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"Six Sigma DMADV Approach for Conceptual Design Synthesis of Car Dashboard"

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Abstract - *The main goals of Six Sigma need to incorporate these specific expected outcomes for the program, and typically fall within the key areas like Quality, Variability, Productivity. Without attacking quality issues in any process, all other improvement efforts will certainly come up short. For doing that Six Sigma implementation can differ widely between organizations, depending on their individual goals and operational strategies.*

In this project I have successfully applied many design processes related with six sigma like Identify Customer CTQs/ Customer Survey, develop a Fishbone Diagram, Input Requirement Checklist, Quality Function Deployment, Design Concepts (Competitive assessments (Benchmarking), Tradeoff Analysis, Engineering Analysis - Develop System & Subsystem Models, Error Proofing and Fixing, Validation, etc.

The aim is to achieve the essential function at the lowest overall cost while maintaining customers' optimum value assurance. In this project I try to develop a such dashboard design which follow a plastic design guideline, and analyze and discuss the results to Obtain valid conclusions which follows a design Standards. Plastic part dashboard is designed by following Plastic trim design guidelines as well as DFM (Design for manufacturing) and DFA (Design for Assembly) guidelines. This project intends to explore the adoption of Six sigma as a value creation tool. This project presents the basics of Six sigma and its different phases that can be implemented to a dashboard for its optimization.

Key Words: Conceptual design, Car Dashboard design, six sigma, concept validation, DMADV, Instrumental Pannel.

1. INTRODUCTION

Six Sigma is a statistical approach to improving business processes by reducing defects and their causes in the manufacturing process. The focus of Six Sigma is on reducing variation that occurs in the manufacturing process to improve product quality and increase company profit.

Automotive dashboard is one of the most important parts in vehicle interior parts. Automotive manufacturer need to consider the quality, cost, reliable design and safety of the product when study the conceptual design of automotive parts. Ergonomics design criteria is considered during design process. In the context of the dashboard, ergonomic design will ensure the display in the instrument cluster can be easily seen and the vehicle control system can be easily reached by the driver.

There are dozens of useful qualitative and quantitative Six Sigma techniques that are part of the Six Sigma toolbox. While many of the techniques are utilized for a specific purpose, this project will review the key techniques that are most commonly used during a Six Sigma project. The standardized process used was the lean six-sigma methodology called DMADV (Define, Measure, Analyze, Design, and Verify). The idea of dashboard design can be illustrated in a few conceptual designs. To choose final design, the best design selected using the concept score used six sigma tools. The CAD modeling of final design was performed by using CATIA P3 V5- 6R2017 software.

2. DEFINE

2.1 Voice of the Customer

CTQ's: "Voice of the Customer"

Who Is the Customer?

•Customer - Whoever receives the output of your process.

–Internal Customer Vs. External Customer

•Output - The material or data that results from the operation of a process.

•Process - The activities you must perform to satisfy your customer's requirements.

•Input - The material or data that a process does something to or with.

•Supplier - Whoever provides the input to your process.

Table -1: Voice of the Customer

VOC Checklist	Engineering Comments
Refined plastic material	choice of Material
Attractive design	Plastic Trim
Durability	Rigid and strong material
Wear and tear resistance	Durability
Comfortable and convenient System	Good ergonomics
Reliable design/ flexible	Good ergonomics

design	
Dashboard Design must be follow best quality requirement And easy to manufacture	While Dashboard design, it must follow Plastic design guidelines & trim guidelines.
The dash board spares should be easy to replace	Plastic features & BIW Current design
dashboard Design & Verification must follow standard guidelines as per FMVSS 201 & ECE-R-21	Safer Design
DFM Suitability of Concept	Reliable design/ flexible design
Low Complexity of Concept	Reliable design/ flexible design
Long Service Life	Reliable design/ flexible design

2.2 Process Map

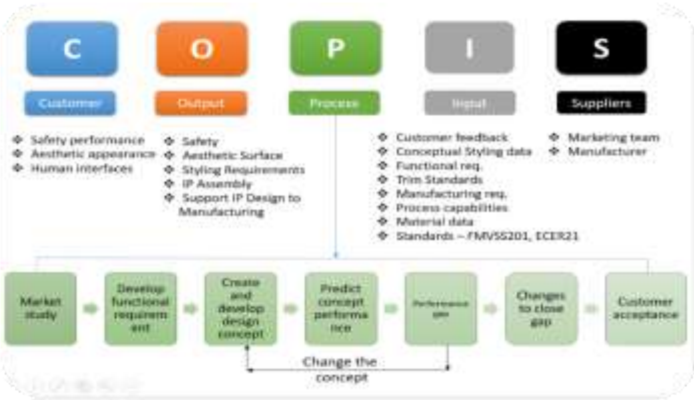

Fig -1: Process map

2.3 Fishbone Diagram

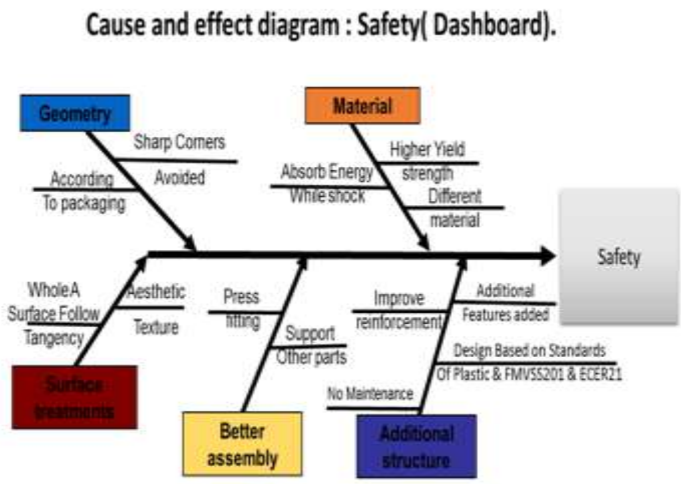

Fig -2: Cause and effect diagram : Customer satisfaction (Dashboard)

Fig -3: Cause and effect diagram: Safety (Dashboard).

3. MEASURE

3.1 Input Requirement Checklist

Table -2 Input Requirement Checklist

Domain Specific	Type of Input Requirement
Common	Customer Approval method in case of Design Change/ Requirement Change/ Concept Approval / Final Approval
Common	Look alike designs / models/ surface / reference mesh for bench marking
Product Design	Product Specifications
Product Design	DFA / DFMEA requirement (Tools, Formats. RPN scores etc)
Product Design	Benchmarking data (eg. RPN threshold) and other Critical Characteristics defined
Tool Design	Routing Sheets
Class-A	Technical specification for class-surface activity obtained
Class-A	Tolerence_Position Continuity
Class-A	Tolerence_Tangent Continuity
Class-A	Tolerence_Curvature Continuity
Class-A	Slab surface – Order
Class-A	Transition surface – Order
Class-A	Applicable regulation details
Class-A	External projection regulation details
CAE	Components available As Per The Spec Format
CAE	Segregation Of The Surfaces
CAE	Thickness Assigned As Per Spec Form/Curve Data
CAE	Surfaces Are Mid-Planed
CAE	Gumdrop / Adhesive Representation/Hemming

	and related property data available
CAE	Average Element Size
CAE	Maximum Element Size
CAE	Minimum Element Size
CAE	Weld Type And Data Provided
CAE	Part ID is available
CAE	Symmetrical Parts Information Available
CAE	Any parts defined at origin and needs proper space relationship for relocation
Modeling	Min/ Max Draft
Modeling	Unspecified Fillets
Modeling	Unspecified Wall thickness
Modeling	Manufacturing Process
Modeling	Physical Sample for Reference

3.2 Quality Function Deployment (QFD)

3.2.1 QFD of Product Design

Table -3 QFD of Product Design

QFD Title:	**QFD D Design**	
Y's		**X's**
Customer Expectation	**Importance**	**Product Requirement**
Product reliability	8	Mechanical systems were not over designed by safety factors to avoid failures.
Volume and packaging	7	Dimensions and curvature
Design for strength and stiffness	8	Durability
Design According to DFM	10	Clear in Draft With MTD
Design According to Aesthetic	10	Follow A Surface Tangency
Design According to DFA	8	Simple Assembly Method
Design for Safety	9	Design Based on Standards of Plastic & FMVSS201 & ECER21
Less weight of Product	7	Reduce Thickness Of Part

Table -4 QFD of Product Design Score

Customer Expectation	Importance	Dimensions and curvature	Durability	Clear in Draft With MTD	Follow A Surface Tangency	Simple Assembly Method	Plastic & FMVSS201 & ECER21	Reduce Thickness Of Part	Total
Product reliability	8	H	M	M	H	L	H	L	352
Volume and packaging	7	H	M	H	M	H	M	H	336
Design for strength and stiffness	8	L	H	L	L	M	H	H	288
Design According to DFM	10	H	M	H	H	H	H	H	660
Design According to Aesthetic	10	M	L	H	H	M	L	L	300
Design According to DFA	8	H	L	M	M	H	H	H	416
Design for Safety	9	H	M	M	H	M	H	H	432
Less weight of Product	7	H	M	L	L	L	M	H	196
Total		479	213	333	393	321	439	459	

By using QFD of Product Design in that Customer Expectation vs Product Requirement importance relationship is developed. And by taking the reference of this QFD of Product Design Score is generated. By using this QFD of Product Design Score chart pareto graph for design is generated as follows.

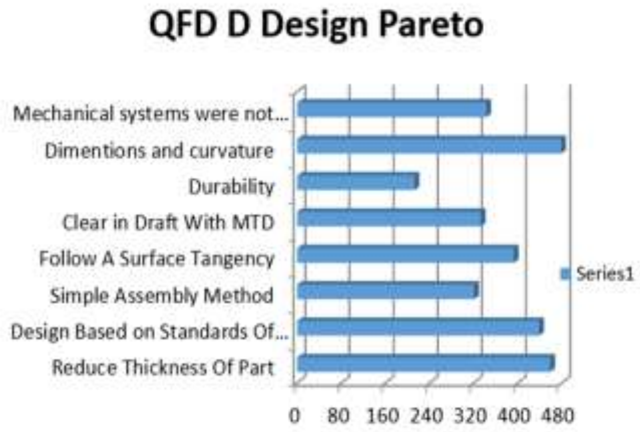

Chart -1 QFD of Product Design Pareto

*Due to research paper length restrictions I have skip the QFD importance list and score card for next QFD functions and directly present pareto chart.

3.2.2 QFD of Product Characteristics pareto

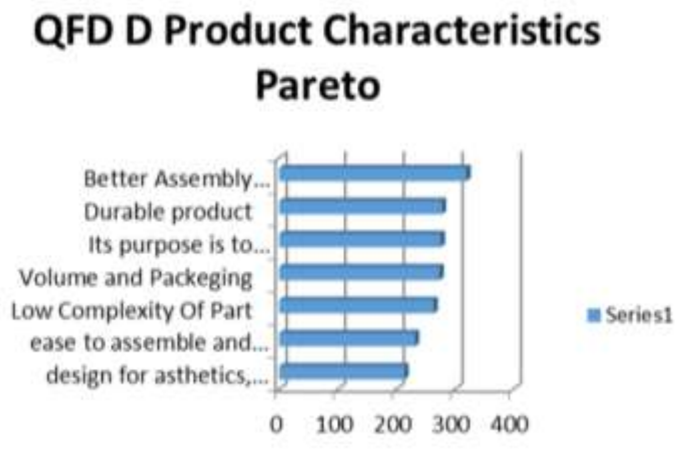

Chart -2 QFD of Product Characteristics pareto

3.2.3 QFD D Manufacturing Pareto

Chart -3 QFD D Manufacturing Pareto

4 ANALYSE

Design Concepts (Competitive assessments)

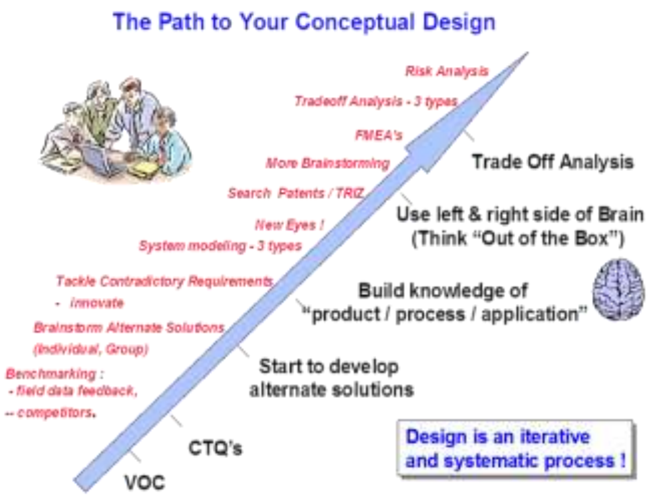

Fig -4: Conceptual design pathway

From above Competitive assessments 5 different concept are generated and best concept is selected by using trade off analysis. The visualization process is a process in which concept design sketches convert to CAD model. The visualization process contains three stages. The first stage is mainly developing a visual structure, creating wireframes and delivering a wide range of sketches, while in the next style development stage, the general look is created based on the first stage and the function hierarchy structure. In the last visualization stage, the whole design is refined by looking into details in CAD model.

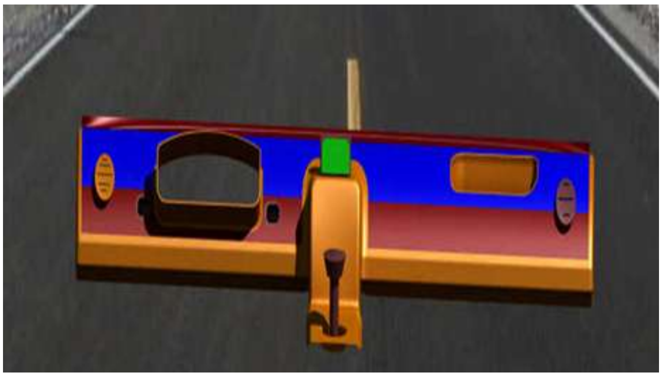

Fig -5: Concept Visualization Model

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5. DESIGN

In a Design Mechanical Cad Modelling involved for that CATIA V5 software is used.

•Proper design can help decrease the incidence and severity of errors

–by eliminating the causes of some,

–by making errors discoverable, once they have been made.

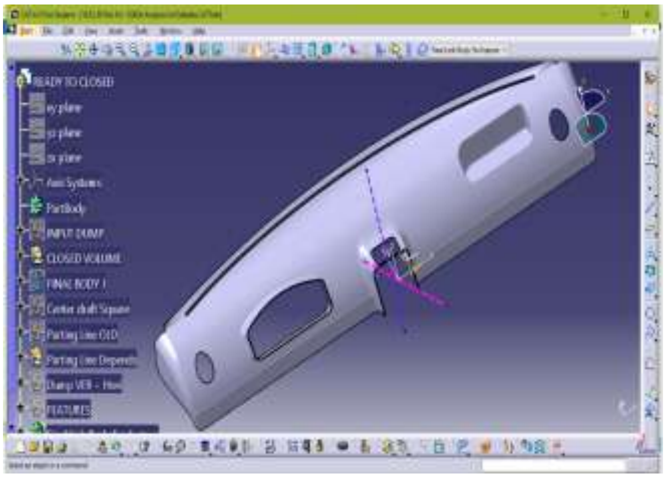

Fig -6: CAD Model (Follows Tangency)

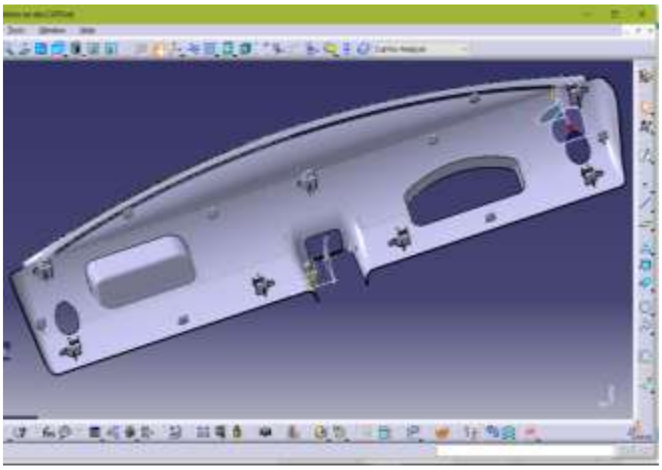

Fig -5: CAD Model (without Ribs)

6 VERIFY

6.1 Verify design model according to VOC Checklist and plastic trim standard

In Following model designing From Visualization Model to Fully modified Cad model All the Criterial discussed in trade off analysis are completely followed. Like Whole Part is Clear in a Draft analysis in 0.48 degree (plastic part Standard guidelines) with feature in main tolling direction and on whole part Follows a tangency throughout. The thickness of a dashboard I have taken is 2.5mm with no variable thickness.

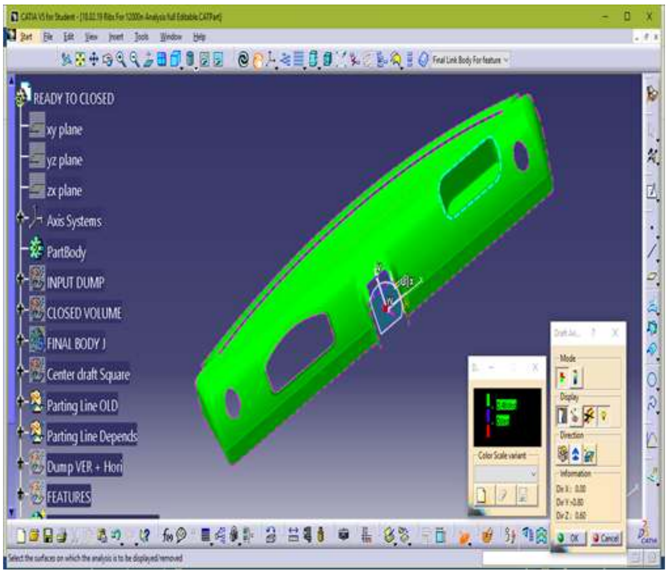

Fig -6: CAD Model (Clear in Draft analysis)

6.2 verify design for structural safety

A structural analysis is done for analysing the designed model is structural safe.

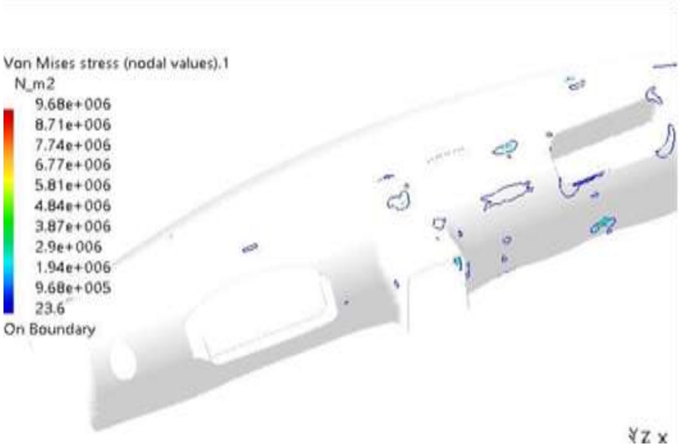

Fig -7: Von Mises stress (nodal values)

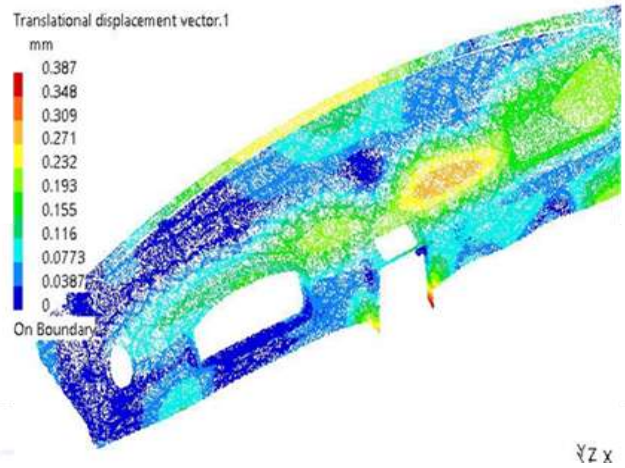

Fig -7: Translational displacement vector

Material PC Copolymer (High heat) is a most appropriate material for the dashboard. It obtain that von mises stress generated in the part by using this material is 9.59E^6 which is less than its yield stress 7.60E^7 (Taken Nodal values), and specified node translational displacement is only 0.16mm. After doing analysis successfully it is shows that design is safe.

6.3 Verify designed model for head impact analysis

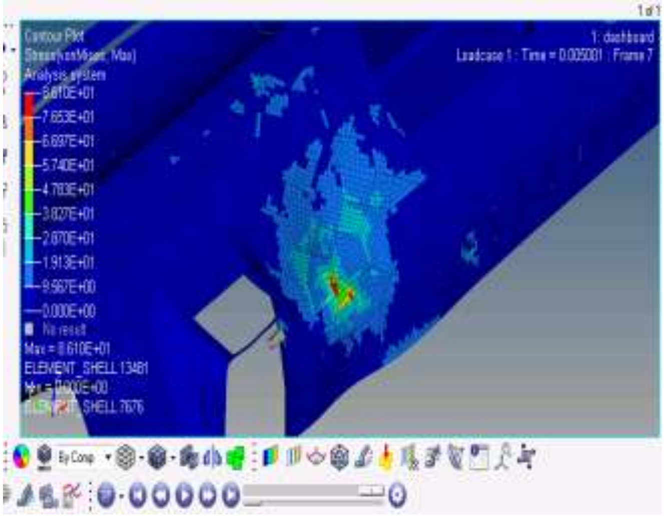

Fig -8: Stress (Von-Mises) Nodal.

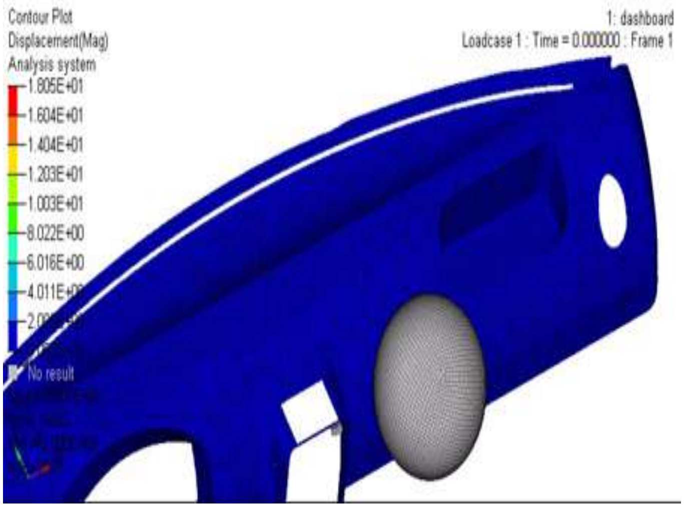

Fig -9: Displacement

Von mises stress is maximum generated in dashboard is only 86 pa. hourglass energy is 35Joule. About the energy total energy is maximum and constant throughout the whole analysis, as in the graph shows kinetic energy is decreasing and the same KE is converted into the internal energy and internal energy of system is increasing.

HIC is obtain from simulation is 647.19 and from calculation is 615.801. the Percentage error between this two is 5.097%. The g is obtained is 13.58g. The values of HIC is less than 1000 and g is less than 80g. So According Standard FMVSS 201 & ECE-R21 Design And analysis of dashboard is safe.

7 CONCLUSIONS

In this Project as discussed above paper I am develop a CAD Model by conceptual design then convert it into wireframes and surfaces using tool CATIA V5. I am done further modification in the model by following a plastic design trim guideline and successfully modified to clear in draft and follow tangency. Many other further modifications also done over it according to Plastic trim industry standard.

The whole project follows a six sigma DMADV methodology to increase the value of project in terms of cost reduction of process and weight reduction of dashboard. material PC Copolymer (High heat) is a most appropriate material for the dashboard. It obtains that von mises stress generated in the part by using this material is 9.59E^6 which is less than its yield stress 7.60E^7 (Taken Nodal values), and specified node translational displacement is only 0.16mm. While work towards Weight reduction thickness I found in a research paper is 4 mm its I am successfully reduced throughout a part 2.5mm, to maintain stiffness ribs are added on a part.

For structural safety I am done a structural analysis and it found that yield strength of a is greater than the obtain von mises stress in the part, so the structurally mechanical design is safe. Also, the force is calculated from the references of standard Head impact standard FMVSS201 & ECE-R21 so current design is follows the head impact safety according to standards.

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