

Envelopes

Every system is confined to operate within an envelope. For humans, this envelope extends from the Poles to the deserts and, with the help of technology, from the depths of the oceans to the vacuum of space. Temperature, pressure, humidity, radiation, vibration—and untold other

ambient effects determine whether the systems we design and build can operate reliably in the real world. This is why engineering is challenging.

The envelope of operation drives the control system—conversely, the control system limits the envelope of operation. Every control system has its limits, imposed by the ability of its hardware and software to respond to commands and disturbances that

conspire to push the system outside of its range of safe operation. When the boundaries of that range are breached, the consequences can be severe when the control system is critical to safety. Examples range from computer-assisted surgical instruments to nuclear power plants.

An aircraft is designed to operate reliably within a given envelope. The response of the aircraft is thoroughly

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Contributors



Naira Hovakimyan with Arik Melikyan, her advisor and mentor, New Year's 2000.



Hans Butler with his sons Rick and Frank on a Norwegian glacier.



Belinda Batten with her friends Meleah and Scott Ashford in Scotland.



Naira Hovakimyan at the Ice and Snow festival in Harbin, China.



Evgeny Kharisov at the AIAA GNC Conference in Hawaii.



Irene Gregory monitoring a flight test.

studied within this envelope through wind-tunnel testing and simulation to ensure its performance and develop the control system that aids the pilot. But what happens when an aircraft is forced to operate outside this envelope? If the dynamics of the aircraft are not well known outside this region, then pilots cannot gain flight experience on a simulator, which is limited to models constructed from analysis and data.

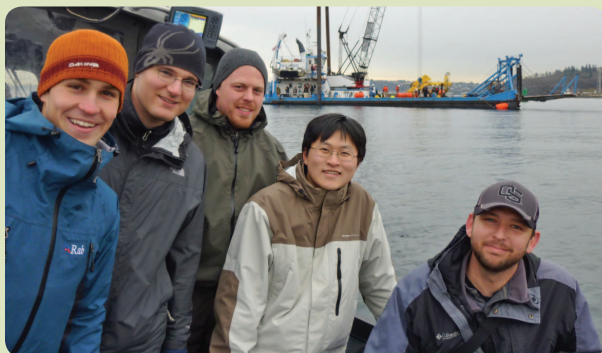
Some anomalies, such as actuator failures, can be tested on a flight simulator. For example, by simulating a damaged control surface, a pilot can gain experience in using alternative actuators, such as thrust, to compensate for a nonworking elevator or rudder. However, this kind of simulation-based experience is meaningful

only when the aircraft flies within the flight envelope that is well characterized by data.

When an aircraft experiences an anomaly that is beyond its normal flight envelope, the pilot is faced with the need to learn how the plane behaves while devising—in real time—strategies to control it. A preprogrammed control system is also at a disadvantage since the aircraft is now flying outside the envelope within which the control system was designed to operate. The solution to this problem lies in the use of adaptive control, which can augment the preprogrammed controller and thereby extend its envelope.

Adaptive control for aircraft operating in a highly uncertain environment is the subject of the article “Adaptive Control and the NASA X-15-3 Flight Revisited,” which appeared in the June 2010 issue of *IEEE Control Systems Magazine* (CSM). That article describes how progress in adaptive control since the fatal 1967 flight of the X-15 has made adaptive control a viable

technology for safety-critical aircraft systems. The feature article “ \mathcal{L}_1 Adaptive Control for Safety Critical Systems” by Naira Hovakimyan, Chengyu Cao, Evgeny Kharisov, Enric Xargay, and Irene Gregory continues



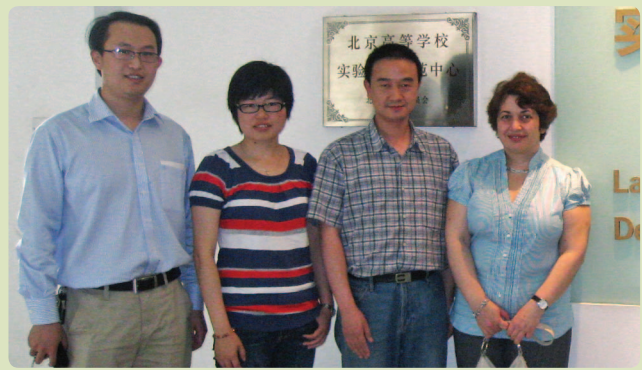
Ean Amon (center) and friends at the deployment of Columbia Power Technology's Sea Ray wave energy device in Puget Sound.



(From left) Enric Xargay, Irene Gregory, Naira Hovakimyan, and Chengyu Cao at NASA Langley AirSTAR Sim Development facility with Enric Xargay at the controls.



Ted Brekken, along with Christy Anderson Brekken, daughter Nora, and son Anders.



(From right) Naira Hovakimyan, Chengyu Cao, and friends at Tsinghua University.

that story with an emphasis on a control technique that accounts for unexpected anomalies with bounded transient behavior and guaranteed robustness margins.

For the “Applications of Control” column in this issue, Hans Butler describes the challenges and technological approaches to high-precision position control for optical processing of integrated circuits. Both speed and accuracy are crucial to this application to maximize throughput while achieving positioning at the nanometer scale.

For “Ask the Experts,” Ted Brekken, Belinda Batten, and Ean Amon respond to a query about the potential uses of control technology in generating “green” energy from ocean waves. Their response describes the diverse

worldwide effort aimed at developing wave-energy converters as well as the role of control technology in realizing that objective.

This issue also includes an educational article on an event aimed at increasing the interest of young students in mechatronics, as well as a book review relating to the feature article in this issue. We also include an obituary of Herb Rauch, a former editor-in-chief of CSM. An interview with Herb appeared in the August 2011 issue of this publication.

The date of the 50th anniversary CDC is rapidly approaching.

The date of the 50th anniversary CDC is rapidly approaching. This event will be a milestone in the development of our field in general and the IEEE Control Systems Society in particular. If you haven’t already made plans to attend, there is still time. This will be *the* event that everyone will be talking about for the next 50 years. You don’t want to miss it! See you there.

Dennis S. Bernstein



Chengyu Cao at Fort Pickett, Virginia, during GTM flight test.



Evgeny Kharisov at Inner Harbor in Baltimore, Maryland.



Irene Gregory hiking Old Rag in Virginia.



Hans Butler



Belinda Batten in Edinburgh, Scotland.



Enric Xargay visiting the Roman city of Empuries on the Catalan coast.