Optimization of segregation distances between harnesses for aeronautical applications

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Segregation rules are one of the three solutions to overcome EMC problems together with filtering of disturbances at the equipment inputs and shielding of cable links (braiding, covering, over-braiding, etc.). These rules enable mass reduction in the selection of cables and optimal route definition in which compatible cables (having similar levels of susceptibility and emissivity) can be installed inside the same bundles or nearby bundles, in the aircraft. The main parameters influencing the design of these "routes" are the distance that separate the routes from each other and the distance from the electrical structure, in order to avoid the effects of friction, electrical arcing (in the event of damage the insulators) and electromagnetic (EM) stresses [1]. Compatibility to environmental constraints [2] is usually obtained by the installation of filters or EM shields. Internal EMC constraints between the "routes" are solved by the application of a minimum distance ensuring that EM coupling constraints will not exceed equipment susceptibility thresholds. We suggest that, to the first order, this minimum distance is determined by modeling a pair of routes of similar length, adjusting and optimizing the segregation distance between them as shown in Figure 1. In this problem, this distance will vary mainly with the nature of the routes (EM sensitive versus EM not-sensitive) but also with the distance of each "route" from the nearest electrical reference, the coupling length and the crossing angle between two routes (as the routes can travel in parallel or cross each other with an angle).

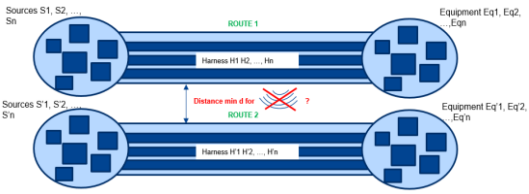

Figure 1. Principle for determining the minimum distance between two "routes"

Two questions result from this approach:
• How to determine this minimum distance considering the large number of configurations that are required?
• If it is not possible to respect this minimum distance in the real aircraft installation, what level confidence can we give to lower distances in order to have their installation accepted?
The second question is motivated by a significant number of requests for exemption from the cable design teams who have to deal with modifications of the 3D model of the aircraft and from the installation teams who cannot install the harnesses as specified, generally for mechanical reasons. To this extend, we propose to generate segregation distance tables when designing these routes to assess the level of acceptance of exemption distances. The large number of configurations to process, the complexity of route arrangements, the ranges of variation of parameters regarding installation justify the development of statistical methods especially customized to the problem in order to be able to solve in acceptable time.
To answer these questions, Safran Electrical & Power initiated the CS2-ANALYST project (CFP07 GA 821128) that brings together two French partners (ONERA and Axessim) and two Italian partners (IDS - Ingegniera Dei Systemi and the University of Aquila). The objective is to develop a modeling tool allowing cabling design teams to assess the optimal segregation distance in Figure 1's configuration with calculation performance compatible with the team requirements. Several statistical approaches such as Kriging or Smolyak as well as acceleration methods will be evaluated during this project. Various test cases have been defined and will be used to test the developed methods. More details will be provided during the presentation of this work at the conference.

References

[1] C.Jullien, A.Dieudonne and J.Genoulaz, "Sensitivity Crosstalk Analysis Study for Aeronautics Test Case", *32nd URSI GASS,* Montreal, August 2017
[2] RTCA DO160, "Environmental Conditions and Test Procedures for Airborne Equipment".