A Summary of Techniques for Reliability Analysis

(FMEA, FTA, Data Analysis)\

MFE634 – S2017

8.1 FMEA

Definition

- Reliability is the ability of a product to perform a required function under stated conditions for a stated period of time.
- Four implications become apparent:
- 1. The quantification of reliability in terms of a probability
- 2. A statement defining successful product performance
- 3. A statement defining the environment in which the equipment must be operate
- 4. A statement of the required operating time between failures

8.1 FMEA

Definition

Reliability quantification:

1. Apportionment
2. Prediction
3. Analysis

Reliability prediction is a continuous process starting with paper predictions based on a design analysis, plus historical failure-rate information.

Two Techniques to exam failure:

1. FMEA(Failure Mode and Effect Analysis)
2. FTA(Fault Tree Analysis)

Availability is the ability of a product, when used under given conditions.

8.1 FMEA

Use the tables below to set the cutoff values for color coding the SEV and RPN columns.

Severity (SEV)	Value	Color
If SEV >=	8	
Otherwise		
If SEV <=	3	

Risk Priority Number (RPN)	Value	Color
If RPN >=	300	
Otherwise		
If RPN <=	100	

FMEA#																Revised metrics			
Step#	Process Map - Activity	Key Process Input	Potential Failure Mode	Potential Failure Effects	SEV	Potential Causes	OCC	Current Controls	DET	RPN	Actions Recommended	Responsibility	Target End Date	Actions Taken	Actual End Date	SEV	OCC	DET	RPN
1	Not enough people to keep the or	Guard	Local officers were injured	Chaos, More people died	7	Low ability of commander and unreasonable distribution of available team	5	Set up supervisor department	8	280	Set up a standard for the security	Emergency	2/24/2017	Specialist a officier to check all the standard works well	2/20/2017	7	3	5	105
2	Not enough small boats to rescue	Transport	Poor Quality of boats reducing boats lifetime; Not enough budget on boats buying	Cause lots of troubles to make the rescue harder	9	Wrong estimation for boats needed during rescue	7	Testing how long per boat needed for one rescue;Estimating how many times per boat could be used one day	5	315	Check boats quality and quantity periodly	Government	2/24/2017	Record service condition of the boats	2/21/2017	9	4	3	108
3	Poor quality of barrier for preven	Quality of barrier	Can not keep the flood out	More people may be flushing by flood	8	Poor quality of material	4	Increase the standard of material	4	128	Make the standard of barrier for disaster	Government	2/24/2017	Check the barrier condition timely	2/21/2017	8	2	2	32
4	Some doctors are not capable fo	Doctor	Poor school education; Poor selecting standard for doctor	More people can not cured in time	10	More people died	5	Make high standard for doctor training	8	400	Training the doctor periodly	Emergency	2/24/2017	Rescue simulation to improve the doctor's level	2/21/2017	9	3	6	162
5	Foods and shelters are not enoug	Foods and shelters	Not sufficient foods in stock; Foods in stock were damaged;/	More people can not get food and no place to live	9	More people will ill even died	4	Establish a plan to store the food and shelter	5	180	Found a food and shelter storage	Government	2/24/2017	According to high level to check the food and shelter periodly	2/21/2017	9	2	3	54

Failure Mode Effects Analysis (FMEA)

- An FMEA:
  - Identifies the ways in which a product or process can fail (bottom up analysis)
  - Estimates the risk associated with specific causes
  - Prioritizes the actions that should be taken to reduce risk
- FMEA is a team tool
- There are two different types of FMEAs:
  1. **Design**
  2. **Process**

- RPN is the product of the severity, occurrence, and detection scores. Typically these are given a value between 1-10 which allows for better precision in estimates and a wide variation in scores.
- RPN = Severity X Occurrence X Detection

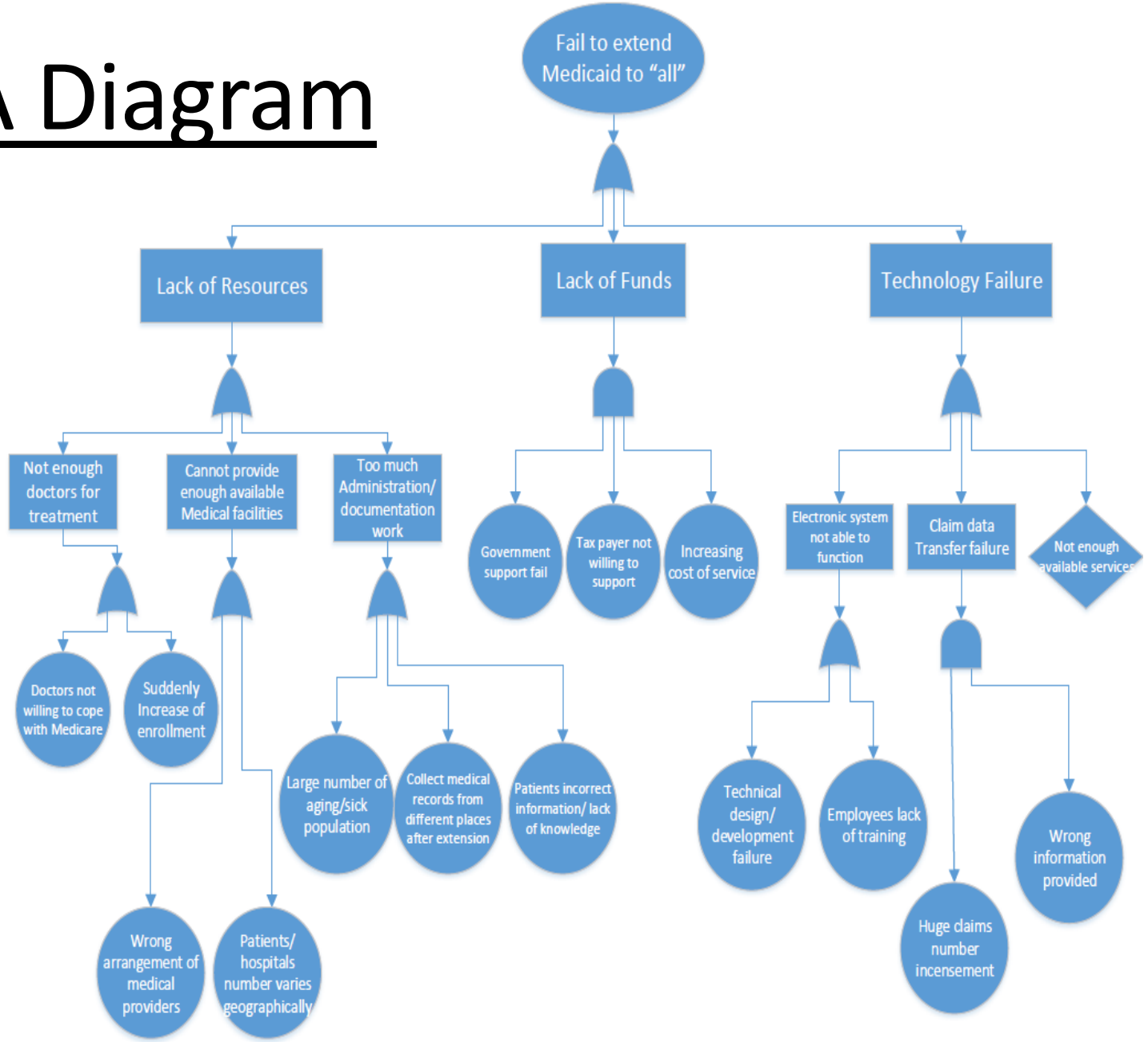
FMEA

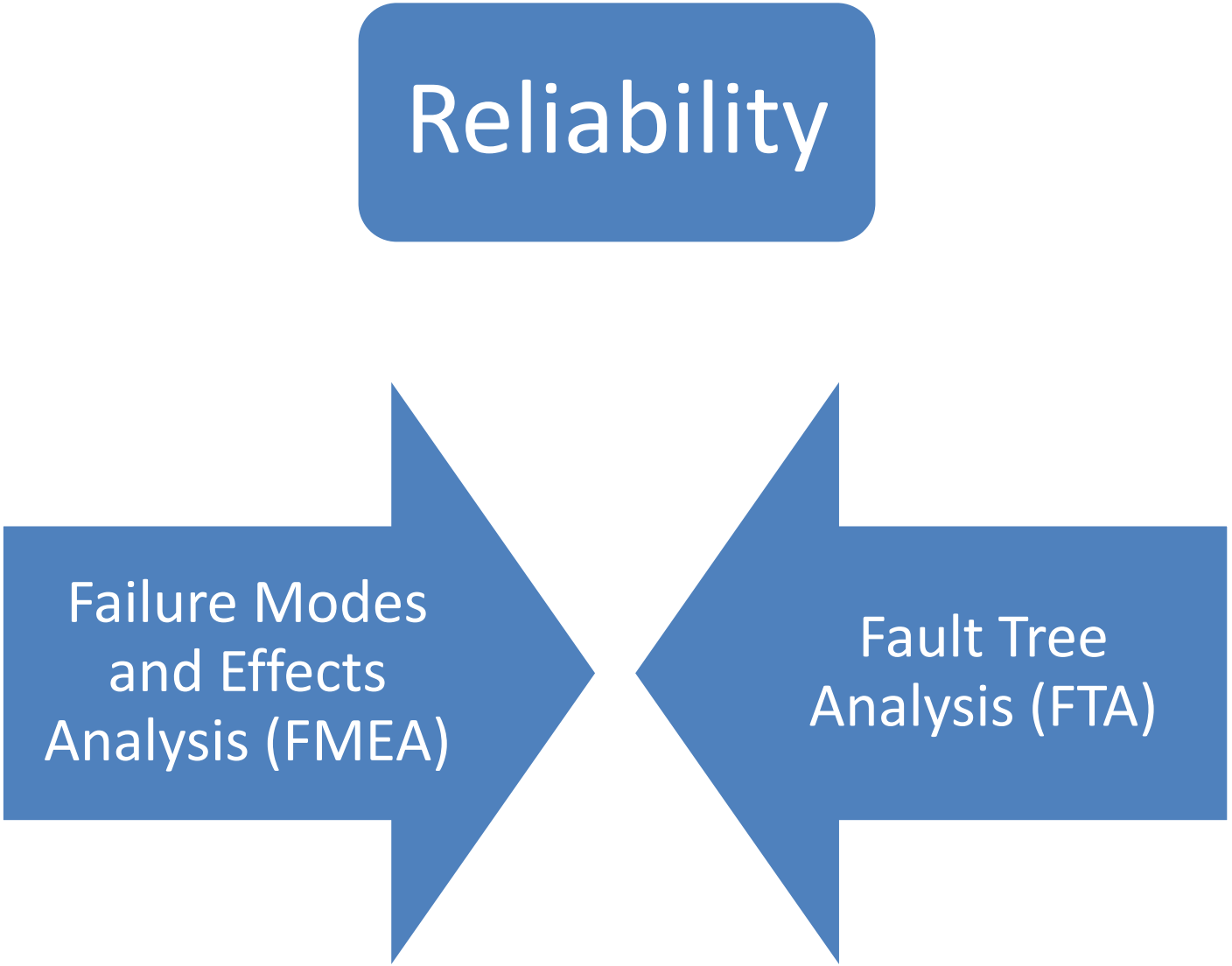
Function	Failure Mode	Effects	Severity	Causes	Occurrence	Detection Action	Ease of detection	Risk Priority Number	Recommended Actions
Medicare	Cannot see Doctor	Long wait time to see doctor	5	Claims Processing Times	5	None	5	125	Training
	Eligibility	No Insurance	9	No/Little insurance opportunities	5	None	5	200	Creation of Additional Healthcare Options
Medicare for All	Not enough Doctors	Long wait times to see doctor	8	Doctors not willing to work with Medicare	5	None	6	200	Expand Medical Network
				Mass enrollment	7	None	7	392	Limit Number of new enrollees, Phased approach
				Large Sick/Aging Population	6	Update Notice	7	336	Expand Medical Network

Fault Tree Analysis (FTA)

- A top down failure consequence assessment technique in identifying safety concerns so that product modifications can be made:
  - Identification of a single failure point and safety concerns
  - Evaluation of software, non-machine interfaces and design change impacts
  - Simplification of maintenance and trouble-shooting procedures
  - Assessment of modification or enhancements

FTA Diagram

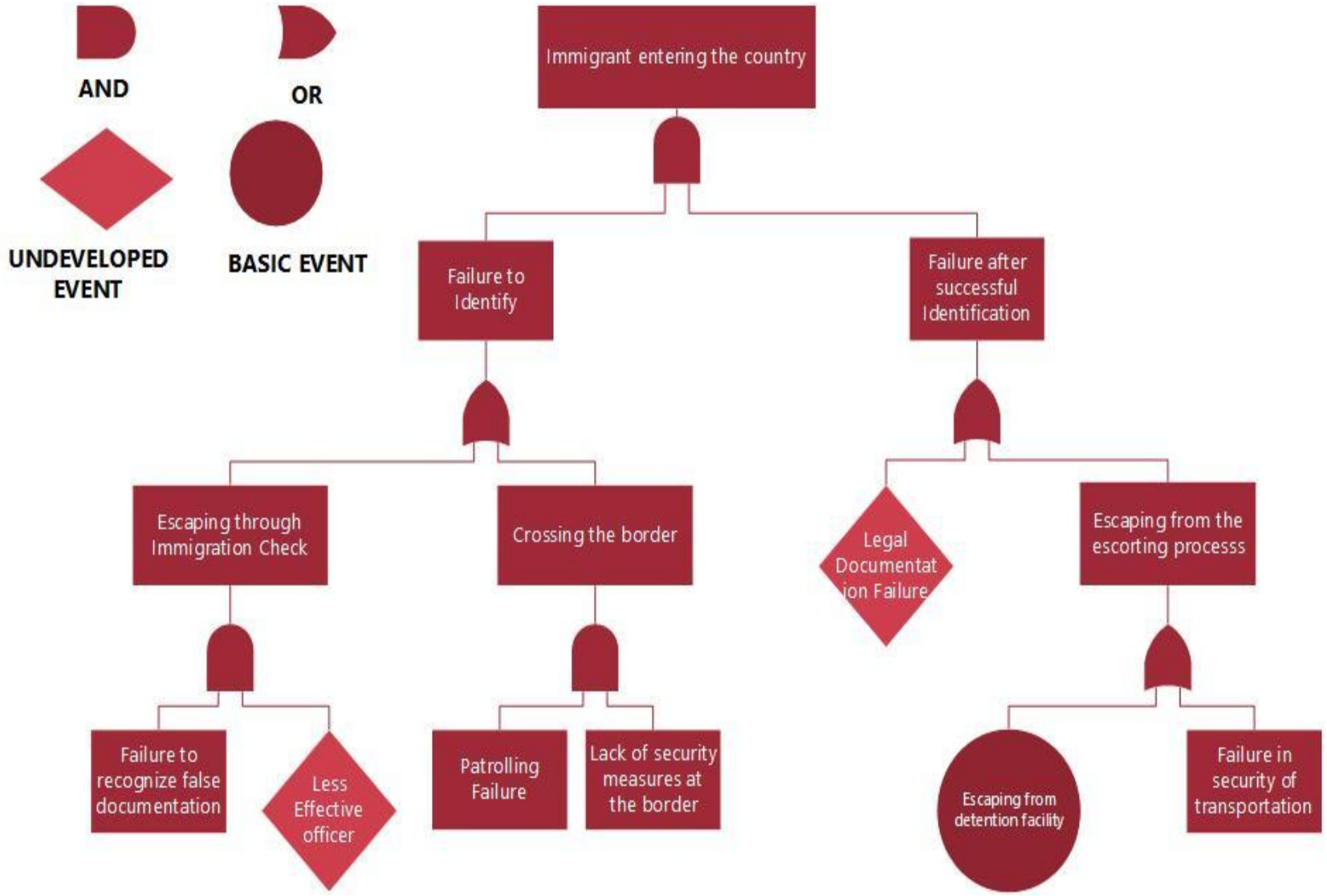

Fail to extend Medicaid to "all"
Lack of Resources
Lack of Funds
Technology Failure
Not enough doctors for treatment
Cannot provide enough available Medical facilities
Too much Administration/ documentation work
Government support fail
Tax payer not willing to support
Increasing cost of service
Electronic system not able to function
Claim data Transfer failure
Not enough available services
Doctors not willing to cope with Medicare
Suddenly Increase of enrollment
Large number of aging/sick population
Collect medical records from different places after extension
Patients incorrect information/ lack of knowledge
Technical design/ development failure
Employees lack of training
Wrong information provided
Huge claims number incensement
Wrong arrangement of medical providers
Patients/ hospitals number varies geographically


Reliability
Failure Modes and Effects Analysis (FMEA)
Fault Tree Analysis (FTA)

Failure Mode Effect Analysis (FMEA)

Process Step	Failure Mode	Severity 1-10 10 = most severe	Occurrence 1-10 10 = highest prob. of occurrence	Detection 1-10 10 = lowest prob. of detection	RPN[1]	Improvement Action
1 DHS identifies illegal immigrants	Immigrants Escape	10	2	9	180	Trained officers and Improved checking
2 Prepare Legal Documentation	Incorrect Documentation and Data entry errors	7	3	6	126	Training Employees for Legal documentation
3 Determining Detention of Immigrants	Wrong Determination	9	6	7	162	Identify the legal and political flaws
4 Accommodate Detained Immigrants	Lack of facility	5	8	2	80	Improve accommodation capacity
5 Escorting detainees back	Lack of resources	9	3	5	135	Improving Political ties and arranging

Fault Tree Analysis



Failure Modes And Effects Analysis (FMEA)

- FMECA is a step by step approach for identifying all possible failures in a design, manufacturing or assembly process, or product or service.
- FMECA is one of the most important and most widely used tool of reliability analysis.

Failure Modes And Effects Analysis (FMEA)

FUNCTION	FAILURE MODE	EFFECTS	CAUSES	OCCURRENCE	SEVERITY	DETECTION	RPN	ACTIONS
ZIKA VIRUS SPREAD CONTROL	Pregnancy	Infant death	Body fluids	4	8	6	192	Medication
	Mosquitos	Rapid Spread	Unhygienic	7	8	7	392	Use repellants
	Travel	Transmission	Travel to affected areas	5	7	7	245	Avoid affected areas
	Sex	Transmission	Semen	6	5	4	120	Use Condoms

Failure Modes And Effects Analysis (FMEA)

Criticality Analysis

A relative measure of the consequence.

Difficult to perform for a functional FMEA due to the lack of detailed failure data at this level.

Failure Mode Criticality Number = α x *frequency x hours of cycles x* β

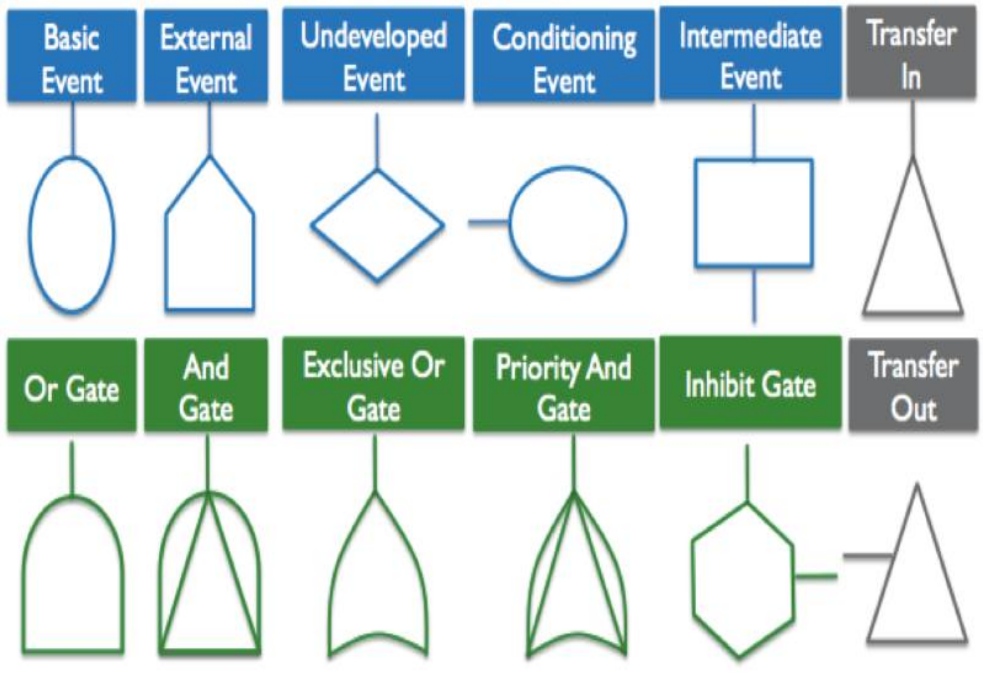
α -the percent of occurrence of each failure mode.

Frequency – the rate of occurrence.

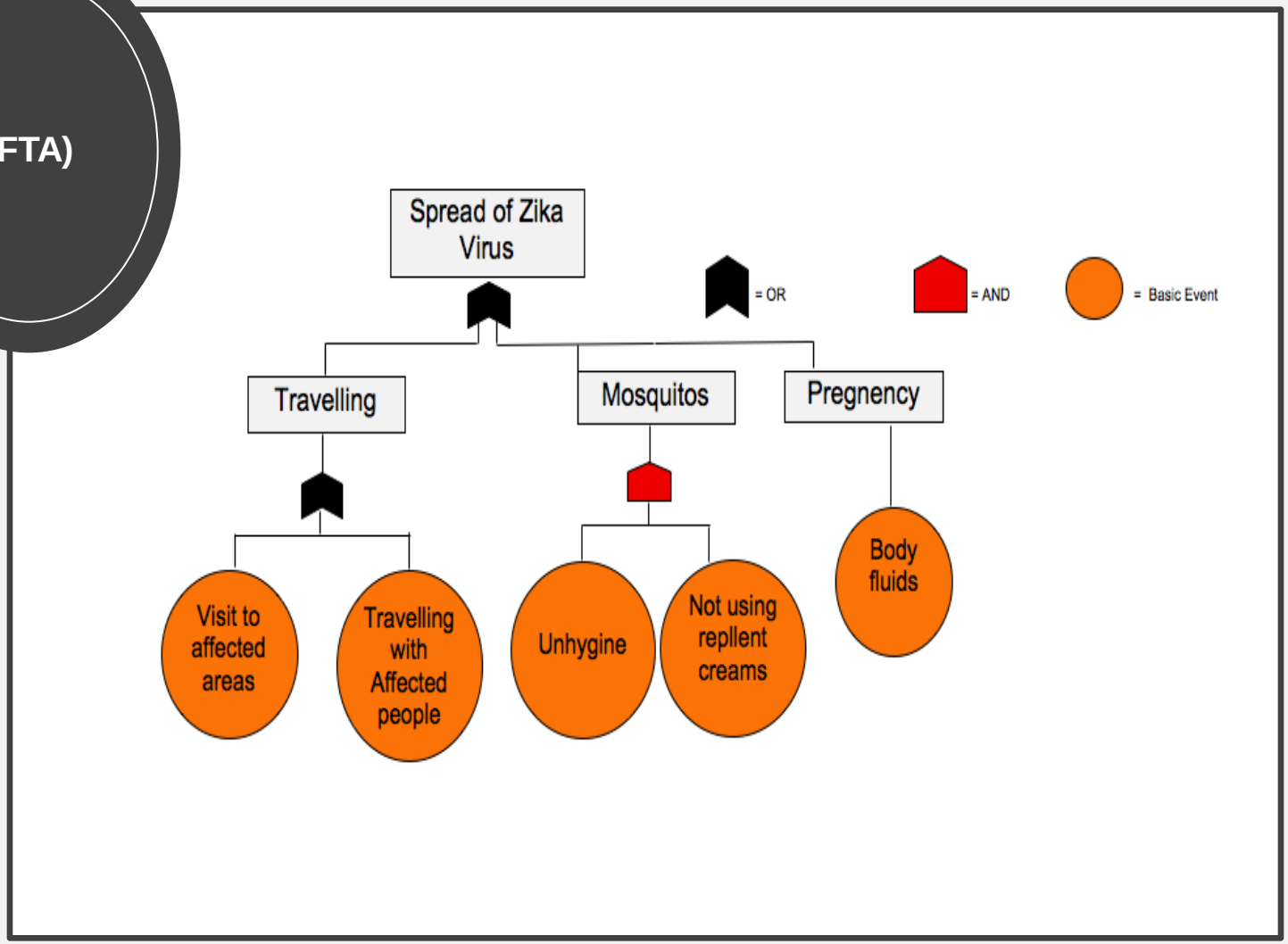
β – Probability that the failure effect will occur.

FAULT TREE ANALYSIS (FTA)

- FTA is a top down failure consequence assessment technique to identify safety concerns
- Will identify the causes of product failures which may then be eliminated
- Updating the FTA to reflect design changes will assess whether previous problems have been eliminated, or new problems have been introduced.



(FTA)


Spread of Zika Virus
= OR
= AND
= Basic Event
Travelling
Mosquitos
Pregnency
Visit to affected areas
Travelling with Affected people
Unhygine
Not using repllent creams
Body fluids

Reliability Analysis

- **Scanning device:** Patho Screen Field scanners
- **Operating Environment**: Zika virus positive test
- **Objective:** For an Patho screen scanner manufacturer, 70% of the kits should pass through the warranty period without generating a claim.

Reliability Assumptions

- Assume the lives are independent
- Suppose the distribution of the lives (Times to Failure) it is exponential
- Use the complete data (n=25)
- Confidence Level $\alpha = 0.05$
- Assume the Mean Time To Failure (MTTF) is 24 months

Data Analysis

Time to failure (Months)			
18.821	6.1743	17.711	29.354
8.7656	13.576	17.066	
9.1493	0.2326	13.466	
4.2561	0.6535	58.034	
8.3138	11.724	3.2838	
15.908	2.3612	4.4358	
12.977	19.424	2.6607	
1.1271	1.8911	17.914	

Generate the exponential data.

Calculate the Total Test Time

$$T = \sum T = 299.27 \text{ Months}$$

For the Chi-Square Distribution
DF=2*25 = 50, based on our data:

$$X^2_{2n,\alpha/2} = X^2 (50, 0.025) = 32.35$$
$$X^2_{2n,\ 1-\alpha/2} = X^2 (50, 0.975) = 71.40$$

MTBF Calculations: $\left(\frac{2T}{\chi^2_{2n,1-\alpha/2}}, \frac{2T}{\chi^2_{2n,\alpha/2}}\right)$

(2 * 299.27)/32.35 = 18.502
(2 * 299.27)/71.4 = 8.382

95% CI for the MTTF
= (8.382 , 18.5)

95% CI FOR THE FAILURE RATE

= (1/MTTF-2, MTTF-1) = (1/8.382 , 1/18.502)
= (0.05405 , 0.11929)

Sample point estimators:
Est. MTTF = Avg. = 11.9708
Est. Rate = 1/MTTF = 0.0835366

95% CI for Reliability for Mission Time = 10

- R-upper(T) = P(x>= T) = EXP(-λ1*T)
- = EXP(-0.054*10) = EXP (-0.54) = 0.5827
- R-lower(T) = P(x>= T) = EXP(-λ2*T)
- = EXP(-0.119*10) = EXP (-1.19) = 0.304

- **95% CI: (0.304, 0.5827)**

- Therefore, 95% of the times the true Reliability for
- Mission Time = 10 units is between 30.4% and 58.27%

- The goal was not meet, since the reliability is very low.