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STRUCTURAL MODELLING BY MBS METHOD APPLIED TO LINKAGES USED TO AIRCRAFT CONTROL

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Abstract: The aim of the paper is structural modelling of linkages used in airplane control, on bases of the Multibody System method (MBS). In virtual prototyping of the aircraft , these linkages have to be modeled by a minimum number of bodies (MBS min). In the paper an appropiate algorithm is descriebed and also applied for concrete mechanical systems. This will be the bases for kinematic and dynamic modelling of these subsystems as parts of the whole product (airplane).

1. INTRODUCTION

Generally control surfaces of an aircraft include : ailerons , rudder , elevator , tabs and flaps(see figure1). Movement of this surfaces generate roll, pitch and yaw. During the fly flaps move between "cruise posision" and "landing position" by intermediate of mechanical transmissions.

In design process of an aircraft one of the main step is virtual prototyping.
In virtual prototyping of the aircraft, mechanical systems are considered as Multibody Systems (MBS). They have to be modelled as MBS with minimum number of bodies (MBS min) to favorise obtaining real time simulation of aircraft.

The aim of this paper is structural modelling of linkages used for actioning of aileron as multibody systems. On bases of MBS, kinematic and dynamic models could be obtained.

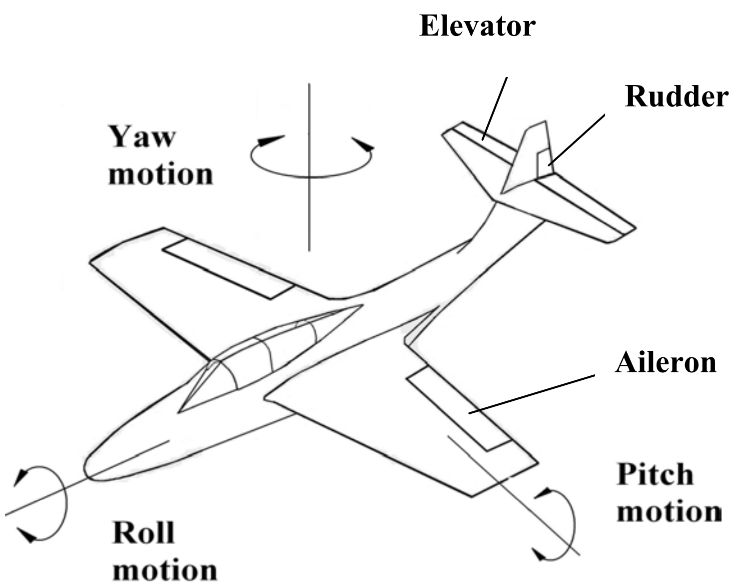

Fig 1- Aircraft controls

2.THEORETICAL CONSIDERATION

According to MBS theory , a mechanical system is considered as a collection of bodies linked between them by geometrical and driving constraints[4,2,8].
The body is an entity which in the dynamic model will have mass and moment of inertia, and also could take over the external forces.
Motion of a rigid body in space can be described by six generalized coordinates - S_x , S_y , S_z = translation, φ_z ,φ_y ,φ_z = rotation (x,y,z are the orthogonal axes) Planar motion has S_x , S_y , φ_z

Global Reference Frame GRF is a coordinate system represented three orthogonal axes fixed in time. This coordinate system is rigidly connected to fixed body [4,2,8,9].

Body Reference Frame BRF is a coordinate system formed by three orthogonal axes connected to each mobile body component to the MBS system[4,2,8].

In a linkage having "n" elements number of bodies n_b is :

$$n_b \leq n \qquad (1)$$

Generally:

$$n_{b\,min} \leq n_b \leq n$$

$n_{b\,min}$ representing the minimum number of bodies for modeling a concrete linkage

The geometrical constraint imposes restrictions in bodies relative motion. Number of restriction is
r =1 and r = 2 in the case of planar systems (S =3), respectiv r = 1…5 in the case of three dimensional systems (S = 6).

The restrictions are imposed by joints or composite joint [4,9]. In planar systems they are: rotation R
(r =2), translation T (r =2), rotation-rotation RR (r =1), rotation –translation RT (r =1)curve – curve CC (r = 1) [4,2,8].

Driving constraints corespond to the mobility M of the system Of course $M \geq 1$ .Between number of bodies n_b number of geometrical constraints (Σr) in a concrete space S , and mobility M there is the relation [2,4,8]

$$M = S\,(n_b - 1) - \Sigma\, r \qquad (2)$$

The algorithm for MBS modelling with minimum number of bodies has the following steps:

a. Identifying the bodies , in order:
   - fixed body,
   - input body (bodies),
   - output body (bodies),
   - bodies with more than two connection,
   - bodies with applied forces,
   - other bodies (if necessary).
b. Identifying geometrical constraints:
   - type ,
   - location,
   - number of restriction.

3. STRUCTURAL ANALYSIS OF CONCRETE LINKAGE

In the paper , one linkage used for aileron control is analized.
The bases of this linkage is wing structure , that represent for the linkage – fixed body. The output body is the ailerons. The input motion is generated by pilot from control lever by intermediate of mechanical / hydraulic actuators.

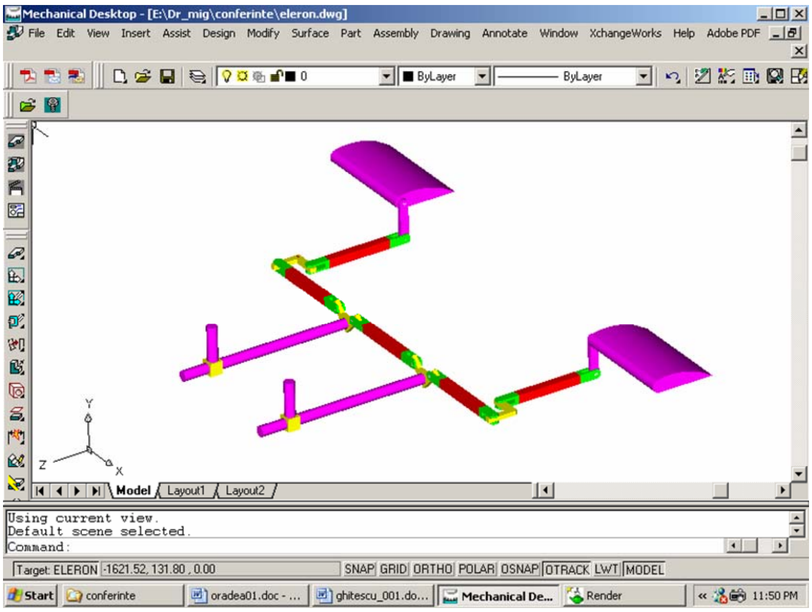

Fig 2 – Aileron controls – 3D model

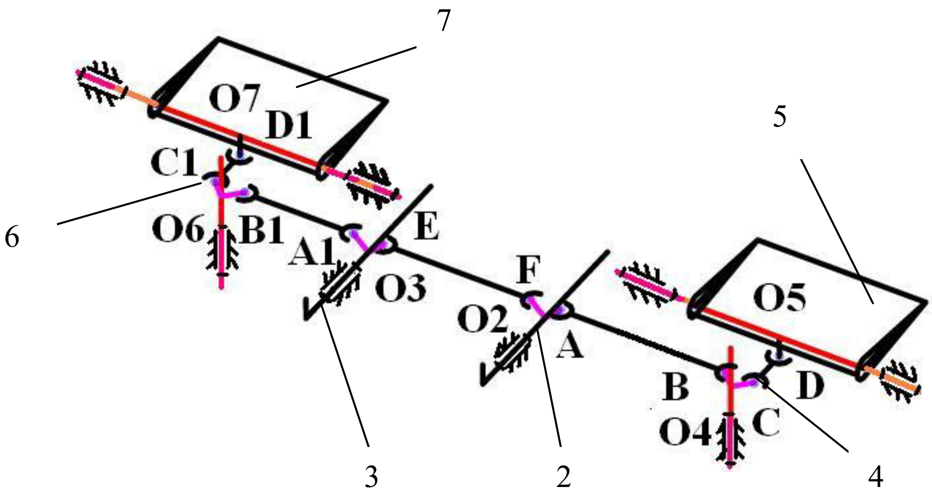

Fig 3 – Aileron controls –

The linkage from fig 2 and 3 is modeled as MBS min having 7 bodies, six geometrical constraints type R and five geometrical constraints type SS. The input body is body 2 and the output bodies are the ailerons 5 and 7. Mobility M =1.
Figure 3 represent structural scheme at this aileron mechanism.

Table 1: aileron control (see fig 3)

Body i Body j	gc	Location	Number of constraints
1-2	R	O2	5
1-3	R	O3	5
1-4	R	O4	5
1-5	R	O5	5
1-6	R	O6	5
1-7	R	O7	5
2-3	SS	EF	1
2-4	SS	AB	1
2-5	-	-	-
2-6	-	-	-
2-7	-	-	-
3-4	-	-	-
3-5	-	-	-
3-6	SS	A1B1	1
3-7	-	-	-
4-5	SS	CD	1
4-6	-	-	-
4-7	-	-	-
5-6	-	-	-
5-7	-	-	-
6-7	SS	C1D1	1

$$M = S\,(n_b - 1) - \Sigma r$$

$$\Sigma r = 35 \tag{3}$$

$$n_b = 7 \quad \text{si} \quad S = 6$$

$$M = 1$$

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