



VTOL Design Loads and Interaction of Systems and Structures

Emily LEWIS
Structures and Cabin Safety Expert

Your safety is our mission.

An Agency of the European Union 

Design Loads VTOL MoC

→ General

→ Design Load Requirements:

→ VTOL.2200 Structural Design Envelope

→ VTOL.2215 Flight loads conditions

→ VTOL.2205 Interaction of systems and structures

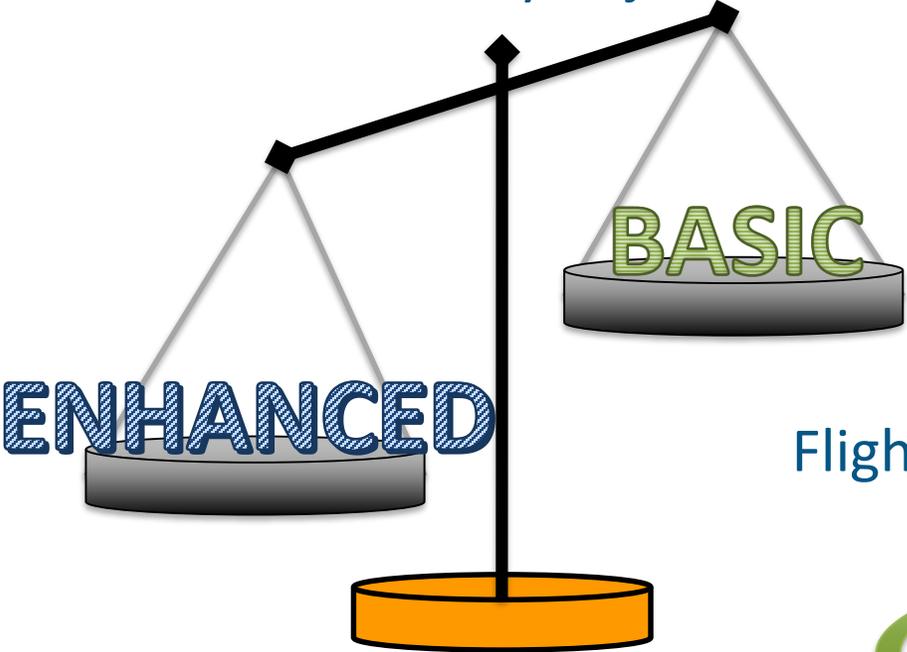
→ VTOL.2220 Ground and water loads

→ Summary

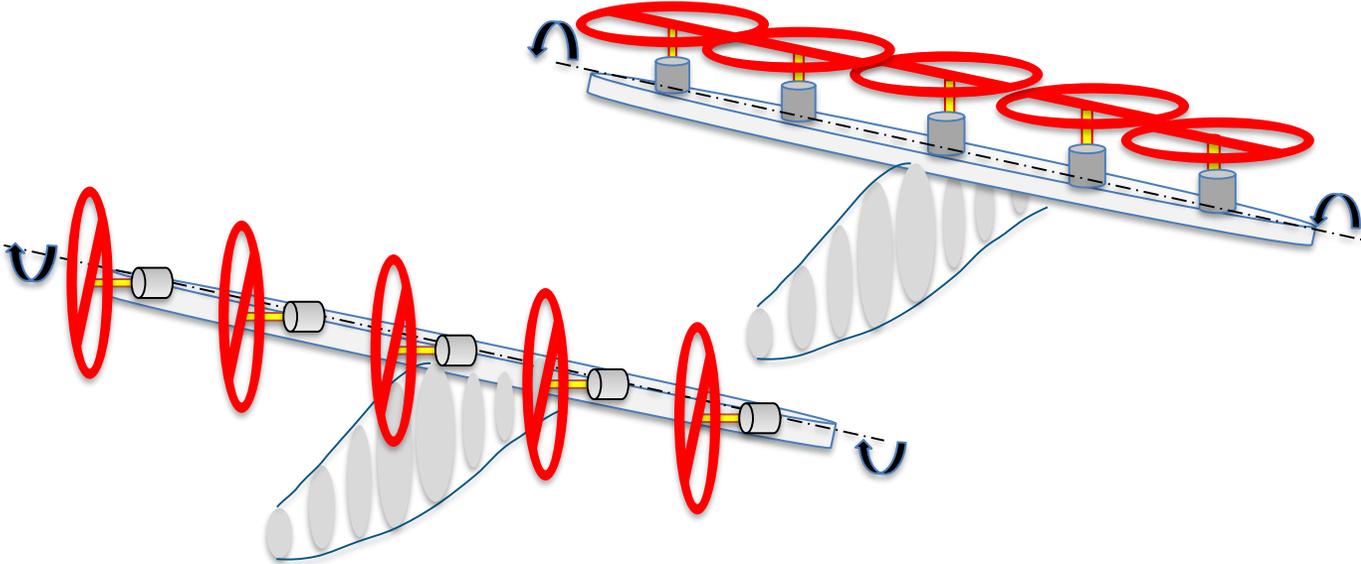
General

Complexity of VTOL aircraft

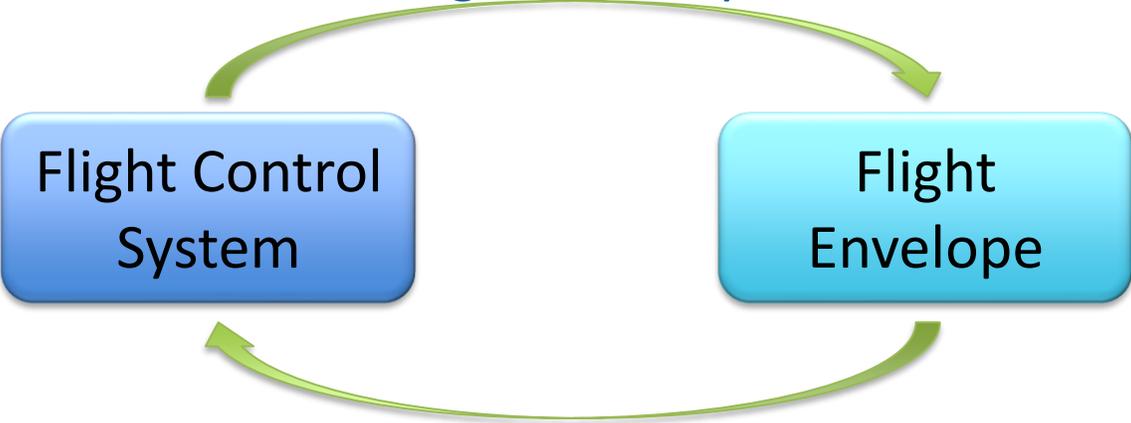
Different safety objectives:



Different configurations and modes:

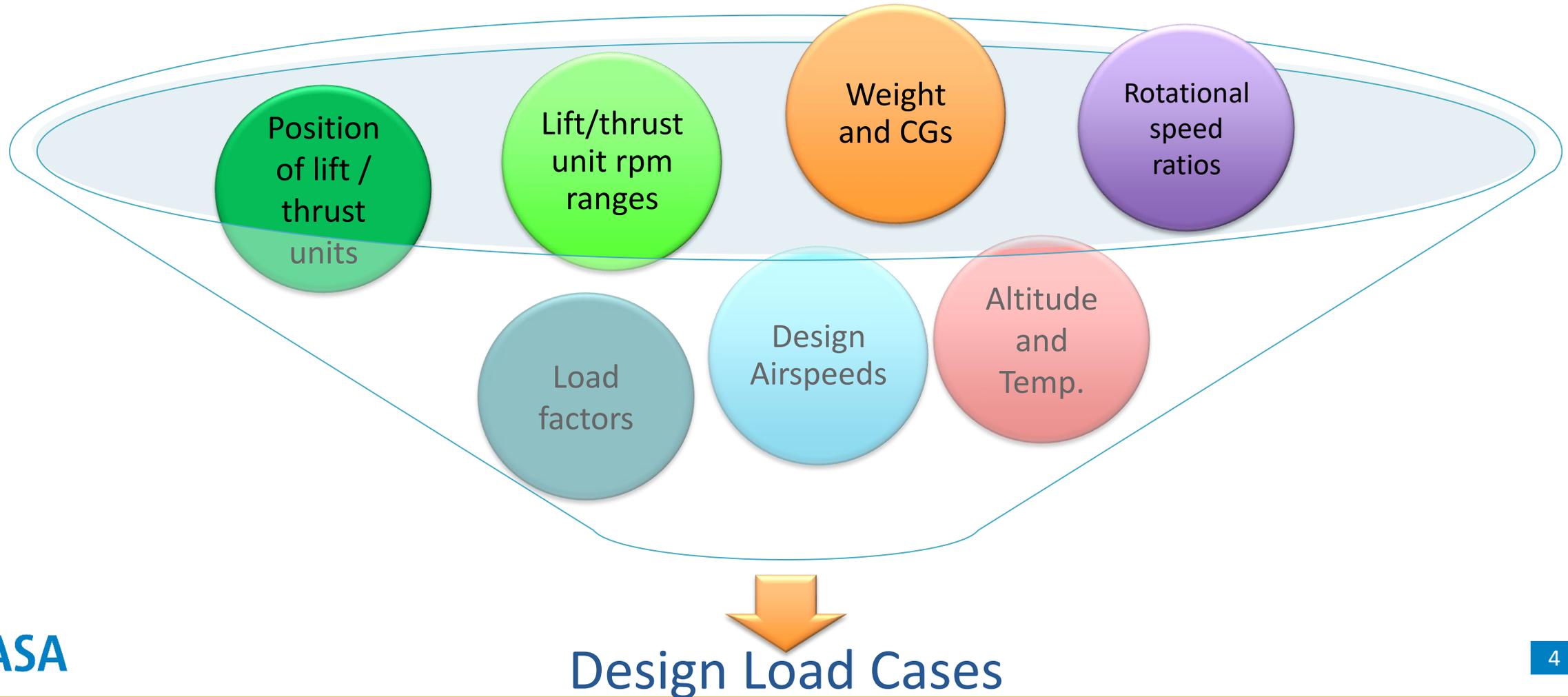


Flight control system interaction with flight envelope:

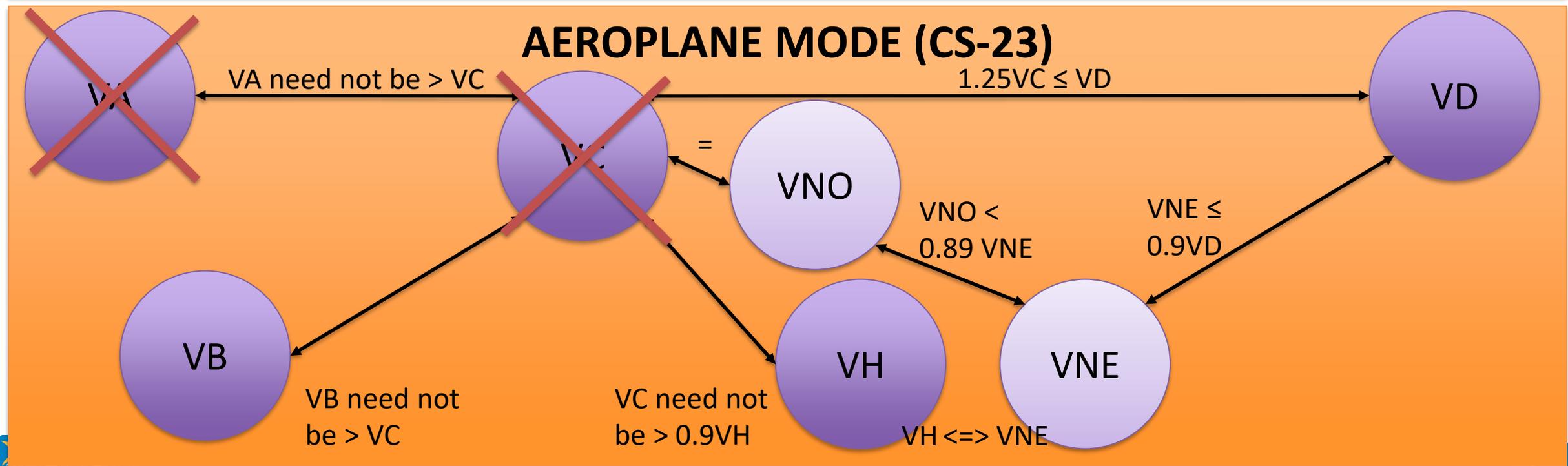
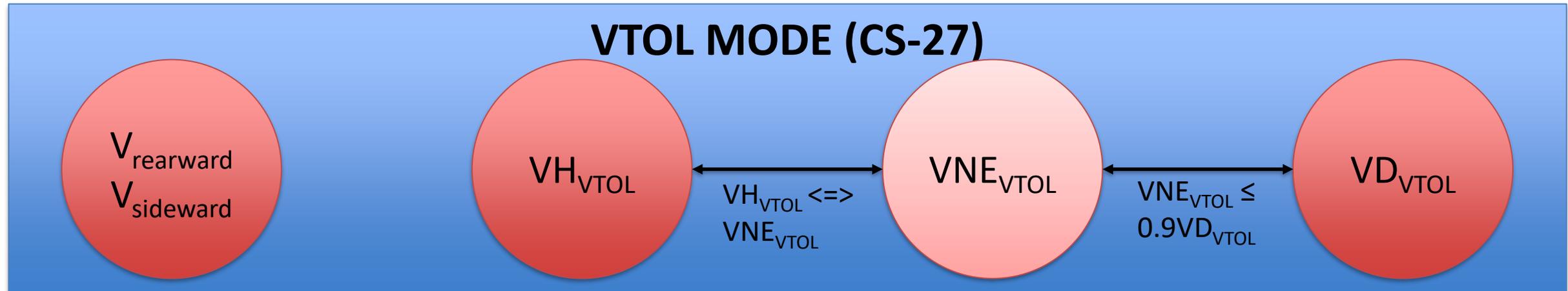


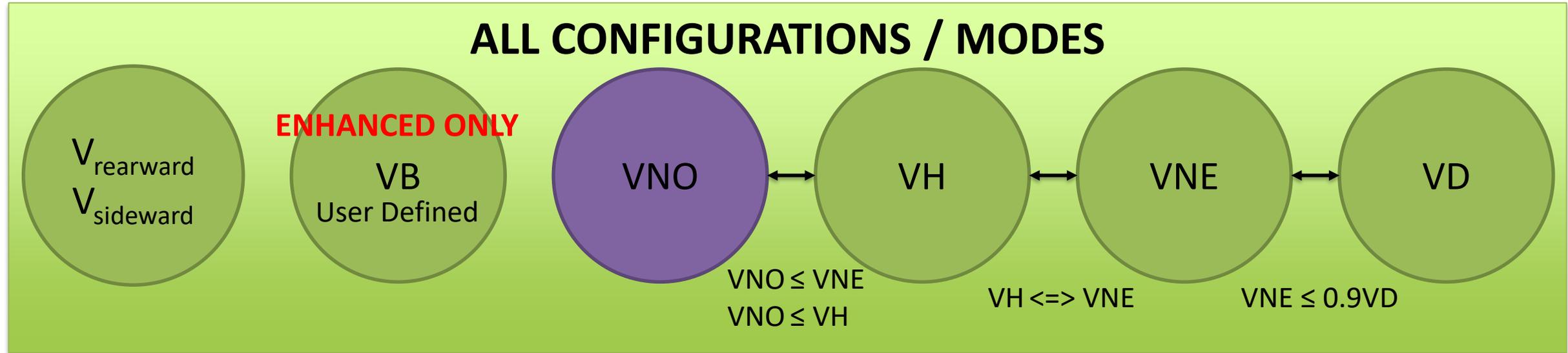
VTOL.2200 Structural Design Envelope

- Proposed MOC published 25 May 2020
- 15 comments reviewed and MOC under revision

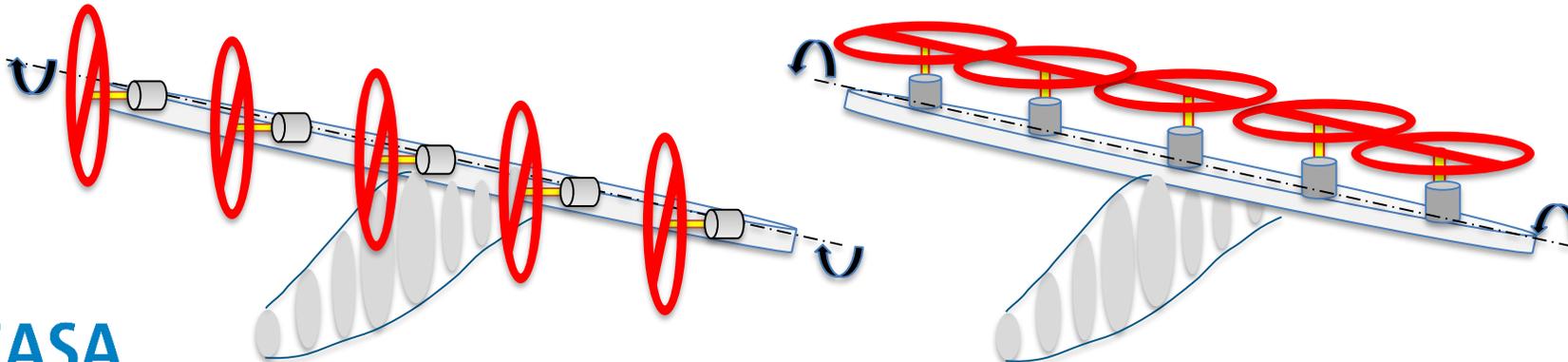


VTOL.2200 Design Airspeeds



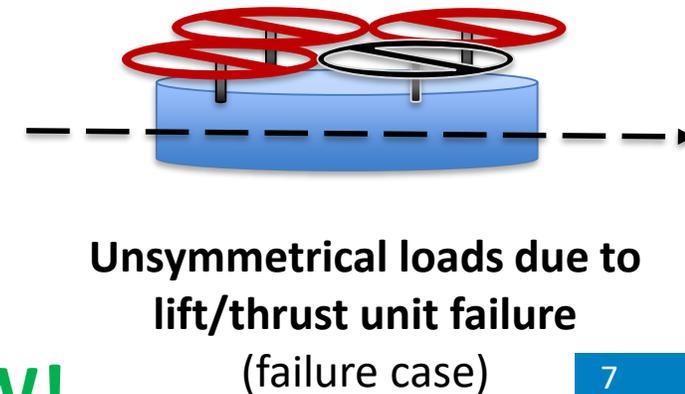
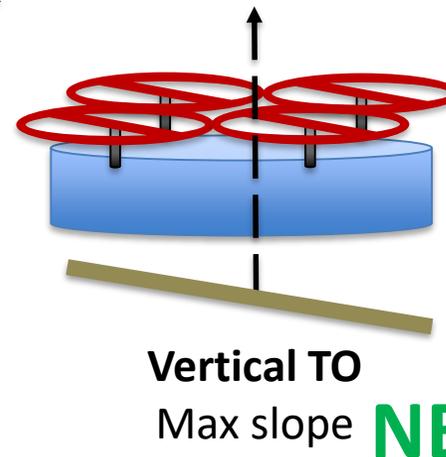
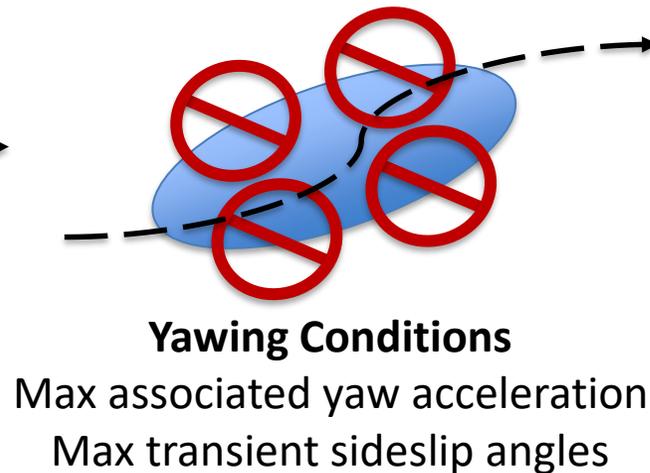
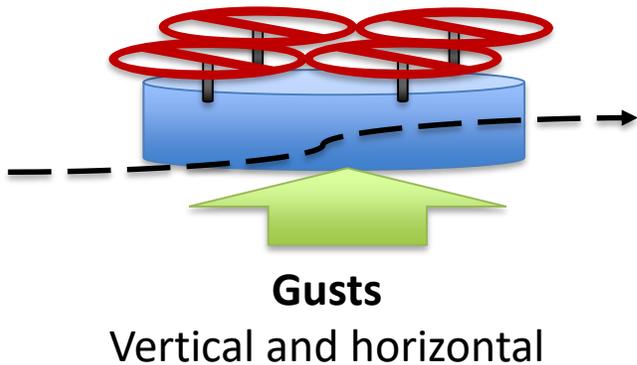
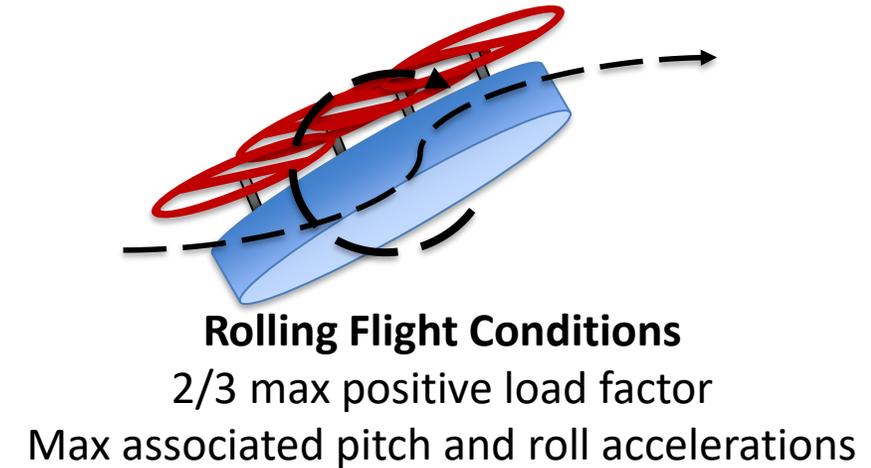
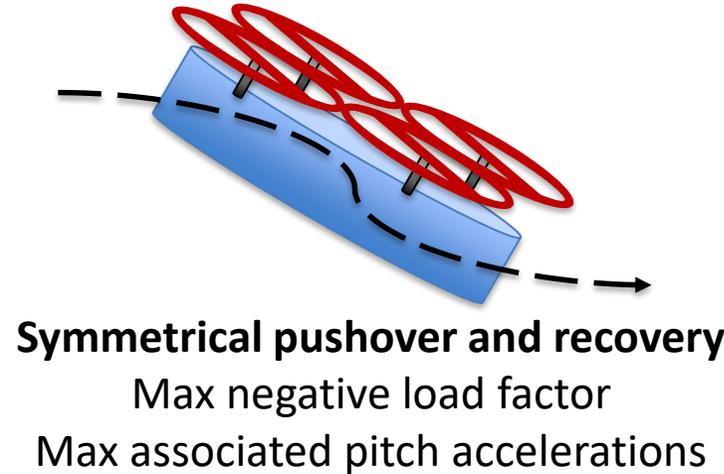
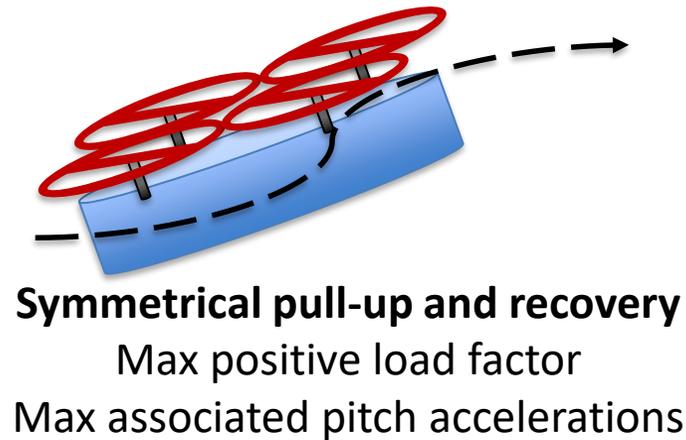
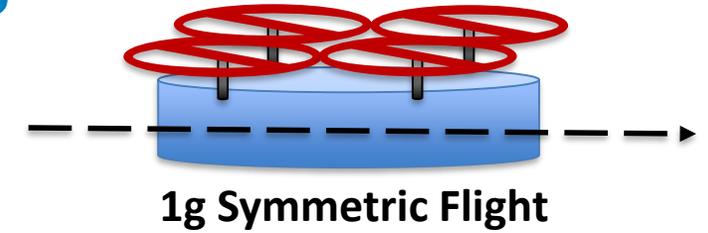


**All configurations and modes should be considered for design airspeed(s)
definition: more than one airspeed definition set may be necessary**

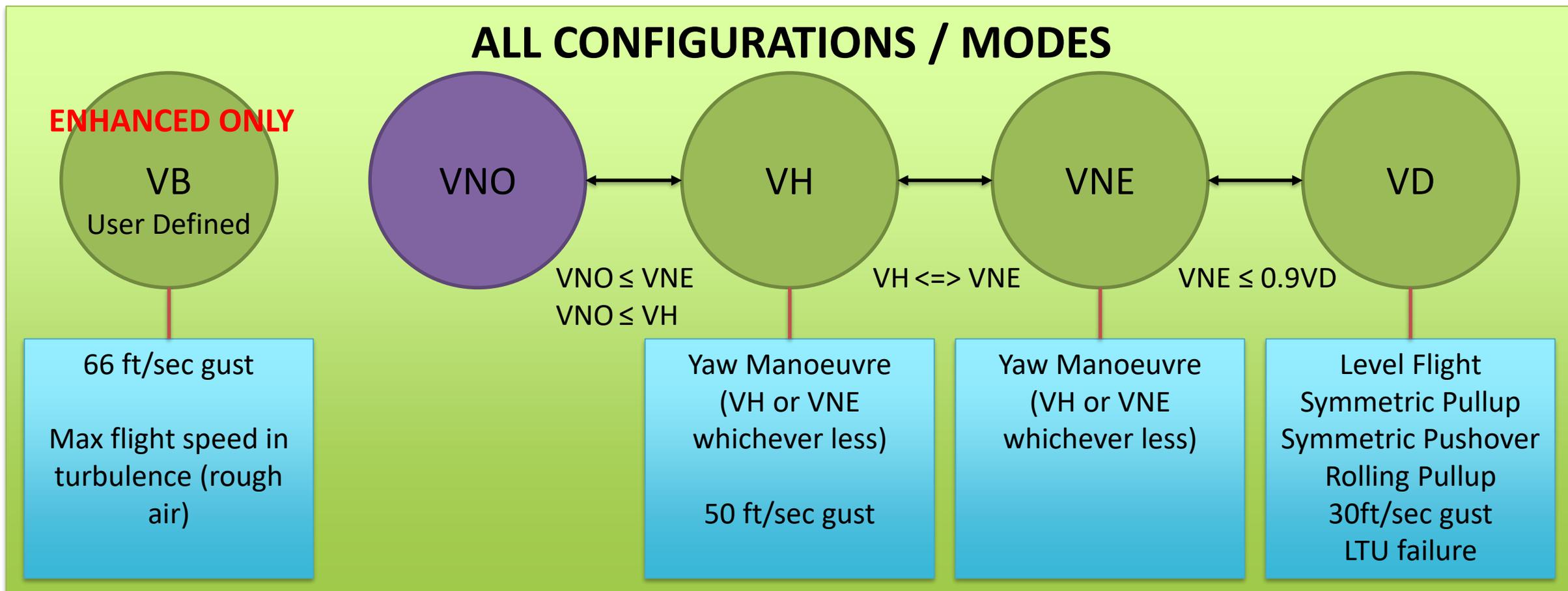


VTOL.2215(a) Flight Load Conditions

- Proposed MOC published 25 May 2020
- 19 comments reviewed and MOC under revision



Design Airspeeds / Flight Loads



All critical speeds and configurations should be considered for each flight manoeuvre, up to the aircraft maximum defined: VD(s), VH(s) or VNE(s)

VTOL.2205 Interaction of systems and structures

System failures:

Flight control systems (FBW)

Autopilots

Stability augmentation systems

Load alleviation

Flutter control

Fuel / energy management

VTOL.2205 Interaction of systems and structures

→ MOC based on CS 25 Appendix K



→ Scenarios to consider:

System fully operable	System in failure condition		Failure indication	Dispatch with known failure conditions
	At time of occurrence	Continuation of the flight		
Nominal condition	Static Strength ⁽¹⁾ Residual Strength Vibrations Flutter (if failure causes velocity increase)	Static Strength ⁽¹⁾ Residual Strength Vibrations Flutter ⁽¹⁾ Fatigue & Damage Tolerance	Detectability	Limitations may be established

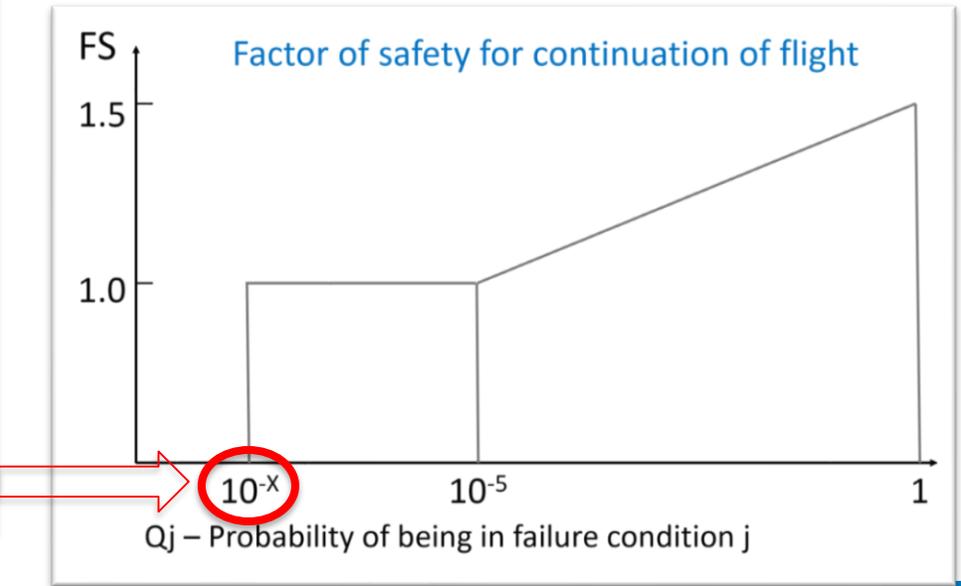
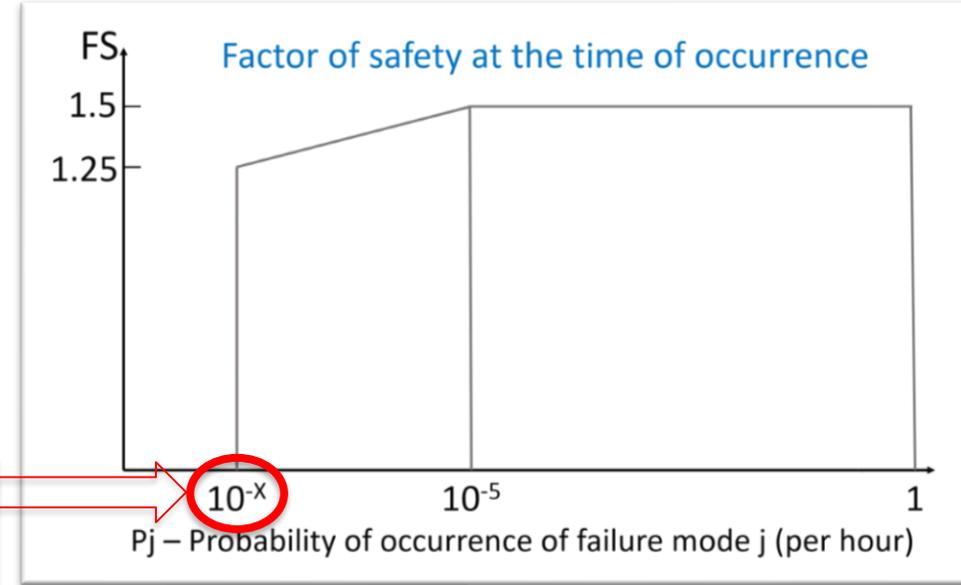
⁽¹⁾ For determination of **Safety Factor** and **Flutter Speed**, the probability will be consistent with the safety objective defined in SC VTOL for Category Enhanced and Category Basic (no. passengers)

Reference: MOC VTOL.2510 Equipment, systems, and installations

Table 1: Safety Objectives

Maximum Passenger Seating Configuration		Failure Condition Classifications			
		Minor	Major	Hazardous	Catastrophic
		Allowable Qualitative Probability			
		Probable	Remote	Extremely Remote	Extremely Improbable
		Allowable Quantitative Probability (Note C and D)			
		Development Assurance Level			
Category Enhanced	-	$\leq 10^{-3}$ FDAL D (see Note B)	$\leq 10^{-5}$ FDAL C	$\leq 10^{-7}$ FDAL B	$\leq 10^{-9}$ FDAL A
Category Basic	7 to 9 passengers (Basic 3)	$\leq 10^{-3}$ FDAL D (see Note B)	$\leq 10^{-5}$ FDAL C	$\leq 10^{-7}$ FDAL B	$\leq 10^{-9}$ FDAL A
	2 to 6 passengers (Basic 2)	$\leq 10^{-3}$ FDAL D (see Note B)	$\leq 10^{-5}$ FDAL C	$\leq 10^{-7}$ FDAL C (see Note A)	$\leq 10^{-8}$ FDAL B (see Note A)
	0 to 1 passenger (Basic 1)	$\leq 10^{-3}$ FDAL D (see Note B)	$\leq 10^{-5}$ FDAL C	$\leq 10^{-6}$ FDAL C (see Note A)	$\leq 10^{-7}$ FDAL C (see Note A)

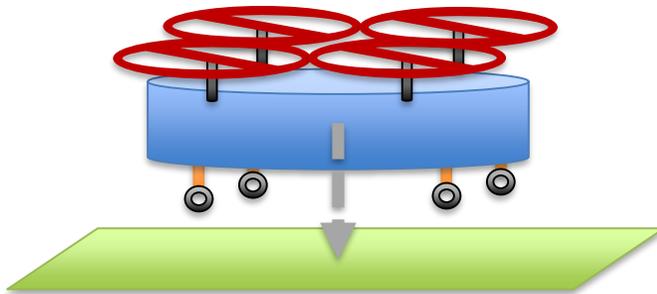
[Quantitative safety objectives are expressed per flight hour]



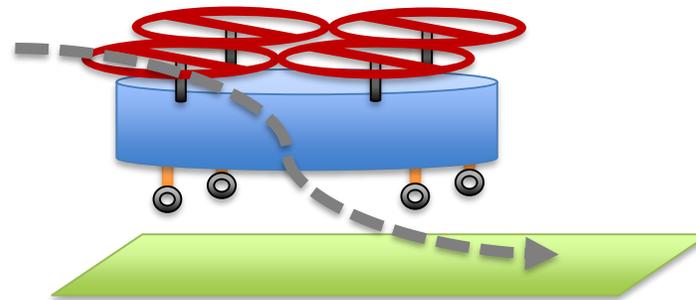
VTOL.2220 Ground and Water Loads

➤ Ground conditions:

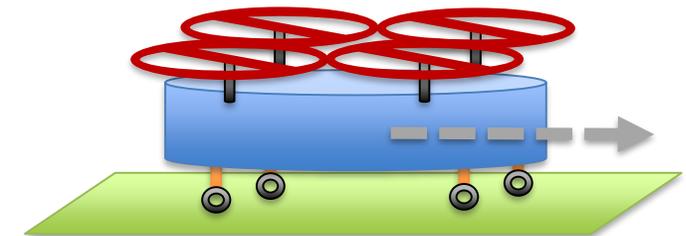
- ✓ Proposed MOC published 25 May 2020
- ✓ 3 comments reviewed and MoC under revision



Vertical Landing
(based on CS-27)



Conventional Landing
(based on CS-23)



Taxiing
(based on CS-27 and CS-23)

➤ Water conditions:

- Seaplane and amphibian water landing loads to be addressed in Phase 3 MOC

Summary

- **Complexity** in VTOL design load definition: different safety objectives, configurations and modes, and complex flight control systems
- **Interaction of systems and structures** needs comprehensive analysis to consider all failures that could influence loading and flutter
- Many valuable comments received during Phase 1 consultation will lead to **improvement and simplification** of the proposed design load MoCs
- **Further design load MoCs** will be released for public consultation in Phases 2 and 3

Thank you for your attention

Feel free to submit your questions on our live event platform....

easa.europa.eu/connect



Your safety is our mission.

An Agency of the European Union 