1	*Dynamic Safety Risk Assessment*

1. The Risk Index (RI) is formulated as :

To involve the latent impacts of safety-related accidents and incidents, impact on business was added to the formula. These changes and modifications could be introduced as:

$$\text{Risk Index} = RI = (p^{1/\alpha} \cdot S^{\frac{1}{\beta}}) + I^{1/\gamma}$$

Where P denotes probability, S – severity, and I – impact on business, and α, β, γ – the weighting factors for probability, severity and impact on business, respectively

2. The field risk (FR) is formulated as:

$$\text{Field Risk Index} = (FR)i = \frac{\sum_{i=1}^{N}(RI)i}{N}$$

Where RI is the safety risk index of a safety report and N is the total number of safety reports received in a definite field

3. The Overall Safety Index (OSI) of the organization:

The safety Field risks from different sectors: engineering and maintenance, flight operations, security, airport services, dispatch, training, air medical centers, and areas, such as ramp, hangar, etc., are summed up to obtain the Overall Safety Index of the organization:

$$\text{Overall Safety Index} = OSI = \sum_{i=1}^{P}(wi \cdot FRi)$$

Where FRi is the safety Field risk, Wi indicates the corresponding weighing coefficients for each field derived by the FANP comparison method, and P is the number of operational fields (sectors/departments/areas).

2	*Fuzzy Analytical Network Process (FANP)*

Triangular Fuzzy scale definitions as :

The Fuzzy numbers used in this method are triangular Fuzzy numbers and the Fuzzy scale utilized in this method
These scales are used for pair comparison. Suppose two triangular fuzzy numbers

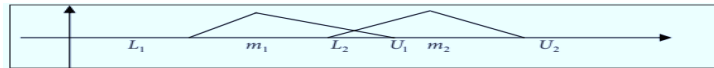$$M_1 = (L_1, m_1, U_1) \qquad M_2 = (L_2, m_2, U_2)$$

$$M_1 + M_2 = (L_1 + L_2, m_1 + m_2, U_1 + U_2)$$

$$M_1 \times M_2 = (L_1 L_2, m_1 m_2, U_1 U_2)$$

Linguistic scale	Reciprocal scale
Just equal	=A(1,1,1)
Equally important	=B(2/3,1,3/2)
Strongly more important	=C(3/2,2,5/2)
Very strongly more important	=D(5/2,3,7/2)
Absolutely more important	=E(7/2,4,9/2)

A=	1.00	1.00	1.00
B=	0.67	1.00	1.50
C=	1.50	2.00	2.50
D=	2.50	3.00	3.50
E=	3.50	4.00	4.50

1/A=	1.00	1.00	1.00
1/B=	0.67	1.00	1.50
1/C=	0.40	0.50	0.67
1/D=	0.29	0.33	0.40
1/E=	0.22	0.25	0.29

Two triangular fuzzy numbers in coordinate axis

Step 1: The value of fuzzy synthetic extent with respect to the ith object is defined as:

$$S_i = \sum_{j=1}^{m} Mij \times \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij} \right]^{-1}$$

Step2: The degree of possibility of S2≥ S1   is defined as:

$$V = (Sj \rangle S_i) = height \ (S_i \cap Sj) = U(d) = \begin{cases} 1 & m_j \rangle m_i \\ 0 & L_i \geq U_j \\ \dfrac{l_i - u_j}{(m_j - u_j) - (m_i - l_i)} & otherwise \end{cases}$$

Step 3: The degree of possibility for a convex Fuzzy number to be greater   than K convex fuzzy numbers Mi (i=1,2,………..,k) can be defined by :

$$V = (S \rangle S_1, S_2, \ldots, S_k) = V[(S \rangle S_1) \ and \ \ldots(S \rangle S_k)] = \min V(S \rangle S_i) \quad for \ i = 1,2,\ldots k$$
$$d'(A_i) = \min (S \geq S_i) \quad for \quad i = 1,2,3,\ldots .k$$

Step 4: Via normalization, the normalized weight vectors are :

$$W' = (d'(A_1), d'(A_2), \ldots \ldots \ldots d'(A_n))^T$$

Step 5 : Where W is a non-fuzzy number :

$$w = ((d(A_1'), d'(A_2)', \ldots \ldots \ldots d'(A_n))^T$$

Fuzzy Analytical Network Process (FANP)

Linguistic scale	Reciprocal scale
Just equal	=A(1,1,1)
Equally important	=B(2/3,1,3/2)
Strongly more important	=C(3/2,2,5/2)
Very strongly more important	=D(5/2,3,7/2)
Absolutely more important	=E(7/2,4,9/2)

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C=	1.50	2.00	2.50
D=	2.50	3.00	3.50
E=	3.50	4.00	4.50

1/A=	1.00	1.00	1.00
1/B=	0.67	1.00	1.50
1/C=	0.40	0.50	0.67
1/D=	0.29	0.33	0.40
1/E=	0.22	0.25	0.29

Engineering and Maintenance field	Probability			Severity			Impact on business		
Probability	1.00	1.00	1.00	1	1	1	0.67	1.00	1.50
Severity	1.00	1.00	1.00	1.00	1.00	1.00	1.50	2.00	2.50
Impact on business	0.67	1	1.5	0.40	0.50	0.67	1.00	1.00	1.00

	L			M			U		SUM	inverse summation
S1	2.67			2.40			3.17		8.24	0.09
S2		3.00			2.50			4.00	9.50	0.11
S3			3.50			2.67			5.00	11.17	0.12

	2.67	3.00	3.50
	3.50	4.00	4.50
	2.07	2.50	3.17
sum	8.24	9.5	11.17

	L	M	U
S1	0.239033124	0.315789474	0.424757282
S2	0.313339302	0.421052632	0.546116505
S3	0.185317816	0.263157895	0.384708738

$$S_i = \sum_{j=1}^{m} Mi \times [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{ij}]^{-1}$$

s1>s2	0.514202487
s1>s3	1
s2>s1	1
s2>s3	1
s3>s1	0.734595713
s3>s2	0.311297815

$$V = (Sj \rangle S_i) = height(S_i \cap Sj) = U(d) = \begin{cases} 1 & m_j \rangle m_i \\ 0 & L_i \geq U_j \\ \dfrac{l_i - u_j}{(m_j - u_j) - (m_i - l_i)} & otherwise \end{cases}$$

S1	0.514202487
S2	1
S3	0.311297815
SUM	1.825500302

$V = (S)S_1, S_2, \ldots, S_k) = V[(S)S_1) \text{ and } \ldots(S)S_k)] = \min V(S)S_i) \quad for \ i = 1,2,\ldots.k$

$d'(A_i) = \min \ (S \geq S_i) \quad for \quad i = 1,2,3,\ldots \ .k$

$W' = (d'(A_1), d'(A_2), \ldots \quad \ldots \quad d'(A_n))^T$

Probability	0.281677569
Severity	0.547795034
Impact on business	0.170527397

$$W = ((d(A_1'), d'(A_2)', \ldots\ldots\ldots d'(A_n))^T$$

Corresponding weighing coefficients for each options- Each field:

Options- Each Field	corresponding coefficients-weight for each field
Engineering and Maintenance	36.67
Flight Operations	61.33
Airport Services	1.33
Security	0.67

As follow stages :

Triangular Fuzzy scale definitions:

A	1.00	1.00	1.00
B	0.67	1.00	1.50
C	1.50	2.00	2.50
D	2.50	3.00	3.50
E	3.50	4.00	4.50

Linguistic scale	Reciprocal scale
Just equal	=A(1,1,1)
Equally important	=B(2/3,1,3/2)
Strongly more important	=C(3/2,2,5/2)
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Absolutely more important	=E(7/2,4,9/2)

1/A	1.00	1.00	1.00
1/B	0.67	1.00	1.50
1/C	0.40	0.50	0.67
1/D	0.29	0.33	0.40
1/E	0.22	0.25	0.29

ALL options-field matrix

Probability	Engineering and Maintenance	Flight Operations	Airport Services	Security
Engineering and Maintenance	A	A	1/C	1/D
Flight Operations	A	A	1/C	1/D
Airport Services	C	1/C	A	1/B
Security	D	1/D	B	A

Severity	Engineering and Maintenance	Flight Operations	Airport Services	Security
Engineering and Maintenance	A	B	1/C	1/D
Flight Operations	1/B	A	1/D	1/D
Airport Services	C	D	A	1/B
Security	D	D	B	A

Impact on Business	Engineering and Maintenance	Flight Operations	Airport Services	Security
Engineering and Maintenance	A	1/B	1/C	1/D
Flight Operations	B	A	1/C	1/D
Airport Services	C	C	A	1/B
Security	D	D	B	A

STAGE 1 :

	Engineering and Maintenance	Flight Operations	Airport Services	Security
Engineering and Maintenance	A	A	1/C	1/D
Flight Operations	A	A	1/C	1/D
Airport Services	C	1/C	A	1/B
Security	D	1/D	B	A

STAGE2 :

M ij	6	7	8	16.71667	0.043215
M ij	6	7	8	19.66	0.050865
M ij	2.466666667	3	3.84	23.14	0.059821
M ij	2.25	2.66	3.3		

STAGE3 :

	L	M	U
S1	0.259291271	0.356052899	0.478564
S2	0.259291271	0.356052899	0.478564
S3	0.106597522	0.1525941	0.229711
S4	0.097234226	0.135300102	0.197408

STAGE4 :

s1>s2	1	
s1>s3	1	
S1>s4	1	1

s2>s1	1	
s2>s3	1	
S2>s4	1	1

s3>s1	0	
s3>s2	0	
s3>s4	1	0

s4>s1	1	
s4>s2	0	
s4>s3	0.840024813	0

STAGE5 :

S1	36.66666667
S2	61.33333333
S3	1.333333333
S4	0.666667

SUM	1

Engineering and Maintenance	36.67
Flight Operations	61.33
Airport Services	1.33
Security	0.67

1   *Corresponding coefficients - weighing for each criteria- safety risk parameters :*

Options	Criteria	coefficients for each criteria
ENGINEERING & MAINTENANCE	PROBABILITY	17
	SEVERITY	82
	IMPACT ON BUSINESS	1
FLIGHT OPERATIONS	PROBABILITY	90
	SEVERITY	9
	IMPACT ON BUSINESS	1
AIRPORT SERVICES	PROBABILITY	54
	SEVERITY	40
	IMPACT ON BUSINESS	6
SECURITY	PROBABILITY	28
	SEVERITY	55
	IMPACT ON BUSINESS	17

As follow stages :

2   *Triangular Fuzzy scale definitions:*

Linguistic scale	Reciprocal scale
Just equal	=A(1,1,1)
Equally important	=B(2/3,1,3/2)
Strongly more important	=C(3/2,2,5/2)
Very strongly more important	=D(5/2,3,7/2)
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A	1.00	1.00	1.00
B	0.67	1.00	1.50
C	1.50	2.00	2.50
D	2.50	3.00	3.50
E	3.50	4.00	4.50

1/A	1.00	1.00	1.00
1/B	0.67	1.00	1.50
1/C	0.40	0.50	0.67
1/D	0.29	0.33	0.40
1/E	0.22	0.25	0.29

3   *All criteria - safety risk parameters matrix*

Engineering and Maintenance Department	Probability	Severity	Impact on business
Probability	A	1/C	C
Severity	C	A	D
Impact on business	1/C	1/D	A

Flight Operations Department	Probability	Severity	Impact on business
Probability	A	D	E
Severity	1/D	A	D
Impact on business	1/E	1/D	A

Airport Services DEPARTMENT	Probability	Severity	Impact on business
Probability	A	C	C
Severity	1/C	A	E
Impact on business	1/C	1/E	A

Security DEPARTMENT	Probability	Severity	Impact on business
Probability	A	A	B
Severity	1/A	A	C
Impact on business	1/B	1/C	A

Safety Risk index measurement :

First month

Triangular Fuzzy scale definitions:

Linguistic scale	Reciprocal scale
Just equal	~A(1,1,1)
Equally important	~B(2/3,1,3/2)
Strongly more important	~C(3/2,2,5/2)
Very strongly more important	~D(5/2,3,7/2)
Absolutely more important	~E(7/2,4,9/2)

ALL criteria - safety risk parameters matrix

Engineering and Maintenance

FLIGHT Operations

AIRPORT SERVICES

SECURITY

Coefficients

RI & FR

OSI

1	*Overall Safety Index (OSI) trend-monthly :*

Month	Safety Risk Index-OSI
Jan	1.13
Feb	1.7
Mar	1.6
Apr	1.5
May	1.2
Jun	1.09
Jul	1.09
Aug	2
Sep	1.9
Oct	1.8
Nov	1.8
Dec	1.9

OVERAL SAFETY RISK

2	*NORMALIZED- Overall Safety Index (OSI) trend-monthly :*

Month	Safety Risk Index-OSI	Safety Rate
Jan	1.00	
Feb	1.50396827	50.40
Mar	1.415499548	41.55
Apr	1.327030826	32.70
May	1.061624661	6.16
Jun	0.964309067	-3.57
Jul	0.964309067	-3.57
Aug	1.769374435	76.94
Sep	1.680905713	68.09
Oct	1.592436991	59.24
Nov	1.592436991	59.24
Dec	1.680905713	68.09

Overall Safety Index(OSI) Rate