

BACHELORS DEGREE ASSIGNMENT SPECIFICATION

Student name:	BLACKMORE	Student P number:	
Programme:	BEng Automotive and Manufacturing streams		
Module:	Advanced Stress Analysis & FEA	Module Level (4, 5, 6):	6
Module code:	M6X00420	Contribution to Overall Module Assessment (%):	50 %
Lecturer:	Kelvin Lake	Internal Verifier:	Rob Goodson
Assignment Title:	Can FEA replace physical testing?	Assignment No (x of x):	1 OF 1
Hand Out Date:	25/02/2020	Submission deadline:	29/03/2020

Referencing:	In the main body of your submission you must give credit to authors on whose research your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have read or quoted in order to complete this assignment (e.g. for books: surname of author and initials, year of publication, <u>title of book</u> , edition, publisher: place of publication).			
Disclosure:	I declare that this assignment is all my own work and that I have acknowledged all materials used from the published or unpublished works of other people. All references have been duly cited.			
Student's Signature:	<i>Assignments will not be accepted without a signature here</i>	Date:		
Turnitin: Lecturer to tick to indicate if an electronic version of the assignment must be submitted to Turnitin. Note: the Turnitin version is the primary submission and acts as a receipt for the student. Penalties for late submission: Up to four weeks late, maximum mark of 40%. Over four weeks late, Refer. Only Year Tutors and the Programme Director may grant an extension.			YES	✓
			NO	

Learning Outcomes tested (from module syllabus)	Assessment Criteria To achieve each outcome a student must demonstrate the ability to:
Demonstrate an ability to analyse a range of engineering problems using advanced stress analysis principles.	

- DO NOT put this form into Turnitin or it will match many similarities with other students' submissions.

TASK DESCRIPTION

This assignment explores FEA and the role that it plays in product development. It is expected that the student will research this topic (referencing any sources used, using Harvard or Vancouver).

GUIDANCE FOR STUDENTS IN THE COMPLETION OF TASKS



The above image shows a component undergoing physical testing and the corresponding FE model. Your task for this assignment is to discuss the following;

1. Why companies typically carryout FE analysis alongside physical testing.
2. How a physical test may be correlated to an FE model.
3. If you think that FE analysis can (or should) ever replace physical testing.

In order to do this, you should consider a case study and use this to discuss the above tasks.

This report should be 3000 words long and should be submitted via moodle

STRUCTURAL SECTION MARKING CRITERIA AND STUDENT FEEDBACK

This section details the assessment criteria. The *extent* to which these are demonstrated by you determines your mark. The marks available for each criterion are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Common Assessment Criteria Applied	Marks available	Marks awarded
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions.		
(Assessed in point 1)	30	22.5
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.		
(Assessed in point 2)	30	23.1
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence		
(N/A)	0	
4. Practical Application and Deployment Deployment of methods, materials, tools and techniques; application of concepts; formulation of innovative and creative solutions to solve problems.		
(Assessed in point 3)	30	19.2
5. Skills for Professional Practice Attributes in professional practice: individual and collaborative working; deployment of appropriate media; presentation and organisation.		
(Assessed in report presentation and structure)	10	7

Assignment Mark Overall (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		71.8	%
	Up to one-week late			
	Over one week late			

COMMON ASSESSMENT AND MARKING CRITERIA

	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
Assessment Criteria	0-29%	30-39%*	40-49%	50-59%	60-69%	70-79%	80-100%
1. Research-informed Literature Extent of research and/or own reading, selection of credible sources, application of appropriate referencing conventions	Little or no evidence of reading. Views and findings unsupported and non-authoritative. Referencing conventions largely ignored.	Poor evidence of reading and/or of reliance on inappropriate sources, and/or indiscriminate use of sources. Referencing conventions used inconsistently.	References to a limited range of mostly relevant sources. Some omissions and minor errors. Referencing conventions evident though not always applied consistently.	Inclusion of a range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.	Inclusion of a wide range of research-informed literature, including sources retrieved independently. Selection of relevant and credible sources. Very good use of referencing conventions, consistently applied.	A comprehensive range of research informed literature embedded in the work. Excellent selection of relevant and credible sources. High-level referencing skills, consistently applied.	Outstanding knowledge of research-informed literature embedded in the work. Outstanding selection of relevant and credible sources. High-level referencing skills consistently and professionally applied.
2. Knowledge and Understanding of Subject Extent of knowledge and understanding of concepts and underlying principles associated with the discipline.	Major gaps in knowledge and understanding of material at this level. Substantial inaccuracies.	Gaps in knowledge, with only superficial understanding. Some significant inaccuracies.	Evidence of basic knowledge and understanding of the relevant concepts and underlying principles.	Knowledge is accurate with a good understanding of the field of study.	Knowledge is extensive. Exhibits understanding of the breadth and depth of established views.	Excellent knowledge and understanding of the main concepts and key theories. Clear awareness of challenges to established views and the limitations of the knowledge base.	Highly detailed knowledge and understanding of the main theories/concepts, and a critical awareness of the ambiguities and limitations of knowledge.
3. Analysis Analysis, evaluation and synthesis; logic, argument and judgement; analytical reflection; organisation of ideas and evidence	Unsubstantiated generalisations, made without use of any credible evidence. Lack of logic, leading to unsupportable/missing conclusions. Lack of any attempt to analyse, synthesise or evaluate.	Some evidence of analytical intellectual skills, but for the most part descriptive. Ideas/findings sometimes illogical and contradictory. Generalised statements made with scant evidence. Conclusions lack relevance.	Evidence of some logical, analytical thinking and some attempts to synthesise, albeit with some weaknesses. Some evidence to support findings/ views, but evidence not consistently interpreted. Some relevant conclusions and recommendations, where relevant	Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data and situations without guidance. An emerging awareness of different stances and ability to use evidence to support the argument. Valid conclusions and recommendations, where relevant	Sound, logical, analytical thinking; synthesis and evaluation. Ability to devise and sustain persuasive arguments, and to review the reliability, validity & significance of evidence. Ability to communicate ideas and evidence accurately and convincingly. Sound, convincing conclusions / recommendations.	Thoroughly logical work, supported by evaluated evidence. High quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Strong, persuasive, conclusions, justifiable recommendations.	Exceptional work; judiciously selected and evaluated evidence. Very high quality analysis, developed independently or through effective collaboration. Ability to investigate contradictory information and identify reasons for contradictions. Highly persuasive conclusions
4. Practical Application and Deployment Effective deployment of appropriate methods, materials, tools and techniques; extent of skill demonstrated in the application of concepts to a variety of processes and/or contexts; formulation of innovative and creative solutions to solve problems.	Limited or no use of methods, materials, tools and/or techniques. Little or no appreciation of the context of the application.	Rudimentary application of methods, materials, tools and/or techniques but without consideration and competence. Flawed appreciation of the context of the application.	An adequate awareness and mostly appropriate application of well established methods, materials, tools and/or techniques. Basic appreciation of the context of the application.	A good and appropriate application of standard methods, materials, tools and/or techniques. Good appreciation of the context of the application, with some use of examples, where relevant.	A very good application of a range of methods, materials, tools and/or techniques. Very good consideration of the context of the application, with perceptive use of examples, where relevant. Evidence of some innovation and creativity.	An advanced application of a range of methods, materials, tools and/or techniques. The context of the application is well considered, with extensive use of relevant examples. Application and deployment extend beyond established conventions. Innovation and creativity evident throughout.	Outstanding levels of application and deployment skills. Assimilation and development of cutting edge processes and techniques.
5. Skills for Professional Practice Demonstrates attributes expected in professional practice including: individual initiative and collaborative working; deployment of appropriate media to communicate (including written and oral); clarity and effectiveness in presentation and organisation.	Communication media is inappropriate or misapplied. Little or no evidence of autonomy in the completion of tasks. Work is poorly structured and/or largely incoherent.	Media is poorly designed and/or not suitable for the audience. Poor independent or collaborative initiative. Work lacks structure, organisation, and/or coherence	Can communicate in a suitable format but with some room for improvement. Can work as part of a team, but with limited involvement in group activities. Work lacks coherence in places and could be better structured.	Can communicate effectively in a suitable format, but may have minor errors. Can work effectively as part of a team, with clear contribution to group activities. Mostly coherent work and is in a suitable structure.	Can communicate well, confidently and consistently in a suitable format. Can work very well as part of a team, with very good contribution to group activities. Work is coherent and fluent and is well structured and organised.	Can communicate professionally and, confidently in a suitable format. Can work professionally within a team, showing leadership skills as appropriate, managing conflict and meeting obligations. Work is coherent, very fluent and is presented professionally.	Can communicate with an exceptionally high level of professionalism. Can work exceptionally well and professionally within a team, showing advanced leadership skills. Work is exceptionally coherent, very fluent and is presented professionally.

Student Self Evaluation Form

Student name:		Student P number:	
Programme:		Year of programme	
Assignment Title:			

This section repeats in brief the common assessment criteria detailed on previous pages. The *extent* to which these are demonstrated by you determines your mark. Using these criteria, tick the box that best indicates the level of achievement you feel you have achieved with regard to each of them.

Common Assessment Criteria Applied	Level of Achievement						
	REFER		3 rd	2:2	2:1	1 st	1 st
	OUTRIGHT FAIL	UNSATISFACTORY	SATISFACTORY	GOOD	VERY GOOD	EXCELLENT	EXCEPTIONAL
1. Research-informed Literature	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
2. Knowledge and Understanding of Subject	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
3. Analysis	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
4. Practical Application and Deployment	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐
5. Skills for Professional Practice	0-29% ☐	30-39% ☐	40-49% ☐	50-59% ☐	60-69% ☐	70-79% ☐	80-100% ☐

PLEASE COMMENT ON AREAS IN WHICH YOU FEEL THAT YOU HAVE PERFORMED WELL	PLEASE COMMENT ON AREAS YOU FEEL THAT YOU NEED TO DEVELOP

Student's Name		Date	
Student's Signature			

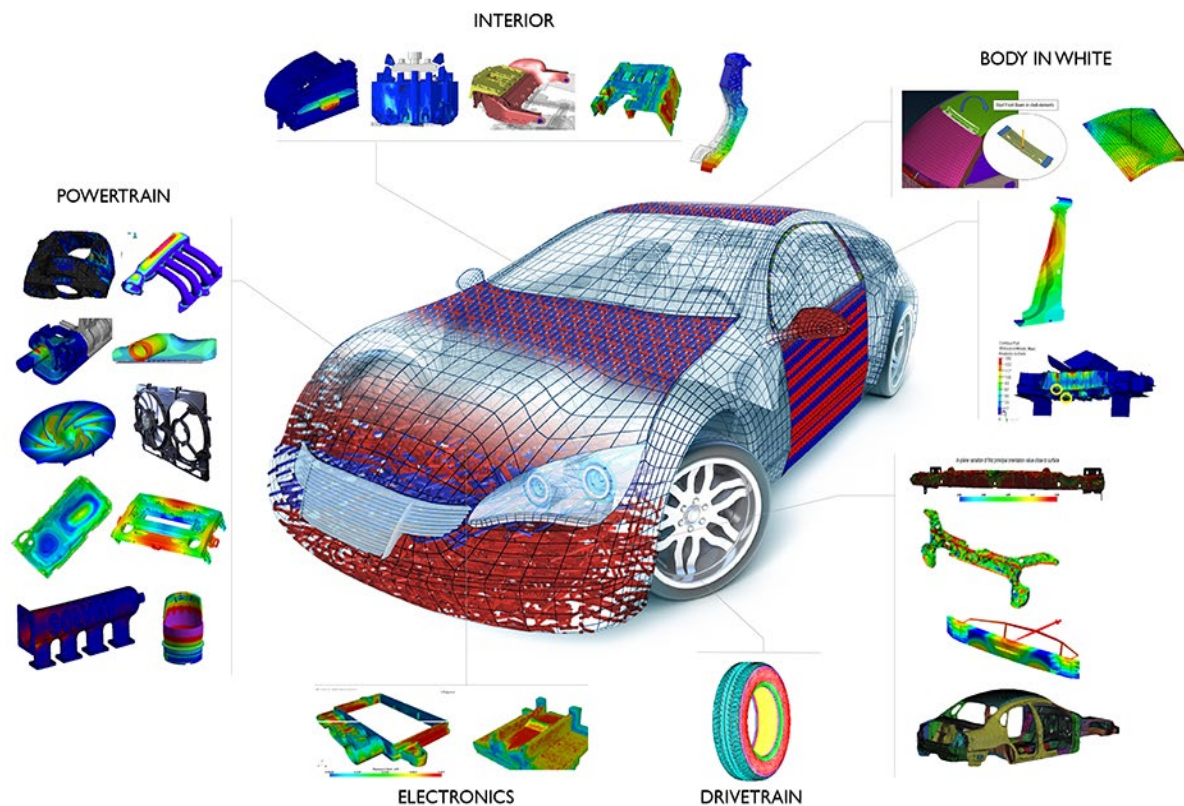
CAN FEA REPLACE PHYSICAL TESTING?



Joseph Julian Blackmore
Student Number: 1702858

Date: 25/03/20

Module Code: M6X00420



(Altem Technologies , n.d.) *Figure 1*

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4. Should finite element analysis ever replace physical crash testing?

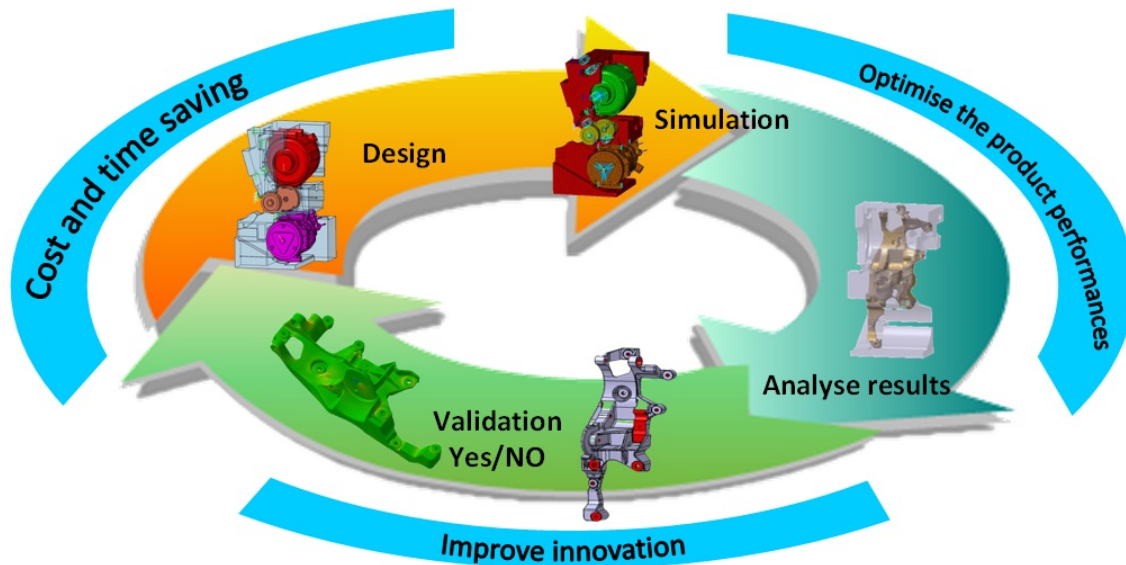
4.1 Conclusion

1. Introduction

Finite element analysis (FEA) is a method of predicting how a component or entire system reacts to real world forces such as heat, vibration, fluid flows, and mechanical loadings utilising computational resources. FEA is used in a wide variety of engineering disciplines in order to allow design engineers to more efficiently complete their component and overall system designs. As technology continues to advance at a rapid rate, the accuracy and usability of computational resources continues to develop. Today engineers have access to far more powerful and easy to use computational resources than they did even as little as a decade ago. As the power and understanding of computational methods such as FEA continues to grow, this raises questions about how far should FEA be taken in regards to the engineering design process, such as can FEA have the potential to completely replace physical testing altogether?. In this report the FEA method is evaluated in terms of understanding why companies use this method in the automotive industry, how computational tests using FEA can be correlated to physical tests, in addition to discussing if FEA can ever replace physical testing. In the automotive industry FEA can be applied to aid the design and development of vehicles in a variety of aspects. FEA can be used to inform design decisions so that individual components and the overall vehicle can meet the requirements needed in order to satisfy the vehicle specification. Extensive testing and product development is required when developing a new product in the automotive industry. This is necessary so that the manufacturer is confident that a vehicle will achieve the desired performance in regards to occupant safety, noise vibration and harshness damping, aerodynamic efficiency and being able to meet the set criteria for performance in extreme conditions and durability. FEA has been, and will continue to be, a fundamental part of the vehicle design process.

GOOD INTRO

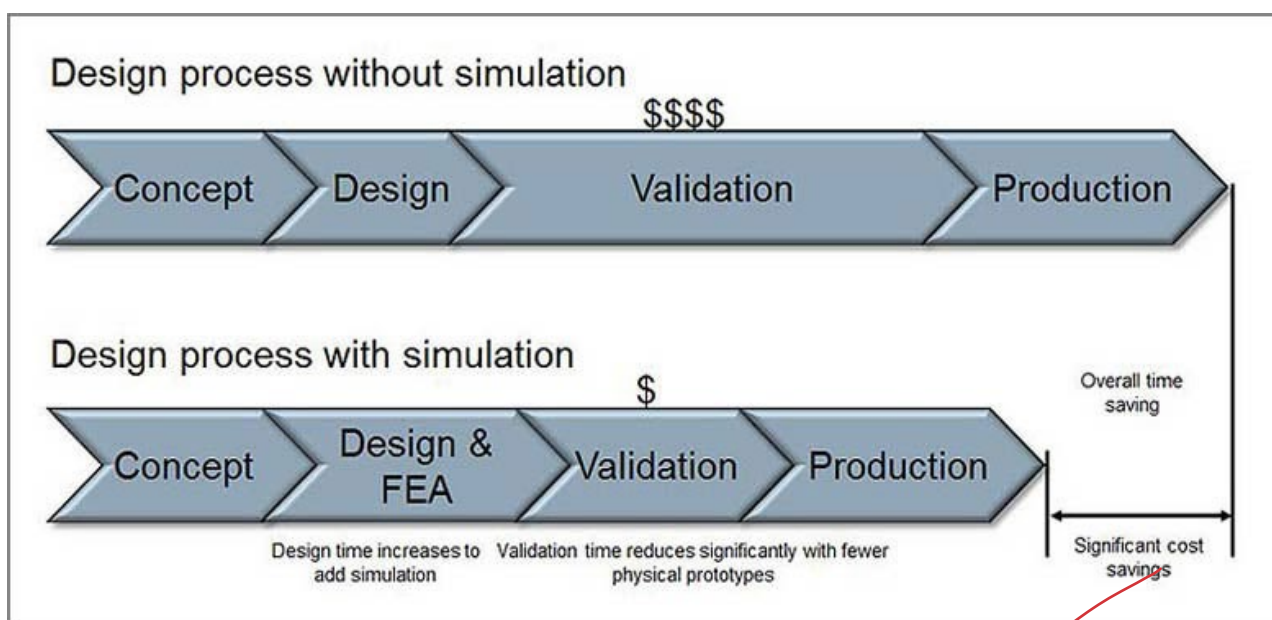
Figure 2 (S. Roth, 2011)



2. Why is finite element analysis used alongside physical testing?

The automotive industry is extremely competitive, manufacturers are under constant pressure from competitors and increasingly stringent regulatory requirements. This forces the continual development of new technology and improved designs to be implemented as quickly and effectively as possible in order for manufacturers to stay ahead of the curve. The development of new models has historically been a time consuming and expensive process, therefore any computational resources that can reduce the cost and timescale of the development process will give a great advantage within the automotive sector. Computer aided design began to make its way into the automotive industry in the late 1960s to early 1970s as two dimensional wire frame and mesh renderings began replacing drafting boards. Between 1970 and 1980 surface and solid modelling was introduced, whilst 3D cad wire frames were introduced in the early 1980s. (Keenan, 1995). Car manufacturers realised that utilising this ever evolving and improving technology to design their vehicles could give them an advantage over the competition as time to market is exceptionally important in this sector. This has led to computer aided design and the FEA method becoming an intrinsic part of the automotive engineering design process. Moving predictive simulation to as early in the design process as possible is a major objective within the automotive industry, as this can allow the manufacturer to reduce development time and costs by reducing the number of design cycles and eliminating as much physical testing as possible (Abbey, 2014). By utilising FEA, alternative designs and materials can be compared more quickly and without the need for physical testing comparisons.

Figure 3 (Belhe, 2014)



2.1 How utilising FEA reduces the overall time and financial cost of product design

SPENT

The FEA process increases the amount of time that is spent in the design phase of the product development when compared to only relying on physical testing to inform design decisions. However, by investing resources in the design phase greater financial and time savings can be made by greatly reducing the money and time spent in the validation phase of the design process. This validation phase is reduced when the FEA process is used in conjunction with physical testing as less physical testing is required in order to validate different design prototypes. By analysing design prototypes using the finite element method, prototype designs that are found to be unfeasible with limited doubt by the simulations can be discarded earlier in the validation stage. By using FEA, design engineers can discard designs that are unsuitable before needing to physically test them in order to prove whether they should be taken further along the design process or not. Reducing the amount of physical testing not only has the benefits of reducing the time and money spent validating designs, but also reduces material waste and energy consumption in the development of a product. This is of particular significance in the automotive industry as vehicles are complex systems made up of thousands of components with differing material properties and varying requirements for yield strength, durability, impact absorption etc. Due to the nature of vehicle design the FEA process and physical testing can be carried out on a component basis, on a sub-system basis or on the entire vehicle.

GOOD CONSIDERATION OF THE IMPACT OF FEA ON THE

2.2 Why FEA is used in conjunction with physical testing in order to improve vehicle safety

DESIGN PROCESS

FEA is of particular use when used in conjunction with physical testing by automakers in order to improve the safety of their vehicles. Physical testing of vehicle safety and structural integrity in the case of an impact in particular is an expensive and time consuming process. This is a necessary expenditure however as any engineering oversights regarding the structural performance of their vehicles can result in costly recalls and even lawsuits in the case of failures that affect the safety of the vehicle. By utilising the FEA method to optimise and validate vehicle design in order to improve occupant protection, this gives automakers the ability to improve their designs based on prior knowledge whilst reducing the amount of physical tests that are required in order to make continual design improvements. FEA is of particular use in its ability to offer design optimisation, many CAD software packages offer the ability to use FEA in order to produce optimised component designs that meet the durability and impact absorption properties required as efficiently as possible. Design optimisation software can allow design engineers to make more informed design decisions by offering data informed guidance so that the engineers can find the most suitable compromise in component geometry in terms of meeting the physical

ALSO, REGS OFTEN MEAN THAT PHYSICAL TESTING MUST BE DONE.

properties required, minimum component mass and manufacturability. By using FEA to optimise component designs as effectively as possible, automotive engineers have been able to achieve continually improving designs in regards to safety, whilst minimising the weight gain of their vehicles in order to maintain sufficient fuel consumption and performance. In order to validate the performance of a vehicle in regards to occupant safety a variety of impact scenarios are carried out by an independent body, such as by Euro NCAP in Europe and by the IIHS in North America. It is vitally important that new models brought to the market achieve commendable results in such tests as poor ratings can result in potential customers choosing a competitors offering instead. It is crucial that the design development of vehicles in regards to improving occupant safety is a collaborative process between the data collected from the physical tests carried out, and the computational simulations that are developed using FEA. This is required so that the physical properties of the components meet the expected mechanical resistance suggested by the initial numerical computer simulations. As with all simulations, the results achieved are always a prediction, the accuracy of which is entirely dependent on the quality of the information inputted into the computer by the user. (Cecchel, et al., 2019).

3. How physical testing can be correlated to a finite element analysis model in vehicle crash testing

A vehicle can be considered as a complex compound structure made up of thousands of mechanical and electrical components that undergo complex cyclic loadings along with dealing with weathering and extreme temperatures through regular usage. This presents a significant challenge in being able to predict the behaviour of a vehicle in a range of impact scenarios. A car manufacturer needs to thoroughly test their design in order to ensure that they have a deep understanding and confidence in their design before any vehicle can be sold to the general public. In the past structural performance was largely based on failure predictions based on material strength or the yield strength, this was used to predict how fluctuating loads could cause failure through fatigue or how applying loads that surpass the yield stress of the component would cause it to fail in the result of an impact. In practice, material failure is influenced by a wide variety of factors such as surface quality, surface treatments, harmonics, stress or strain range and cycle sequence effects. If a loading is fluctuating with time, as would be the case in the real-life application of a component such as in a front wishbone as a part of a suspension system for example, further uncertainties are brought into the equation that are not considered simply by using the material properties to estimate the potential for component failure. By using a properly developed FEA technique, this allows the design engineers to consider the variety of aspects that influence the durability and structural integrity of a component in a real-life usage scenario. (Abdullah, et al., 2008)

In order for vehicle impact simulations to accurately convey how a vehicle will perform in a crash, data that has been collected from physical tests needs to be used to inform the information inputted into the simulation programme. By using data collected from physical tests to correlate with an FEA model, the accuracy of the simulations can be continually improved. Poor correlation between FEA simulations and physical tests can lead engineers to make poor design choices, wasting time and money in the process. The method of correlating physical tests to the FEA simulation will vary depending on the type of testing that is being carried out. In order to collect useful data from vehicle crash tests, very detailed observation is carried out by engineers and a variety of sophisticated sensors are used to record data from the tests.

3.1 How sensors are used to record data from physical crash tests to inform crash simulations

As the entire purpose of completing vehicle crash tests is to improve the protection of the occupants inside the vehicle, the biomechanical stresses exerted on the passengers needs to be established. In order to protect vehicle occupants as effectively as possible, the transfer of energy resulting from an impact needs to be diverted as much as possible away from the occupants whilst maintaining the structural integrity of the vehicle. Maintaining a strong 'survival cell' is necessary so that the passenger compartment of the vehicle is not compromised, thus resulting in serious injury. By using sophisticated crash test dummies, strategically placed accelerometers and high speed cameras, the forces exerted on the passengers can be recorded, allowing for the ability to test the impact absorbing abilities of improved vehicle designs.

The acceleration severity index (ASI) was developed to classify the severity of inertia force on an occupant theoretically placed at the vehicles centre of gravity. According to the European standard EN 1317-2:2010, (NSAI Standards, 2010) three impact severity levels are classified as A, B and C classes for full frontal impacts, the respective recommended values of ASI for each class are:

- Class A: $ASI \leq 1$
- Class B: $1.0 \leq ASI \leq 1.4$
- Class C: $1.4 \leq ASI \leq 1.9$

The impact Severity Class A affords a greater level of comfort for vehicle occupants than Class B and C. The larger the value calculate for the ASI, the more the impact consequences for the passengers are dangerous. The impact severity rating estimated by the discrete finite element analysis simulation can be compared to those recorded in the physical vehicle crash test in order to validate the accuracy of the simulation.

3.2 Case study comparing a physical test and FEA simulation

In the following case study the results obtained by a variety of crash simulation techniques and the results obtained by a full scale crash test (FSCT) carried out by the National Highway Traffic Safety & Administration (NHTSA) was compared. The NHTSA is a North American based entity that tests and issues safety ratings on passenger vehicles. The fundamentals of the physical test were as follows;

Vehicle: 2004 Ford Taurus

Test weight: 1739kg

Velocity at impact: 55.9 km/h

Crash type: Full frontal impact into a non-deformable barrier

The data obtained from the physical crash test was used to calibrate the simulation software using a genetic algorithm, a mathematical method used to solve solutions based on natural selection. The genetic algorithm is applied to solve a variety of optimization problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, nondifferentiable, stochastic, or highly nonlinear (Abrahamson, 2004). Such a method can be used to compare the kinematic results from the full-scale physical crash test and the FEA simulation.

A visual comparison between the vehicle deformity that occurred in the physical test and the vehicle deformity calculated by the FEA simulation, in a full frontal 56km/h impact with a non-deformable barrier, can be compared below;

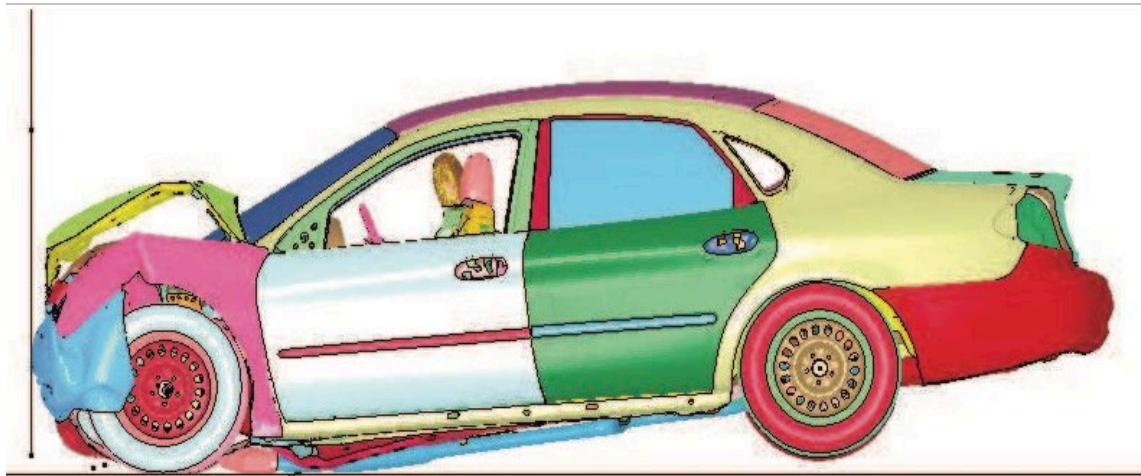


Figure 4

(B. Munyazikwiye, et al., 2018)



Figure 5 (NHTSA , 2004)

In the case study in question the parameters recorded by the physical test carried out by the NHTSA and a finite element analysis simulation that was carried out by the NHTSA (using LS-DYNA software) can be compared. The same parameters were also recorded for a lumped parameter model (LPM) . The LPM was calibrated to both the data gained from the physical test and the FEA simulation in order to evaluate its ability to accurately predict basic crashworthiness parameters. The LPM can be calculated in around 15-30 minutes compared to around 14 hours for the full FEA model in this particular case study (B. Munyazikwiye, et al., 2018). The results gained were as follows;

Table 1

<u>Approaches</u>	<u>Parameters</u>	<u>Results of 56km/h impact</u>
FSCT	<i>Tm (s)</i> <i>Cm (m)</i> <i>ASI (-)</i>	0.0723 0.7551 2.5
FEA	<i>Tm (s)</i> <i>Cm (m)</i> <i>ASI (-)</i>	0.0801 0.7180 2.0
LPM calibrated to FSCT	<i>Tm (s)</i> <i>Cm (m)</i> <i>ASI (-)</i>	0.0738 0.7508 2.6
LPM calibrated to FEA	<i>Tm (s)</i> <i>Cm (m)</i> <i>ASI (-)</i>	0.0793 0.7108 2.0

Key:

- **Tm** (time at maximum dynamic crush in seconds)
- **Cm** (maximum dynamic crush in metres)
- **ASI** (accident severity index)

In this particular study the results suggest that the initial FEA model carried out by the NHTSA did not estimate the same degree of accident severity as the physical test calculated. By completing the physical test then producing a LPM with the data gained, a more accurate simulation was produced. This data can be correlated with the known material properties of this particular vehicle in order to improve the accuracy of the initial FEA models in the future.

INTERESTING CASE
STUDY

4. Should finite element analysis ever replace physical crash testing?

The continued advancement of computationally aided design has been a critical tool in allowing automotive design engineers to improve the safety of passenger vehicles. As the availability and capability of computers and FEA software increased rapidly through the beginning of the 21st century to the current day, the ability of mass production passenger vehicles to protect their occupants has improved significantly. The following test carried out by the ANCAP (Australasian New Car Assessment Program), highlights the advancement automotive design engineers have achieved in vehicle safety in the past twenty years or so. The following test involved crashing a 1998 Toyota Corolla against a 2015 Toyota Corolla in a head-on, partial overlap collision. Both vehicles were accelerated to 40mph before the moment of impact.

Figures 6 & 7 (Berry, 2017)



By comparing the images below the extent of the damage to the drivers occupant area in the older vehicle compared to the newer vehicle can clearly be observed;

Figure 8: The 2015 Toyota Corolla after impact (Berry, 2017).



Figure 9: The 1998 Toyota Corolla after impact (Berry, 2017).



Upon completion of the test, ANCAP awarded the 2015 Toyota Corolla a score of 12.93 out of a possible 16, meaning that there was a high likelihood of all occupants surviving with minor injuries. The 1998 Toyota Corolla merited a score of 0.40 out of 16, meaning it would be highly unlikely for any passengers to survive the impact. The potentially life -saving advancements in vehicle occupant protection achieved in recent history has been achieved by engineers using physical testing and FEA simulations collaboratively to inform their design decisions.

4.1 Conclusion

As computing power and the wealth of experimental data available to engineers in the automotive industry continues to increase, the ability of Finite Element Analysis models to produce ever more detailed crash simulations continues to develop. Conducting a FEA model to simulate a car crash is a time consuming process, however as computing power increases the ability to complete a comparable simulation in detail to the past in a considerably reduced time-frame is possible. This presents an opportunity to automakers in being able to reduce development costs, or to invest the same amount of time in developing improved vehicle safety, but with far superior computational resources than was available in the past. It is difficult to predict how far technology and computational power will advance in the future, however the question of whether FEA could ever replace physical testing is one that needs to be taken seriously. However, a vehicle crash is a complex and dynamic event that is considerably difficult to evaluate computationally without any uncertainty. Death due to road traffic incidents is one of the leading killers in the developed world, and as such governing bodies take the safety of any mass produced passenger vehicle very seriously. Due to the nature of vehicle crash testing, it is highly unlikely that the testing of vehicle safety can ever be fully simulated computationally. However, the role of FEA in aiding engineers to improve vehicle safety should not be overlooked as such developments in technology has doubtlessly saved many lives.

VERY INTERESTING REPORT
DETAILING THE IMPACT OF
FEA ON THE DESIGN PROCESS
& A PRACTICAL APPLICATION OF
FEA. WELL DONE. HOWEVER, YOU
HAVE NOT REALLY ADDRESSED THE
QUESTION, DO YOU THINK THAT FEA
COULD/SHOULD REPLACE PHYSICAL TESTING.

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