Formally specifying fault trees

Software Modelling and Verification Group

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1 Case study01

– **Description**: 01-2trainsElec-Elect - system with a normal and a standby train.
– **Diagram**:

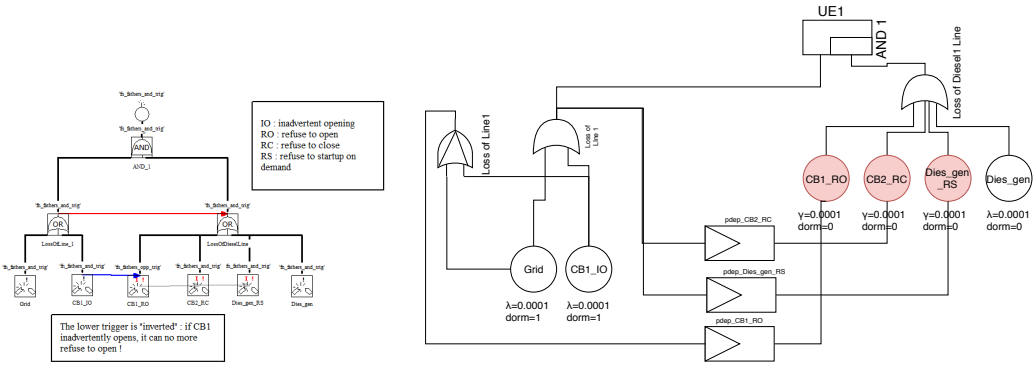

Fig. 1. Case study 01

– **Results**:

Table 1. Results of case study 01.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.008259466	0.009800534	0.009107576	0.196		
2000	0.031515555	0.034424445	0.032947577	0.131		
3000	0.065328235	0.069411765	0.067290387	0.28		
4000	0.106511031	0.111588969	0.108821453	0.457		
5000	0.152577995	0.158482005	0.154961298	0.692		
6000	0.199952232	0.206507768	0.203719495	0.982		
7000	0.251340196	0.258439804	0.253576334	1.337		
8000	0.29981474	0.30730526	0.303387034	1.702		
9000	0.346793106	0.354566894	0.352304317	2.159		
10000	0.394002912	0.401977088	0.399715913	2.647		

– **Questions:** Why CB1IO should occur once channel has switched to diesel line. CB1 do not IO and we have already checked that it didn't fail to refuse to open?

2 Case study02

– Description: 02-3trains - standby redundancy:
– **Diagram**:

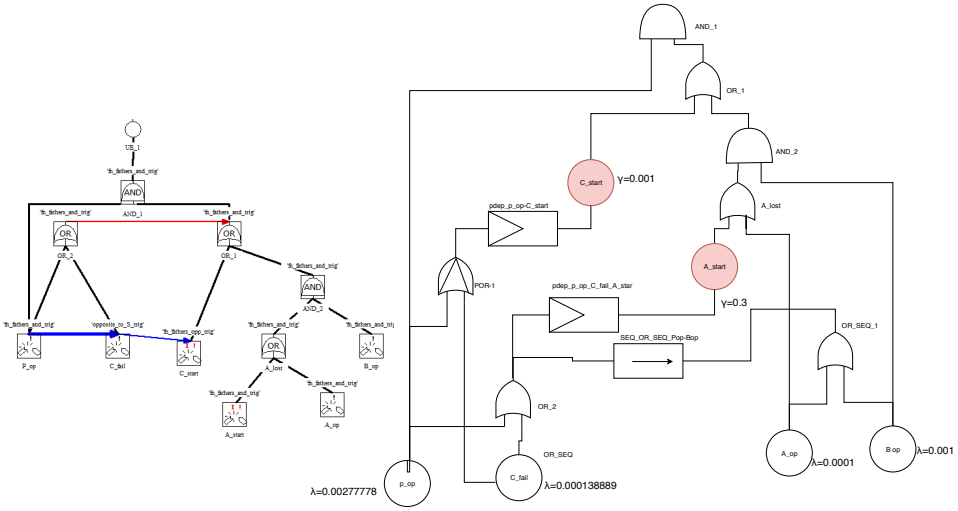

Fig. 2. Case study 02

– **Results**:

Table 2. Results of case study 02.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.160854881	0.166885119	0.164754305	0.046		
2000	0.322032272	0.329667728	0.325911406	0.139		
3000	0.425807544	0.433872456	0.429243721	0.28		
4000	0.496827256	0.504972744	0.500518369	0.474		
5000	0.551072073	0.559167927	0.555118511	0.731		
6000	0.597762472	0.605737528	0.60033059	1.004		
7000	0.636861994	0.644678006	0.639514036	1.353		
8000	0.671255065	0.678884935	0.674272407	1.785		
9000	0.702158497	0.709581503	0.705446535	2.212		
10000	0.730390751	0.737589249	0.733545524	2.685		

– **Questions:** Do you have a paper or document describing all variants of BDMP constructs and their semantics, e.g., this example uses "opposite_to_S_trig", "fn_fathers_opp_trig" and "fn_fathers_and_trig". Though, apparently, the BDMP looks quite simple with only three triggers.?

3 Case study03

– Description: 03-CCF - Common cause failures
– **Diagram**:

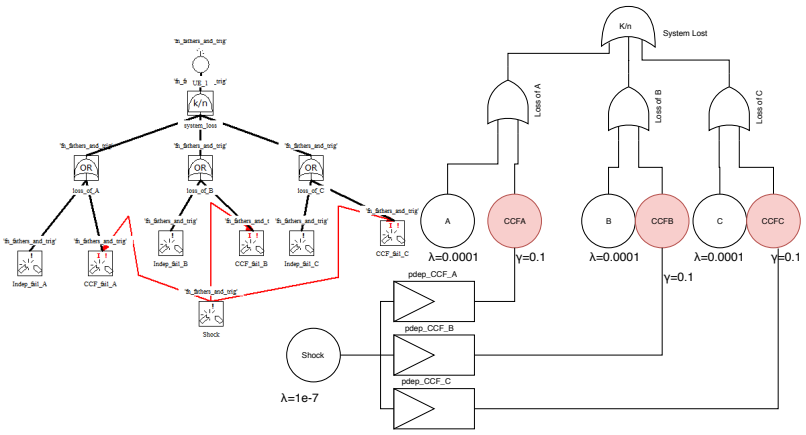

Fig. 3. Case study 03

– **Results**:

Table 3. Results of case study 03.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.023972105	0.026527895	0.025450697	0.056		
2000	0.083854611	0.088425389	0.086680058	0.157		
3000	0.162314051	0.168365949	0.166732146	0.308		
4000	0.249299639	0.256380361	0.254438672	0.509		
5000	0.335642782	0.343357218	0.342666363	0.761		
6000	0.41990466	0.42795534	0.427064379	1.07		
7000	0.497567271	0.505712729	0.505173879	1.425		
8000	0.56936136	0.57741864	0.575799061	1.834		
9000	0.632962836	0.640797164	0.638566353	2.281		
10000	0.689272995	0.696787005	0.693618419	2.784		

4 Case study04

– Description: 04-Demoeng - 3 lines electrical system
– **Diagram**:

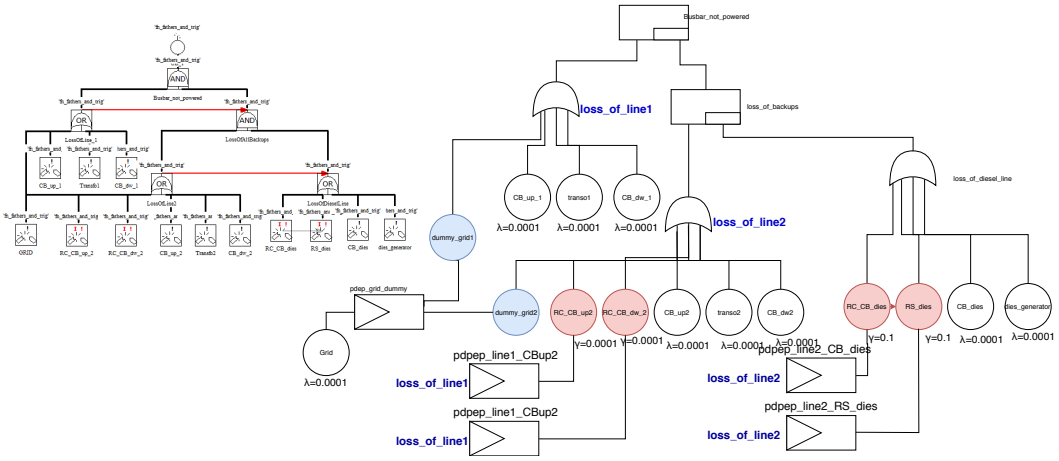

Fig. 4. Case study 04

– **Results**:

Table 4. Results of case study 04.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.010727806	0.012472194	0.011366252	0.061		
2000	0.045678965	0.049141035	0.046858866	0.167		
3000	0.100830808	0.105789192	0.103304569	0.33		
4000	0.173771944	0.179988056	0.174467809	0.529		
5000	0.251071433	0.258168567	0.253873828	0.781		
6000	0.332002987	0.339697013	0.336019953	1.091		
7000	0.412554347	0.420585653	0.416746074	1.453		
8000	0.489697565	0.497842435	0.493199416	1.868		
9000	0.561322196	0.569397804	0.563630952	2.352		
10000	0.625035067	0.632904933	0.627146567	2.832		

5 Case study05

– Description:05-Demoeng_simp - 3 lines electrical system
– **Diagram**:

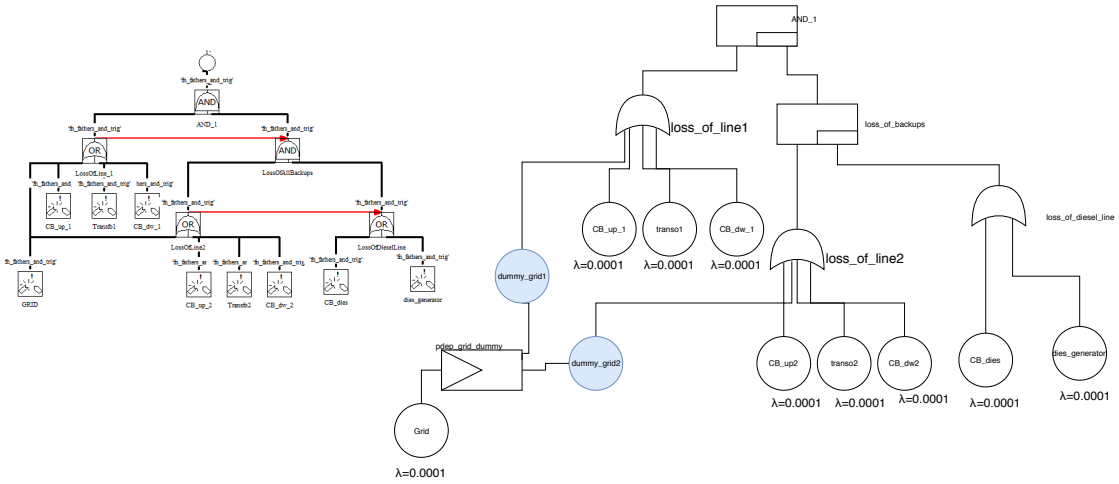

Fig. 5. Case study 05

– **Results**:

Table 5. Results of case study 05.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.011373275	0.013166725	0.011338493	0.038		
2000	0.046022906	0.049497094	0.046799628	0.122		
3000	0.10125625	0.10622375	0.103219594	0.258		
4000	0.170792804	0.176967196	0.174365742	0.442		
5000	0.249797326	0.256882674	0.253763089	0.681		
6000	0.331933186	0.339626814	0.335907458	0.959		
7000	0.413093605	0.421126395	0.416636914	1.314		
8000	0.488967644	0.497112356	0.493096987	1.702		
9000	0.558519254	0.566600746	0.563537248	2.108		
10000	0.621497503	0.629382497	0.627062523	2.607		

6 Case study06

– Description: 06-Excl - Exclusivity of failure modes of a cpt
– **Diagram**:

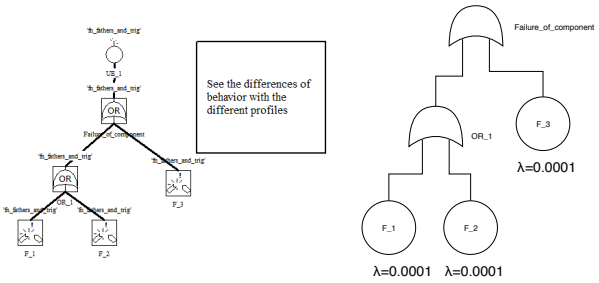

Fig. 6. Case study 06

– **Results**:

Table 6. Results of case study 06.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.255282245	0.262417755	0.259181779	0.001		
2000	0.448115927	0.456224073	0.451188364	0.001		
3000	0.588928212	0.596931788	0.59343034	0.001		
4000	0.694370581	0.701849419	0.698805788	0.001		
5000	0.772744716	0.779535284	0.77686984	0.001		
6000	0.831926181	0.837973819	0.834701112	0.001		
7000	0.876434382	0.881745618	0.877543572	0.001		
8000	0.907881359	0.912538641	0.909282047	0.001		
9000	0.931470515	0.935529485	0.932794487	0.001		
10000	0.949139946	0.952660054	0.950212932	0.001		

7 Case study07

– Description: 07-Excl1 - A and B work in parallel. After a failure of A, B can no longer fail and vice versa.
– **Diagram**:

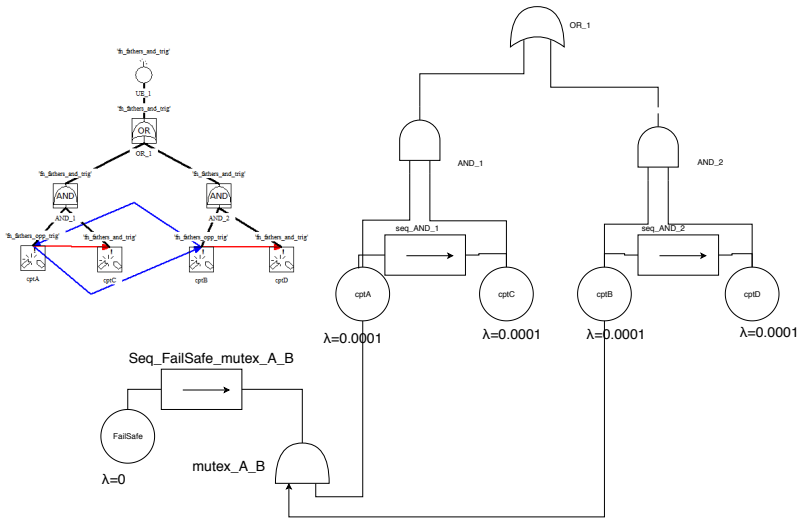

Fig. 7. Case study 07

– **Results**:

Table 7. Results of case study 07.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.008077542	0.009602458	0.009055917	0.001		
2000	0.030938188	0.033821812	0.03285854	0.001		
3000	0.063879042	0.067920958	0.067175195	0.001		
4000	0.104798807	0.109841193	0.108688872	0.001		
5000	0.149700629	0.155559371	0.154818122	0.001		
6000	0.197676071	0.204203929	0.20357094	0.001		
7000	0.247070077	0.254129923	0.253426356	0.001		
8000	0.29705446	0.30452554	0.30323859	0.001		
9000	0.345526358	0.353293642	0.352159569	0.001		
10000	0.392056256	0.400023744	0.399576401	0.001		

8 Case study08

– Description: 08-PC - Qualitative model of a PC
– **Diagram**:

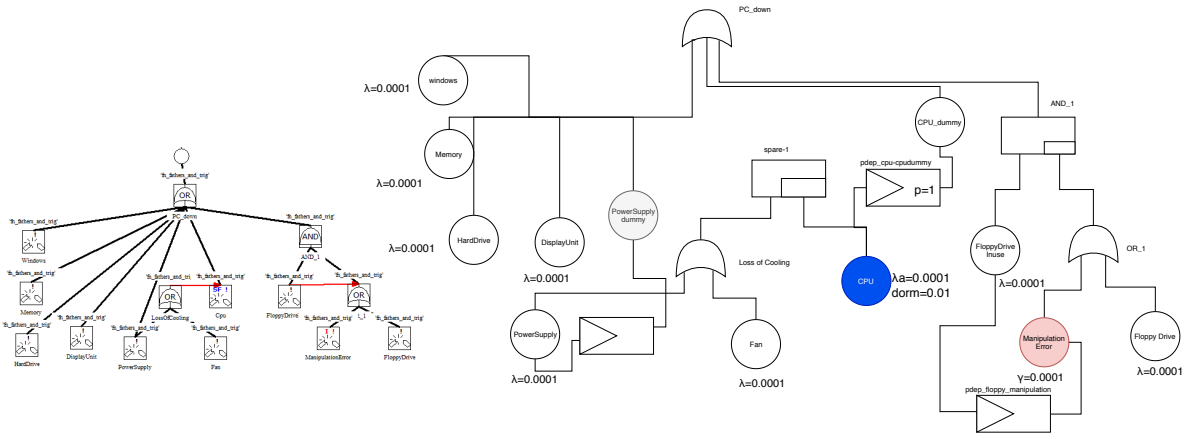

Fig. 8. Case study 08

– **Results**:

Table 8. Results of case study 08.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.400492244	0.408487756	0.404844624	0.262		
2000	0.647267802	0.655032198	0.651353626	0.001		
3000	0.796218627	0.802741373	0.798467422	0.002		
4000	0.882987118	0.888172882	0.884825805	0.001		
5000	0.932565899	0.936594101	0.934824057	0.001		
6000	0.961401243	0.964478757	0.963433297	0.001		
7000	0.978366309	0.980673691	0.979639091	0.001		
8000	0.987569293	0.989310707	0.9887386	0.001		
9000	0.993108057	0.994391943	0.993808684	0.002		
10000	0.99610446	0.99705554	0.996614419	0.002		

9 Case study09

– Description: 09-Phases - System with two phases of operation
– **Diagram**:

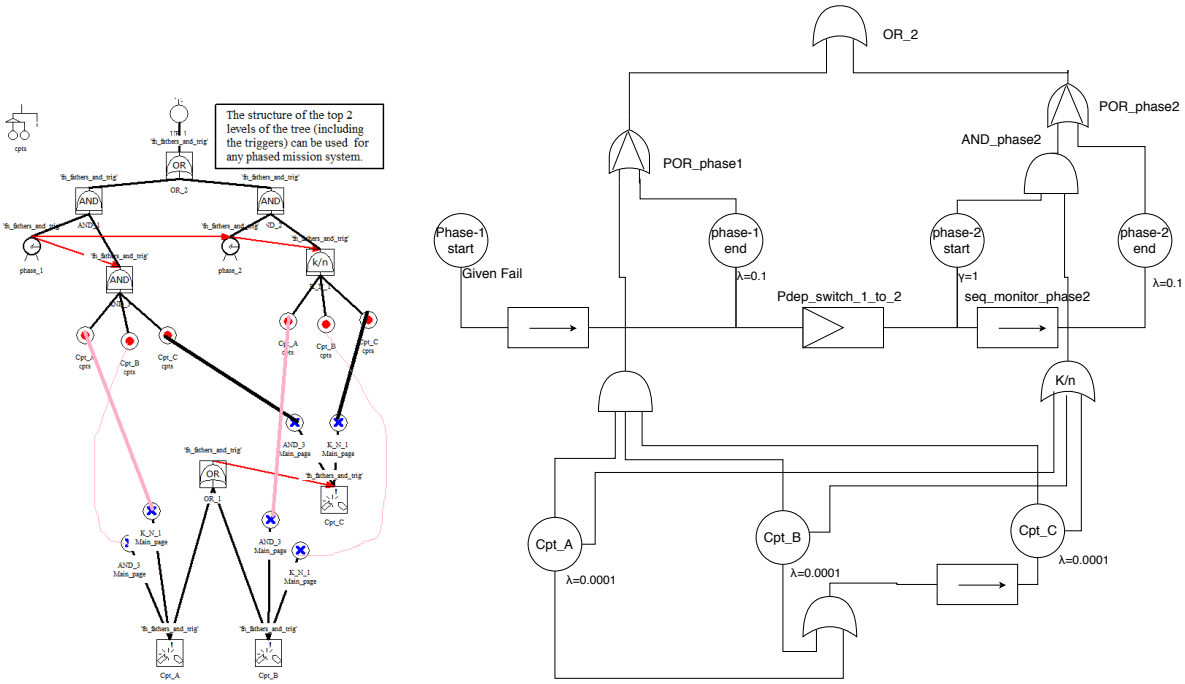

Fig. 9. Case study 09

– **Results**:

Table 9. Results of case study 09.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
100	9.35492E-06	1.50451E-05	1.19E-05	0.077		

– **Remark** next phase is started when previous goes from 1 to 0 but trigger color and name is still same. It makes difficult to isolate reparable and non repairable system in coherent DFTs.

10 Case study10

– Description: 10-Project_risks
– **Diagram**:

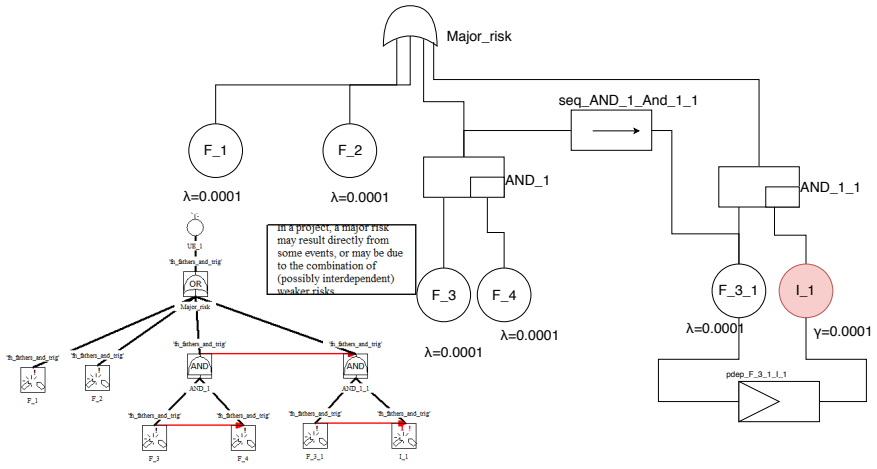

Fig. 10. Case study 10

– **Results**:

Table 10. Results of case study 10.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.181737782	0.188062218	0.185099957	0.001		
2000	0.335303722	0.343016278	0.341426037	0.001		
3000	0.466604262	0.474735738	0.471459442	0.001		
4000	0.57393706	0.58198294	0.578328103	0.001		
5000	0.661476313	0.669163687	0.66530476	0.001		
6000	0.732288946	0.739471054	0.735521779	0.001		
7000	0.788462583	0.795077417	0.791824072	0.001		
8000	0.834233116	0.840246884	0.836707684	0.001		
9000	0.869924487	0.875355513	0.872309526	0.001		
10000	0.898314516	0.903185484	0.900425863	0.002		

– **Question** F_3_1 and I_1 are never activated because as soon as AND_1 fails TLE is 1.

11 Case study11

– Description: 11-Redund1 - Standby redundancy
– **Diagram**:

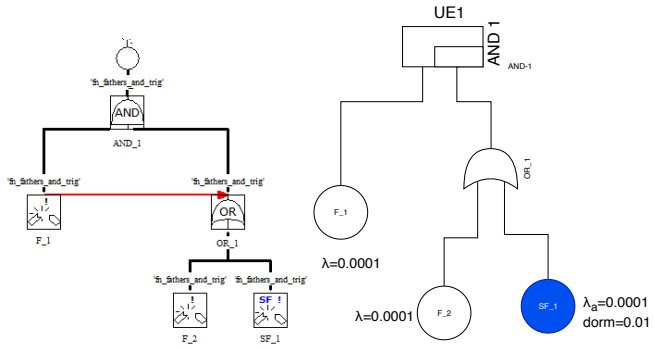

Fig. 11. Case study 11

– **Results**:

Table 11. Results of case study 11.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.008757798	0.010342202	0.009492157	0.001		
2000	0.033375704	0.036364296	0.034381745	0.001		
3000	0.069430838	0.073629162	0.070168338	0.001		
4000	0.111183545	0.116356455	0.113338335	0.001		
5000	0.158740727	0.164739273	0.16116893	0.001		
6000	0.20881987	0.21548013	0.211569339	0.001		
7000	0.259752352	0.266927648	0.262952358	0.001		
8000	0.309840781	0.317399219	0.314130599	0.001		
9000	0.359492165	0.367327835	0.364232782	0.001		
10000	0.407721218	0.415738782	0.412636336	0.001		

12 Case study12

– Description: 12-Redund2 - Standby red. with on demand failure
– **Diagram**:

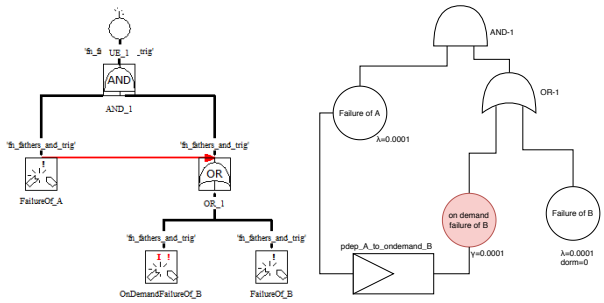

Fig. 12. Case study 12

– **Results**:

Table 12. Results of case study 12.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.004001807	0.005098193	0.004687889	0.001		
2000	0.016237934	0.018362066	0.017539471	0.001		
3000	0.035501642	0.038578358	0.036958538	0.001		
4000	0.059424868	0.063335132	0.061578748	0.001		
5000	0.087955525	0.092624475	0.090234337	0.001		
6000	0.118759559	0.124080441	0.121934311	0.001		
7000	0.152647454	0.158552546	0.155839745	0.001		
8000	0.187092647	0.193487353	0.191243811	0.001		
9000	0.224134994	0.230965006	0.227554238	0.001		
10000	0.260479164	0.267660836	0.264277906	0.001		

13 Case study13

– Description: 13-Share1 - A and B share spare C
– **Diagram**:

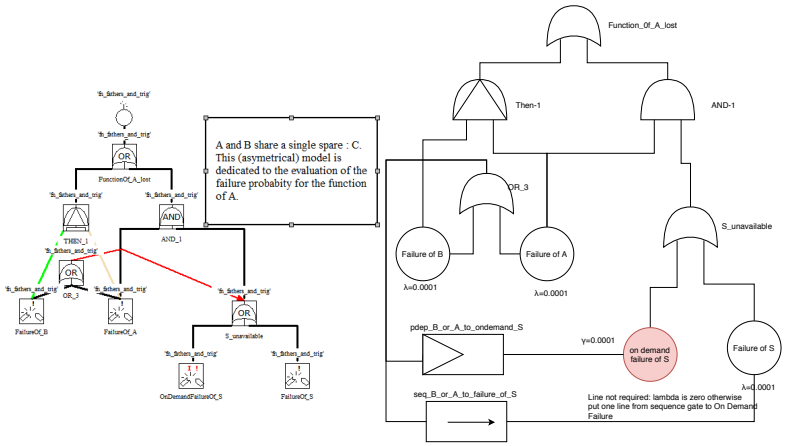

Fig. 13. Case study 13

– **Results**:

Table 13. Results of case study 13.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.008345671	0.009894329	0.009064528	0.001		
2000	0.031241535	0.034138465	0.032873381	0.001		
3000	0.06483528	0.06890472	0.067194395	0.001		
4000	0.105184782	0.110235218	0.108710971	0.001		
5000	0.150514192	0.156385808	0.154841987	0.001		
6000	0.1988191	0.2053609	0.203595702	0.001		
7000	0.247398532	0.254461468	0.253451355	0.001		
8000	0.298509317	0.305990683	0.303263333	0.001		
9000	0.3469128	0.3546872	0.352183696	0.001		
10000	0.395091072	0.403068928	0.399599655	0.001		

14 Case study14

– Description: 14-Switch - Importance of the order of events
– **Diagram**:

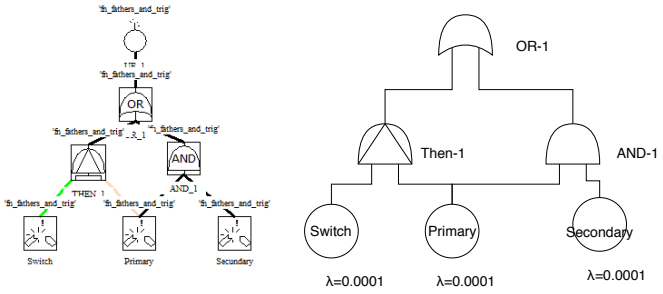

Fig. 14. Case study 14

– **Results**:

Table 14. Results of case study 14.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.012144878	0.013995122	0.013152983	0.001		
2000	0.044470465	0.047889535	0.046309688	0.001		
3000	0.089003231	0.093696769	0.092057499	0.001		
4000	0.140971603	0.146688397	0.145117037	0.001		
5000	0.198202853	0.204737147	0.201769091	0.001		
6000	0.254993547	0.262126453	0.25943199	0.001		
7000	0.31195389	0.31952611	0.316350258	0.001		
8000	0.366187054	0.374052946	0.371365531	0.001		
9000	0.418096957	0.426143043	0.423748267	0.001		
10000	0.467943636	0.476076364	0.473074372	0.002		

15 Case study15

– Description: 15-Boudali_Dugan_2005
– **Diagram**:

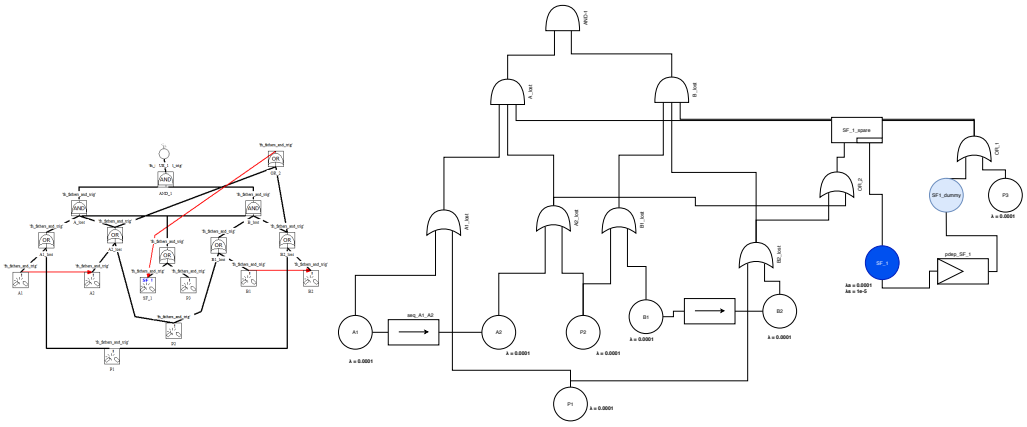

Fig. 15. Case study 15

– **Results**:

Table 15. Results of case study 15.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.001113272	0.001726728	0.001434051	0.002		
2000	0.008863293	0.010456707	0.009842179	0.002		
3000	0.027554963	0.030285037	0.028760096	0.002		
4000	0.057494329	0.061345671	0.059279321	0.002		
5000	0.097566241	0.102453759	0.100827435	0.002		
6000	0.148460498	0.154299502	0.151735992	0.002		
7000	0.204345983	0.210954017	0.209728561	0.002		
8000	0.267369561	0.274610439	0.272323106	0.002		
9000	0.332780785	0.340479215	0.337129768	0.002		
10000	0.397766636	0.405753364	0.402042311	0.002		

16 Case study16

– Description: 16-Cab2_eng - Non parallel non series Reliability block diagram.
– **Diagram**:

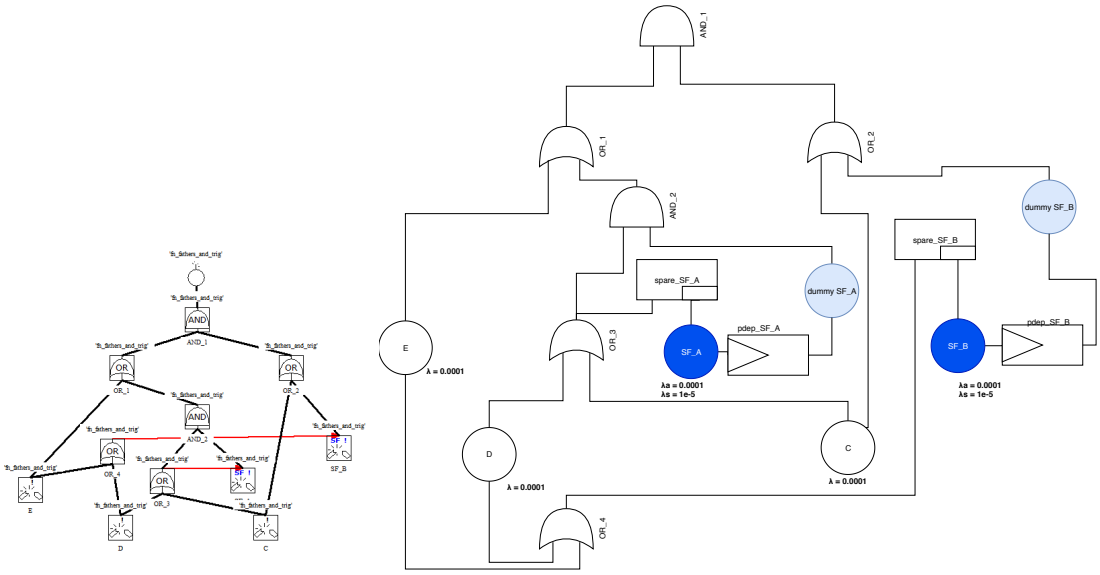

Fig. 16. Case study 16

– **Results**:

Table 16. Results of case study 16.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.01738297	0.01957703	0.01884512	0.002		
2000	0.065466268	0.069553732	0.06727684	0.002		
3000	0.131007143	0.136552857	0.134615771	0.002		
4000	0.208799985	0.215460015	0.212364507	0.002		
5000	0.288724784	0.296135216	0.294138775	0.002		
6000	0.368841289	0.376718711	0.375392985	0.002		
7000	0.446167484	0.454272516	0.453079226	0.002		
8000	0.519711858	0.527848142	0.525311881	0.002		
9000	0.584982274	0.592997726	0.59107129	0.002		
10000	0.643648598	0.651431402	0.649958117	0.002		

17 Case study17

– Description: 17-Demoeng_RESS - Electrical system with 3 trains.- Electrical system with 3 trains.
– **Diagram**:

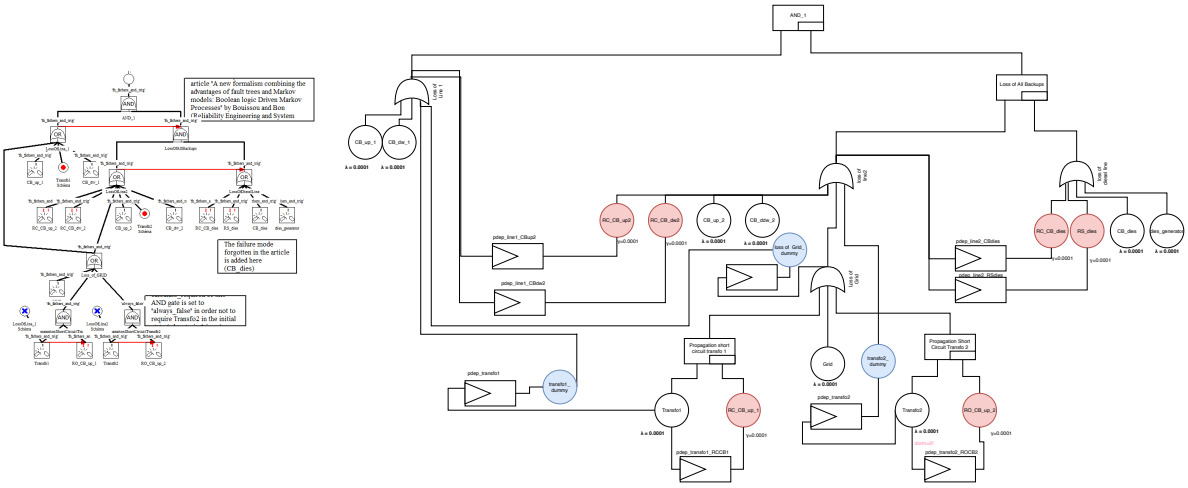

Fig. 17. Case study 17

– **Results**:

Table 17. Results of case study 17.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.010400535	0.012119465	0.011367016	0.081		
2000	0.044283815	0.047696185	0.046861183	0.208		
3000	0.100227297	0.105172703	0.103308506	0.383		
4000	0.171785814	0.177974186	0.174473075	0.613		
5000	0.24972765	0.25681235	0.253880006	0.922		
6000	0.330437456	0.338122544	0.33602662	1.217		
7000	0.411216209	0.419243791	0.416752867	1.6		
8000	0.488027758	0.496172242	0.493206053	2.024		
9000	0.559710489	0.567789511	0.563637232	2.49		
10000	0.6226299	0.6305101	0.627152366	3.021		

18 Case study18

– Description: 18-ESREL 2013 Event trees and Petri nets
– **Diagram**:

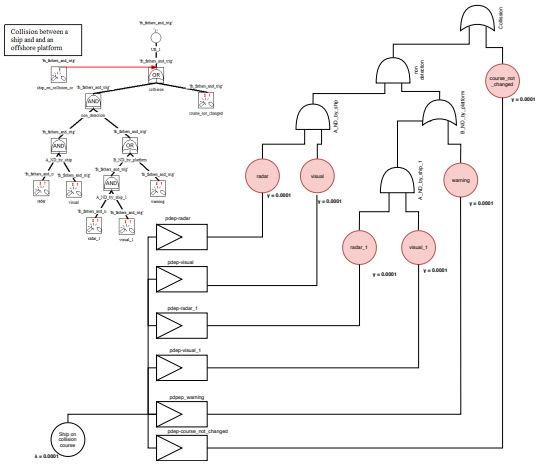

Fig. 18. Case study 18

– **Results**:

Table 18. Results of case study 18.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0	0	9.52E-06	0.523		
2000	-1.57582E-05	3.57582E-05	1.81E-05	1.113		
3000	-1.64274E-05	5.64274E-05	2.59E-05	1.732		
4000	-1.46141E-05	7.46141E-05	3.30E-05	2.422		
5000	-1.46141E-05	7.46141E-05	3.93E-05	3.128		
6000	-1.15156E-05	9.15156E-05	4.51E-05	3.905		
7000	-1.15156E-05	9.15156E-05	5.03E-05	4.779		
8000	-1.15156E-05	9.15156E-05	5.51E-05	5.541		
9000	-1.15156E-05	9.15156E-05	5.93E-05	6.471		
10000	-1.15156E-05	9.15156E-05	6.32E-05	7.441		

19 Case study19

- Description: 19-ESREL 2013 v2
- **Diagram**:NOT MODELED YET

20 Case study20

– Description: 20-MINIPLANT_eng - The MINIPLANT test case, solved with a BDMP.
– **Diagram**:

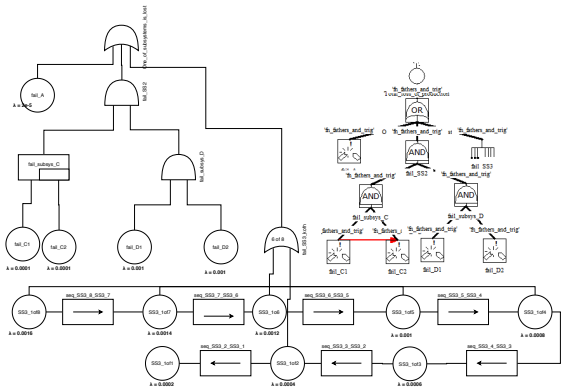

Fig. 19. Case study 20

– **Results**:

Table 19. Results of case study 19.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.177486401	0.183753599	0.1814885741	0.002		
2000	0.542815183	0.550924817	0.547493342	0.002		
3000	0.798472354	0.804967646	0.801450081	0.003		
4000	0.922094719	0.926405281	0.92373362	0.002		
5000	0.971505716	0.974154284	0.97306189	0.002		
6000	0.990762657	0.992257343	0.991011826	0.002		
7000	0.997223093	0.998016907	0.997120816	0.002		
8000	0.999015529	0.999464471	0.999105254	0.002		
9000	0.999608675	0.999871325	0.999728316	0.002		
10000	0.999847147	0.999992853	0.999918984	0.002		

21 Case study21

– Description: 21-Remote Access Server Security - Simple example published in "The promising potenti
– **Diagram**:

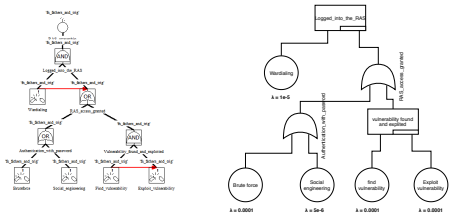

Fig. 20. Case study 21

– **Results**:

Table 20. Results of case study 21.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.000301584	0.000658416	0.000520023	0.001		
2000	0.001554353	0.002265647	0.002049999	0.001		
3000	0.003738868	0.004801132	0.004527543	0.001		
4000	0.006921211	0.008338789	0.007875419	0.001		
5000	0.01093004	0.01268996	0.012009217	0.001		
6000	0.015530198	0.017609802	0.0168427	0.001		
7000	0.020746784	0.023133216	0.022291414	0.001		
8000	0.027115311	0.029824689	0.028275022	0.001		
9000	0.033561786	0.036558214	0.034718707	0.001		
10000	0.039934309	0.043185691	0.04155392	0.001		

22 Case study22

– Description: 22-RESS68 - Test case found in Journal RESS vol 68
– **Diagram**:

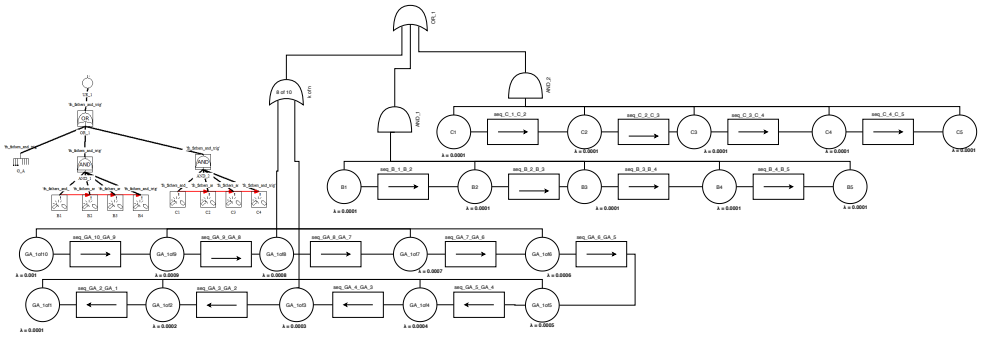

Fig. 21. Case study 22

– **Results**:

Table 21. Results of case study 22.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.061365826	0.065334174	0.062109656	0.003		
2000	0.263625506	0.270834494	0.266500864	0.004		
3000	0.500617428	0.508762572	0.501814388	0.003		
4000	0.690748028	0.698251972	0.692273313	0.003		
5000	0.821391429	0.827588571	0.822011166	0.004		
6000	0.900316284	0.905143716	0.901830279	0.003		
7000	0.946801374	0.950398626	0.947754942	0.003		
8000	0.972376026	0.974983974	0.972956628	0.003		
9000	0.985239406	0.987140594	0.986308433	0.004		
10000	0.992278964	0.993641036	0.993192671	0.004		

23 Case study23

– Description: 23-Two_proc_comp_sys - First model to solve the test case found in article
– **Diagram**:

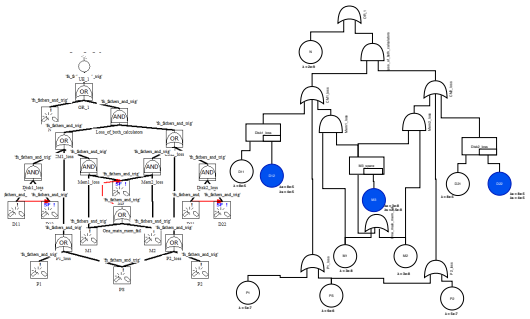

Fig. 22. Case study 23

– **Results**:

Table 22. Results of case study 23.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.005788435	0.007091565	0.00600877	0.002		
2000	0.011865065	0.013694935	0.012245547	0.003		
3000	0.018179364	0.020420636	0.019183245	0.003		
4000	0.025806664	0.028453336	0.027354778	0.003		
5000	0.03564865	0.03873135	0.037241261	0.003		
6000	0.047713501	0.051246499	0.049215424	0.003		
7000	0.062272452	0.066267548	0.063520439	0.003		
8000	0.078925746	0.083374254	0.080270401	0.004		
9000	0.098050929	0.102949071	0.099463137	0.003		
10000	0.119740241	0.125079759	0.12099912	0.003		

24 Case study24

– Description: 24-Cab2_fr - Reliability diagram neither serial nor parallel, with components with reduced failure rate when on standby. Non-repairable system. Failure tree quantization results in a largely overestimated outcome of the unreliability for times around 1000 to 2000 hours.
– **Diagram**:

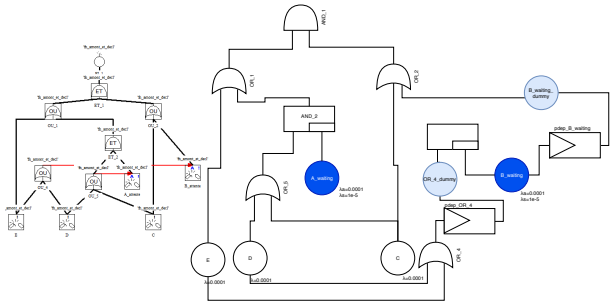

Fig. 23. Case study 24

– **Results**:

Table 23. Results of case study 24.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.01285805	0.01934195	0.01884512	0.002		
2000	0.058936288	0.071663712	0.06727684	0.002		
3000	0.121434549	0.138765451	0.134615771	0.001		
4000	0.19626946	0.21713054	0.212364507	0.002		
5000	0.279201143	0.302598857	0.294138775	0.002		
6000	0.358060303	0.382939697	0.375392985	0.002		
7000	0.437684101	0.463315899	0.453079226	0.002		
8000	0.50542946	0.53117054	0.525311881	0.002		
9000	0.575221412	0.600578588	0.59107129	0.002		
10000	0.635395581	0.660004419	0.649958117	0.002		

25 Case study25

– **Description**: 25-Carburant_moteurs_avion
– **Diagram**:

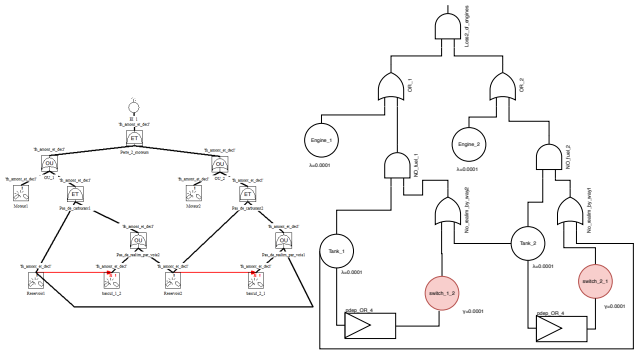

Fig. 24. Case study 25

– **Results**:

Table 24. Results of case study 25.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
100	-0.000164241	0.000564241	0.018031307	0.267		
200	1.8737E-05	0.001381263	0.064641801	0.001		
300	0.000436886	0.002363114	0.129845256	0.002		
400	0.001514884	0.004285116	0.205574241	0.002		
500	0.002534178	0.005865822	0.285678984	0.002		
600	0.00536299	0.00983701	0.365713015	0.002		
700	0.008137609	0.013462391	0.442640294	0.001		
800	0.010884317	0.016915683	0.514535782	0.002		
900	0.013670193	0.020329807	0.580314418	0.002		
1000	0.016393833	0.023606167	0.639502317	0.002		

26 Case study26

– Description: 26-DCC_fonct_demarrage - Passive redundancy with start refusal. System with a normal channel, and a spare channel whose components can fail either when in demand or during operation. In addition, a common cause failure type operation-start is modeled. Note: the gamma of the failure at the corresponding solicitation is set to 1.
– **Diagram**:

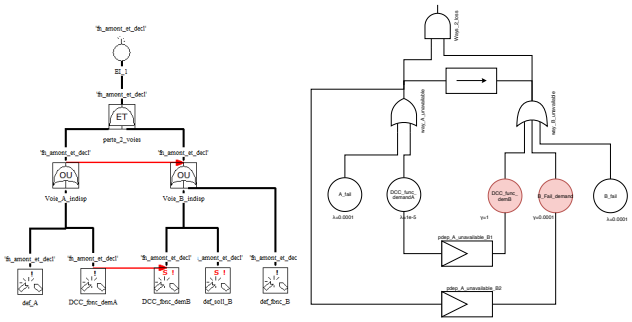

Fig. 25. Case study 26

– **Results**:

Table 25. Results of case study 26.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.011600007	0.017799993	0.01459141	0.037		
2000	0.031388665	0.041011335	0.036993493	0.125		
3000	0.058459002	0.071140998	0.065420714	0.253		
4000	0.092175934	0.107624066	0.098374772	0.438		
5000	0.129699757	0.147500243	0.134604132	0.68		
6000	0.167364491	0.187035509	0.173068876	0.956		
7000	0.204712543	0.225887457	0.212910195	1.298		
8000	0.245349873	0.267850127	0.253423942	1.677		
9000	0.285526644	0.309073356	0.294037729	2.128		
10000	0.325617337	0.349982663	0.33429112	2.628		

27 Case study27

– Description: 27-ex_fonct_bdmp - Introductory example of the user manual.
– **Diagram**:

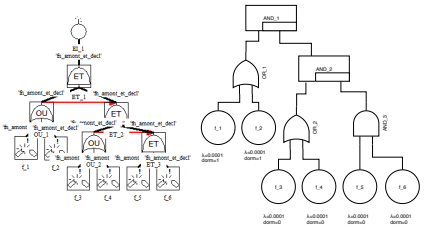

Fig. 26. Case study 27

– **Results**:

Table 26. Results of case study 27.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	-3.09289E-06	0.000123093	2.90E-05	0.001		
2000	0.000143719	0.000416281	0.000403957	0.002		
3000	0.001140053	0.001759947	0.001782727	0.001		
4000	0.004255853	0.005384147	0.004917163	0.001		
5000	0.009785048	0.011454952	0.010488855	0.001		
6000	0.018315387	0.020564613	0.01902539	0.001		
7000	0.029901208	0.032738792	0.03086859	0.002		
8000	0.04443117	0.04784883	0.046174742	0.001		
9000	0.062587828	0.066592172	0.064933135	0.001		
10000	0.084160891	0.088739109	0.086993719	0.001		

28 Case study28

- Description: 28-MMR2004_BDMP_Fr - System operating in 2 phases with phase change reconfiguration. Failures in operation and solicitation are modeled, with various types of dependencies between failures. The studied system is described in an article published at the MMR2004 congress (Authors: Bouissou and Dutuit).
- **Diagram**:NOT MODELED YET

29 Case study29

- Description: 29-phases - Very simple system with 2-phase operation. in phase 1, A, B and C must all be down for the system to be lost, while in phase 2, two failures out of three suffice. In addition, the component C is in passive redundancy and must start as soon as A or B breaks down.
- **Diagram**:NOT MODELED YET

30 Case study30

– Description: 30-Reseau - Bridge communication network with 2 doubled edges. The structure of the BDMP is an OR on minimal cuts.
– **Diagram**:

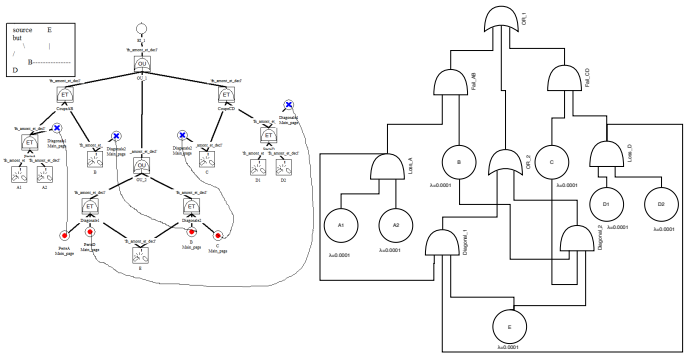

Fig. 27. Case study 30

– **Results**:

Table 27. Results of case study 30.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.001288286	0.003911714	0.002575462	0.002		
2000	0.01430354	0.02109646	0.017579446	0.002		
3000	0.044102084	0.055297916	0.050309945	0.002		
4000	0.093431456	0.108968544	0.100597714	0.003		
5000	0.16061754	0.17998246	0.165105437	0.002		
6000	0.232740054	0.254859946	0.239152774	0.002		
7000	0.310459699	0.334540301	0.317962472	0.002		
8000	0.391459945	0.416740055	0.397375943	0.002		
9000	0.465033418	0.490766582	0.474165218	0.002		
10000	0.532774504	0.558425496	0.546080169	0.002		

31 Case study31

– Description: 31-Variante_sur_barriere_supplementaire - Passive redundancy ex 1. System with a normal channel, and a backup channel consisting of two elements: one has a reduced failure rate when it is on standby, while the other can only fail when it is works.
– **Diagram**:

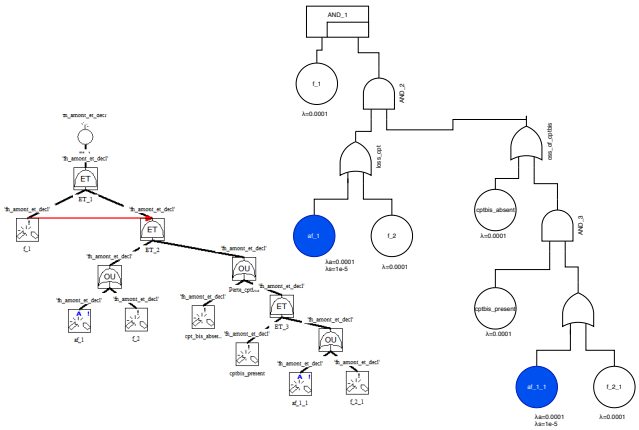

Fig. 28. Case study 31

– **Results**:

Table 28. Results of case study 31.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	7.17357E-05	0.001528264	0.000651245	0.081		
2000	0.002454046	0.005745954	0.004853135	0.002		
3000	0.011689638	0.017910362	0.015024547	0.002		
4000	0.029425221	0.038774779	0.032323439	0.002		
5000	0.052550023	0.064649977	0.056878454	0.002		
6000	0.084169738	0.099030262	0.088101251	0.002		
7000	0.119880083	0.137119917	0.124974877	0.002		
8000	0.158076694	0.177323306	0.166281426	0.002		
9000	0.200293775	0.221306225	0.21076427	0.002		
10000	0.246335556	0.268864444	0.25723342	0.002		

32 Case study32

- Description: 32-maint_prev_calendrier - Modeling of a two-way system in parallel, with scheduled maintenance staggered over time. The maintenance of the y-channel is delayed as long as the x-channel is down.
- **Diagram**: NOT MODELED YET

33 Case study33

– Description: 33-maint_prev_Markov Redondance Passive redundancy with start refusal. System with a normal way, and an emergency channel whose component can fail either at the request or in operation. We have preventive maintenance on each lane. Triggers with the modality "opposite_real_decl" inhibit the maintenance of one channel when the other is unavailable, whatever the reason..
– **Diagram**:

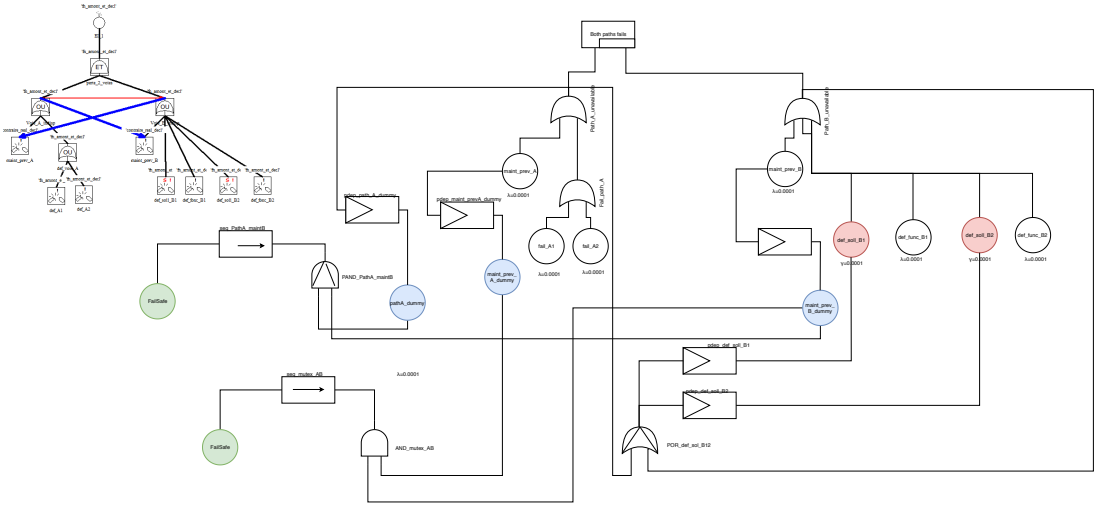

Fig. 29. Case study 32

– **Results**:

Table 29. Results of case study 33.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0.032591512	0.033512488	0.032903061	0.041		
2000	0.107644066	0.109245934	0.108755166	0.128		
3000	0.202685543	0.204760457	0.203645221	0.269		
4000	0.301983078	0.304350922	0.303312816	0.451		
5000	0.398283344	0.400806656	0.399646161	0.69		
6000	0.486983438	0.489558562	0.488392669	0.979		
7000	0.566332911	0.568885089	0.567671868	1.326		
8000	0.635992542	0.638469458	0.637017506	1.773		
9000	0.695593016	0.697960984	0.696767337	2.176		
10000	0.746782527	0.749019473	0.747680177	2.653		

34 Case study34

– Description: 34-BDMP_fr_TSTADIES - Accurate" modeling of DCCs: repairs must be done individually on failed components.
– **Diagram**:

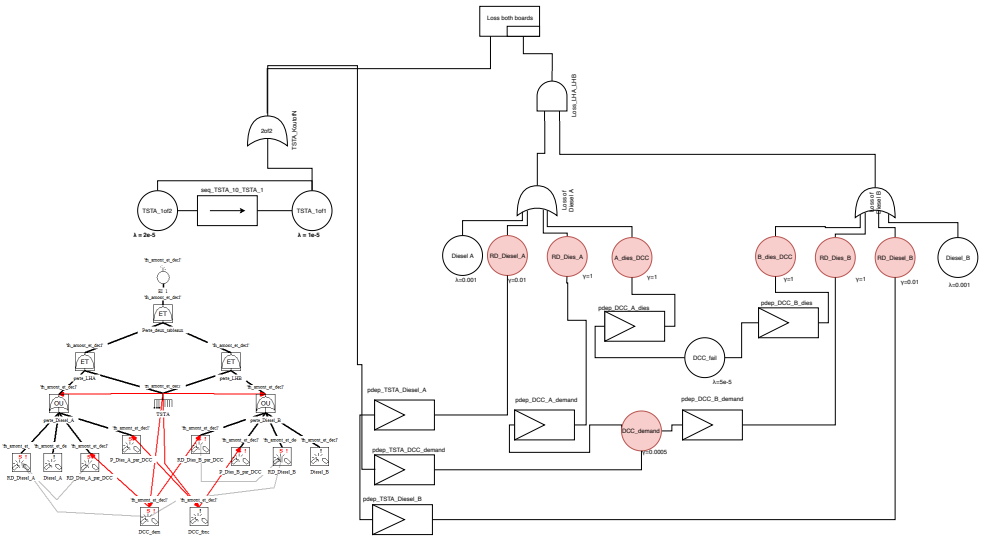

Fig. 30. Case study 34

– **Results**:

Table 30. Results of case study 34.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	4.36218E-06	2.36378E-05	1.08E-05	0.084		
2000	8.8259E-05	0.000143741	0.000104285	0.207		
3000	0.00030834	0.00040566	0.000348104	0.38		
4000	0.000690923	0.000833077	0.000769682	0.614		
5000	0.001282447	0.001473553	0.001375657	0.884		
6000	0.002040415	0.002279585	0.002164487	1.215		
7000	0.002956806	0.003243194	0.003131719	1.598		
8000	0.003982448	0.004313552	0.004271957	2.011		
9000	0.005213193	0.005590807	0.005579587	2.488		
10000	0.006638528	0.007063472	0.007049028	3.023		

35 Case study35

– Description: 35-BDMP_fr_TSTADIES_compar_arbevt - Simplified modeling of DCC. Repairing the DCC repairs both diesels at the same time. The choice of the repair rate is important
– **Diagram**:

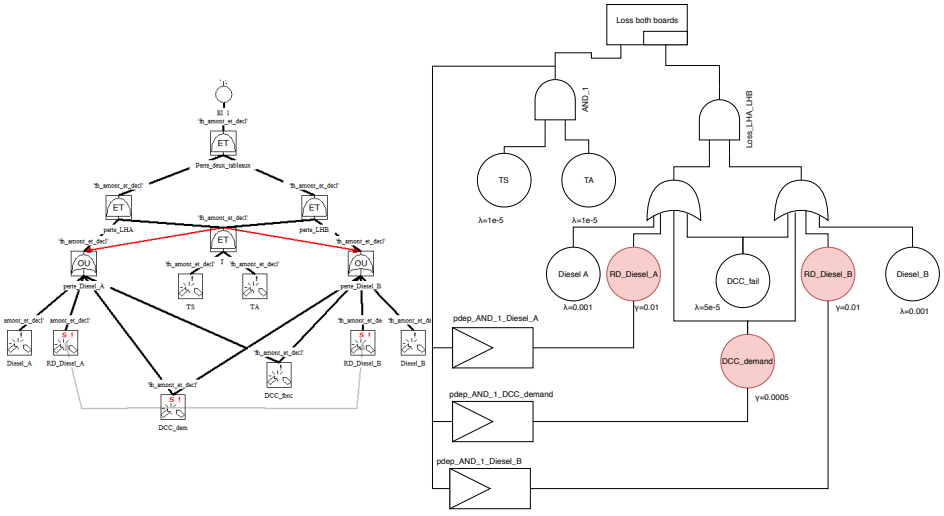

Fig. 31. Case study 35

– **Results**:

Table 31. Results of case study 35.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	9.2666E-06	1.49334E-05	1.13E-05	0.052		
2000	9.74221E-05	0.000114178	0.000104913	0.16		
3000	0.000321756	0.000351644	0.00034507	0.32		
4000	0.000735977	0.000780823	0.000757408	0.502		
5000	0.001316037	0.001375763	0.001348124	0.743		
6000	0.002073515	0.002148285	0.002115916	1.056		
7000	0.003011238	0.003101162	0.003056845	1.422		
8000	0.004118007	0.004222993	0.004166116	1.816		
9000	0.005356714	0.005476286	0.005438713	2.344		
10000	0.006772366	0.006906634	0.006869621	2.736		

36 Case study36

– Description: 36-BDMP_fr_TSTADIES_simpl1 - 137/5000 Simplified modeling of DCC. Repairing the DCC repairs both diesels at the same time. The choice of the repair rate is important
– **Diagram**:

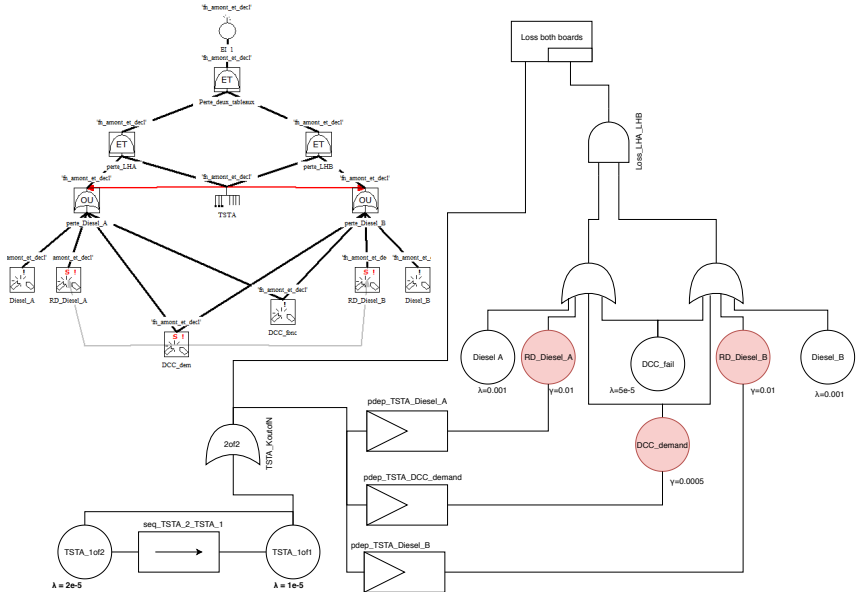

Fig. 32. Case study 36

– **Results**:

Table 32. Results of case study 01.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0	0	1.13E-05	0.054		
2000	-0.000164241	0.000564241	0.000104913	0.169		
3000	-7.58299E-05	0.00107583	0.00034507	0.352		
4000	7.17357E-05	0.001528264	0.000757408	0.591		
5000	0.000308241	0.002091759	0.001348124	0.883		
6000	0.000849205	0.003150795	0.002115916	1.239		
7000	0.001438906	0.004161094	0.003056845	1.402		
8000	0.002057284	0.005142716	0.004166116	2.124		
9000	0.003019698	0.006580302	0.005438713	2.695		
10000	0.004430057	0.008569943	0.006869621	3.335		

37 Case study37

– Description: 37-BDMP_fr_TSTADIES_simpl2 - DCC in operation are not modeled: only DCCs are modeled at startup.
– **Diagram**:

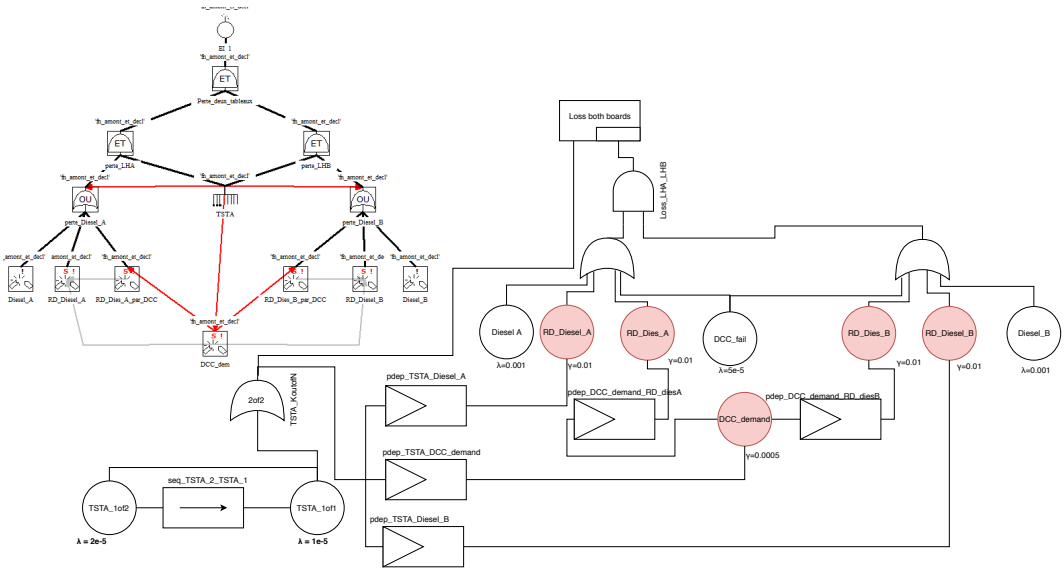

Fig. 33. Case study 37

– **Results**:

Table 33. Results of case study 37.

Time bound	YAMS-LowerBound	YAMS-UpperBound	STORM-DFT (value)	STORM-DFT (time)	FIGSEQ (value)	FIGSEQ (time)
1000	0	0	1.13E-05	0.234		
2000	-0.000157571	0.000357571	0.00010477	0.208		
3000	-0.000115064	0.000915064	0.000344807	0.382		
4000	1.8737E-05	0.001381263	0.00075702	0.609		
5000	7.17357E-05	0.001528264	0.001347611	0.886		
6000	0.000436886	0.002363114	0.002115282	1.225		
7000	0.001438906	0.004161094	0.003056093	1.603		
8000	0.001978785	0.005021215	0.004165249	2.04		
9000	0.003101339	0.006698661	0.005437735	2.574		
10000	0.0045143	0.0086857	0.006868534	3.026		