CABIN ELECTRICAL INSTALLATION FOR BWB AIRCRAFT

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OVERVIEW

This paper presents a conceptual study for the electrical cabin installation in the VELA2 Blended Wing Body aircraft. The increasing amount of cabin configuration options together with the complexity of the requirements for the electrical installation lead to a time–consuming and costly customization process for modern passenger aircraft. The goal of this concept is to allow a quick and cost–efficient adaptation of the electrical cabin installation to the respective customer layout of a Blended Wing Body aircraft. This is made possible through the introduction of cabin main routes that cover a large majority of all cabin relevant electrical bundles. An analysis is performed to identify the main cost drivers for the cabin electrical harness installation. The majority of these use similar route paths, which have been grouped to minimize the amount of harness paths required. To cover the routings required to supply the controlling equipment and the majority of the customized routings, predefined route paths are used. Route path definition is also performed along all of the monument flexible zones, so that any monument position inside of the flex zone can be connected without further effort.

1 INTRODUCTION

Aside from improving, among other things, the operating cost and fuel efficiency, two major aspects during the design of new passenger aircraft are: passenger comfort and the adaptability of the cabin to the airlines' needs.

With flight times easily spanning beyond six hours on long–range flights, airlines want to offer their passengers an increased amount of comfort to relieve the stress created by such long travel on board an aircraft. This includes the provision of in-seat video (even in economy class); the introduction of mood lighting; electrical window shade; and good catering options, to name a few examples.

On the other hand, as operating cost increase due to petrol prices and newly introduced airport security measures, it is essential for the airlines to maximize the utilization of their seating capacities. The demand for first, business and economy class seating differs between routes. Therefore, the airlines want to have either aircrafts with a diverse number of layouts optimized for various routes or they will possibly need to adapt the number of seats in each class.

The demands for both the increased comfort and improved flexibility have a huge impact on the cabin electrical harness installation. To meet the requirements for the passenger comfort, the amount of electrical devices in the cabin increases dramatically. At the same time the electrical connection for all of the cabin devices needs to be highly flexible.

These requirements cannot be met using the classical customization process, during which all bundles related to flexible equipment[1] are routed from source equipment to each cabin device after layout freeze. This paper shows a possible solution for an electrical harness installation, which has the potential to meet these requirements.

2 VELA2 CABIN FLEXIBILITY

2.1 The aircraft VELA2

The VELA2 is an aircraft study for a <u>V</u>ery <u>E</u>fficient <u>L</u>arge <u>A</u>ircraft. It belongs to the <u>B</u>lended <u>W</u>ing <u>B</u>ody aircraft whose outer contours have no strict separation between fuselage and wing and where the fuselage is responsible for a large portion of the aircraft's total lift. This configuration allows for a huge improvement in aerodynamic efficiency, since the interference drag at the wing–fuselage transition is basically eliminated and since the fuselage is also being used for lift generation. More details on the performance data of this aircraft are given in [3] chapter 2.

The VELA2 is equipped with four engines, which are mounted under the wings. To ensure directional stability it will be equipped with two vertical stabilizers mounted in the rear on the left and right side of the passenger cabin (See fig. 1 and fig. 2). The VELA2 cabin is integrated into the central part of the BWB aircraft with an additional pressurized skin, which is fully enclosed by the aerodynamic outer skin. The inner skin is in the shape of four tubes connected to each other; this is required in order to allow the structure to maintain the cabin pressure.

[1] equipment position can be chosen by the airline

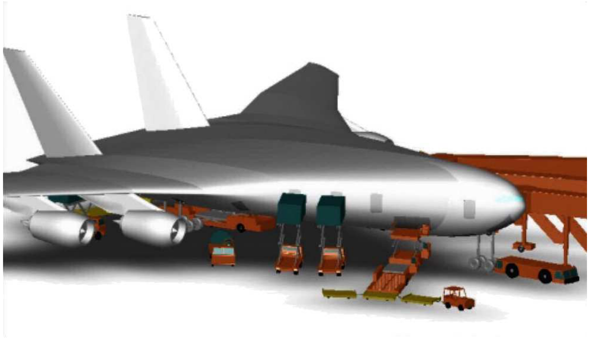

FIG. 1: An outside view of the aircraft VELA2.

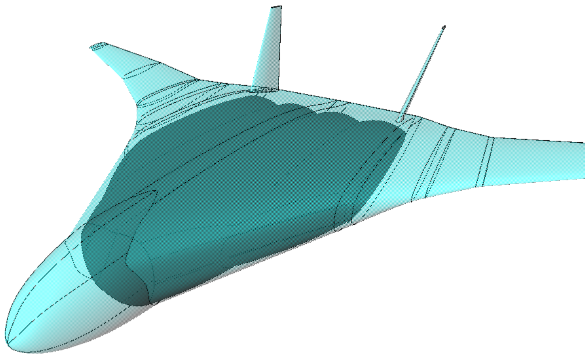

FIG. 2: The pressurized skin containing the VELA2 cabin.

2.2 Flexible Cabin Layout

The cabin layout shown in figure 3 was taken from [2], chapter 6.3.1 and used as reference for this study. It represents a standard three–class layout with flexible areas for the monuments between business and economy class. This flexibility allows the airlines to adapt the number of seats in each class to their business needs by choosing the appropriate monument position.

The layout can be divided into four standard–layouts (so–called sub–cabins) with two aisles, each arranged side-by-side. This is a result of the shape of the pressurized skin described above. Doors and emergency exits are only located at the outer walls of the pressurized skin and the layout needs to account for the respective emergency escape paths, especially in order to get from both inner sections to the underwing exits.

The flexible zones are marked with big blue squares in figure 3. The flex zones are only available in cylindrical parts of the cabin. A customer can place the monuments anywhere inside of these flex zones, but must also consider constraints, such as the emergency escape paths. Most of the flex zones are allocated between two different classes. However, there are also two flex zones defined in economy class. They allow for the maximization of the number of seats in economy class by choosing an optimized arrangement between the monuments, escape paths and seats depending on the position of the split between economy and business class as well as the seat pitch.

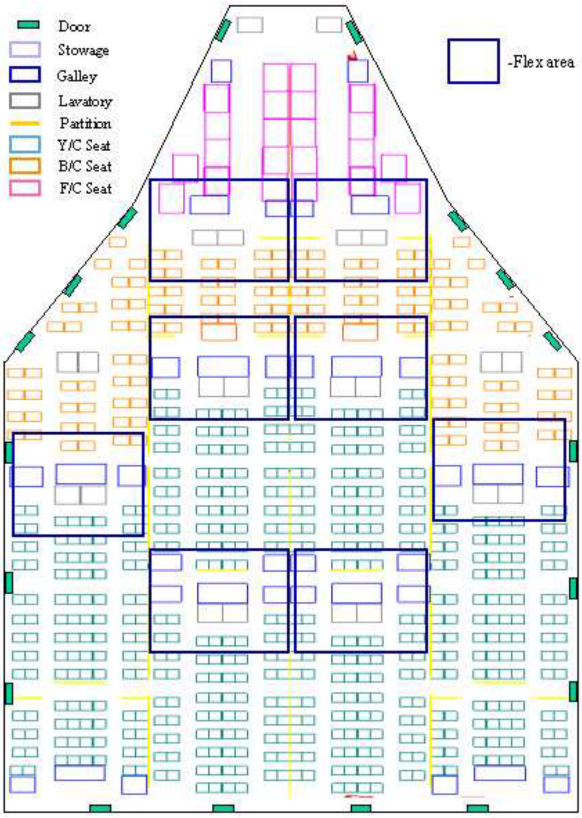

FIG. 3: A VELA2 Three–class cabin layout.

The monument distribution chosen in the standard layout takes into consideration aspects, such as number of passengers per trolley or lavatory as well as the escape path mentioned above. The number of seats, trolleys or lavatories for each class is given in table 1. The amount of passengers having to share one lavatory is 11 for the first class (with the option to use business class lavatories), approximately 17 for the business class and about 41 for the economy class. These values are in the same range as existing standard cabin layouts of current long–range aircraft. The number of passengers per trolley is almost 1 in first class, about 2.7 in business class and approximately 8.3 in economy class. These values are also oriented to current standard layouts.

	F/C	B/C	Y/C	Total
Seats	22	134	496	652
Trolley	20	50	60	130
Lavatory	2	8	12	22

TAB. 1: Properties of the reference layout.

The VELA2 cabin offers an additional challenge on this topic. Due to the wide fuselage, it is not sufficient to consider only the number of passengers per trolley or lavatory. It is also essential to Analise the accessibility for passengers sitting in the different sub–cabins. For example, each passenger must be able to access at least one lavatory without having to switch aisle or sub–cabin. A uniform distribution of the lavatories over the entire cabin is favorable but not always feasible. In this layout, the economy class in the outer sub–cabins has only one lavatory per aisle. It is considerably shorter than the economy class in the inner sub–cabins, which features two lavatories per aisle (see figure 3). The amount of economy–class seats in the outer part is approximately half the amount of seats in the inner fuselage. This leads to 52 economy passengers per lavatory in the outer sub–cabins, whereas in the inner sub–cabins only 36 economy passenger need to share the same lavatory.

Another important aspect is the evacuation of the cabin within 90 seconds. Similar cabin layouts have been analyzed in detail at the HAW Hamburg. The feasibility of an aircraft evacuation in 90 seconds has been proven by analytical means. The results of that study have been recorded in [4], chapter 4.6.

3 CABIN ELECTRICAL INSTALLATION REQUIREMENTS

The electrical installation in the cabin has to fulfill a few sets of requirements each with a different origin. The first set of requirements is driven by safety and reliability aspects. It includes requirements about dividing the installation into different systems, such as essential and non–essential. The segregation of these systems is also covered by these requirements as well as basic principles of installation to protect the bundles from mechanical damage.

The second set of requirements determines the required electrical harness installation. This means, they define, for example which cabin device needs to be supplied by which system categories from which controlling equipment. The supply needs for the controlling equipment itself are covered by these requirements as well.

Further sets of requirements deal with maintenance aspects, installation aspects etc. These will not be treated within the scope of this paper.

3.1 Safety and reliability requirements

3.1.1 System Categories

The electrical harnesses are split into different system categories, in order to ensure a safe function of the electrical installation and to minimize failure propagation. A sensible definition of the system categories relevant for the cabin is given in table 2.

The category “General” covers the biggest part of the electrical bundles required for the cabin with the exception of high–current routes for power supply purposes and routes with an analogous IFE video signal.

System Type	System No.	Route class
General essential	1	1GE
General essential	2	2GE
Gen. non–essential	1	1GN
Gen. non–essential	2	2GN
Galley power	1	1PG
Galley power	2	2PG
Decentr. power	1	1PD
Decentr. power	2	2PD
Analogue video (IFE signal)	-	1A

TAB. 2: System Categories of the cabin electrical installation.

It is subdivided into an essential[2] and a non–essential part; these are again subdivided into systems 1 and 2.

The split into essential and non–essential shall ensure that no non–essential equipment can have any adverse effects on the essential installation. This is especially necessary, as non–essential equipment generally has lower certification requirements than essential equipment. The further split into systems 1 and 2 ensures that the loss of one system does not lead to the total loss of all essential or all non-essential equipment.

On current aircraft, the split into systems 1 and 2 is equivalent to a split into the system installation on the LH and on the RH aircraft side[3]. This definition is not sensible for the VELA aircraft. It would mean, that the sub–cabins on the left hand side would be supplied only by system 1, and the sub–cabins on the right hand side only by system 2. A loss of either system 1 or 2 would lead to a loss of all electrical essential or non–essential functions in both sub–cabins on the affected A/C side. Instead, systems 1 and 2 are used to supply each sub–cabin. Within the sub–cabins, systems 1 and 2 are in principle divided between LH and RH side.

The categories “Galley Power” and “Decentralized Power” contain all bundles with high Ampere–ratings (above 15A.). The division into systems 1 and 2 follows the same rules as discussed for the system category “General”. They are used to supply the power required by the galley inserts (PG–routes) or by the Secondary Power Distribution Boxes (PD–routes). These Boxes replace the former circuit breaker boards. They provide a local power source for cabin equipment such as lighting units. In contrast to circuit breaker boards, the distribution units can provide precise status information about all connected equipment to the central maintenance system. Furthermore, wiring distances to these units are generally shorter than to a circuit

[2]Equipment and devices are essential, if they are needed to ensure the safety of the passengers during the flight or e.g. during an evacuation.

[3]With the exception of some systems, such as emergency illumination, which is only supplied by that system that is connected to the emergency power center.

breaker board.

The last category is "Analogue video" (1A). It contains bundles transmitting the IFE video signal analogously. This category is likely to become obsolete, as in the near future all in-flight entertainment systems will have switched to a fully digital data transfer. The bundles for digital data transfer will then belong to the category "General non–essential". Respectively, the category 1A has not been considered in this study, as fully digital IFE is assumed for the VELA2 aircraft.

3.1.2 Segregation requirements

Segregation of bundles belonging to two different systems is motivated by two different aspects. The first aspect is electro–magnetic compatibility; this means, the distance between the routes must be sufficient in order to avoid electro–magnetic interference. This is especially important if routes with analogous signals or routes with high current ratings are involved.

The second motivating factore is to provide a minimum distance between all bundles in order to avoid arc–tracking in case of insulation damage. The safety distance is independent from the system categories; one inch is considered to provide efficient arc–tracking protection as described in [1], chapter 3.4. This distance is equal to the mechanical requirements for avoiding chafing. It will be dealt with in more detail in the section 3.1.3.

The "General" route categories involve wires with either low current power supply function or with digital control signals. Analogous signals with slow rates of change can also be involved, for example cabin illumination brightness control. Hence, these signals do not generate strong, quickly changing electro–magnetic fields. They are also comparatively insensitive to such fields generated by other sources. As distance between different categories of "General" routes, the mechanical and arc–tracking safety distances are considered sufficient. These provide efficient protection against propagation of errors from one system to another, which is the main motivation of dividing the "General" routes in different categories.

Routes belonging to the category "Power" are completely insensitive to electro-magnetic fields generated by other bundles in the vicinity, because there are no signals whatsoever transmitted within these routes. If the phases of these routes are loaded asymmetrically, they can generate a strong electro-magnetic field that oscillates with the frequency of the alternating current. Respectively, all other routes need to be installed with a sufficient distance to "Power" routes.

As discussed above, the "General" routes are comparatively insensitive to such fields, but an installation too close to "Power" routes can for example lead to oscillation of the cabin illumination. Installing "General" routes three inches away from "Power" routes should be sufficient to avoid this. These values are based on the segregation requirements presented in [1], chapter 3.4.

The last category discussed in this context is the "1A" route transporting an analogous video signal. This route is highly sensitive to external electro–magnetic fields, since the voltage levels of the signal are comparatively low. At the same time, the electro–magnetic field generated by the "1A" routes is negligible. In order to avoid distortion of the video signal, the routes need to be installed sufficiently far away from routes of other categories. in terms of distance to "General" routes, three inches are sufficient, because the "General" routes do not generate a strong electro-magnetic field.

As discussed above, a fully digital IFE system is assumed for the VELA2 aircraft. Digital IFE uses "General" routes for data transmission and the "1A" route is not dealt with any further in the scope of this paper.

3.1.3 Mechanical requirements

The last requirements discussed are the installation requirements in order to avoid mechanical damage to the bundles. For weight saving purposes, the insulation of wires used in modern passenger aircraft is very thin and can easily be damaged. Hence, it is essential to install the cable bundles in such way that:

- the relative movement of the wires within one bundle is not possible,
- the bundle bend radius does not lead to excessive stretching or compressing of wires,
- the different bundles cannot get in contact with each other, and
- that bundles do not come in contact with the structure, other equipment or system installations.

These conditions must be met at all times, considering aspects such as vibrations in flight due to engine imbalance, flight load factors, etc. The slack of the bundle between two supports plays an essential role in this context. The slack allows the bundle to deviate from its originally designed path; due to flight loads and vibrations. The slack can also occur in lateral direction or even upwards. Hence, the respective safety distances are applicable in all directions. The minimum physical separation between two bundles or a bundle and structure or systems installation is one inch. The bundles must be installed in such a way that the one inch distance is maintained even with the applicable slack in the worst possible direction. This is necessary to account for effects that have not been anticipated in the design phase and to provide sufficient arc–tracking protection.

Relative movement of the wires within one bundle is avoided by the use of tie wraps. These are tied around the bundle every three to four inches; thus, fixing all wires and sufficiently inhibiting any relative movement. One side effect of this is a high stiffness of the bundles which leads to an increase of the minimum bend radius. For this study, a minimum bend radius of 5 times the bundle diameter is assumed. A second side effect is the addition of another set of wires to a bundle is a time–consuming process. All tie wraps need to be cut open, the new wires added, and then the entire bundle has to be tied up again. Consequently, the addition of wires to already manufactured wire bundles should be avoided.

The amount of slack that needs to be taken into consideration depends mainly on the distance between two supports. For this paper, the following assumptions have been met: If the distance between two supports is eight inches or less, the slack is negligible. For greater distances, the slack gradually increases up to six inches for the maximum permissible support distance of 25 inches.

3.2 Supplied cabin devices

This concept focuses on the supply of cabin devices installed in the cabin monuments; these are devices installed for example in galleys, lavatories, and stowages. Of course, there are many other devices and equipment that need to be electrically supplied and whose position depends on the cabin layout. As shown in [2], chapter 6, the majority of all customized harnesses are used for the electrical supply of the monuments. Hence, providing a concept that allows quick electrical supply of the monuments will considerably reduce the customization efforts. Furthermore, the routing paths defined for the supply of the cabin monuments can also be used for the supply of other cabin equipment. This way the customization effort for this equipment is reduced as well.

3.2.1 Equipment inside the monuments

Which equipment is installed in which monument depends on a series of factors. The first, is the type of monument. Equipment consuming high amounts of electrical power, such as coffee machines, ovens, or microwaves can only be found in galleys. Hence, the power supply routes, category "PG", are required for galleys rather than any other monuments. Air chilling units (ACU) used for cooling food in the trolleys, are also installed exclusively in galleys. Lavatories and stowages are enclosed compartments that are not permanently occupied. For fire protection reasons, these need to be equipped with smoke detectors. For galleys, smoke detection is not required.

A second factor is the choice of options by the customer. Especially for CIDS[4]–related installations, the customer has a large choice of different options, which are relatively independent of the type of monument. Equipment like Flight Attendant Panels (FAP) or Mini–FAPs belong to CIDS–related installations as well as the handset for communication between different crew members, Additional Information Panels (AIP), Additional Attendant Panels (AAP) etc.

The third factor is installation that is dependent on the cabin layout. "Lavatory occupied signs", "IFE LCD screens" or cameras of the "Cabin Video Monitoring System" (CVMS) are good examples for this. Emergency illumination, for example the "Emergency Floor Path Marking System" is also highly dependent on the cabin layout.

A complete analysis of the equipment installed in the cabin, including the required route categories can be found in [2], chapter 4.5. An example for this analysis is shown in figure 4, which gives an overview over the equipment installed in the galleys of a reference layout (see [2], chapter 5.3.1). The percentages show the distribution of bundles required to connect all equipment of this type installed in galleys. 100% represents all 76 bundles leading to the 16 galleys of the reference layout. The amount of bundles required for each individual galley varies depending on the installation of optional equipment in the galley.

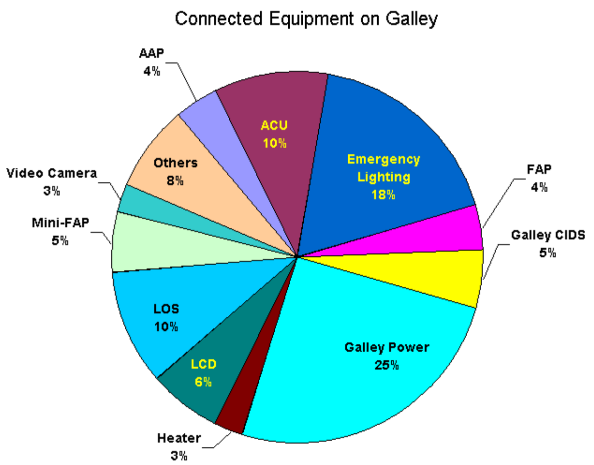

FIG. 4: Distribution of the amount of bundles supplying galley equipment - 76 bundles in total.

3.2.2 Equipment supplying the monuments

Depending on the functionalities of the cabin equipment, they need to be connected to different controlling equipment. As an example, figure 5 gives an overview over the different controlling equipment used to supply cabin equipment in the lavatory.

The percentages show the distribution of bundles leading from an equipment of this type to any equipment in a lavatory. 100% represents all 66 bundles leading to the 15 lavatories in the reference layout (see [2], chapter 5.3.2).

The majority of the supply functions are per-

[4] Cabin Intercommunication and Data System

formed by "Decoder Encoder Units" (DEU), "Secondary Power Distribution Boxes" (SPDB), and "Terminal Blocks" (VT). The VT are used to distribute the power for emergency illumination coming from the "Emergency Power Supply Units" (EPSU).

"Tapping Units" (TU) and "Area Distribution Boxes" (ADB) are used to supply the IFE Video screens mounted on the monuments. The "Area Distribution Unit" controls the cameras of the CVMS. The Flight Attendant Panels are connected in series throughout the aircraft, beginning at the CIDS Directors in the Avionics Bay.

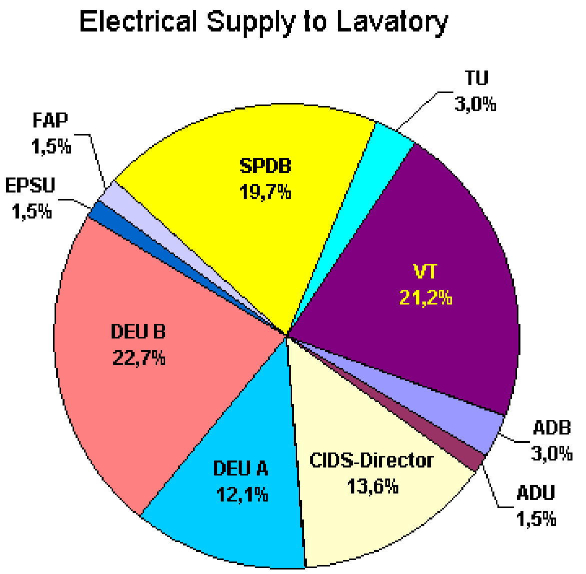

FIG. 5: Percentaged distribution of controlling equipment supplying lavatory functions - 66 bundles in total.

The supplying equipment is similar for all types of monuments. Only for galleys, an additional device is needed to provide galley power. This is done by "Central Terminal Blocks" (CTB).

4 QUICK–ADAPT CONCEPT

To enable a quick reconfiguration of the electrical installation to the customer layout, two aspects need to be considered:

- Supply of the controlling equipment and
- Connection between the controlling equipment and the cabin equipment.

Within certain limits, the controlling equipment needs to be adapted to the customer layout as well; for example the amount and the position of the DEU depends on the location of the consumers within the cabin and the options chosen by the airline. Given this, the electrical installation supplying the controlling equipment needs to be adaptable to these changes as well. In this concept, it is assumed, that flexible longitudinal racks are used to accommodate the equipment and the equipment can be positioned freely within these racks.

The connection between the controlling equipment and the cabin equipment requires the highest amount of flexibility. The bundles start alongside the controlling equipment rack at the controller for that particular application and run towards the cabin equipment which can have a huge variety of different installation positions.

4.1 Control-equipment supply

It is assumed that all of the controlling equipment is installed above the cabin ceiling in longitudinal racks as shown in figure 6. There are two such racks in each sub–cabin, one above each aisle; these racks contain all types of equipment, such as DEU, EPSU, and SPDB. The CTBs for galley power supply are meant to be accommodated inside these racks. The different types of equipment require different types of electrical supply; this can basically be split into the categories "Power Supply", "CAN–Bus signals", and "other signals."

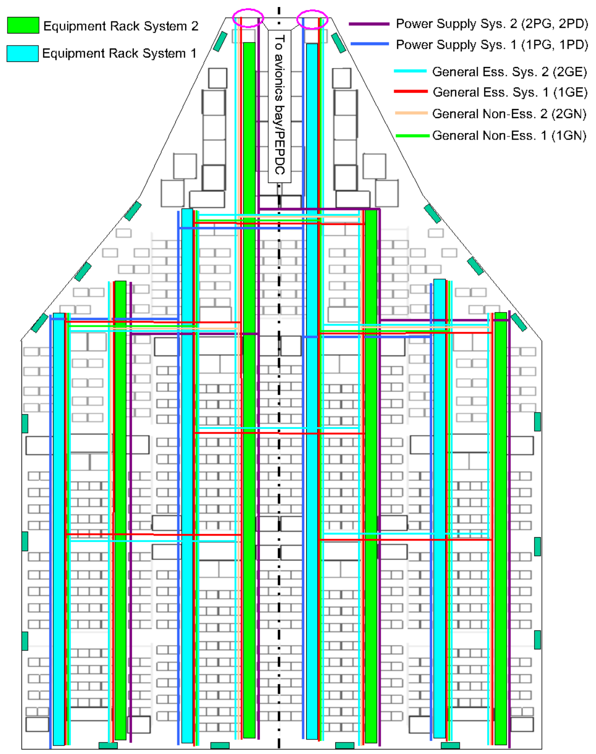

FIG. 6: Equipment Racks and their supply routes.

4.1.1 Power Distribution

Dedicated power supply cables of the route category "P" are required for the Secondary Power Distribution Boxes (SPDB) and the Central Terminal Blocks (CTB) that supply the galleys. They lead from the "Primary Electrical Power Distribution Center"

(PEPDC) to the respective equipment in the rack. According to [1], chapter 3.5.2, the PEPDC is installed in the nose of the VELA; this is a similar position as with most current airliners.

As described in section 3.1.1, the power supply lines are split into four categories: System 1 and 2 each for Galley Power Supply and SPDB Power Supply. Systems 1 for Galley and SPDB supply may be routed together, same for Systems 2. The split between System 1 and 2 is a left–right–split within each sub–cabin. Hence, it is necessary to supply each sub–cabin with both System 1 and 2.

The architecture of the routings is shown in figure 6. The power routes for systems 1 and 2 originate in the "Primary Electrical Power Distribution Center" (PEPDC), which is located in the front of the aircraft below the cabin floor. From there, they move upwards to the two central equipment racks. Due to the distribution of System 1 and 2 into the different sub–cabins, the left central rack is supplied by system 2, because it represents the righthand rack of the respective sub–cabin. Analogously, the right central rack is supplied by System 1.

The power routes then run backwards along the racks to the rear of the cabin. Along the way, parts of the routing deviate into the other sub–cabins so that all racks are supplied either by System 1 or System 2. The left–hand rack in each sub–cabin is supplied by system 1, the righthand rack by system 2.

4.1.2 CAN–bus Distribution

The second important category for the electrical supply is CAN–bus signals. CAN stands for "Controller Architecture Network". The CAN–bus is used to transmit signals from the CIDS directors and other essential controllers in the avionics bay to decentralized controllers in the cabin. This architecture helps to reduce the total amount of wiring required, because the bundles supplying the equipment in the cabin can be routed from the nearest local controller instead of coming from the avionics bay in the aircraft's nose.

The majority of the decentralized controlling functions are performed by the DEU, which controls the intercommunication, the cabin illumination, and fasten seatbelt signs among other things. Some other users of the CAN–bus are the SPDB. The SPDB provides status information on each circuit it controls and receives the commands to switch circuits on or off.

The CAN–bus controls essential and non–essential functions. It uses essential and non–essential bundles of both System 1 and System 2 for data transmission. The bundles belong to the "General" category and are routed in main routes of the respective route category along with other bundles.

The main routing architecture for "General" bundles is also shown in figure 6. It is similar to the architecture for the "Power" routes. This means, that all four route categories (1GE, 2GE, 1GN, 2GN) originate in the avionics bay. From there, the routes go up to the front end of the two central equipment racks and from there, they move towards the rear and branch off to supply all other racks. There are two major differences between the "General" main route architecture and the "Power" main route architecture: Whereas the "Power" routes have a clear split between left and right rack of each sub–cabin, this split is not fully applicable to "General" routes.

The entire emergency illumination is powered by essential system 1, which is the only powered system in the event that power supply is reduced to emergency power. Respectively, system 1 is required on the right and left side of each sub–cabin. Experience has also shown, that for essential system 2, the split cannot be fully maintained either. Hence, both essential categories "1GE" and "2GE" are foreseen on all equipment racks.

The essential routes have additional cross-routings in the rear of the cabin. This is necessary in order to increase the redundancy of the routing architecture so that, for example an uncontained engine rotor failure cannot completely disconnect the equipment racks of any sub–cabin even if the engine debris penetrates the cabin.

4.1.3 Other signal–paths

All other cabin–related signals are also transmitted in the "General" main routings used for the CAN–bus. This is possible because the characteristics of these signals qualify the bundles for one of the "General" categories.

4.2 Cabin equipment supply

The routings for the cabin equipment supply require the highest degree of flexibility. The customer has a broad choice of what type of equipment to install and where to install it. Analyses performed in [2], chapter 6, have shown that the majority of the fully customized equipment is inside of the monuments. This concept respectively focuses on supplying the monuments, but the resulting route paths can of course be used for any type of cabin equipment supply. The customization effort for equipment outside of the monuments will be reduced as well, because the fully–customized routing only needs to cover the distance from the equipment to the nearest main route of appropriate category.

4.2.1 Separate route paths for cabin harnesses

As discussed in 3.1.3, it is important to avoid tying new harnesses upon already installed bundles in order to allow short installation times and to avoid the risk of damaging the installed bundles.

The amount and location of the controlling equipment is generally known at a sufficiently early stage in the customization process for the equipment to be installed during section installation. The harnesses supplying this equipment will be already installed in the section as well. In contrast, the harnesses supplying the cabin equipment are generally installed during final assembly.

Hence, it is important to allocate separate route paths for the cabin harnesses, so that the bundles installed in the section do not need to be touched during cabin harness installation.

4.2.2 Flexible monument supply

The cabin harness concept consists of two parts, enabling a quick and cost–efficient electrical supply to the monuments. The first part is main routing along the equipment racks. Once the harness originating from the cabin equipment reaches these main routes, it can be routed without further design effort to the supplying equipment installed in the rack. The second part is branches in lateral direction and further routing paths in longitudinal direction in the flex zones as well as dedicated routing paths to monuments in fixed positions. These allow for a quick routing from the monument onto the main routing.

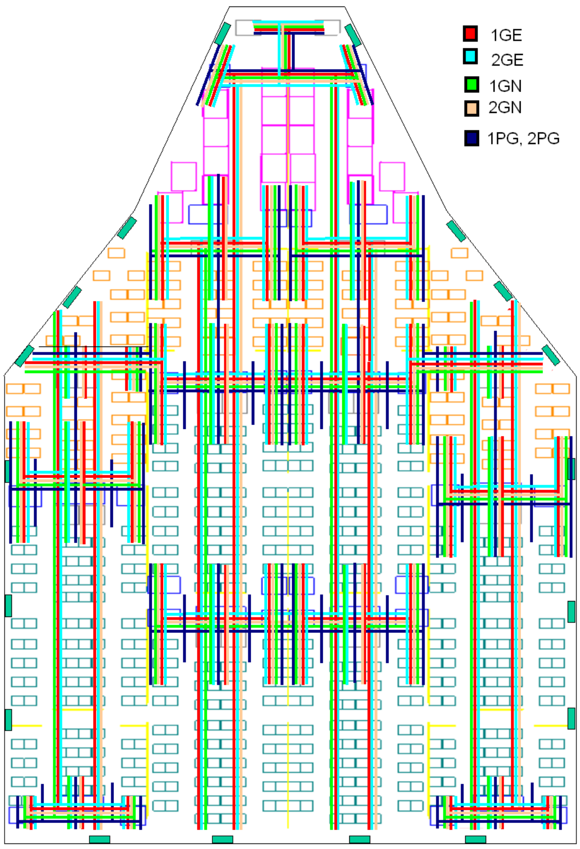

FIG. 7: Routing required for flexible monument supply.

The resulting cabin harness architecture is shown in figure 7. The main routes along the equipment rack also follow the rules described in section 4.1.2. This means, the essential routes "1GE" and "2GE" are foreseen along every rack; the non–essential routes "1GN" and "2GN" are split between the left and the right rack of each sub–cabin.

There are no longitudinal "Power" main routes needed for the cabin harnesses, because the galley power supply is performed locally. CTBs are installed in each monument zone, and the galley power cable is routed only to the nearest CTB; hence, the power cable does not leave the monument zone. The outputs of the second "Power" consumer, the SPDBs, are rated below the Ampere limit for "General" routes; respectively, bundles from the SPDBs to cabin equipment are routed as "General" routes.

The networks supplying the monuments consist of three sets of longitudinal routings with the respective cross routings in each flexible monument zone; two sets for the left and the right lateral monuments and the third set for the center monuments. It is assumed that the monuments have standardized positions for the electrical connectors and that these are harmonized with the position of these routings. For fixed monument position, a set of routings is provided for each of these positions.

It should be noted that all four "General" route categories are foreseen for the monument supply routings. As discussed in section 4.1.2, it is obvious that both essential systems are required at all monuments independent from the fact that these are located on the left or the right side of the sub–cabin. But why is there not a left–right–split between non–essential systems 1 and 2 as with the equipment racks? The reason for this is that some systems such as "Cabin Video Monitoring" only use one of the two non–essential categories for the entire system. The controlling equipment of these systems is installed in the rack on the correct side accordingly, but the cabin equipment can be installed in any monument, regardless of left or right. For example, the "Cabin Video Monitoring" is necessary to monitor the entire cabin and not only that side that is permissible due to the routing category.

For galley power supply, it can be noted, that only one routing path is reserved, although there are two power systems "1PG" and "2PG". Lateral galleys use only the power supply according to their location; left–hand lateral galleys use "1PG" and right–hand lateral galleys use "2PG". The central galleys use either one or the other, but never both at the same time. Hence, it will not be necessary to route both systems in parallel and it is sufficient to allocate space for one power routing, no matter whether "1PG" or "2PG".

Figure 8 shows a typical cross section along the left equipment rack of a sub–cabin within the monument flex area. It demonstrates one possible solution for performing the split between equipment supply harnesses (=Section routing) and cabin supply harnesses along the racks. It is important that the equipment

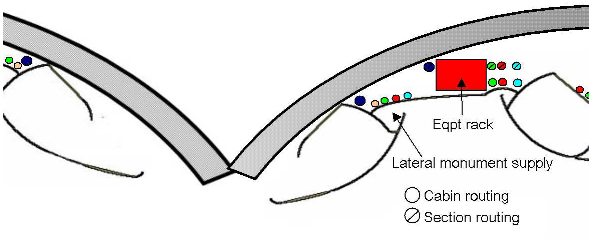

FIG. 8: Cross Section of routings along equipment racks.

supply harnesses are installed above the cabin harnesses, because the equipment supply harnesses will already be installed in the aircraft section, whereas the cabin harnesses will be installed during final assembly and need to be accessible.

5 CONCLUSION

The paper at hand provides installation principles and a layout proposal for the installation of customized electrical bundles into the unique cabin of the VELA2 BWB concept study. The customized and optional equipment and their electrical connections in a very modern civil transport aircraft are analyzed as a basis to determine the need for VELA2 customized harnesses. This results in a layout proposal, which puts special emphasis on airliner's demands for highly customized cabin equipment as well as the option to adapt monument allocations and thus seat layouts within so-called flex-zones throughout the aircraft's life cycle. This goes beyond standards that are offered today.

References

[1] Andre Schmidt: *Integration of ATA92 Systems into a Blended Wing Body Configuration*; University of Applied Sciences, Hamburg, 2006

[2] Dmytro Krychmar: *Integration der kundenspezifischen Elektrik zur Versorgung der Kabinengeräte für eine BWB–Flugzeugkonfiguration*; University of Applied Sciences, Hamburg, 2007

[3] Max Mahnken, Frank Johannsen: *Integration of Cabin Systems in BWB Aircraft Configurations*; University of Applied Sciences in co–operation with QualityPark AviationCenter GmbH, Hamburg, 2006

[4] Stefan Lee: *Konzeptionelle Untersuchung einer Flying Wing Zweideckkonfiguration*; University of Applied Sciences, Hamburg, 2003