

Fleet Management



SMART Short Course
The Aircraft Airworthiness & Sustainment
Conference
Grapevine, Texas – March 21, 2016

Outline



- ✓ SMART|LD fleet management concept
 - ✓ Hazard Function
 - ✓ Application of Hazard to calculate fleet risk
- ✓ Run a simple example
- ✓ Run a more complex example
 - ✓ Fleet demographics input
 - ✓ Fleet risk output

Fleet Management Tab



SMART - Small Aircraft Risk Technology

File Documentation

Results

Load Output File:

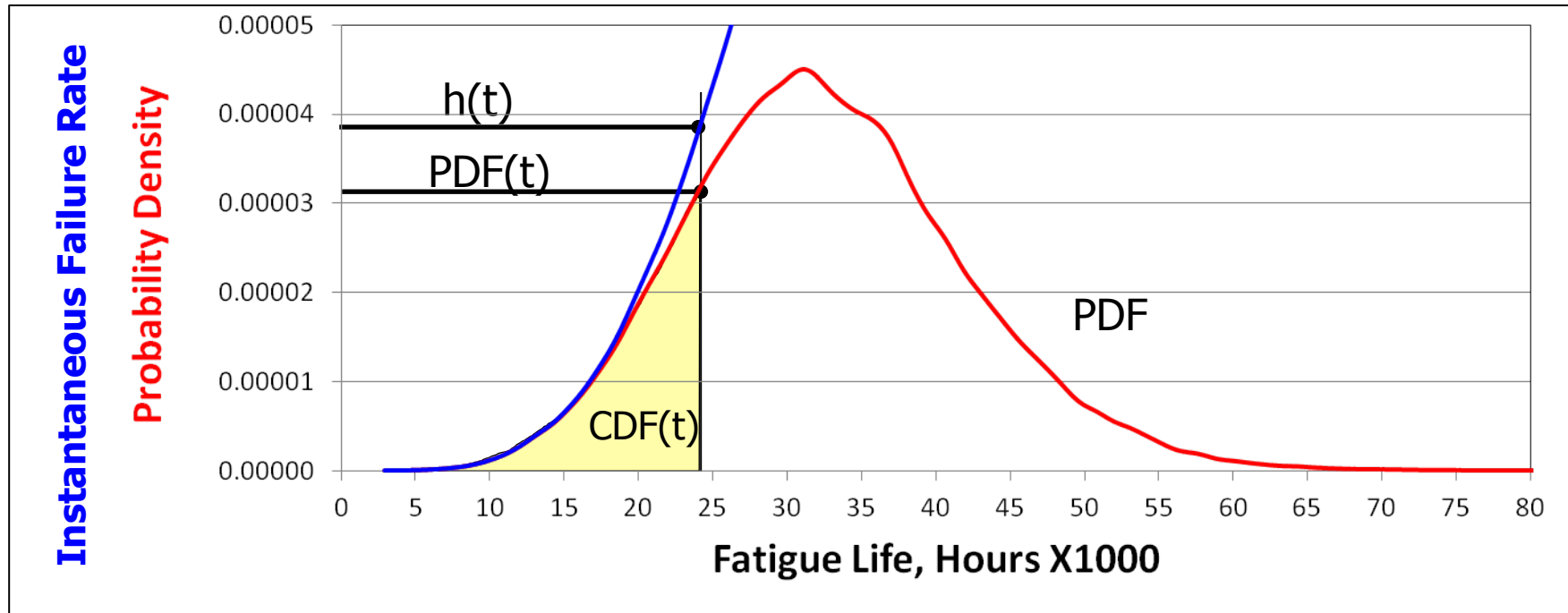
Samples Output Screen out **Fleet Management**

Input File:



Hazard Function $h(t)$

\approx instantaneous failure rate



Interpretation:

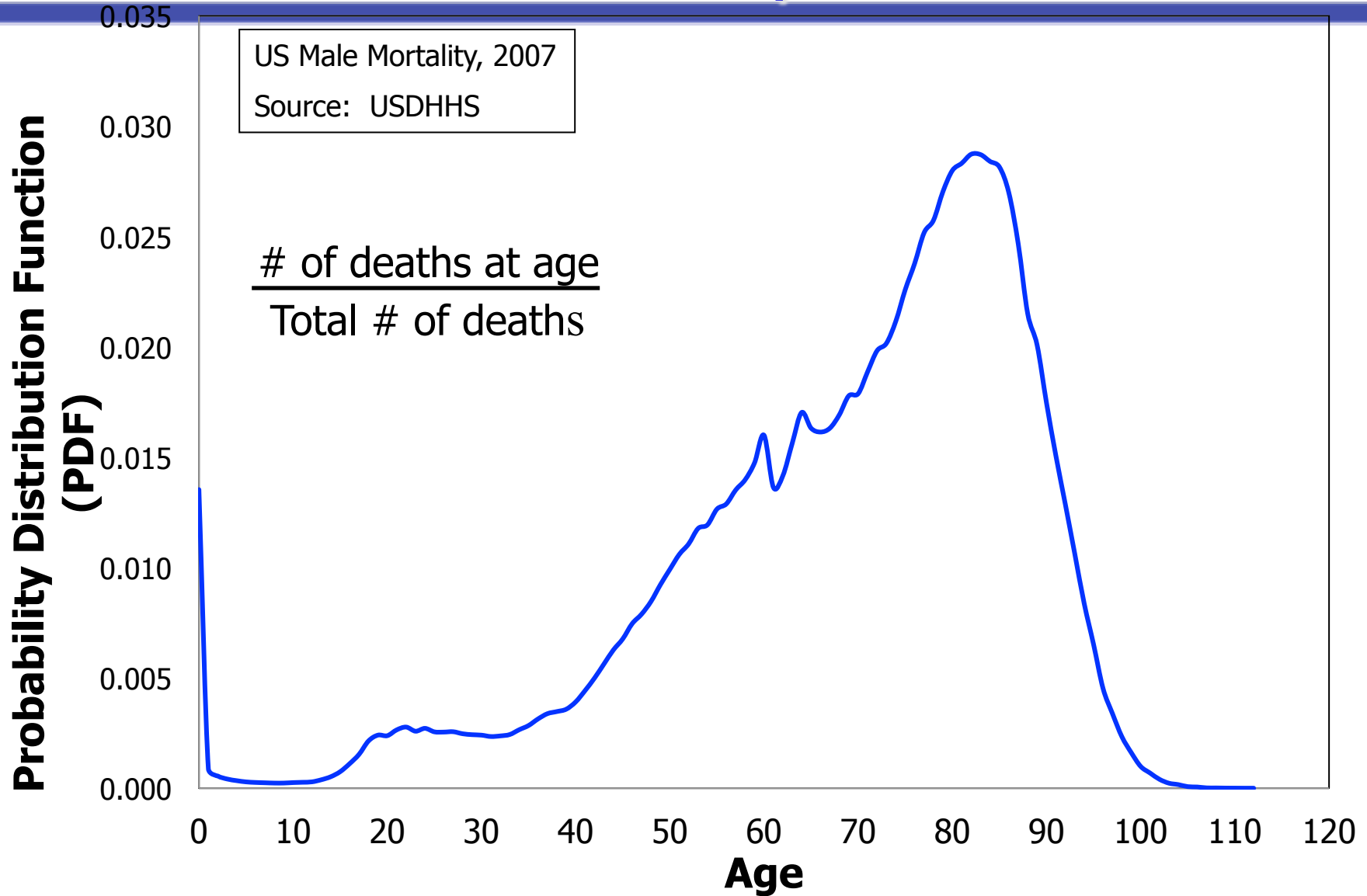
$$\text{Hazard Function } h(t) = \frac{PDF(t)}{1 - CDF(t)}$$

- Consider an individual aircraft found not cracked at time t
- The chances of having a fatigue crack in a small interval $[t, t+dt]$ are then given by: $H(t) \cong h(t)*dt$

PDF: Probability Distribution Function
CDF: Cumulative Distribution Function

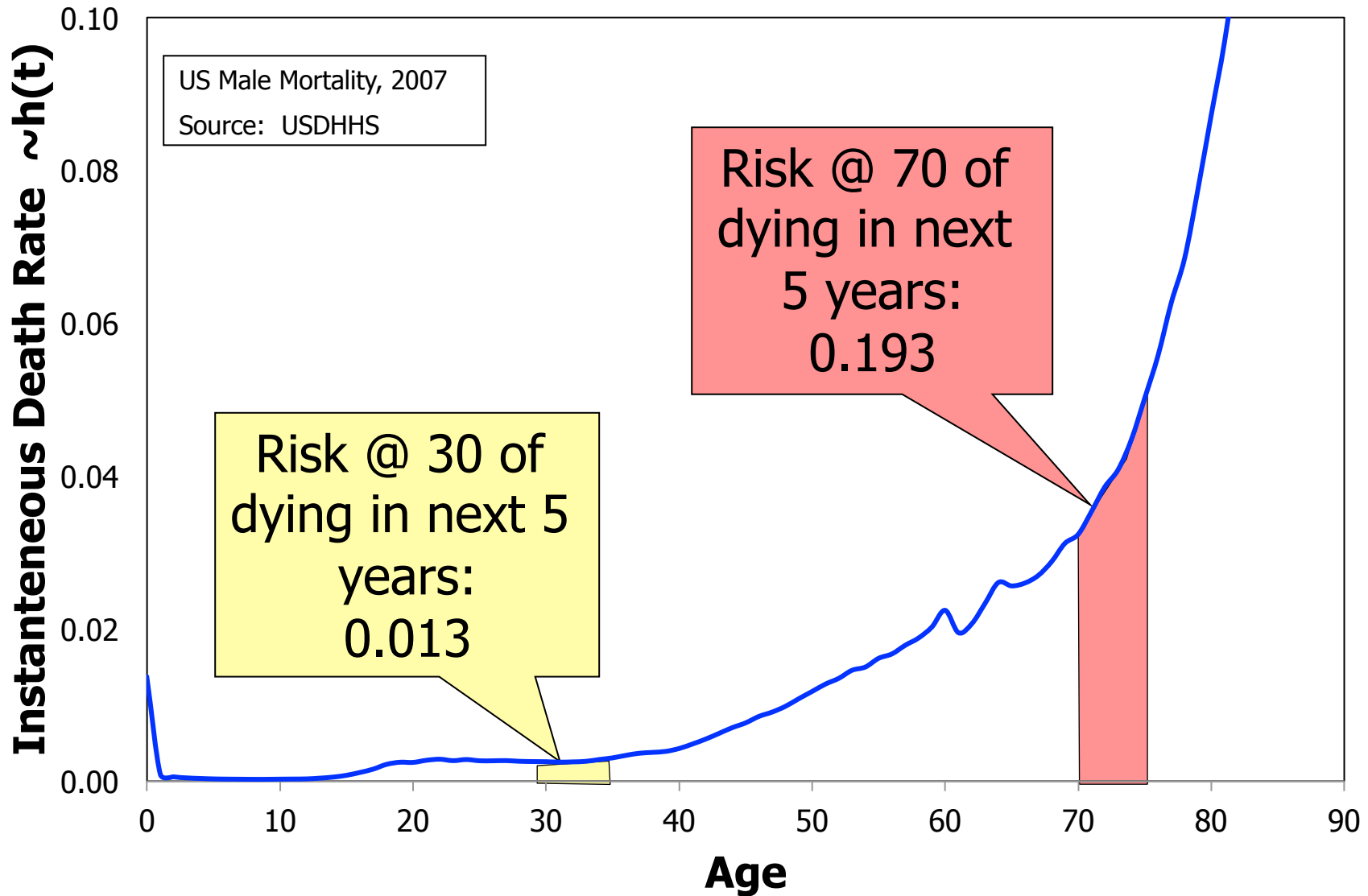


Analogy to Human Mortality





Analogy to Human Mortality



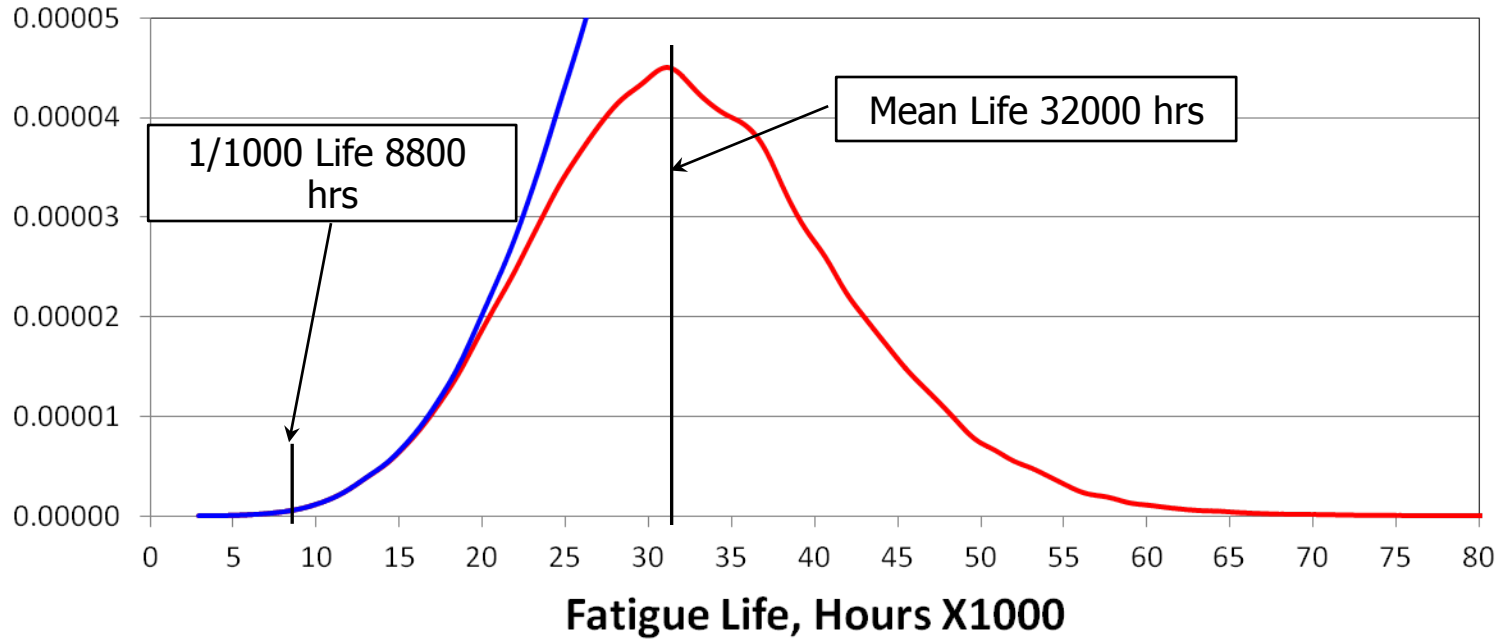


Generic SMART|LD Results



Instantaneous Failure Rate

Probability Density



SMART RESULTS

Probability	Flights-to-Failure	Hours-to-Failure
0.500000	31961	31961
0.100000	21283	21283
0.010000	13683	13683
0.001000	8792	8792
0.000223	5735	5735

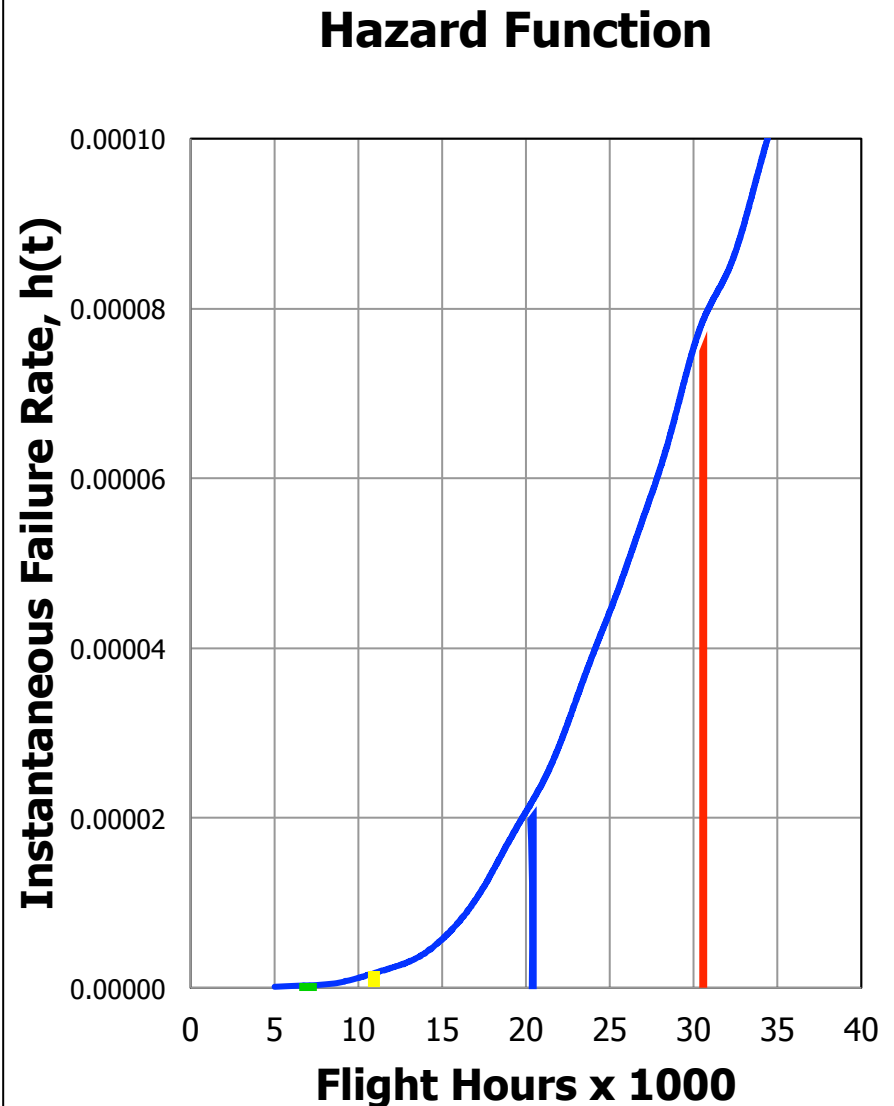


Example – Fleet of 33 Airplanes



Calculate hazard next 100 hrs

No Aircraft	Current Time in Service (Hrs.)	Expected Future Hours	$H_z(t) * dt$	$H_z(t)$
10	5000	100	0	0
10	6000	100	0.00002146	0.00021457
10	10000	100	0.00011706	0.0011706
2	20000	100	0.00207243	0.00414486
1	30000	100	0.00754	0.00754
Total Hazard				0.01307



Fleet Management

Input File:

No Aircraft	Current Time in Service (Hrs.)	Expected Future Hours	$H_z(t) * dt$	$H_z(t)$
10	5000	100	0	0
10	6000	100	2.146E-05	0.00021457
10	10000	100	0.00011706	0.0011706
2	20000	100	0.00207243	0.00414486
1	30000	100	0.00754	0.00754
*			Total Hazard	0.01307



TEXTRON AVIATION

Fleet Management Input



Fleet Management

Input File:

Browse

Compute

Save

Clear

New

	No# Airplanes	TIS	Future Hrs	F4	F5	F6	Hours TIS
	1	10000	1				
	1	10000	10				
	10	10000	1				
✎	10	10000	10				
*							

Fleet Management Output



Generic SMART|LD Run

Fleet Management

Input File:

Browse

Compute

Save

Clear

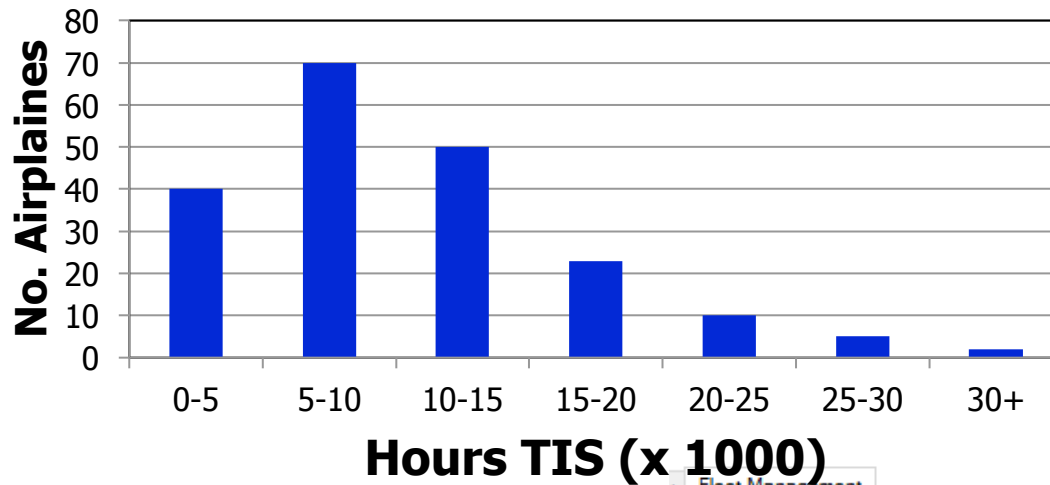
New

	No Aircraft	Current Time in Service (Hrs#)	Expected Future Hours	Hz (τ) *dt	Hz (τ)
▶	1	10000	1	1.17E-06	1.17E-06
	1	10000	10	1.171E-05	1.171E-05
	10	10000	1	1.17E-06	1.171E-05
	10	10000	10	1.171E-05	0.00011706
*				Total Hazard	0.00014

Fleet Hazard



Generic Fleet Demographic



Input File:

No# Airplane#	TIS	Future Hrs	F4	F5	F Hours TIS
70	7500	500	0.00016144	0.01130082	5-10
50	12500	500	0.00134378	0.06718906	10-15
23	17500	500	0.0059775	0.1374825	15-20
10	22500	500	0.01561233	0.15612333	20-25
5	27500	500	0.0291	0.1455	25-30
2	32000	500	0.042105	0.08421	30+
200					
*			Total Hazard	0.60181	

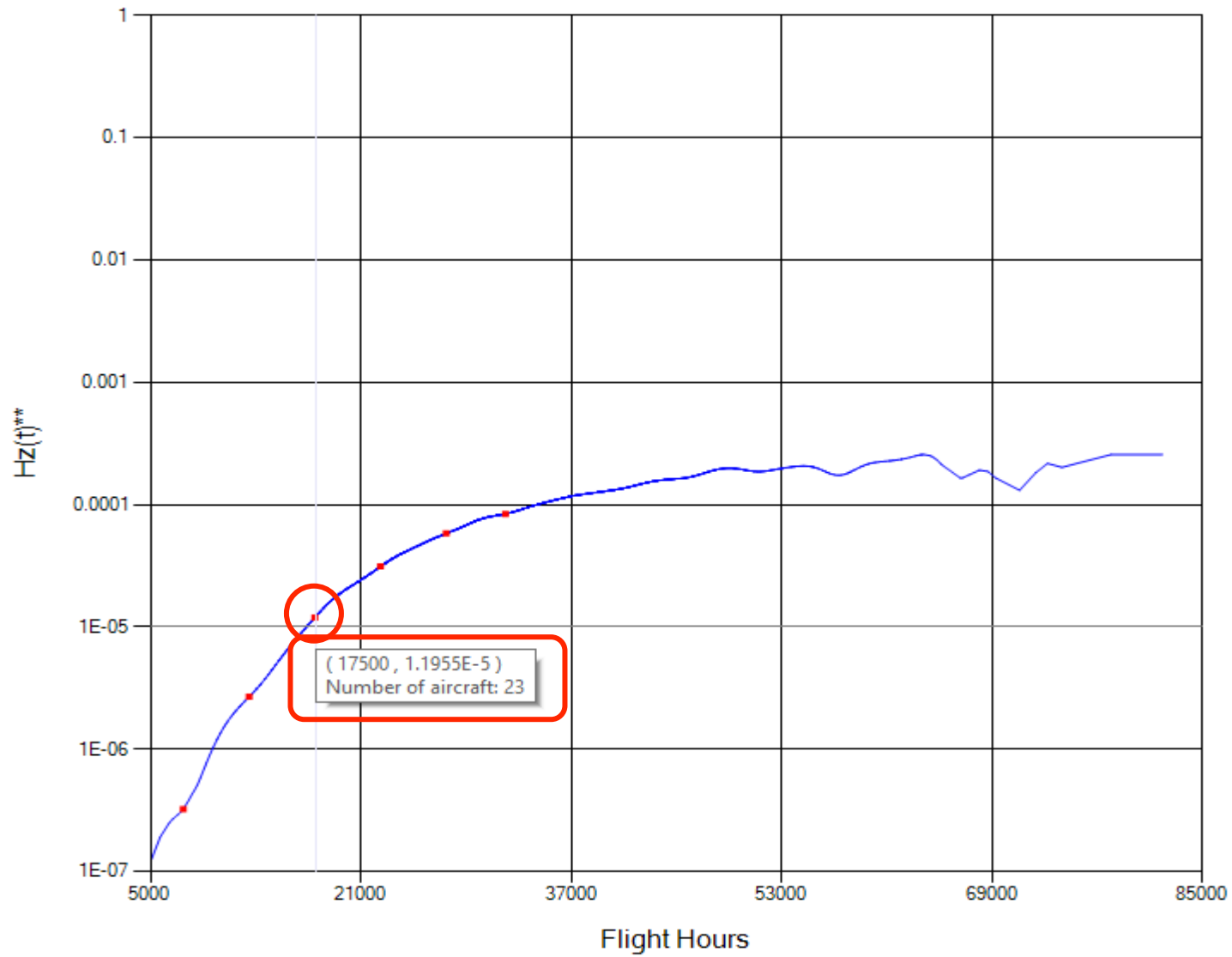
TIS: Time in Service



NuSS
Sustainment
Solutions

TEXTRON AVIATION

Fleet Management Plot



Generic Fleet Output



Fleet Management

Input File:

C:\AANuSS\UTSA\MarvSmart\LD Training\Fleet200L

Browse

Compute

Save

Clear

New

No Aircraft	Current Time in Service (Hrs#)	Expected Future Hours	Hz (t) *dt	Hz (t)
1	26301....	500	0.02569496	0.02569496
1	27055....	500	0.02784509	0.02784509
1	28220....	500	0.03127009	0.03127009
1	29304....	500	0.03520033	0.03520033
1	31247....	500	0.04069192	0.04069192
1	34557....	500	0.05055	0.05055
*			Total Hazard	0.62763



TEXTRON AVIATION

Generic Fleet Output



Generic Fleet Hazard Output to Excel File

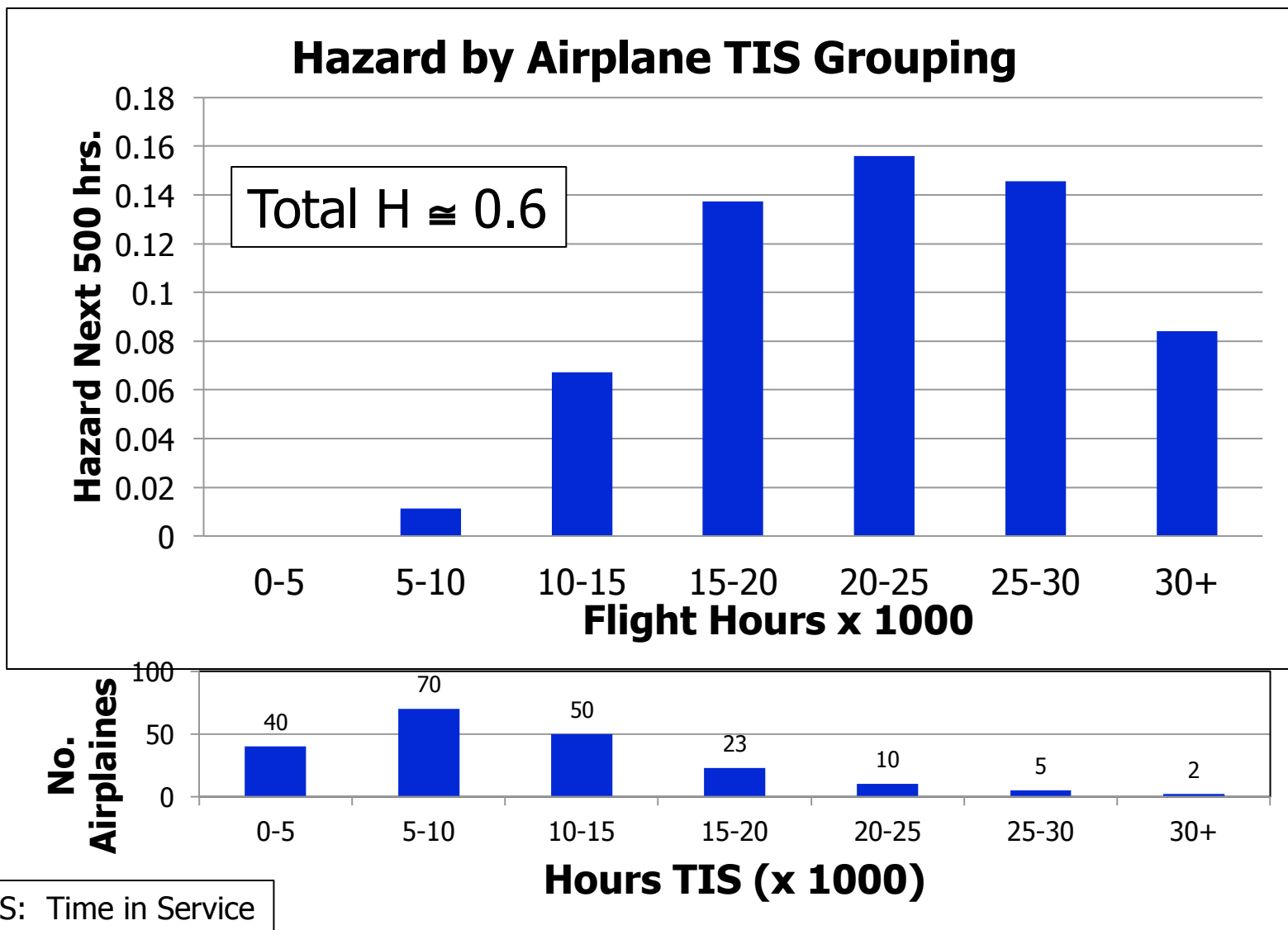
	A	B	C	D	E
190	1	22532.76734	500	0.01569942	0.01569942
191	1	23245.45986	500	0.01766009	0.01766009
192	1	23753.67184	500	0.01902668	0.01902668
193	1	24472.8999	500	0.02084725	0.02084725
194	1	24612.6707	500	0.02119168	0.02119168
195	1	25766.92696	500	0.02418232	0.02418232
196	1	26301.98367	500	0.02569496	0.02569496
197	1	27055.54556	500	0.02784509	0.02784509
198	1	28220.36499	500	0.03127009	0.03127009
199	1	29304.67897	500	0.03520033	0.03520033
200	1	31247.76991	500	0.04069192	0.04069192
201	1	34557.9241	500	0.05055	0.05055
202				Total Hazard	0.62763
203					

Risk Management



- ✓ Fleet risk assessment is easy with this feature
- ✓ Example:
 - ✓ Good estimate of fleet demographics
 - ✓ Easy to determine which TIS groups have highest risk

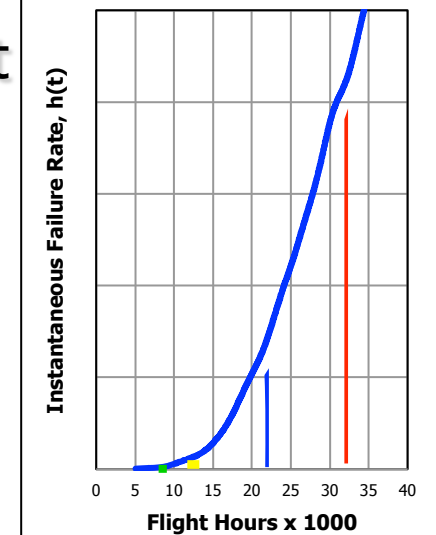
Risk Management



Cautions Using Hazard

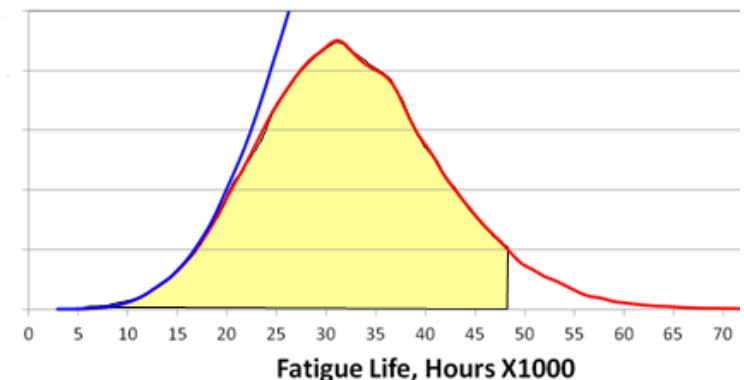


Hazard Function



- ✓ Hazard is “instantaneous” chance of failure at time, t
 - ✓ $H(t) \cong h(t) * dt$
 - ✓ Approximation is close for “dt” small future time
 - ✓ For generic demographic, difference is 9%
 - ✓ H at TIS *1 hr. = 0.00126
 - ✓ H at TIS+500 *1 hr. = 0.00137

- ✓ Hazard function, $h(t) = \frac{\text{PDF}(t)}{1-\text{CDF}(t)}$
 - ✓ For very high flight times well past mean fatigue life, H may be underestimated
 - ✓ Denominator gets progressively smaller toward zero
 - ✓ Numerator also get progressively smaller as there are fewer and fewer unfailed A/C remaining



Summary



- ✓ SMART|LD fleet management is powerful tool
 - ✓ Based on Hazard function
 - ✓ Application of Hazard to calculate fleet risk

- ✓ Enables quantified fleet risk management
 - ✓ Calculates future risk of fatigue failure in individual and fleet aircraft

- ✓ User should understand limitations
 - ✓ Hazard value valid for most of fatigue life
 - ✓ Hazard function valid for “short” future life calculations

Questions

