

# FEMFAT LAB

### LOAD DATA ANALYSIS

Damage equivalent test time reduction

September 22 | XF-T Markus Baumann



# Motivation

# **Motivation**

**MAGNA** 



In the early development process, you want to get results fast with very short computing time.

Long load - time histories prevent this.

# **Motivation**





# With consideration of

- Phase relationship of the input channels must be preserved
- Extreme values should occur
- Damage should be the same



# Workflow

September 22

# Damage equivalent test time reduction







# Background

# **Background rainflow counting**

**Å MAGNA** 

- FEMFAT LAB offline rainflow counting:
  - Starts at biggest minimum
     Sequenzshift: load data before minimum shifted to the end of time data
  - Results closed cycles no residuum





Date: September 22 / Author: ECS St. Valentin

© MPT Engineering / Disclosure or duplication without consent is prohibited

**MAGNA** 

- FEMFAT LAB level selection
  - Based on rainflow counting
  - Selection of "from / to" values with biggest amplitude (highest damage) or with occurrence counts (edit with slider control)

🗈 Le	velSelection					-	- 0	×
File:	G:\_Ticket_data	a\Porsche_Nastra	an_Table	DFile\InputA.rsp				
Leve	elSelection Creat	te signal   Create	lobfile	dup, counting limits				
	[ cica			dyn. oodinting innito				1
		Channel	use	Channelcombinations	Note	•		
	Channel #1	01-M1 afx	TT I	Channelcombinations	Note			
	Channel #2	02-M2 afv						
	Channel #3	03-M3 afz						
	Channel #4	04-M4_bfx	V					
	Channel #5	05-M5_bfy	<b>v</b>					
	Channel #6	06-M6_bfz	<b>v</b>					
	Channel #7	07-M7_cfx	<b>V</b>					
	Channel #8	08-M8_cfy	•					
	Channel #0	09-M9 cfz				*		
	Coverage of ex Min 2 Max 8 Damage	treme values			No. load cycles per	2 .		
	50%	evels		50%				
St	art calculation			Save base setting	15		Cance	:I



Date: September 22 / Author: ECS St. Valentin

# **Background level selection**

- FEMFAT LAB level selection
  - Level selection for each channel and save level for all channels at the same time





**MAGNA** 

### Date: September 22 / Author: ECS St. Valentin

© MPT Engineering / Disclosure or duplication without consent is prohibited

### **Background level selection**





Date: September 22 / Author: ECS St. Valentin

© MPT Engineering / Disclosure or duplication without consent is prohibited



- FEMFAT LAB mixing track
  - Generate a usable test procedure
  - Correlation by means of damage comparison
  - Constraints: target damage values, target time interval, min./max. repetitions





Date: September 22 / Author: ECS St. Valentin

# Preperation

## **Preperation FEMFAT**

# • FEMFAT

- Reference calculation
- Define calculation groups around high damage notes
  - Name "lab....." or "ecs...."
  - This averaged group damage is mixed
- Save a sample job file
  - FEMFAT LAB will generate the batchfile

FEMFAT 5.4 - femfat*		-		×
Datei Ansicht Berechnung Op	tionen Vorlagen Hilfe			
🔿 🔒 🚝 🖪 📓	📝 🚽 Aktuelles Arbeitsverzeichnis: G:/Work/_LevSel/_20201028_Schulung	FEN	ЛF	AT
ChannelMAX C	Gruppen			
FE-Strukturdaten	Gruppen bearbeiten			^
Gruppen	36 - LAB_00000036_n1 Gruppenfilter:			
Kanäle	22 - ALL 23 - analyse 24 - LAR 00000024 n1 C Import 20 Update Voidate Alle löschen			
Werkstoffdaten	25 - LAB_00000025_n1			
🚀 Knoteneigenschaften	26 - LAB_00000026_n1 36 - LAB_0000036_n1 27 - LAB_00000027_n1			
Sinflussfaktoren	28 - LAB_00000028_n1 Elementanzahl: 0			
DMS-Information	30 - LAB_00000030_n1			
	31 - LAB_00000031_n1 📄 Liste 🕞 Export 🗡 Löschen			
Scratch-Einstellungen	33 - LAB_00000033_n1 34 - LAB_00000034_n1			
BASIC	36 - LAB_00000036_n1 ↓			
ChannelMAX	Cruppe erstellen/bestelten			
TransMAX	Knoten Knoten basierend auf Elemente			
HEAT Sehitoglu				
SPECTRAL	O Label: 0 bis 0			
SPOT Remeshing	O Farbe: 0 bis 0			
STRAIN Calc	O Gruppe: 0 bis 0			
Results Manager	Verknüpft mit Elementenlabel:  Verknüpft mit Elementen in Gruppe:  36 bis 36			,



## **Preperation FEMFAT calculation groups**

• In this example we reduced to 27 node groups





**MAGNA** 

# **FEMFAT LAB level selection**

## Level selection



• Reference time histories

### – 3 Tracks

no.	name	samples	time [sec]
1	Track_01.rsp	22528	22528
2	Track_02.rsp	1097728	2196
3	Track_03.rsp	193536	960

- Different sample rate
- 90 Channels
- In summary 1313792 samples and 25684 seconds

# Level selection



## • Reference (target) damage



# Level selection



- Output level selection (interface to FEMFAT)
  - $\sim 4000$  level files
    - For each channel one from to level
  - FEMFAT job file
  - Batch file



# FEMFAT LAB mixing track



- Loop 1
  - Determine mathematical optimum
    - Result:
      - Reduction from 1313792 samples to 3178 (413 / 1)
      - 296 different level pairs
      - Rel. damage between reference and result:
        - max: 1.040
        - min: 0.981
        - Mean 1.010





# **Mixing track**



# • Loop 2

- File selection
- Extrem value coverage
- Channel weighting
- Limit time (samples)
- Change number of file repetition
- Insert common divisor

ECS_40007531_m1         ECS_4002076_m1         ECS_40020876_m1         ECS_4004016_m1         ECS_4004458_m1         ECS_40044282_m1           16         VW_Levelselection_LS1007.fps         2.3788-07         3.2137-07         1.8974-07         1.9154-08         6.5540e-09         2.6498-09           17         WW_Levelselection_LS1002.fps         1.2289-05         2.3788-07         2.21352-07         2.0199-10         1.9134-08         6.5540e-09         2.6498-09           18         WW_Levelselection_LS1002.fps         1.5249-05         2.2358-07         2.2195-07         2.0019-10         1.9134-10         3.7807e-10           19         WW_Levelselection_LS110.fps         2.0749-05         2.3245-08         9.9121e-07         3.2399-09         5.0871e-09         2.5942e-09           20         WW_Levelselection_LS110.fps         1.6212e-11         7.5332e-06         4.8030e-10         9.4610e-09         3.2170e-11         3.37067e-10           21         WW_Levelselection_LS111.fps         2.6800-05         1.5300e-09         1.3758-06         5.3430e-10         2.554e-09         2.6767e-08           23         WW_Levelselection_LS111.fps         2.6800-05         1.5204-09         1.1365e-06         5.2526e-10         1.6786e-10         1.3709e-08           24         WW_Levelselectio	ECS_40048935_n1 3.1425e-07 2.4028e-05 1.16396e-05 3.4138e-11 7.0672e-06 1.6682e-05 6.1766e-08 1.5245e-06	ECS_40042832_n1 2.6493e-09 2.2854e-07 3.7867e-10 2.5942e-09 3.3703e-10 2.6767e-08 4.91012_09	ECS_40040458_n1 6.5540e-09 1.6191e-07 1.1943e-10 5.0871e-09	ECS_40040106_n1 1.9154e-08 1.0283e-07 2.0019e-10	ECS_40023646_n1 1.8974e-07 3.7018e-06	ECS_40020876_n1 3.2137e-07	ECS_40007531_n1		-	
16       W_Levelselection_LS1073.fps       2.3788-07       3.2137e-07       1.8974e-07       1.9154e-08       6.5540e-09       2.6493e-09         17       W_Levelselection_LS1082.fps       2.7992e-05       1.3335e-05       3.7018e-06       1.0223e-07       1.6914-07       2.2894e-07         18       W_Levelselection_LS1092.fps       1.5494e-05       2.2798e-07       2.2019e-07       2.0019e-10       1.1943e-10       3.7867e-10         19       W_Levelselection_LS1102.fps       2.0743e-05       2.3245e-08       9.9121e-07       3.2399e-09       5.0871e-09       2.5942e-09         20       W_Levelselection_LS1110.fps       1.6212e-11       7.5330e-06       6.6514e-07       5.8524e-09       2.6767e-08         21       W_Levelselection_LS111.fps       2.0808e-05       1.5500e-09       1.3762e-06       5.2526e-10       1.6786e-10       1.3709e-08         23       W_Levelselection_LS111.fps       2.6808e-05       3.3320e-06       5.2526e-10       1.6786e-10       1.3709e-08         24       W_Levelselection_LS111.fps       2.6808e-07       3.3326e-06       5.2526e-10       1.6786e-10       8.8974e-10         25       W_Levelselection_LS113.fps       2.6006e-05       3.3320e-09       2.6499e-07       3.2067e-12       2.3005e-09       2.6499e-07	3.1425e-07 2.4028e-05 1.1432e-05 1.6696e-05 3.4158e-11 7.0672e-06 1.6682e-05 6.1766e-08 1.5245e-06	2.6493e-09 2.2854e-07 3.7867e-10 2.5942e-09 3.3703e-10 2.6767e-08 4.01012	6.5540e-09 1.6191e-07 1.1943e-10 5.0871e-09	1.9154e-08 1.0283e-07 2.0019e-10	1.8974e-07 3.7018e-06	3.2137e-07	2 2700 07			
17       WLevelselection_L51088.fps       2.7992e-05       1.3335e-05       3.7018e-06       1.0283e-07       1.6191e-07       2.2854e-07         18       WLevelselection_L51092.fps       1.5249e-05       2.5798e-07       2.2195e-07       2.0019e-10       1.1943e-10       3.7057e-10         19       WLevelselection_L51110.fps       2.0743e-05       2.3245e-08       9.9121e-07       3.2399e-09       3.2370e-11       3.703e-10         20       WLevelselection_L51110.fps       1.6512e-11       7.5339e-08       4.8030e-10       9.4610e-09       3.2170e-11       3.7370a-10         21       WLevelselection_L51110.fps       1.051a-05       7.5667e-13       1.5320e-06       6.0514e-07       5.8524e-09       2.6767e-08         22       WLevelselection_L5111.fps       2.080e-05       1.5600e-09       1.3769e-06       5.3480e-10       2.254a-09       4.8181e-08         23       WLevelselection_L5111.fps       2.1389e-07       1.5894e-09       1.313e-05       5.2526e-10       1.6766e-10       1.3709e-08         25       WLevelselection_L5113.fps       3.767re-12       9.5082e-09       2.6499e-07       3.6067e-11       2.3305e-09       6.7461e-09         27       WLevelselection_L5113.fps       3.6279e-06       3.35279e-06       8.2652e-08       1.68	2.4028e-05 1.1432e-05 1.6696e-05 3.4158e-11 7.0672e-06 1.6682e-05 6.1766e-08 1.5245e-06	2.2854e-07 3.7867e-10 2.5942e-09 3.3703e-10 2.6767e-08 4.0101-00	1.6191e-07 1.1943e-10 5.0871e-09	1.0283e-07 2.0019e-10	3.7018e-06		2.3788e-07	ction_LS1073.fps	VW_Levelsel	16
18       VW_Levelselection_L51092.fps       1.5249e-05       2.5798e-07       2.2195e-07       2.0019e-10       1.1943e-10       3.7867e-10         19       WW_Levelselection_L5117.ps       2.0743e-05       2.3245e-08       9.9121e-07       3.2399e-09       5.0071e-09       2.5942e-09         20       WW_Levelselection_L51110.fps       1.6212e-11       7.5339e-08       4.8030e-10       9.4610e-09       3.2170e-11       3.3703e-10         21       WW_Levelselection_L51110.fps       1.6312e-05       7.5667e-13       1.5320e-06       6.0514e-07       5.8524e-09       4.8767e-08         22       WW_Levelselection_L51115.fps       2.1389e-07       1.5294e-09       1.1365e-06       5.5480e-10       2.2543e-09       4.8181e-08         23       WW_Levelselection_L51115.fps       2.1389e-07       1.5294e-09       1.13165e-06       5.2526e-10       1.6766e-10       1.3709e-08         24       WW_Levelselection_L5113.fps       3.6207e-06       3.3320e-09       2.3431e-07       3.6077e-10       2.3045e-09       6.794e-08       2.3041e-10       8.9974e-10         25       WW_Levelselection_L5113.fps       3.6279e-06       3.3820e-09       1.2541e-07       1.1219e-08       8.0542e-09         26       WW_Levelselection_L5113.fps       3.6279e-06       8.2552e-0	1.1432e-05 1.6696e-05 3.4158e-11 7.0672e-06 1.6682e-05 6.1766e-08 1.5245e-06	3.7867e-10 2.5942e-09 3.3703e-10 2.6767e-08	1.1943e-10 5.0871e-09	2.0019e-10		1.3335e-05	2.7992e-05	ction_LS1088.fps	VW_Levelsel	17
19     W/Levelselection_L511.fps     2.0743e-05     2.2845e-08     9.9121e-07     3.2399e-09     5.0871e-09     2.5942e-09       0     W/Levelselection_L51100.fps     1.6212e-11     7.5339e-08     4.8030e-10     9.4610e-09     3.2170e-11     3.3703e-10       12     W/Levelselection_L51100.fps     1.6713e-05     7.5667e-13     1.5320e-06     6.0514e-07     5.8242e-09     2.6767e-08       22     W/Levelselection_L51111.fps     2.0880e-05     1.5600e-09     1.3769e-06     5.3480e-10     2.2543e-09     4.8181e-08       23     W/Levelselection_L51115.fps     2.1899e-07     1.5294e-09     1.1352e-06     5.2526e-10     1.6766e-10     8.8974e-10       24     W/Levelselection_L5117.fps     2.6206e-06     3.3320e-09     1.311e-07     6.2974e-08     2.9041e-10     8.8974e-10       25     W/Levelselection_L5117.fps     3.6777e-12     9.5082e-09     2.6496e-07     3.6057e-90     6.7461e-09       25     W/Levelselection_L5113.fps     3.6279e-06     1.3259e-06     8.2652e-08     1.8682e-06     2.3011e-07     2.2341e-08       26     W/Levelselection_L5113.fps     3.6279e-06     1.3459e-06     8.2652e-08     1.8682e-06     2.3011e-07     2.2341e-08       27     W/Levelselection_L51136.fps     3.6279e-06     1.3459e-06     8.2652e-08<	1.6696e-05 3.4158e-11 7.0672e-06 1.6682e-05 6.1766e-08 1.5245e-06	2.5942e-09 3.3703e-10 2.6767e-08	5.0871e-09		2.2195e-07	2.5798e-07	1.5249e-05	ction_LS1092.fps	VW_Levelsel	18
20         VW_Levelselection_LS1100.fps         1.6212e-11         7.3339e-08         4.8030e-10         9.4610e-09         3.2170e-11         3.3703e-10           21         VW_Levelselection_LS1110.fps         1.0513e-05         7.5667e-13         1.5320e-06         6.0514e-07         5.8524e-09         2.6767e-08           22         VW_Levelselection_LS1111.fps         2.0880e-05         1.5600e-09         1.3709e-06         5.3520e-06         5.8524e-09         4.8181e-08           22         VW_Levelselection_LS1111.fps         2.0880e-05         1.5600e-09         1.3769e-06         5.2526e-10         1.6766e-10         1.3709e-08           24         VW_Levelselection_LS112.fps         2.6206e-06         3.3320e-09         1.3131e-07         6.2974e-08         2.9041e-10         8.8974e-10           25         VW_Levelselection_LS113.fps         3.7677e-12         9.5082e-09         2.6499e-07         3.0607e-11         2.335e-09         6.7461e-09           26         VW_Levelselection_LS113.fps         3.6279e-06         1.3459e-06         8.2652e-08         1.6862e-06         2.3011e-07         2.2341e-08           27         VW_Levelselection_LS113.6fps         3.6279e-06         1.3459e-06         8.2652e-08         1.6862e-06         2.3011e-07         2.2341e-08           2.	3.4158e-11 7.0672e-06 1.6682e-05 6.1766e-08 1.5245e-06	3.3703e-10 2.6767e-08		3.2399e-09	9.9121e-07	2.3245e-08	2.0743e-05	ction_LS11.fps	VW_Levelsel	19
VW_Levelselection_LS1110.fps         1.0513e-05         7.5667e-13         1.5320e-06         6.0514e-07         5.8524e-09         2.6767e-08           22         VW_Levelselection_LS1111.fps         2.0880e-05         1.5000e-09         1.3769e-06         5.4340e-10         2.2543e-09         4.8181e-08           23         VW_Levelselection_LS1115.fps         2.1389e-07         1.5294e-09         1.1365e-06         5.2526e-10         1.6766e-10         1.3709e-08           24         VW_Levelselection_LS1115.fps         2.6306e-06         3.3320e-09         1.3131e-07         6.2974e-08         2.0911e-10         8.8974e-10           25         VW_Levelselection_LS113.fps         3.7677e-12         9.5082e-09         2.6499e-07         3.6067e-11         2.3305e-09         6.7461e-09           26         VW_Levelselection_LS113.fps         3.6279e-06         3.335e-09         8.2652e-08         1.2541e-07         1.1219e-08         8.0542e-09           27         WU_Levelselection_LS113.fps         3.6279e-06         1.3459e-06         8.2652e-08         1.6862e-06         2.3011e-07         2.2341e-08           review result:	7.0672e-06 1.6682e-05 6.1766e-08 1.5245e-06	2.6767e-08	3.2170e-11	9.4610e-09	4.8030e-10	7.5339e-08	1.6212e-11	ction_LS1100.fps	VW_Levelsel	20
12         VW_Levelselection_LS1111.fps         2.0880e-05         1.5600e-09         1.3769e-06         5.3480e-10         2.2543e-09         4.8181e-08           13         WW_Levelselection_LS1115.fps         2.1389e-07         1.5294e-09         1.1365e-06         5.5256e-10         1.6766e-10         1.3709e-08           14         WW_Levelselection_LS112.fps         2.2606e-06         3.3320e-09         1.3131e-07         6.2974e-08         2.9041e-10         8.8974e-10           15         WW_Levelselection_LS113.fps         3.677e-12         9.5082e-09         2.6496e-07         3.6067e-11         2.3056-09         6.7461e-09           16         WW_Levelselection_LS113.fps         3.6279e-06         8.3857e-10         1.7002e-08         1.2541e-07         1.1219e-08         8.0542e-09           17         WU_Levelselection_LS113.6fps         3.6279e-06         3.259e-06         8.2652e-08         1.6862e-06         2.3011e-07         2.2341e-08           Verview result:         FEMFAT-Damage values           Load Target         Loa	1.6682e-05 6.1766e-08 1.5245e-06	4.0101- 00	5.8524e-09	6.0514e-07	1.5320e-06	7.5667e-13	1.0513e-05	ction_LS1110.fps	VW_Levelsel	21
13       WW_Levelselection_LS1115.fps       2.1389e-07       1.5294e-09       1.1365e-06       5.2526e-10       1.6786e-10       1.3709e-08         14       WW_Levelselection_LS112.fps       2.6206e-06       3.320e-09       1.3131e-07       6.2674e-08       2.9041e-10       8.8974e-10         55       WV_Levelselection_LS112.fps       3.677e-12       9.5082e-09       2.6499e-07       3.607e-11       2.3355e-09       6.7461e-09         6       Wu_Levelselection_LS113.fps       3.677e-12       9.5082e-09       2.6499e-07       3.607e-11       2.335e-09       6.7461e-09         77       WW_Levelselection_LS113.fps       3.6279e-06       1.3459e-06       8.2652e-08       1.6862e-06       2.3011e-07       2.2341e-08         6       evelow result:       FEMFAT-Damage values       Load Target       Lo	6.1766e-08 1.5245e-06	4.8181e-08	2.2543e-09	5.3480e-10	1.3769e-06	1.5600e-09	2.0880e-05	ction_LS1111.fps	VW_Levelsel	2
VW_Levelselection_LS112.fps         2.6206e-06         3.3320e-09         1.3131e-07         6.2974e-08         2.9041e-10         8.8974e-10           55         WW_Levelselection_LS113.fps         3.7677e-12         9.5092e-09         2.6499e-07         3.607e-11         2.3305e-09         6.7451e-09           66         WW_Levelselection_LS113.fps         1.0188e-07         8.3857e-10         1.7002e-08         1.2541e-07         1.1219e-08         8.0542e-09           76         WW_Levelselection_LS113.6fps         3.6279e-06         1.3459e-06         8.2652e-08         1.3662e-06         2.3011e-07         2.2341e-08           review result:           review result:           Secure Value:           Load Target           Load Single Ries	1.5245e-06	1.3709e-08	1.6786e-10	5.2526e-10	1.1365e-06	1.5294e-09	2.1389e-07	ction_LS1115.fps	VW_Levelsel	3
15     W/Levelselection_LS113.fps     3.7677e-12     9.5082e-09     2.6499e-07     3.6067e-11     2.3305e-09     6.7461e-09       16     W/Levelselection_LS113.fps     1.0188e-07     8.3857e-10     1.7002e-08     1.251e-07     1.1219e-08     8.0522e-09       77     W/Levelselection_LS1136.fps     3.6279e-06     1.3459e-06     8.2652e-08     1.6862e-06     2.3011e-07     2.2341e-08       FEMFAT-Damage values       review result:       Issue to the total		8.8974e-10	2.9041e-10	6.2974e-08	1.3131e-07	3.3320e-09	2.6206e-06	ction_LS112.fps	VW_Levelsel	4
16         W/Levelselection_LS1130.fps         1.0188e-07         8.3857e-10         1.7002e-08         1.2541e-07         1.1219e-08         8.0542e-09           7         W/Levelselection_LS1130.fps         3.6279e-06         1.3459e-06         8.2652e-08         1.6662e-06         2.3011e-07         2.2341e-08           review result:           review result:           Essuit         Value           Load Target           Load Target           Load single files           Malysis	1.6729e-11	6.7461e-09	2.3305e-09	3.6067e-11	2.6499e-07	9.5082e-09	3.7677e-12	ction_LS113.fps	VW_Levelsel	!5
VW_Levelselection_LS1136.fps         3.6279e-06         1.3459e-06         8.2652e-08         1.6862e-06         2.3011e-07         2.2341e-08           verview result:         Value         Value         Image: Value	3.9534e-08	8.0542e-09	1.1219e-08	1.2541e-07	1.7002e-08	8.3857e-10	1.0188e-07	ction_LS1130.fps	VW_Levelsel	26
c FEMFAT-Damage values Load Target Load Target Load single files imiliarity value: 1.1 Vin 0.19 Calculate damage Calculate damage	2.2811e-06	2.2341e-08	2.3011e-07	1.6862e-06	8.2652e-08	1.3459e-06	3.6279e-06	ction_LS1136.fps	VW_Levelsel	27
Verview result:         FEMFAT-Damage values           Secult         Value           Calc. time in h:         0           Std. dev:         1.42           Imiliarity values:         1.1           Winn         0.19										¢
Value         Load Target           Jalc. time in h:         0           Itd. dev.:         142           imiliarity value:         1.1           Analysis         Calculate damage		es	FEMFAT-Damage values						iew result:	/ervi
Calc. time in h:     0       Load single files       Load single files       imiliarity value:     1.1       dim     0.19       Calculate damage		get	Load Tar					Value	lt	Resu
Itd. dev:         1.42           imilarity value:         1.1           Jim         0.19		fler	Load single					0	time in h:	Calc.
imilarity value: 1.1 Ain 0.19 Calculate damage								1.42	dev.:	td. d
din 0.19 Calculate damage			Analysis					1.1	larity value:	imil
		amage	Calculate d					0.19		Min
Max 5.3		-						5.3		Иaх
Vean 0.857 Select channels	Combine films					s	Select channel	0.857	n	Mear
Jsed files 4 Load selected channels Save selected channels Calculate Mixing Co	compline mes		Calculate	ed channels	Save select	selected channels	Load	4	files	Jsed
used channels 27	Parameter input						Output	27	channels	used

# **Mixing track**



## Result

- Reduction from 1313792
   samples to 2598 (506 / 1)
- 25 different level pairs
- Rel. damage between reference and result:
  - max: 1.000
  - min: 0.94



# **Mixing track**

**MAGNA** 

### • Result damage abs. / rel.



Date: September 22 / Author: ECS St. Valentin

# Conclusion

Date: September 22 / Author: ECS St. Valentin

© MPT Engineering / Disclosure or duplication without consent is prohibited

# Conclusion



### • FEMFAT compare calculation

- The combination of different levels returns an increase in the damage.
   Amplitudes(the from of one level pair to one to of another level pair is typically higher then the highest from to level in single level pairs)
- A higher reduction of input level pairs results in a higher damage in the selected nodes
- Typical time reduction factor between 500 and 1000 in stochastic time histories

# DRIVING EXCELLENCE. INSPIRING INNOVATION.

Date: September 22 / Author: ECS St. Valentin

© MPT Engineering / Disclosure or duplication without consent is prohibited