# Lessons Learned from Three Decades of Global Automation Experience Across Five Industries

## *Authors:*

Lane Desborough

*Date Submitted:* 2021-10-21

*Keywords:* automated insulin delivery, artificial pancreas, diabetes

*Abstract:*

My current work on Automated Insulin Delivery (the so-called “artificial pancreas”) directly benefits from two decades of experience gained implementing and remotely monitoring automation in complex and challenging industrial cyberphysical systems all over the world; systems upon which society depends. This talk will cover topics including experimentation, modeling, simulation, and outcome measure sample statistics, as well as controller design considerations including human factors, objective functions, and final control element challenges.

*Record Type:* Published Article

*Submitted To:* LAPSE (Living Archive for Process Systems Engineering)

| | |
|---|---|
| *Citation (overall record, always the latest version):* | LAPSE:2021.0791 |
| *Citation (this specific file, latest version):* | LAPSE:2021.0791-1 |
| *Citation (this specific file, this version):* | LAPSE:2021.0791-1v1 |

CSChE Systems & Control Transactions

Open Access Original Research

**Conference Proceedings**
Canadian Chemical Engineering Conference 2021
October 24-27, Montréal, Québec, Canada

PSEcommunity.org/LAPSE:2021.0791

PSE PRESS

# Lessons Learned from Three Decades of Global Automation Experience Across Five Industries

**Lane Desborough**

Nudge BG, Inc., Thousand Oaks, California, USA Lane@NudgeBG.com

## ABSTRACT

My current work on Automated Insulin Delivery (the so-called "artificial pancreas") directly benefits from two decades of experience gained implementing and remotely monitoring automation in complex and challenging industrial cyberphysical systems all over the world; systems upon which society depends. This talk will cover topics including experimentation, modeling, simulation, and outcome measure sample statistics, as well as controller design considerations including human factors, objective functions, and final control element challenges.

**Keywords**: automated insulin delivery, artificial pancreas, diabetes

**Date Record:** Original manuscript received October 20, 2021. Published October 21, 2021

## INTRODUCTION

In 1921 insulin was discovered by Banting, Best, Collip, and Macleod at the University of Toronto. For the first time, a diabetes diagnosis was not a death sentence; people with insulin-requiring diabetes (all people with Type 1 Diabetes and some people with Type 2 Diabetes) were able to control this incurable condition by injecting insulin to lower their blood glucose.

In the intervening hundred years, insulin and its delivery methods, together with blood glucose sensing technology have made tremendous advances, however for people living with insulin-requiring diabetes a substantial cognitive burden remains: every few hours they must decide how much insulin to deliver to compensate for the myriad sources of variation in blood glucose – for their entire life.

In parallel, in the same intervening hundred years, automation has fundamentally transformed other domains including the continuous process and power generation industries.

If the purpose of control is to safely transfer variability from a place where it hurts (the controlled variable) to a place where it doesn't hurt as much (the manipulated variable) in order to make a human's job easier, then the majority benefit of automation these past hundred years has accrued to humans in industry, not humans with chronic diseases such as diabetes.

In the past decade, contemporary automation methods first developed for process automation have finally begun to be applied to the automation of insulin delivery. The so-called artificial pancreas holds great promise to reduce burden for those living with insulin-requiring diabetes.

## LESSONS FROM INDUSTRIAL AUTOMATION

Early in my career I was fortunate to develop a strong academic and industrial foundation in process control from my supervisor Dr. Tom Harris at Queen's University and from my colleagues at Nova Chemicals Joffre Alberta, respectively.

From 1988 through 2010, I had the privilege of traveling all over the world to implement and remotely monitor automation at chemical plants, mines, oil refineries, paper mills, and power plants while employed at Honeywell and General Electric.

This diversity of experience exposed me to dozens of concepts, principles, methods, tools, and practices used to design, develop, implement, operate, and maintain automation (Table 1).

## TYPE 1 DIABETES: A BROKEN LOOP

When our ten year old son was diagnosed with Type 1 Diabetes in 2009, I knew very little about the disease. I was shocked to learn that despite the availability of continuous glucose monitor (CGM) and insulin pump technology, the "loop" had not been closed. People with diabetes were performing open-loop control.

Our family quickly learned that management of insulin-requiring diabetes, while seemingly simple (one input, one output), is actually an incredibly complex interplay of algorithms, hardware, behaviors, and physiology (Figure 1).

- adaptive control
- advanced alarm management
- alarm design
- alarm standards
- anomaly detection
- automated code generation
- automated decision support
- automation benchmarks
- automation trust
- batch control
- behavioral economics
- closed-loop identification
- configuration management
- constraint control
- control algorithms (PID, MPC)
- control hazard analysis
- control objective
- correlated observations
- coupling and complexity
- cybersecurity
- DevOps
- display guidelines
- dynamic design of experiments
- dynamic modeling
- emergency shutdown systems
- empirical modeling
- ethnography
- Firmware/software updating
- functional safety
- gain scheduling
- hierarchical control
- high fidelity simulation
- inferred properties
- interoperability i.e. OPAF, OPC
- job task analysis
- lean / agile development
- mode confusion
- model-based design
- feedforward control
- nonfunctional requirements
- nonlinear control
- operator training
- performance monitoring
- procedural automation
- real time optimization
- remote monitoring and diagnostics
- requirements management
- resilience engineering
- robust control
- Operator role transformation
- safety driven design i.e. STAMP
- sensor issues
- sensor validation
- standards management
- state estimation
- statistical process control
- systems engineering
- testing
- valve cams, strapping tables
- wireless systems

**Table 1:** Proven concepts for controlling time varying, poorly modeled, complex, nonlinear, interacting stochastic systems

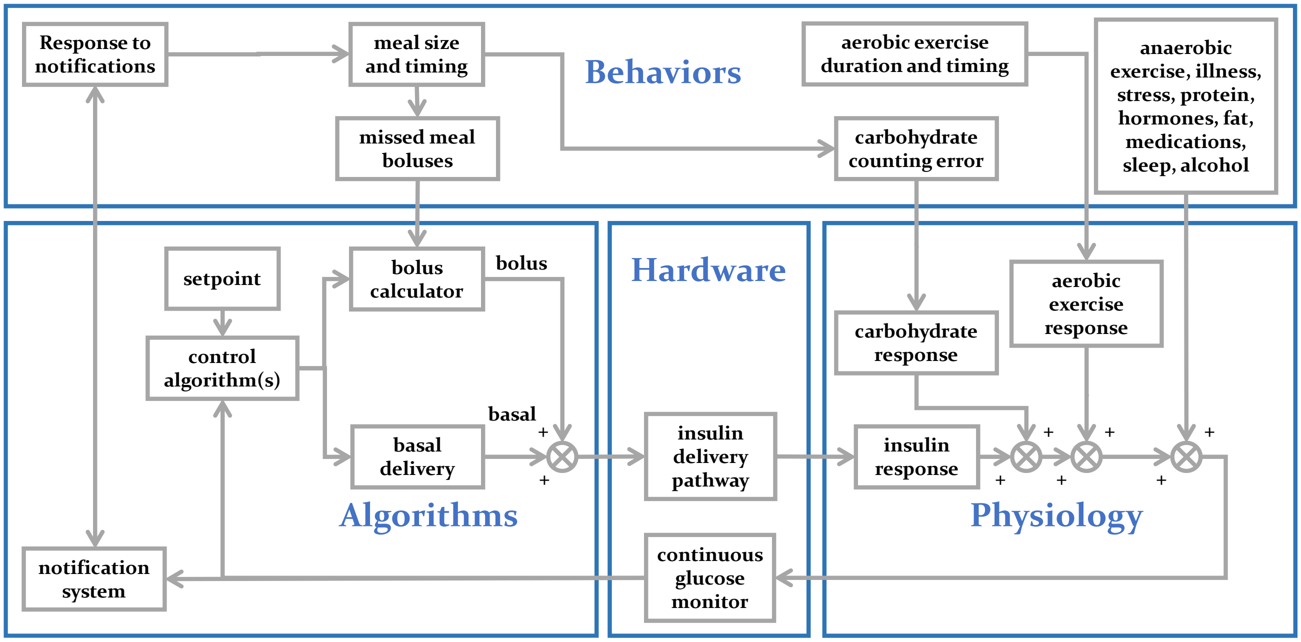

**Figure 1.** Automated Insulin Delivery: a complex interplay of algorithms, hardware, behaviors, and physiology

## CONCLUSION AND RECOMMENDATION

Within months of my son's diagnosis I found myself at Medtronic Diabetes, leading the team responsible for commercializing Medtronic's next step towards automated insulin delivery (AID).

Twelve years and three companies later, I still believe that many of the challenges confronting AID have already been overcome in other domains. More work remains to apply the concepts in Table 1 to AID in order to reduce the burden for those who live with diabetes.

---

This conference proceeding has not been peer reviewed.