Title:
Comparison of two Different Approaches of a class-A Surface Creation

Authors:
Jana Gulanová, jana.gulanova@stuba.sk, Slovak University of Technology in Bratislava
Samo Lonek, samo.lonek@gmail.com, Slovak University of Technology in Bratislava
Ladislav Gulan, ladislav.gulan@stuba.sk, Slovak University of Technology in Bratislava

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Introduction:
This paper briefly describes the procedure of a class-A surface modelling. There are presented various quality conditions, which needs to be undertaken during development. Later there are compared two approaches of car body components development. Introduction to this topic is presented in [3], where are broadly described tools of Generative Engineering Design methodology within the surface-based components development. New method is presented in this paper, but mostly within the development of a class-A surface. STRAK is a common name to group of specialists in the automotive company focused on this specific phase of the development.

Class A surface development procedure:
Procedure of a car body development within the automotive industry is divided into several phases. The basic workflow between conceptual design and preliminary design is shown in Fig. 1. Each phase is important from different point of view:

CAS – styling provides competitiveness and overall aesthetics;

STRAK – class-A surface development provides important qualities of car body visible surface;

CAD – for the component development, there are fulfilled several functional qualities.

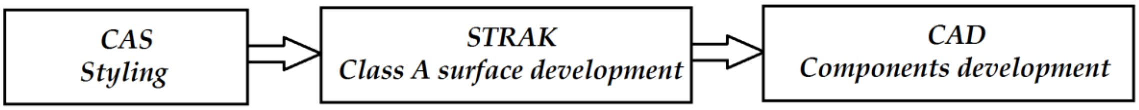

Fig. 1: Flow of designing process.

STRAK is a German term for a class-A surface. It has its origin in the ship building industry, where was used STRAK as a curve template [1,5]. In this paper, the term is mostly used to name development of a class A surface as a method or a special department in automotive company modelling CAD quality surfaces using designated system (such as Alias or ICEM Surf). In following sections, there are broadly described some aspects of STRAK modelling and then compared with new method proposed as a part of Generative Engineering Design methodology.

Patches geometrical continuity:
Quality of a class-A surface is usually driven by several specific tools. Crucial one is a tool for changing order of a patch and level of continuity between patches so that the quality is different. Modifiability of control points row is affected as follows:

- Point continuity. Patches are connected with G^0 continuity, so there is an edge between. In case of modification, there is influenced/determined only edging row of control points. Higher order patches provide infinite solutions of overall shape. (Fig. 2 b))
- Tangent continuity. Patches are connected with C^1 continuity, connection is smooth. In case of modification, there are influenced/determined two rows of control points. (Fig. 2 c))

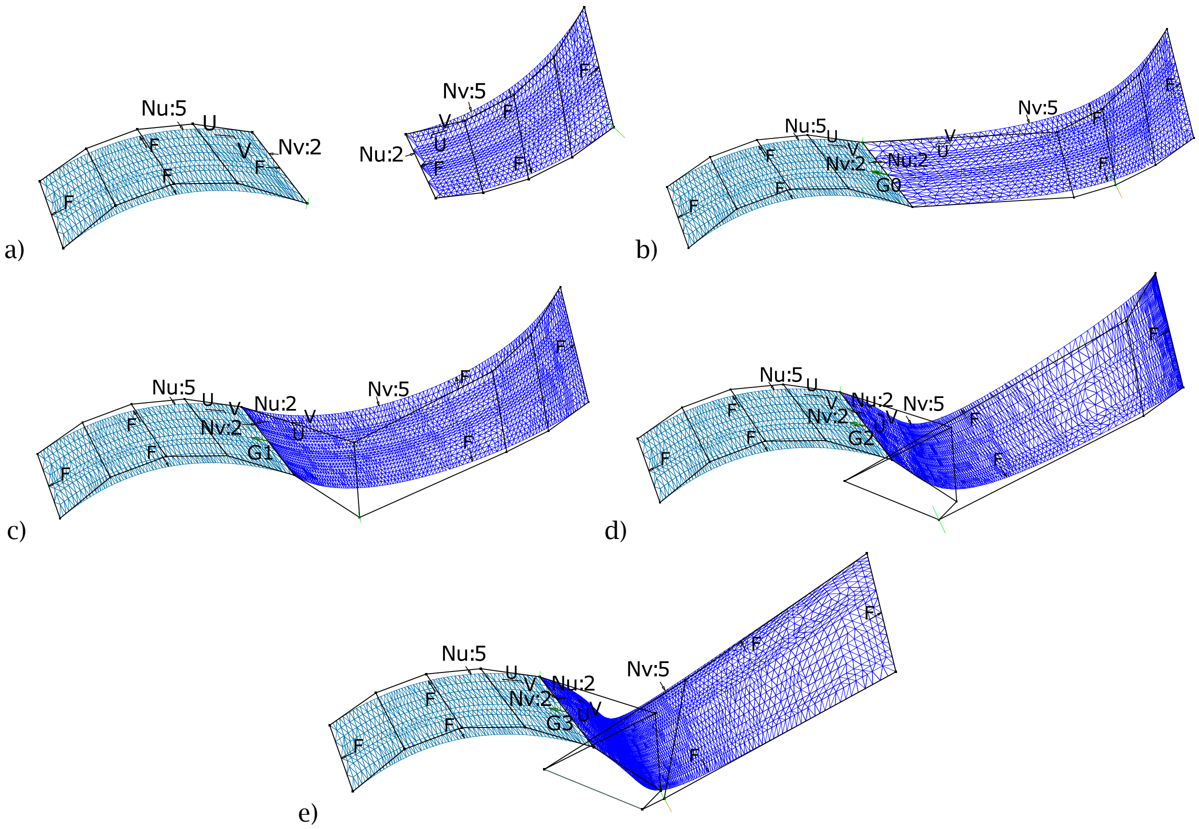

Fig. 2: Two patches of same order connected using various level of continuity: a) no connection; b) point continuity; c) tangent continuity; d) curvature continuity; e) torsion continuity.

- Curvature continuity. Patches are connected with C^2 continuity, connection is smooth. In case of modification, there are influenced/determined three rows of control points. (Fig. 2 d))
- Torsion continuity. Patches are connected with C^3 continuity, connection is smooth. In case of modification, there are influenced/determined four rows of control points. (Fig. 2 e))

Row of control points is an edge of control polygon connecting two or more control points along one parameter of a surface, either u or v. This modelling mathematics is behind any class-A procedure. Whenever the CAD of a class A surface is created by using specialized system (Alias, ICEM Surf), or using general CAD system (CATIA), there needs to be patches having particular order to achieve appropriate quality. [4]

STRAK procedure, or a class-A surface modelling, is divided into several steps regarding level of continuity. It is described in [3]. Based on such a procedure, there was created a class-A surface of sports vehicle as a further step to previous work. Stages are shown in Fig. 3. First step is shown in Fig.3 a). It is a styling from designer or CAS. Then there is shown in Fig. 3 b) a clay model taken from real model made by using Rapid Prototyping technologies. And finally, there is shown a complete class-A surface of whole car body in Fig. 3 c). The complete CAD of a class-A surface was made in specialized module of CATIA called ICEM Shape Design.

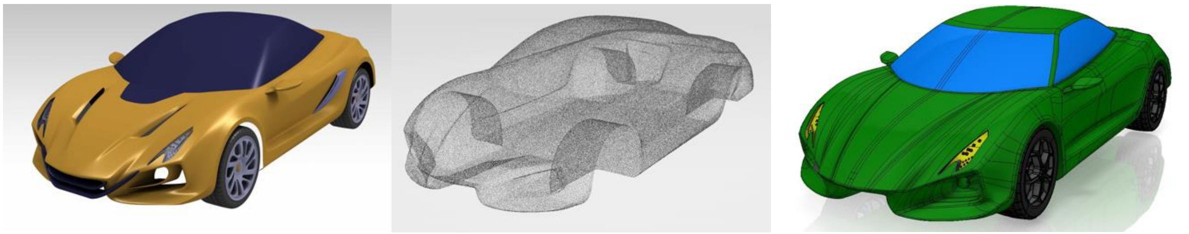

Fig. 3: a): CAS; b): Clay model; c): a class A surface.

Various modelling approaches:
STRAK is known in the automotive industry as a middle stage between styling creation and components development. Its goal is to recreate class-A surfaces using concrete mathematical description such as Beziér or B-spline. Class A surface is an overall surface of vehicle body. It is built as a clay model, which needs to be transformed to a CAD quality class A. For such a purpose, there are patches used. Their connection is based on particular level of continuity. After that patches are blended and filleted. The complete class-A surface consisting of dozens of patches is then frozen and transformed to CAD. It means an output of STRAK system such as ICEM Surf or Alias is input to CAD system such as CATIA or NX. Described approach is shown in Fig. 4 a).

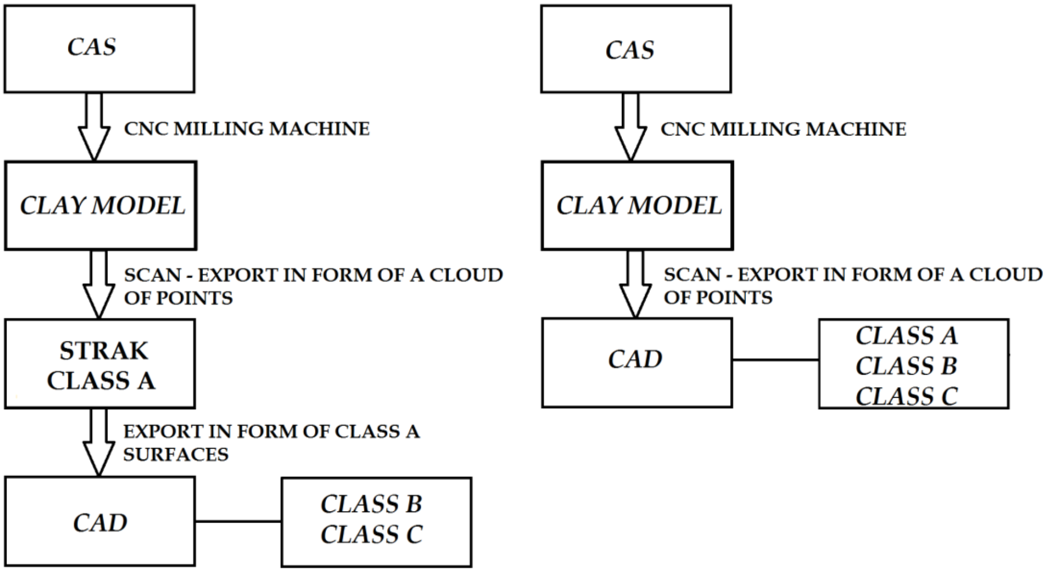

Fig. 4: a) Development approach involving STRAK step; b) Development approach missing STRAK → Generative Engineering Design methodology.

In contrast to described STRAK procedure, there is another approach missing particular STRAK phase. It is shown in Fig. 4 b) System CATIA is enabling a separate module using ICEM Surf tools. The clay model in a form of a Cloud of Points is directly inserted to CAD. The main advantage is lying in the possibility to generate modified components in case of a class-A surface change. The reason is lying in the input of development phase. There are separate patches using active connections in a form of a blend or a fillet, which are active all the time during the detailed design. In case of modification made within class A surface patches, all affected components are remodelled automatically with minimal human intervention [2,3]. Such an advantage is not possible in case of using specific STRAK procedure, since all the surfaces are frozen in one group and inserted to CAD system.

Learning aspects of two modelling approaches:

Learning aspects described in this section are based on experiences from pedagogical process at the Institute of Transport Technology and Engineering Design, Faculty of Mechanical Engineering, Slovak University of Technology. Students start with basic knowledge on CAD, later they learn how to use specific procedure of shape modelling. It is learned on components engineering design, what is suitable for functional features creation and other engineering steps regarding design. It is represented by Generative Shape Design module in CATIA. Such a procedure is not suitable for a class-A surface creation, since it does not utilize freeform surfaces. On the other hand, learning engineering design using CAD provides sufficient basics of surface modelling in general context.

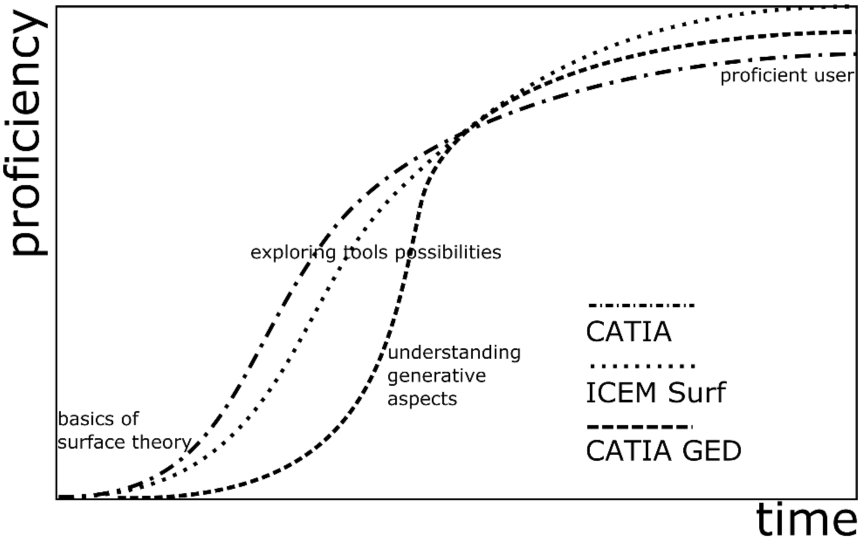

Fig. 5: Learning curve comparing three different procedures.

Comparison of two modelling approaches may be done among various aspects. One of them is learning process. Approximate learning curve is shown in Fig. 5. It is approximate because there were no specific observations focused on proficiency of students. It is only based on experiences from studies of CAD systems at the Slovak University of Technology.

Learning aspects are considered among three different design procedures:

1. CATIA – used without any advanced knowledge as a similar tool as ICEM Surf;
2. ICEM Surf;
3. CATIA GED – CATIA with GED method enabling automatic modifications.

The learning curve consists of three following stages. Firstly, it is necessary to acquire basics of surface modelling theory, such as freeform curves and surfaces, control polygon, continuity levels, isoparametric curves, etc. Secondly, users explore tools possibilities to create or modify curves or surfaces. Use of CATIA GED is conditioned by broader knowledge of GED tools, so that second stage is slower in comparison to others. Thirdly, users achieve the highest proficiency, which is different for each procedure.

Comparison of two different modelling approaches:
Comparison is shown in Tab. 1, there are similar aspects compared in each row.

	ICEM Surf		CATIA (ICEM module)
+	system designated to build and modify class A surfaces.	+	system connecting various applications such as CAS, STRAK, CAD, FEM, MOCK UP, etc.
+	surfaces of different mathematical description: Beziér, B-spline and NURBS [5].	+	modification of a class A surface after the detailed design is created; enabled by using GED [1].
+	higher precision of created surfaces and connection.	+	more advanced GUI (graphical user interface).
+	learning process leads to higher proficiency of user able to adapt to any tool suitable for class A surface creation.	+	user learns to use developed knowledge tools suitable for GED.
+	manual tools of modification with wide possibilities of of resulting shape.	-	automatic tools disabling control of created connections.
+	optical verification of result enabled with deformation of view.	-	needs better computer hardware.
-	missing tree history and other linking CAD tools.	-	only one kind of mathematical description of a surface.
-	result is frozen, patches need to be remodelled manually in case of change.	-	missing specific tools used for creation of patches or modification of properties.

Tab. 1 two different approaches of a class A surface development process compared within similar objectives.

Conclusion:
Presented paper briefly explain crucial aspects of two different approaches to a class-A surface creation and modification. Even though, there are significant advantages of new method using module directly in a CAD system, it is difficult to involve it in a real development process. In the practice, there are no projects known to be using CAD system for a class-A surface development. That is one of reasons, for Laboratory of Generative Engineering Design, to be working on a new methodology, which saves time respecting a high-quality standard [2,3].

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