Progettazione di veicoli aerospaziali (AA-LZ)

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Lecture series:

Conceptual Design of subsonic commercial aircraft

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Lesson 2: Guess Estimation: Wing Surface and Engine Thrust

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2.1

Guess Data Estimation: a short recap on MTOM and mass breakdown

Recap of assignments from Lect.1

Assignment 1.1: To write down an initial list of requirements for an aircraft that shall replace A350, with an entry into service in 2030. Please, while listing the requirements, refer to the categories reported in Sect.1.4

Assignment 1.2: On the basis of the list of Requirements elicited in the previous step, identify a good list of reference aircraft and collect data to be used as meaningful statistical population.

Assignment 1.3: Critical Analysis of statistical trends. Verify whether your statistical population fits the trend reported in literature (e.g. Raymer) or suggest improvements to the simple mathematical models (e.g. updates of coefficients).

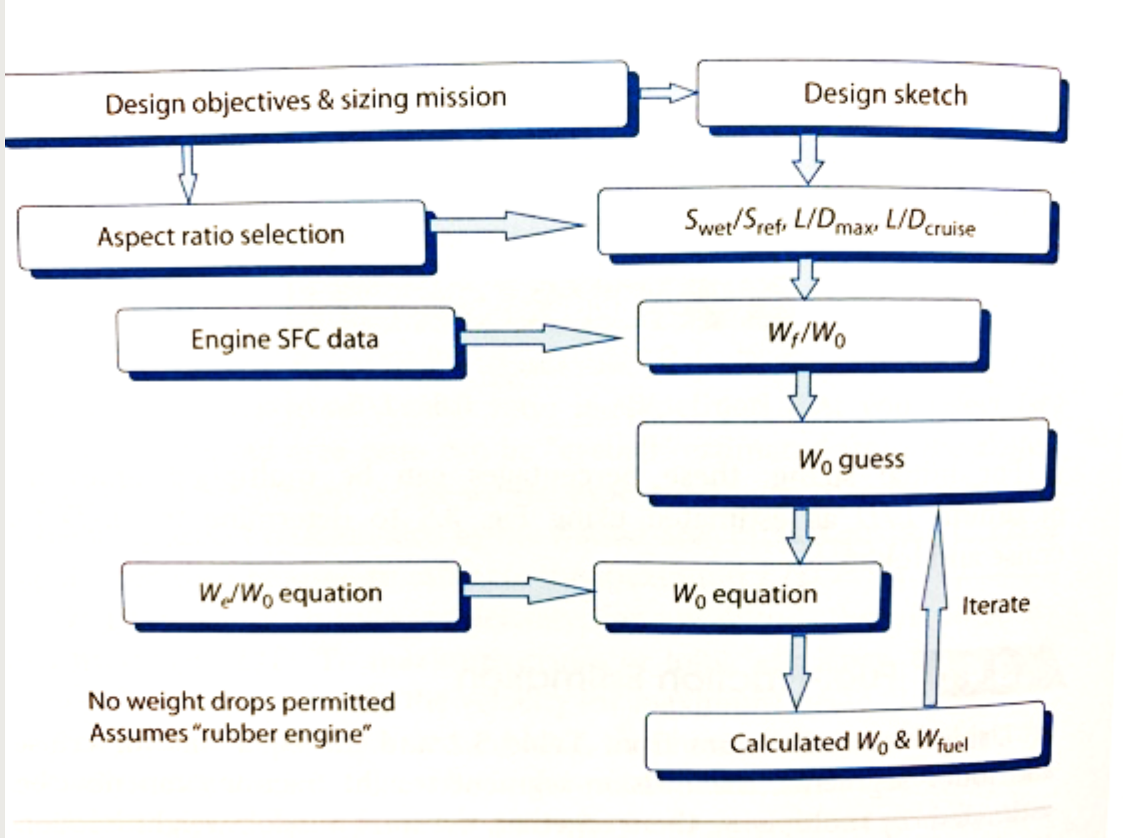
Assignment 1.4: Guess data estimation for the reference case study. Apply the original or improved statistical trends to perform the first guess data estimation for the reference case study. Please, report all iterations needed to convergence to the design maximum take-off mass. An example of iterations is reported into [1], pages 43-52.

Recap of assignments from Lect.1

2.1

Guess Data Estimation: a short recap on MTOM and mass breakdown

$$m_{TO} = \frac{m_{crew} + m_{payload}}{1 - \left(\frac{m_{fuel}}{m_{TO}}\right) - \left(\frac{m_{empty}}{m_{TO}}\right)}$$



Iterative procedure to estimate m_{TO}

Most influential requirements on m_{TO}

$$f(n_{pax})$$

$$m_{TO} = \frac{m_{crew} + m_{payload}}{1 - \left(\frac{m_{fuel}}{m_{TO}}\right) - \left(\frac{m_{empty}}{m_{TO}}\right)}$$

$$f\left(R, \frac{L}{D}, sfc, M_{cr}\right)$$

2.2

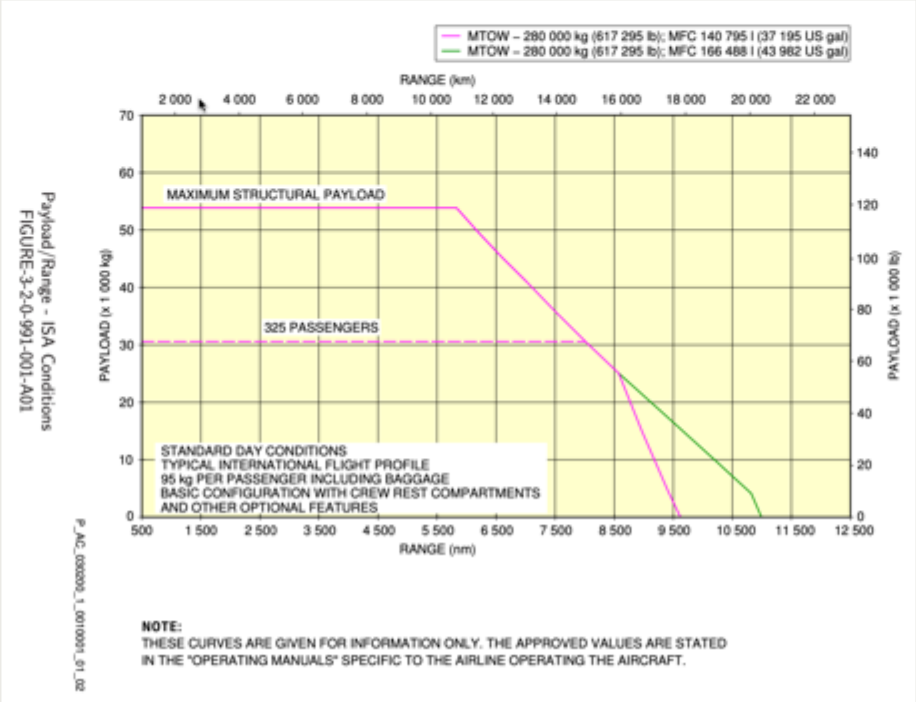
Guess Data Estimation: Sensitivity Analysis and Trade Studies

Variations of payload mass and maximum range are the most influential on m_{TO}.

Sensitivity analyses are used to understand the impact of a variation of one of these parameters on to the m_{TO}.

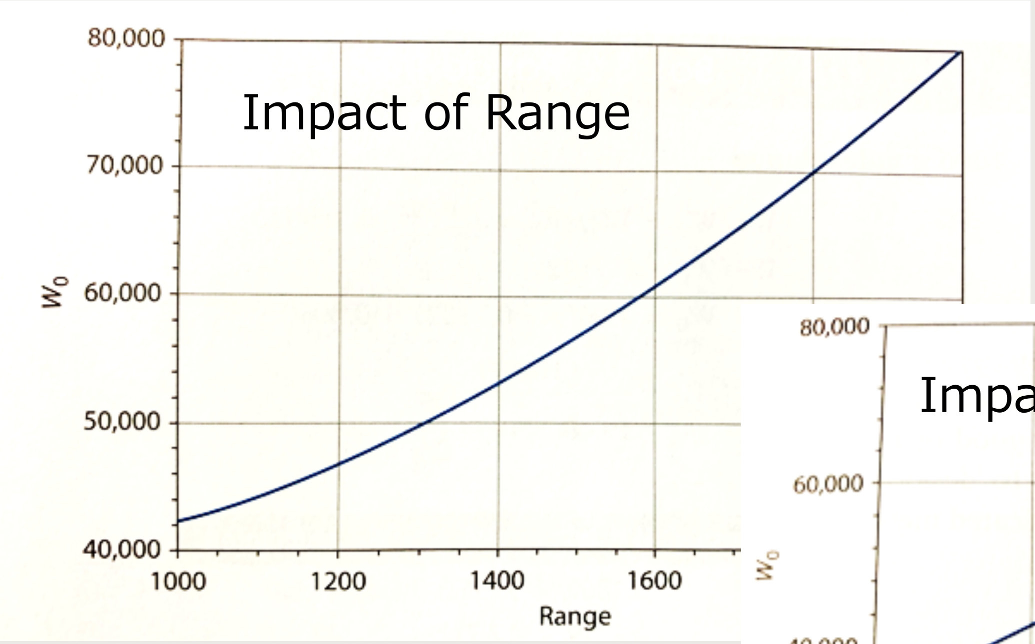
Trade Studies are then used to see the effect of the combined variation of a set of parameters onto m_{TO}, thus allowing to trade-off the best set of parameters. In this case, the best set of parameters should maximize performance requirements while minimizing the m_{TO}.

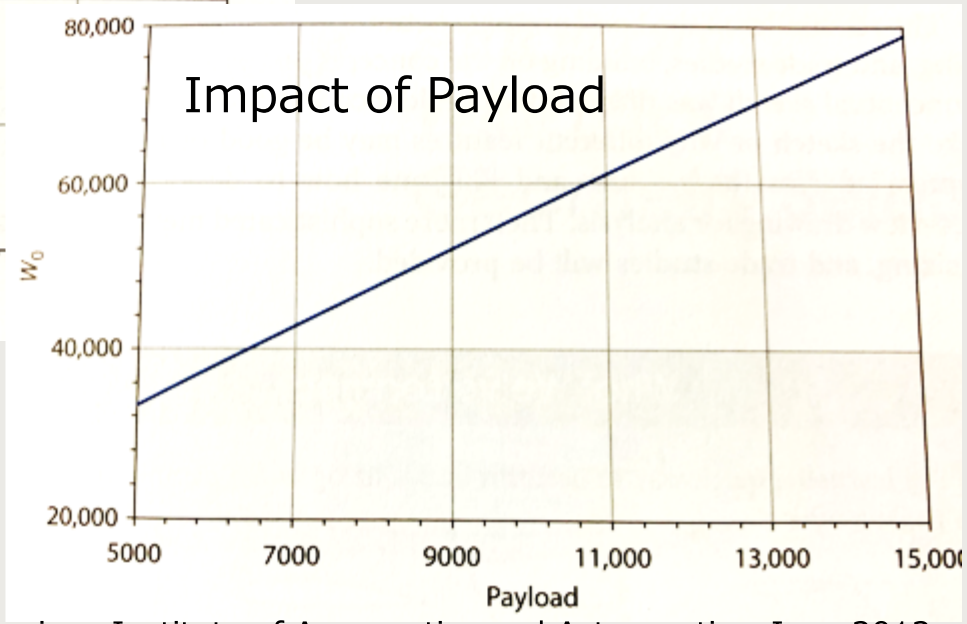
Payload Mass and Range



Trade studies

During Conceptual design phase, the evaluation and refinement of requirements, involving stakeholders, represent a fundamental part. Typical examples are "Range Trade" and "Payload Trade".





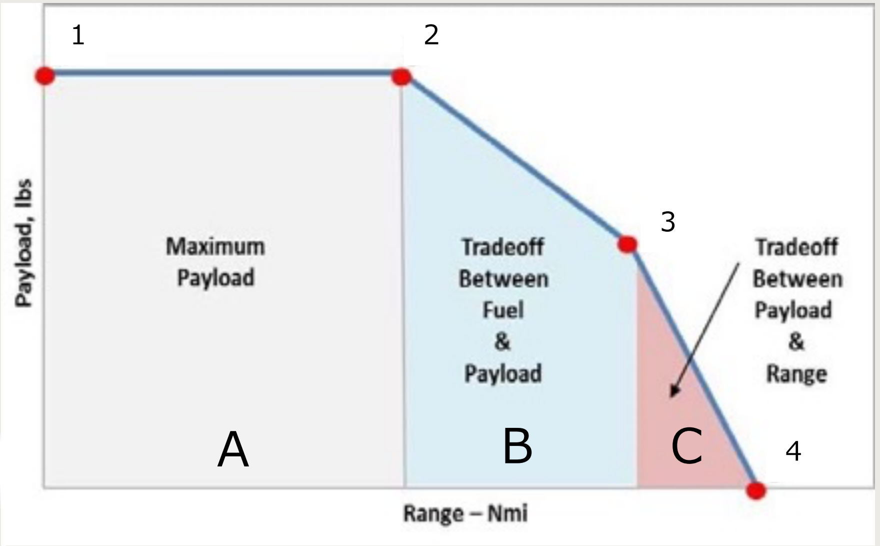
To better understand and predict trends, please refer to the mathematical derivation of m_{TO} equation.

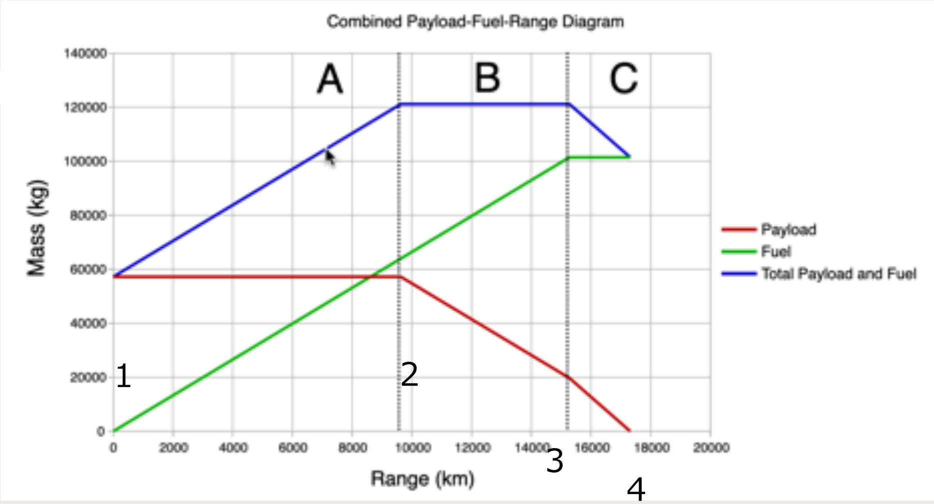
2.2

Guess Data Estimation: Sensitivity Analysis and Trade Studies

[1] Raymer, Daniel. Aircraft design: a conceptual approach. American Institute of Aeronautics and Astronautics, Inc., 2012.

Evaluate Operational Flexibility: Payload – Range Diagram





[1] Ackert, Shannon. "Aircraft payload-range analysis for financiers." *Aircraft Monitor: San Francisco, CA, USA* (2013).

1: $R_1 = 0;\ m_{pay_1} = (m_{pay})_{max}$

A: Fuel can be added as needed to reach any range needed in this area, but payload cannot exceed the certified or physical maximum possible for the aircraft. *MTOM increases*

2: $R_2 = R_{max}\left((m_{pay})_{max}\right);\ m_{pay_2} = (m_{pay})_{max}$

B: There is still space in the fuel tanks to add more fuel, but the maximum take-off weight of the aircraft has been reached (pt.2). In order to fly further, some payload must be offloaded in order to allow more fuel to be loaded. *MTOM is reached and kept constant*

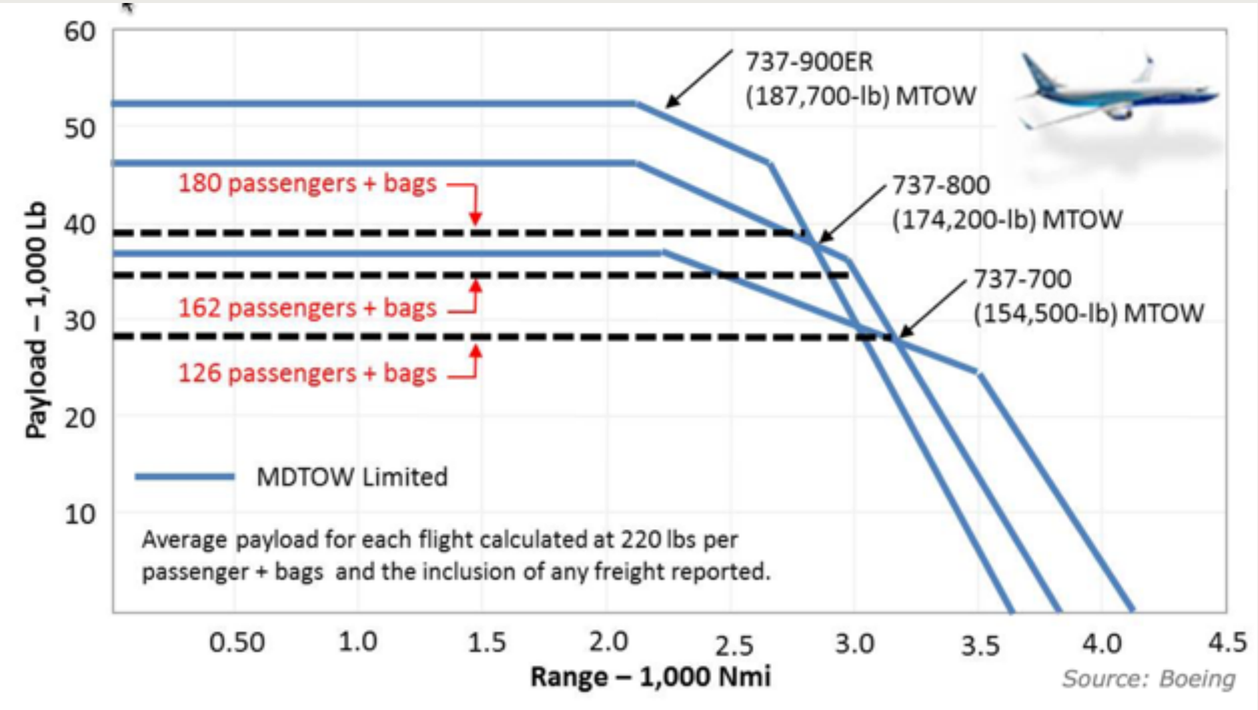
3: $R_3 = R_{max}\left(m_{f_{max}}\right);$

$m_{pay} = (m_{pay})_{max} - (m_{f_3} - m_{f_2})$

C: The aircraft fuel tanks are full, so the only way to fly further is to reduce the total weight of the aircraft by reducing the payload further. Due to the reduced total aircraft weight, the aircraft is then able to fly further, even with the same amount of fuel. *MTOM decreases*

4: $R_4 = R_{max}\left(m_{f_{max}}, m_{pay} = 0\right);\ m_{pay} = 0$

Define a Payload – Range Diagram



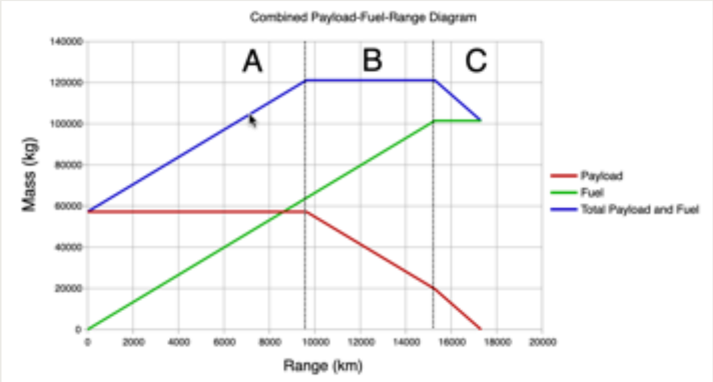
2.2

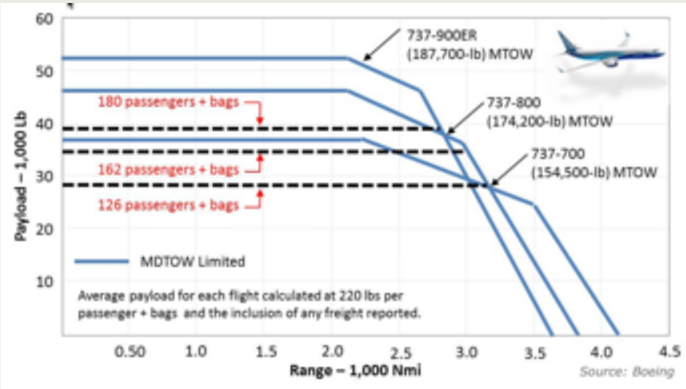
Guess Data Estimation: Sensitivity Analysis and Trade Studies

The above example illustrates how the ***family concept*** can assist airlines to better match an aircraft model (i.e., 737-700, 737-800, etc.) to specific parts of its network. **Operational flexibility** becomes especially important in fleet planning as future range and payload requirements can be adjusted more easily by selecting smaller and/or larger-sized variants of an aircraft type you already operate.

[1] Ackert, Shannon. "Aircraft payload-range analysis for financiers." *Aircraft Monitor: San Francisco, CA, USA* (2013).

Case Study: Payload Trade and Range Trade





2.2

Guess Data Estimation: Sensitivity Analysis and Trade Studies

HOMEWORK

Assignment 2.1: Payload and Range Trade

Let's define a plausible variation interval for Payload and Range requirements and analyse the impact onto the m_{TO}. Perform a Trade off and identify a suitable design point that guarantees to the aircraft concept to be competitive with A350 and competitors.

Assignment 2.2: Payload-Range Diagram

A) Create a Payload-Range Diagram representative of your aircraft concept.
B) On the basis of the results achieved in A), draw different Payload-Range diagrams to explore the possibility to create a family concept.

Assignment 2.3: City-pairs

Once the maximum range requirement is refined, identify a set of city-pairs that can be connected with no-stop flight.

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Wing Surface and Engine Sizing

In the first step of the aircraft preliminary design phase, the aircraft's most influential parameter, i.e. MTOM, is determined. The second crucial step is the preliminary estimation of **wing surface area** $\boldsymbol{S_{ref}}$ and **engine thrust** $\boldsymbol{T}$. In particular, the following parameters shall be estimated:

Wing Loading $\left(\frac{W}{S}\right)$

Thrust-to-Weight ratio $\left(\frac{T}{W}\right)$

Unlike the procedure followed for MTOM estimation, in this case the methodology does not make use of statistic assessment, but it requires a more detailed investigation of **aircraft performance requirements** and it employs **flight mechanics theories**.

Set of aircraft performance requirements to be used at this stage

- Stall speed V_s
- Maximum speed V_{max}
- Maximum rate of climb ROC_{max}
- Take-off run S_{TO}
- Ceiling altitude h_c
- Turn characteristics (Turn Radius r_t Turn Rate ω_t)

[1] Raymer, Daniel. Aircraft design: a conceptual approach. American Institute of Aeronautics and Astronautics, Inc., 2012.
[2] Sadraey, Mohammad H. *Aircraft design: A systems engineering approach*. John Wiley & Sons, 2012.

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Wing Surface and Engine Sizing:

A **4-steps procedure** can be followed:

1) Derive equations for each performance requirement, trying to express them as a $f\left(\frac{T}{W}, \frac{W}{S}\right)$

2) Rewrite equations in the form $\frac{T}{W} = f\left(Req_i, \frac{W}{S}\right)$ and graphically represent the curves in a single plot (aka Matching Chart) with wing loading as horizontal axis and thrust-to-weight ratio as vertical axis.

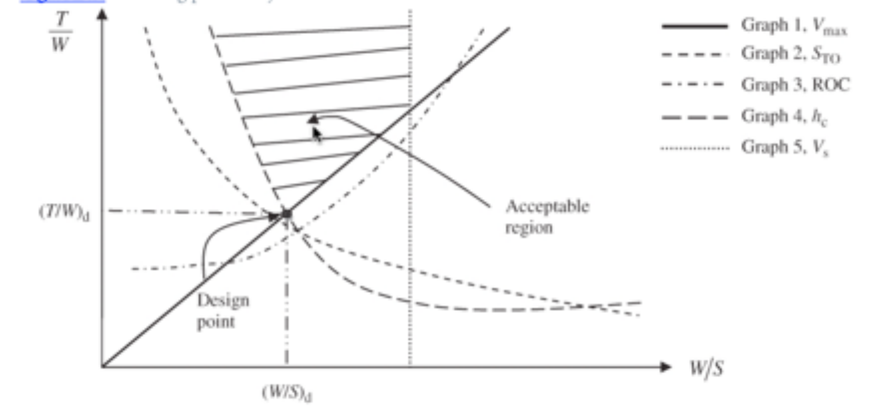
3) Identify the acceptable region of the diagram

4) Identify the Optimum Design Point inside the acceptable region and evaluate T and S (W is known)

[1] Raymer, Daniel. Aircraft design: a conceptual approach. American Institute of Aeronautics and Astronautics, Inc., 2012.

[2] Sadraey, Mohammad H. *Aircraft design: A systems engineering approach*. John Wiley & Sons, 2012.

Figure 4.8 Matching plot for a jet aircraft



Wing Surface and Engine Sizing: steps 1,2 and 3

1) Derive equations for each performance requirement, trying to express them as a $f\left(\frac{T}{W},\frac{W}{S}\right)$

Set of aircraft performance requirements to be used at this stage

- Stall speed V_s
- Maximum speed V_{max}
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- Ceiling altitude h_c
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2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Please note that this methodology has been presented for the first time by NASA and then later on in-depth analysed and improved by several authors including Roskam and Raymer. The Matching Chart theory is currently very widely used and implemented in different automatized tool.

Wing Surface and Engine Sizing: steps 1,2 and 3

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Eq.1) Stall Speed Equation (V_s)

Except for helicopters and VTOL aircraft (that can fly with zero forward speed), all other fixed-wing aircraft need to have a a minimum airspeed in order to be airborne, thus a limit to the minimum allowable speed exists and it is referred to as stall speed. To guarantee longitudinal trim at any flight speed ($L = W$), when aircraft speed lowers down, being closer to stall, the aircraft lift coefficient must be increased, becoming closer to $C_{L_{max}}$.

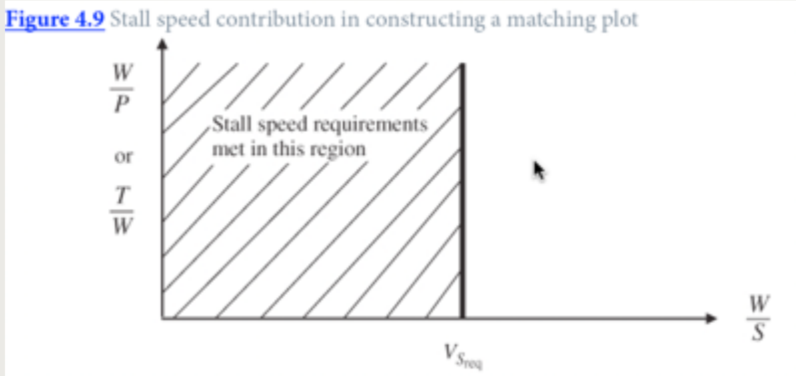
Step 1

$$L \geq W$$

$$L = \frac{1}{2}\rho V_s^2 S C_{L_{max}}$$

Step 2

$$\frac{W}{S} \leq \frac{1}{2}\rho V_s^2 C_{L_{max}}$$



Step 3

This is also known as landing requirement

Wing Surface and Engine Sizing: steps 1,2 and 3

Eq.1) Stall Speed Equation (V_s)

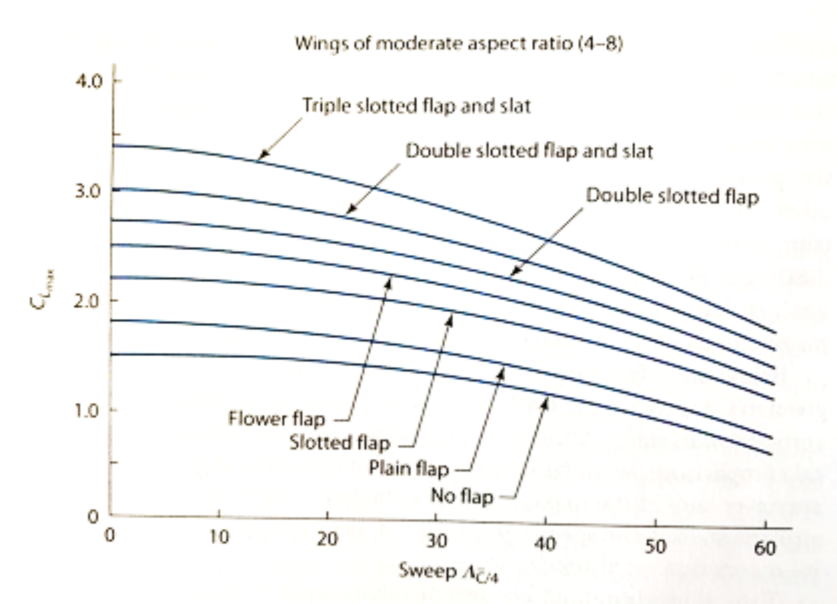
$$\frac{W}{S} \leq \frac{1}{2}\rho V_s^2 C_{L\,max}$$

$\boldsymbol{\rho}\ \left[\frac{kg}{m^3}\right]$ is the air density evaluated in cruise conditions

$\boldsymbol{V_s}\ \left[\frac{m}{s}\right]$ is stall speed. Unlike the aircraft covered in CS-23, the CS-25 regulating large transport aircraft does not provide any maximum stall speed requirements. A suggestion might be to set this requirement starting from the required approach speed, duly considering safety factors accounting for rearward gust or wind shear. (Suggestion $V_s = \frac{V_{approach}}{1.3}$)

$\boldsymbol{C_{L\,max}}$ is the maximum lift coefficient. Very difficult to estimate without knowing the wing geometry. Usually,

$1.2 \leq C_{L\,max} \leq 1.5$ for no-flap wing
$1.5 \leq C_{L\,max} \leq 5$ for flap wing



[1] Raymer, Daniel. Aircraft design: a conceptual approach. American Institute of Aeronautics and Astronautics, Inc., 2012.

Wing Surface and Engine Sizing: steps 1,2 and 3

Eq.1) Stall Speed Equation (V_s)

$$\frac{W}{S} \le \frac{1}{2}\rho V_s^2 C_{L_{max}}$$

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

No.	Aircraft	Type	m_{TO} (kg)	S (m^2)	V_s (knot)	$C_{L_{max}}$
1	Volmer VJ-25 Sunfun	Hang glider/kite	140.5	15.14	13	3.3
2	Manta Fledge III	Sailplane/glider	133	14.95	15	2.4
3	Euro Wing Zephyr II	Microlight	340	15.33	25	2.15
4	Campana AN4	Very light	540	14.31	34	1.97
5	Jurca MJ5 Sirocco	GA two seat	760	10	59	1.32
6	Piper Cherokee	GA single engine	975	15.14	47.3	1.74
7	Cessna 208-L	GA single turboprop	3 629	25.96	61	2.27
8	Short Skyvan 3	Twin turboprop	5 670	35.12	60	2.71
9	Gulfstream II	Business twin jet	29 700	75.2	115	1.8
10	Learjet 25	Business twin jet	6 800	21.5	104	1.77
11	Hawkeye E-2C	Early warning	24 687	65.03	92	2.7
12	DC-9-50	Jet airliner	54 900	86.8	126	2.4
13	Boeing 727-200	Jet airliner	95 000	153.3	117	2.75
14	Airbus 300	Jet airliner	165 000	260	113	3
15	F-14 Tomcat	Fighter	33 720	54.5	110	3.1

Table 4.11 Typical values of maximum lift coefficient and stall speed for different types of aircraft

No.	Aircraft type	$C_{L_{max}}$	V_s (knot)
1	Hang glider/kite	2.5–3.5	10–15
2	Sailplane/glider	1.8–2.5	12–25
3	Microlight	1.8–2.4	20–30
4	Very light	1.6–2.2	30–45
5	GA light	1.6–2.2	40–61
6	Agricultural	1.5–2	45–61
7	Home-built	1.2–1.8	40–70
8	Business jet	1.6–2.6	70–120
9	Jet transport	2.2–3.2	95–130
10	Supersonic fighter	1.8–3.2	100–120

[2] Sadraey, Mohammad H. *Aircraft design: A systems engineering approach*. John Wiley & Sons, 2012.

[1] Raymer, Daniel. Aircraft design: a conceptual approach. American Institute of Aeronautics and Astronautics, Inc., 2012.

Wing Surface and Engine Sizing: steps 1,2 and 3

Eq.2) Maximum Speed (V_{max})

Thinking that for commercial transport aircraft, maximum speed can be reached in cruise conditions, too guarantee aircraft longitudinal trim, the following equilibrium equations can be written:

Step 1

$$L = W$$
$$D = T$$

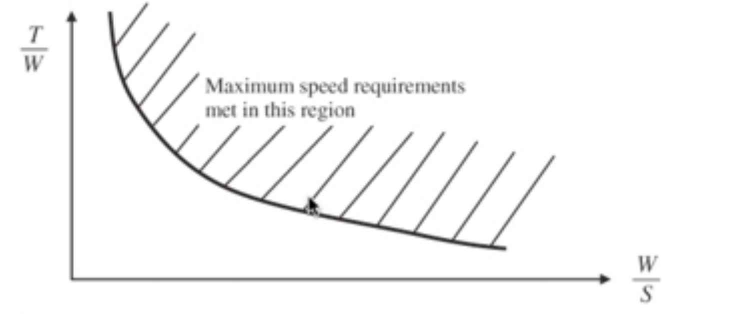
$$L = \frac{1}{2}\rho V_{max}^2 S C_L$$
$$D = \frac{1}{2}\rho V_{max}^2 S C_D$$
$$T_h = T_0\left(\frac{\rho}{\rho_{SL}}\right) = T_0\sigma$$

Step 2

$$\frac{T}{W} = \frac{\rho_0 V_{max}^2 C_{D0}}{2\left(\frac{W}{S}\right)} + \frac{2K}{\rho\sigma V_{max}^2}\left(\frac{W}{S}\right)$$

Step 3

Figure 4.10 Maximum speed contribution in constructing a matching plot for a jet aircraft



This is also known as cruise requirement

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Wing Surface and Engine Sizing: step steps 1,2 and 3

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Eq.2) Maximum Speed (V_{max})

$$\frac{T}{W} = \frac{\rho_0 V_{max}^2 C_{D0}}{2\left(\frac{W}{S}\right)} + \frac{2K}{\rho\sigma V_{max}^2}\left(\frac{W}{S}\right)$$

$\boldsymbol{V_{max}}$ is the aircraft maximum speed. This requirement can be easily estimated knowing cruise speed, assuming that $V_{max} = 1.25\, V_{cr}$

$\boldsymbol{C_{D_0}}$ can be estimated through this equation

$$C_{D_0} = \frac{2T_{sl} - \frac{4KW^2}{(\rho\sigma V_{max}^2 S)}}{(\rho_0 V_{max}^2 S)}$$

$\boldsymbol{K} = \frac{1}{\pi e\ AR}$, with $0.7 < e < 0.95$

Table 4.12 Typical values of C_{D_o} for different types of aircraft

No.	Aircraft type	C_{D_o}
1	Jet transport	0.015–0.02
2	Turboprop transport	0.018–0.024
3	Twin-engine piston prop	0.022–0.028
4	Small GA with retractable landing gear	0.02–0.03
5	Small GA with fixed landing gear	0.025–0.04
6	Agricultural	0.04–0.07
7	Sailplane/glider	0.012–0.015
8	Supersonic fighter	0.018–0.035
9	Home-built	0.025–0.04
10	Microlight	0.02–0.035

Table 5.8 Typical values of wing aspect ratio

No.	Aircraft type	Aspect ratio
1	Hang glider	4–8
2	Glider (sailplane)	20–40
3	Home-built	4–7
4	General aviation	5–9
5	Jet trainer	4–8
6	Low-subsonic transport	6–9
7	High-subsonic transport	8–12
8	Supersonic fighter	2–4
9	Tactical missile	0.3–1
10	Hypersonic aircraft	1–3

Wing Surface and Engine Sizing: steps 1,2 and 3

Eq.3) Take-off distance (S_{TO})

Usually, take-off requirements are spelled out in terms of minimum ground run requirements, since every airport has a limited runway. As it appears from the mathematical derivation, both T/W and W/S contribute to take-off distance.

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Step 1

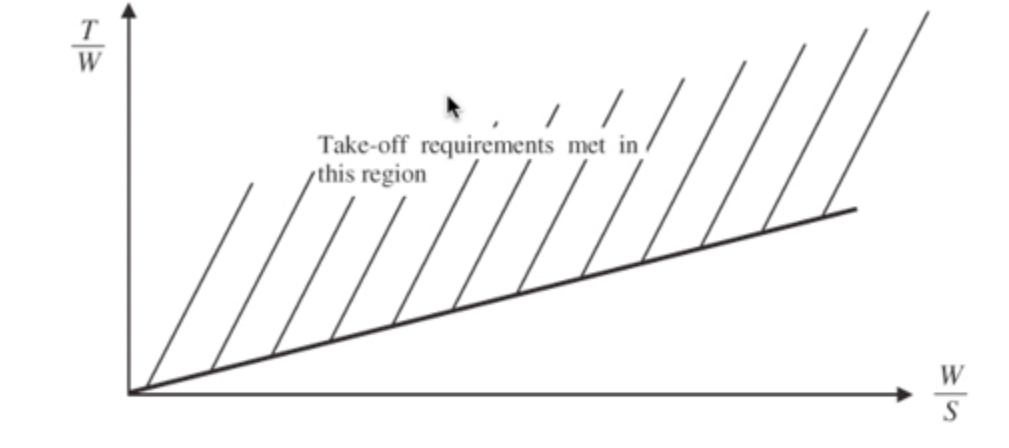
$$T - D - \mu(W - L) = a\frac{W}{g}$$

Step 2

$$\frac{W}{S} = (TOP)\sigma C_{L_{TO}}\left(\frac{T}{W}\right)$$

Step 3

Figure 4.13 Take-off run contribution in constructing a matching plot for a jet aircraft



Wing Surface and Engine Sizing: steps 1,2 and 3

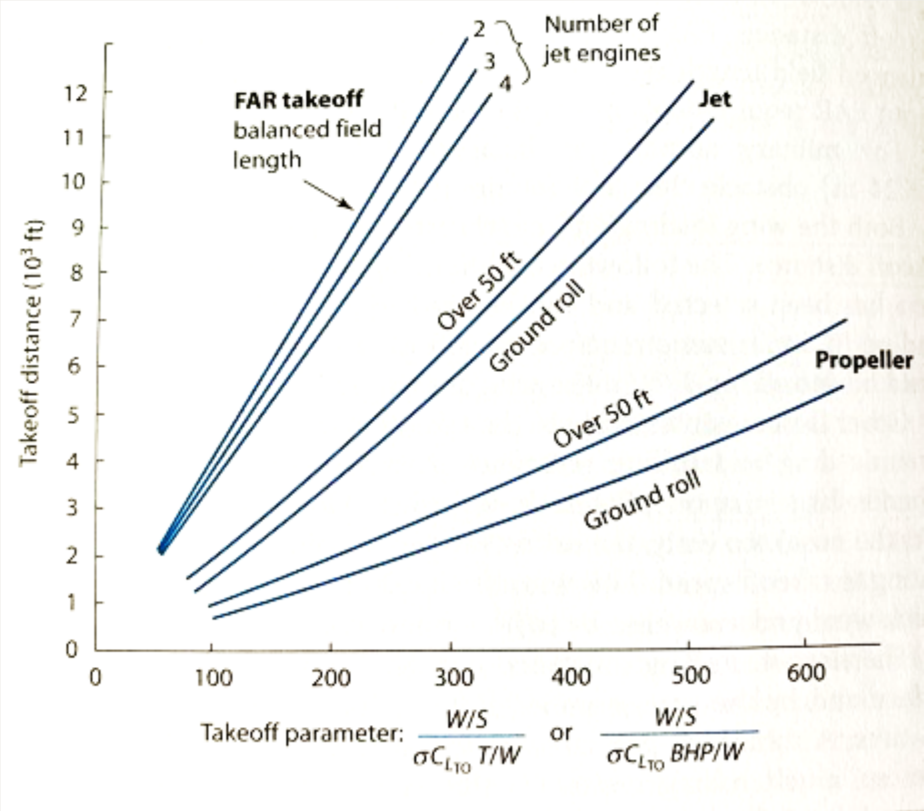
2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Eq.3) Take-off distance (S_{TO})

$$\frac{W}{S} = (TOP)\sigma C_{L_{TO}}\left(\frac{T}{W}\right)$$

TOP is the take-off parameter and can be estimated using the plot by Raymer, once the take-off distance is known



$C_{L_{TO}}$ can be estimated starting from $C_{L_{max}}$. See Roskam to select the proper values, assuming the presence/absence of high lift devices

Wing Surface and Engine Sizing: steps 1,2 and 3

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Eq.4) Rate of Climb (ROC_{max})

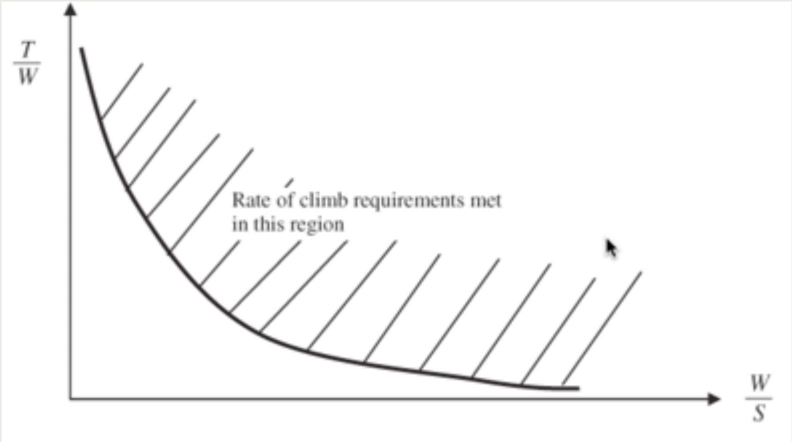
For civil aircraft, climb requirements are set in CS 23 or CS25 and must be met.

Step 1

$$ROC = \frac{P_{available} - P_{requested}}{W}$$

Step 2

$$\frac{T}{W} = \frac{ROC}{\sqrt{\frac{\left(\frac{2W}{S}\right)}{\rho\sqrt{\frac{C_{D_0}}{K}}}}} + \frac{1}{\left(\frac{L}{D}\right)_{max}}$$



Step 3

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

Wing Surface and Engine Sizing: steps 1,2 and 3

Eq.5) Ceiling h_c

The ceiling is defined as the highest altitude that an aircraft can safely have a straight level flight. The absolute ceiling, is the altitude at which the ROC is zero.

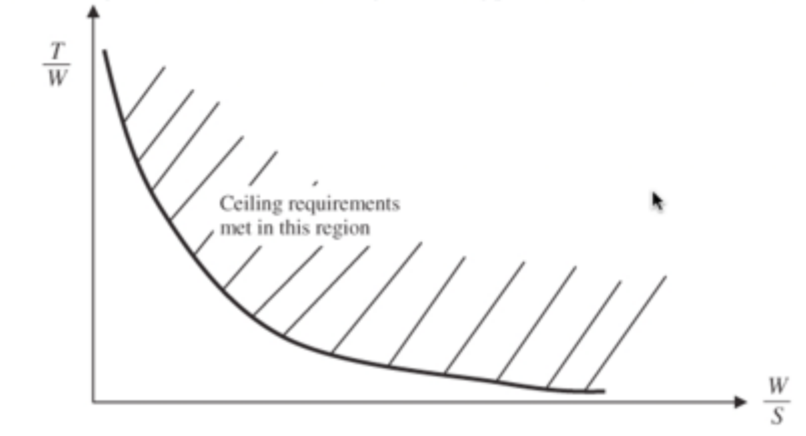
Step 1

$$ROC_C = \frac{P_{available} - P_{requested}}{W}$$

Step 2

$$\frac{T}{W} = \frac{1}{\sigma \left(\frac{L}{D}\right)_{max}}$$

Figure 4.17 Ceiling contribution in constructing a matching plot for a jet aircraft



Step 3

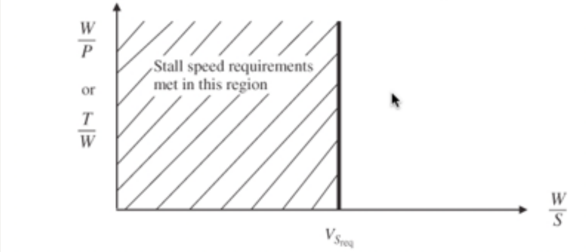
Wing Surface and Engine Sizing: step 4

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

4) Identify the Optimum Design Point inside the acceptable region and evaluate T and S (W is known)

Figure 4.9 Stall speed contribution in constructing a matching plot



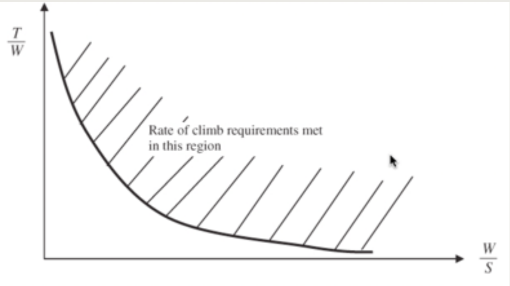


Figure 4.10 Maximum speed contribution in constructing a matching plot for a jet aircraft

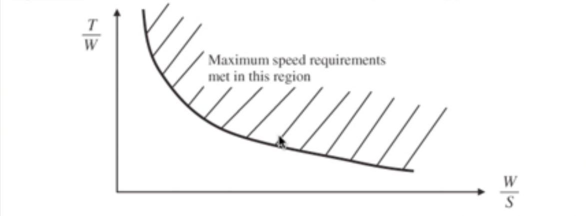


Figure 4.17 Ceiling contribution in constructing a matching plot for a jet aircraft

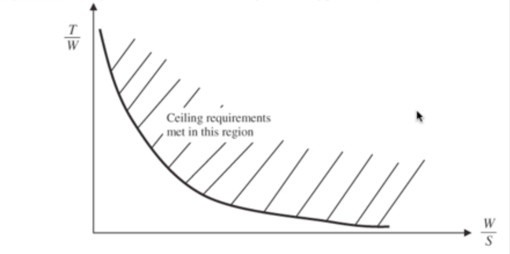
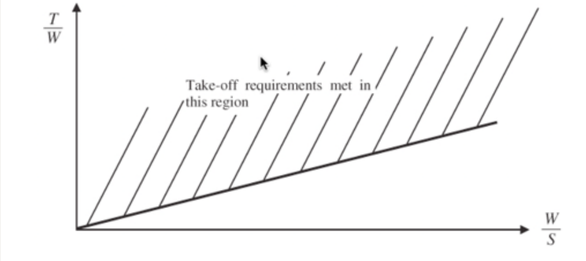


Figure 4.13 Take-off run contribution in constructing a matching plot for a jet aircraft



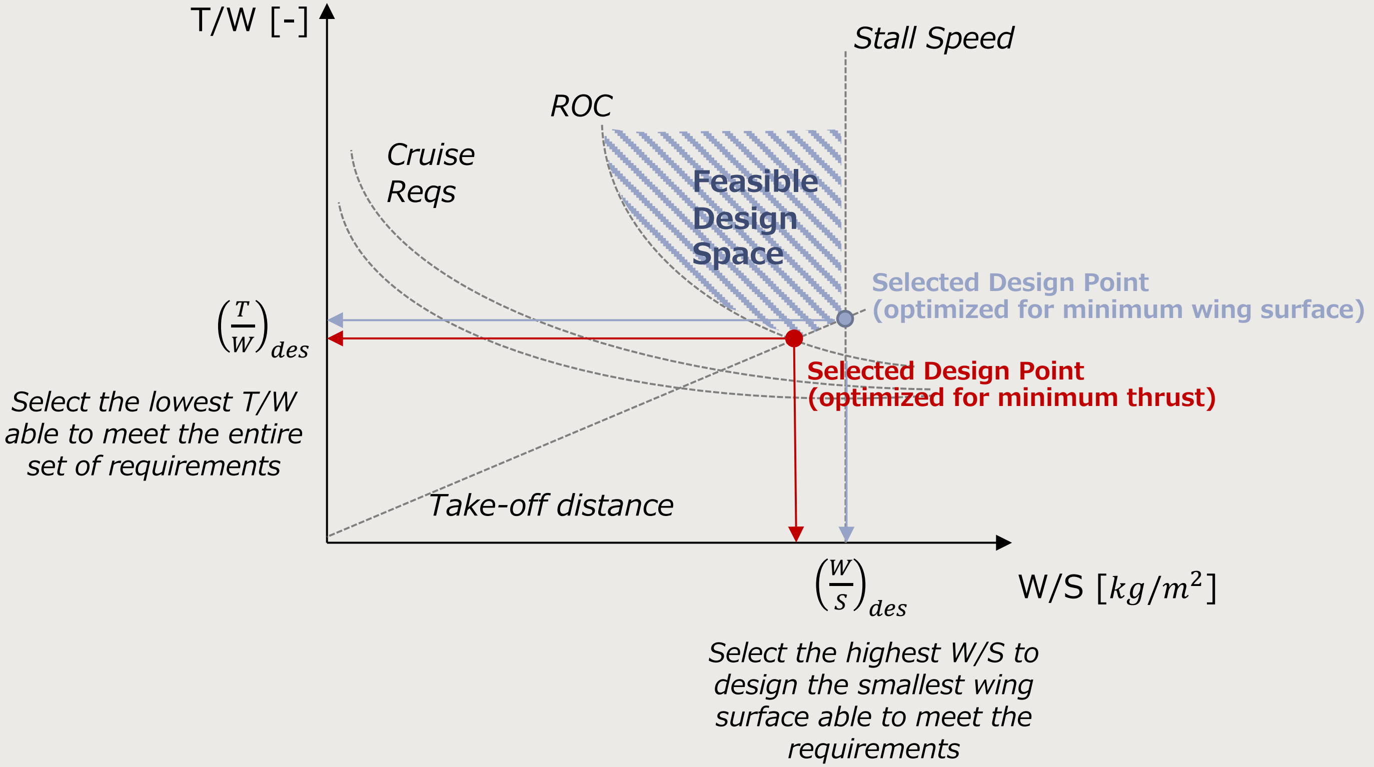
Let's put them all into a single plot
T/W = f(W/S)

Wing Surface and Engine Sizing: step 4

2.3

Guess Data Estimation: Wing Surface and Engine Sizing

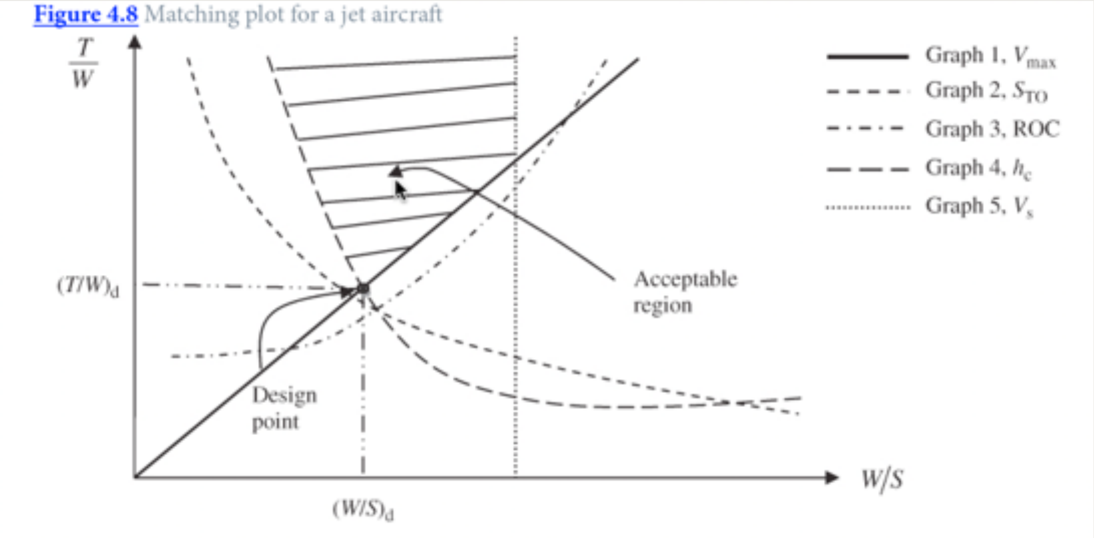
4) Identify the Optimum Design Point inside the acceptable region and evaluate T and S (W is known)



$$T_{des} = \left(\frac{T}{W}\right)_{des} m_{TO}\, g$$

$$S_{des} = \frac{m_{TO}}{\left(\frac{W}{S}\right)_{des}}$$

Case Study: Matching Chart



2.3

Guess Data Estimation: Wing Surface and Engine Sizing

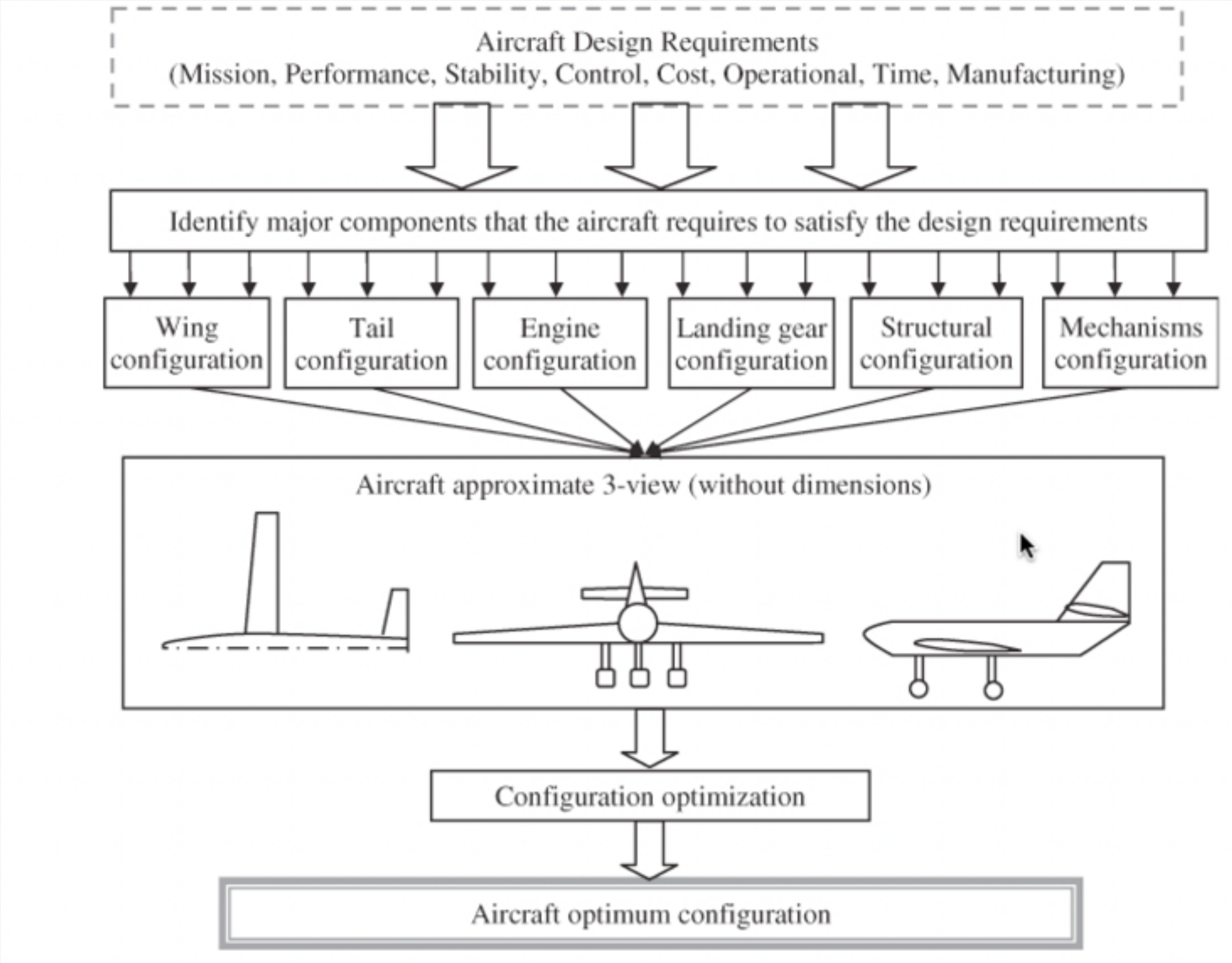
HOMEWORK

Assignment 2.4: Matching Chart
Build the Matching Chart for your case study and define Wing Surface and Engine Thrust

Aircraft and Components configurations

2.4

Aircraft Configuration alternatives



Aircraft and Components configurations

2.4

Aircraft Configuration alternatives

To define the aircraft configuration it is worth starting from the identification of the major aircraft components and their design alternatives. Some ideas are reported in the following table.

Table 3.2 Aircraft major components with design alternatives

No.	Component	Configuration alternatives
1	Fuselage	Geometry: lofting, cross-section Seating arrangement What to accommodate (e.g., fuel, engine, and landing gear)?
2	Wing	Type: swept, tapered, dihedral Installation: fixed, moving, adjustable Location: low wing, mid-wing, high wing, parasol
3	Horizontal tail	Type: conventional, T-tail, H-tail, V-tail, inverted V Location: aft tail, canard, three surfaces
4	Vertical tail	Single, twin, three VT, V-tail
5	Engine	Type: turbofan, turbojet, turboprop, piston-prop, rocket Location: (e.g., under fuselage, under wing, beside fuselage) Number of engines
6	Landing gear	Type: fixed, retractable, partially retractable Location: (e.g., nose, tail, multi)
7	Control surfaces	Separate vs. all moving tail, reversible vs. irreversible, conventional vs. non-conventional (e.g., elevon, ruddervator)

Aircraft and Components configurations

2.4

Aircraft Configuration alternatives

No.	Configuration parameter	Configuration alternatives
1	Conventionality	(i) Conventional and (ii) non-conventional
2	Power	(i) Powered and (ii) unpowered
3	Propulsion	(i) Turbojet, (ii) turbofan, (iii) turboprop, (iv) piston prop, and (v) rocket
4	Number of engine	(i) Single-engine, (ii) twin-engine, (iii) tri-engine, (iv) four-engine, and (v) multi-engine
5	Engine and aircraft cg	(i) Pusher and (ii) tractor
6	Engine installation	(i) Fixed and (ii) tilt-rotor
7	Engine location	(i) Under wing, (ii) inside wing, (iii) above wing, (iv) above fuselage, (v) beside fuselage, and (vi) inside fuselage, etc.
8	Number of wings	(i) One-wing, (ii) biplane, and (iii) tri-plane
9	Wing type	(i) Fixed-wing and (ii) rotary-wing (a. helicopter and b. gyrocopter)
10	Wing geometry	(i) Rectangular, (ii) tapered, (iii) swept, and (iv) delta
11	Wing sweep	(i) Fixed sweep angle and (ii) variable sweep
12	Wing setting angle	(i) Fixed setting angle and (ii) variable setting angle
13	Wing placement	(i) High wing, (ii) low wing, (iii) mid-wing, and (iv) parasol wing
14	Wing installation	(i) Cantilever and (ii) strut-braced
15	Tail or canard	(i) Tail, (ii) canard, and (iii) three-surfaces
16	Tail type	(i) Conventional, (ii) T shape, (iii) H shape, (iv) V shape, and (v) + shape, etc.
17	Vertical tail	(i) No vertical tail (VT), (ii) one VT at fuselage end, (iii) two VT at fuselage end, and (iv) two VT at wing tips
18	Landing gear	(i) Fixed and faired, (ii) fixed and un-faired, (iii) retractable, and (iv) partially retractable
19	Landing gear type	(i) Nose gear, (ii) tail gear, (iii) quadricycle, and (iv) multi-bogey, etc.
20	Fuselage	(i) Single short fuselage, (ii) single long fuselage, and (iii) double long fuselage, etc.
21a	Seating (in two-seat)	(i) Side-by-side and (ii) tandem
21b	Seating (with higher number of passengers)	(i) $1 \cdot n$, (ii) $2 \cdot n$, and (iii) $3 \cdot n, \ldots, 10 \cdot n$ (n = number of rows)
22	Luggage pallet	Based on types of luggage and payload, it has multiple options
23	Cabin or cockpit	(i) Cabin and (ii) cockpit
24	Horizontal tail control surfaces	(i) Tail and elevator and (ii) all moving horizontal tail
25	Vertical tail control surfaces	(i) Vertical tail and rudder and (ii) all moving vertical tail
26	Wing control surfaces	(i) Aileron and flap and (ii) flaperon
27	Wing-tail control surfaces	(i) Conventional (elevator, aileron, and rudder), (ii) ruddervator, (iii) elevon, (iv) split rudder, and (v) thrust-vectored
28	Power system	(i) Mechanical, (ii) hydraulic, (iii) pneumatic, (iv) FBW,[a] and (v) FBOb[b]
29	Material for structure	(i) Full metal, (ii) full composite, and (iii) primary structure: metal, secondary structure: composite
30	Secondary control surfaces	(i) Trailing edge flap, (ii) leading edge slot, and (iii) leading edge slat

[a] Fly-by-wire (electrical signal).

[b] Fly-by-optic (light signal).

Start imaging your aircraft layout and the configuration of its main component.

In the coming lectures, you will be guided through the selection of the best architecture and preliminary sizing of main aircraft components.

What’s next?

Lesson 3 (15th October)

- ✓ Q&A session (about Lesson 1 and Lesson 2 Assignments)
- ✓ Introduction to CAD Modelling