# Development of Instrumentation Adapted by C.M.M.S. Dedicate to Poly-articulated Mechanisms

(Computer-assisted Maintenance Management System)

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**Abstract:** In this article three study phases have been discussed: Landing phase of a civil transport aircraft, when part of the flow entering the reactors is redirected by thrust reversers. Phase of the functional and technical study of which reflects on the aircraft maintenance component, without forgetting the phase of synthesis of the landing system mechanisms. The approach presented relates to the description of the different instruments and languages used for the control of vibratory behavior in a maintenance plan. Active devices are used mainly in systems where the excitation acts permanently on the system and the minimization of the amplitude of the vibrations is the dominant criterion. This is the reason why it is important to plan and control the technical aspect which will contain the landing system from the point of view of geometry, torques, positions, speeds and accelerations, and trajectories from the mechanism design phase.

**Keywords:** Synthesis of mechanisms,Measurement and Instrumentation, CAD Prototype.

## 1. INTRODUCTION

Once in flight, the landing gear is a hindrance because it increases the aircraft's drag (resistance in the air). On fast airplanes, the gear can retract into the fuselage or into the wings. We speak of retractable or retractable train. Thus since the beginnings of aviation, aircraft landing gears have always had wheels. Indeed, the first plane was to take off in 1890, already had wheels. Then followed for the most historically known in 1906, the addition of the dynamic absorber creates an ant resonance at the natural frequency of the system without an absorber. Otherwise, the aircraft is qualified as a fixed train. Aircraft braking evolved considerably over the period 1945-1995, with the advent of carbon brakes and the introduction of a new principle of braking regulation. We adopted a synthesis of the most complicated mechanisms to integrate preventions from operating instructions with a CAD-CMMS coupling [15, 17, 18].

*Abbreviations and Acronyms*

**A.T.R.:** Regional transport aircraft.
**B.I.T.E.:** Built-In Equipment.
**C.A.D.:** Computer Aided Design.
**C.E.A.:** Atomic Energy Commission.
**E.R.A.M.:** Studies and realization of mechanical accessories.
**F.H.S.:** Standard hydraulic fluid.

**C.P.M.:** Computer-aided production management.
**C.M.M.S.:**Computer-assisted Maintenance Management.
**I.N.R.I.A.:** N. I. Rin Computer Science and Automation.
**M.R.P.:** Management Resource Planning (p.p. method).
**R.T.O.:** Refused Take-Off.
**S.A.O.:** Computer Aided Specifications.

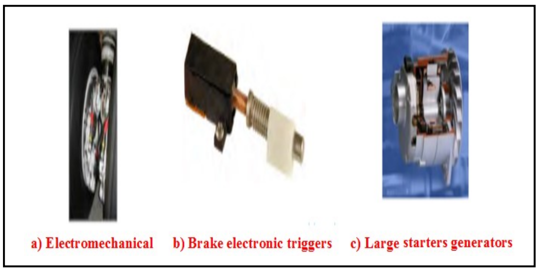


Fig. 1 Components of an electronic measuring instrument [3, 21].

## 2. PROBLEMS

*A. Problem: the potential problems are aimed at submitting an extended solution to the following subjects:*

The analysis of the landing is in every respect similar to that of the takeoff. A few parameters differentiate the takeoff landing, however. Landing is also broken down into three phases, namely approach, flare and ground breaking. The approach, which is the final phase of the descent, is made with an instrument approach angle of 3 to 5 ° (3 ° for an instrument descent).

*B. Systems of differential equations describing the dynamic behavior of a landing gear:*

The speed at the start of the approach (at a height of 50 feet) must be 30% faster than the stall speed under normal landing conditions. The aircraft will arrive on the ground with a given minimum speed (operational speed).

Sensor test benches are used more and more thanks to the many technical advances recorded in recent decades in the fields of advanced maintenance, sensors and materials. While in industry, smart technology electromechanical components have widely established themselves for their efficiency, ease of construction and lack of error returns.

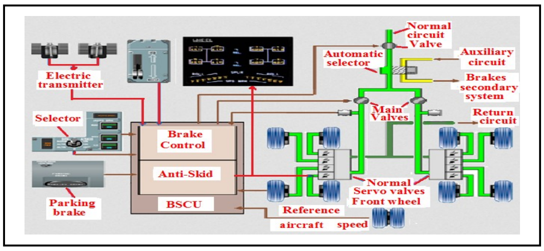


Fig. 2 Components Air brakes and brake system.

## 3. LANDING GEAR (ANALYSIS AND FORMALIZATION)

When an airplane lands, the wings or fuselage support the mass of the airplane. During its impact with the ground, special loads generally vertical and longitudinal are applied to the axles of the wheels. Typically, the interactions to be studied and considered for a helicopter are those appearing during the phases of taxiing at high speed over an obstacle or in the presence of (vibrations of the wheel due to the elasticity of the landing gear leg), when the ground resonance phenomenon which includes large deflections on the landing gear and aerodynamic forces of the rotating rotor, during high speed landings.

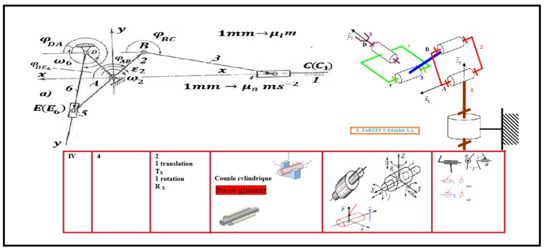

Fig. 3 Summary of mechanisms [15]

A main undercarriage included two half-pendulums articulated on the same axis of the box and each receiving a dolly. The forces were taken up by a damper-connecting rod-rocker assembly (figures). A pitch damper positioned the wheels with the gear retracted [22].

*A. Main classes of landing gear*

An aircraft is an assembly of several mechanical systems which interact with each other to create lift, reaction or movement in order to reach a next destination. The movement of an aircraft on the ground is subject to the presence of landing gear. These allow the aircraft to move or land safely. However, this does not prevent an aircraft from landing without the intervention of a landing gear.

*B.Principle of Modeling of a 3D multi-body system*

• The analytical models developed and presented in the previous chapters are based on modeling hypotheses of the overall dynamic behavior of the type of landing gear considered. In order to validate these analytical models, we propose to develop a CAD model (3D model) of the current landing gear based on a multi-body CAD approach which breaks down the landing gear into three sub-systems and which allows to work on each subsystem individually before assembling them.

• Degrees of freedom and contacts taken into account. As it was defined (mathematical modeling of the Landing Gear), two degrees of freedom were considered in the simulation, a third degree linked to the drag force "drag" was considered. added to make a total of **3** degrees of freedom.

•Dynamic simulation of the response of a landing gear during landing phase part serves as an integrating part of the pneumatic element on the landing gear structure. It is also used to configure the flight status and the flight parameters and to start the calculations.

•The simulation on Simulink is configured according to the needs of the requested end results - the end load results that an engineer would need to complete their product development tasks.

*C. Instrumentation*

The various electronic and electrical components (laser, photodiode, modulator, amplifier, multiplexer, optical fiber (transmission channel) and others, have an impact on the quality of the instruments of a control cell, also the signal transmission has short and long distance broadband. [1, 4, 6] whatever one starts from an input signal to an output signal to which modulations have been made determine the quantity measured, then control signals [2, 3, 4].

We have chosen to develop a mixed PID structure because the action of the integral and derivative element is decoupled, thus allowing a dissociated adjustment on the robustness (integral action) and the dynamics (derivative action) of the corrector. The structure of the PID thus conceived is presented on the following figure 4:

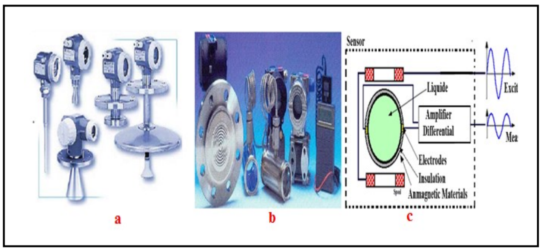


Fig. 4 a. Microwave sensors, b. Pressure measurement [pressure measurement.htm] c. Electromagnetic flowmeter sensor

After implantation of the corrector on the Matlab / Simulink model of the demonstrator, we proceeded to the adjustments of the corrector empirically from a method derived from the numerical method and analysis of the simulation results.

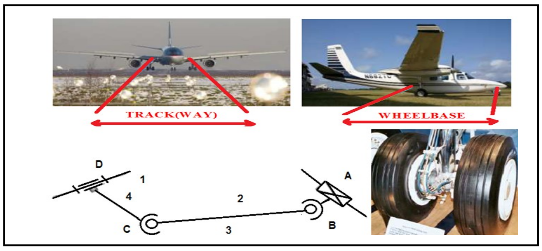


Fig. 5 Retractable aircraft undercarriage: 1, 2, 3, and 4 elements or link, A, B, C and D kinematic couples [17]

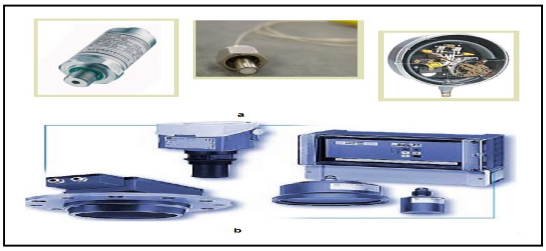

Fig. 6a.Pressure measurement b. combined mounting [17]

*D.Balances of Interacting Forces in the System*

•For the case of the landing gear, the equations of motion can be transformed into a form where the momentum is state vectors.

•This approach (CAD, Instrumentation, CMMS) makes preventive maintenance (certified equipment [12]) an asset. Indeed, it is common that question marks remain [7, 3, 10].

•Semi-active method In his work, Kruger shows that during taxiing phases, planes are subjected to mechanical excitations leading to uncomfortable situations for passengers and constraining vibrations for the structure of the aircraft.

•As J. Veaux explains to us in his book [27], the taxiing speeds of planes during take-off phases can reach 360 km / h, thus generating vibrations that are felt when one is a passenger.

•The objective is then to isolate the structure as much as possible from external mechanical stresses in order to ensure passenger comfort and the durability of the aircraft while facilitating air-to-ground and ground-to-air maneuverability of the aircraft.

• The landing gear is therefore a key element of the aircraft's kinematics.

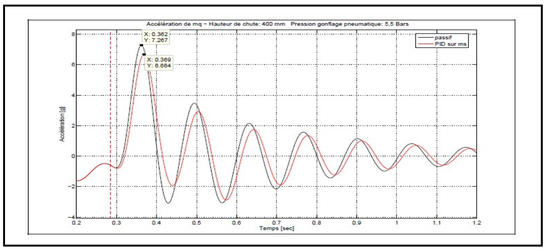

Fig. 7Passive and PID comparison over ms - acceleration of mq.

## 4. CLASSIC TESTS AND SPECIFIC TESTS

Undercarriages are not only structural elements whose mechanical strength must be validated by tests, they are also functional elements whose performance must be verified. This is all the more imperative as their performance largely defines the stresses that their structure must withstand. Several functions are involved, such as lifting the train and, if necessary, steering the wheels, but it is the absorption of the residual vertical kinetic energy of the aircraft on landing that is most essential. and the most characteristic.

### *A. Static tests*

For these tests, the undercarriage is mounted on a solid metal frame that mimics its attachments on the aircraft.

1) *It is equipped with false wheels.*
2) *The frame also receives cylinders*.

a) Most of the time hydraulic, which apply the forces to the false wheels on the ground.
b) The effects of which are to be measured.

### *B. Electrical measurement application*

Wheel orientation controls: JK
We now turn to a second category of systems associated with the landing gear. These are those dedicated to the orientation of the wheels, the purpose of which is to improve the ability of the aircraft to be steered on the ground.
Hydro mechanical controls:
In this technology, the deflection of the control devices and the angular orientation position of the wheels are transmitted mechanically, by links made up of rods or cables, to a hydro mechanical distributor located as close as possible to the engine device178.
These two inputs drive a small follower differential, mounted on the distributor, and designed to cause the displacement of the dispenser drawer when there is disagreement between them.

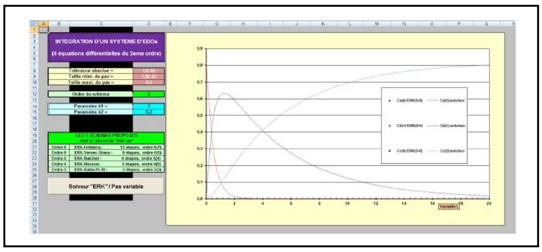

Fig. 8 An example of a file for writing, printing, and outputting program data. [22]

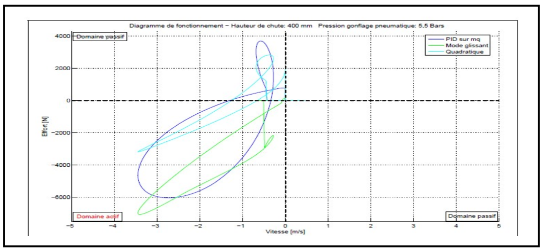

Fig. 9Curves of the developed correctors.

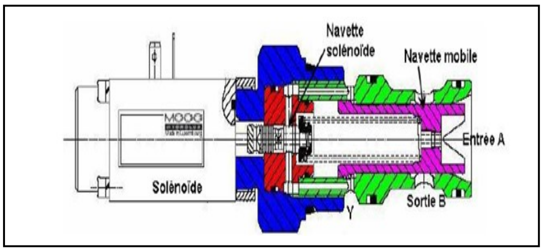


Fig. 10 Servovalve.

### *C. Experimentation (experimental setup of the experiment)*

*In this part, we propose to experimentally validate the semi-active demonstrator previously developed, these two devices are connected in parallel.*

The first step consists in determining the optimal target force that the semi-active device must approach so that the global force transmitted to the suspended mass ms, minimizes the first peak of acceleration of the beam mass of the aircraft (mq).

Maintenance interventions

The mechanical systems (aircraft landing mechanisms, etc.) are supervised by fault detection devices with or without a robot in a maintenance cell, CMMS software, test benches, validation benches: electrical engineering, power electronics, mechanical, pneumatic, hydraulic and automatic; to analyze displacements, by photoelectric measurement.

Application of electric measurement (photodiode, caliber, accelerometer…)

A measuring instrument [9,13, 16] is an electrical system (usually electromagnetic or photoelectric) that is autonomous, that is to say that can be used alone. As with all measuring devices, it is important that the output signals formed are as interpretable as possible to the input signals from which they derive.

Measuring a standard of circular shape (ring, ball joint, pivot link, etc.) has often been proposed to check the geometry of a kinematic chain with shape defects. These equivalent defects can be exhibited by numerical analysis (see results) and they will be used to analyze the constants appearing in the permutation method [13].

The temperature probe corrects variations in the propagation speed due to variations in the temperature of the element in question. Speed measurement Linear speed (see angular), by linear, linear wave or pulse tachometers.

**Output of program results:**

Program execution can be done in different ways; it is reserved for the programmer to define when and how his program will be executed. In this report the program will run through a macro dropped on the VBA file. This macro acts as an exciting element of the functions. However, the programming data will be written and executed on the VBA file, however the results will be printed in an Excel file.

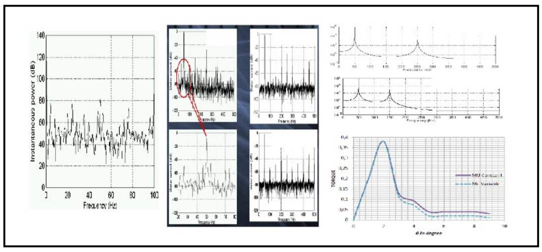

Fig. 11 FFT of instantaneous power & High resolution spectral analysis.

**As a results:** Particularly, it is a question of realizing a schedule for the maintenance of mechanical systems of different nature, under the development of a platform of assistance to the design of systems. Exp. G.P.A.O./G.M.A.O. the results obtained are validated in applications in fields ranging from medical to machine tool, including rapid handling as well as precise handling, among others. A very advanced report on the use of management software in the field of G.P.A.O. production stations and more specifically the measurement and control instruments., it is dimensioned by choosing the appropriate method which allows the dimensioning, and the optimization of the desired request.…

***Validation***

***(Description of the test platform)***

As part of this work, an aircraft landing gear model is modeled on different programs using mathematical models. A model specifically based on the commercial code, Adams / Aircraft, was investigated and simulated according to the software concepts and the methods currently used in business. Although this model is based on an analytical mathematical model, many assumptions have been made to characterize the structure of the model in particular the pneumatic structure, but this has not given satisfactory results.

***Results interpretation***

From this analysis, with a view to minimizing the acceleration peak experienced by the aircraft landing gear during a hard landing, we have developed a semi-active method that aims to be simple in setting implementation of the device and allowing transformation of an existing passive landing gear into semi-active landing gear.

## 4. CONCLUSION & OUTLOOK

This article made it possible to propose a method for selecting kinematic diagrams for the maintenance cell processes, we carried out a validation using the data from the modeling of a structure using the Computer Aided Production Management software (CAPM), as well as the insertion of all the causes of significant errors having an assignable character. In addition, the problem of planning the plans was solved with different software from G.M.A.O. (Computer Aided Maintenance Management) in three global production environments, a multiplatform simulation linking different sectors of the aeronautical industry.

Several components of the landing gear structure now require improvements in order to optimize their impact on the environment. Their mechanical complexities and their ability to withstand certain loads from the aircraft and other subsystems require improvement in order to meet the various manufacturing and certification requirements.

The company [Air Algeria] must constantly work to increase their competitiveness, today we have a generation of new graduates of mechanical systems programmed on the basis of didactic design software and approved technicians and future modeling experts, software interface.

### *References*


[1] Temmar Abdelkader, Analyse et optimisation des performances des composants optoélectroniques et optiques pour les systèmes de télécommunications à fibres optiques à haut débit : Réseau d'accès et longue distance, Laboratoire de Recherche Appliquée en TIC, Institut National des Télécommunications et des TIC (INTTIC) d'Oran.

[2] Chris Paredis, A plan for a simulation-based design study of an aircraft landing gear shock absorber, Georgia Institute of Technology, spring 2007.

[3] Curry, Norman S. Aircraft landing gear design Principles and practices. Washington: American Institute of Aeronautics and Astronautics, series editor- Inc. -chief. 1988.

[4] Hadjira Belaidi, Optimal control and strategy of autonomous mobile robot 2D/3D simulation, Magister in electrical drives and controle, University M'hamed Bougara BOUMERDES, June 2009.

[5] Abdelkader Benmisra, Abdelhalim Brahimi & col., Brevet Robot [ALG. M.-O. 1], I.N.A.P.I. ALGERIA

[6] Abdelkader Benmisra; Moufida Irki & col., Synthesis of an Automatic Welding Line, 5th (ICEMAEP'2019) CONSTANTINE, ALGERIA, October 22nd -24th 2019.

[7] AGARD, la Conception, la qualification et la maintenance des trains d'atterrissage sans vibration Papers presented at the 81st Meeting of the AGARD Structures and Material Panelheld u1 Banff; Cam 4-5 October 1995.

[8] Aforp.fr, Dépannage des systèmes mécaniques automatisés, Réf n° OIF012-12. Accés web juillet 2020.

[9] Samia HACHEM, "application-gestion-consommation-énergétique, master professionnel en nouvelles technologies des télécommunications et réseaux, ," Université Virtuelle de Tunis.

[10] D. Diallo, M.E.H. Benbouzid, methods de detection et de diagnostique, SEEDS – MACS, Paris le 27 septembre 2007.

[11] Mario Boras Eoin, Cosgrave Jean-Michel Plankeele, Instrument Maintenance, Biopharma LC Meeting Eschborn, , 2012.

[12] Air-Algérie, Instrumentation et mesures industrielles, Monitoring et surveillance d'infrastructures, Expertise et auscultation d'ouvrages vieillissants, Brochure-technique-2020.

[13] François Hennebelle, Détermination des incertitudes de mesures sur machines à mesurer tridimensionnelles, Arts et Métiers ParisTech, 2007.

[14] Tadjer Fatima Zohra, Mérabet Nassima, Réalisation d'une application mobile sur la base du module de gestion de la maintenance industrielle (GMAO) Odoo, Master en Informatique, Univ-Tlemcen, 2018.

[15] Allali & Benmisra, Cours et Traveau dirigés Théorie des Mécanismes, E-learning, Université BLIDA 1 2020.

[16] Karim Bourouni, Mesures et Instrumentaion, Ecole Nationale d'Ingénieurs de Tunis, Janvier 2011.

[17] Artobolovsky I. I. « Théorie des mécanismes et des machine »,Edition Sciences Moscou, 1988.

[18] Michel Aublin, René Boncompain.« Systèmes Mécaniques. Théorie et dimensionnement », Collection science Sup. Dunod, 2005.

[19] Maria Makarov, M. Grossard, P. Rodriguez-Ayerbe, and D. Dumur, "A Frequency-Domain Approach for Flexible-Joint Robot Modeling and Identification" 16th IFAC Symposium on System Identification (SYSID 2012). Bruxelles, Belgique, 2012.

[20] Helping HR to understand the strategic value chain Mayo, Andrew Strategic HR Review; Nov/Dec2005, Vol. 5 Issue 1, p32-35 The article explains how using a cause and effect analysis system will help determine how human resources' (HR) agenda should be set in order to directly support key strategic outcomes.

[21] Cours théoriques BIA Edition 2013 - 2014 André PARIS - FI - FE 1

[22] Grégory Pinon, Jean-Marc Cherfils, Xavier Bouteiller, Laurent Blin et Elie Rivoalen, Modélisation numérique des écoulements externes d'inverseur de poussée. Une aide pour la conception des nacelles. 18 ème Congrès Français de Mécanique Grenoble, 27-31 août 2007.

[23] Ouali Mohammed, Optimization the Trajectories of Robot Manipulators Along Specified Task, in International Journal of Intelligent Engineering and Systems, February 2018.

[24] Bratec H., Rivoalen E., Huberson S. 2003 Modélisation numérique d'un jet issu d'un inverseur de poussée plan. 16 ième Congrès Français de Mécanique.

[25] Pinon, G. 2005 Modélisation numérique de jets transverses : Application au cas des inverseurs de poussée d'un avion en phase d'atterrissage. PhD thesis Université du Havre, Le Havre.

[26] Ghiringhelli, G.L. and Gualdi, S. "Evaluation of a landing gear semi active control system for complete aircraft landing", Aerotecnica Missili e Spazio, , vol. 83, January 2004.

[27] Veaux, J. "Les trains d'atterrissage et les systèmes associés", Edition : Centre des hautes études de l'armement, division histoire de l'armement, 2006.