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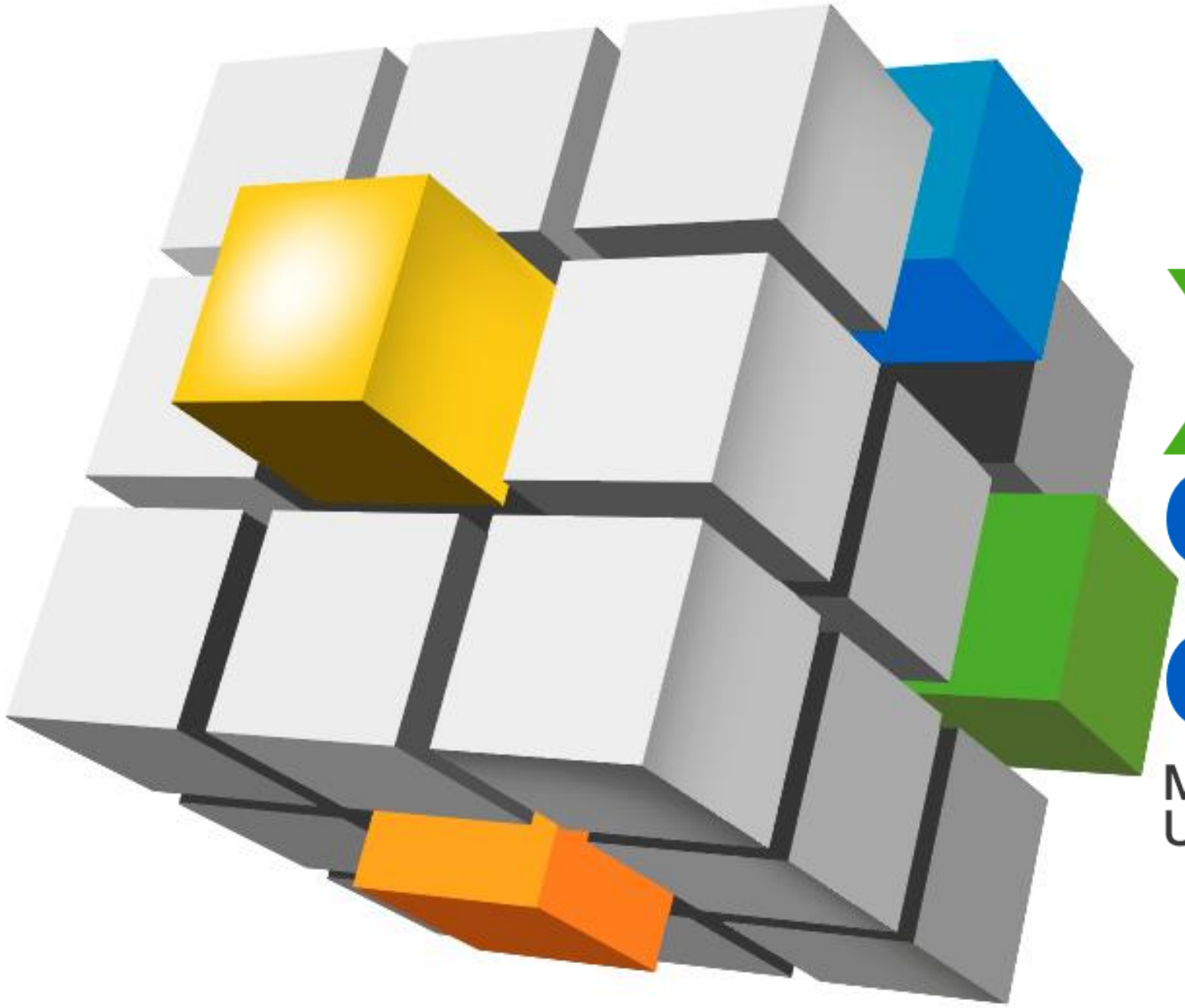

XIX Congreso de Confiabilidad

Madrid, 22 de noviembre de 2017.
Universidad Europea de Madrid

XIX Congreso de Confiabilidad

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Application of Accelerated Life Testing during the development of equipment for Reliability Demonstration

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Outline

1. Introduction
2. Accelerated Life Testing
3. High precision stepper actuator application
4. Reliability Demonstration Plan of a Flight Control Actuator
5. Conclusion

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1. Introduction

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1. Introduction
CESA Presentation

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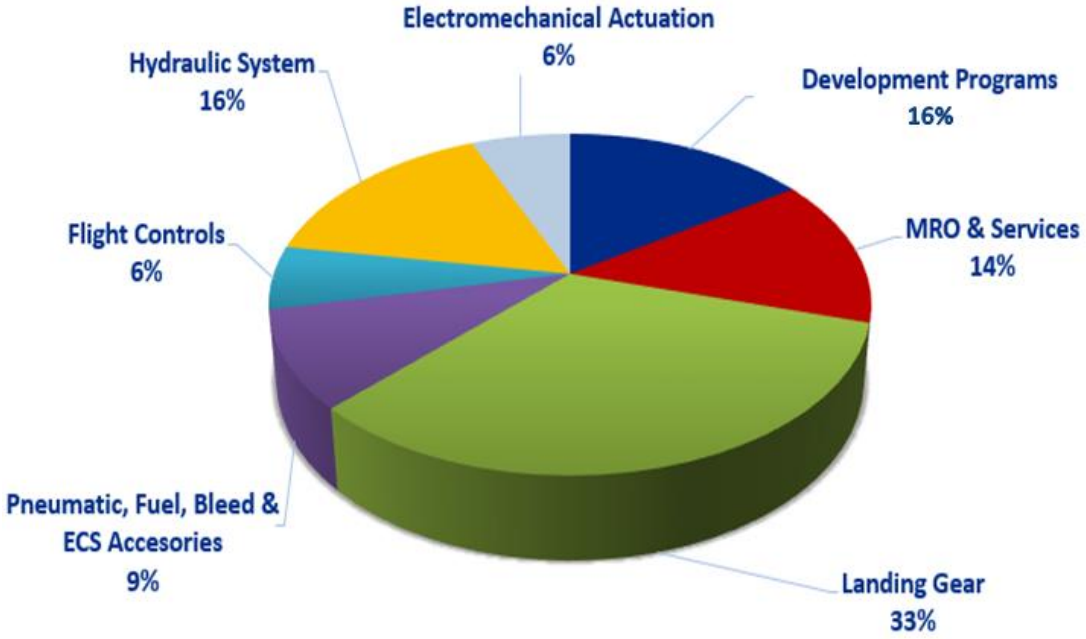
60%	40%
AIRBUS DEFENCE & SPACE	UTC Aerospace Systems



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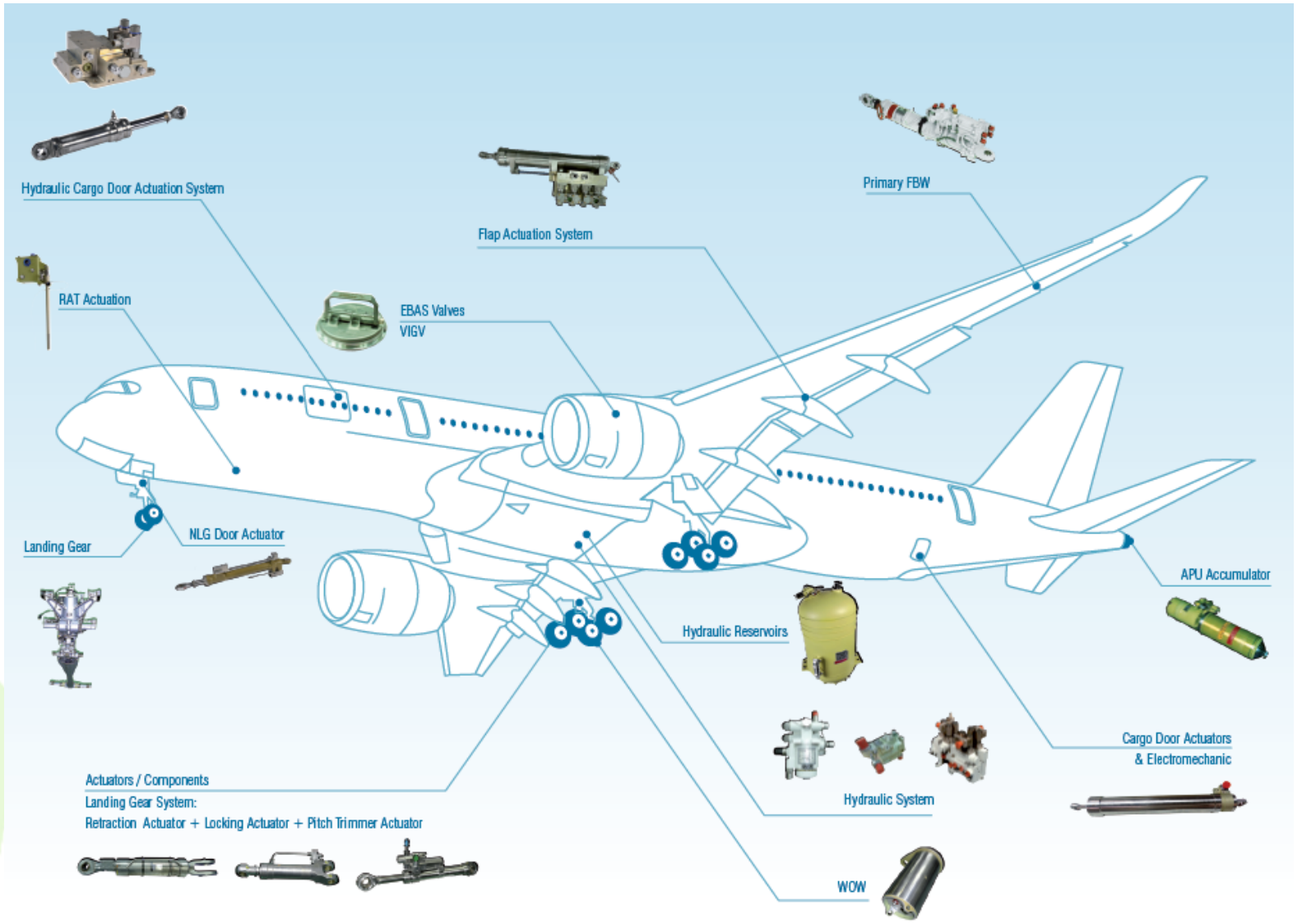
1. Introduction

CESA Products



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1. Introduction

CESA Research & Development

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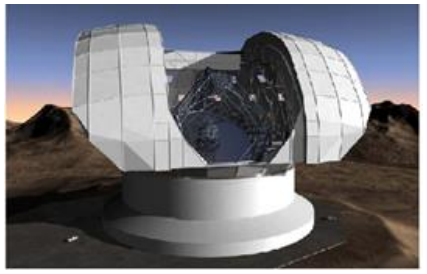
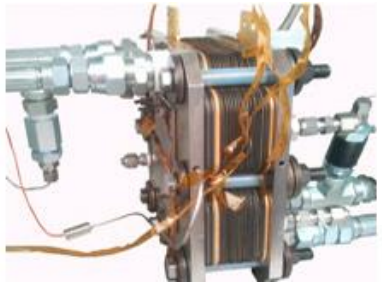
CDTI Centro para el Desarrollo Tecnológico Industrial

SINTONIA

PROSAVE2





Clean Sky

Clean Sky 2

RESI

Actuation 2015

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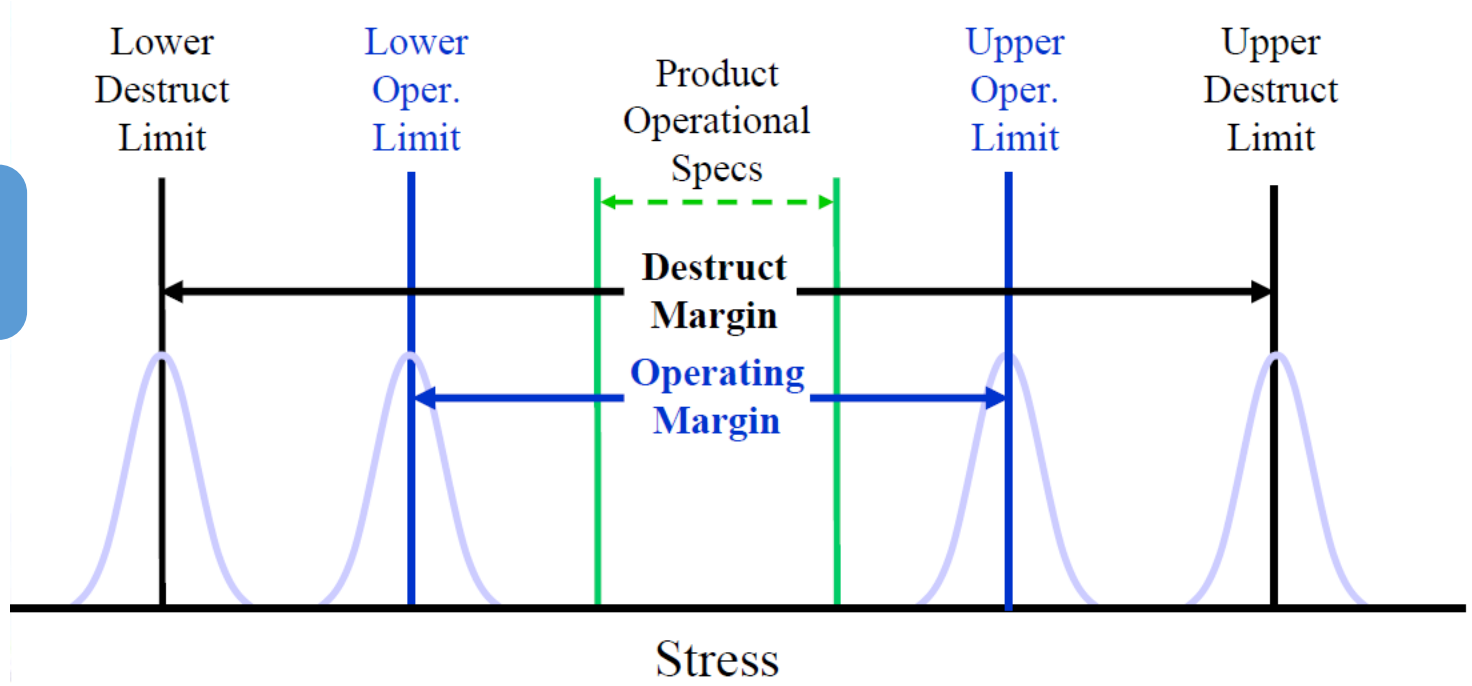
1. Introduction

Accelerated Testing

HALT



Source: HALT vs. ALT presentation for theIEEE Reliability Society by Mike Silverman

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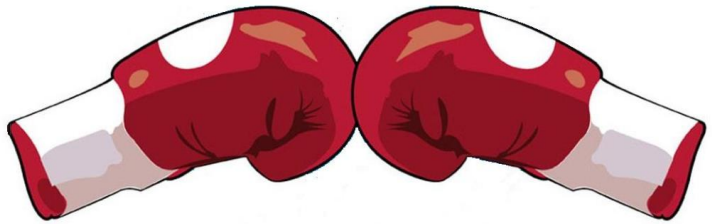
1. Introduction
Accelerated Testing

HALT

Identifies design weaknesses

- Increases reliability
- Qualitative
- Provides valuable feedback in designing quantitative tests
- Exploration

vs.



ALT

Product's Life prediction

- Identify dominant failure mechanisms
- Quantitative
- Test
- Acceptance criteria

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2. Accelerated Life Testing

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2. Accelerated Life Testing

New development

No In-Service data

Calculation?

Source: www.dreamstime.com
www.fotosdeautosdeportivos.com
www.blog.jakpat.net

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2. Accelerated Life Testing

Test → Product's Life estimation → Validation of theoretical value

Source: www.sidilab.com

How do we design the Test?

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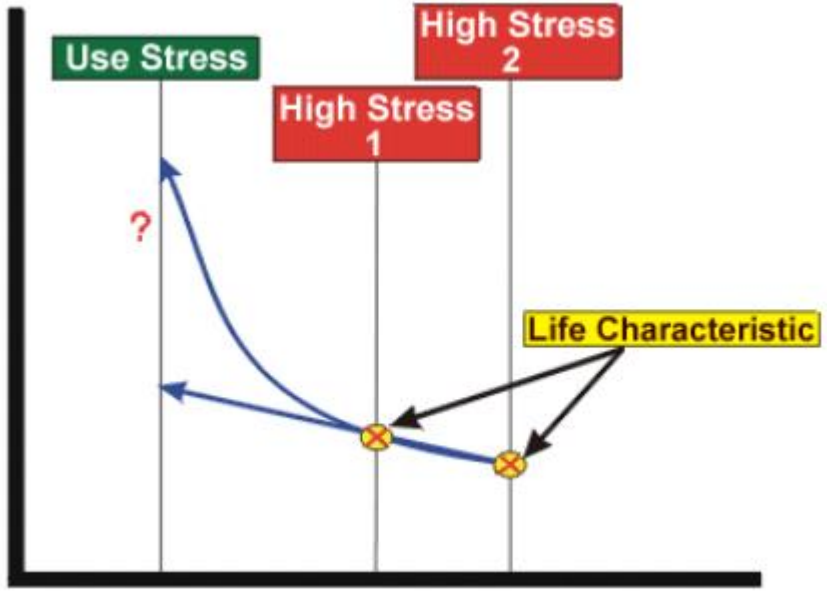
2. Accelerated Life Testing



Accelerating parameters:

- Usage rate acceleration
- Overstress acceleration

Life distribution & Life Stress Models

Source: www.blogg.bt.no www.weibull.com www.readingcraze.com

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2. Accelerated Life Testing

Sample size?

	When H0 is true	When H1 is true
Do not reject H0	correct decision (probability = 1- α)	Type II error (probability = β)
Reject H0	Type I error (probability = α)	correct decision (power = 1 - β)

Risk control approach

$$1 - CL = \sum_{i=0}^{f} \binom{n}{i} (1-R)^i R^{n-i}$$

Non-Parametric Binomial equation

$$1 - CL = \sum_{i=0}^{f} \binom{n}{i} (1-R(t))^i R(t)^{n-i}$$

Parametric Binomial equation

$$\chi^2_{1-CL,2} = -2\ln(1-CL)$$

Chi-squared distribution

Source: www.blogg.bt.no www.weibull.com www.readingcraze.com

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3. High precision stepper actuator application

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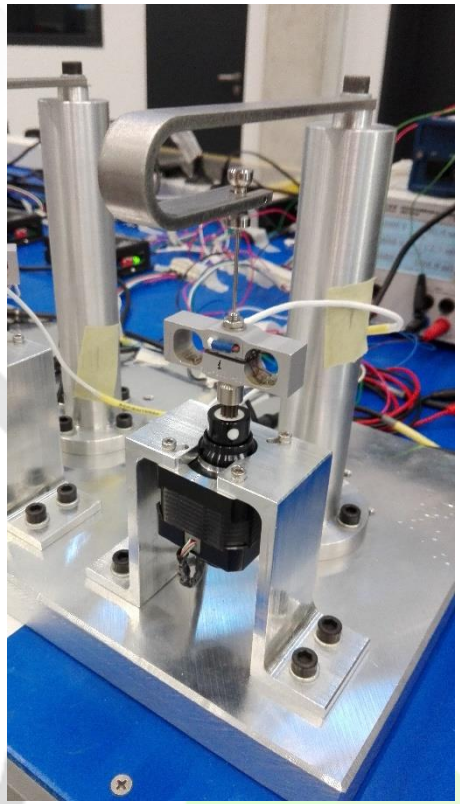
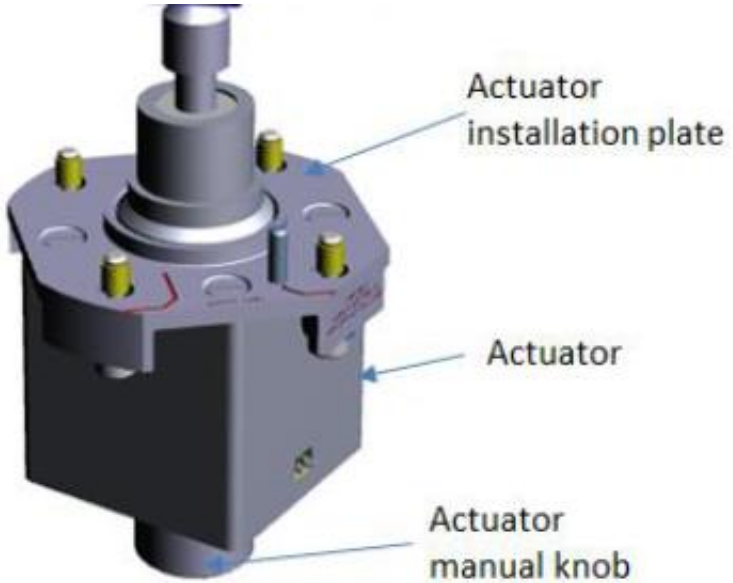
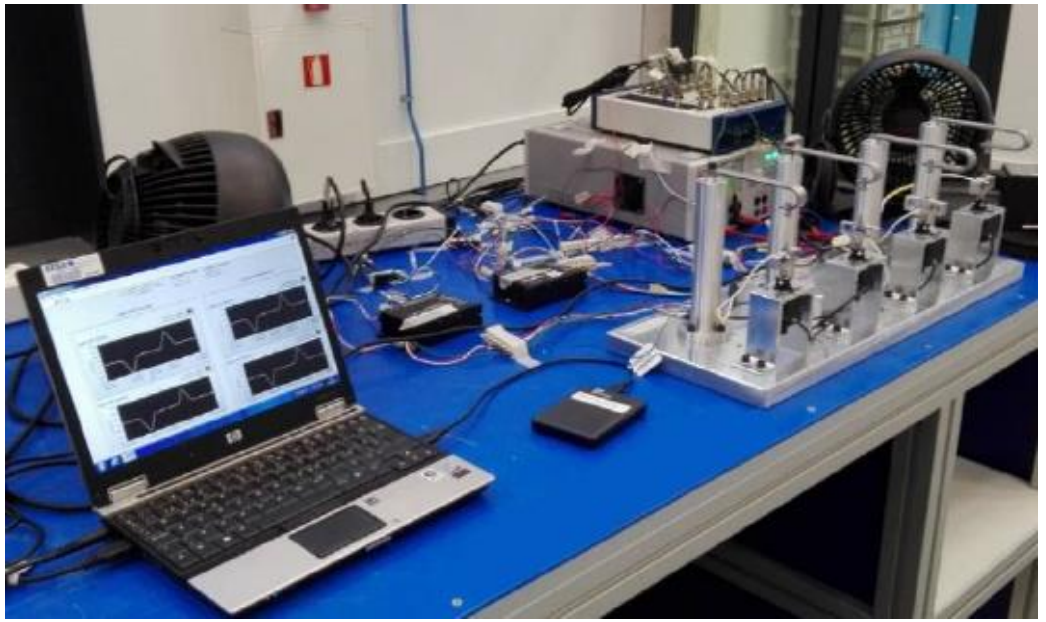
3. High precision stepper actuator application







- Usage rate acceleration
- MTBF objective: 1.2 millions of cycles
- Between 1 - 10 million cycles →wear-out increase
- 5 units

Source: CESA internal documentation

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3. High precision stepper actuator application

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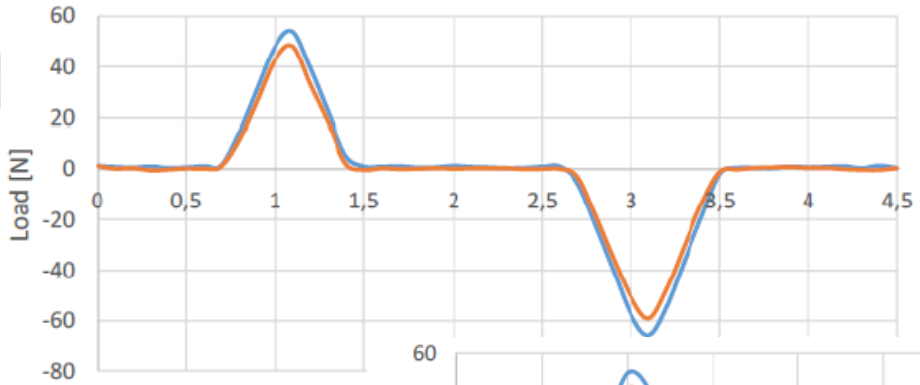
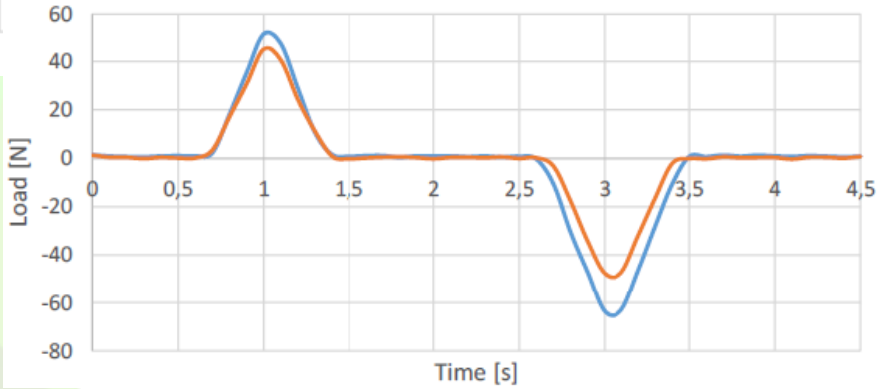
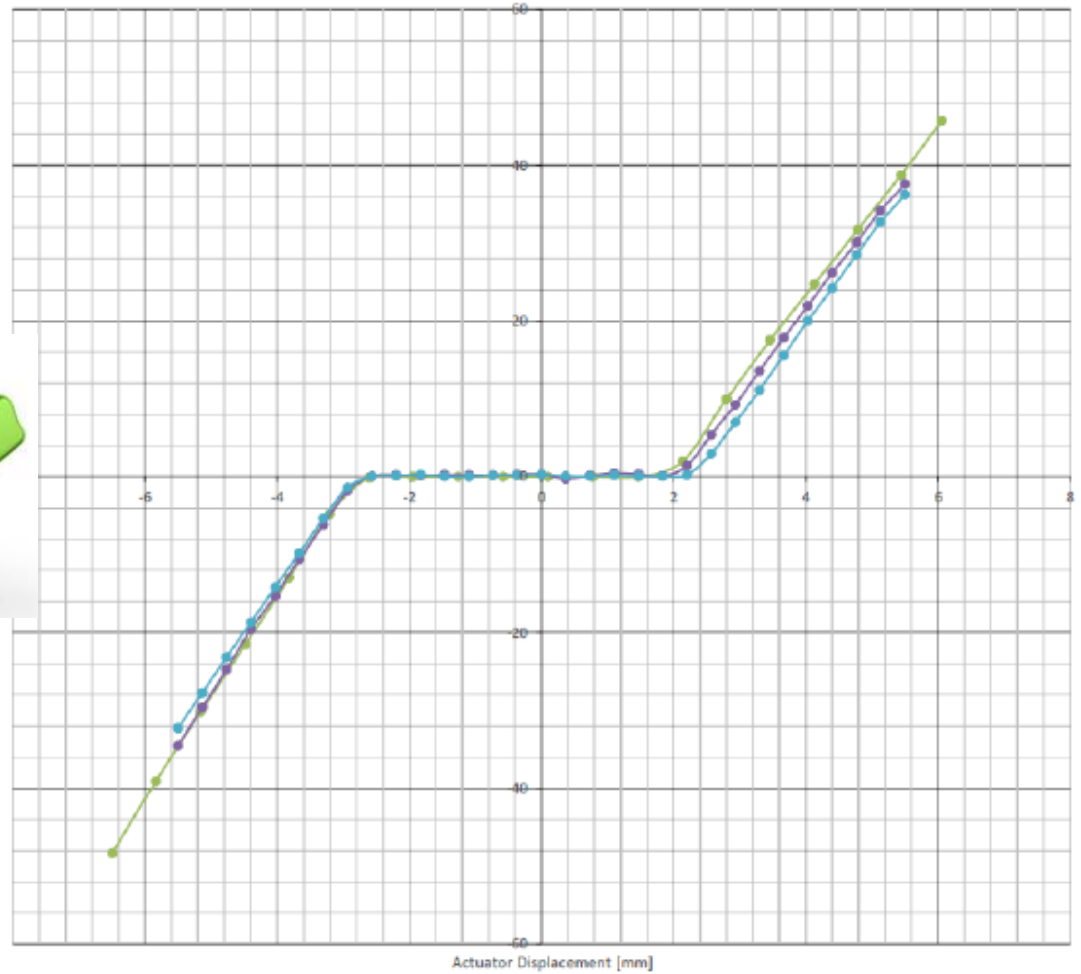
Sample size	Allowed failures			
	0	1	2	3
1	2 820 667			
2	1 410 333	2 382 454		
3	940 222	1 588 302	2 173 281	
4	**705 167**	1 191 227	1 629 961	2 045 990
5	**564 133**	**952 981**	1 303 968	1 636 792
6	470 111	794 151	1 086 640	1 363 993







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4. Reliability Demonstration Plan of a Flight Control Actuator

1. Introduction
2. Accelerated Life Testing
3. High precision stepper actuator application
4. ***Reliability Demonstration Plan of a Flight Control Actuator***
5. Conclusion

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4. Reliability Demonstration Plan of a FC Actuator

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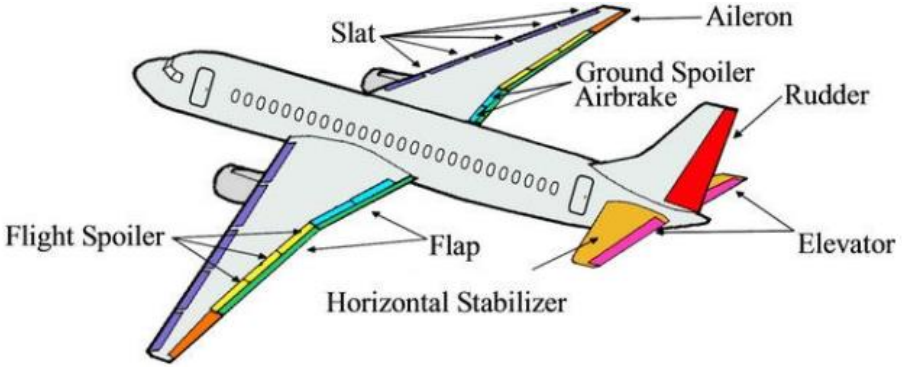

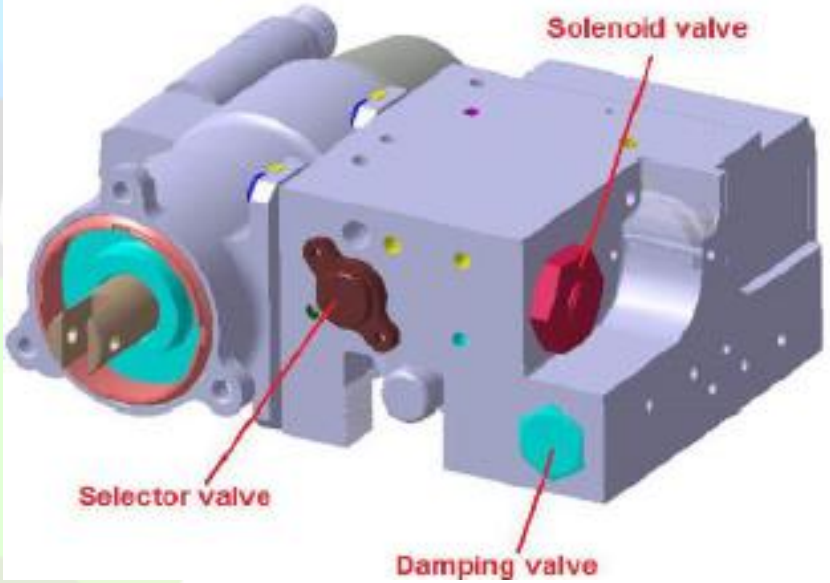

Equipment	MTBF (FH)
Aileron, Elevator & Rudder servo-actuator	21 000
Spoiler servo-actuator	29 000

80% CL	Allowed failures				
# Units on test	0	1	2	3	4
1	1.6094	-	-	-	-
2	0.8047	2.2483	-	-	-
3	0.5365	1.2476	2.6351	-	-
4	0.4024	0.8733	1.5494	2.9138	-
5	0.3219	0.6737	1.1189	1.75	3.1311

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4. Reliability Demonstration Plan of a FC Actuator

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Aileron	Allowed failures				
# Units on test	0	1	2	3	4
1	10 191	-	-	-	-
2	5094	14231	-	-	-
3	3396	7897	16680	-	-
4	2547	5528	9807	18444	-
5	2038	4266	7085	11081	19826

Spoiler	Allowed failures				
# Units on test	0	1	2	3	4
1	124	-	-	-	-
2	62	172	-	-	-
3	41	96	202	-	-
4	31	67	119	224	-
5	25	52	86	135	241

WE NEVER CLOSE

# Units on test	Allowed failures					
	Aileron			Spoiler		
	0	1	2	0	1	2
2	7.1	19.8	-	0.086	0.24	-
3	4.7	11	23.1	0.057	0.13	0.28

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5. Conclusion

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5. Conclusion

- Reliable product assurance through usage rate acceleration
  - Simple application
  - Difficult to verify in applications where multiple conditions chracterize the product

- Reliability Growth Testing
  - Valuable know-how

Source: www.dreamstime.com
www.influenceversuscontrol.wordpress.com

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Acknowledgements

Questions?

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