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FAULT TREE ANALYSYS IN RELATION TO MAKING A HOT DRINK

References. See footnotes and references section 0.

Abstract

The intent of this report is to explore Fault Tree Analysis and Perform a basic FTA calculation for successfully making a hot drink.

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2. Introduction and Background

Fault Tree Analysis (FTA) is an analytical process to problem solving by which the starting point is the unwanted event. Events that lead to the original unwanted event are then evaluated based upon their relationship and immediate effects. [1]

FTA is widely used in various engineering disciplines to explore, detail and document hazard accident sequences. On a small scale the quickest method to achieve a basic FTA is to create a Fault Tree Diagram.

The components that make up a Fault Tree Diagram can be seen below.

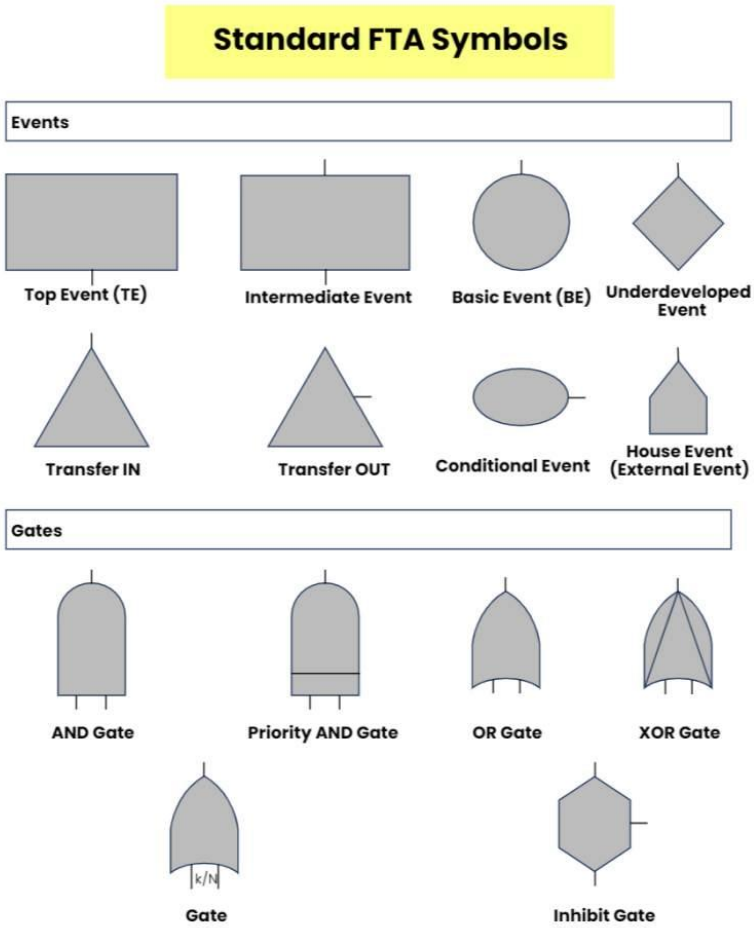

Figure 1 - FTA Symbols [2]

These symbols can then be combined to create an FTA Diagram, example pictured below.

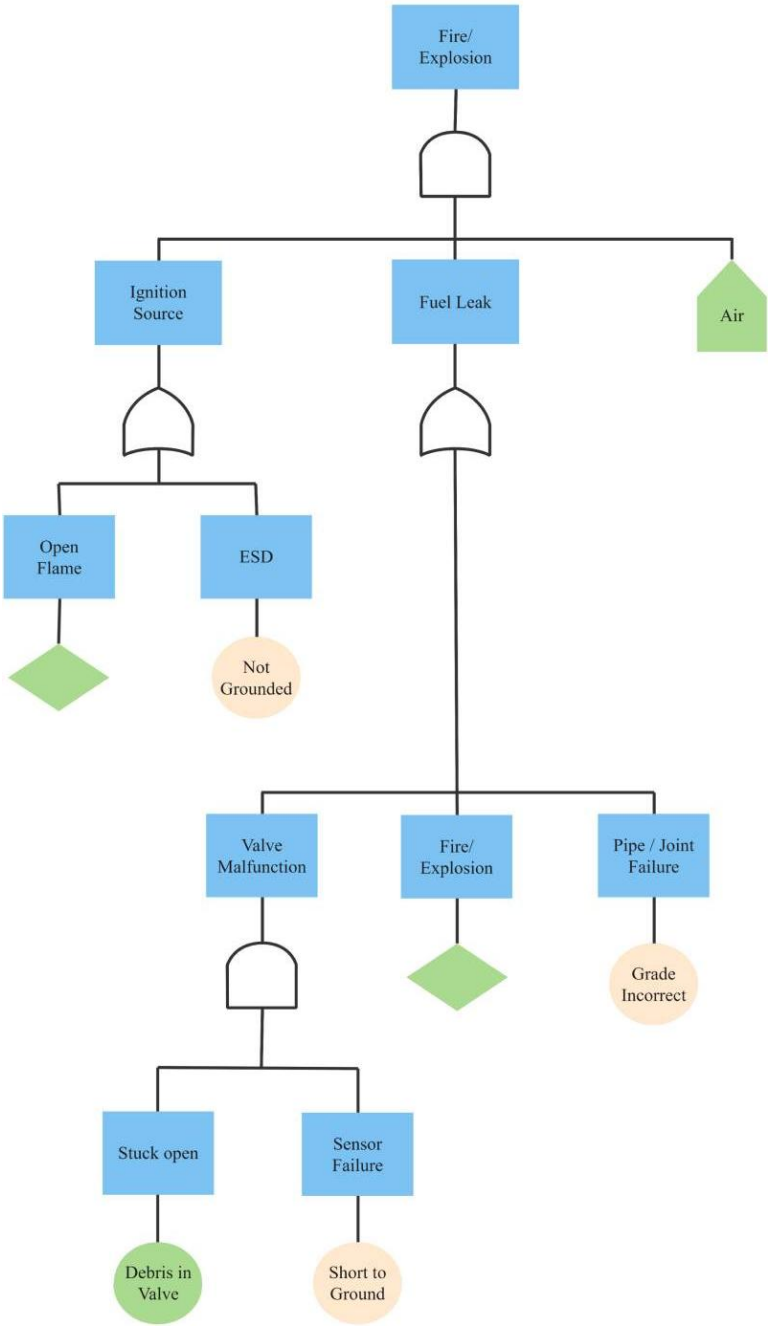

Figure 2 - FTA Diagram Example. [2]

3. FTA Calculations

The initial task set by the lecturer was to calculate the chance of success for a given scenario. The scenario provided is as follows.

3.1. Task 1

"Bill wants to make a cup of tea. Use the process chart provided to calculate his chance of success".

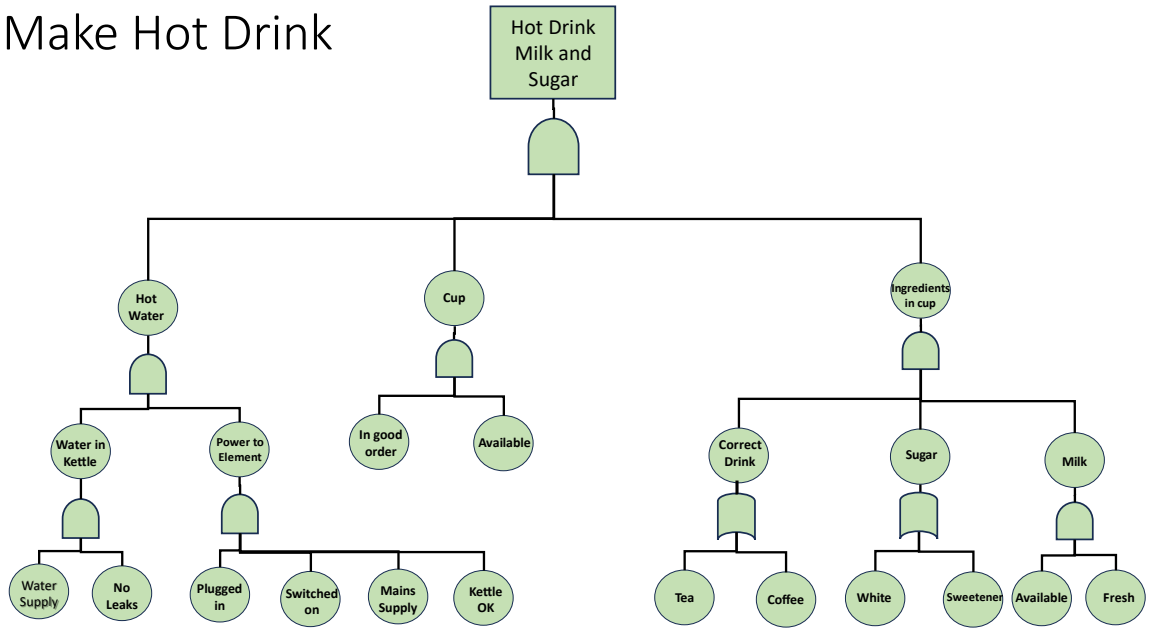

Figure 3 - Provided Success Tree [3]

Event Description	Provided Probability
Tea availability	0.8
Coffee availability	0.9
Chance of leaky Kettle	0.1
Chance of water supply failure	0.01
Kettle reliability	0.99
Plug in operation reliability	0.7
Switch on reliability	0.7
Mains supply failure chance	0.01
Cup availability	1
Cup reliability	0.7
Milk availability	0.9
Milk freshness	0.8
Sugar availability	0.6
Sweetener Availability	0.9

Table 1 – Bills Probabilities [3]

To easily answer this question the first stage was to create Table 2 detailing how Bill's probabilities change overnight. These numbers could then be used in the initial calculations that where first done by hand and then entered a spreadsheet for confirmation. Figure 4 below shows the results from the manual calculations. Providing a final probability of success in the day of 0.4737 or 47.37%. This was confirmed by the spreadsheet entry in Figure 5.

Event	Provided Probability	Daytime Parameters		Nighttime Parameters		
		P Failure	P Success	P Failure	P Success	Modifier
Tea availability	0.8	0.2	0.8	0.2	0.8	100%
Coffee availability	0.9	0.1	0.9	0.1	0.9	100%
Chance of leaky Kettle	0.1	0.1	0.9	0.1	0.9	100%
Chance of water supply failure	0.01	0.01	0.99	0.01	0.99	100%
Kettle reliability	0.99	0.01	0.99	0.01	0.99	100%
Plug in operation reliability	0.7	0.3	0.7	0.475	0.525	75%
Switch on reliability	0.7	0.3	0.7	0.475	0.525	75%
Mains supply failure chance	0.01	0.01	0.99	0.01	0.99	100%
Cup availability	1	0	1	0.1	0.9	90%
Cup functionality	0.7	0.3	0.7	0.37	0.63	90%
Milk availability	0.9	0.1	0.9	0.1	0.9	100%
Milk freshness	0.8	0.2	0.8	0.2	0.8	100%
Sugar availability	0.6	0.4	0.6	0.4	0.6	100%
Sweetener Availability	0.9	0.1	0.9	0.1	0.9	100%

Table 2 - Bills Diurnal Probabilities

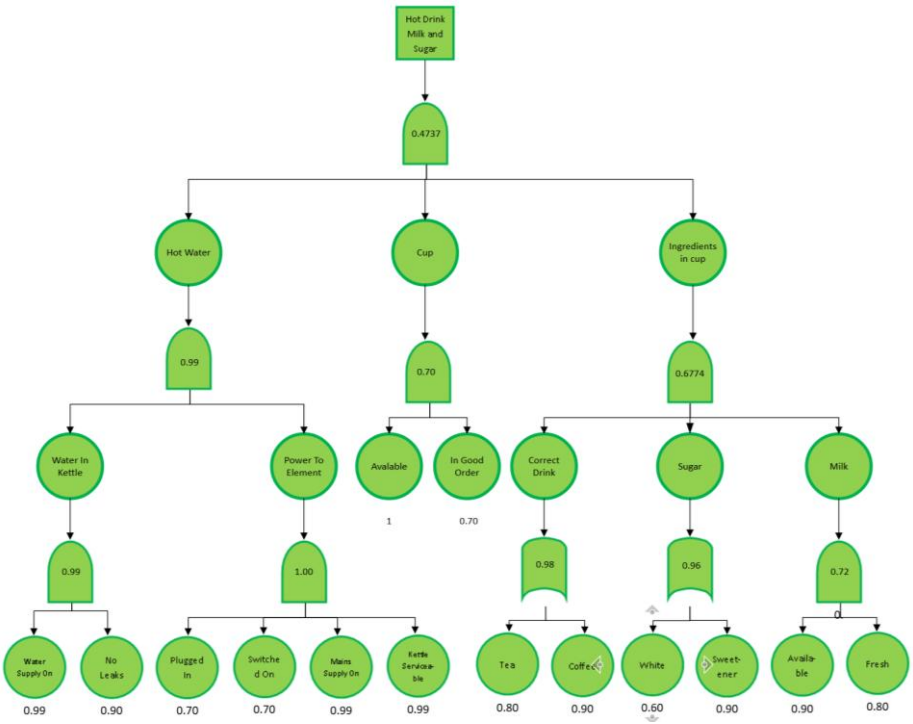

Figure 4 – FTA Daytime Hand Calculations

V	W	X	Y
Daytime Sucsess Probability			
Sucsess 47.37%	**Hot Water** 0.9990	**Water In Kettle** 0.9990	**Water Supply** 0.9900
			Leaks 0.9000
		Power to Equipment 1.0000	**Plugged In** 0.7000
			Switched On 0.7000
			Mains Supply 0.9900
			Kettle Functonal 0.9900
Hot Drink Milk and Sugar	**Cup** 0.7000	**In Good Order** 0.7000	
Failure 52.63%		**Avalable** 1.0000	
	Ingredeants in Cup 0.6774	**Correct Drink** 0.9800	**Tea** 0.8000
			Coffee 0.9000
		Sugar 0.9600	**White** 0.6000
			Sweatener 0.9000
		Milk 0.7200	**Avalable** 0.9000
			Fresh 0.8000

AA	AB	AC	AD
Nighttime Sucsess Probability			
AB4*AB16*AB20 **Sucsess** 9.24%	**Hot Water** 0.2407 AC4*AC8	**Water In Kettle** 0.8910 AD4*AD6	**Water Supply** 0.9900
			Leaks 0.9000
		Power to Equipment 0.270140 AD8*AD10*AD12*AD14	**Plugged In** 0.5250
			Switched On 0.5250
			Mains Supply 0.9900
			Kettle Functonal 0.9900
Hot Drink Milk and Sugar	**Cup** 0.5670 AC16*AC18	**In Good Order** 0.6300	
Failure 90.76% 1-AA15		**Avalable** 0.9000	
	Ingredeants in Cup 0.6774 AC20*AC24*AC28	**Correct Drink** 0.9800 1-((1-AD20)*(1-AD22))	**Tea** 0.8000
			Coffee 0.9000
		Sugar 0.9600 1-((1-AD24)*(1-AD26))	**White** 0.6000
			Sweatener 0.9000
		Milk 0.7200 AD28*AD30	**Avalable** 0.9000
			Fresh 0.8000

Figure 5 - Spreadsheet Calculator

3.2. Task 2

"Bill has woken up in the middle of the night and wants to make a cup of tea. Use the probability multipliers provided to show where his key errors may lie when acting under fatigue.
"Bill's ability to plug in and switch on the kettle will drop to 75% of normal and his ability to select a cup will drop to 90% of normal".

3.3. Answers

Using the data in Table 2 the same calculations could be re performed and

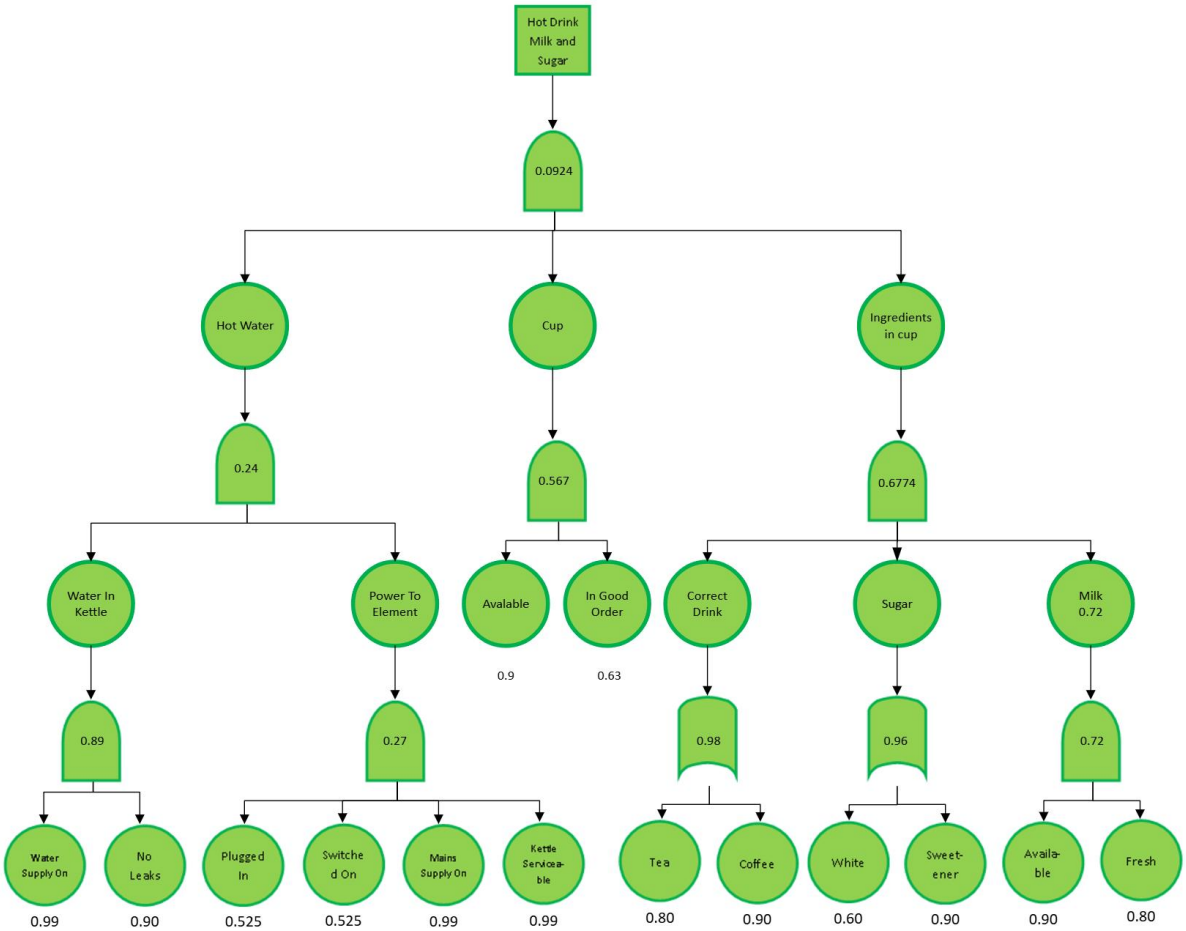

Figure 6 created. This shows that at night Bills probability of success is 0.0924 or 9.24%. This was confirmed by the spreadsheet entry in Figure 5.

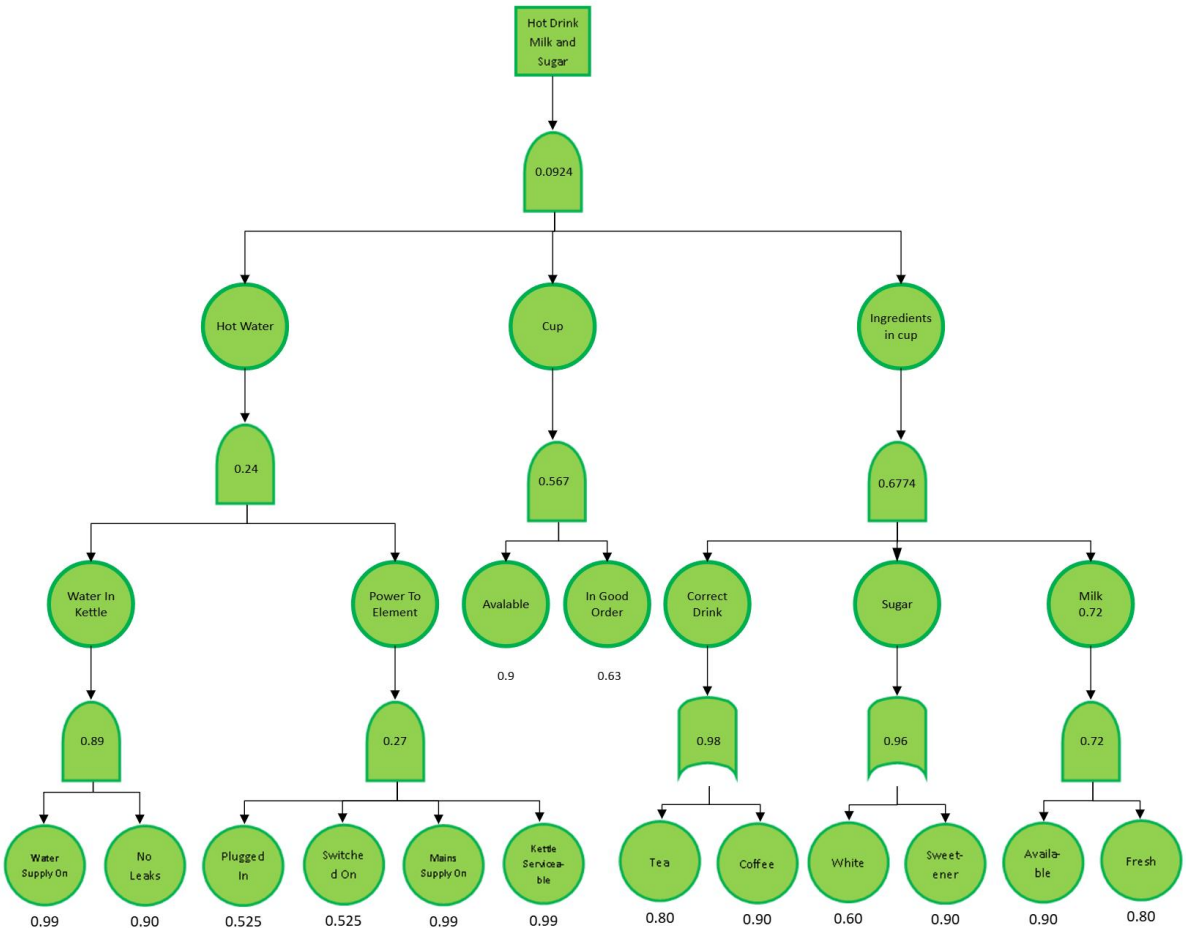

Figure 6 - Fault Tree for Making any Hot Drink with Milk and Sugar at Night

4. Human Factors

The change in success reliability can mathematically largely be proportioned to the availability of the Hot Ater as at night this drops by 75% to 24% causing the drop in success reliability. This change can likely be apportioned to his ability to use the kettle properly This could indicate a complicated kettle or particularly poor performance. An additional factor that could be considered is Bills ability to retrieve a cup accurately and keep it in good order (Unbroken). It is likely that at night his physical and mental performance is reduced, as supported by research [4]. The likely reduction in ability often referred to as PVT score is likely the cause of any misplaced, cups that get broken. Additional factors that have not been considered are medical conditions that Bill could have. For example, if Bill where to have Parkinson's disease, then large amounts of the failures could be attributed to the shaking associated with this disease. Whilst the underlying problem would not be able to be solved within the parameters of this system of making a cup of hot drink. Mechanisms could be put in place to minimise certain aspects and improve the likelihood of success. An example of this would be leaving the kettle plugged in, using non-breakable mugs and a larger switch on the kettle to make activation easier.

5. Conclusions

Although functional the success trees provided form an unconventional method to present 'Fault Tree' flow. More conventionally the fault trees would list the faults that exist, working up the tree to eventual accidents. For example, in this case a question could be asked 'what is the likelihood of failure to make any hot drink with milk and sugar' this would then translate into the Fault tree in Figure 7 below.

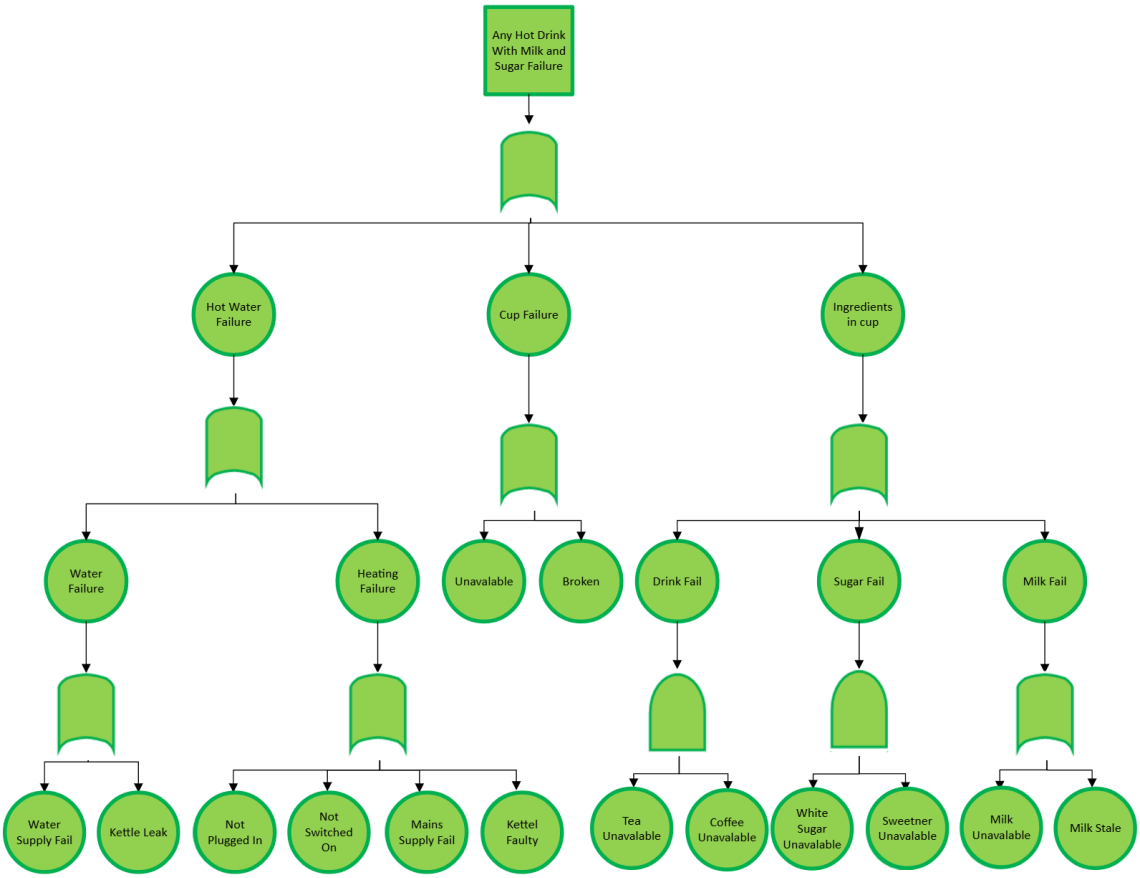

Figure 7 - Fault Tree V2

In this new fault tree, any one of the failures under the ‘OR’ sections would lead to a failure of the process where for the drink and sugar ‘AND’ sections both parts would need to fail for a top event failure. This would be a more conventional layout for the question and how it is commonly laid out engineering documentation. Fundamentally both approaches will yield the same results demonstrating that there is a low chance of success or high chance of failure however you choose to look at the scenario.

In conclusion Bill should not be making any hot drinks as a success rate of 47% when at peak performance is far below what would be considered practical. He should simply fill a mug with cold water and be happy with a drink although even this scenario would only have a best case (daytime) success of 69%.

6. References

[1] Safety Culture, “A Brief Guide to Fault Tree Analysis (FTA),” safetyculture, 14 05 2024. [Online]. Available: https://safetyculture.com/topics/fault-tree-analysis/. [Accessed 04 04 2024].

[2] edrawmax, “A Complete List of Fault Tree Analysis Symbols,” edrawmax, [Online]. Available: https://www.edrawmax.com/article/fault-tree-analysis-symbols.html. [Accessed 04 04 2025].

[3] UWTSD, “L5 - Systems Engineering & Work-Based Group Project (ACDA5021&ACDA5022),” [Online]. Available: https://moodle.uwtsd.ac.uk/course/view.php?id=12137. [Accessed 04 04 2025].

[4] E. B. S. &. B. G. acer-Childs, “he effects of time of day and chronotype on cognitive and physical performance in healthy volunteers.,” *Sports Med - Open,* vol. 4, no. 1, p. 47, 2018.