



INSTITUTO
TECNOLÓGICO
DE AERONÁUTICA

— 1950 —

Towards Deriving Loads Spectra Representing Operational Life: Equivalent Flight Profile vs Single Flight Profiles

Juliana Diniz Mattos - ITA

Mariano Andrés Arbelo - ITA

Frank Machado - EMBRAER

Main objectives:

Describe two approaches to derive typical load spectra for Damage and

Tolerance Design and present a case study with an evaluation of the pros

and cons of each solution.

Damage Tolerance Design

Requirements

Typical Loading Spectra – How is the airplane going to fly?

Loading Spectra x Flight Load Sequence

Two Approaches to Derive Typical Loading Spectra

Study Case

Conclusions

Certification Requirements

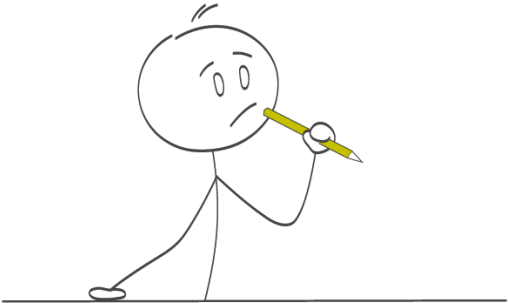
Typical Loading Spectra



Analysis, supported by test evidence



Inspections or other procedures must be established



Market Requirements

Operation

Lifetime

Inspection Plan

Certification Requirements

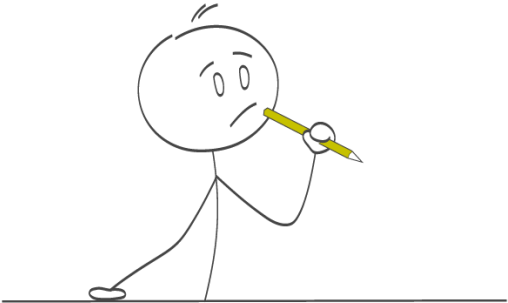
Typical Loading Spectra



Analysis, supported by test evidence



Inspections or other procedures must be established



Market Requirements

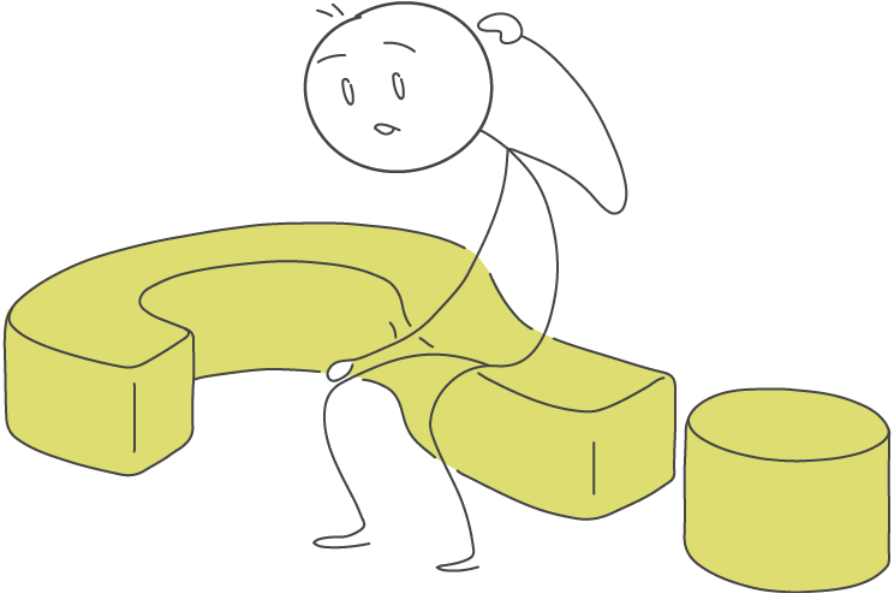
Operation

Lifetime

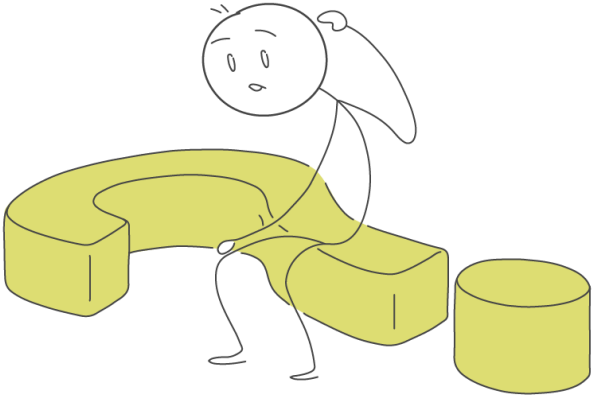
Inspection Plan

Typical Loading Spectra is an essential key for Damage Tolerance Design

How is the Airplane Going to Fly ?

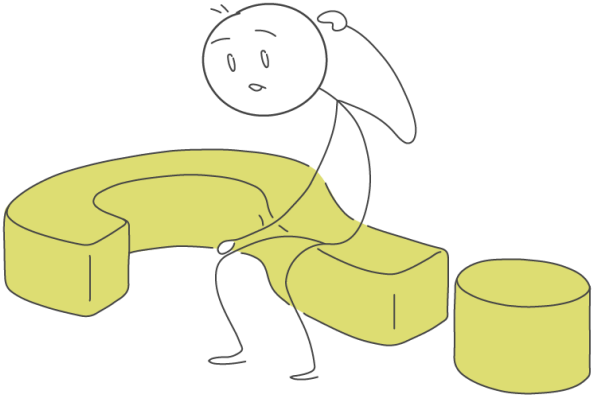


How is the Airplane Going to Fly ?



Range

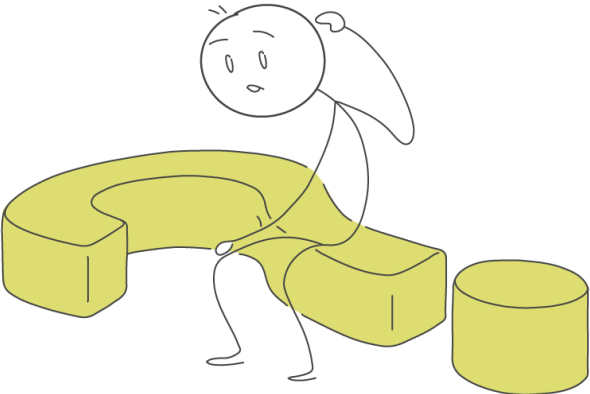
How is the Airplane Going to Fly ?



Range



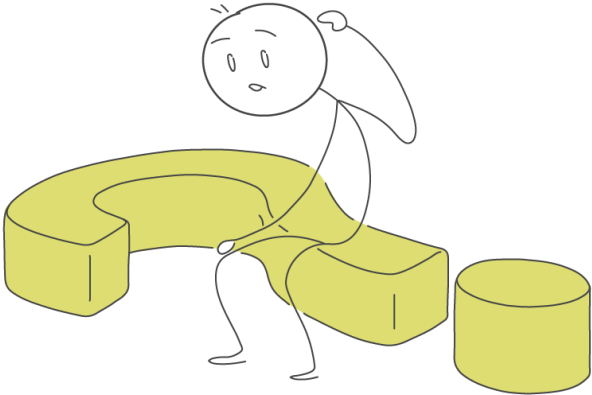
How is the Airplane Going to Fly ?



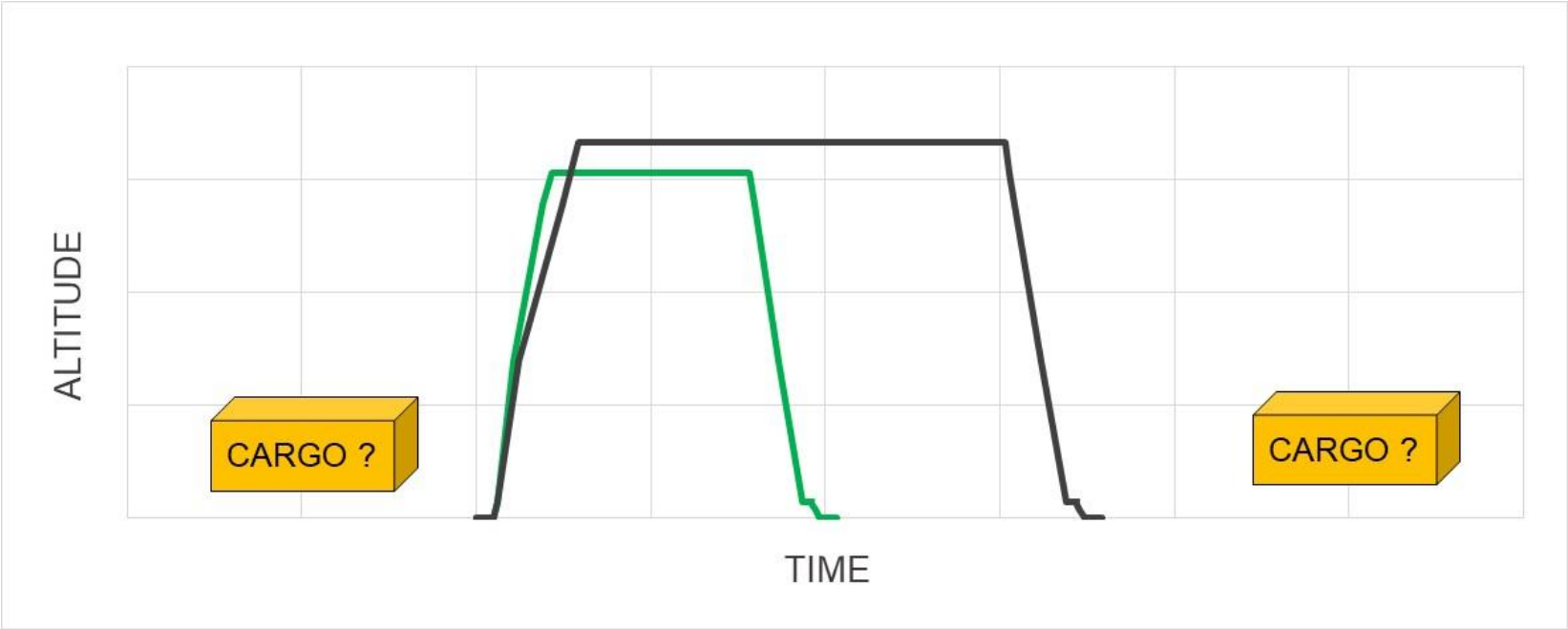
Range
Payload



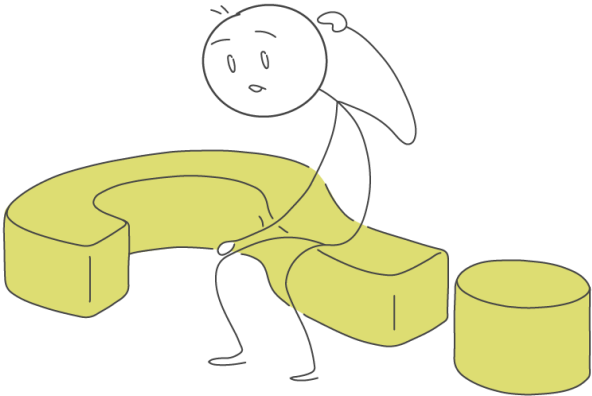
How is the Airplane Going to Fly ?



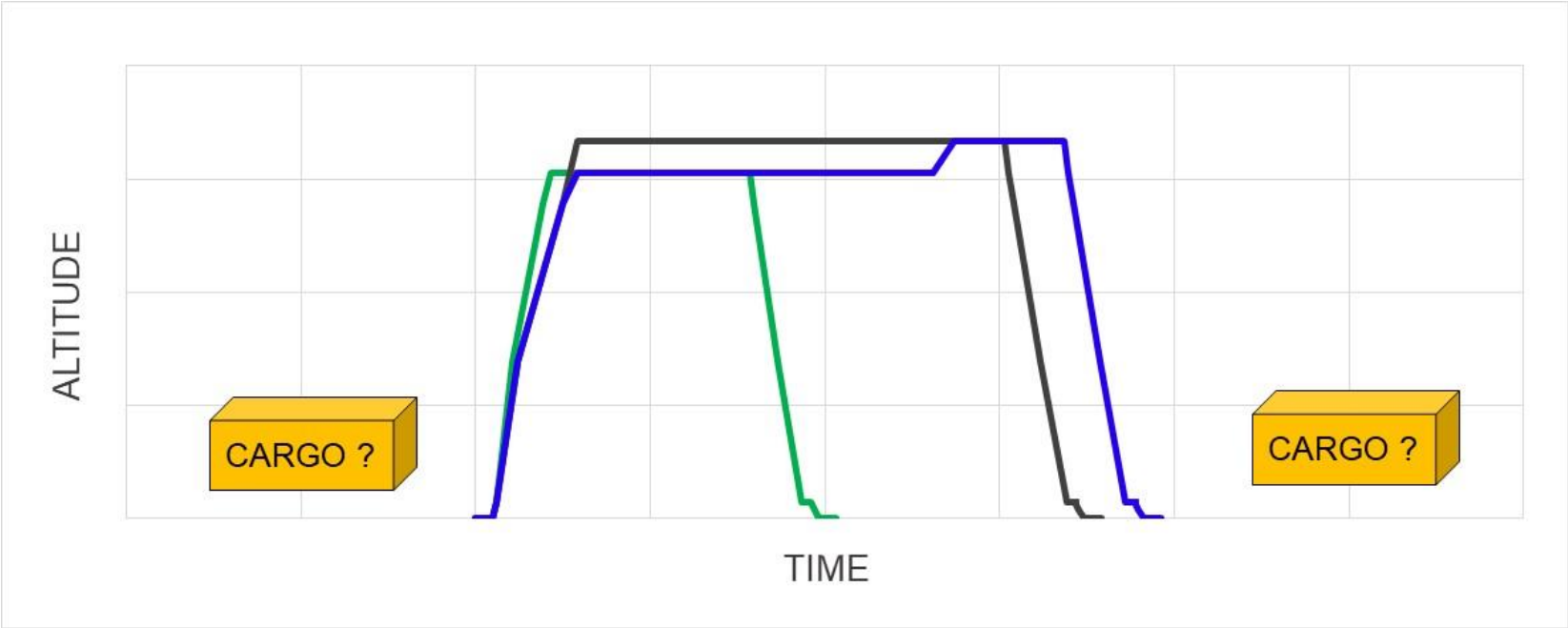
Range
Payload
Flight Level



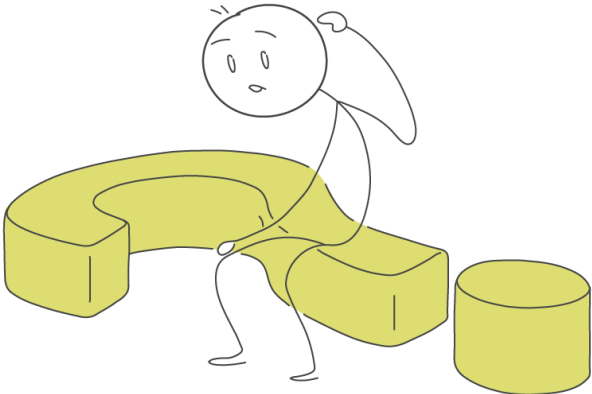
How is the Airplane Going to Fly ?



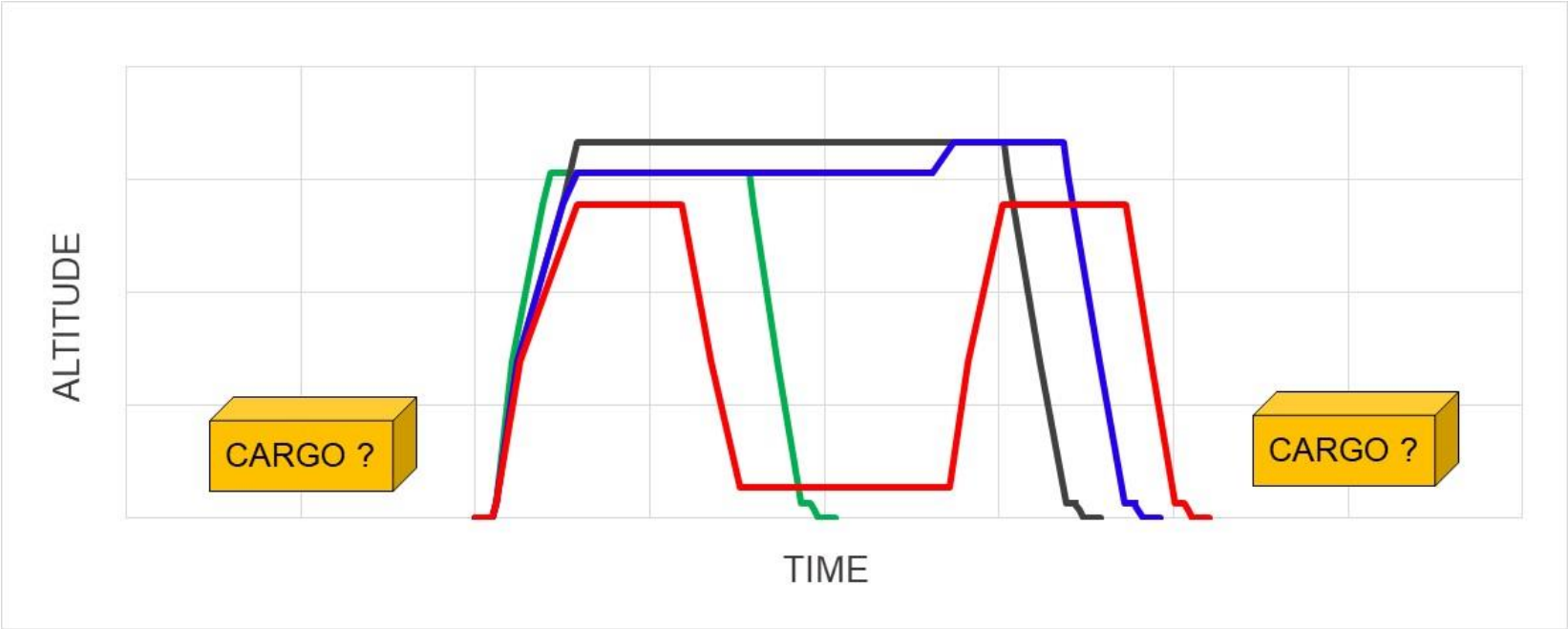
Range
Payload
Flight Level



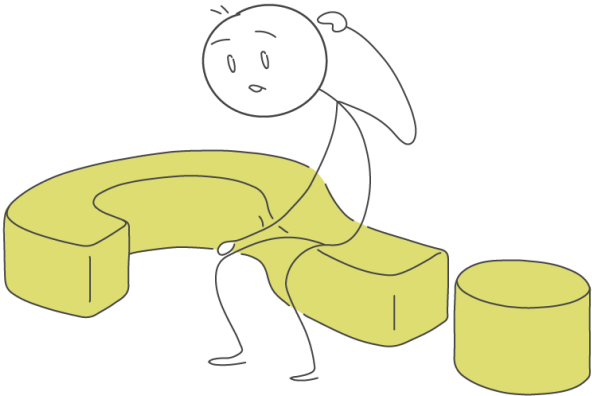
How is the Airplane Going to Fly ?



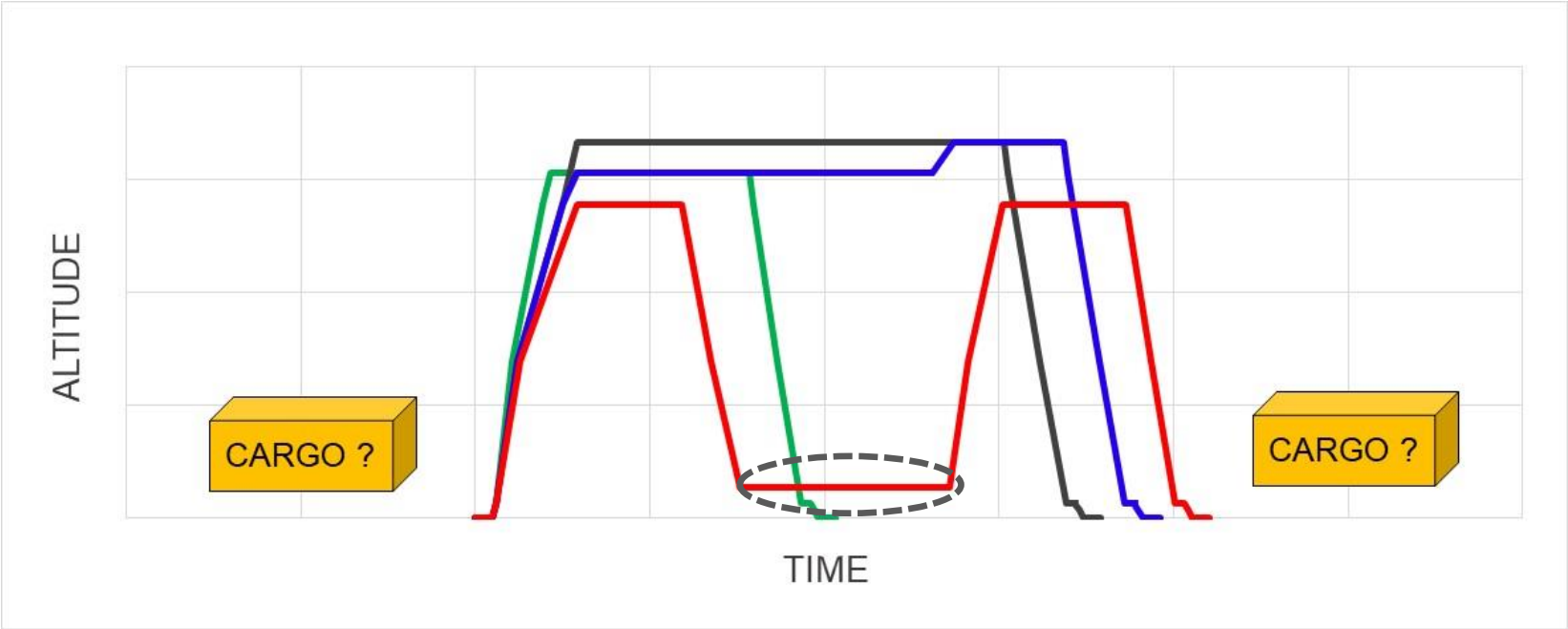
Range
Payload
Flight Level
Operations



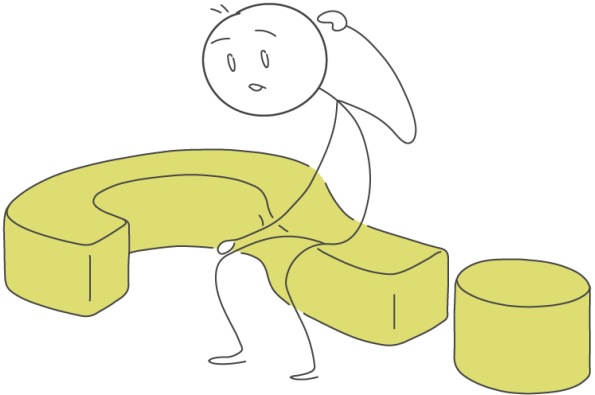
How is the Airplane Going to Fly ?



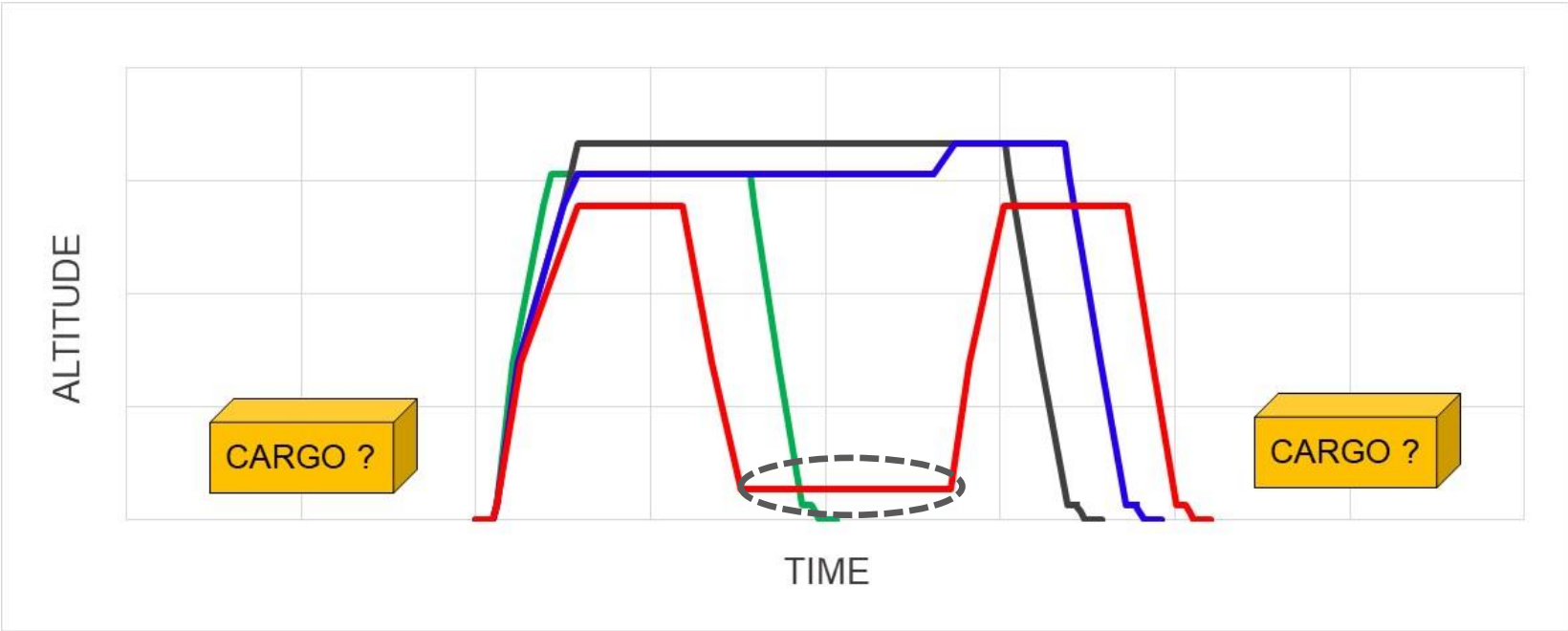
- Range
- Payload
- Flight Level
- Operations



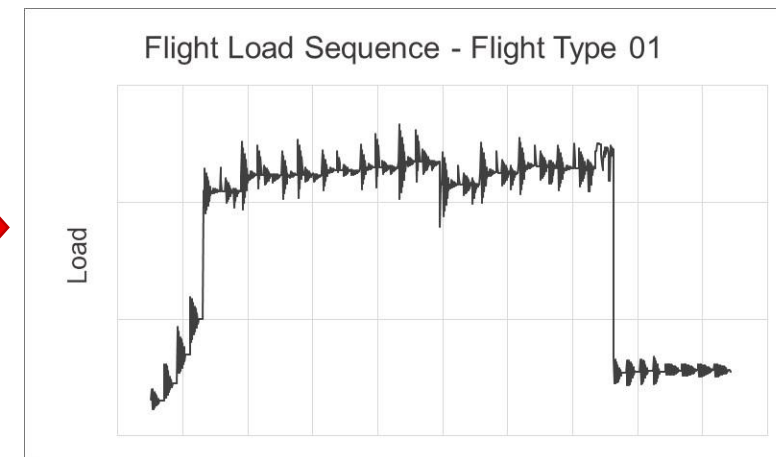
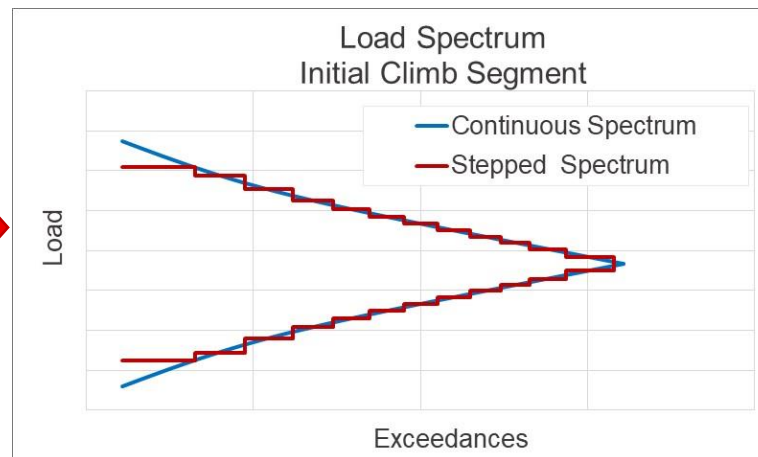
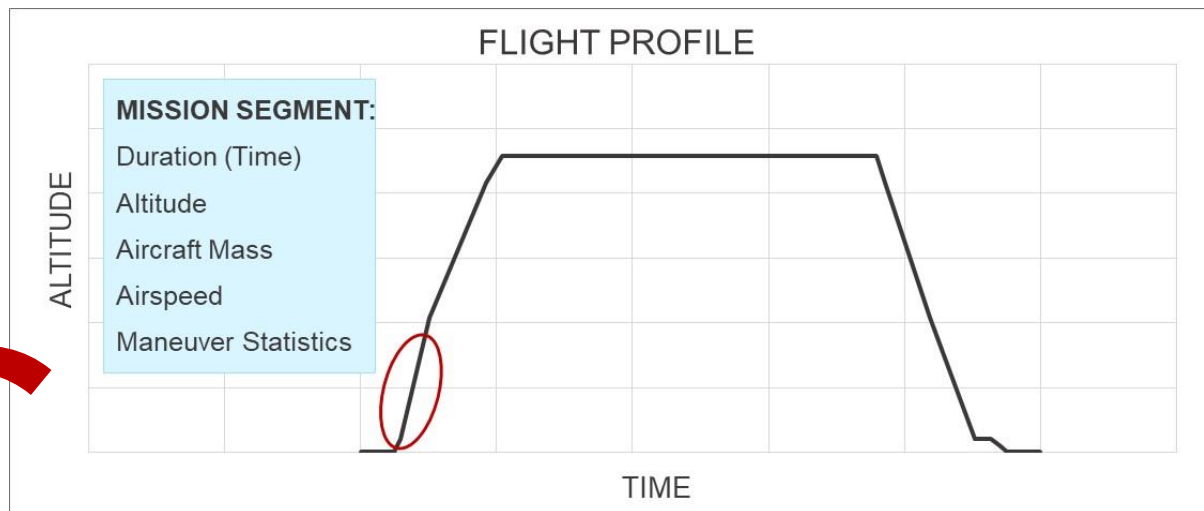
How is the Airplane Going to Fly ?



- Range
- Payload
- Flight Level
- Operations
- % Occurrence



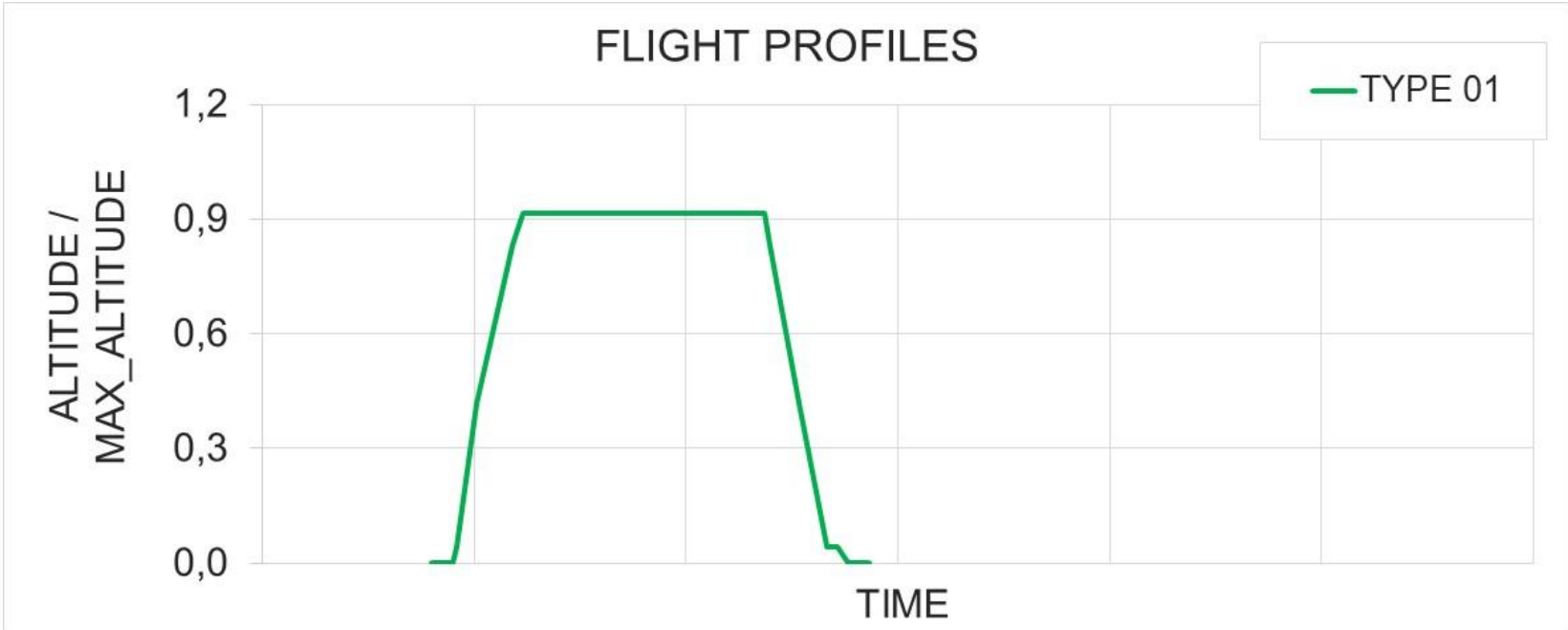
Loading Spectra x Flight Load Sequence



Two Different Approaches to Derive Typical Loading Spectra



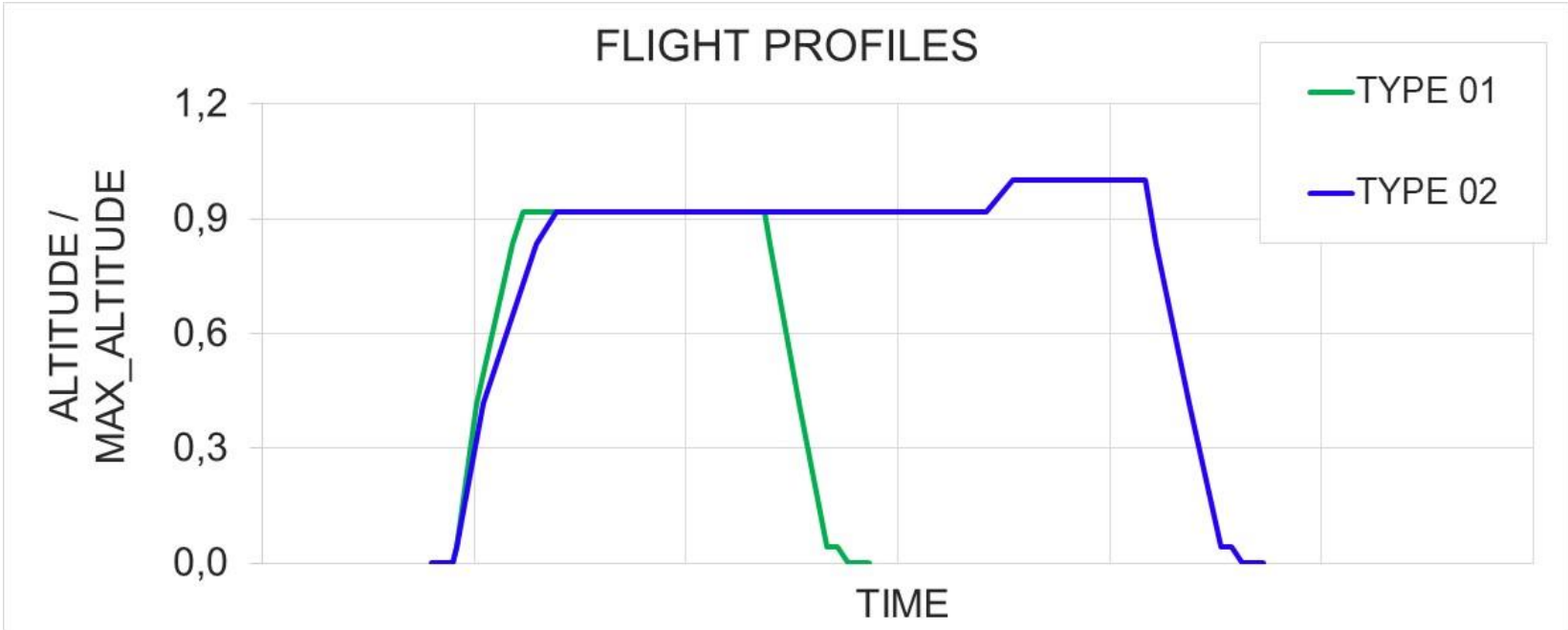
A hypothetical operation.



Two Different Approaches to Derive Typical Loading Spectra



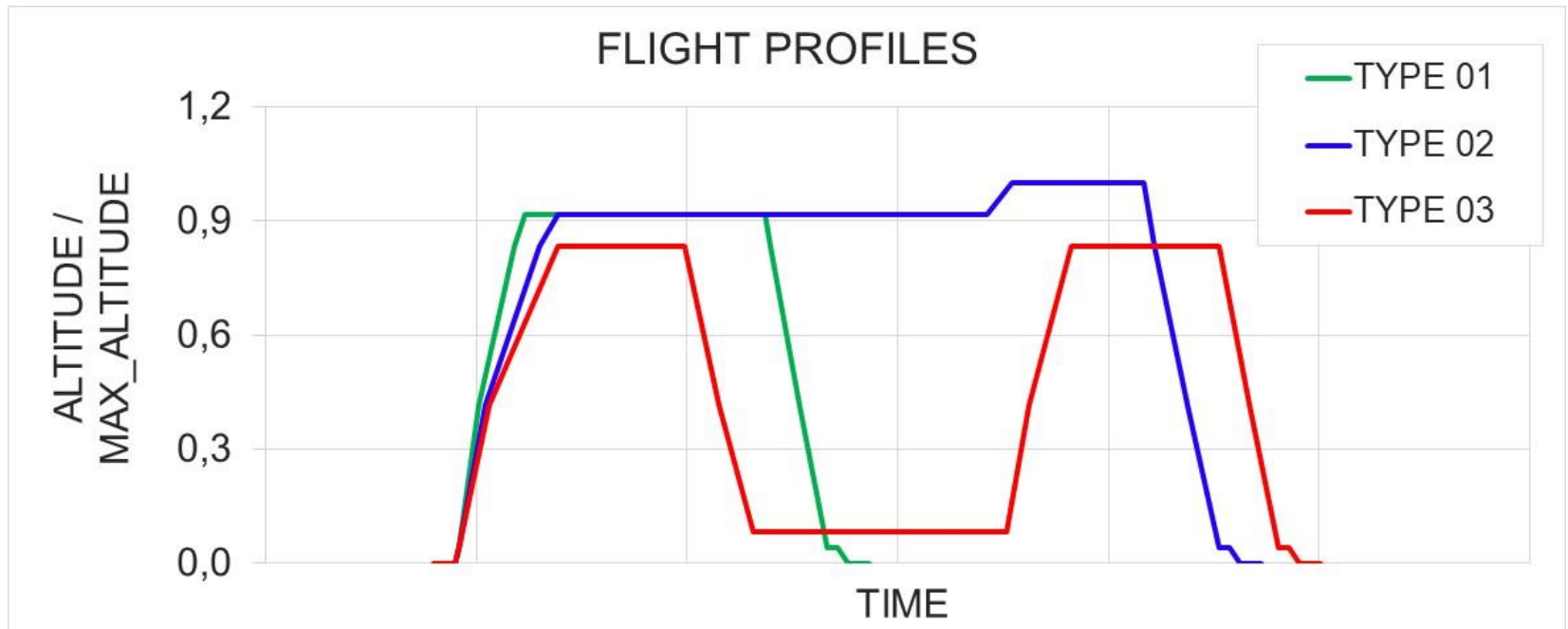
A hypothetical operation.



Two Different Approaches to Derive Typical Loading Spectra



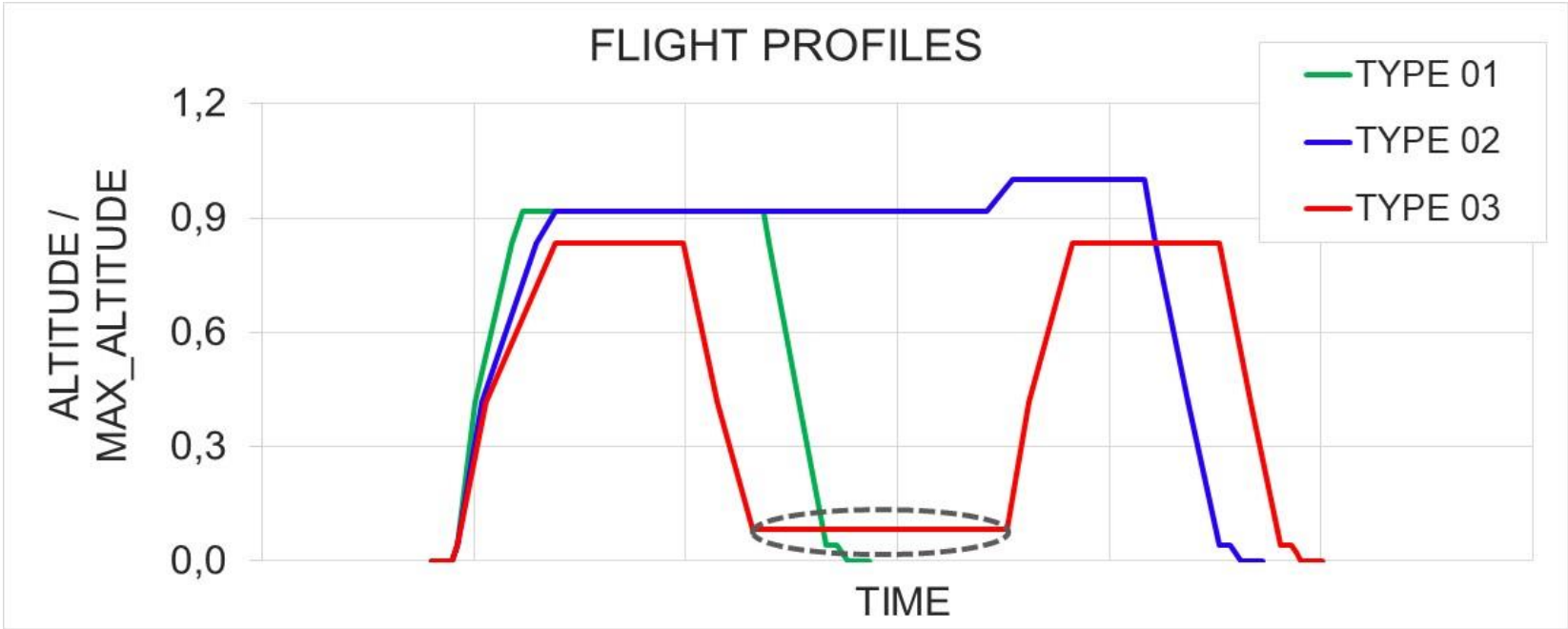
A hypothetical operation.



Two Different Approaches to Derive Typical Loading Spectra



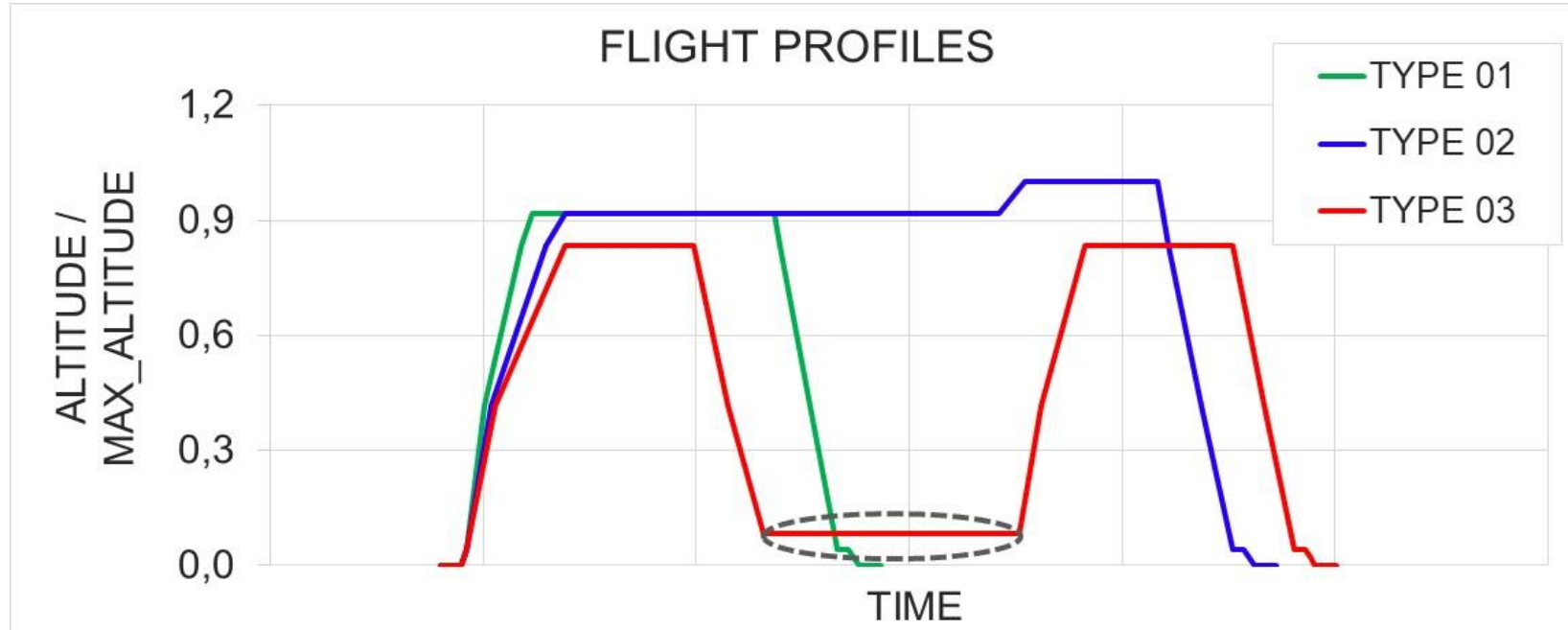
A hypothetical operation.



Two Different Approaches to Derive Typical Loading Spectra

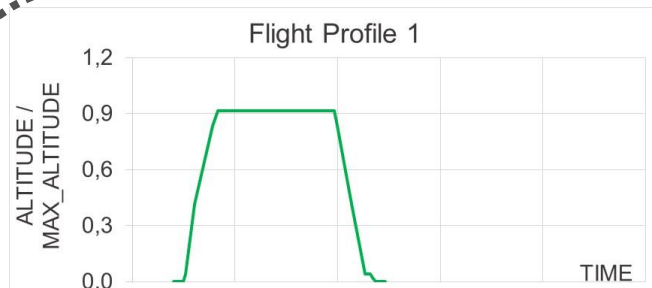


A hypothetical operation.

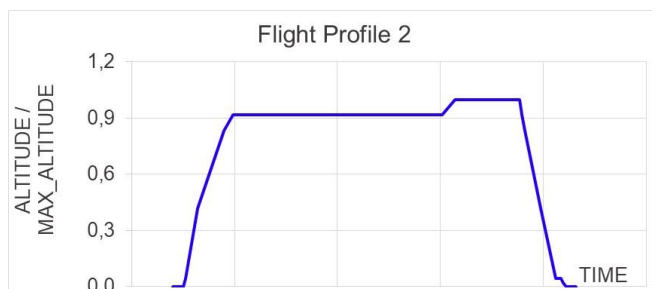


FLIGHT PROFILE	% FLIGHTS
1	30
2	60
3	10
	100

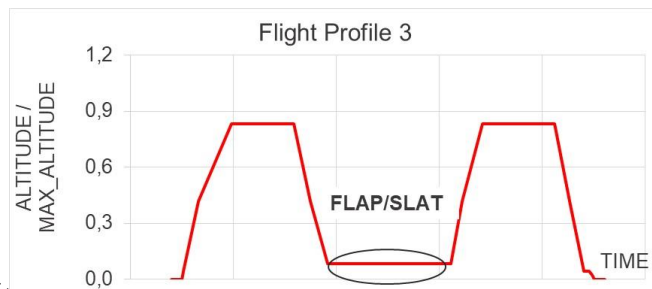
Single Flight Profiles



FLIGHT PROFILE	FLIGHTS %
1	30

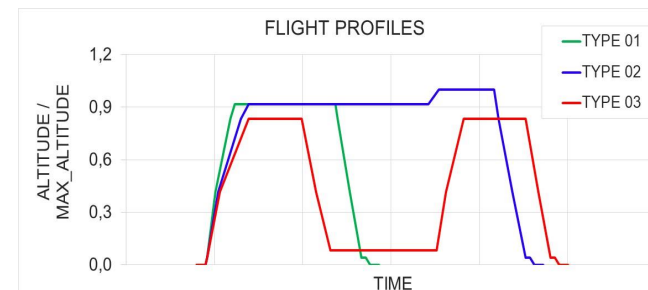


FLIGHT PROFILE	FLIGHTS %
2	60



FLIGHT PROFILE	FLIGHTS %
3	10

Equivalent Flight Profile



FLIGHT PROFILE	FLIGHTS %
1	30
2	60
3	10
	100

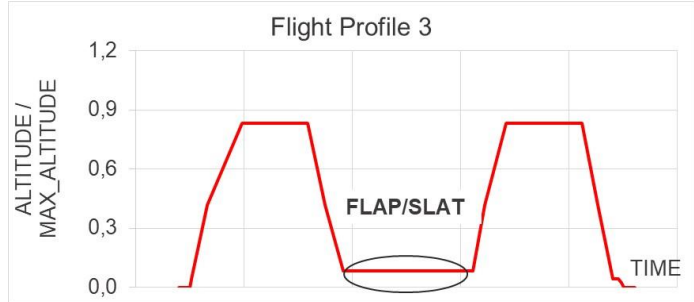
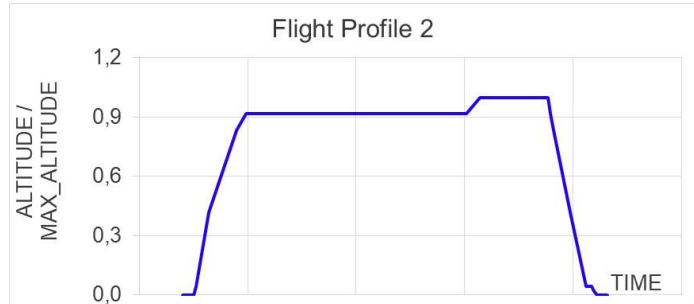
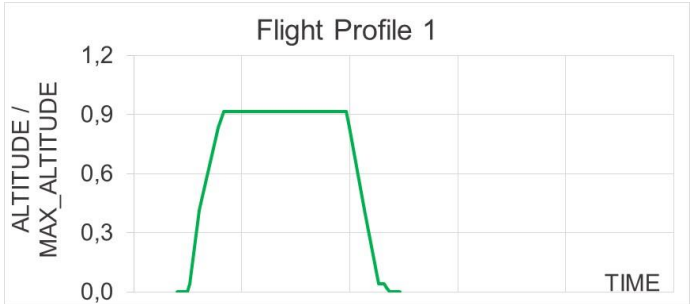


FLIGHT PROFILE	FLIGHTS %
Equivalent	100

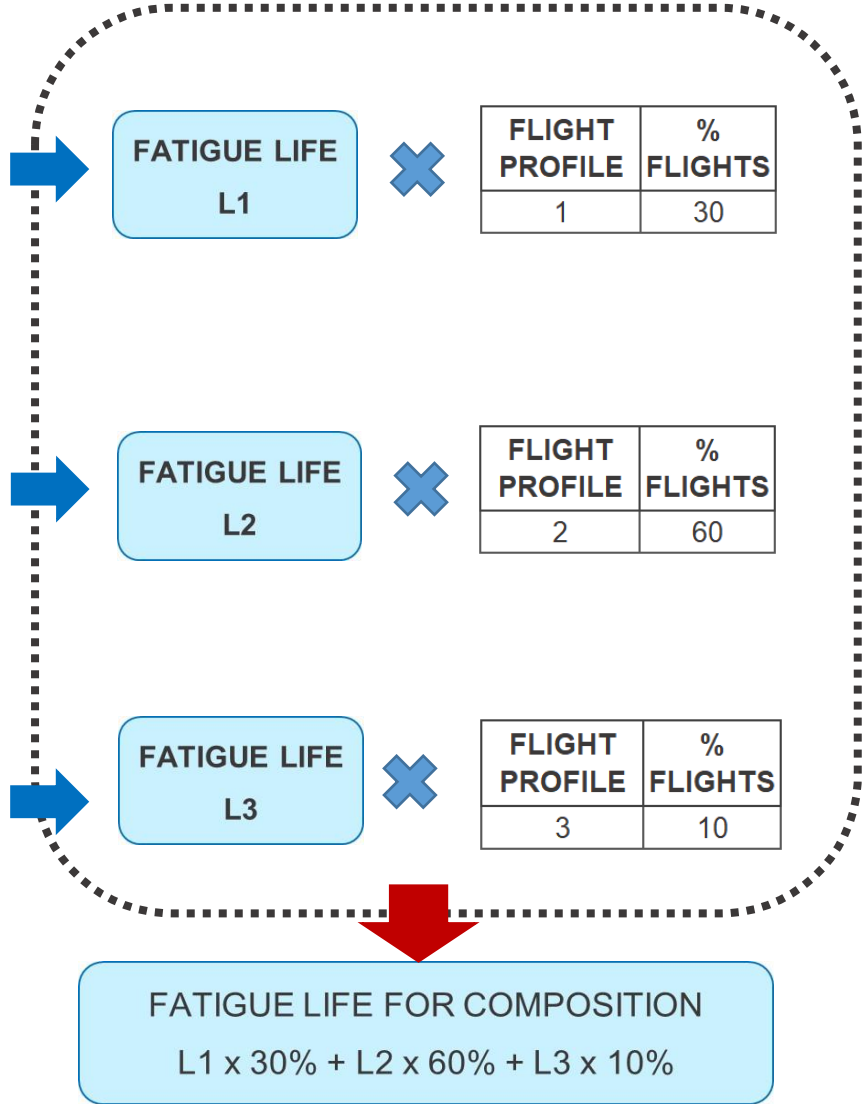
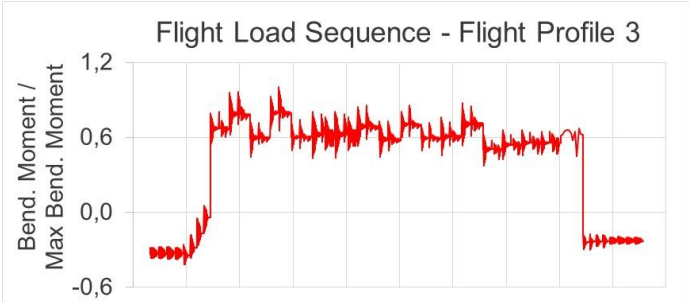
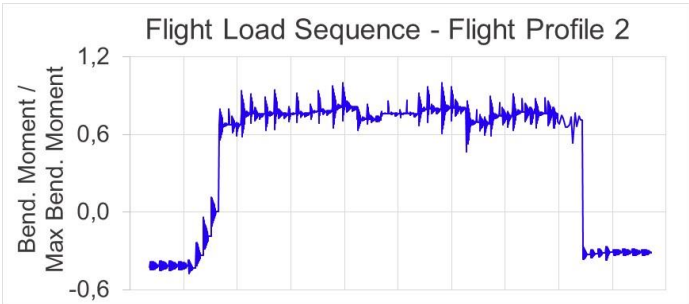
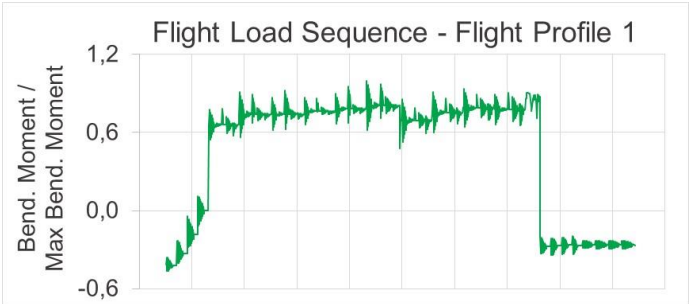
Single Flight Profiles



FLIGHT PROFILES

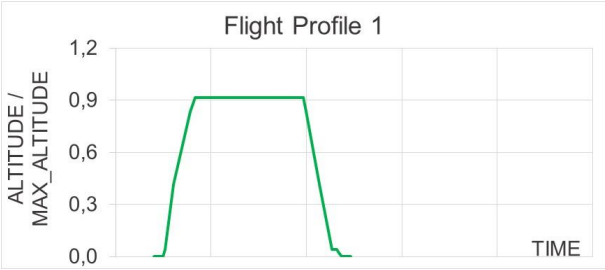


FLIGHT LOAD SEQUENCES



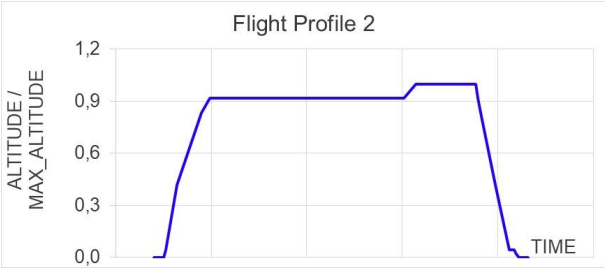


FLIGHT PROFILES

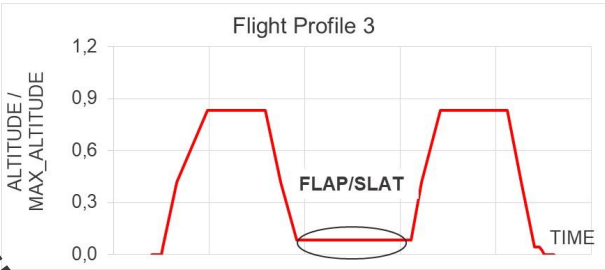


FLIGHTS DISTRIBUTION

FLIGHT PROFILE	% FLIGHTS
1	30

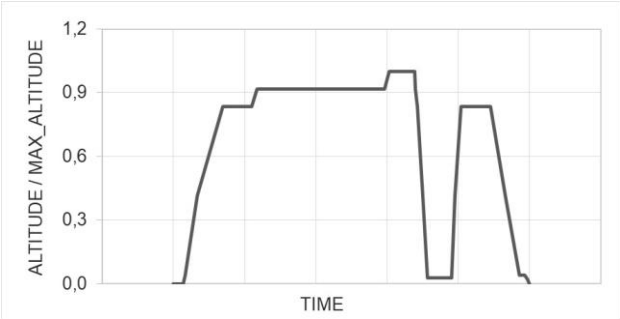


FLIGHT PROFILE	% FLIGHTS
2	60

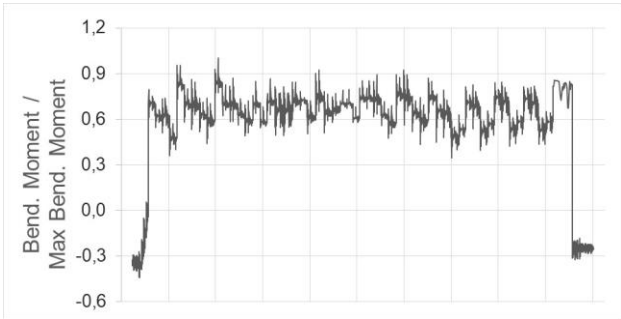


FLIGHT PROFILE	% FLIGHTS
3	10

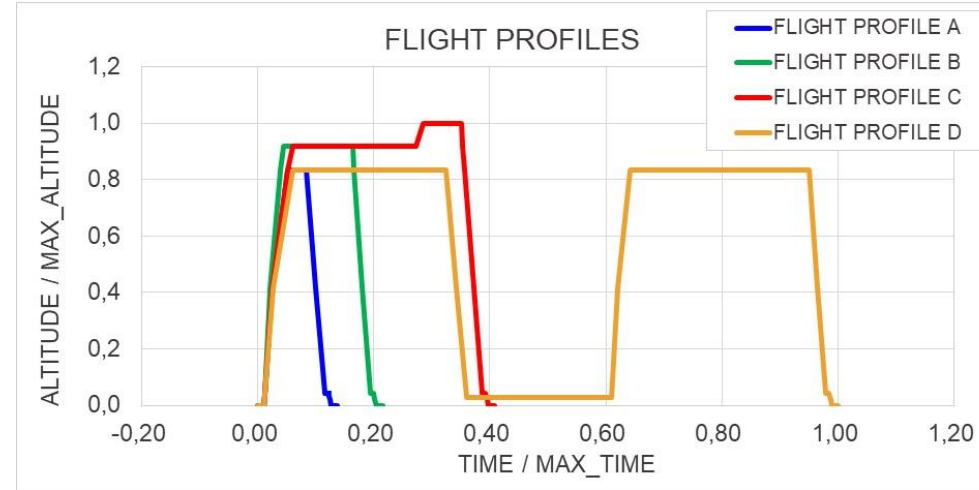
EQUIVALENT FLIGHT PROFILE



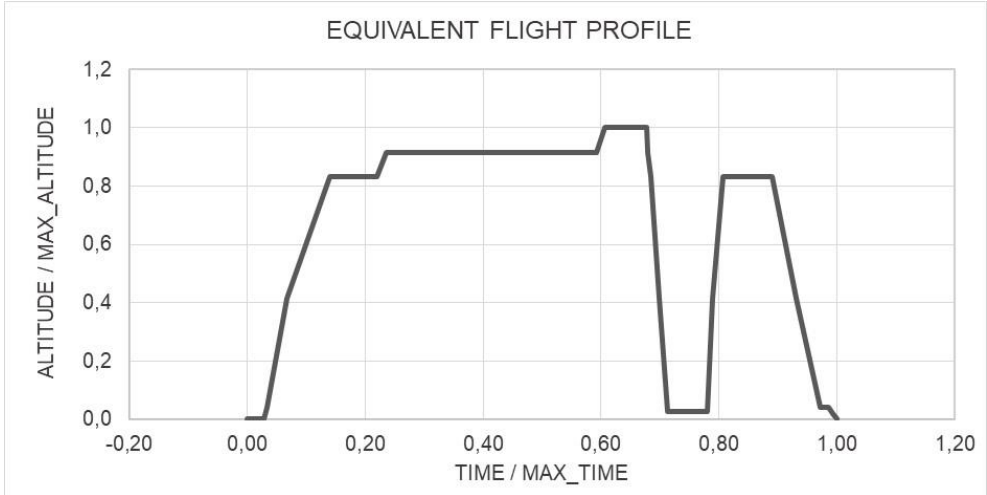
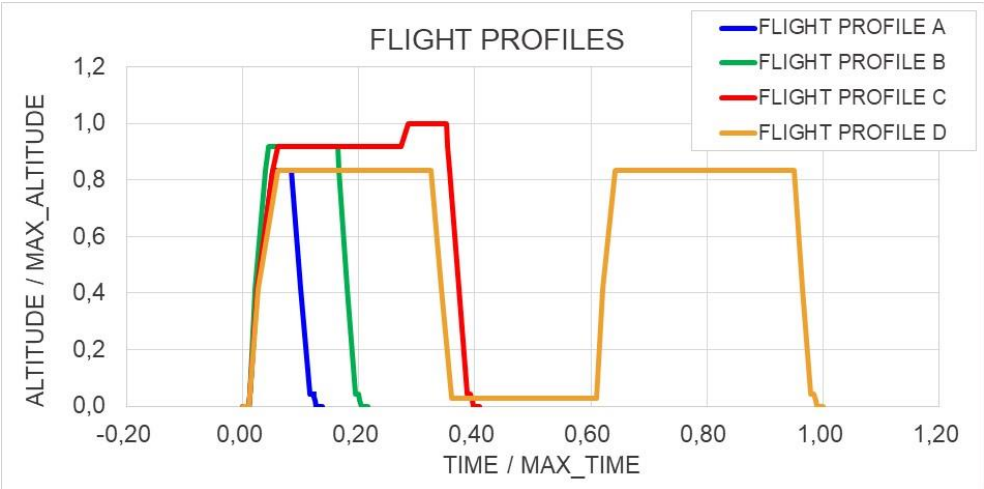
FLIGHT LOAD SEQUENCE



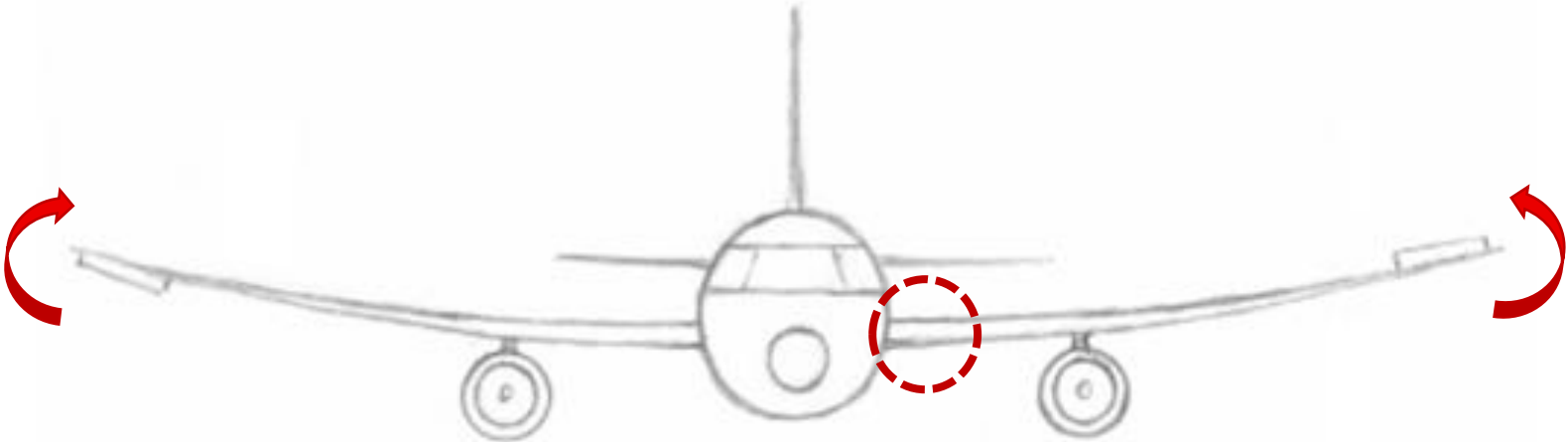
FATIGUE LIFE

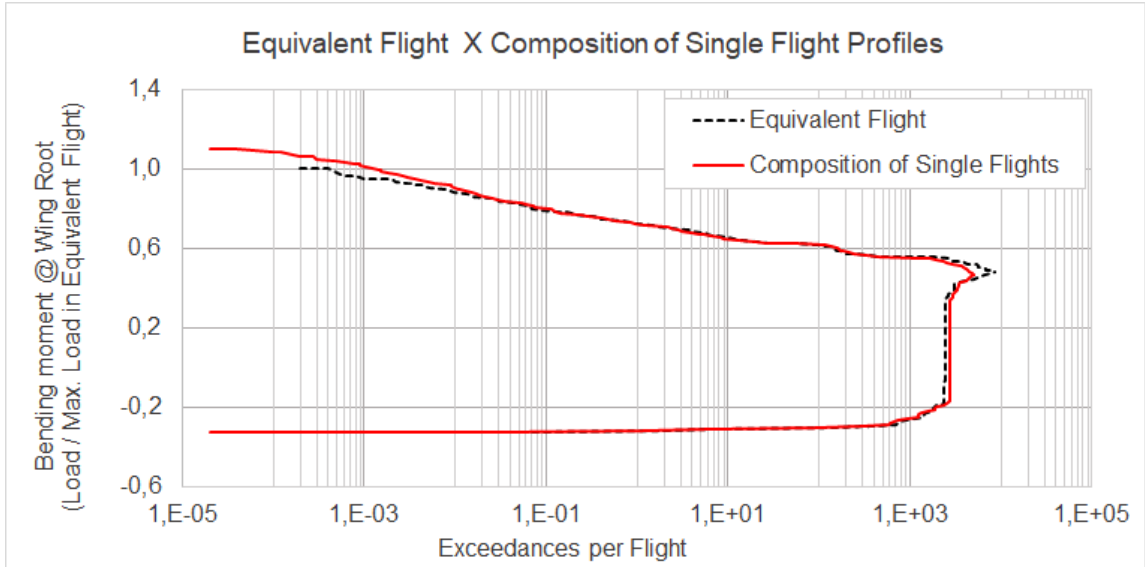
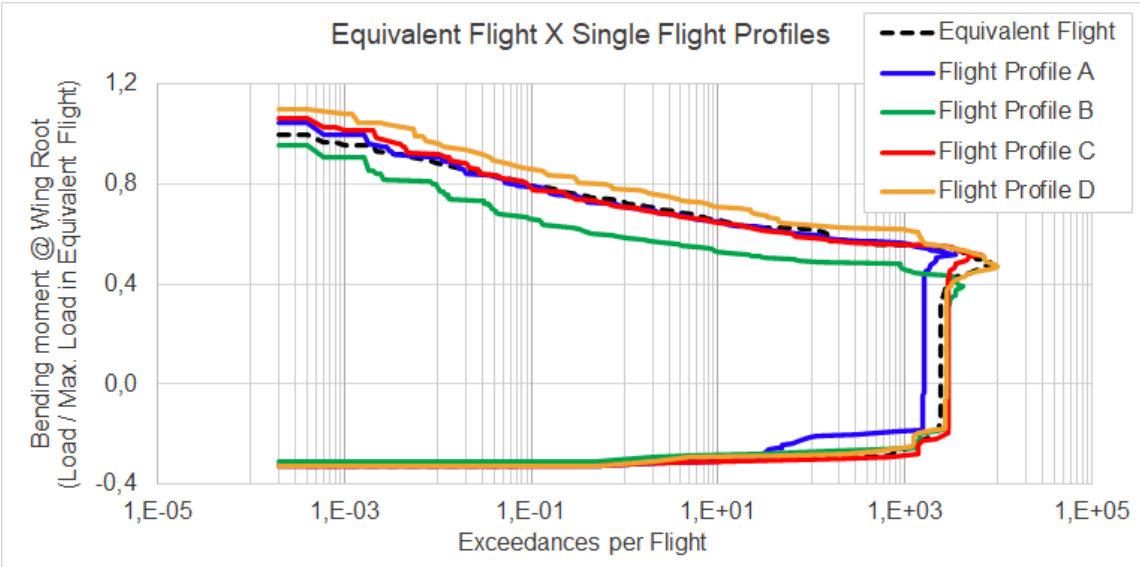


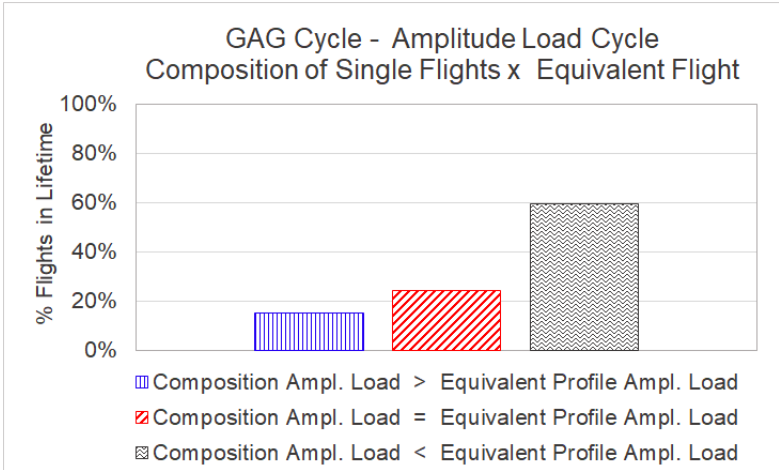
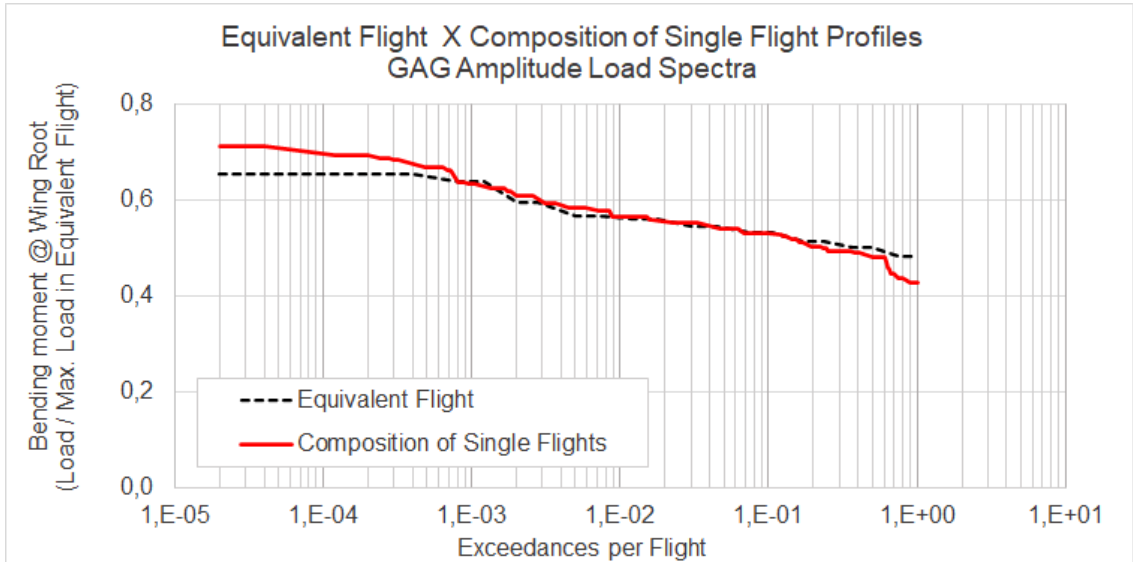
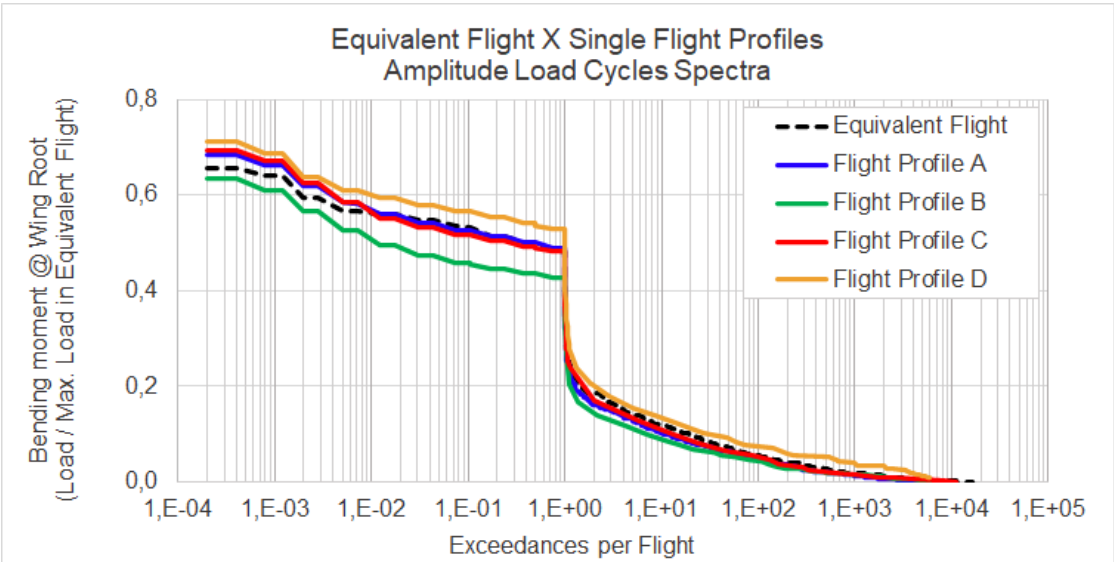
FLIGHT PROFILE	% FLIGHTS	BEFORE TAKE-OFF			AFTER LANDING		
		PAYLOAD	FUEL	TOW	PAYLOAD	FUEL	LDW
		(% MAX PAYLOAD)	(% MAX FUEL)	(% MAX TOW)	% MAX PAYLOAD	(% MAX FUEL)	(% MAX LDW)
A	10	77%	28%	90%	77%	13%	92%
B	40	15%	33%	72%	15%	11%	71%
C	40	54%	54%	90%	54%	12%	84%
D	10	36%	100%	97%	36%	12%	78%

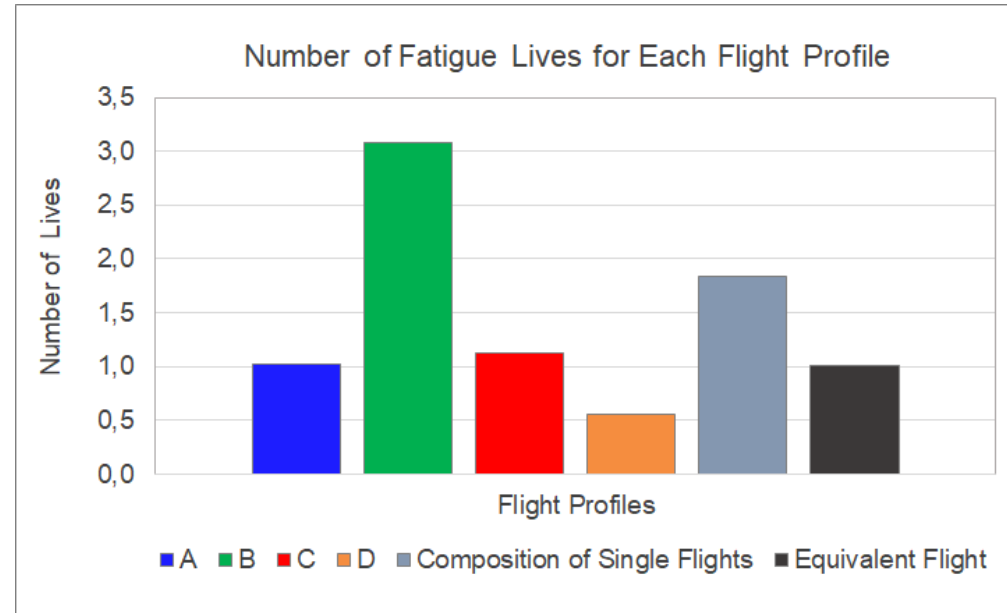


Flight-Profile α	Flight-Time $\cdot\alpha$	Flights $\cdot(\%)$ α
α	ΔT_n α	$Dist_{SF}$ α
A α	0.12 α	10 α
B α	0.20 α	40 α
C α	0.40 α	40 α
D α	1.00 α	10 α
EQUIVALENT α	0.35 α	100 α









- Composition lead to almost twice the lifetime derived for Equivalent Flight Profile
- Equivalent Flight Profile results are more affected by the “more demanding” flight profile (D) than the Composition.

The Analysis indicates:

- Equivalent Flight Profile lead to lower amount of work
- Single Flights Composition leads also to the fatigue results for each original flight profile.
- Equivalent Flight Profile is a conservative approach
- Composition of Single Flights lead to loads spectra strict to the usage considered
- Each approach can be a good solution, according to the moment in the course of the product history.



INSTITUTO
TECNOLÓGICO
DE AERONÁUTICA

— 1950 —

