



Regional Seminar

Aircraft stability on the ground and aircraft centre of gravity limits

Presented by
Steve BARKER / Senior Performance Engineer

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- 2 Basic loading rules
- 3 Aircraft CG limitations

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1 Aircraft ground stability

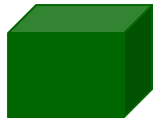
2 Basic loading rules

3 Aircraft CG limitations

1 Aircraft ground stability

- Tip up limit definition
 - Cargo offloading

Weight on NLG

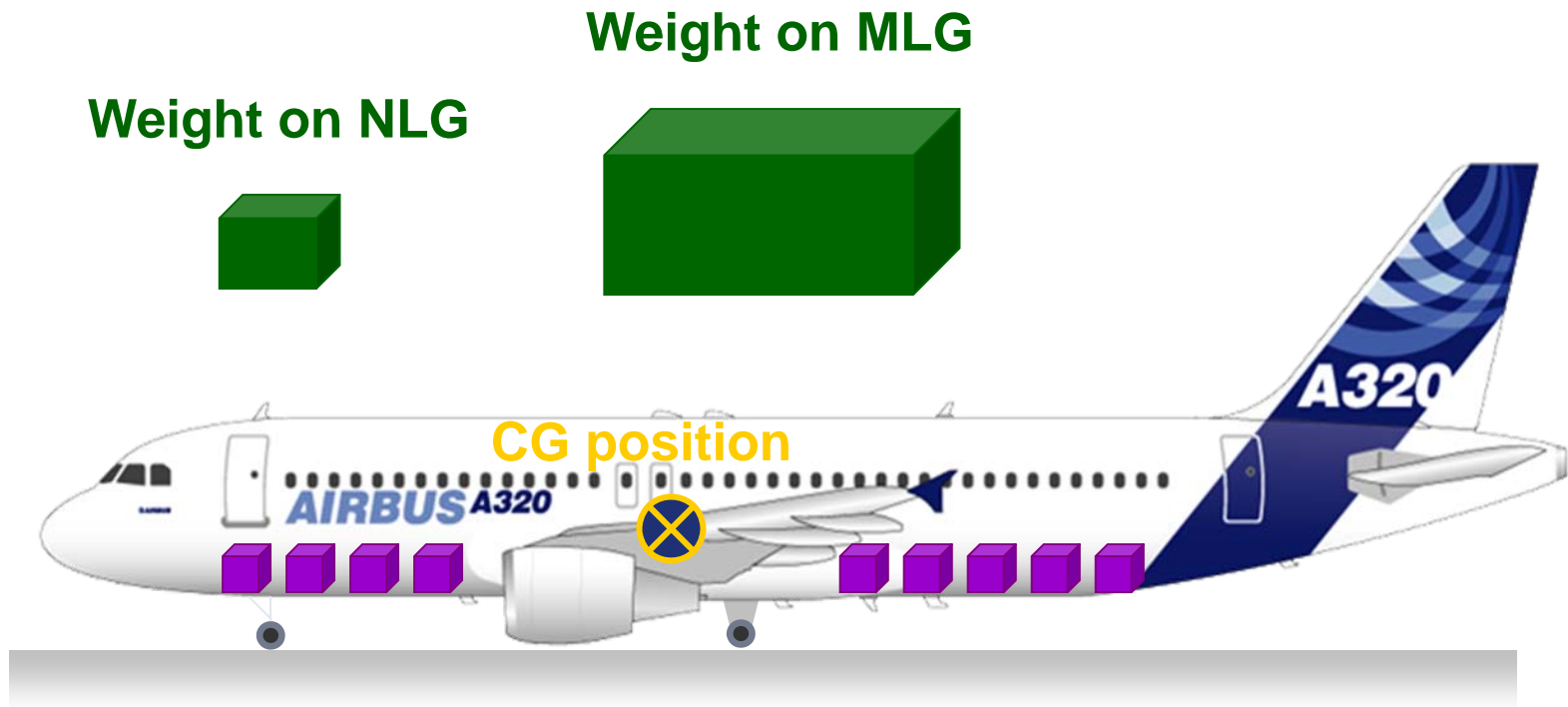


Weight on MLG



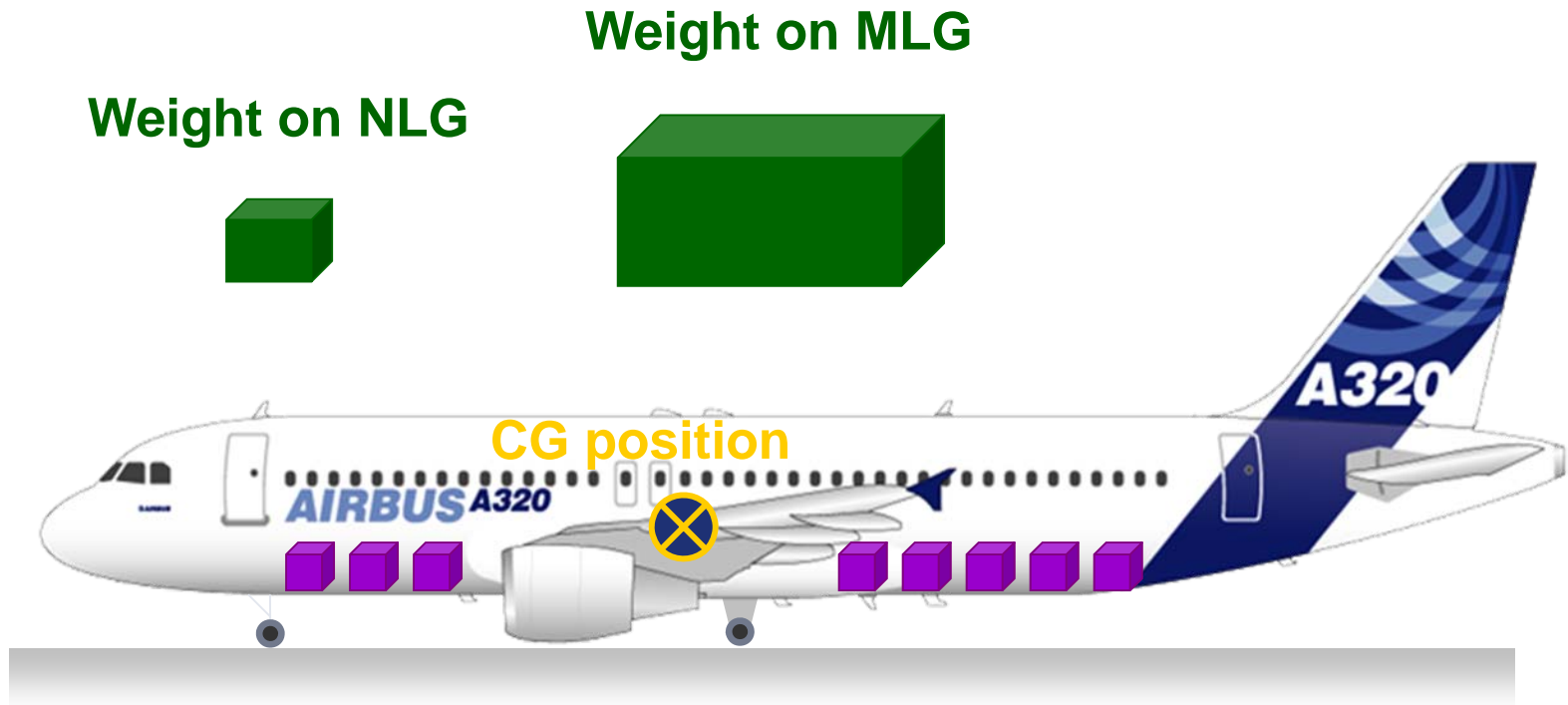
1 Aircraft ground stability

- Tip up limit definition
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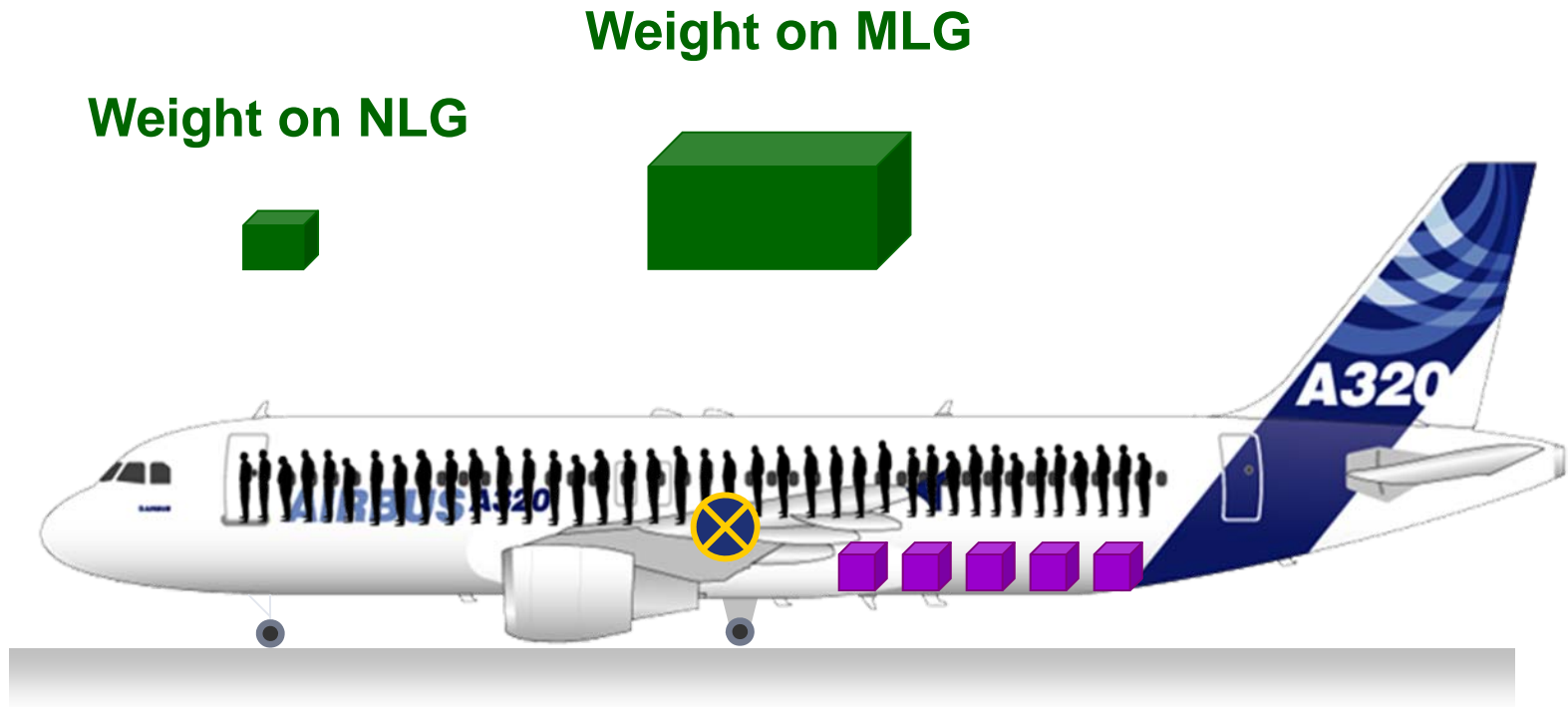
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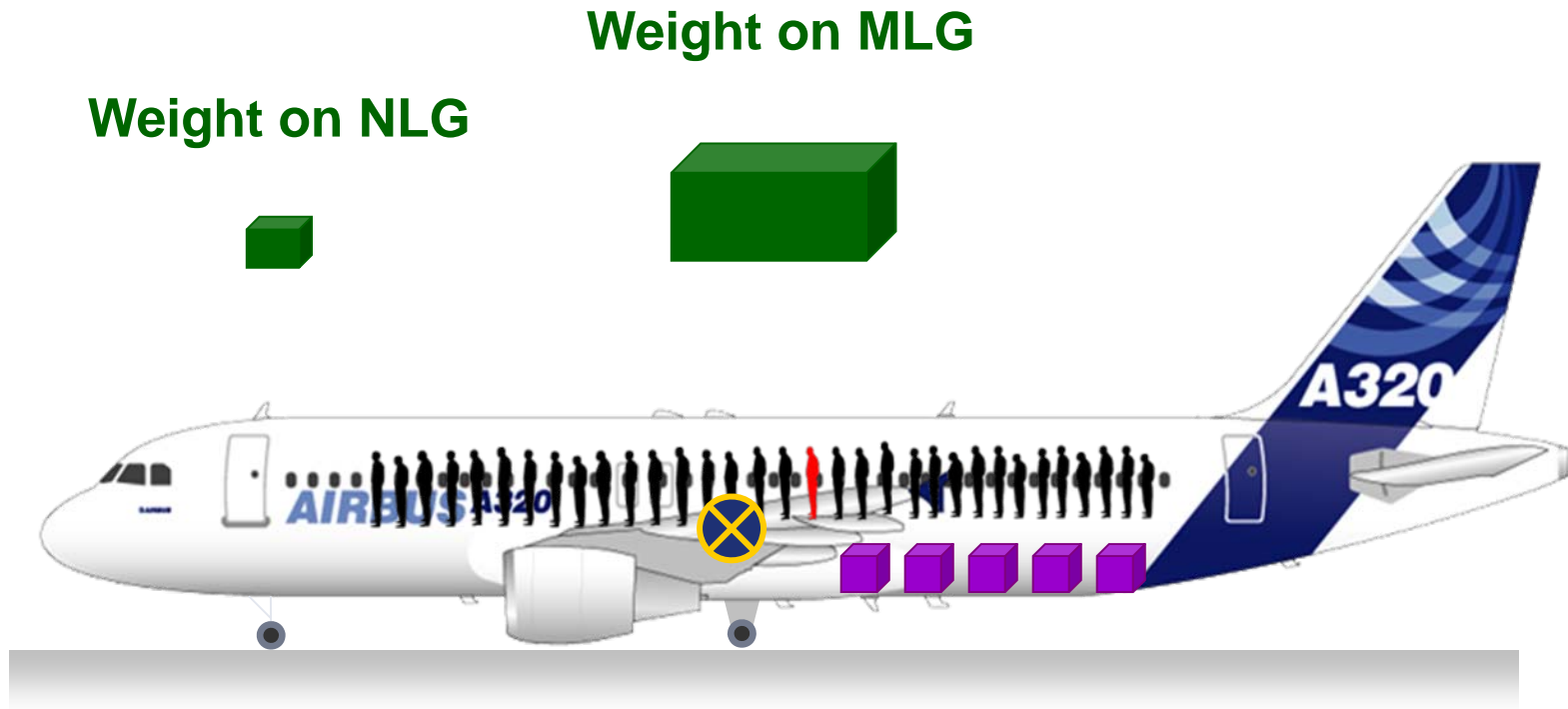
1 Aircraft ground stability

- Tip up limit definition
 - Passengers disembarking



1 Aircraft ground stability

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 - Passengers disembarking



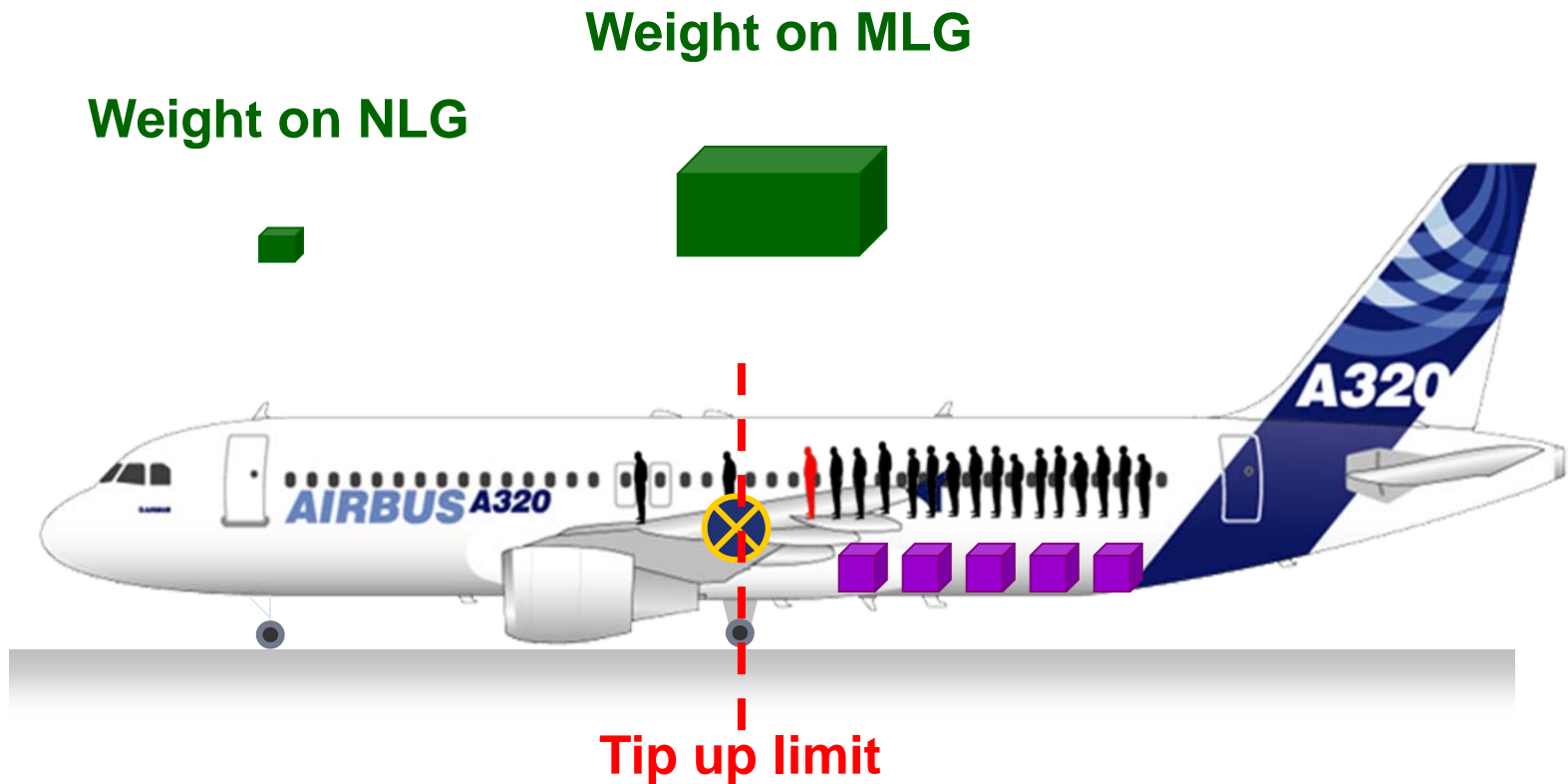
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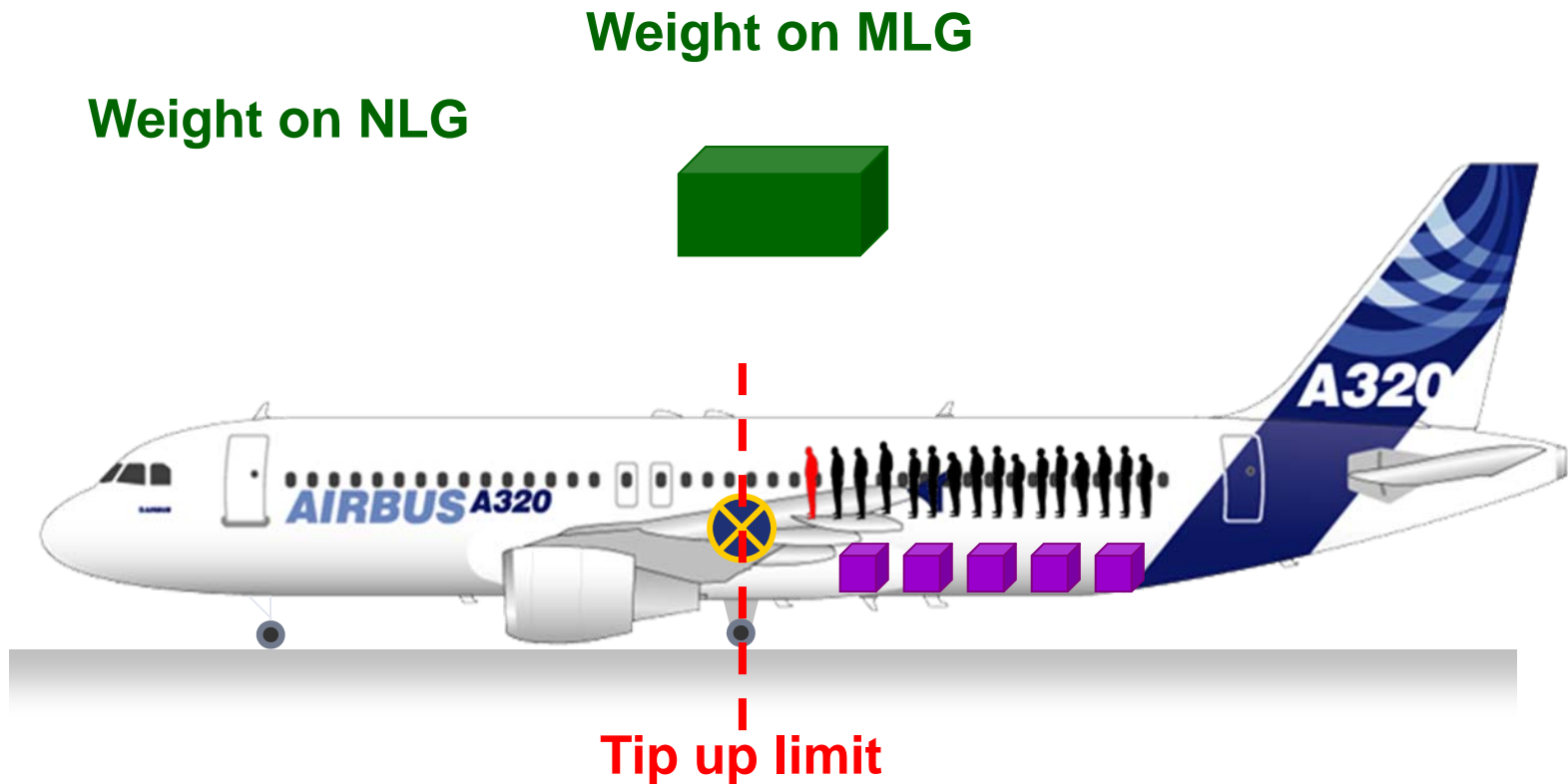
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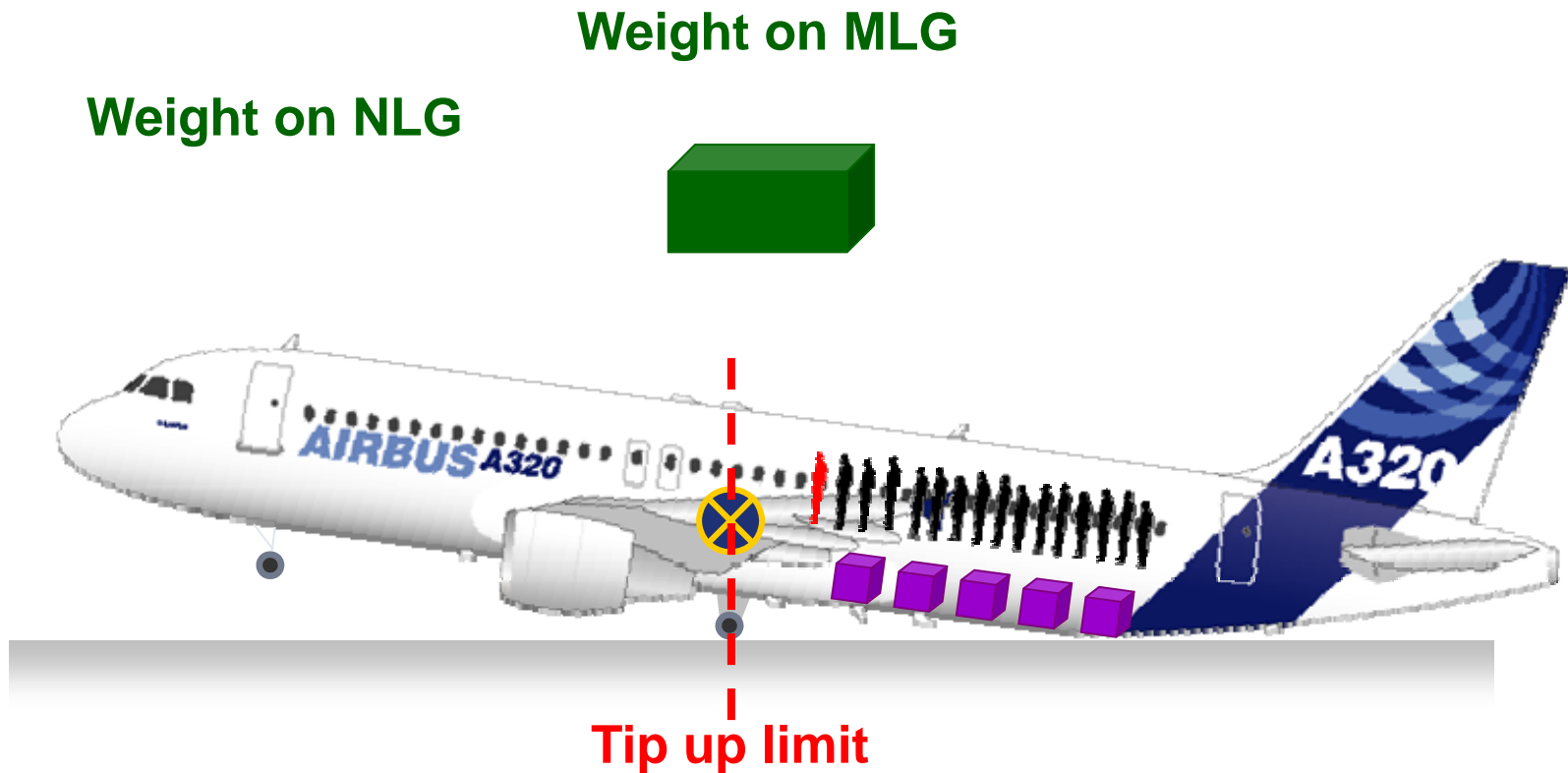
1 Aircraft ground stability

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1 Aircraft ground stability

- Tip up limit definition
 - Passengers disembarking



1 Aircraft ground stability

- Tip up detection
 - In the cockpit: ECAM warning
 - On ground: Nose strut extension
 - At aircraft doors: Stairs/ramp misaligned

Stop loading/unloading cargo

1 Aircraft ground stability

- Wind effect

Weight on NLG



Weight on MLG



Pitch up moment



Lift



Tip up limit



1 Aircraft ground stability

- Wind effect

Weight on NLG



Weight on MLG



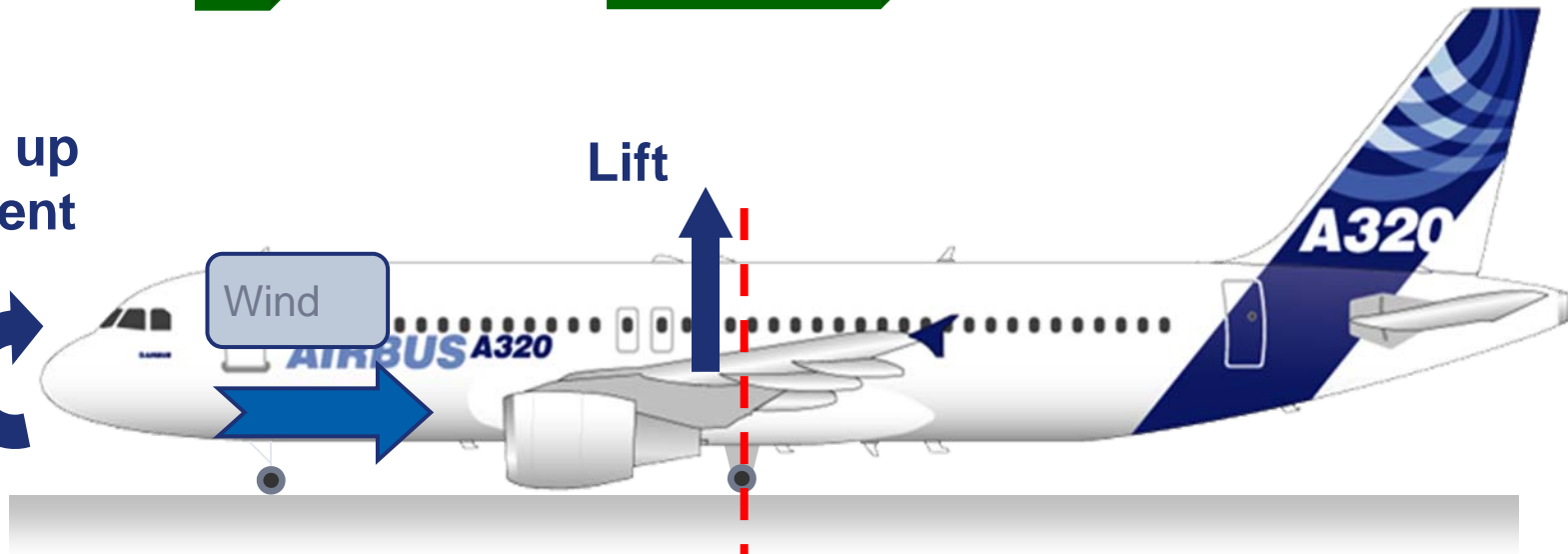
Pitch up moment



Lift

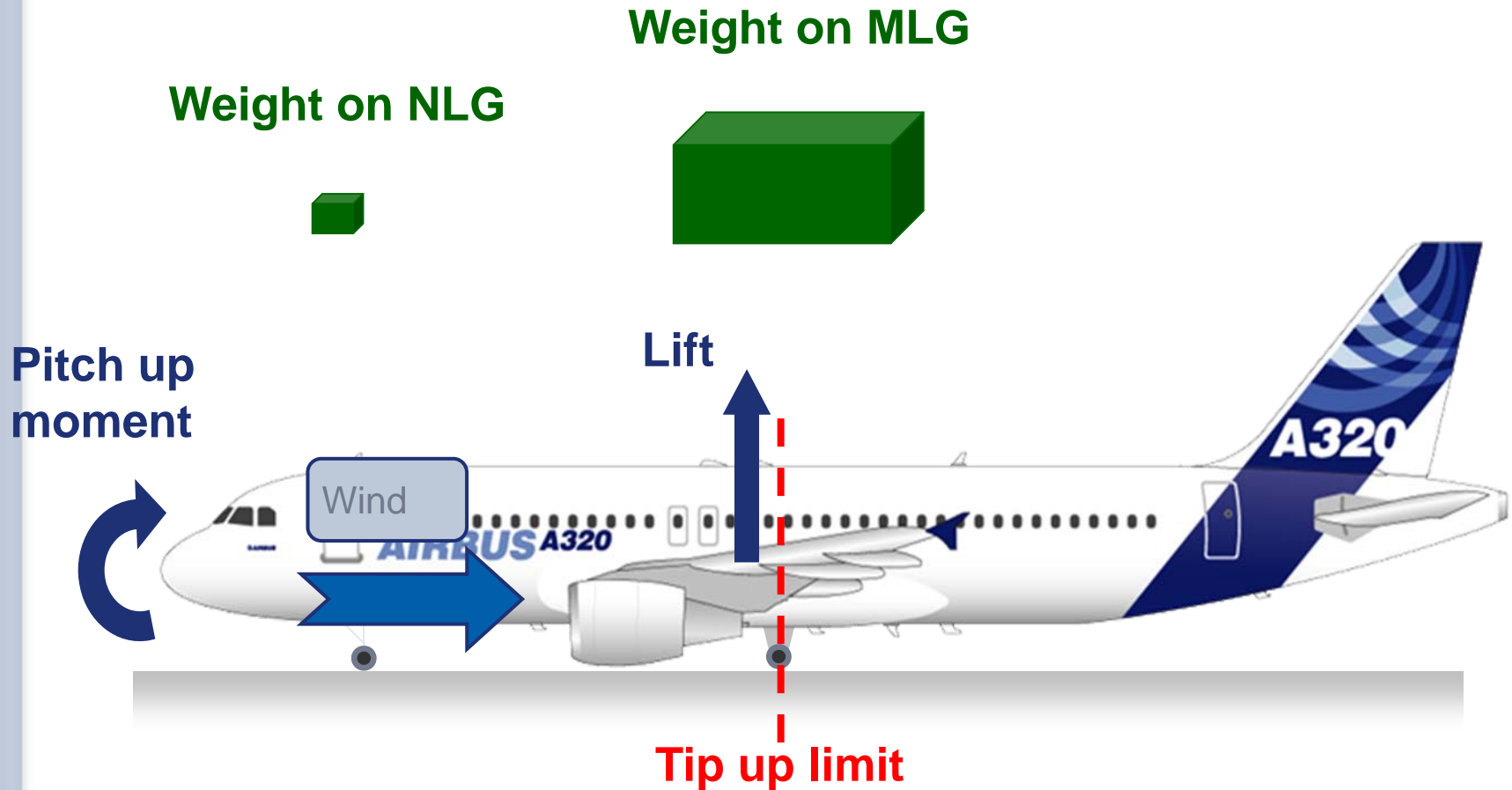


Tip up limit



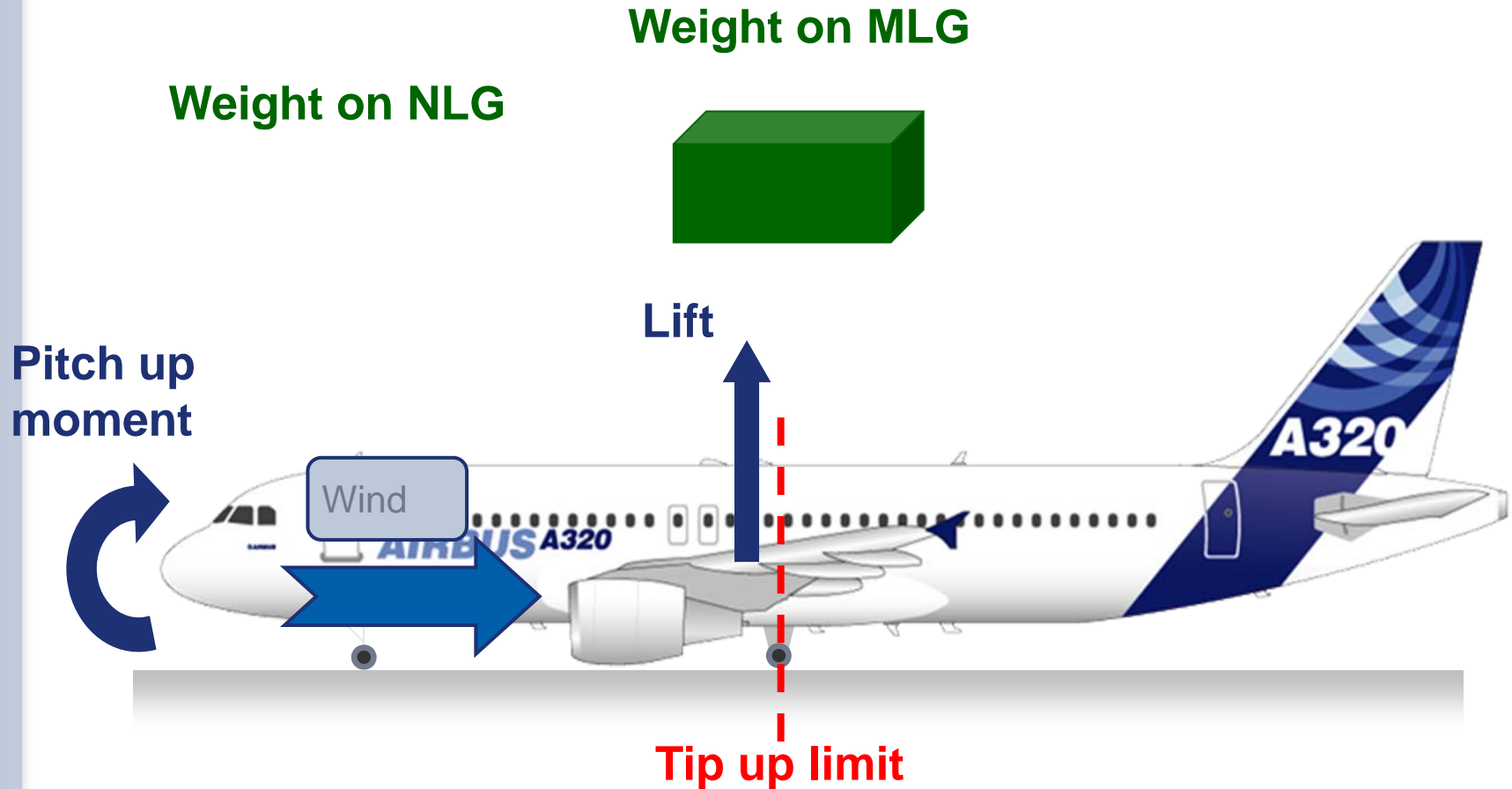
1 Aircraft ground stability

- Wind effect



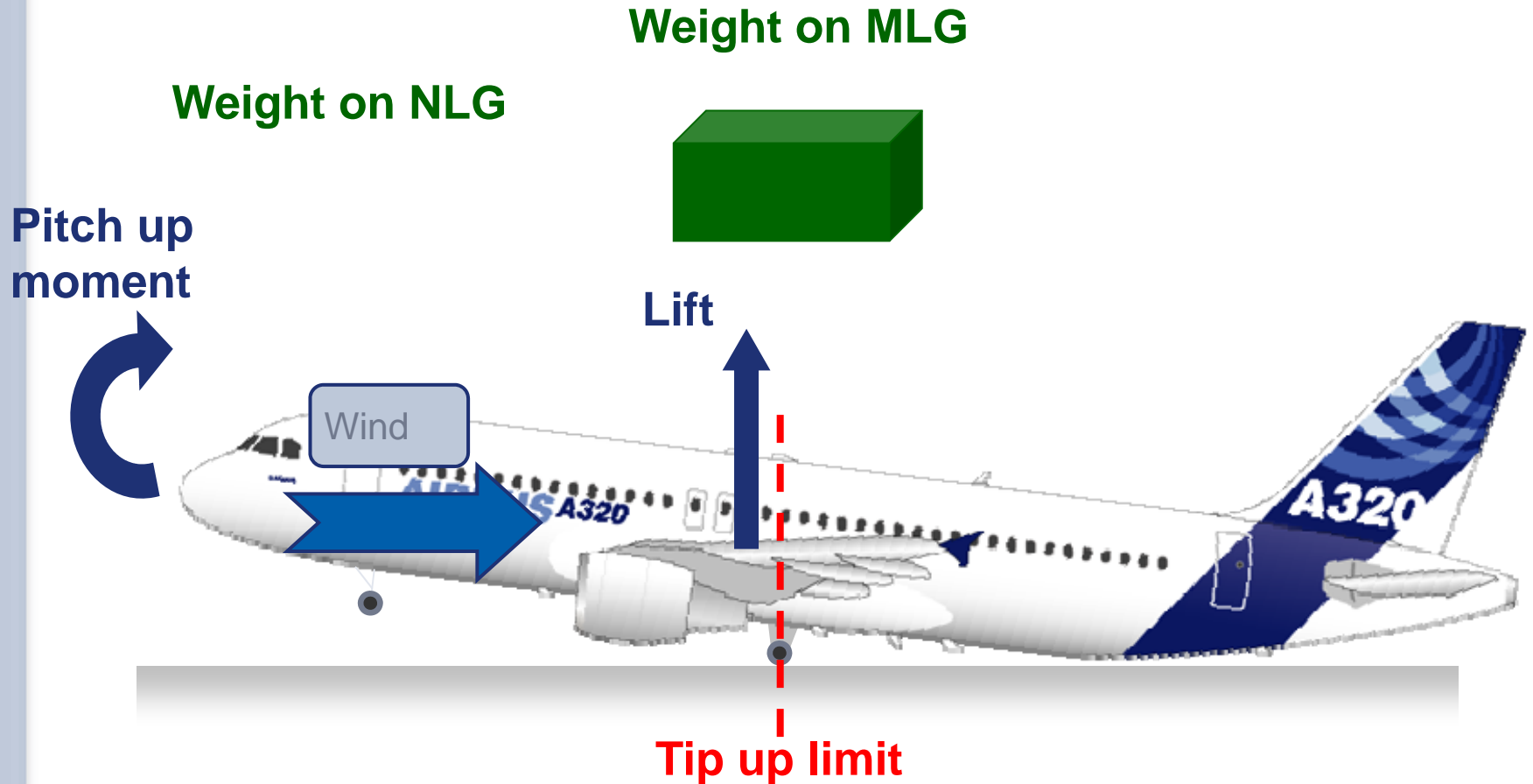
1 Aircraft ground stability

- Wind effect



1 Aircraft ground stability

- Wind effect



1 Aircraft ground stability

- Sensitivity to tip-up
 - Aircraft nose or tail heavy



A318
A321



A319
A330
A380
A310
A321 with ACTs

A320
A340
A300-600

1 Aircraft ground stability

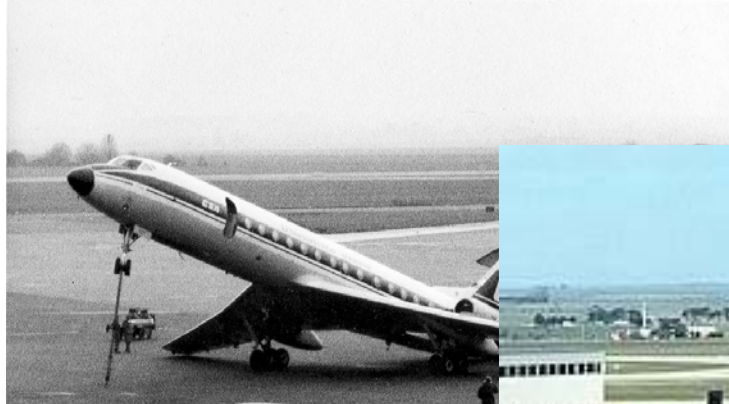


Photo by Kjell Nilsson

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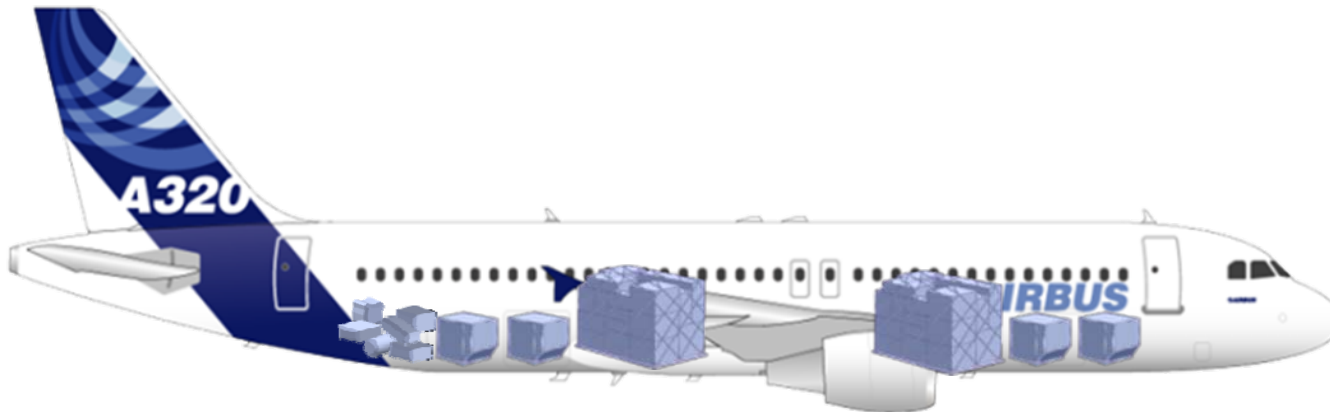
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Aircraft CG limitations

2

Basic loading rules

- Distributing the cargo load
 - Pyramid-shaped loading
 - Place heavier loads closest to the wing box



2

Basic loading rules

- Loading & offloading procedures
 - An aft TOCG may improve takeoff/landing performance and handling, but in some cases (A320).....

It increases the risk of tail-tipping

Following simple rules during the process of loading and offloading will help preventing tail-tipping

2

Basic loading rules

- Loading & offloading procedures
 - Golden rules
 - Keep the maximum weight as forward as possible
 - On A320 avoiding loading & offloading passengers through the rear passenger door

Loading/offloading cargo hold sequences:

Load forward cargo hold before loading aft hold



Unload aft cargo hold before unloading forward hold

2

Basic loading rules

- Loading distribution
 - Passengers
 - Make sure the number of passengers per section is correct
 - Make sure distribution of passengers per section is not extreme
 - Cargo
 - Check for containers or pallets wrongly positioned
 - Check data on loading documents match the real load
 - Nets
 - Check installation & condition of nets

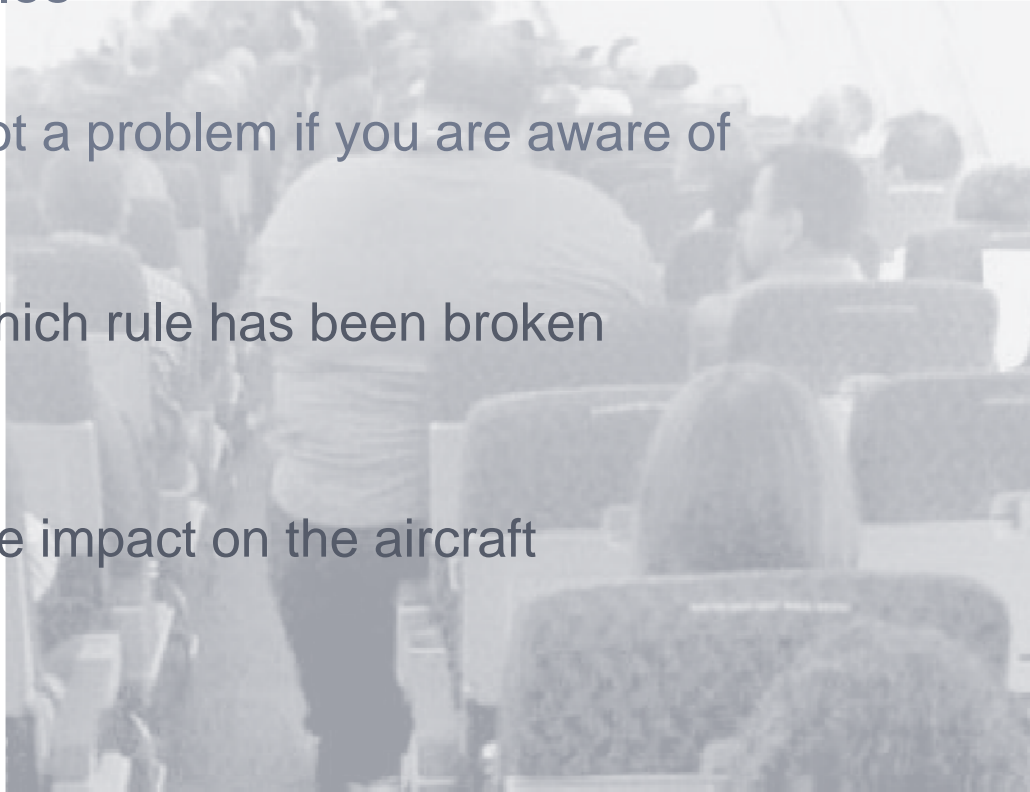
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Basic loading rules

- In some cases, it may not be necessary to follow all of the above mentioned rules

... this is not a problem if you are aware of

- which rule has been broken
- the impact on the aircraft



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Aircraft ground stability

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Basic loading rules

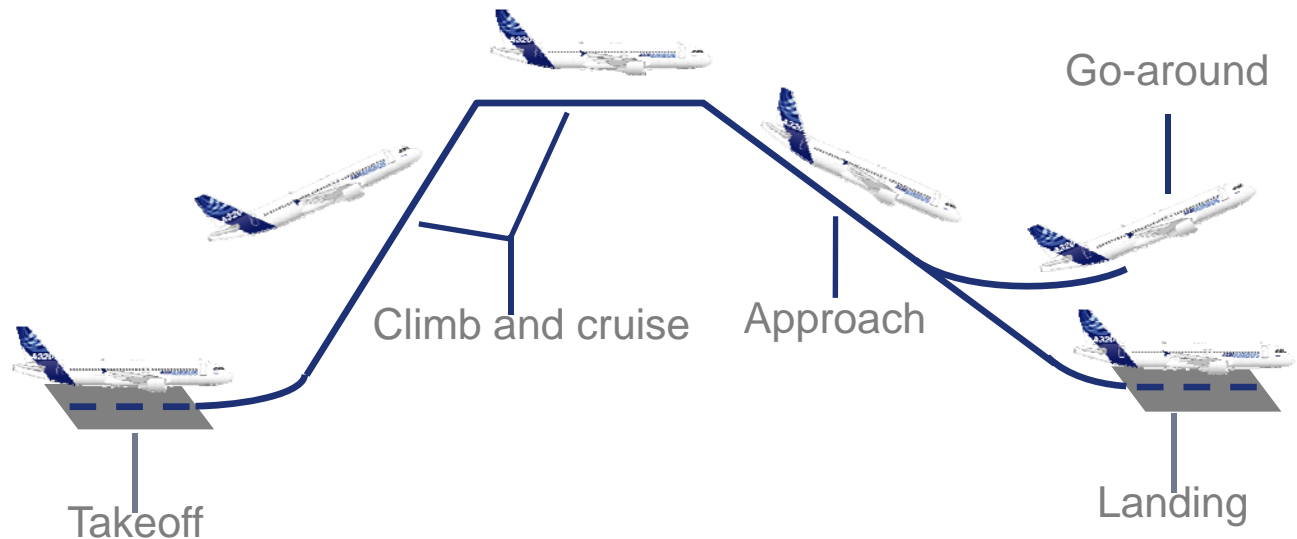
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Aircraft CG limitations

3

Aircraft CG limitations

- In addition to the risk of tail tipping, the CG location, both forward and aft, plays a vital role in aircraft manoeuvrability.
 - On the ground
 - Structural and controllability limitations
 - In the air
 - Manoeuvrability and stability



3

Aircraft CG limitations on the ground

- Takeoff limits summary



FORWARD

- ① Nose gear strength (high TOW)
- ② Ability to rotate
- ③ Manoeuvrability
 - + elevator efficiency
- ④ Maximum elevator deflection
 - + extreme load factor

AFT

- ① Main gear strength (high TOW)
- ② Nose gear adherence
- ③ Tail strike

3

Aircraft CG limitations on the ground

- Landing limits summary



FORWARD

- ① Nose gear strength
- ② Manoeuvrability
+ elevator efficiency
- ③ Maximum elevator deflection
+ extreme load factor
- ④ THS stall limit

AFT

- ① Main gear strength
- ② Neutral point
- ③ Go-around
- ④ α -floor protection

3 Aircraft CG limitations in the air

- In-Flight limits summary



FORWARD

- ① Manoeuvrability
+ elevator efficiency
- ② Maximum elevator deflection
+ extreme load factor
- ③ THS stall limit

AFT

- ① Neutral point
- ② 1° per g
- ③ Go around
- ④ α -floor protection

Handling qualities / Structures

Conclusion

Aircraft CG is critical to aircraft safety

- Controlled loading and offloading of passengers and cargo is essential to avoid tail tipping
- Simple basic rules to be followed
- Aircraft CG impacts all phases of flight

Understanding aircraft CG improves safety

Thank you

Xie xie

谢谢



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