Modeling of mechatronics system on example on window regulator: conceptions and troubles

Sergey Petkun[1]

[1]System Integration Door Modules, Brose Fahrzeugteile SE & Co.KG,Bamberg, Berliner Ring 1, D-96052 Bamberg; *sergey.petkun.brose.com*

Abstract. The mechatronics systems are inalienable part of present industrial progress. They are extended from small micro devices in nano range up to huge systems like ocean liners. Common for such systems is presence of four important components: mechanical system providing energy from electrical motors managed by an electronic with software control. Mechatronics is technology combining electronics and mechanical engineering. The microsystems (MEMS) are excluded from our consideration. Mechatronics systems will be restricted to dynamical systems in this paper. The movement is necessary part of dynamics. The company, manufacturing the all four components of mechatronics device, is absolute exception in industry. The most of companies are suppliers of one or two subcomponents to the whole mechatronics system. Every supplier takes a focus on own product and its domain. The simulation is not required at all if device works fine after assembling. This ideal case happens not very often because of growing complexity. In reality, there are a number of loops to set device in robust working state. At present, the modern progress is very paradoxal: the systems are becoming more complex and at the same time, they are designed in shorter period. The system simulation can help to cope with these difficulties. The problems, connected with the system simulation, are considered in this paper from industrial point of view. Electrical window regulator will be analysed as an example of mechatronics system. It has all necessary components like mechanical part with motor-controlled electronics with software. The simulation system BroSAnT will be given as an example of realization the system analyse.

Introduction

Today, the progress of industry is characterized with high dynamics. Every domain has its own inner development. Electronics is on the way of quantity expansion (more CPUs, memories and so on) and minimization of sizes (microminiaturization the chips). The mechanics tries to optimize the weight of construction (new forms and materials). The software offers more functionalities. The drives and motors are offered in very wide choice in power, sizes and prices. All these processes run under the pressure of costs and time. All these effects influence the process of development the mechatronics systems. Plenty questions arise during the development of the system modelling. Every simulation is to answer at certain special questions. The many questions can be formulated to whole system during the development. At the same time, there are relatively small number among them, which are technically correct formulated. The main attention to system is in its functionality. The functionalities of the product are strategical moment in business. The management makes the decisions about the desired functionality. The skill of management is concentrated in economic and financial area as a rule. That is why, they formulate the correct technical questions very seldom. The process of globalization leads to growth the managing structures and their hierarchy. The technical knowledge and experience remain at the bottom of this hierarchy. The opinion of experts has the small weighting on taking the decisions. Technical understanding is the first what is needed for mechatronics simulation. Wherefore, the target group of mechatronics simulation is engineering staff for integration system from supplied subsystems (components). Usually this staff is called application team. The assembling of system is the right place for system simulation of mechatronics systems. But there is no time for simulation as a rule in project schedule. The development of components is already almost finished at the phase of system integration. Every change of the component prototype leads to increasing the costs of product. The last member in the development chain of the system, namely the integration (application) engineer, is the judge for what must be changed for optimal system operation. But this engineer is not decisionmaker. The economic competition and market pressure give rise to shifting the decision-making to purchasing department. The decisions of dominated financial sectors often lead to some technical problems which arise later during the integration phase or yet even later during recall campaigns.

The industrial planning process goes out from the point of view that all components are designed properly for its functional purposes. The stumble stone is here the possible problem which can occur during the integration subsystems. All components meet all purchaser's requirements and despite that, the device does not operate properly. The system simulation would be helpful on phase of the formulating the proper requirements for components. However, it is no clear enough who should provide such simulation for the integration engineering at this phase. The business of suppliers is already finished after delivery their product. As a rule, the supplier is not required to deliver a model of its component, which could be used for simulation purposes. The modelling on system level can be used for different purposes. An excellent introduction in the modelling of mechatronics devices can be found in [1].

1 Mechanical part

The stress, strain, stability, durability and endurance are in focus of interests the mechanics during the development of mechanical devices. The creation of mechanical construction begins from CAD (**C**omputer-**A**ided **D**esign) drawing. It is very easy to produce an animation of a moving object based on its geometry at this phase. For mechanical engineering the animation of motion is the first step of understanding functionality of the system. The important questions arise already in initial phase of design: tolerances, choice of materials, the geometry variations under wear-out, temperature Influences and so on. The engineer gets answers for these questions partly from test, partly from own experience and simple calculations, sometimes from literature and, of course, from the simulation department. There are a number of complex tools, which are trying to answer on questions of interest.

Very often, CAD drawings are the initial input as source for mechanics simulations. Engineer uses the geometrical drawings for creation of simulation model. The next step is to fill CAD geometry with physical content of material properties. After that, the different kinds of element connections (joints) have to be created. At this manner, the model for MBS (**M**ulty**B**ody **S**imulation) is created. ADAMS(MSC Software) and SIMPACK(Dassult Systèmes) are typical examples of MBS and are used at early development phase. There are many simulators in MBS group from commercial up to free like MBDYN. All of them produce an excellent animation of system motion. Often, they combine the analytical approach with numerical FEM (**F**inite **E**lement **M**ethod). The model parametrization is most important and difficult part during its building for modelling of dynamics. Parameter identification is the weakest place of simulation. For example, translational and rotational stiffnesses are needed to set in all 3 dimensions for free joint. It is needed already to determine 6 unknown parameter for only single. Next step is to bring in modelling object the loses (for example, friction) in form of acting external or internal forces. There is not sure information sources for it in many cases.
All this information is not really needed for kinematic animation, which is frequently mixed up with the result of dynamical motion. The complexity of inner life of the tools from one side and requirement for easy usability of it from another one, leads to creation a user-friendly GUI (**G**raphical **U**ser **I**nterface). All computational mechanism is hidden behind this user interface. The inexperienced user is very often overloaded by the amount of information necessary for simulation. The geometrical preparation (proper mesh) of the model is no single task of simulation engineer. The user of such tool has to provide a lot of information about external environment: external forces for stress and strain simulation (boundary conditions). Wherein, it is oft forgotten, that the quality of output information depends not only from tool but also from quality of input information. The model will be simulated after successful geometrical preparation, filling physical content and forces in it. The result analysis is required no less experience than task of preparation for the input data . Several models are arisen at the end of development the mechanics. They bring the answers on various problem formulations . As a rule, all of them are pure analog.

2 Electrical part

The electronics task in system simulation seems only easier as mechanical one. The correct management of motor requires proper functionality under unlimited combinations of conditions and effects. The most important of them are thermal and climate influences. The manufacturing tolerances are strong connected with prices. It has also to be taken into account. The temperature appears two time as object of interest. The thermal behaviour electronics components is studied in different environment conditions and operation modes. The diverse simulations are created during the development the controlling device. The focus of interests is shifted in direction of robust operation in the prescribed environment. The new field of interest, in comparison with mechanics, is EMC (**E**lectro**M**agnetic **C**ompatibility). 3D-models are used for estimation of electromagnetic radiation and temperature distribution. The functionality of electronics component is studied at the begin of design process by means of simulation the electrical schematic. The thermal and EMC models of electronics are analog almost always, but functional one consists from both analog and digital parts. The animation is fully absent as part of result analysis in simulation world of electronics. There are many models of electronics components, which are based its behaviour. The physical complexity of electronics cannot be described by means of simple analytical mathematical language. The progress of electronics have gone more empiric than mechanics. The creation of the stable working electronics devices is not possible without clear understanding of the functionality of its elements. The supplier provides already the most important parameter of electronics part for the functional modelling. In contrast of mechanisc, the absence of animation during the development of electronics played positive role for electronics progress. The same as in mechanics development, many models of electronics are created for different purposes and types. There are analog, digital and mixed models.

3 Software part

The smart thinking is very important part of modern mechatronics system. It is packaged in form software (so called firmware) in electronics chip. That is why that the software in mechatronics sense is also part of modern electronics. The irony of progress consists in that the "brain" of mechatronics system is fully digital in contrast to real world which is analog (at least macro world). The peculiarity of software part is deceptiveness of easy, cheap and fast development. But it is a part as complex as the two others. Only its distribution is easy and cheap. As a rule, the software is relative unproblematic to adapt for usage in simulation. The proficiency is in that the "small adaptation" of software should behave the same like original one. The software plays in mechatronics simulation very important role. It is "an incorrupt judge" to the suitability and quality of the rest of the simulation. The software knows nothing about the rest of the simulation. It can be embedded in real hardware or only in reproduction of its reality. If the software shows the same behaviour in simulation as in real hardware, it means that the modelled rest of system is proper for this deepness level. The great advantage the software part in comparison with rest parts, that it can be embedded in whole simulation in form shared library like *dll* or *so*. The problem of know-how protection is usually solved with it.

4 Drive part

The energy source is needed for dynamics and namely for motion. The electrical motor is used as the source of energy for most of mechatronics systems. There are huge range of motors from micro up to giant size. The great range of different constructions is available nowadays. The transformation of electrical energy in mechanical one is common intended purpose of all motors. Series of simulations arise during the development of motor. The motor models are developed and used during development of mechanics or electronics also. Peculiarity the development of motors is the simulation of magnetic field dynamics for proper choice of its topology.

The development of this mechatronics component is closely connected with both domains: in mechanics (dynamical movement, friction) and in electronics (current-voltage characteristics, thermal behaviour). Constructive combination of the motor with some gears leads to conception of the drive. The end user is needed power from supplying energy. The power can be got from motor through rotational velocity. For example, the drive unit of electrical window regulator consists from electrical motor combined with worm gear. This constructive combination brings the properties named self-locking. At the end of drive development, a few different models are available. Every of them answers on specific class of questions. There are both analog and digital models, 1D and 3D.

5 Simulation integration

From above mentioned, the idea comes about the integration already available simulations into some overall system simulation. This concept is named FMI (**F**unctional **M**ock-Up **I**nterface). It is some kind of generalization of the concept of co-simulation, where two or more simulators run in parallel simultaneous. They exchange information with each other during running process. The main idea of this concept is to organize the interface for information exchange between dynamical models of different components. Another concept consists in attempting to describe as many as possible subsystems in frame of the same language. It gives possibility to use a single simulator for evaluation. There are various trends going out from different domains. The electronics gone way to extend the available language on integration of mechanics in it. The VHDL (**V**ery **H**igh Speed Integrated Circuit Hardware **D**escription **L**anguage)) was extended to VHDL AMS (**A**nalog **M**ixed **S**ignal) on this way [2]. The language SIMSCAPE(Mathwork) was come from software and algorithm sector. It was wish to stay in environment SIMULINK(Mathwork). The language MODELICA was initiated from mechanics and drive domains for possibility to analyse the whole system [3]. There are few of simulators both commercial and free based on MODELICA language. All these languages are based on principles network simulation (nodal analysis). The main purpose of this languages is to find some small set of basic (fundamental) models with aim to enclose as many as possible mechanical effects. The main device classes should be built by means of these properties. It is like searching the letters for alphabet to allow writing as many as possible words by means this language.The set should not be very big but versatile and powerful. All models can be divided in two groups "fundamental properties" and "constructive solutions". Example of last one is rack and pinion model, which serves for transformation from rotational to translational movement and vice versa. Classical example of fundamental model is model of mass, which is described the effect of inertia. Property of elasticity is modelled with ideal spring and so on. The simulators are based on network concept (node and mesh principles) The base laws for electrical domain are Kirchhoff's laws. Kirchoff's law for nodes: **The algebraic sum of ingoing and outgoing currents (I_i) in any node is equal to zero**.

$$\sum_{i=1}^{n} I_i = 0$$

Kirchoff's law for mesh: **The sum of voltage drops (ΔV_i) around any closed loop is zero**.

$$\sum_{i=1}^{n} \Delta V_i = 0$$

Analogue of Kirchoff' node law is in mechanics D'Alembert's principle of inertial: **The sum of all forces inclusive inertial forces (F_i) in node is equal zero**.

$$\sum_{i=1}^{n} F_i = 0$$

The mesh Kirchoff's law has analogy in mechanics with principle of continuity the mesh: **The algebraic sum of all deformations (Δu_i) around any closed loop is zero** (the mechanical chain is not permitted to be disrupted).

$$\sum_{i=1}^{n} \Delta u_i = 0$$

The language VHDL AMS is standardized. But there is not defined in language standard the force flow direction. The model of mass can be defined as

$F^i = -m * \ddot{x}$ or $F^i = +m * \ddot{x}$

It does not matter which definition is taken. They are valid both and can have a place. There is very unusual treatment of inertia properties in [4]. This model describes only action of inertial force F^i the mass m in the node by an acceleration $\ddot{x}$. The consequences of this choice have at once influence on choice the sign for the elasticity force in spring and rest of mechanical elements dealing with force. For example, ideal elasticity properties should have the cooresponing to mass model sign

$F^e = -k * \Delta x$ or $F^e = +k * \Delta x$

Where F^e- elastic force, k - spring stiffness, Δx - its deformation relative to unstressed state. The choice of sign (force flow direction) is in language standard VHDL not prescribed. That is why it is not reasonable to use VHDL AMS mechanical model without knowing which direction is chosen. It is relatively easy to determine chosen direction for two terminal model. But it is not so trivial it to determine for model with many terminals. At present, there are a wide range of mechanical models with one or another direction. The both variants are used actual. Models from electrical sector are not affected by the sign choice on mechanical forces. In MODELICA the flow of force in flanges is clearly defined. It is useful to clear out requirements for simulation from the target user group sight. It brings more clarity for way the creation of the system simulation for whole mechatronics device.

6 Requirements for system simulation

The target group of potential users of system simulation was already defined as integration engineering team. To make the whole system to more robust and safety, they need the virtual prototype of their system for successful and effective working. The wish of integration (application) team is to build the whole system from "black" boxes: mechanical part, control electronics with software, electrics (drive). The simulation building should be reflected in this approach: the parameter which are known from real system combination should be reflected in the simulation parameters. Only developer of subsystem has deepest knowledge about it's at most an can estimate on expert level quality of behaviour own subsystem especially in case of fail problem. But the behaviour is their component in whole system is not so well known for them, because they develop component stand-alone without rest environment. They are indifferent to whole system. Only proper behaviour their part is interested and important for them.

System integration is the last member in development chain. The time pressure is very probable at the end of project schedule. It leads to demand on restriction the simulation time. Many days-simulations can be acceptable on component development phase. But it is unacceptable during integration period. The parameter set should be famous to integration engineers from their daily work. The integrators don't need very precise information from component's sector. Some specific requirement comes from our experience for long period: very important to organize the clear and effective simulation analysis of their results. The many different situations can be simulated for the virtual device with relative quick calculation time during short period. It can come to information chaos if the system of result analysis is not well organized.

There are the big differences on usage simulation tool in different component's domain. It is connected with complexity of tools, duration of evaluation time, post process proceeding and so on. In mechanics domain the simulation activity is separated from construction sector. The dominant method of calculation is FEM in mechanical domain. Usage of this method needs the big and complex process of preparation the input data, long calculation time and laborious post process for analysis of the results. It leads to natural separation simulation engineering from construction one. Table calculation tool Excel is used frequently for their own calculation. The situation is differed in electronics sector. The FEM approach is used as in mechanics for some complex simulation how heat distribution in space (3D) of electronics plate. But functional simulation is made by electronics developer itself. The simulation usage is separated from developer only partly in software sector. Sometimes the developer himself simulates its part with SIMULINK or others simulator. Different simulations are in use by electrics (drive) sector for choice topology of motors, prognoses of acoustic and thermal behaviour and so on. Almost all of them are based on FEM calculation. Their simulation usage is separated from direct developer. They have own simulation teams.

It happens very seldom that the first integration of all subsystems is acceptable at once for series production. The integration loops are need for optimization of interaction the system parts with each other. Simulation of whole system can be very useful to determine what must be changed and why. The subsystem suppliers are usually locally distributed. That is why, the network accessibility to simulation is strong required.

7 System dynamics

The dynamical interaction between subsystems during the movement is absent on subsystem level. Especially it is important in situation when the system state is changing. It can be changed from movement to stop or start up process. The most of dynamics is concentrated in start-stop phases. The next important point is connected with digital behaviour of simulation system. The pure "zero" does not exist in simulation the same as in reality. Classical analytical oscillation model "spring-mass" with damping is represented by equation

$$m \cdot \ddot{x} + d \cdot \dot{x} + k \cdot x = 0 \quad (1)$$

where mass m oscillates on the spring with stiffness k and damping d. This model reflects many cases from reality very good. The only problem is with it that the mass in this model is never stopped according to this model despite presenting of damper in system. Usage of the classical model for dry friction (2) leads frequently to numerical oscillation [5]. The concise mathematical definition of dry friction is not simple to realize in frame of simulation language. The numerical stop state means zero velocity. The stop (zero-velocity state) depends on computers, tools, used algorithms during computation and many other reasons. By this way the new parameter is appeared in models something like " if velocity is less as 10E-15, it means that the velocity is equal zero". It is the usual way of behaviour modelling.

$$F^{fric} = \begin{cases} -k \cdot N \cdot \frac{\dot{x}}{|\dot{x}|}, & \text{if } \dot{x} \neq 0 \\ -F, & \text{if } \dot{x} = 0, |F| \leq k \cdot N \\ -k \cdot N \cdot \frac{F}{|F|}, & \text{if } \dot{x} = 0, |F| > k \cdot N \end{cases} \quad (2)$$

where F is the resultant of all forces, other than frictional ones, N - magnitude of normal (pressure) force, k - friction coefficient and $\dot{x}$ - velocity of point the applied friction force.

Dynamics will have more and more place in all mechatronics system in future. It is consequence of economic competition in the world. The mechanical part is optimized for minimization of energy consumption during movement. It lead to reduction of losses in motion, what means the reducing friction forces. The second term in (1) damping d is nothing else the friction, which is dependent from velocity of motion. The less damping coefficient d is this differential equation, the more dynamics is in system mass-spring.

The friction in mechanics (losses) is negative feedback from point of view of the system theory. It is well known, if the smaller negative feedback is in system, then the less stable system is. All what is won from smooth-running system (smaller energy source, weight), will be lost in fight for system stabilization. Not the only mechanics struggles with friction. In electronics the analogue of friction is heat. The thermal management plays important role in usage of electronics. The classical mechanics has great progress for ideal case - without losses like friction. All analytical methods in mechanical science is functioned fine so long the friction forces or thermal effects are absent. But main friction laws (Amontons', Coulomb's) are empirical, however. Drive of window regulator has motor armature which is the worm of worm gear at the same time. Worm gear is used in car window regulator for position keeping of glass in case of switched off electrical motor. However, the price for it, is immolation the efficiency of drive. The self-locking of worm drive needs not the less than 50% of losses. All these losses are friction. The simulation in mechatronics without considering friction at system level has no practical sense at all. The implementation of mathematical description for friction (2) in simulation language represents the challenge for every developer [6]. The model should reflect not only mathematical sense but also be a numerically robust. There are a lot of other thing to do by it beside integration subsystem in whole system. They are activities like validation of simulation quality, constant update of libraries of subsystem, educating the subsystem supplier on effect of the embedding their component in whole system. The requirements for models are permanent changed with growing understanding of the system. It is useful to keep in mind, that any model is only a reflection of some reality side. By strong declination form initial problem, it can be occurred that the model is out "it's working range". New model or extension for old one is asked for new problem formulation. It is important always do not forget the "golden rule": the model should be lightweight as possible, but it has to consist all necessary properties for answering on questions to simulation. The verification and validation of subsystem models belong also to activities of system region, because of the model developer has not the complete test environment. It is very important not lose the sense of system view despite constant wishes for its extension. There are domain specific tools exactly for these purposes. The building of the system simulation requires the right system vision, which based on experience of developer and close cooperation with component designer.

8 BroSAnT like example of system simulation

BroSAnT is acronym from **Bro**se **S**ystem **A**nalyse **T**ool [7]. The electrical **W**indow **R**egulator (WR) for automobile is one among the products of company Brose. This regulator is perfect representative of mechatronics system. The physical drive is motor combined constructive with worm gear. The BroSAnT is ordinary client-server service for whole company worldwide. Of course, the service is accessible for the users having proper access rights.

Almost any mechatronics system is potential dangerous for user. The uncontrolled energy flow can damage the human. The WR is not exclusion from this rule. To provide safety usage of electrical WR, there is requirement for protect the human against pinch by means of window glass in domestic legislations. These legal requirements differ a little bit from country to country. But in principal, it is the same by all: electrical WR with automatic lift up function must have anti-trap protection against damaging of human under all conditions. A contact jam is allowed. But maximal jam force is restricted to 100 Newtons. The term "all condition" is more as 3D test space: (climate ($-40°C \rightleftharpoons +80°C$), working($9V \rightleftharpoons 16V$) - testing ($10\frac{N}{m}; 20\frac{N}{m}; 65\frac{N}{m}$), time($now \rightleftharpoons \infty$). In addition to, the measure gauge can be place at any placed on window glass. That is why, it is very important to have virtual tool for preliminary testing of setting of firmware. The focus of simulation was an maximal force reached during clamping before reversing of the window glass.

The building of virtual WR reflects the real development process: choose the mechanical variant of WR, drive, electronics and firmware. Some input blocks are also added, to tune the measure and working condition. There is possibility to set measure gauge position on glass, stiffness of it. The glass geometry was considered through setting the action direction the gauge. The whole switch sequence and battery voltage are in input block of working condition, because the firmware was embedded with minimal adaptation. Additional information about the door of car and mass of glass was placed in separate input block. The choice of input information was minimized only for indeed necessary. The task is sending on to server after creation the WR with chosen parameters. Server sends back the simulation result of transient simulation to client after calculation of given task,. All models were developed in VHDL AMS. The simulator is SABER(Synopsis) at present. But thanks, VHDL AMS standardization can be changed on some another simulator. It is clear that mechanical engineer has not so deep knowledge about drive, electronics and or software. That is why concept of model libraries of components was realized. For example, the drive choice is based on name of drive manufacture and it's model. The simulation time is about the real time. It is very satisfactory for end user.

If other questions are set to simulation, it can lead to some other tool and modelling language. The process of anti-trap function remains, but the problem is state a little bit another like that "Which influence does the glass tiling have on clamping process?" Another tool was chosen for answering on this question. More detailed glass geometry information was needed for this problem. The simulator was chosen MATHEMATICA (Wolfram Research Inc.) with its own language: WL (**W**olfram **L**anguage):. The information about this modelling is in [8]. In the first simulation [7], the most important was distribution the kinetic energy between participants of motion. The friction and mass distributions become the leading role in second simulation. The simulation process remains the same despite usage of different simulators (SABER and MATHEMATICA). It is based on the server client concept. All information, which the simulator is needed, is keeping on server. The client knows model only through its parametrization. For end-user the model is only named parameter set. Such simulation has great potential, because yet on development phase, the different domain can test some future features which are too expensive to realize in reality or at all not possible. If all subsystems are inside single company, how it was in BroSAnT case, it is easier to get information and feedback from the subsystem supplier. But it is more exclusion as rule.

The parametrization of model is very significant for simulation building according this concept from one side. From another one, essential knowledge about the subsystem is very important. The parameter set says very much about what is the most important for component from view as participant in system cooperation. Some companies are active by simulation usage, other make accent on testing methods or rely on own experience. The companies, which supplied such parts like seal, simulate by means of FEM the elastic properties to get the necessary pressure profile for sure sealing. But there is no simulation activities by them during the time that glass goes up or down. The friction, which is the most responsible for dynamic behaviour, is up to now not in focus of their interest. The frictional properties of seal are very strong dependent from climate, thermal and assembling conditions. It makes the formulation of problem more difficult.

If only single parameter is in input unknown, it can be found on the base of comparison simulation result with measure some value (parameter identification process). Unfortunately, the case single unknown parameter is more exclusion as rule. It is needed high proficiency to proper model parametrization.

Measuring methods, in anti trap actions, play very important role and have the big influence on process of pinch itself. Real measurings can be make if only the whole object exists already as real hardware. The changes in technological process of manufacturing or assembling the door can lead to new measuring cycle, because of they serve as base for firmware calibration.

There are almost always the both analog and digital parts in the system simulation of mechatronics device. VHDL AMS simulators have two cores: one for digital and an another for analog evaluation. The language WL gives the possibility to proceed the events in it. But the combination of analog and event parts together is task of model developer.

9 Summary

The simulation of mechatronics devices requires the using system of approach to problem. An universal simulation does not exist, because of every simulation delivers the answers on technically correctly formulated questions. The subsystems from different domains are necessary "bricks" to build system simulation. These component models are also dependent upon formulated problems. The features, which are interesting for one problem, can be not useful at all for another

There is big gap between modern engineering and industrial science at present. The complexity of tools makes the user full helpless by usage of it. It would be developed the universal simulation tool from point view of the tool developer. In the same time, the main task the simulation engineer is quickly to give answer at industrial questions but no rather investigate of power of the tool which can do all. The trust to "universal" tools is inverse proportional to complexity of tool. The great example for it is progress on development of operational systems for PC. The mechatronics device is the best possibility to learn how can be coped the complexity of real system.

The most important rule of system simulation is "all what for problem is needed and nothing else!". Consequences of this rule is clear separation the interests on level subsystem and system. Only integration engineer can formulate correctly the requirement to simulation on system level. The questions like who and where should such simulation be created, maintained are remaining open in modern industrial structure. It can be seen the trend and interest to system understanding, but every domain has its accent at own product. The constantly rising complexity of integrated parts in system leads to growing interest to technical analysis on system level. The system simulation can help really by that. The system simulation is useful at early development phase to assure the concept. The system simulation will been having place in near future at some service companies offering the testing of mechatronics concepts. The certification of components of mechatronics system will be reason for supplying the models of subcomponent of system level. It will be not reasonable to start the mechatronics project without virtual testing for proper functionality of device. Such approach is already approved in domain of electronics. To sell the subcomponent, a company will be forced to deliver functional model at system level. The such testing is not full warranty of project success however it is better protection of technical solution than it is happened at present.

More dynamics brings essential changings in methods of analysis the system. "Analysis of curvers" will replace the "analysis of numbers". For effective system analysis, it is required more analogies between electronics and mechanics domains. It will bring the understanding of system at more higher level.

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