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Definition of a Configuration Module for a Concurrent Design Facility

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Abstract

A CDF is an advance design installation, equipped with a network of computers, multimedia devices and software all interconnected to each other. It allows to implement the Concurrent Design (CD) to the project development; specifically for the space missions. This methodology consist of a design style based on the continuous flow of information, previously defined as design parameters, among all the space subsystems. This information is exchanged between all users using a database, so information is continuously updated.

The configuration of a satellite refers to the location of the different equipments, hardware and components in the primary structure. The definition of the configuration should be developed at the same time as the rest of the subsystems are defined. However, commonly in designs that are made in a CDF, the configuration used to be shifted until the satellite design has been fully defined. This causes that at the final stages of development, especially for small satellites, problems about the positioning and the available free space arise. Discovering that a certain component does not fit inside the satellite or that there is not enough external surface for some equipment are typical errors that appear if a correct design of the configuration has not been made.

This module allows creating a simplified CAD model of the satellite with all the necessary equipment to define the configuration in a very simple way. Based on Microsoft Excel® and connected with Dassault CATIA®, the module automatically create a dummy model of all the components, with the proper properties (volume and mass). It provides the user a complete equipment list and the values of the centre of gravity (C.o.G.), as well as the inertia matrix, once the configuration have been defined.

1. Introduction

1.1 Introduction to Concurrent Design Facilities

A Concurrent Design Facility or CDF is an advanced design facility, equipped with a network of computers, multimedia devices and various installed and interconnected software tools. This configuration allows implementing a Concurrent Design (CD) philosophy to the development of space missions.

The CD methodology, sometimes called as Concurrent Engineering (CE), consists of a design style based on the continuous flow of information. This information is transmitted in the form of previously defined parameters and values, among all the different subsystems design parameters that form a space mission. If any update that affects other subsystems occurs, the system transmits and modifies the information in the database of all the linked computers. In this way, this design method saves time avoiding many errors due to changes in the design that are not communicated by the responsibles. The CD methodology implies an iterative design, in which the flow of information is worked on until a first iteration is achieved. Each of these iterations are closed when the requirements of the mission are met. Once this has been achieved, a new iteration is carried out, modifying the necessary aspects so that an optimization of the previous iteration is achieved, whether of size, cost, mass… Once the iterative process has been completed, the results are studied to verify the viability of the project (phase 0 and phase A of the project).

Among the main advantages of Concurrent Design, specifically of its application in the field of space missions, it have to be highlighted the time reduction necessary to obtain relevant information to verify the feasibility of a complex mission (such as the total power required, the volume or the preliminary cost of the mission). By applying the Concurrent Design in a CDF, the communication between specialists from the different subsystems improves considerably, since they are all in the same place and at the same time. A demonstration of this time reduction lies in the evolution of ESA's preliminary analysis times: more than twenty years ago, the study time was between six and nine months, while currently it is between three and six weeks [1].

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Nowadays, the Concurrent Design is a methodology that only applies to preliminary phases, although space industry plans to expand its use to all stages involved in the development of a space project.
ESA established a CDF in ESTEC in 1998 and since then, it has developed a growing activity around it, using it in multiple mission studies, such as the Solar Orbiter satellite or the ExoMars mission. They have also been developing a set of own tools, the OCDT [2], a set of software tools developed by student to design the different subsystems in a CDF. Other institutions such as NASA also use this methodology and have their own concurrent design facility.
The IDR/UPM Institute (University Research Institute of Microgravity “Ignacio Da Riva”) from the *Universidad Politécnica de Madrid* (UPM) is a research, development and training centre oriented to space science and technology. It was founded in 1974, under the direction of the professor Ignacio Da Riva (1930-1991) with the initial name of LAMF/ETSIA; but it was not until 1998 when it was consolidated as an official research institution associated with the UPM.
Over the years, the IDR/UPM Institute has worked on many space projects [3], such as the Solar Orbiter [4] [5] or the Sunrise telescope [6]; and it has collaborated with large space institutions such as the National Aeronautics and Space Administration (NASA) or the European Space Agency (ESA). However, among all the space projects developed by the IDR/UPM Institute, one of the main milestones was the development, launch and operations of the UPMSat-1 and UPMSat-2. They are two university and scientific satellites whose main mission was the demonstration of the capacity of the UPM to design, develop, build, test, integrate and operate a satellite. These satellites were developed with modest features, while keeping in the execution of the mission all the complexity of a complete space system [7] [8] [9].
The IDR/UPM currently has its own Concurrent Design Facility at the Montegancedo campus. This facility is being updated and utilized at an increasing rate, using as a base the tools developed by the ESA mentioned above, as well as an own set of design modules and a database based on Microsoft® Excel®. These design modules allows the creation, modification and sharing of different design parameters. An image of the CDF of Montegancedo can be seen in Figure 1: a set of computers connected to each other in which each one is developing, individually, a main subsystem of the mission and transmitting information to the rest of the subsystems through the database.

Figure 1: Concurrent Design Facility (CDF) at the Montegancedo Campus, where it can be seen the equipment connected to each other with different work interfaces.

The current objective of the CDF is to carry out space projects in which multiple design options are evaluated simultaneously, in the initial phases (phase 0 and phase A). Therefore, it is needed to have simplified models of the systems to be studied, which allow these analyses to be carried out. The engineers working in the CDF use the design models, sharing and updating different inputs and outputs respect to each others. These models have been established as design modules depending on the different subsystems that coexist in a mission; thus, it would have a module belonging to the attitude determination and control subsystem, another of the communications subsystem… These modules can include theory and/or mathematical formulas to stablish a preliminary design of the correspondent subsystem, or even include connexions to an external specific design software, depending on the concrete subsystem.

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1.2 Introduction to the configuration of a satellite

The configuration of a satellite refers to the arrangement of the different components in the primary structure. That is the reason why most of the mechanical requirements derive from the satellite configuration, which can affect decisions as fundamental as the type of launcher that can be selected, depending on the spacecraft centre of gravity or its size.
Before defining a preliminary configuration, it is necessary to solve some issues related to the design process of the other subsystems involved, such as the satellite control method, the type of communication to be integrated, the need for a propulsion system, the total power required, which determines the necessary area of solar panels and the size of the battery… In the temporal design sequence of the CDF modules, which is included in Figure 2, the configuration module would be placed as the last subsystem to begin designed, once the other subsystems are relatively defined. It should be highlighted that this scheme is the one that includes the sequence of execution of the different modules for the system formed by the tools developed by ESA, so for the modules developed by the IDR, the sequence does not have to be the same. Although, it can serve as a base to place the configuration module.

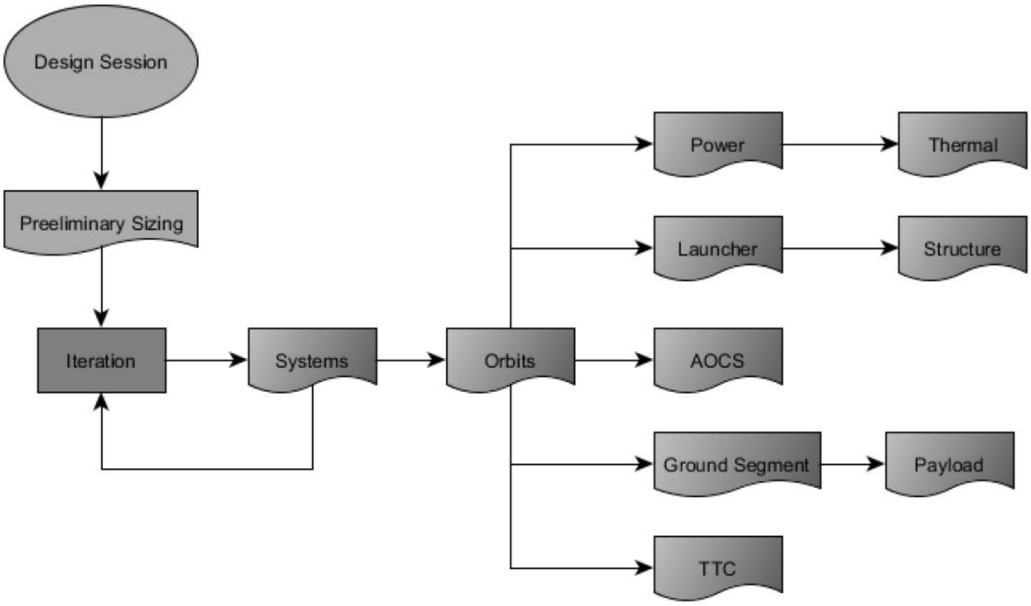

Figure 2: Scheme of the execution sequence of the modules developed by ESA.

The first step in designing a satellite, once the high-level requirements have been identified, is to define, at least in a preliminary way, the orbit and the functions that the payload must perform. This also includes the different mechanical and electrical properties: the mass, the size or power consumed. Normally these estimations are made in a statistical approach based on a collection of data from previous missions. This allows reducing the list of possible launchers, from which a minimum envelope can be obtained. The selection of a launcher originates a selection of the maximum size of the satellite and introduces some limitations of the centre of gravity.
The next step is to define the components that may affect the most to the satellite properties, either by mass, size or other special characteristics. Once the most critical components from each of the subsystems have been defined, a preliminary list of equipment can be completed. This list includes information such as quantity, size and mass of all different equipment. At this point in the design of the configuration, it can be foreseen how will be the required input parameters for each of the subsystems. With this list, together with the envelope of the launcher and the fields of vision of the optical and communication elements, and including the primary structure obtained from the structure subsystem, the definition of the satellite configuration could be started.
Regarding the outputs of the module, the aforementioned list of equipment is a first step to define all the possible information that can be obtained from the configuration module. In this list all the necessary information must be included to be able to define, at least physically (shape, mass, number, position ...), each one of the equipment included in the satellite.

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2. Design of a new project methodology application

ESA has adopted the next definition for the Concurrent Engineering [10]: "Concurrent Engineering (CE) is a systematic approach to integrated product development that emphasises the response to customer expectations. It embodies team values of co-operation, trust and sharing in such a manner that decision making is by consensus, involving all perspectives in parallel, from the beginning of the product life-cycle". Essentially, CE provides a collaborative, co-operative, collective and simultaneous engineering working environment.
When a space project starts at the CDF, the first step is to define completely the mission. One of the next options must be followed, depending on two different situations:

- If the client has provided the requirement list, all these requirements must be check in order to understand and assign them to one or several disciplines (all the subsystems defined in a satellite).
- If the client provides a description list of the properties that the satellite must fulfil, the nominal requirements must be extracted from this list by analysing the description of the mission.

The next step is to create and coordinate the teams that must work on the satellite design depending on the defined requirements. The teams shall be defined depending on the different subsystems involved in the project (e.g. the attitude determination and control subsystem, the structural subsystem, the communications subsystems…).
The main objective of the CE process is to ensure that the study meets the customer requirements within the time and cost assigned. The process make the most efficient and effective use of experts and their tools in order to create a design. An important challenge for each team is to develop a process that is consistent and repeatable, but flexible enough to allow the necessary changes during a CDF study/session. Given that the members of a CDF team generally vary according to the studies, it is important to have consistent processes in order to generate easily traceable results and reduce the variations in the output products of the study. It is not required for the process to be the same in the concurrent teams of different centres, but it is necessary to define the interfaces between the different teams that carry out distributed collaborative design sessions, similar to the interface agreements between subsystems.
A consistent systematic process is essential to reach a conclusion and finalize a design (including all the documentation generated) in an allotted time. The individual secondary steps differ in response to the needs of the customer and the requirements and composition of the individual CDF teams. The scheme shown in Figure 3 captures, at the highest level, a representative process for a design study sequence. This sequence begins with the customer initial mission concept and goes to the final products. The details of each step can vary between the CDF teams, but the main steps are still quite similar. The amount of time it takes to complete a particular step or study can vary from days to weeks or months, depending on the level of detail of the study or the complexity of the mission concept.

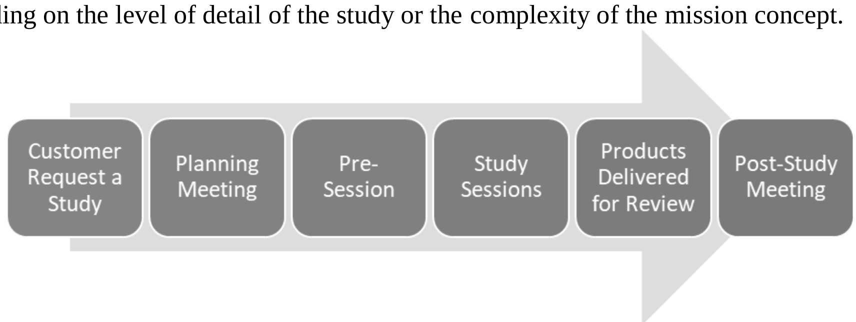

Figure 3: Typical Concurrent Engineering Process.

During the development of the different design modules, projected for the application in the CDF, it is intended not only to design the configuration module itself, but also to implement a new work methodology that represents an advance in terms of systems engineering or concurrent design.
Currently, large amounts of management methodologies used by a number of companies are in development. Agile methodologies [11] have been increasing these days, due to its versatility and capability to admit changes throughout the project time. Agile system engineering practices are well-established methodologies in software projects and are now being explored and studied to be applied in complex hardware projects. These practices permit a flexible and development working environment while allowing risk uncertainties to be managed in a disciplined manner. This methodology will serve as a basis to generate in the future a proper work method adapted to the modules developed for the IDR Concurrent Design Facility.

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3. Design parameters for the configuration module

The first fundamental subsystem to study is the payload, which is the starting point for the design of the satellite configuration, and usually includes the heavier components. Once the payload requirements have been identify, especially those that may affect the spacecraft configuration, the next steps refer to those other subsystems that may require having a certain position for their operation. An example of this effect could be the communication subsystem antennas, which must be pointing to ground stations in order to establish a communications link. The disposition of the Sun, Star or Earth sensors from the attitude determination and control subsystem must be chosen according to their operation. Another example is the arrangement of the solar panels, which must be such as to provide the necessary electrical power for the operation of the satellite and all its components.
From each one of the subsystems, the most critical components for the configuration must be defined first, being those that have less effect on the configuration, either by mass or by size, defined later. All the information related to the importance of the configuration when designing a satellite, the configuration definition itself, as well as the Figures 4 and 5 shown in this chapter have been obtained from [12].

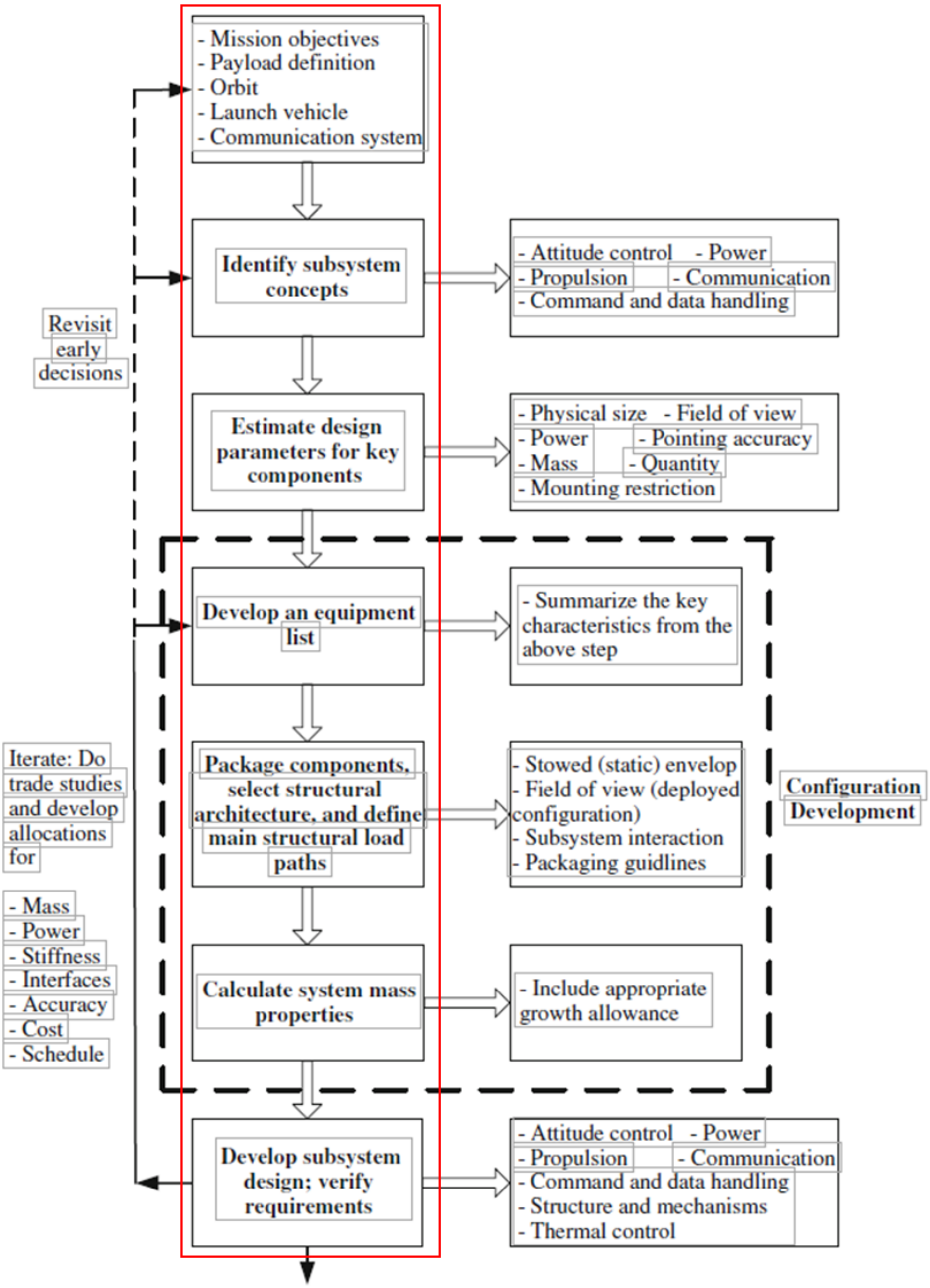

Figure 4: Diagram of the general steps for defining the configuration of a satellite [10].

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In Figure 4 it can be seen a general process of defining the configuration of a satellite. Due to the unique properties and requirements of each mission, a single process cannot be applied to all satellites, as each one will have a set of requirements specific to the project and the objective of the mission, but it can provide guidelines to be taken into account to define the key aspects that affect a typical configuration.
In this figure, the main design sequence has been highlighted in red, while the information from the right of the boxes includes clarifications of the parameters or subsystems involved in these design steps. In addition, the design steps of the satellite configuration are shown in a solid black box. As previously mentioned, the steps defined are:

- To define the requirements based on the objectives of the mission: the orbit, the payment charge…
- To define the main components of the subsystems, to estimate the design parameters of the main components and to position them in the primary structure.
- To calculate the mass and properties of the system.
- To check that the requirements are met.

Once the steps described in the scheme have been carried out, the different outputs obtained from this process are:

- The satellite configurations, both in folded and unfolded situations, if any.
- A list of equipment including quantity, mass and size for each component.
- The definition of the location of all satellite components based on a reference system and the properties of mass, inertia moments and centre of mass of the satellite as a whole.

From this part of the study, a first outline on the configuration module outputs can be obtained, as well as the subsystems that are affected by the different choices made during the configuration design.
If an emphasis is placed on the so-called “critical components” of each of the subsystems that define a space mission, it is observed that in general they refer to components that require a specific location in the satellite or a certain orientation. Most of these components are located either on the outside or on the inside limits of the satellite, so that a part of the component can protrude outside, if required. Other components could require a specific situation because of its size or its mass. A specific case is that of solar panels, since depending on the requirements it may be necessary for them to be deployable, which would include an extra configuration, in a deployment situation. Other components that may require deployment are those that have mechanical components. An example of the later situation is shown in Figure 5.
From this idea, the components are categorized as "external" or "internal" in the configuration module. To measure whether or not the elements fit into a satellite, the internal components that are to be included must be looked at, while the external ones will go on the external surface of the structure, being the total external surface a critic design parameter.

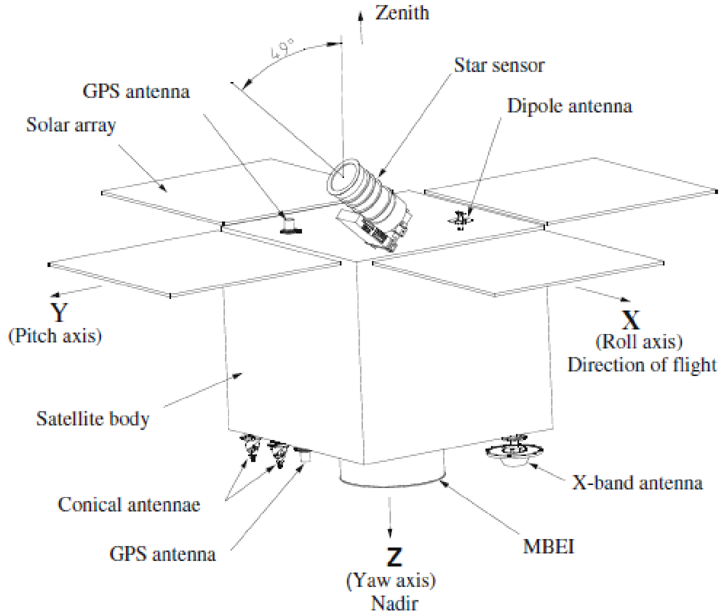

Figure 5: Typical external configuration for a satellite in its deployment configuration [12].

It should be noted that there are some general positioning criteria that apply not only to a subsystem or an equipment itself, but to anything who has specific properties or meets a set of requirements. A general criterion that must be considered refers to the symmetry of the satellite and is applied mainly to equipment that has a considerable mass.

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Maintaining the symmetry of the satellite is usually beneficial for the design of the configuration, so in general the components are usually placed so that the centre of gravity remains as close as possible to the symmetry axes of the satellite. That is why normally the components of greater weight are always located closest to the vertical axis of symmetry.

3.1 Subsystems design parameters

One aspect to be considered is the set of input parameters of each of the subsystems, that is, the number of parameters that are needed to define these subsystems, in terms of their configuration. The main values, according to the configuration criteria, that define an equipment are its number, its size and its mass.
This is why the mentioned parameters were defined as inputs for each subsystems: number, mass and dimensions; apart from the possible variants that could have some of the components, as it is the case of the actuator for attitude control, which can be of inertial or magnetic type.
These variants allow the designer to configure the form of the equipment within the module, so that depending on the component and the subsystem to which it belongs, several design options that affect the volume and shape can be selected:

- Related to the communications subsystem, the user can choose between including patch antennae or wire antennae. He also can choose between a transceiver or a set of receiver and transmitter. These options are shown in Figure 6.

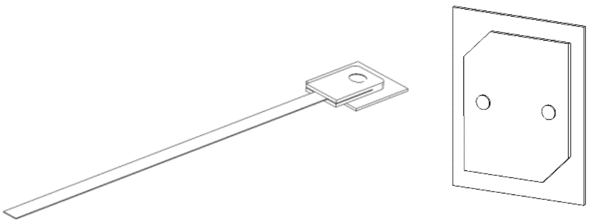

Figure 6: Design options for the communication subsystem antenna: cable (left) or patch (right).

- Defining the ADCS (Attitude Determination and Control Subsystem), the user can select a set of magnetometers or star-trackers for the sensor equipment (Figure 7). Related to the ADCS actuators, the users can choose between magnetorquers or reaction wheels (Figure 8).

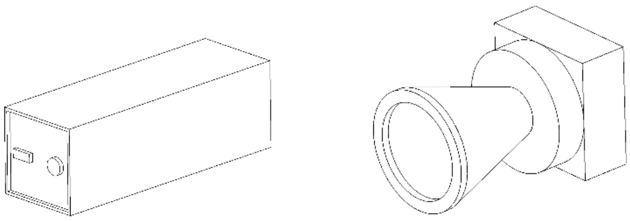

Figure 7: Design options for the ADCS sensors: magnetometer (left) or Star-tracker (right).

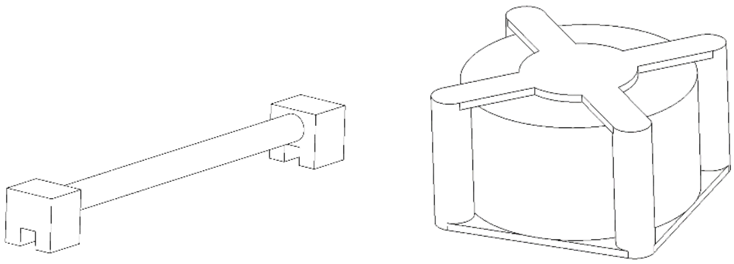

Figure 8: Design options for the ADCS actuators: magnetorquers (left) or reaction wheels (right).

- At least, during the definition of the payload, once can select between an experiment box or a camera-type experiment (Figure 9).

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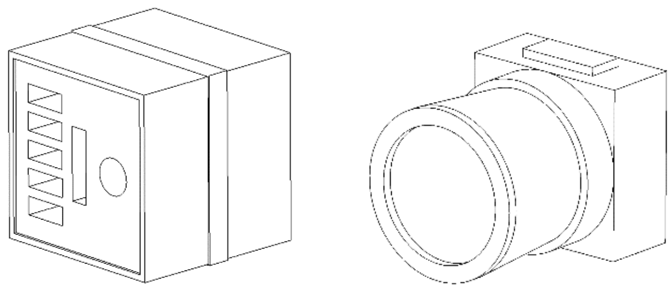

Figure 9: Design options for the payload: experiment box (left) or camera-type (right).

Once the main components of each subsystem have been defined, a study must be made for each of the subsystems, checking if there is any other element that, by size, mass, position or any other characteristic, could have a significant impact on the configuration of the satellite. If they exist, these devices must be defined as auxiliary components.
In order to define these auxiliary components, a set of parameters necessary for the definition of the properties must be introduced:

- Name of the component.
- Type of configuration, external or internal.
- Subsystem to which it belongs.
- Mass of the component.
- Dimensions, broken down into height, width and depth.

These components will be simulated as boxes of the dimensions indicated (Figure 10), with the corresponding weight and with the colour associated to the subsystem that has been indicated. These options allow the user to include in the 3D model and the equipment list any relevant equipment from the satellite, even if it is already predesigned in the module or not.

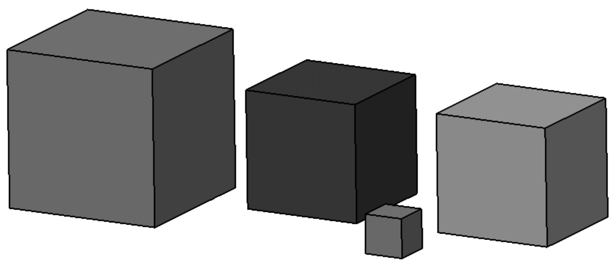

Figure 10: Example of the generated three-dimensional models that simulate the auxiliary components.

3.2 Configuration design parameters

Once all the equipment related to the different subsystems have been defined, there are still some parameters related specifically to the satellite configuration. One of the aspects that influence the design of the configuration, which is independent of the rest of the subsystems, is the number of trays. The user, according to the number of components as well as the requirements of the mission must define this parameter.
For this, the number and the shape of the trays must be generated according to the structure provided (Figure 11).

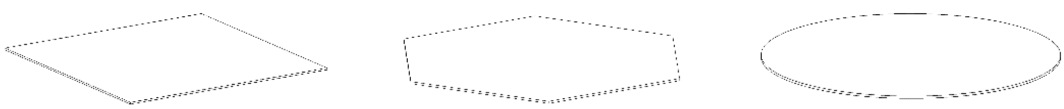

Figure 11: Possible selectable shapes of satellite trays: square (left), hexagonal (centre) and circular (right). These will be defined with the corresponding form of the primary structure.

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4. Configuration Module for a Concurrent Design Facility

The configuration module allows the user, in an Excel® interface, to generate a complete CAD model with the satellite structure and all the components and equipment with a relevance in the configuration (size, mass, special location…). In order to achieve that, all the design parameters discussed in Chapter 3 must be implemented in the program code. The following list includes all the subsystems and its principal equipment that have been implemented in the configuration module:

- **Communication subsystem**: Antennae and transceivers.
- **Propulsion subsystem**: Engines and propellant tanks.
- **Power subsystem**: Battery and solar panels.
- **Thermal subsystem**: Radiators.
- **ADCS**: Actuators and sensors.
- **Payload**.
- **Structure**.

The next steps are related to the satellite configuration design using all this information generated by the module. It can be seen in the next Table 1 the sequence that the user must follow to achieve a proper satellite configuration using the CDF module. This sequence includes the closed loop that occurs with the thermal subsystems: The thermal responsible needs the complete configuration in order to simulate the thermal behaviour of all the components, but the final configuration must include the thermal components.

Table 1: Simplified sequence of the design process of the module configuration associated with it.

Steps	**Actions**
1	All the input parameters of all subsystems are collected (except for thermal control) and its components are defined.
2	All the defined components are included in the 3D model and positioned relative to it, depending on the position constraints.
3	The positioning information and the defined number of trays is sent to the thermal control module, which will perform the calculations that determine the necessary components.
4	This documentation is imported from the configuration module, including in all the positioned components those belonging to the thermal control.
5	The requirements are checked again: if they are met, the design is closed. Otherwise, another iteration is carried out.
6	The complete satellite model, including the components belonging to the thermal control subsystem, is sent to the advanced structural calculation module.

4.1 Configuration module operation and functions

Once the user has defined all the equipment relevant to the satellite configuration, the software automatically generates a CAD model using all the properties defined in the module. A capture of the CAD design software including the initial result generated by the configuration module is shown in Figure 12. As it can be seen, the components are all located in the centre of coordinates imposed for the model, which is always located in the centre of the lower base of the satellite. The trays and the main structure are always located according to these coordinates. They have a 6 degrees restriction, so they are always placed in the same point after updating, being the movement allowed only to the components.

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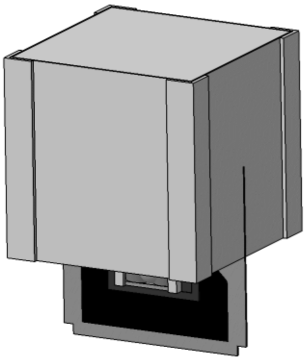

Figure 12: Result of the generation of the CAD model. This includes the primary structure, the trays and all the equipment defined in the list of components.

At this point, the work of the configuration module consists of positioning the equipment in the satellite structure, making a distinction between internal and external components. In addition, the specific constraints of the components and the mission requirements must be considered. An example of these restrictions can be the antennas, which may have to point in the -Z axis when a spin control is defined.

During the development of the equipment positioning, and due to the iterative nature of the concurrent design, modifications may arise in the model: components that must change their dimensions, equipment that must increase in number, components that are no longer included... If the user generates the new list of components and activates the generate model button, all the components, both new and existing ones, will return to the original position, the imposed coordinate centre, and all restrictions, in case of having generated them, they will disappear. In order to fix this, a button to just update the model has been included. If any modification is made during the development of the positioning of the equipment, it is enough to modify the components that must be updated, either main or auxiliary components, and activate the "Update Model" button. This button does not modify any component but those with the changes and it does not modify any equipment position. Using this option, the model is updated without losing the progress that has been made in the equipment positioning: in the case of introducing new equipment, these will appear at the origin of coordinates, without the rest of the components being modified; in case of modifying the properties of a component, it will be automatically updated, without modifying its position. Finally, in case of eliminating any component, for example, an antenna, the last antenna generated will be eliminated, while the rest of the components will keep their position.

Finally, the result of the design of the configuration for an example of small satellite, both from the exterior and the interior, has been included in Figure 13.

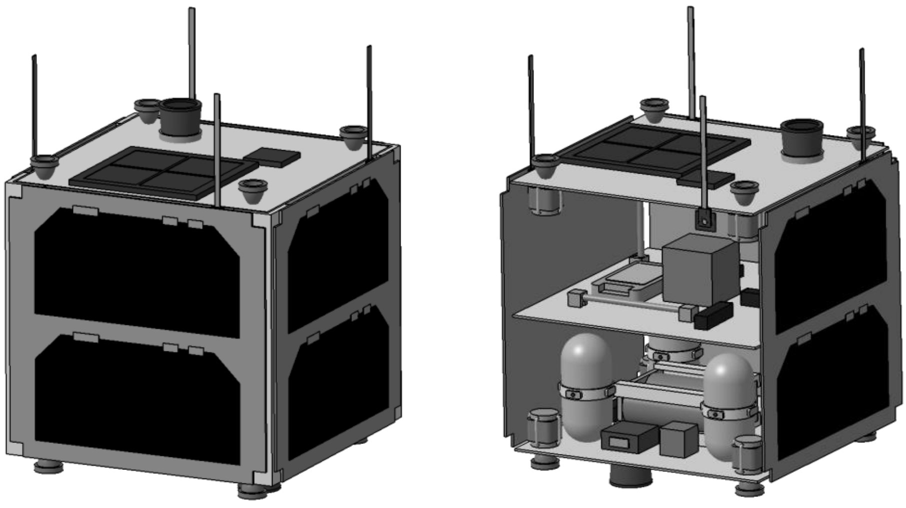

Figure 13: Result of the design of the configuration for a small satellite: external view (left), and internal view (right).

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4.2 Configuration module outputs

When the configuration design has been completed, the user can return to the Excel® file from the CAD software to complete the operations that the configuration module allows. When the model is generated/updated, an updated list of components is created, which includes all the information relevant to the definition of the configuration (Figure 14): equipment name, type, subsystem, mass, volume, external configuration or internal and tray in which it has been positioned.

SATELLITE COMPONENTS LIST								
Component	Type	Subsystem	Mass	Units	Volume	Units	Configuration	Position
Antenna	Wire	Communications	1	kg	400,00	mm^3	External	Tray C
Antenna	Wire	Communications	1	kg	400,00	mm^3	External	Tray C
Antenna	Wire	Communications	1	kg	400,00	mm^3	External	Tray C
Antenna	Wire	Communications	1	kg	400,00	mm^3	External	Tray C
Transmitter	-	Communications	2	kg	3500,00	mm^3	Internal	Tray B
Receiver	-	Communications	2	kg	3500,00	mm^3	Internal	Tray B
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray C
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray C
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray C
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray C
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray A
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray A
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray A
Engine	-	Propulsion	3	kg	2000,00	mm^3	External	Tray A
Propulsant tank	-	Propulsion	4	kg	16000,00	mm^3	Internal	Tray A
Propulsant tank	-	Propulsion	4	kg	16000,00	mm^3	Internal	Tray A
Propulsant tank	-	Propulsion	4	kg	16000,00	mm^3	Internal	Tray A
Propulsant tank	-	Propulsion	4	kg	16000,00	mm^3	Internal	Tray A
Solar panel	Fixed	Power	5	kg	10000,00	mm^3	External	
Solar panel	Fixed	Power	5	kg	10000,00	mm^3	External	
Solar panel	Fixed	Power	5	kg	10000,00	mm^3	External	
Solar panel	Fixed	Power	5	kg	10000,00	mm^3	External	
Battery	-	Power	6	kg	25840,00	mm^3	Internal	Tray A
Radiator	-	Thermical	7	kg	5000,00	mm^3	External	Tray A
Radiator	-	Thermical	7	kg	5000,00	mm^3	External	Tray C
Sensor	-	AOCS	8	kg	500,00	mm^3	Internal	Tray B
Sensor	-	AOCS	8	kg	500,00	mm^3	Internal	Tray B
Sensor	-	AOCS	8	kg	500,00	mm^3	Internal	Tray B
Sensor	-	AOCS	8	kg	500,00	mm^3	Internal	Tray A
Actuator	Magnetic	AOCS	9	kg	1250,00	mm^3	Internal	Tray A
Actuator	Magnetic	AOCS	9	kg	1250,00	mm^3	Internal	
Actuator	Magnetic	AOCS	9	kg	1250,00	mm^3	Internal	Tray B
Experiment	Camera	Payload	10	kg	4500,00	mm^3	External	Tray A
Experiment	Camera	Payload	10	kg	4500,00	mm^3	External	Tray C
Ebox	Auxiliar	Power	50	kg	8000,00	mm^3	Internal	Tray B
Experiment	Auxiliar	Payload	50	kg	1000,00	mm^3	Internal	Tray A
OBC	Auxiliar	Communications	50	kg	3375,00	mm^3	Internal	Tray B
Radar	Auxiliar	AOCS	50	kg	450,00	mm^3	External	Tray C

Figure 14: Equipment list generated by the configuration module including all the equipment and its properties: equipment name, type, subsystem, mass, volume, external or internal configuration and tray in which it has been positioned.

In addition, the module includes two additional operations that allow completing the information provided to the user. One of them is a list where the weight is collected by tray, so the mass distribution can be studied. The second set of information comes from the 3D model and provides the values of the coordinates of the centre of gravity of the entire satellite. The C.o.G. is referenced to the coordinate system defined in the model (located in the centre of the satellite's lower tray) as a function of weight and of the position of each one of the components. In addition, the satellite's inertial matrix is calculated and included.

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5. Conclusions and future work

From all the information gathered about the design of a satellite configuration, one of the first points that must be emphasized is the importance of the design of the satellite configuration itself. The configuration may affect to the correct fulfilment of the missions requirements, while the operation of most equipments depends on the position and orientation, such as the solar panels, attitude control sensors or antennae.
The minimization of the mass is one of the most common requirements in space project, since it has a direct impact in the total budget of the mission. The distribution of the equipments and, therefore, the mass distribution in the satellite affects, as mentioned in this paper, design values as important as the coordinates of the C.o.G., which can limit the use of a launcher.
Another requirement that highlights the importance of the configuration design is the total volume of the satellite. Due to some aforementioned factors, as the satellite total dry mass or the total volume envelope curve provided by the launcher systems, the satellite internal volume or the total external surface are critic design values. A good configuration design allows optimize the total volume in order to minimize it. That is why a correct distribution of the different equipment is of vital importance when designing a satellite.

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