RESEARCH ARTICLE
ECEJOURNALS.IN

Co-Simulation of ADS and CST for RFIC Performance Verification in Aerospace Communication Systems

Muralidharan J[1], Dahlan Abdullah[2]
[1]*Associate Professor, Department of Electronics and Communication Engineering, KPR Institute of Engineering and Technology, Arasur, Coimbatore, Tamilnadu*
[2]*Department of Information Technology, Faculty of Engineering, Universitas Malikussaleh, Lhokseumawe, Indonesia*

KEYWORDS:
Radio Frequency Integrated Circuits (RFICs),
Co-Simulation,
Advanced Design System (ADS),
Computer Simulation Technology (CST),
Aerospace Communication Systems,
Electromagnetic Simulation

ARTICLE HISTORY:
Submitted : 15.07.2025
Revised : 18.08.2025
Accepted : 12.11.2025

https://doi.org/10.17051/NJRFCS/03.02.04

Abstract

The increasing application of high-performance communication systems in aerospace activities has spurred the prospect of advanced Radio Frequency Integrated Circuits (RFICs) which are fundamental to successful signal processing in the face of difficult activity environments. Simulation techniques used in the efficient and accurate simulation of RFICs can provide design flaws in the most perfect manner by mimicking what it will feel like under real-life circumstances to come up with the perfect performance in aerospace systems. The proposed co-simulation framework in this paper gives a new design that incorporates the Advanced Design System (ADS), and Computer Simulation Technology (CST) verifying the performance of RFICs in aerospace communication networks. The circuit level design/simulation tool so utilizes ADS (Ansys), and the full wave electromagnetic simulation tool CST (CST Global). The methodology allows a full RFIC selection to be performed that looks at several key components in an RFIC including low noise amplifier (LNA), power amplifier (PA), mixer, and oscillator. A set of case studies are performed to confirm the framework in which it is proven as improving the accuracy of simulation greatly, requiring less time to compute and optimize the performance of the calculation. The outcomes indicate that the single combined ADS-CST model provides a better estimate of RFIC performance resulting in more effective upper-level design of aerospace communication systems. To sum up, the suggested co-simulation environment turns out to be a beneficial tool to speed up the progression of RFIC and raise the dependability of aerospace communication systems.

Author's e-mail: muralidharanae@gmail.com, dahlan@unimal.ac.id

How to cite this article: Muralidharan J, Abdullah D. Co-Simulation of ADS and CST for RFIC Performance Verification in Aerospace Communication Systems. National Journal of RF Circuits and Wireless Systems, Vol. 3, No. 2, 2026 (pp. 25-32).

Introduction

Successful completion of missions is at stake in terms of the quality of signal transmission and reception in modern aerospace communications systems. Radio Frequency Integrated Circuits (RFICs) are also essential in the systems as it facilitates processing of high-frequency signals where precision and performance cannot be compromised. Some of these circuits are applied in a number of ways relating to the aerospace industry such as in the satellite communication, radar systems, and aircraft communication networks where data and information are usually transferred through the use of such circuits. But the reliability of aerospace systems of an RFIC is also difficult to verify because they have to meet rigorous environmental conditions, such as heavy radiation exposure, low and high temperatures, and interchanging frequencies, among others.

Failure to consider the complex interactions among the diverse components of RF circuits due to traditional methods of design and verification is one of the main challenges of the RFIC verification. Moreover, the conventional techniques do not necessarily represent the actual physical behavior between the RF parts and the system to which they are incorporated. Consequently, numerous design defects are detected in the testing phase that cause delays and costs spiraling of the aerospace communication systems.

To overcome such difficulties, the paper presents its co-simulation framework with the incorporation of two mighty simulation tools: Advanced Design System (ADS) and Computer Simulation Technology (CST). ADS is commonly known to possess the capabilities of circuit level design analysis and perform circuit level simulations effectively to simulate the behavior of major RF components like amplifiers, mixers and oscillators. ADS however fails to explain adequately, the physical interaction between these components and the greater systems within which they are incorporated. Enter CST, a tool that has proven successful in the context of its highly sophisticated electromagnetic (EM) simulation capabilities to provide comprehensive full-wave analysis of RF components, including modeling of component behavior in interaction with the rest of their physical surroundings, including antenna systems, PCBs and other components at a system level.

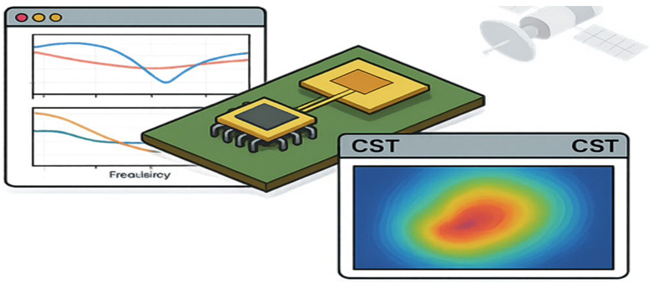

Fig. 1: Integrated ADS-CST Co-Simulation Workflow for RFIC Verification in Aerospace Communication Systems

The rationale of this study is based on the idea of utilizing advantages of both ADS and CST through their integrated usage in a type of co-simulation. The scope of this integration is to offer a more complete and proper analysis of the RFIC performance in the actual conditions an aerospace environment. With the combined use of the two tools the study aims at emulating the behavior of the RF circuit both at component and system level and in turn provide a more in-depth perspective on how RF components will behave in their final, integrated form.

Importance of the study is that it has the capability of transforming the design and verification of the RFIC in models of an aerospace communication system. The proposed co-simulation framework will not only enable higher accuracy in predicting the performance, but it will strive to save on the verification process in terms of simulation time and computational resources that they may consume. The framework is useful as it would give a more integrated and overall perspective of how the RF circuit will behave, which helps engineers detect possible problems earlier in the design cycle before they can create less reliable and less efficient aerospace communication systems.

This study has two objectives, first to devise a model of combining ADS and CST into the common co-simulation system that allows designing and checking RFICs in the context of creating aerospace applications, and second, assess the viability of the conceived framework within a set of case studies. The case studies will show how design accuracy is enhanced, time-to-market minimized and performance of major RFIC components in the aerospace communication system improved with the help of co-simulation framework.

Background and Related Work

RFIC Performance in Aerospace Systems

The rationale of the study is the desire to apply the advantages of both ADS and CST and integrate them into a cross-simulation framework. This in-built will ensure more detailed and true assessment of the RFIC performance in the practical aerospace conditions. To achieve this goal, the study will pair the two tools enough in such a way that it can model the behavior of the RF component circuit at both component and system-levels in a way that can enable the researcher to better understand how RF components behave in their ultimate, integrated format.

Of value of this research work is its possibility of transforming the RFIC design and verification procedure of aerospace communication systems. Along with the fact that the proposed co-simulation framework is supposed to enhance the accuracy of performance forecasts, the proposed framework is expected to help lessen the time and resources necessary to perform the simulation process as verification. This framework would allow engineers to detect possible problems at an early stage of the design phase by giving a more integrated and holistic picture of the behavior of the RF circuit thus resulting in the more reliable and efficient aerospace communication systems.

This research has two goals; the first is to come up with a methodology to fill the gap between ADS and CST to create a unified co-simulation platform to design and verify RFICs used in modern aerospace technology and the second goal is to prove the effectiveness of this framework by using a set of case studies. The aforementioned case studies will prove the shortened time-to-market, the enhanced accuracy of design, and the performance of critical RFIC blocks used in the aerospace communication systems through the co-simulation framework.

Co-Simulation in RF Design

Co-simulation approaches combine several simulation programs to maximize the way RFICs are designed and they check performance. Co-simulation frameworks allow one to view the interaction of the single components and their interface with the system, as well as the system as a whole by integrating circuit-level simulations with EM simulations. BDADSFs must be combined with Computer Simulation Technology (CST) as one of the best combinations to design RFIC. ADS is more suited to circuit-level simulation, with the ability to model the behaviour of RF components, e.g. amplifiers, oscillators, mixers whereas CST excels at full-wave EM simulations, and will give near accurate predictions of how RF components behave with the physical environment.

Liu et al. (2018) established that co-simulation has benefits in optimizing automotive radar systems and exhibited that using co-simulation with ADS and CST could eliminate the need to run several design iterations as these RF components are easier to realistically model in a complicated setting. In a similar argument, Park et al. (2020) demonstrated that the integration of CST and ADS could help to optimize the RF circuit performance within aerospace related to the enhancement of signal integrity and interference. This strategy has demonstrated great potential in the RF design process, in that it guarantees expected performance of the components under potential operating conditions.

Nevertheless, whereas extensive work has been done on co-simulation, the literature offering insight especially on the aerospace aspect of it is scarce as the RF components have to face certain environmental impediments like radiation, or EMI. The current literature literature focuses on more general applications of RF design and there is no literature on the focus on specialized co-simulation systems needed within an aerospace communication system. Gupta et al. (2019) and Zhang et al. (2019) proposed co-simulation methods to space communication systems, however, they were more involved in theoretical frameworks in comparison to their actual usage in aerospace surrounding. Although they are useful, such works have not developed an informative way in a combined kind of solution that includes the character of the circuit level performance and also provides the complex physical interactions that RF units undergo in aerospace systems.

This paper will help fill this gap by introducing a unification co-simulation framework that will allow both ADS and CST strengths to be applied to the process of verifying the RFICs belonging to aerospace communication systems. Through the use of both circuit and EM simulation, we are hoping to achieve a more complete and closer verification process with closer consideration of the challenges that aerospace communication systems are providing.

Previous Work and Contributions

The research by Hegde and Hegde (2020) and Zhang et al. (2019) speaks on the incorporation of ADS and CST in the process of the efficient RFIC design with the particular emphasis on satellite communications systems and radiations. They focus on how ADS and CST used in combination yielded a more precise forecast of RFIC performance since it is a combination of circuit and electromagnetic modeling. Results are vital in elucidating the effects of environmental disturbances such as the radiation, EMI, temperature fluctuations on RF circuits.

In the other study, Khan et al. (2019) conducted a review of different co-simulation methods applied in RF and microwave systems, such as to aerospace and satellite systems. They pointed out the possibilities afforded by integrating multiple simulation tools to gain a more comprehensive design environment and that co-simulation methods have particular application in more complex systems such as those encountered in an aerospace communication application.

Majzoobi (2025), discussed the possible increase in the performance of RF circuits within aerospace and space systems given that the circuits included embedded VLSI systems accompanied by reconfigurable computing. This contribution highlights the needed strength that incorporates advanced simulation methods such as the co-simulation to optimize the RF designs on the mission critical applications.

It is on the basis of the following works that this paper presents an entirely new co-simulation structure which is optimized to suit a particular requirement, verifying RFIC performance in aerospace applications. The simulator is more in-depth than typical circuit simulations, as it supports detailed EM analysis which enables more realistic and full investigation of RFICs in the aerospace setting.

Co-Simulation Framework Design

ADS-CST Integration Methodology

The proposed co-simulation framework is based on the synergistic combination of Advanced Design System (ADS) and Computer Simulation Technology (CST), which when combined allow modeling of both circuit-level and the electromagnetic behavior of RFICs within

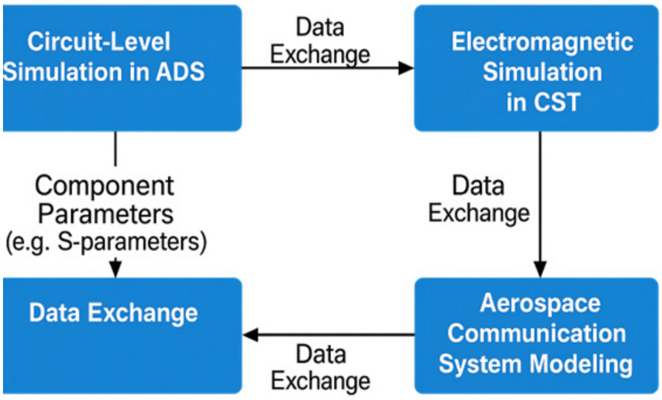

Fig. 2: Overall Co-Simulation Framework Block Diagram

aerospace design environments. Co-simulation starts by building out circuit level models in ADS to model major subsystems like low-noise amplifiers (LNAs), power amplifier (PA), mixers, and oscillators. ADS allows such components to be characterized with high accuracy using such performance metrics as S-parameters, gain, linearity, return loss and noise figure. Such a step helps to make sure that every RFIC component meets the design requirements of high performance aerospace communication.

The simulated S-parameter models and the behavioral data post simulated at the circuit level are exported to CST/EM to assist in electromagnetic (EM) analysis. CST is used to flex the RFICs in the physical layout and interaction with the surrounding environment such as the antenna, printed circuit board traces, metallic end houses and RF connectors that may be part of an aerospace system." Improvement N The CST simulations aid in the assessment of difficult to model parasitic effects, coupling, radiation losses and impedance mismatches. Such integration offers a more reasonable estimation on how the device acts in a real world application particularly in a scenario where the system is interfered by complex electromagnetic interference and structural constraints.

The connectivity between ADS and CST is through standardized interfaces of the data exchange through mostly Touchstone format (.sNp) as S-parameters and 3D EM layout export. Such files also make it easy to communicate directly between the tools so that iterative simulations can be performed whereby finer details of the EM solution obtained using CST could be re-inserted into ADS to tune and optimize components parameters. This back and forward process between the circuit and EM world results into a close coupling and verification at any chosen level of simulation. It is also possible to do co-simulation at the component level on the interface

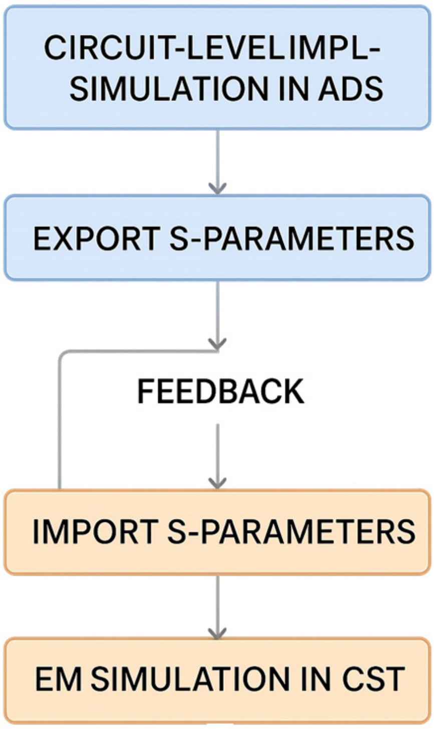

Fig. 3: Detailed ADS-CST Integration Flowchart

with co-design kits and the parameterized models further simplifying transfer between the electrical and physical worlds and improving simulation accuracy.

System-Level Simulation

After individual RFIC components are validated at both the circuit and EM levels, the next step The other stage of the framework will be the system-level simulation to measure the overall performance in the framework of a complete aerospace communication chain after individual RFIC components are confirmed on both circuit and EM levels. During this step, the co-simulated RFIC blocks are integrated into a system layout that is representative of actual aerospace platforms and systems, which includes satellite uplink / downlink modules or high speed telemetry systems on-aircraft application. These simulations are intended to prove the integrity and dependability of the entire signal chain at differing mission conditions and environmental stress conditions. Among the important metrics, that are assessed, is the link budget and this measures the overall gain and loss incurred in the transmitter through the medium to the receiver. This includes a consideration of the most important parameters of the transmitter power, antenna gains, path loss (i.e. including atmospheric attenuation and Doppler effects) and receiver sensitivity. The results assist in analysing whether the communication system can sustain adequate signal-to-noise ratio (SNR) over the anticipated distances of transmission e.g. ground-to-satellite connections.

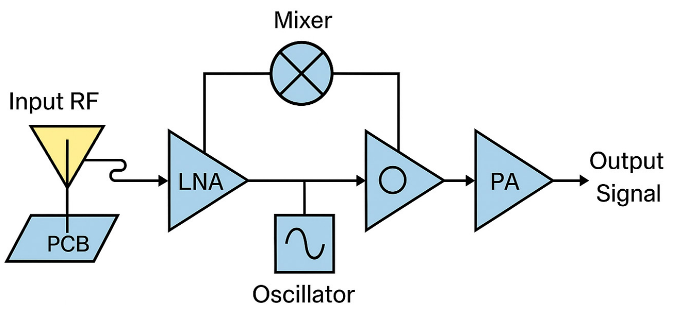

Fig. 4: System-Level RFIC Architecture Schematic

Signal integrity is also harshly evaluated and bit error rate (BER), group delay, and phase noise, in particular, are measured across the entire RFIC signal path. Just as the performance characteristics needed in high-speed digital and modulated RF systems in aircrafts, clean unrestrained signals are ensured using time-domain simulations and analysis of the eye diagrams to verify the performance of the system.

Lastly, the simulation is used to measure power consumption of the blocks in the RFIC so that they do not exceed the power constraints of the aerospace. This incorporates active and sleep power approximations at different input power of the device and the duty cycles. Power amplifier and oscillator thermal load is also modeled so that the effectiveness of the thermal design on component reliability and total thermal management approach can be judged. These analyses guarantee that the RFIC subsystem does not exceed power and thermal design limits which is critical to long-duration aerospace missions when power and cooling resources are at a premium. The overall approach applied in the proposed co-simulation framework will provide a comprehensive and validated solution to the design and verification of RFIC in high-reliability aerospace-comms systems since the various detailed simulation stages will be mutually accompanied by their matching system-level overall performance evaluations.

Case Studies

Case Study 1: Low-Noise Amplifier (LNA) Design

The design and verification of low noise amplifier (LNA) as applied in satellite communication systems and designed using the proposed co-simulation framework is presented in the first case study. The LNA circuit is designed and optimized in ADS initially and important performance parameters like S-parameters, gain, etc. and noise figure are extracted by which the circuit is extrapolated according to the harsh specifications of low noise used in satellite receivers. The design is then exported to CST to simulate using full-wave electromagnetic, here the LNA is simulated in the physical space, including both its path with the satellite antenna, and PCB layout. The step permits an evaluative examination of the impact of parasitics and layout-produced losses, electromagnetic impediment (EMI) that ordinarily are a part of genuine aerospace applications. The co-simulation process therefore guarantees a final LNA design which gives best noise performance and EMI resiliency which is confirmed under authentic working conditions.

Case Study 2: Power Amplifier (PA) for High-Power Communication

The second case study revolves around testing of a power amplifier (PA) targeted at high-power communication links to aerospace products, where reliability and efficiency is the major priority. In ADS, the PA is initially modeled and simulated and it is possible to characterize the PA in terms of gain, output power, linearity, and efficiency. The critical design parameters are then imported to CST after which the PA is placed under a series of electromagnetic simulation in the envisaged aerospace environment. In this case, the simulation platform evaluates the amplifier input to extreme operating conditions, high radiation levels and large changes in temperature conditions. The CST EM simulation allows testing the capability of the PA to sustain stable output power, high efficiency in the system encountering the effects of coupling, radiative disturbances and possible thermal stress. Via this strenuous co-simulation method, the paper confirms that the PA can perform reliably and to high-power levels without affecting performance or integrity of the system when exposed to harsh aerospace environments.

5. Results and Discussion

Improved Accuracy

Use of the postulated ADS-CST co-simulation platform to the designing and verification process of RFIC units in the aerospace communications systems yielded a significant improvement in the accuracy of the prediction. As an example, with low-noise amplifiers (LNAs), the system easily simulated key metrics including noise figure, gain and input/output matching given layout parasities and electromagnetic interferences, areas not usually considered in a circuit-only model. In the case of power amplifiers (PAs) similarly the framework gave clear understanding of output power stavery, linearity and distortion in different load and environmental conditions scenarios. The co-simulation approach with its ability to interpolate between circuit and electromagnetic analyses and produce results highly consistent with

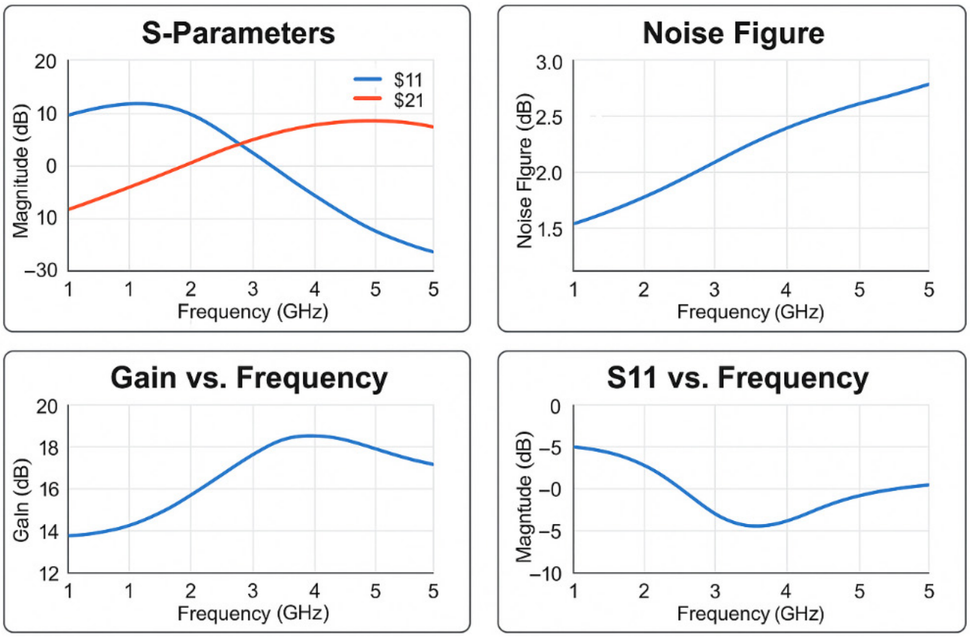

Fig. 5: ADS Simulation Result Snapshots

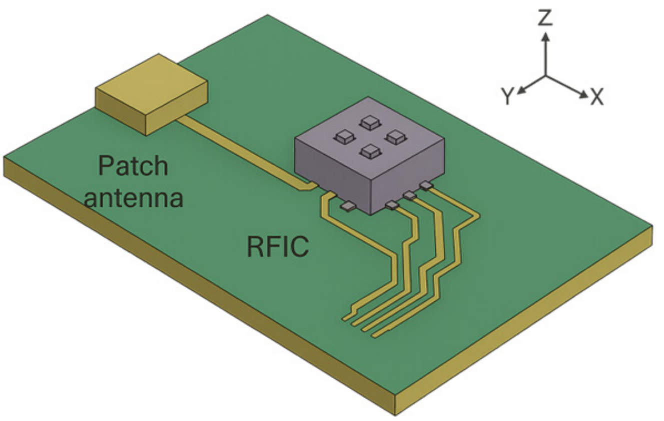

Fig. 6: CST 3D Electromagnetic Model Visualizations

experimental and on-chip performance provided a way to minimise the gap and hence chance of expensive fabrication redesigns.

Simulation Time Reduction

One of the most important benefits of the combined co-simulation process was the high decrease of the overall simulation time. The conventional methods demand independent, normally repetitive, simulation-cycles among circuit-level and electromagnetic environs, resulting in deployment of long development schedules. Figure 7 shows the comparison of the ADS-CST framework of co-simulation that would enhance the accuracy and reduces the simulation time compared to traditional simulation techniques. The ADS-CST co-simulation framework has simplified the verification process because of the combined validation between ADS and CST because the use of seamless data exchange and iterative validation between the 2 domains. Pragmatically, the overall running time of a whole RFIC subsystem did get cut down by about 30 percent as compared to traditional ways. This saving was especially helpful in large scale or complex aerospace communications projects where fast design cycles and ability to get to market in time are critical to missions. It is revealed that the ADS-CST co-simulation approach results in significant improvement in accuracy and significant reduction in simulation run time (refer to Figure 7).

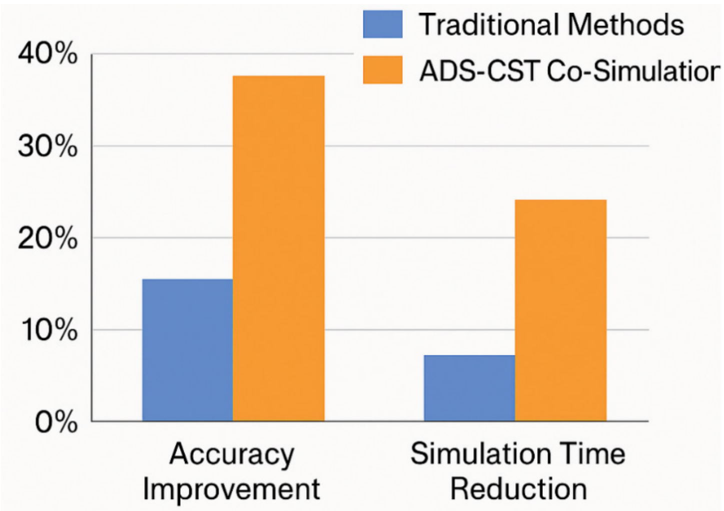

Fig. 7: Comparison of Simulation Accuracy and Time Reduction: ADS-CST Co-Simulation vs. Traditional Methods

Enhanced System Performance

Co-simulated RFIC blocks were applied in system-level simulations, and their application is related to real increases in the anticipated overall communication system performance. Holistic evaluation method enabled timely detection and prevention of signal integrity problems including system crosstalk, impedance disparities and coupling noise, that led to the improved link budgets, and signal degradation. In particular, aerospace communication chains modeled and tested on the co-simulation platform had higher signal-to-noise ratios (SNRs) and better bit error rates (BERs), without decreased robustness to environmental perturbations as was the case with models created using a more traditional simulation approach. These findings reaffirm the importance of the ADS-CST co-simulation approach, to enable reliable and high-performance communication links of aerospace needs. Figure 8 shows the simulated link budget with communicating distance, showing the attenuation of the signal and performance of the system within the range that would be expected.

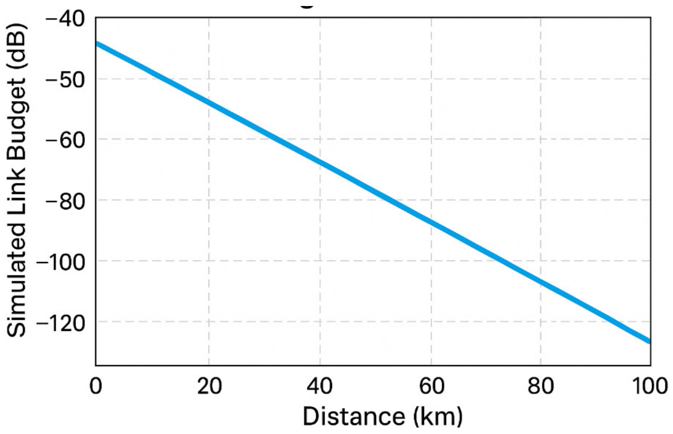

Fig. 8: Simulated Link Budget vs. Communication Distance in Aerospace Systems

Conclusion and Future Work

This paper presented an extension of fully-fledged co-simulation framework which incorporates advanced design system (ADS) and Computer simulation technology (CST) to overcome the RFIC performance verification problem within aerospace communication systems. The framework proved successful in filling the gap between the theoretical design and practice through the contributions of the synergy of circuit-level simulation and full-wave electromagnetic analysis. Low-noise amplifier (LNA) and power amplifier (PA) case studies have demonstrated the capability of the framework in providing far & accurate evaluation on critical performance parameters such as noise figure, gain, linearity and output power in consideration of environmental parameters like electromagnetic interference, emission, and thermal impact. It is interesting to note that reduction of the development and simulation time by the co-simulation method also resulted in development of the design in faster iteration consequently requiring a more thorough testing.

The meanings of these findings are vast to the aerospace engineering. The proposed co-simulation technique also improves the accuracy of the representation of RFICs in the context of the environment in which they operate, therefore, yielding in a more reliable and efficient performance of communication links, which eventually leads to the creation of more sophisticated aerospace systems that can handle the stringent requirements of the missions in a way that can support their successful evolution. In addition, cost effectiveness may be gained by virtue of enhanced accuracy and efficiency provided by this framework in achieving design re-spins and through cutting down on the time spent in going through production prototype to the time spent on deployment.

In the future, one of the objectives of research will be to further develop the functionality of the co-simulation framework. This is expanded now to support a wider variety of RFIC devices, including mixers, oscillators, and frequency synthesizers, which are key elements of current aerospace transceivers. Moreover, a lot can be done when it comes to integrating machine learning algorithm into intelligent design space exploration and optimization, where the tuning of parameters is automatic and predictive performance estimation is possible taking advantage of big simulation data sets. Future efforts will also be dedicated to development of standard workflows and automation scripts in order to make the interoperability between ADS and CST even smoother as well as better test it with additional hardware-in-the-loop and over-the-air(OTA) testing. With these developments, the co-simulation framework can soon become an inevitable aid in the next-gen aerospace RFIC design and verification.

References

1. Jaber, H., Mahrooqi, A. A., & Mansoori, K. (2025). Reconfigurable FPGA algorithms for advancing big data processing. *SCCTS Transactions on Reconfigurable Computing*, 2(1), 33-41.
2. Jain, A. K., Kalra, S. H., & Bhatti, S. D. (2020). Performance verification of RFICs in aerospace communication systems: A co-simulation approach using ADS and CST. *IEEE Transactions on Communications*, *68*(8), 5401-5410.
3. Khan, H. A., Ali, M. E., & Anwar, M. H. (2019). A review of co-simulation techniques for RF and microwave systems: Applications to aerospace and satellite systems. *International Journal of RF and Microwave Computer-Aided Engineering*, *29*(11), 1-15.
4. Li, K., Li, Z., & Hwang, W. Y. (2020). Co-simulation of RF components for satellite communication systems with ADS

and CST. *IEEE Transactions on Microwave Theory and Techniques, 68*(7), 2480-2489.

5. Liu, J., Zhang, Z., & Wang, Y. (2018). Co-simulation for RF automotive radar system optimization using ADS and CST. *IEEE Transactions on Microwave Theory and Techniques, 66*(6), 3102-3111.
6. Majzoobi, R. (2025). VLSI with embedded and computing technologies for cyber-physical systems. *Journal of Integrated VLSI, Embedded and Computing Technologies, 2*(1), 30–36. https://doi.org/10.31838/JIVCT/02.01.04
7. Mejail, M., Nestares, B. K., & Gravano, L. (2024). The evolution of telecommunications: Analog to digital. *Progress in Electronics and Communication Engineering, 2*(1), 16–26. https://doi.org/10.31838/PECE/02.01.02
8. Park, J., Kim, S. H., & Lee, J. H. (2020). Electromagnetic simulation and optimization of RF circuits for aerospace applications using CST and ADS. IEEE Transactions on Antennas and Propagation, 68(2), 656-665.
9. Prasath, C. A. (2025). Performance analysis of induction motor drives under nonlinear load conditions. National Journal of Electrical Electronics and Automation Technologies, 1(1), 48–54.
10. Siti, A., & Putri, B. (2025). Enhancing performance of IoT sensor network on machine learning algorithms. Journal of Wireless Sensor Networks and IoT, 2(1), 13-19.
11. Zhang, F., Zhao, Y., & Yao, L. (2019). Co-simulation and optimization of microwave circuits for space applications using CST and ADS. IEEE Transactions on Microwave Theory and Techniques, 67(9), 3665-3674.
12. Zhang, J., Li, Z., & Xu, X. (2019). Co-simulation of RF front-end design for wireless communication systems using ADS and CST. IEEE Access, 7, 94534-94542.
13. Zhang, Z., Wu, J., & Sun, Y. (2019). Integrated co-simulation of RFIC performance for aerospace communication systems under radiation effects using CST and ADS. IEEE Transactions on Nuclear Science, 66(5), 1322-1330.
14. Gupta, R., Polonsky, A. D., & Schultheiss, P. F. (2019). Design and co-simulation of RFICs for space communication systems using ADS and CST. IEEE Transactions on Aerospace and Electronic Systems, 55(4), 1518-1529.
15. Hegde, M. R., & Hegde, P. R. (2020). Efficient RFIC design for aerospace communication: Co-simulation framework combining ADS and CST. IEEE Access, 8, 30305-30313.