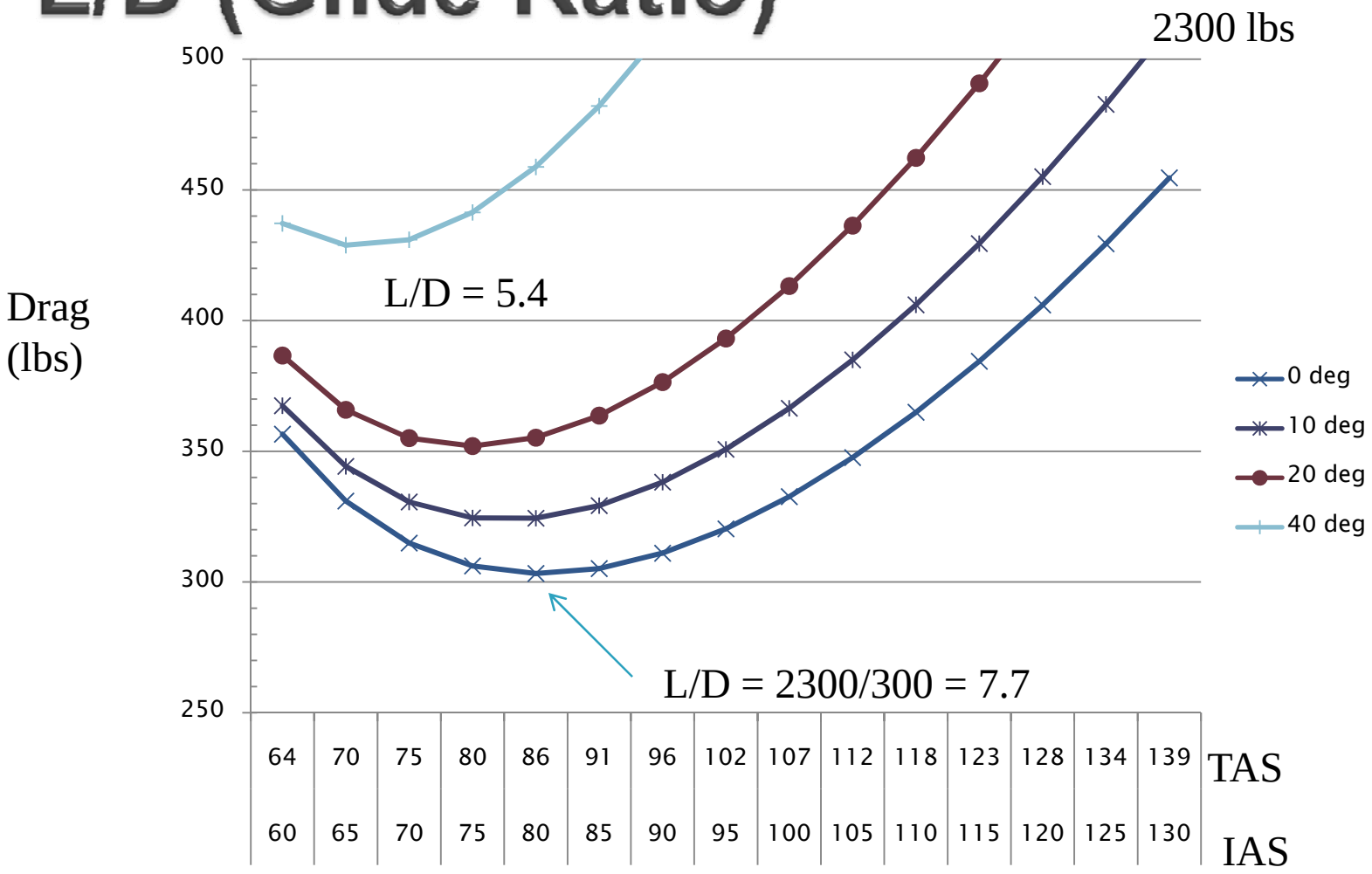
Curve Fit


500
450
400
350
300
250
64 70 75 80 86 91 96 102 107 112 118 123 128 134 139
60 65 70 75 80 85 90 95 100 105 110 115 120 125 130
TAS
IAS

Smoothed data



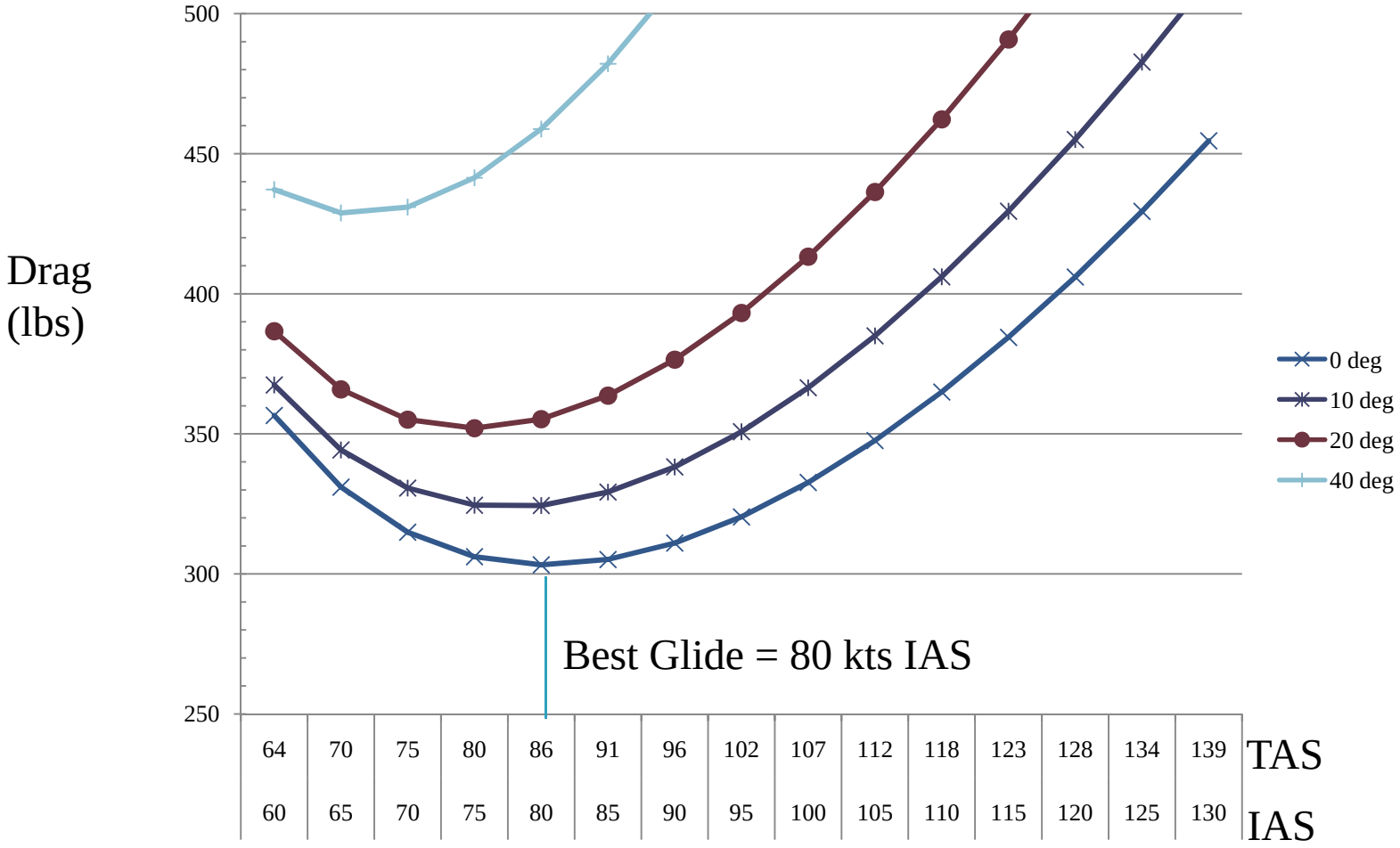
L/D (Glide Ratio)



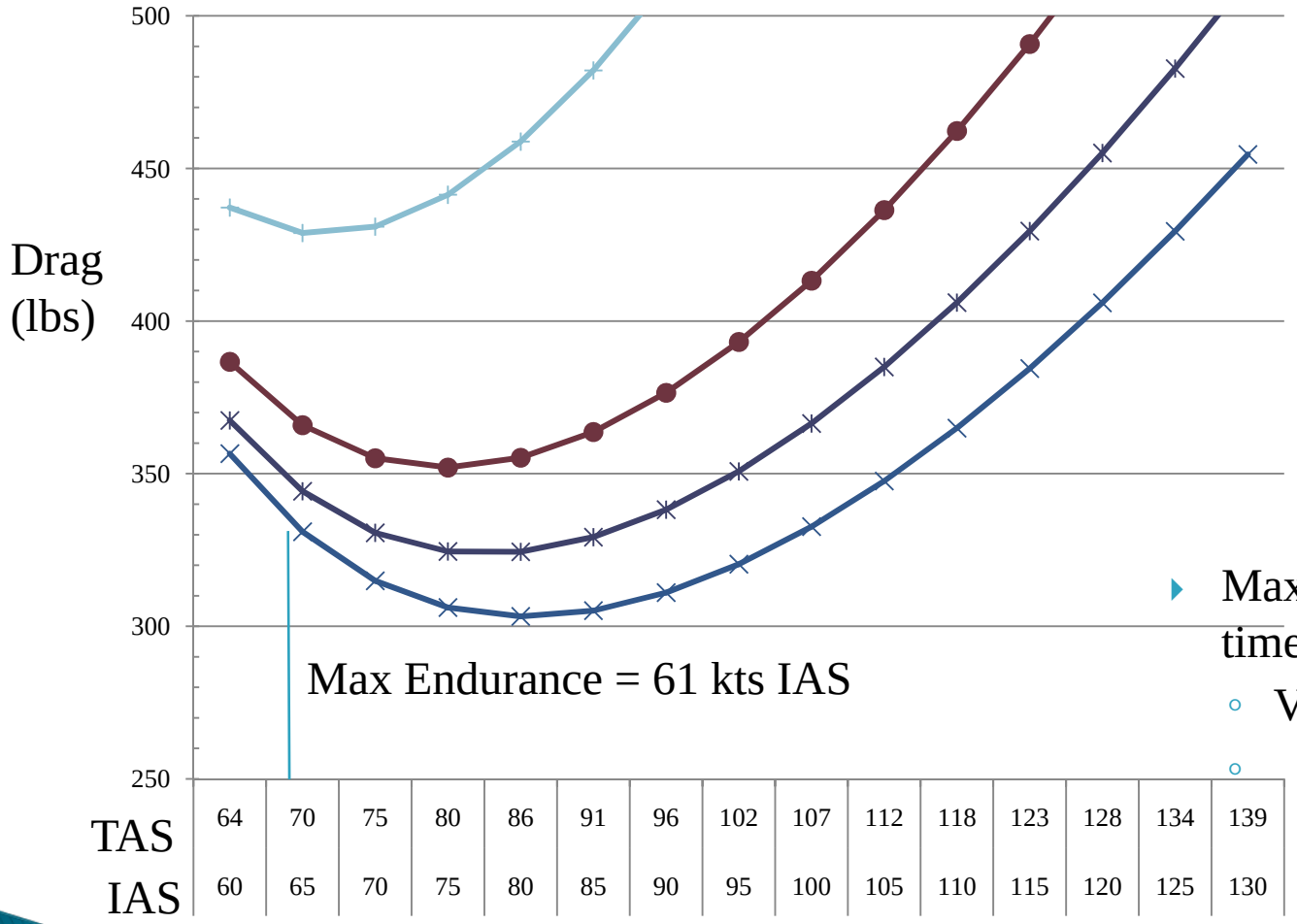
Effect of Flap

- Small initial deflections cause noticeable changes in C_L without large changes in C_D.
- In General:
  - First 50% of flap deflection causes >50% total change in C_L
  - Last 50% of flap deflection causes >50% total change in C_D

Best Glide, Vy, Max Range, Min Thrust for Level Flight.



Max Endurance, Least Rate of Decent, Best Angle of Climb, Min Pwr for Level Flight.



- Maximum endurance (max time airborne)
  - Vme = Vgl / 1.316
  - = 80 / 1.316 = 61 kts

Best Cruise Speed

Optimum Cruise

- Best fuel flow per knot
- Voc = Vgl * 1.316
- = 80 * 1.316 = 105 kts

Conclusion

- Fly around taking some data
- Do some data analysis
- Determine Glide Ratio, Best Glide Speed, Vx, Vy, Optimum Cruise and Max Endurance Speed.