Fast Coupled Loads Analysis Method:

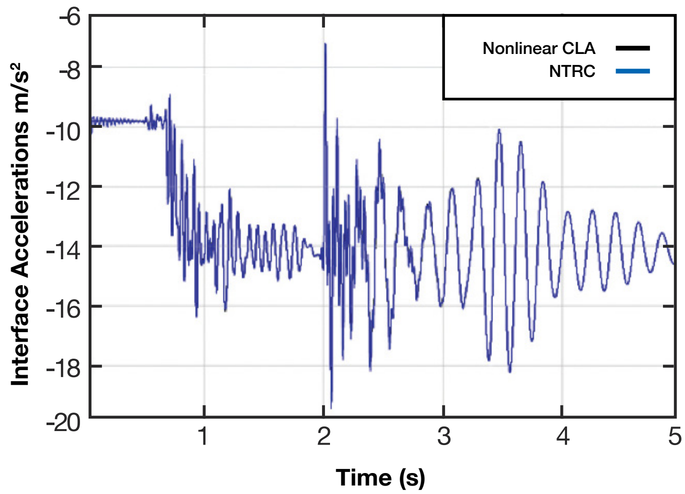
Norton-Thevenin Receptance Coupling

A new method called Norton-Thevenin Receptance Coupling (NTRC) has been developed to perform coupled loads analysis (CLA). NTRC attempts to reduce the dependency of the payload organization on high CLA costs, long analysis schedules, lack of standard capabilities to evaluate multiple payload configurations, and unavailability of launch loads from the launch vehicle (LV) provider when needed.

NTRC provides a tool that payload developers can use to obtain launch loads at a fraction of the cost of a CLA at any time it is required in the payload design cycle. While NTRC is not intended to replace the formal load cycles performed by the LV provider, it will provide the ability to reduce the conservatism in defining preliminary design loads, assess the impact of design changes between formal load cycles, perform trade studies, and perform parametric loads analysis where many different design configurations can be evaluated with a minimum amount of data required from the LV provider.

NTRC condenses all the necessary information into the launch vehicle to payload/s connection points or boundary degrees-of-freedom (BD). The launch vehicle model is represented by its impedance at its BDs; its forcing functions are represented by the acceleration at those BDs when the payload is absent; and the payload is represented by its impedance at the same BDs. Payload responses are represented by transfer functions of selected response to interface BDs.

The NTRC methodology is exact in the frequency domain. Time domain replication and accuracy is outstanding. In order to deploy NTRC Agency wide and get the return on investment, a second phase is envisioned to benchmark the whole set of CLA events for the Agency's most utilized launch vehicles. A NASA New Technology Report has been filed. e-NTR#: 1450108519. *For more information, contact Daniel Kaufman, Goddard Space Flight Center, daniel.s.kaufman@nasa.gov.*



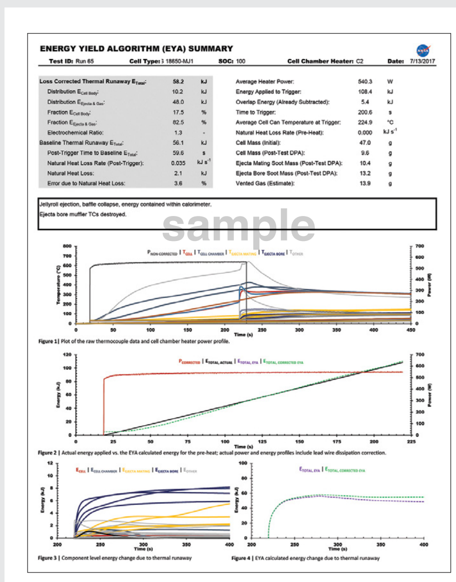
Interface accelerations in LV thrust direction capturing all relevant characteristics of Pad Separation CLA.

Calorimetry of Lithium-ion Cells During Thermal Runaway

Lithium-ion (Li-Ion) cells are widely used in consumer products. Recent well-publicized events involving Li-Ion batteries in devices such as laptop computers, electric cars, commercial aircraft and even toys have drawn attention to the phenomenon of thermal runaway – where stored energy within the cell is rapidly released as heat along with vented effluents. With increased use of Li-Ion cells in space applications such as extravehicular activity hardware, care must be taken to ensure the battery design does not promote propagation of thermal runaway to adjacent cells.

Thermal runaway can be studied through calorimetry - a precise measurement of heat liberated during the thermal runaway process. Existing calorimetric methods such as Accelerating Rate Calorimetry (ARC) provide data on the total energy yield from a cell during thermal runaway. But ARC cannot separate the fraction of energy conducting through the cell casing from that venting from the cell. Understanding how the released energy is apportioned informs the design process, improves the ability to model heat transfer in the battery and allows for more effective thermal runaway mitigations in the battery design.

A new calorimeter for the popular 18650-sized Li-Ion cell has been developed under an NESC assessment and is designed to measure the total energy yield as well as the fractions conducted and vented. An instrumented cell is placed into the cell chamber and heated until thermal runaway is triggered. Separate heat transfer paths measure the energy yield from the cell as its energy is conducted through the calorimeter. Effluents can be collected for further analysis. *For more information, contact: Steven Rickman, Johnson Space Center, steven.l.rickman@nasa.gov.*



The calorimeter's energy yield algorithm software tallies the energy release by analyzing temperature changes in the calorimeter as a result of the thermal runaway.