



SENS4ICE

SENSORS AND CERTIFIABLE HYBRID ARCHITECTURES
FOR SAFER AVIATION IN ICING ENVIRONMENT

SENS4ICE Icing Wind Tunnel Capabilities and Test Procedures

1st Project Symposium

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This document does not contain any export controlled technical data



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SENS4ICE Icing Wind Tunnel Requirements

- 💧 One of the main objectives of SENS4ICE is to develop and mature different ice detection technologies
- 💧 There are 10 different ice detectors being developed by the project partners
- 💧 Most of these ice detectors target detection and discrimination between App O and App C conditions
- 💧 Detectors performance need to be tested in relevant environment at icing wind tunnel
- 💧 Extensive icing wind tunnel tests are planned in the project
 - 💧 28 weeks of testing distributed over four facilities
 - 💧 Parallel testing planned to meet project timeline
- 💧 Testing will provide data for technology selection towards flight test



Icing Wind Tunnel Test Matrix

- 💧 Covers a wide icing envelope for App C and App O conditions
- 💧 Four categories of test points were included:
 - 💧 Common test points between all tunnels for comparison
 - 💧 Common test points at least between two tunnels, e.g. high speed test points
 - 💧 Additional test points required to be tested for all sensors in a specific tunnel
 - 💧 Optional "nice to have" test points, e.g. "outer regions" of App. O, temperatures ~ 0C or with very low LWC.



SENS4ICE Test Matrix

Example test matrix – Collins

COLLINS Test Matrix,
App C conditions

Condition	Aircraft True Speed (knots)	Aircraft True Speed (m/s)	Static Temp (°C)	Static Temp (°F)	MVD (µm)	LWC (g/m3)	IM/CM	Required Run Time (min)	Optional Run Time (min)	Run Optional Test? (Y/N)	Optional Test Profile	# of Test Repetition
1	78	40	-20	-4	15	0.3	CM	10	5	N	ON/OFF	1
2	78	40	-10	14	20	0.42	CM					
3	78	40	0	32	23	0.54	CM					
4	130	67	-30	32	15	0.8	CM					
5	130	67	-20	-4	18	0.25	CM					
6	130	67	-10	14	20	0.42	CM					
7	165	85	-30	-22	17	0.18	CM					
8	165	85	-20	-4	15	0.3	CM					
9	165	85	-10	14	23	0.34	CM					
10	78	40	-20	-4	22	1.5	IM					
11	78	40	0	32	20	2.5	IM					
12	78	40	-10	14	28	1.2	IM					
13	130	67	-30	32	23	2	IM					
14	130	67	-20	-4	30	0.8	IM					
15	130	67	-10	14	25	1.4	IM					
16	165	85	-30	-22	20	1	IM					
17	165	85	-20	-4	23	1.3	IM					
18	165	85	-10	14	32	0.8	IM					

Condition	Aircraft True Speed (mph)	Aircraft True Speed (m/s)	Static Temp (°C)	Static Temp (°F)	MVD (µm)	LWC (g/m3)	Required Run Time (min)	Optional Run Time (min)	Run Optional Test? (Y/N)	Optional Test Profile	# of Test Repetition
1	170	76	-17.7	0	188.6	0.42	5	5	N	ON/OFF	1
2	170	76	-17.7	0	122.3	0.46					
3	170	76	-17.7	0	189.5	0.56					
4	170	76	-17.7	0	169.1	0.78					
5	170	76	-17.7	0	183.8	0.78					
6	170	76	-17.7	0	155.4	0.94					
7	170	76	-17.7	0	134.9	0.99					
8	170	76	-17.7	0	163.5	0.82					

COLLINS Test Matrix, App O conditions (preliminary)



SENS4ICE Test Matrix

Example test matrix – NRC

Condition	Aircraft True Speed (knots)	Aircraft True Speed (m/s)	Static Temp (°C)	Static Temp (°F)	MVD (µm)	LWC (g/m3)	IM/CM	Required Run Time (min)	Optional Run Time (min)	Run Optional Test? (Y/N)	Optional Test Profile	# of Test Repetition	TUBS ref	collins ref	TsAGI ref	NRC ref
1	165	85	-30	-22	17	0.18	CM							7		1
2	130	67	-30	-22	15	0.8	CM							4		2
3	78	40	-20	-4	24	0.18	CM						3			3
4	130	67	-20	-4	18	0.25	CM							5		4
5	78	40	-20	-4	15	0.3	CM	10	5	N	ON/OFF	1	1	1		5
6	272	140	-18	-0.4	20	0.5	CM								1	6
7	78	40	-18	-0.4	20	0.6	CM								3	7
8	272	140	-15	5	20	0.5	CM								7	8
9	78	40	-15	5	20	0.6	CM								9	9
10	78	40	-10	14	30	0.21	CM						4			10
11	78	40	-10	14	25	0.3	CM						6			11
12	165	85	-10	14	23	0.34	CM							9		12
13	78	40	-10	14	20	0.42	CM						5	2		13
14	130	67	-10	14	20	0.42	CM							6		14
15	78	40	-10	14	15	0.6	CM						2			15
16	78	40	0	32	23	0.54	CM							3		16
17	165	85	-20	-4	20	0.21	CM									17
18	165	85	-20	-4	30	0.11	CM									18
19	165	85	-20	-4	35	0.08	CM									19
20	165	85	-20	-4	40	0.06	CM									20
21	165	85	-10	14	35	0.15	CM									21
22	165	85	-10	14	40	0.1	CM									22
23	165	85	-30	-22	25	0.1	CM									23
24	165	85	-30	-22	35	0.05	CM									24
25	165	85	0	32	30	0.38	CM									25
26	165	85	0	32	40	0.15	CM									26
27	165	85	-10	14	20	0.3	CM									27
29	165	85	-10	14	20	0.14	CM									29



SENS4ICE Test Matrix

Example preliminary test matrix – TU Braunschweig

Condition	Aircraft True Speed (knots)	Aircraft True Speed (m/s)	Static Temp (°C)	MVD (µm)	LWC (g/m ³)
20	78	40	-20	< 40 µm	0.2
21	78	40	-20	< 40 µm	0.32
22	78	40	-20	> 40 µm	0.2
23	78	40	-15	< 40 µm	0.2
24	78	40	-15	< 40 µm	0.35
25	78	40	-15	> 40 µm	0.21
26	78	40	-10	< 40 µm	0.2
27	78	40	-10	< 40 µm	0.36
28	78	40	-10	> 40 µm	0.23
29	78	40	-5	< 40 µm	0.2
30	78	40	-5	< 40 µm	0.2
31	78	40	-5	> 40 µm	0.25
32	78	40	0	< 40 µm	0.2
33	78	40	0	< 40 µm	0.43
34	78	40	0	> 40 µm	0.27
40	78	40	-17.8	122	0.46
43	78	40	-17.8	164	0.82
46	78	40	-17.8	189	0.42

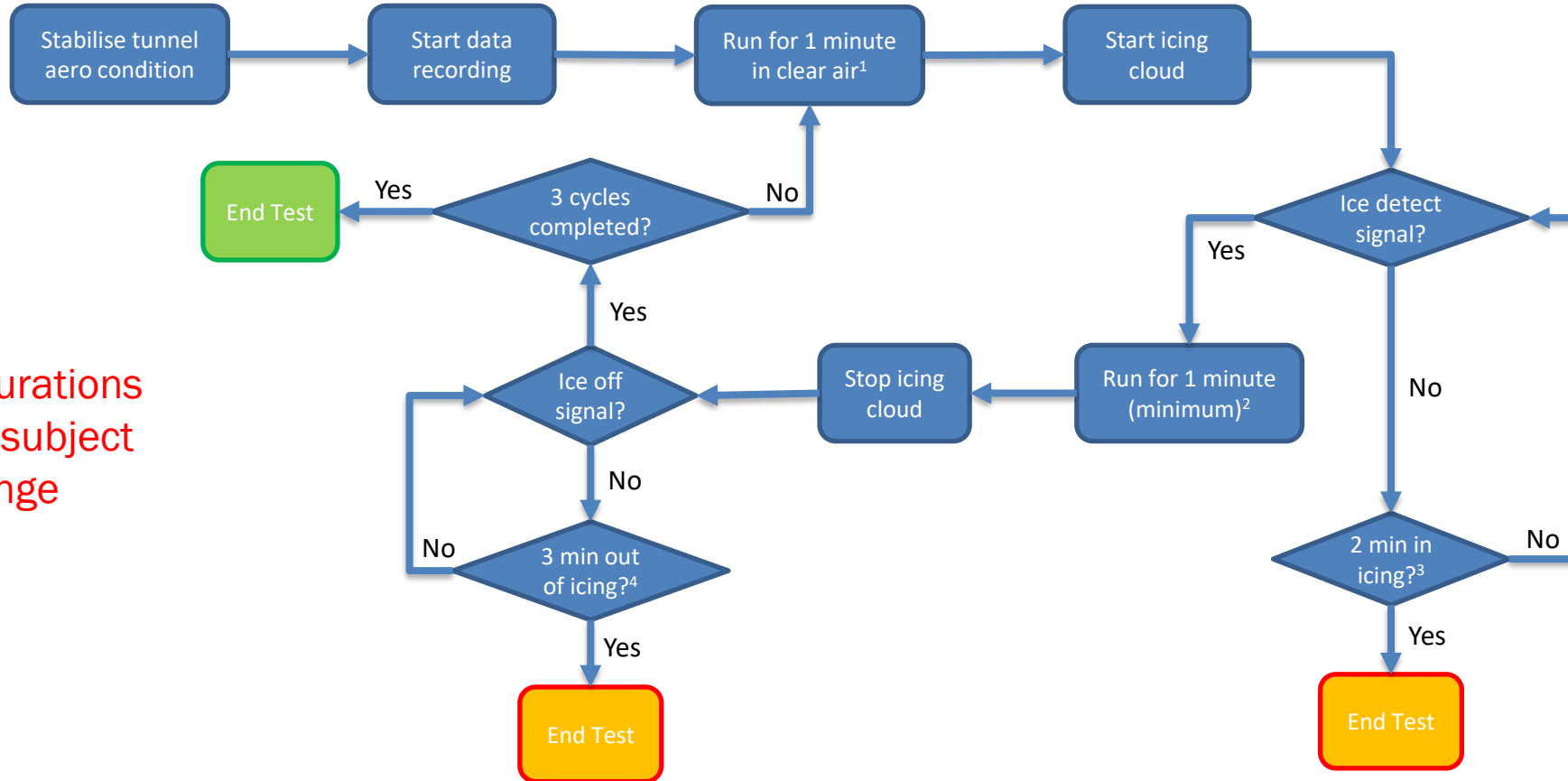


Test Procedures

- Establish a common approach which can be used for all sensors
- Based on requirements from AS5498A (ED-103 Rev A)
- Focus on generating maximum data during test window to allow better assessment of sensor performance



Test Procedures – App C Conditions



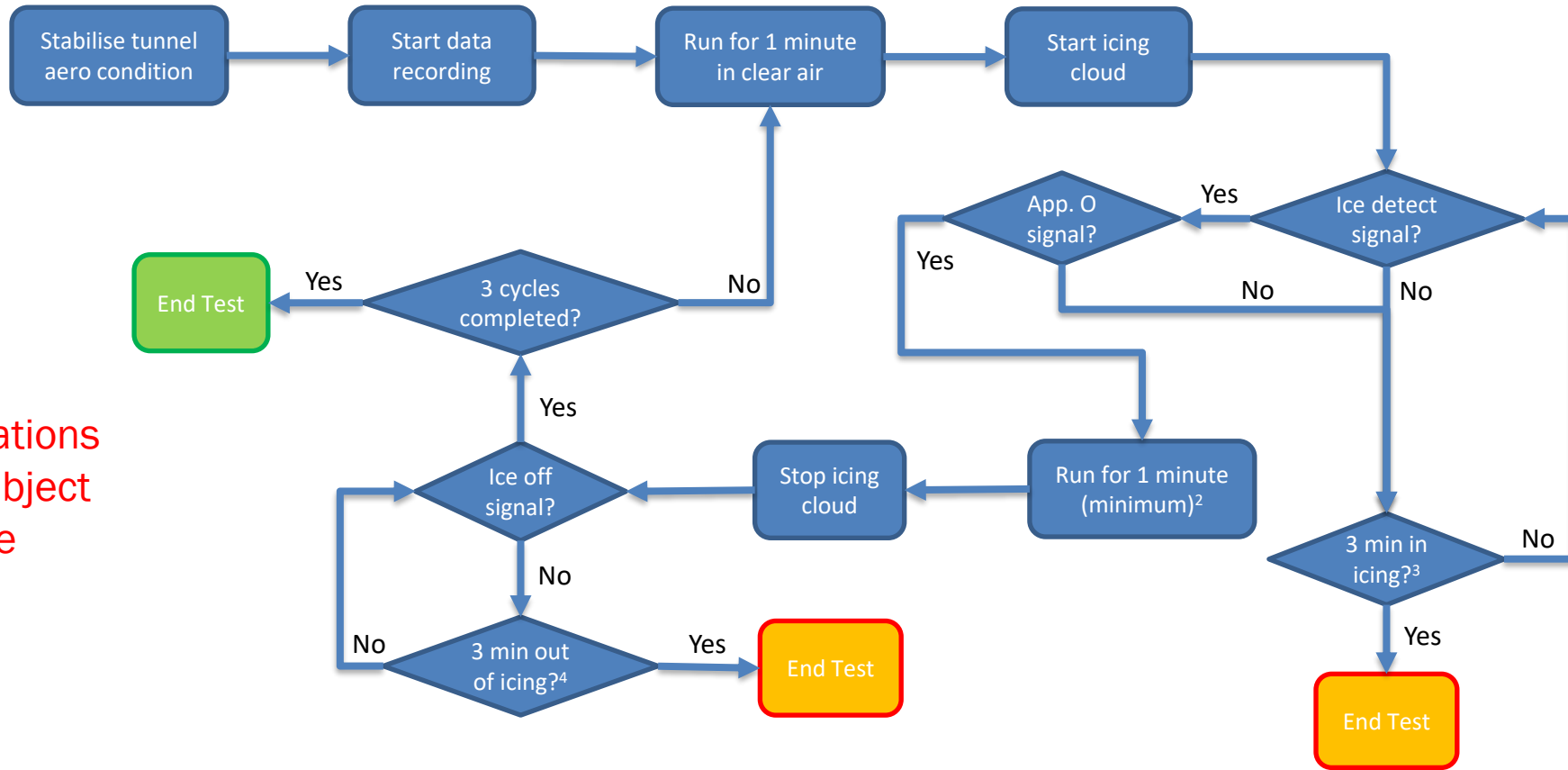
Run time durations stated are subject to change

Notes:

1. Running in clear air for 1 minute is required to check for false-positives
2. Running for minimum of 1 minute in icing after ice-detect is required to check for false-negatives
3. Based on maximum Appendix C detection time in AS5498A being 99 seconds
4. Based on AS5498A time to detect exit being a maximum of 3 minutes



Test Procedures – App 0 Conditions



Run time durations stated are subject to change

Notes:

1. Running in clear air for 1 minute is required to check for false-positives
2. Running for minimum of 1 minute in icing after ice-detect is required to check for false-negatives
3. Based on maximum Appendix O detection time in AS5498A being 160 seconds
4. Based on AS5498A time to detect exit being a maximum of 3 minutes



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