Hidden Beliefs in Verification Decisions

An Experimental Study with Aerospace Engineering Practitioners

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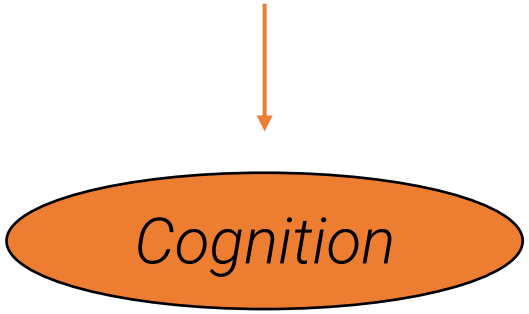
Engineering Verification

PROCESS + PEOPLE

- Verification Strategy

- Verification Engineer
- Test Engineer
- Subject Matter Expert

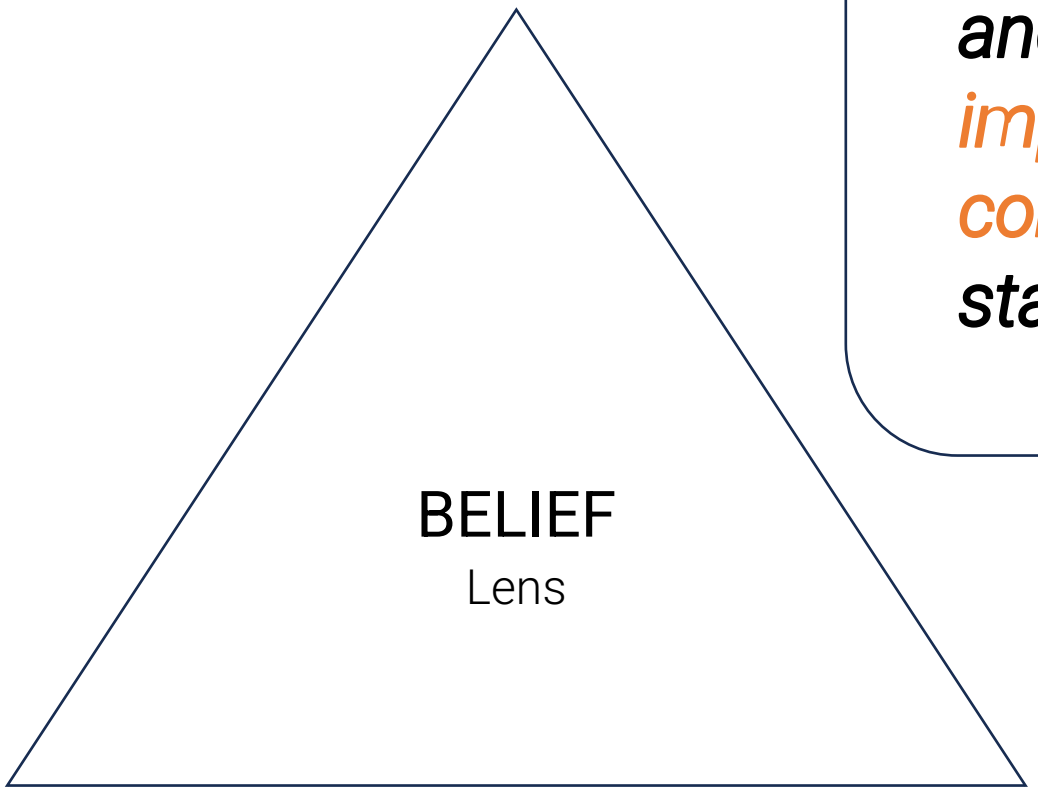


Verification ACTIVITY

Verification EVIDENCE ➡ Compliance ASSESSMENT

Verification MATRIX

Requirement	Description	Compliance	Verification Evidence	Method	Report
Thrust	Aircraft shall produce thrust of at least 110kN	Yes	Engine Test Report	Test	Thrust produced by the engine measure through testing.



- *Hidden beliefs refer to propositions and premises that the engineer implicitly uses to claim and justify compliance but does not explicitly state as part of the rationale.*

BELIEF

- *Combines evidence and knowledge containing assertions about the specified context that are inferred from the application of knowledge to the evidence produced.*
- *Confidence of the engineer codified in compliance assessments represents their state of belief.*

BIAS

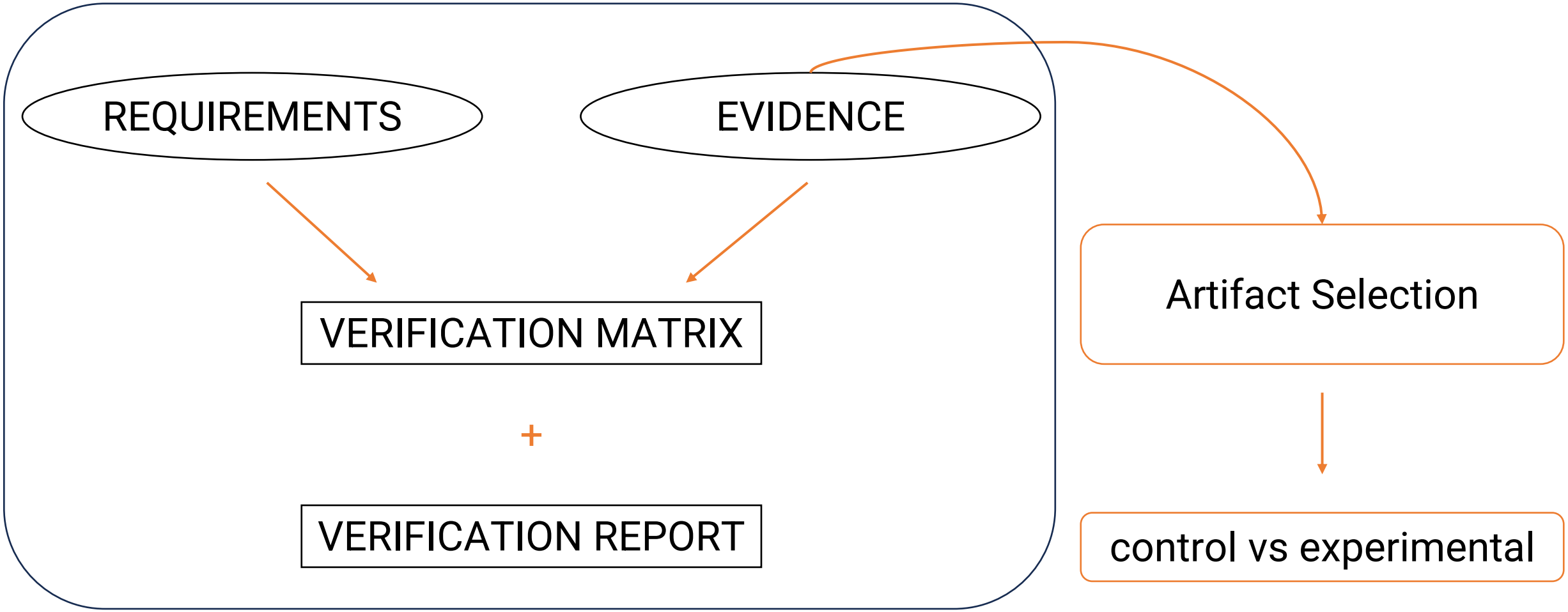
- *Inconsistency between a judgement of compliance and the information provided through evidence.*

BELIEF ≠ BIAS

Do HIDDEN BELIEFS manifest?

Let's TEST it!

- Aerospace Engineering Practitioners
- Familiar with Aircraft Design



Control	Experimental
Step 1 Requirements Document	*Step 1* Requirements Document
Step 2 Verification Matrix 1 Verification Evidence Set A *Step 3* Verification Report	*Step 2* Verification Matrix 1 Verification Evidence **Set B** *Step 3* Verification Report
Stage I	
Step 4 Verification Matrix 2 Verification Evidence **Set B** *Step 5* Verification Report	*Step 4* Verification Matrix 2 Verification Evidence Set A *Step 5* Verification Report
Stage II	

ID	Requirement		Compliance (Yes/ No)	Verification Evidence
1	Internal Configuration	Aircraft shall fit at least 180 passengers and 4 crew members (flight attendants)		
2	Dimensions	Aircraft shall fit in a hangar of at least length 45m, height 20m, width 40m		
3	Takeoff Specifications	Aircraft shall meet the following takeoff specifications: VTO ≥ 1.18Vs VCT ≥ 1.1Vs		
4	Cruise Specifications	Aircraft shall achieve service ceiling of at least 11000m		
5	Thrust	Aircraft shall produce thrust of at least 110kN		
6	Cruise Specifications	Aircraft shall achieve minimum range of 5500km		
7	Mass	Aircraft maximum takeoff weight (loaded and fueled) (MTOW) shall be no more than 80,000kg		
8	Dimensions	Aircraft wingspan shall not exceed 37m (34m desired)		

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Verification Evidence

Set A

- Engine Test Report
- Aircraft Mass Budget and Flight Analysis
- Aircraft Interior Configuration
- **Aircraft Technical Drawing I**

Set B

- Engine Test Report
- Aircraft Mass Budget and Flight Analysis
- Aircraft Interior Configuration
- **Aircraft Technical Drawing II**

Engine Test Report

6.0 RESULTS AND CONCLUSION

The AirJet engine tested by Jet Engine Test Wing (JETW) in accordance with regulations set forward by the UD Transportation Department (US TD) and the Federal Aviation Ministry (FAM) was found to be in compliance with the requirements of airworthiness.

Among the tests conducted (detailed above), this report details findings of On-Wing and Test Cell testing of the jet engine **SRB42 SE-40.** Summary of results are as follows:

	Unit	**Engine Type**
		SRB42 SE-40 NH1
Engine thrust produced	kN	90
Flat rate temp.	°C	30
Fan diameter	in	63
Bypass ratio	-	5.4
Climb pressure ratio	-	35.8
Cruise sfc	lbf/lb/h	0.543
Fuel consumption	kg/h	3500

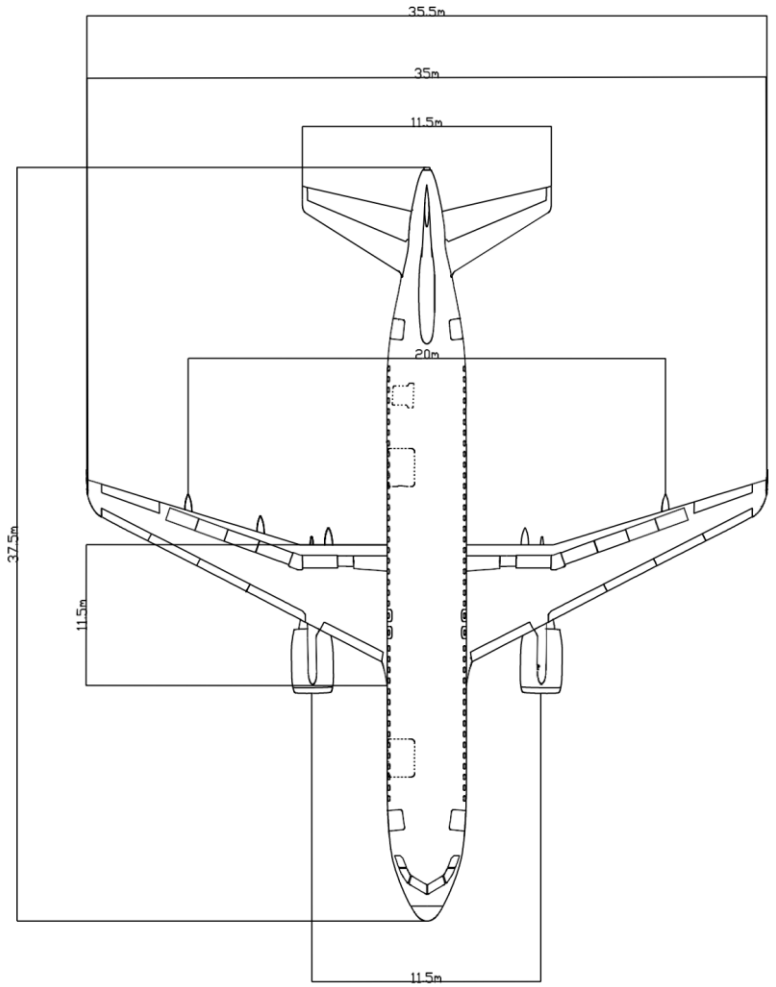
This report focuses on the engine thrust produced by the engine under specified test conditions, which was found to be 90kN. Being in compliance with airworthiness standards, the engine **SRB42 SE-40** is certified as required.

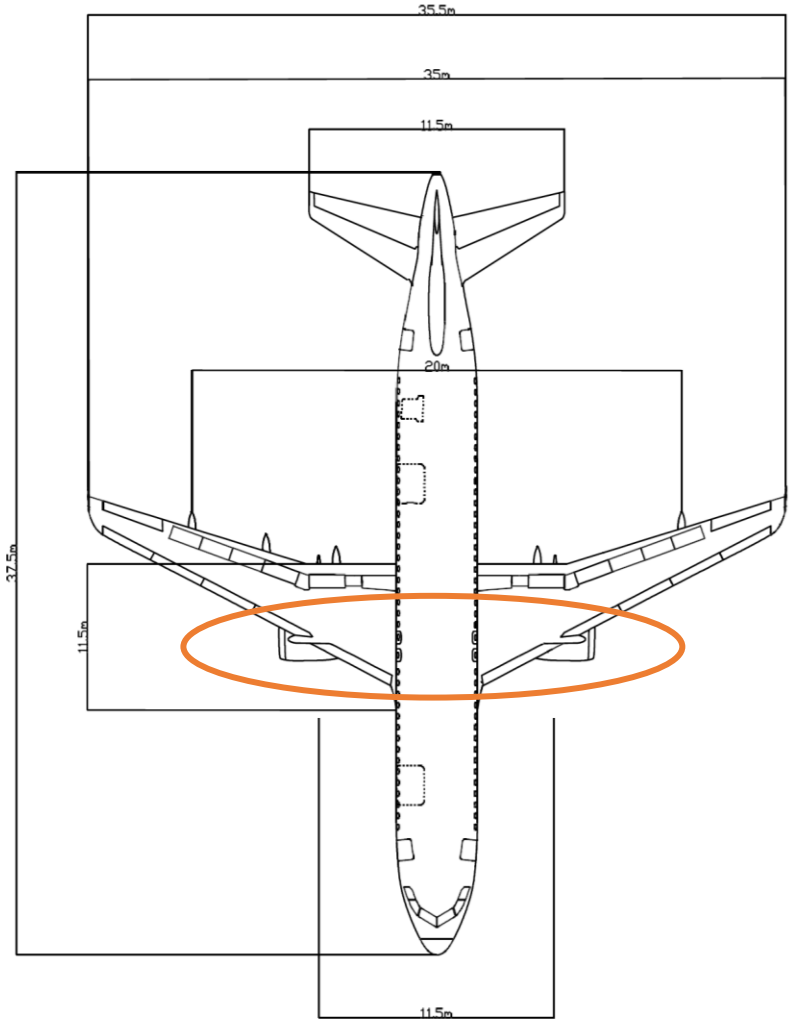
Flight Analysis

2. Aircraft Specifications

 Aircraft	 Fan Diameter	 Entry into Service	 Bypass Ratio	 Number of Engines
SkyCorp 007	63”	1989	5.4	2

Aircraft Technical Drawing I & II





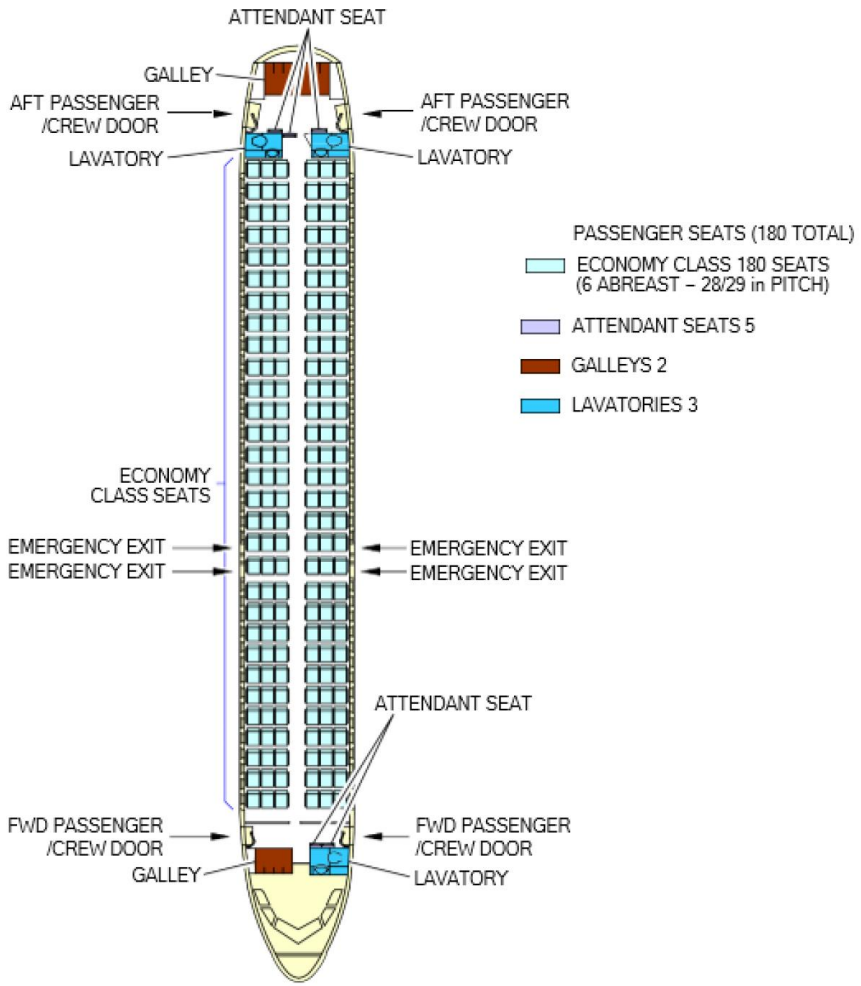
Aircraft Mass Budget

8. Mass Breakdown

**All values in kg*

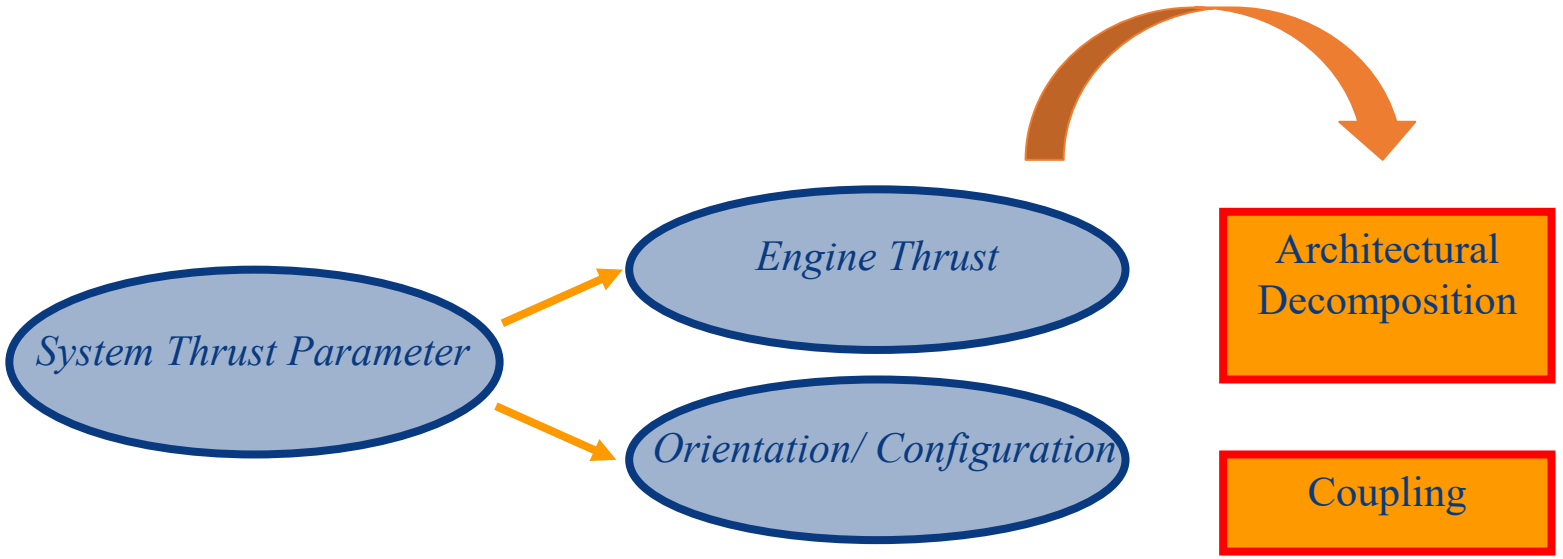
A	**MANUFACTURING EMPTY MASS**	**42428**	**54.39%**
	fuselage group	**12131**	**15.55%**
	frame and skin	7923	10.16%
	stabilizer	837	1.07%
	fin	458	0.59%
	undercarriage	2913	3.73%
	wing group	**7815**	**10.02%**
	struct.box	6345	8.13%
	flaps	761	0.98%
	slats	342	0.44%
	spoilers	171	0.22%
	ailerons	77	0.10%
	winglets	119	0.15%
	empennage group	**4500**	**5.77%**
	rudder	840	1.08%
	elevator	1420	1.82%
	tailfin	1570	2.01%
	tailplane	670	0.86%
	power group	**6906**	**8.85%**
	engine	3200	4.10%
	propeller	2666	3.42%
	ramjet	1040	1.33%
	fixed equipments group	**11076**	**14.20%**
	furnishings	4830	6.19%
	surface controls	1035	1.33%
	fuel systems	286	0.37%
	hydraulics	551	0.71%
	electrics	883	1.13%
	avionics	566	0.73%
	APU	430	0.55%
	air conditioning	657	0.84%
	misc. systems	1838	2.36%
	Manufacturing Contingency	12%	9360
B	**OPERATIONAL EMPTY MASS**		
	operational group	**3382**	**4.34%**
	crew	700	0.90%
	operational items	2682	3.44%
C	**MAXIMUM TAKEOFF MASS**		
	Operators Empty Mass	45810	58.73%
	Design Payload	13650	17.50%
	Design Fuel	18540	23.77%
	Maximum Takeoff Mass	78000	100.00%

Aircraft Interior Configuration



"Aircraft shall produce thrust of at least 110kN"

REQUIREMENT



PARAMETER + MEASURE OF PERFORMANCE

Ideal Selection

"Aircraft shall produce thrust of at least 110kN"

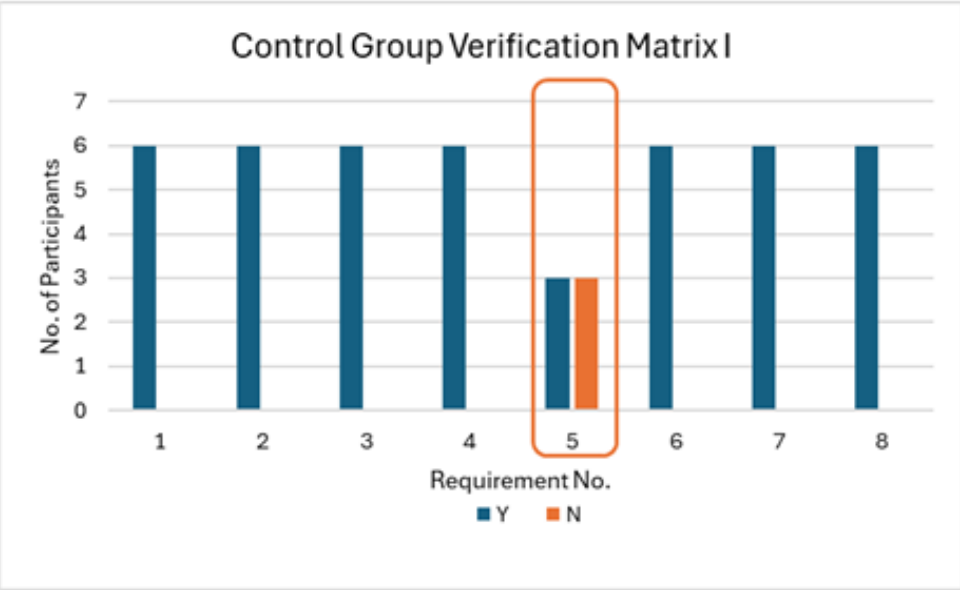
Set A

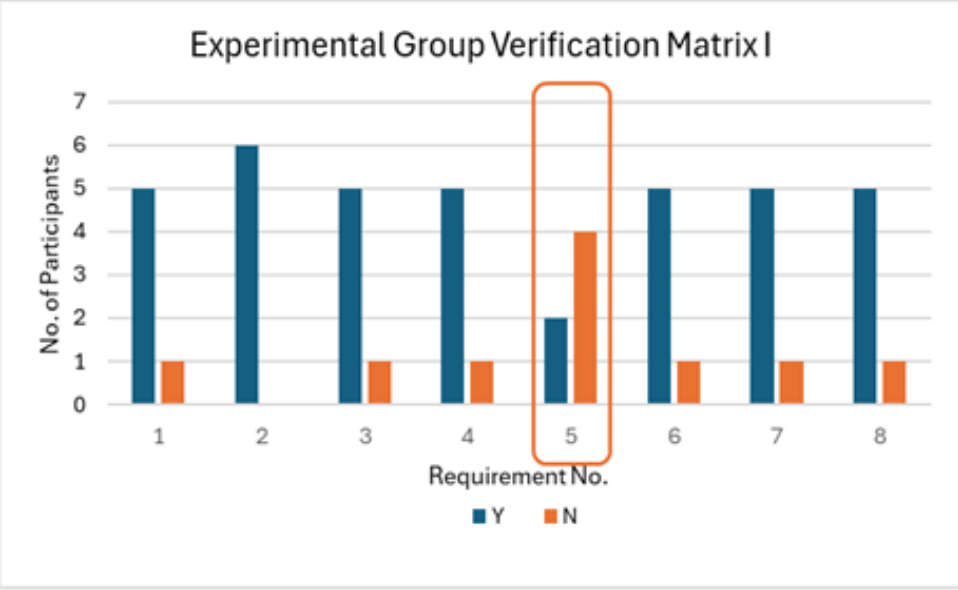
- **Engine Test Report**
- **Aircraft Mass Budget and Flight Analysis**
- Aircraft Interior Configuration
- **Aircraft Technical Drawing I**

Set B

- **Engine Test Report**
- **Aircraft Mass Budget and Flight Analysis**
- Aircraft Interior Configuration
- **Aircraft Technical Drawing II**

Stage I
Compliance Decisions

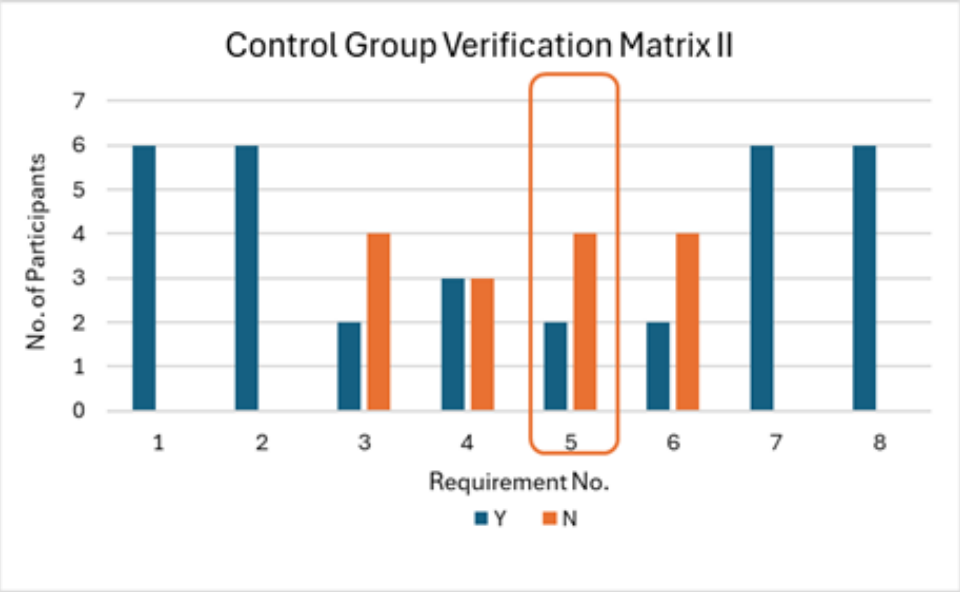


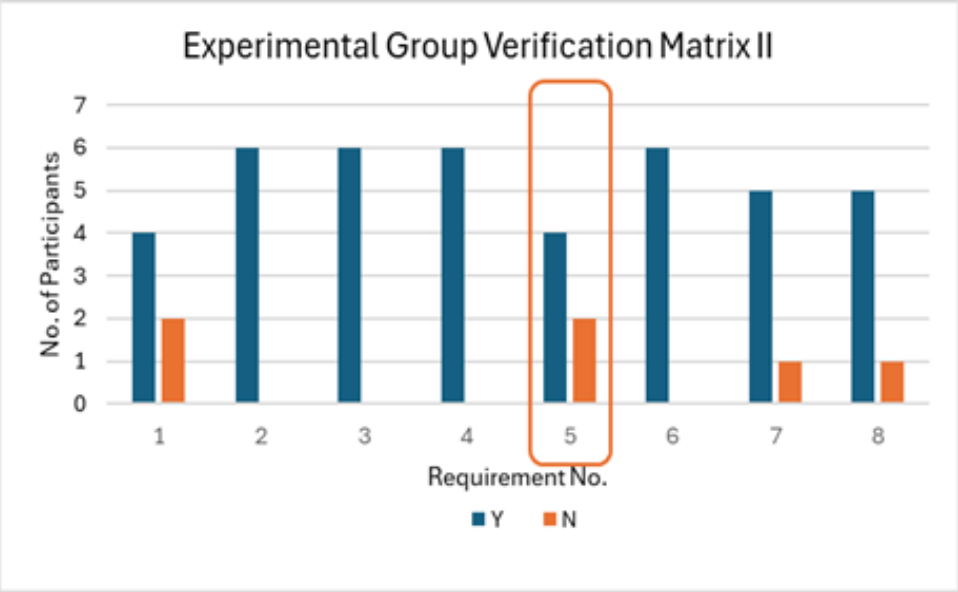


Stage I
Artifact Selection

Artifact No.	Evidence Artifact	Control Group	Experimental Group
1	Engine Test Report	100%	100%
2	Flight Analysis	0%	0%
4	Technical Drawing I	0%	X
5	Technical Drawing II	X	33%

Stage II
Compliance Decisions





Stage II
Artifact Selection

Artifact No.	Evidence Artifact	Control Group	Experimental Group
1	Engine Test Report	66%	100%
2	Flight Analysis	15%	15%
4	Technical Drawing I	X	33%
5	Technical Drawing II	50%	X

EXPECTATION.....

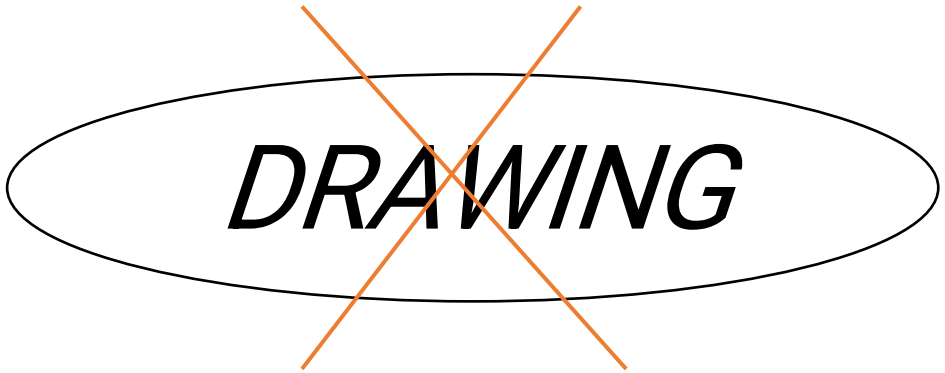
Thrust Requirement

Range Requirement

Speed Requirement

Cruise Requirement

REALITY !!!



2 engines?

inconsistency

trust

misinterpretation

>50% participants used the drawing at least once

Why is this important?

symptom of an assumption not being validated

inconsistency between the assumption and the reality of the project being evaluated

Why is this important?

engineers with a different set of hidden beliefs

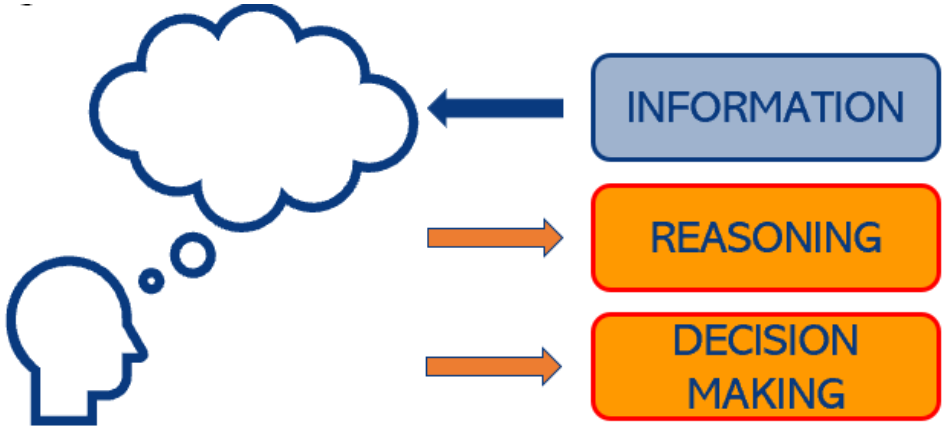
gaps in assessment

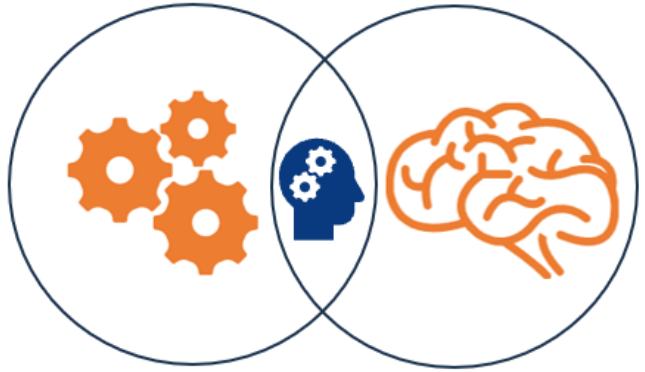
Why is this important?

cognitive assistants trained on data from real projects

training data may contain significant gaps in the complete reasoning behind the verification assessment

WHAT NEXT?





STUDENTS ✓ EXPERTS ?

Expertise, Perception, Cognition…

THANK **YOU**

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