

Health assessment of landing gear retraction and extension hydraulic system based on improved risk coefficient and FCE model

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Table S1. Statistical table of detection difficulty

u_i	Test procedure/ operation	Subtask number	Number of reference programs	Tools / equipment/ consumables	Number of procedures	
					Preparation	Operating
u_1	Sampling oil detection	29-11-00-200-801	9	Cleaning bottle for taking hydraulic oil sample	6	8
u_2	Check for noise and bubbles (Refer to u_5)	—	—	Adjust / Test	—	—
u_3	Hydraulic oil overheat warning system - adjust / test	29-32-00-730-802	2	COM-1552TEMPCAL Heater probe kit COM-3924 Tester - thermal switch COM-3950 Heater probe accessories COM-3951 Heater probe accessories COM-3952 Heater probe assembly	—	5
u_4	Check the oil filtration assembly for differential pressure indicators	29-11-61-210-801	2	Visual inspection	—	5
u_5	MLG extending- retracting - adjustment / testing	32-32-00-710-802	8	Visual inspection	11	11
	NLG extending- retracting - adjustment / testing	32-33-00-710-802	9	Visual inspection	12	10
u_6	Instrument testing	29-00-00-790-801	8	External leak detection table	—	6
u_7	Instrument testing	29-00-00-790-803	7	COM-1786 Internal leakage check flowmeter COM-1787 Ammeter COM-1793Digital multimeter SPL-1788 Cable STD-163 Portable hydraulic trolley	20	5
u_8	Instrument testing	29-00-00-790-801	8	External leak detection table	—	6
u_9	Check the pipeline for scratch, wear and corrosion	Service inspection	—	Visual inspection、 Chromatographic detection	—	—
u_{10}	Check the oil quantity indicator	Service inspection	—	Visual inspection	—	—

Table S2. Statistical table of maintenance difficulty

u_i	Test procedure/ operation	Subtask number	Number of reference programs	Tools / equipment/ consumables	Number of procedures	
					Preparation	Operating
u_1	Replace hydraulic oil	29-00-00-900-801	34	SPL-1795 Lock - tank breather valve	17	20
				SPL-6107 Oil drain hose		
				STD-163 Portable hydraulic trolley		
				STD-1154 Container		
				STD-3901 Anti-hydraulic oil container		
u_2	Bleed the air from the hydraulic system	29-00-00-870-801	15	D00153 Hydraulic oil	—	10
				—		
u_3	Heat exchanger - Inspection / testing	29-11-04-200-801	2	COM-1550 Lap test table	—	5
	Heat exchanger - remove / install	29-11-04-000-801	7/10	COM-1550 Lap test table	7	5/21
				A00436 sealant		
u_4	Pressure pack filter element - Remove / install	29-11-71-000-802/ 29-11-71-400-802	9/8	A02315 Artificial rubber low density sealant	2	7/16
				D00054 Lubricant for hydraulic components		
				D00153 Hydraulic oil		
u_5	Landing gear selector valve - remove / install	32-31-51-020-801	3/8	Sealing ring,Wave filter	3	8/20
				COM-1550 Lap test table		
				A02315 Artificial rubber low density sealant		
				C00913 Non drying resin mixture		
				D00153 Hydraulic oil		
u_6	MLG uplock actuator - remove / install	32-32-41-000-801	2/7	G50136 Non drying corrosion inhibitor paste	3	7/16
				G50171 Preservative		
				SPL-4896 Adapter Component- uplock		
				D00153 Hydraulic oil		
				D00633 Aircraft general grease		
u_6	MLG downlock actuator - remove / install	32-32-51-000-801	4/8	Sealing ring,Joint,Limiter	3	8/20
				D00153 Hydraulic oil		

				D00633 Aircraft general grease		
				Sealing ring、Joint、Safety pin		
u_7	Refer to u_6	—	—	—	—	—
				A00436 Sealant		
				B00148 2-Butanone		
u_8	Cleaning, replacement and anti-corrosion	29-00-00-916-801	3	G00009 Organic corrosion inhibitors	—	4
				G00034 Cotton wipe		
				Absorbent wipe		
u_9	Cleaning, replacement and anti-corrosion	32-00-11-100-801	3	B00130 Propan-2-ol	2	3
u_{10}	Refueling and tank pressurization	29-09-00-860-801	4	STD-77 Regulated, dried and filtered air source	—	15

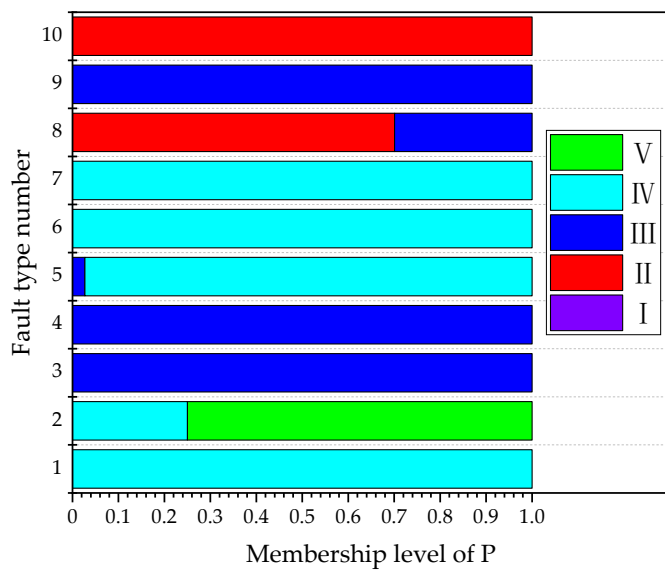
Table S3. Simulation of case data parameters

$RPN - M$ coefficient index	Impact Indicators	Reference weights	$y_{\min}$	$y_{\max}$
P	1.Frequency	0.50	8	32
	2. λ	0.50	11.0434	38.4022
S	1. $\gamma_{\max}$	0.50	0.07	2.24
	2. $\eta_{\max}$	0.50	21.46%	126.97%
D	1.Number of reference programs	0.33	2	17
	2.Tool material complexity	0.33	1	5
	3.Number of preparation and operating procedures	0.33	5	44
M	1.Number of reference programs	0.33	3	34
	2.Tool material complexity	0.33	1	7
	3.Number of preparation and operating procedures	0.33	4	57

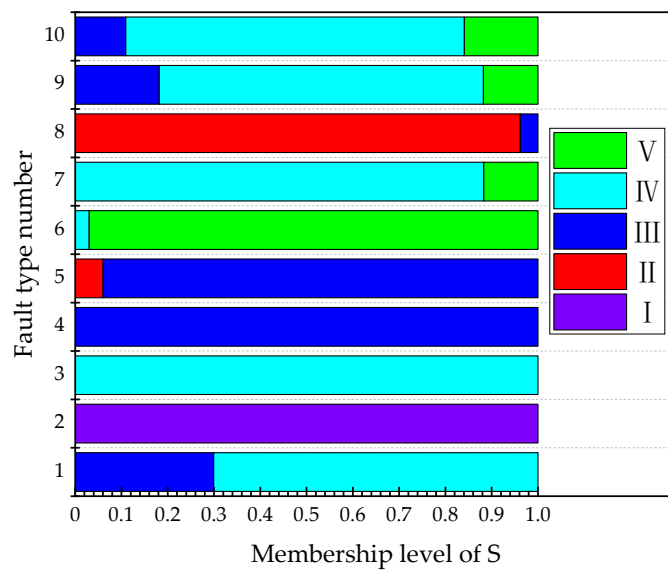
Table S4. Experts scoring the impact hazards of fault types 9 and 10

Expert number	u_9					u_{10}				
	Level	Level	Level	Level	Level	Level	Level	Level	Level	Level
	I	II	III	IV	V	I	II	III	IV	V
1	0	0	14	62	4	0	0	18	73	1
2	0	0	12	61	7	0	0	8	76	11
3	0	0	11	79	6	0	0	11	65	19
4	0	0	8	87	5	0	0	4	92	21
5	0	0	19	66	13	0	0	8	97	26
6	0	0	24	58	0	0	0	9	75	17
7	0	0	20	70	17	0	0	13	84	19
8	0	0	9	68	6	0	0	9	69	12
9	0	0	25	51	17	0	0	16	77	10
10	0	0	17	76	6	0	0	12	96	7
Average	0	0	17.968	69.315	11.666	0	0	12.222	81.823	17.783
Membership degree	0	0	0.1816	0.7005	0.1179	0	0	0.1093	0.7317	0.1590

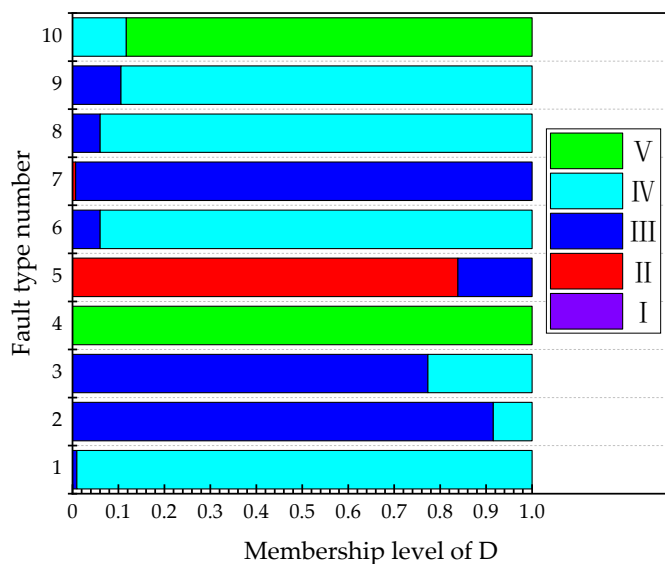
Supplementary note: The score range is from 0 to 100. The higher the score, the higher the degree of conformity of this grade, but the total score of the same expert is not necessarily 100.



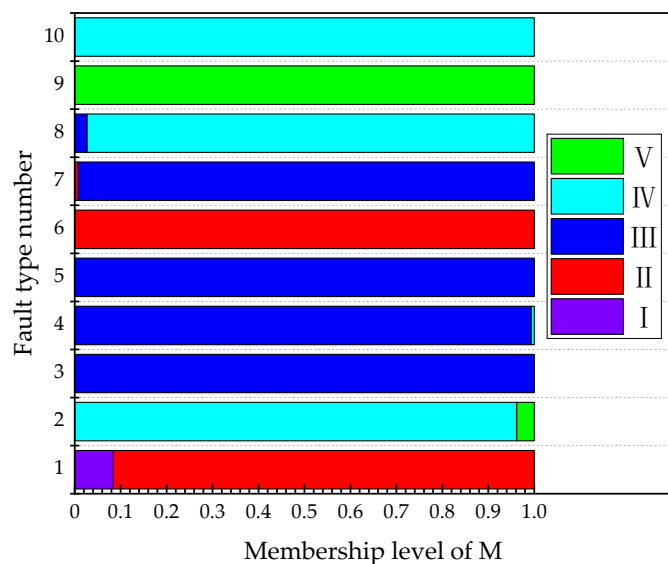
(a)



(b)



(c)



(d)

Figure S1. Membership level histogram: (a) Membership of P; (b) Membership of S; (c) Membership of D; (d) Membership of M.