



aspen|aerogels®

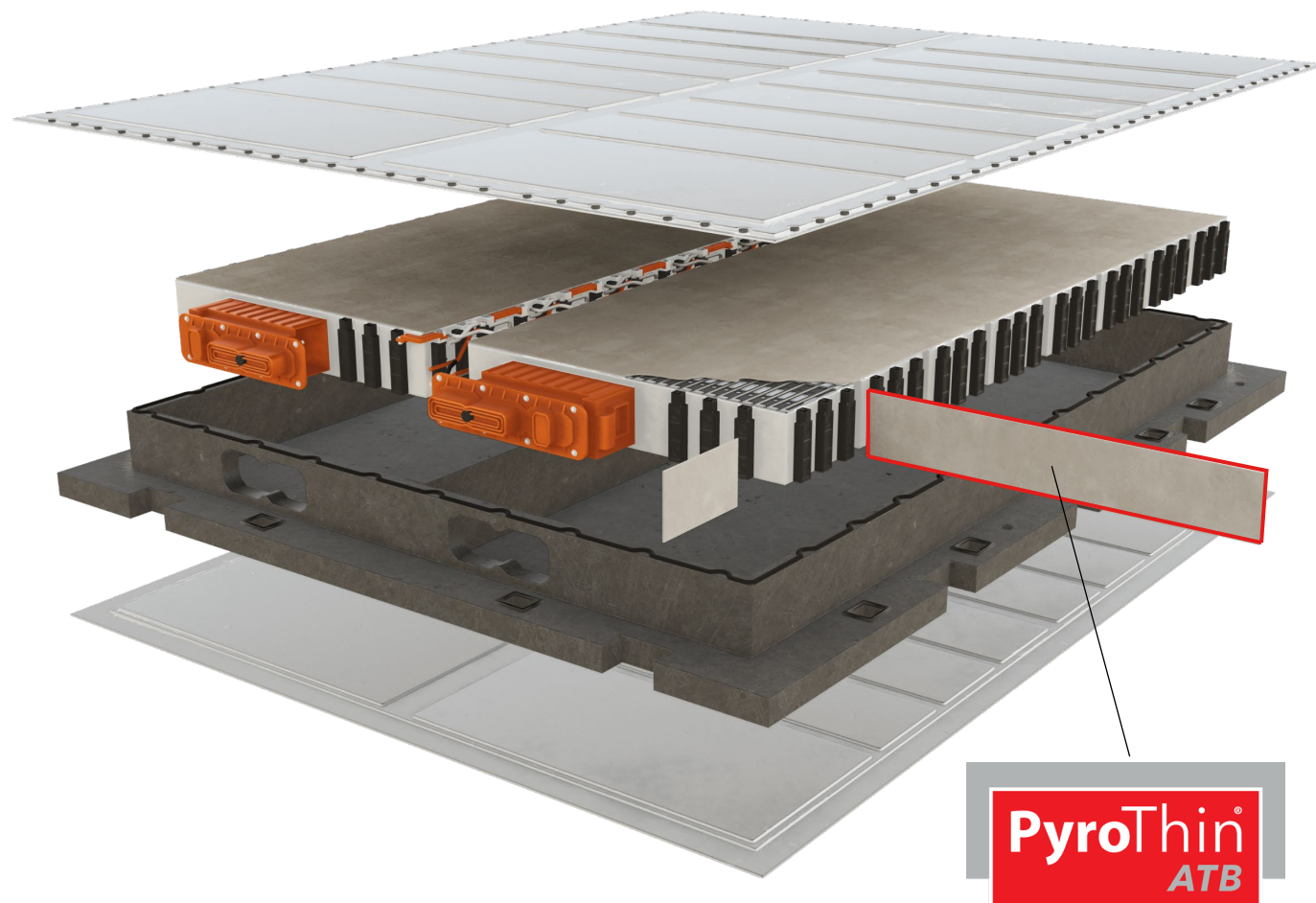
PyroThin®  
ATB

# Predictive Performance: Visualizing a Lifetime of Mechanical Loads Within a Battery Module

Tyler Gurian, *Senior Program Engineer*



# Aspen is The Global Leader in Aerogel Technology



**PyroThin®**  
ATB

**2001**  
Aspen Aerogels Founded

**1<sup>st</sup> Insulation  
for Oil & Gas** **2003**  
*Subsea pipelines*

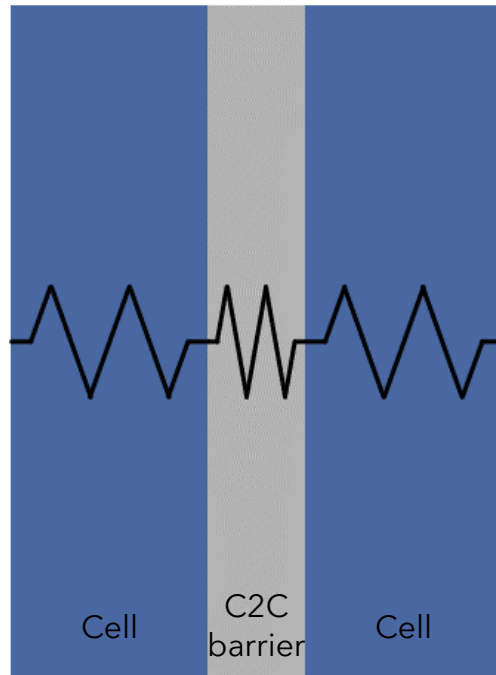
**1<sup>st</sup> PFP Products** **2008**  
*Passive fire protection*

**1<sup>st</sup> BEV Sales** **2016**  
*Battery thermal  
management (Tier 3)*

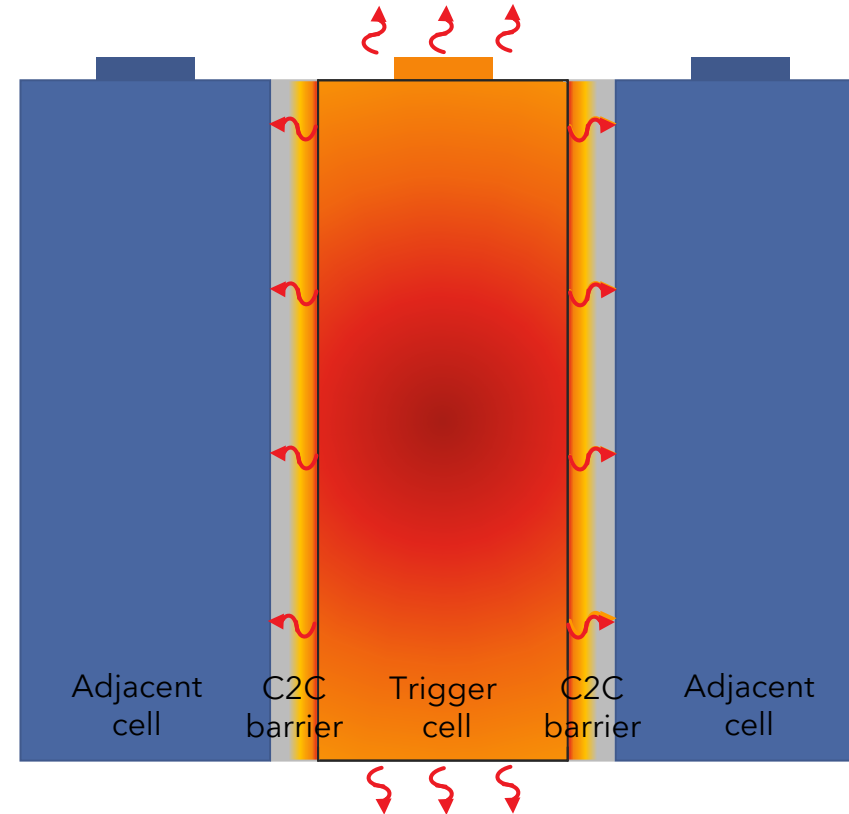
**Installed Base of \$1B** **2020**

**Automotive Production** **2021**  
*OEMs in NA & Asia*

# Cell-to-Cell (C2C) Barriers Have Two Jobs



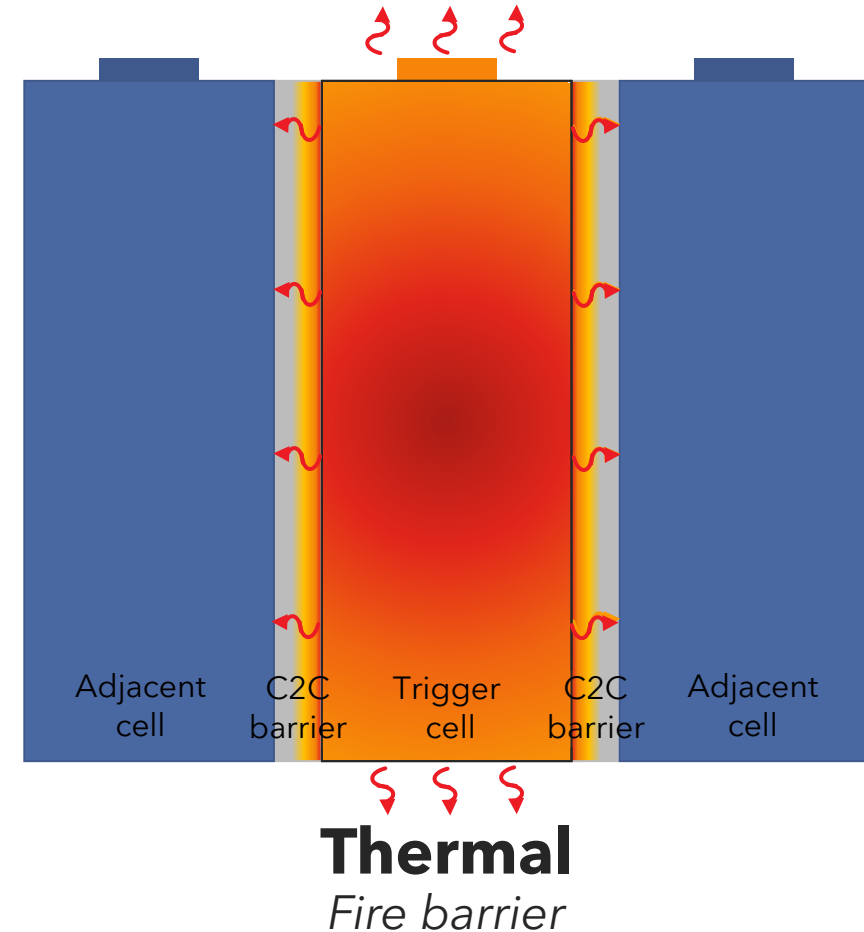
**1. Mechanical**  
*Compression pad*



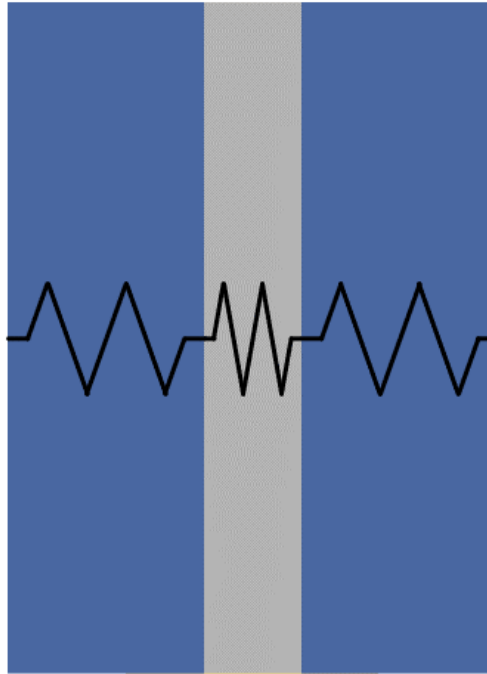
**2. Thermal**  
*Fire barrier*

# Cell-to-Cell (C2C) Barriers Have Two Jobs

- PyroThin has achieved TP stop in applications as thin as 1.4mm
- PyroThin can be formulated to withstand extended exposure up to 1000°C
- PyroThin fully retains thermal and dielectric performance through End of Life
  - High strain, extended mechanical cycling, extreme climatic cycling, etc.

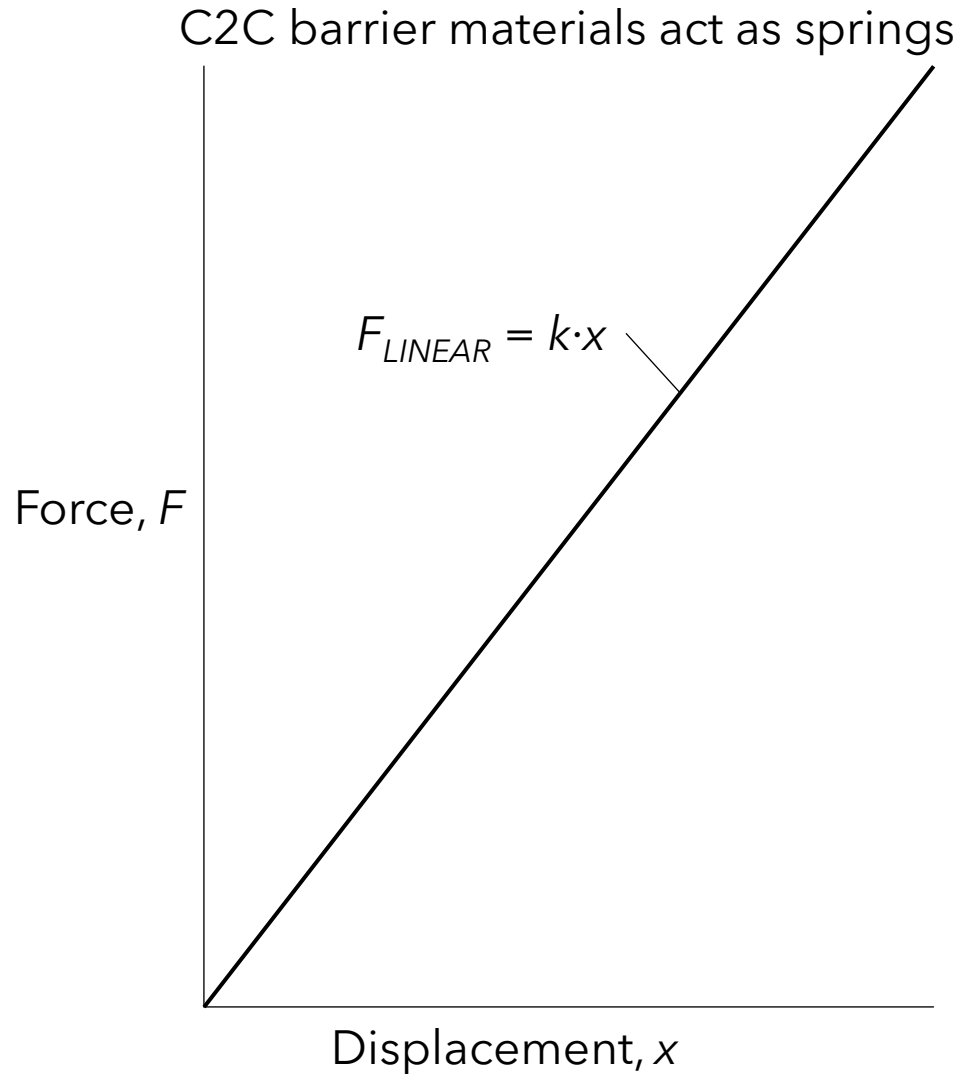


# Cell-to-Cell (C2C) Barriers Have Two Jobs



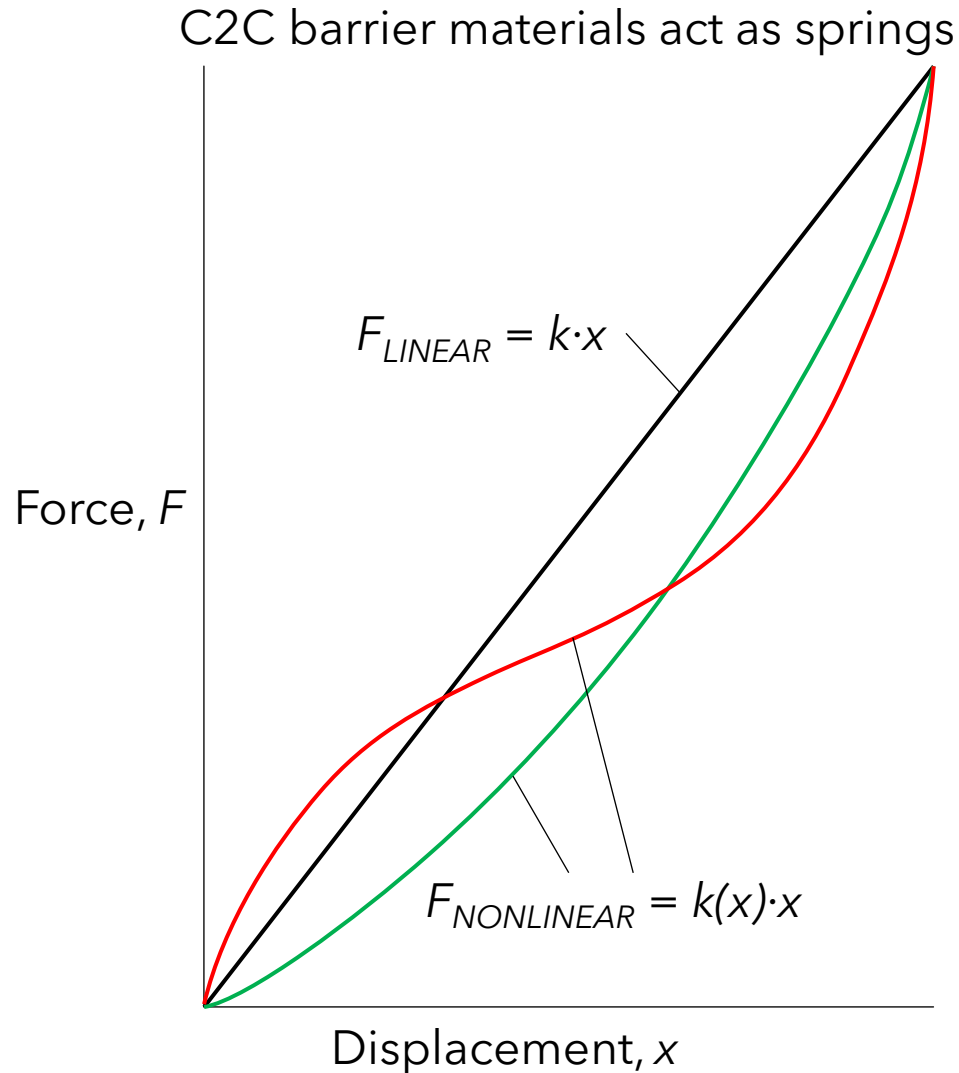
**Mechanical**  
*Compression pad*

# The Challenge of Specifying C2C-Barrier Mechanical Characteristics



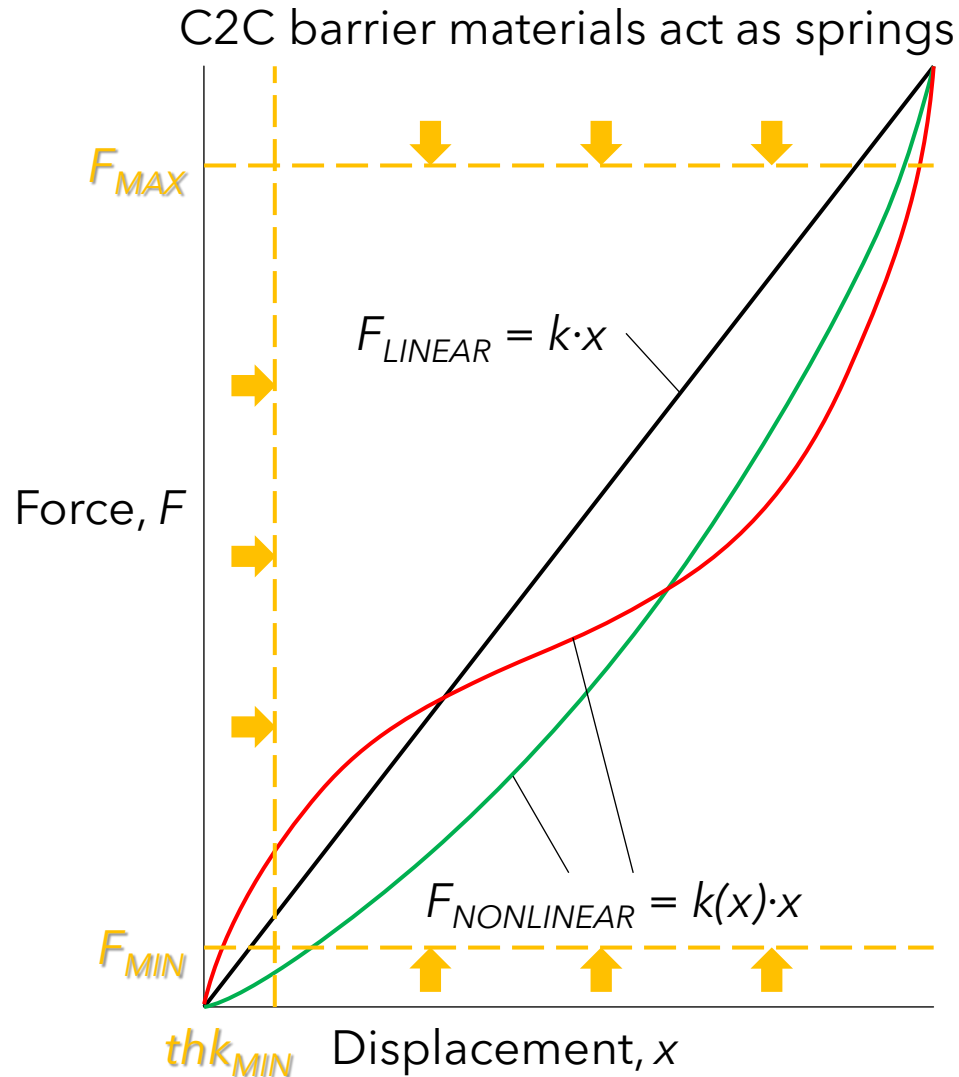
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  - Spring constant =  $k$

# The Challenge of Specifying C2C-Barrier Mechanical Characteristics



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- Nonlinear springs are better described with *functional* specifications of the desired system-level behaviors
  - Minimum & maximum cell-face pressures

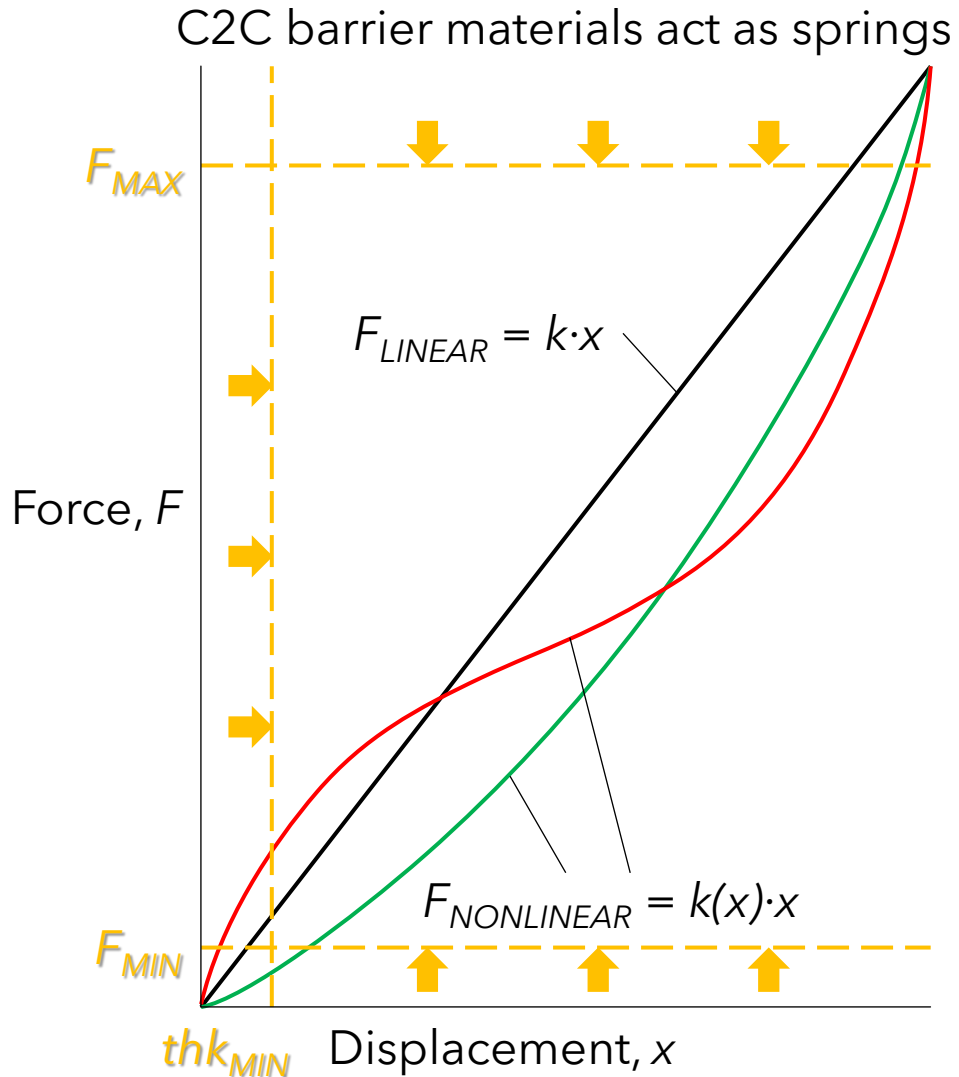
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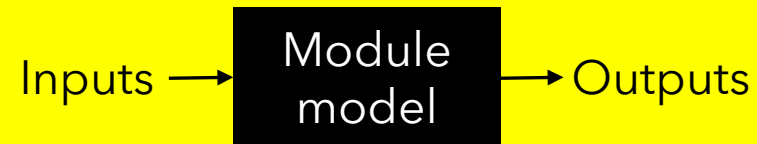


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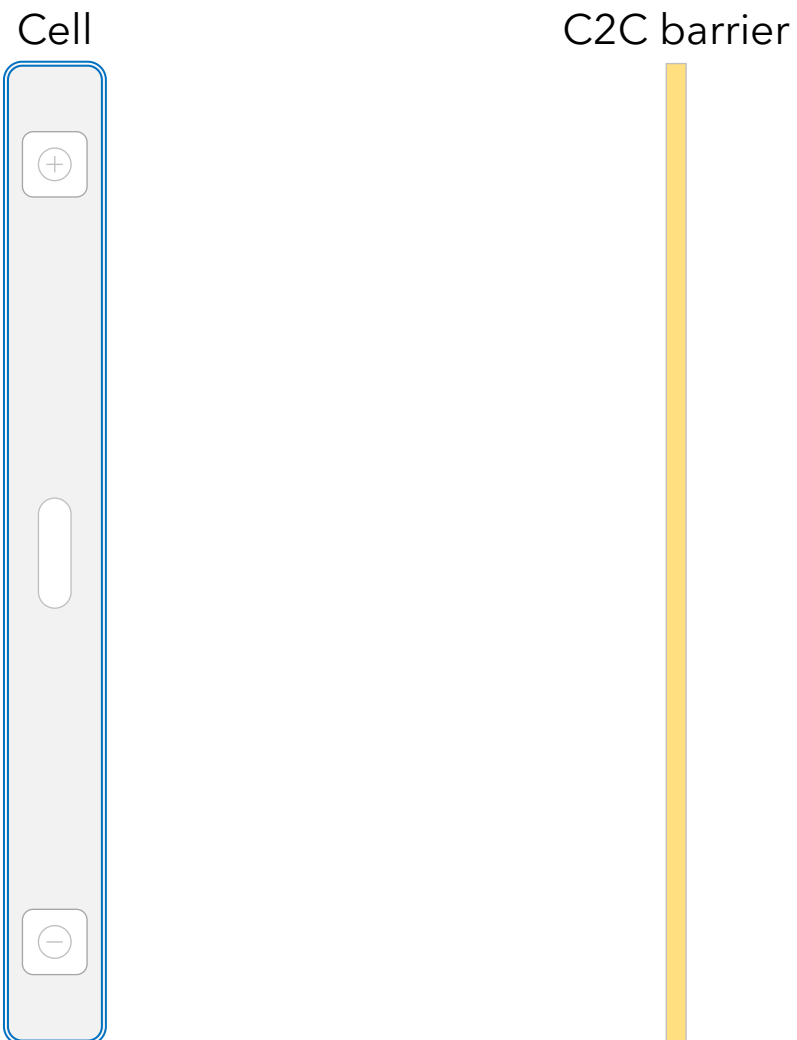


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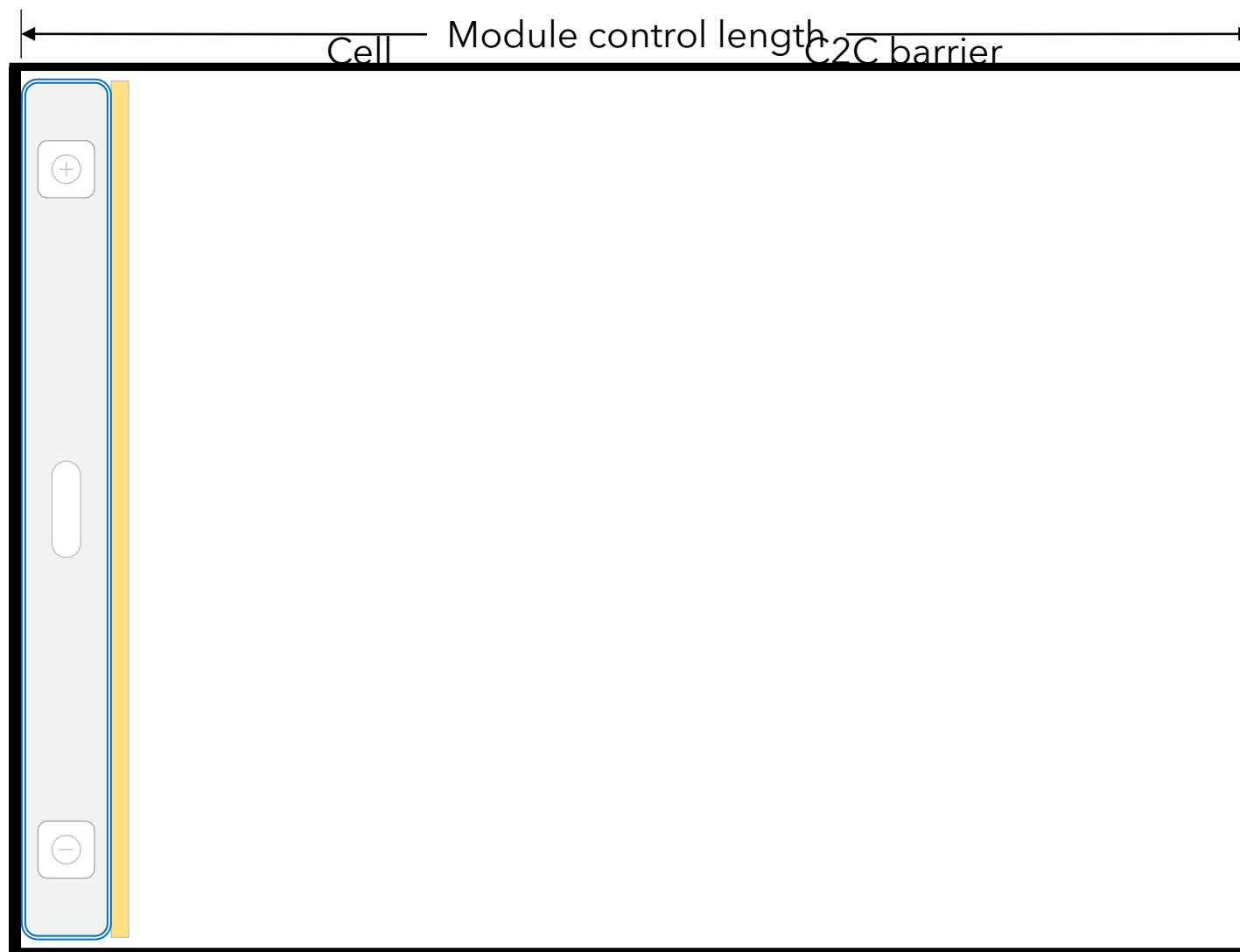
To make functional specifications work, you need a way to predict system-level performance.



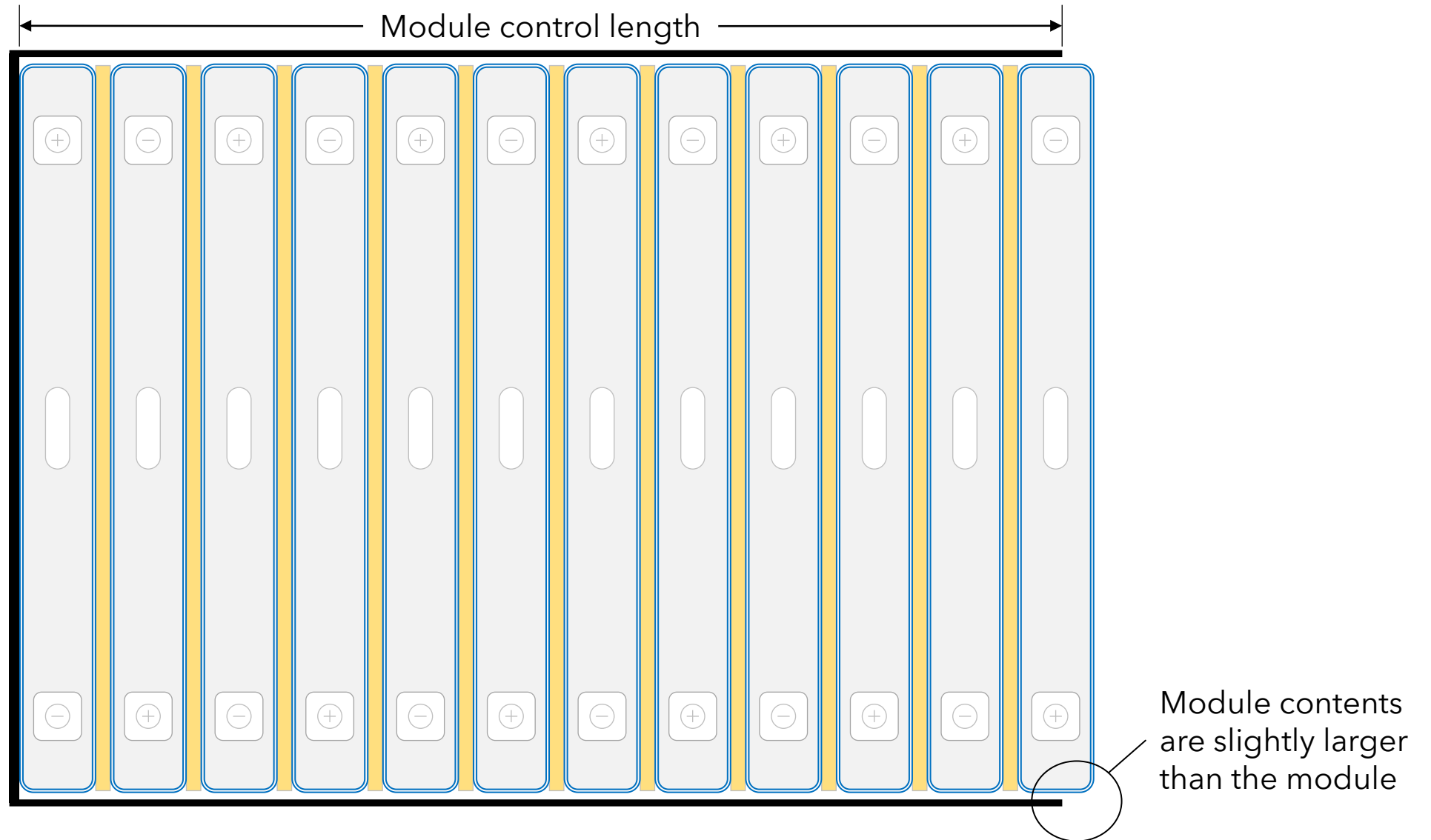
# Assemble Cells and C2C Barriers Into the Module Housing



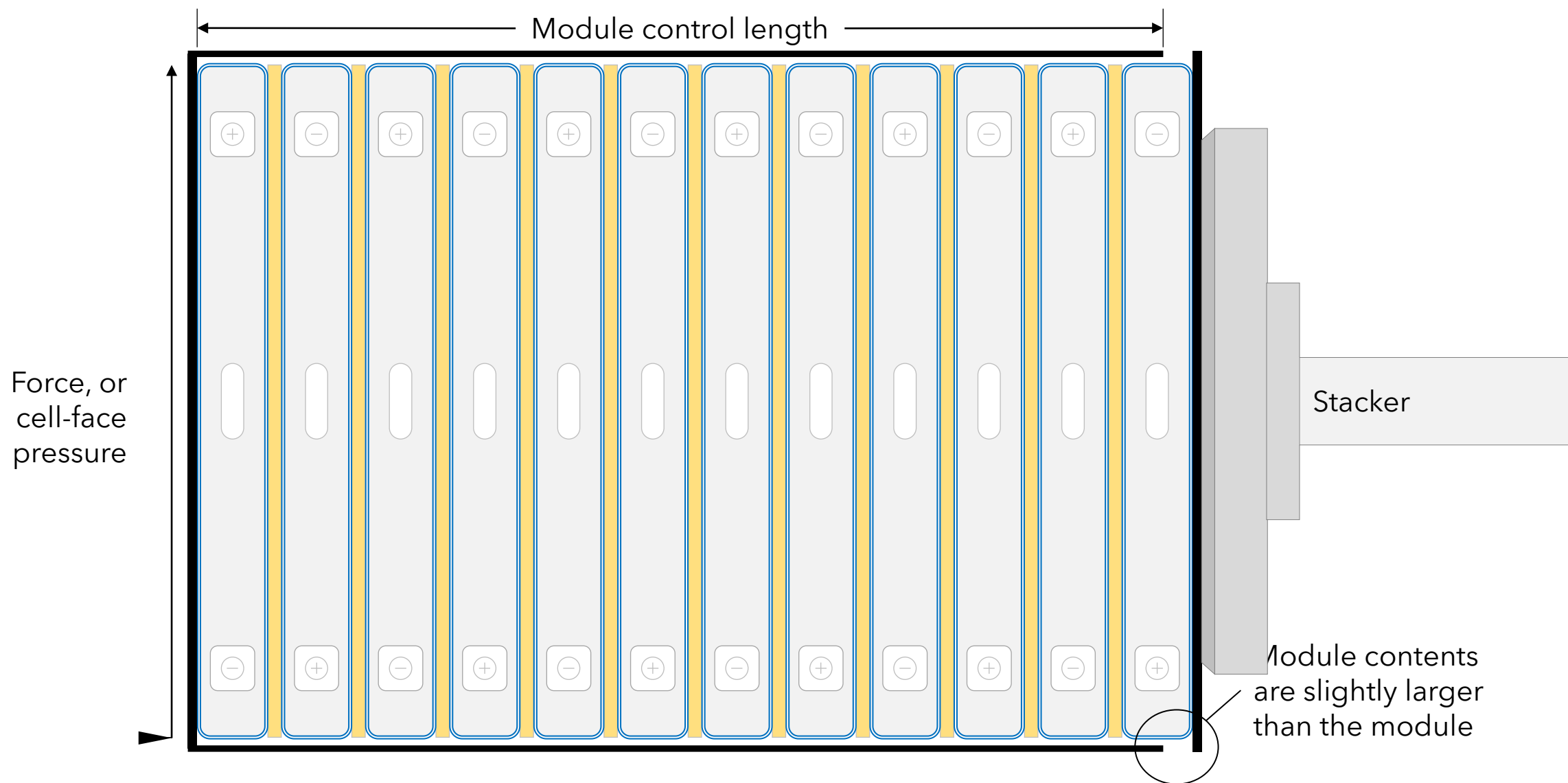
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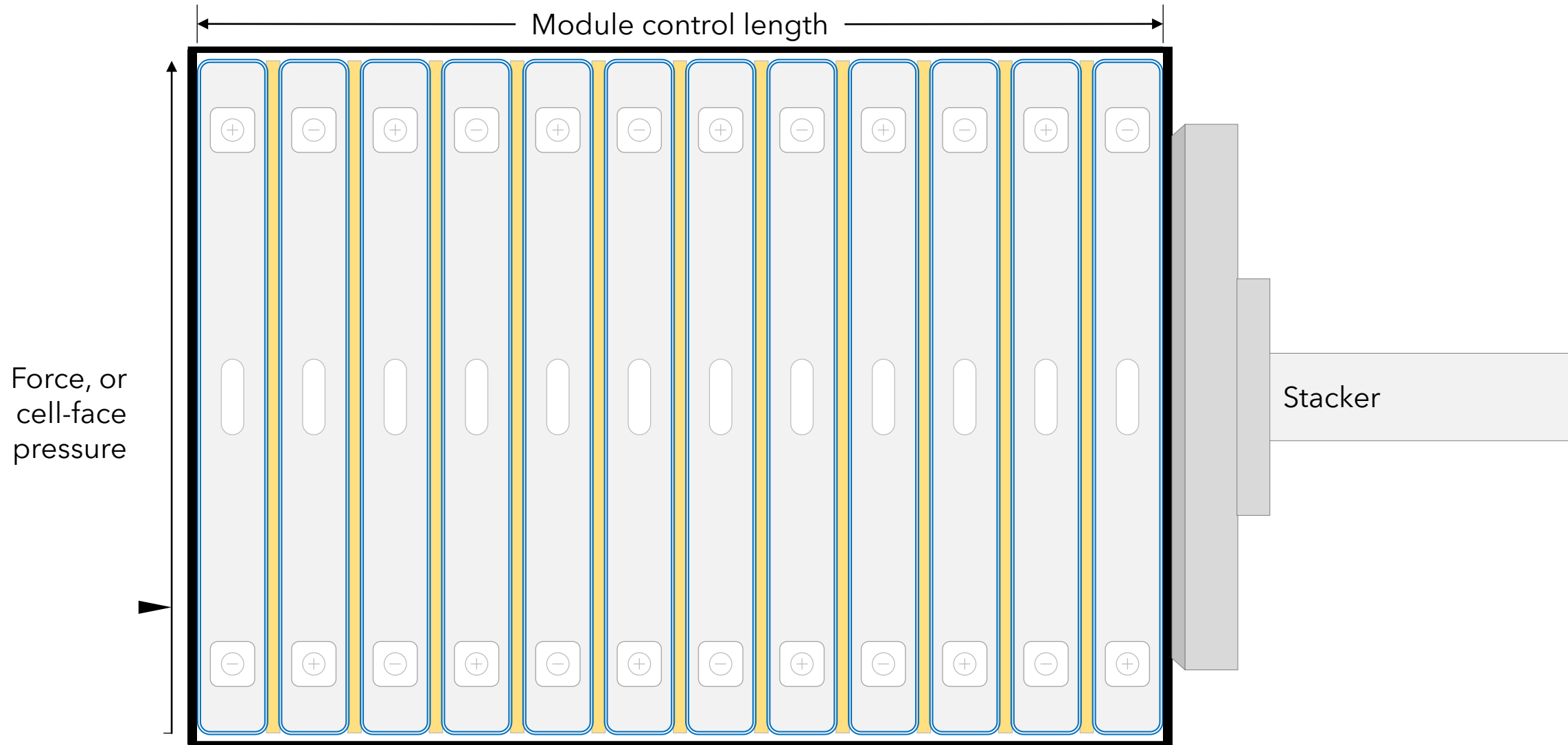
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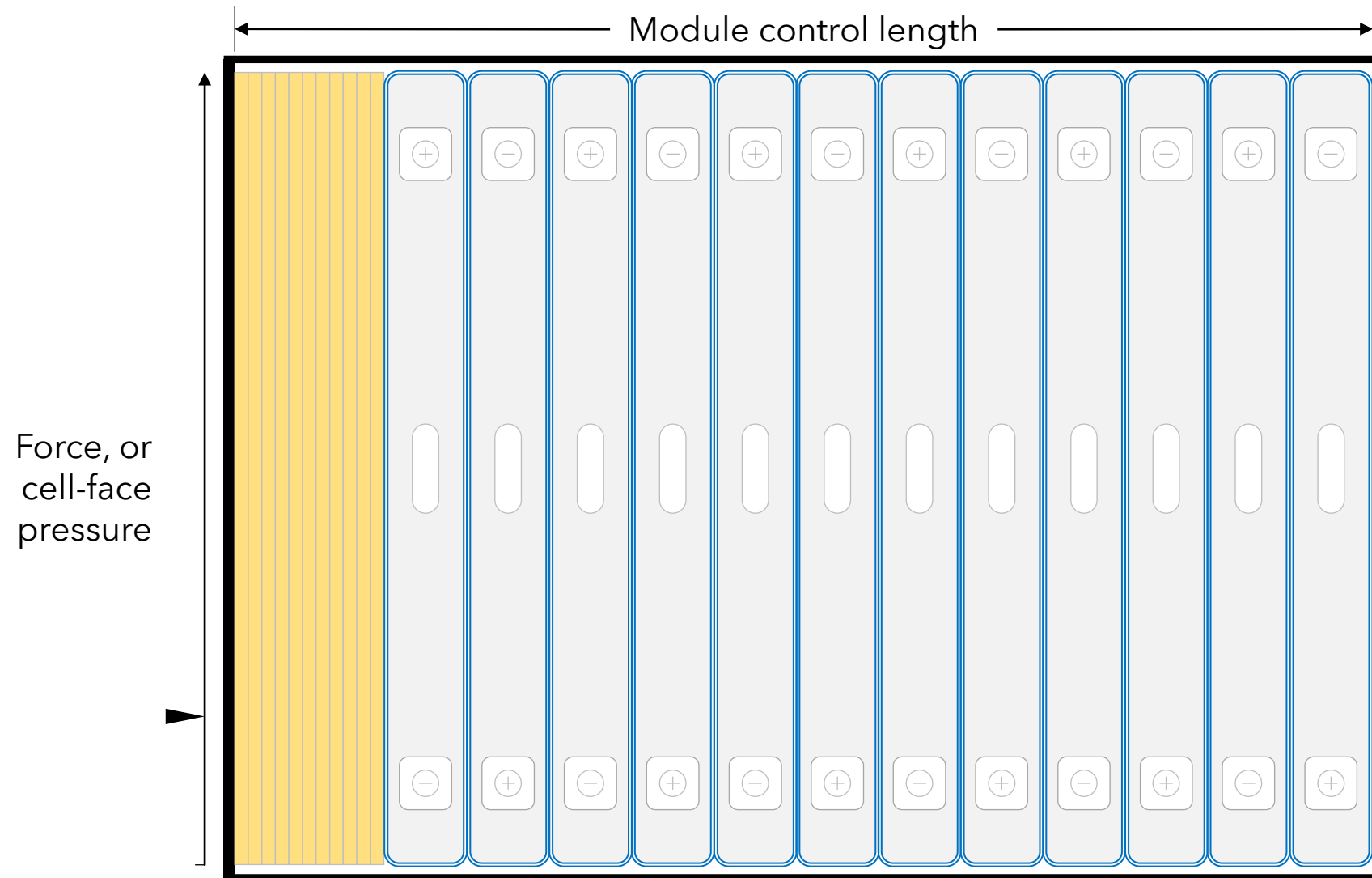




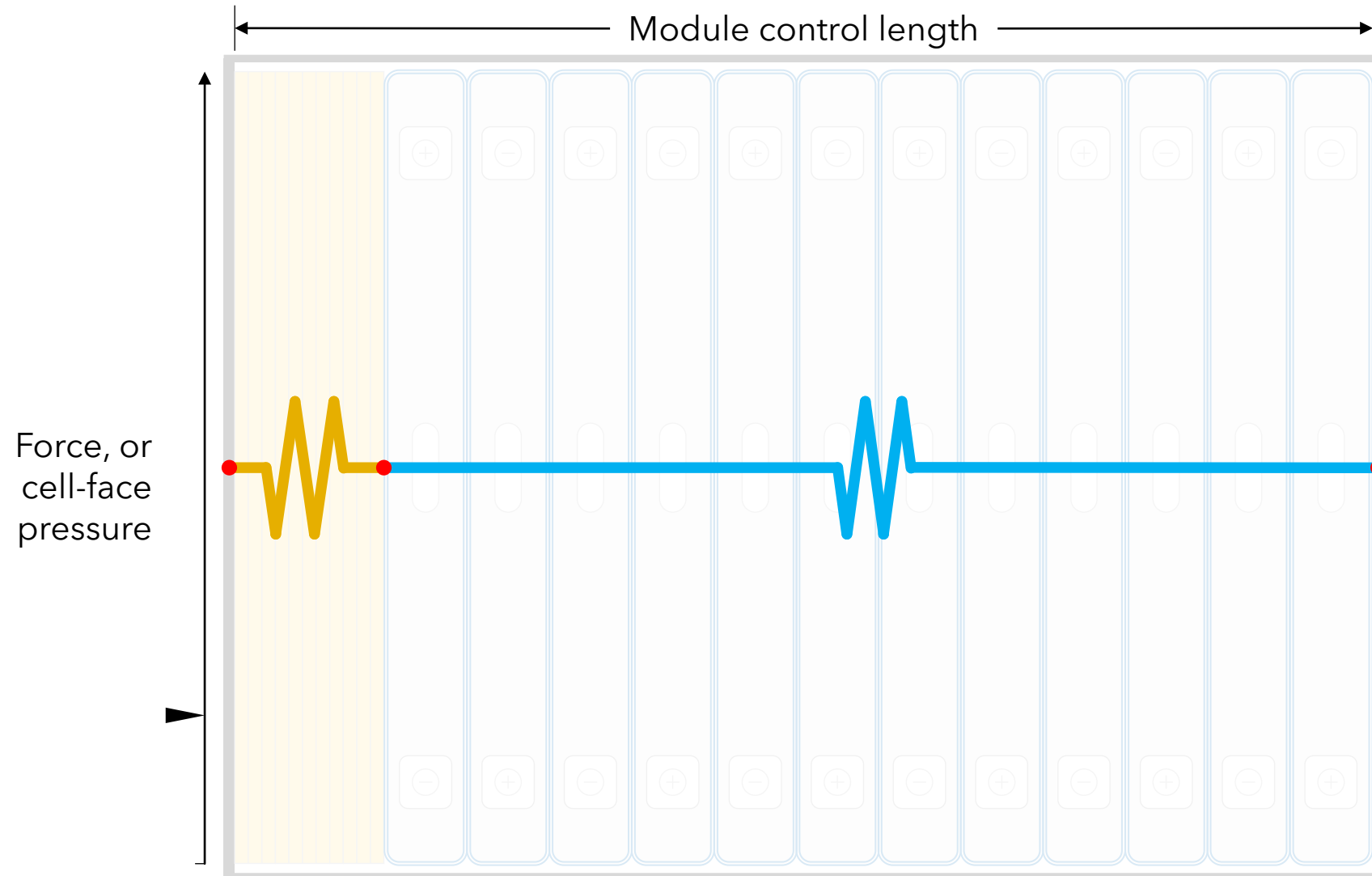
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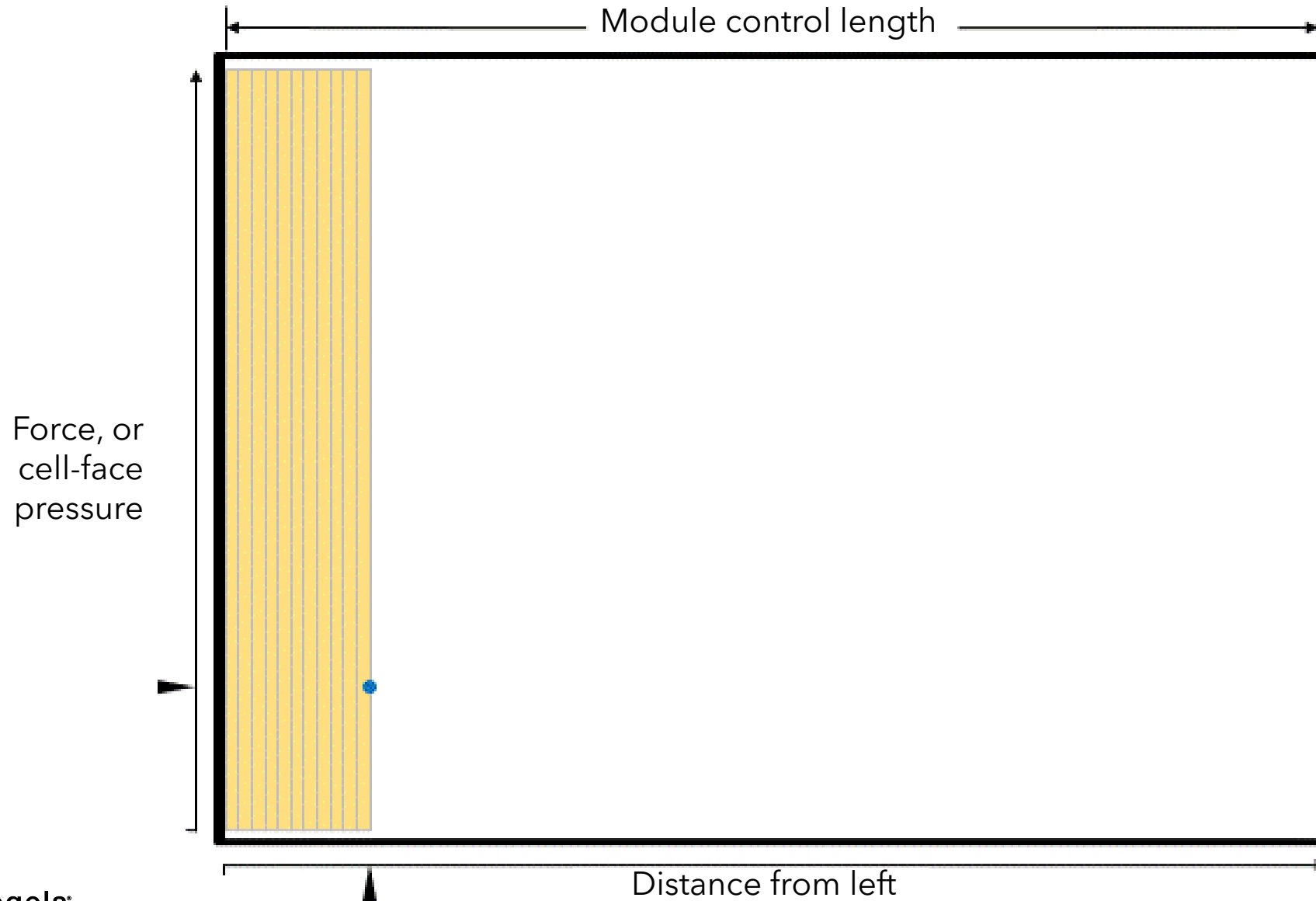
# Regroup Parts



# Regroup Parts and Notice They Form a Two-Spring System

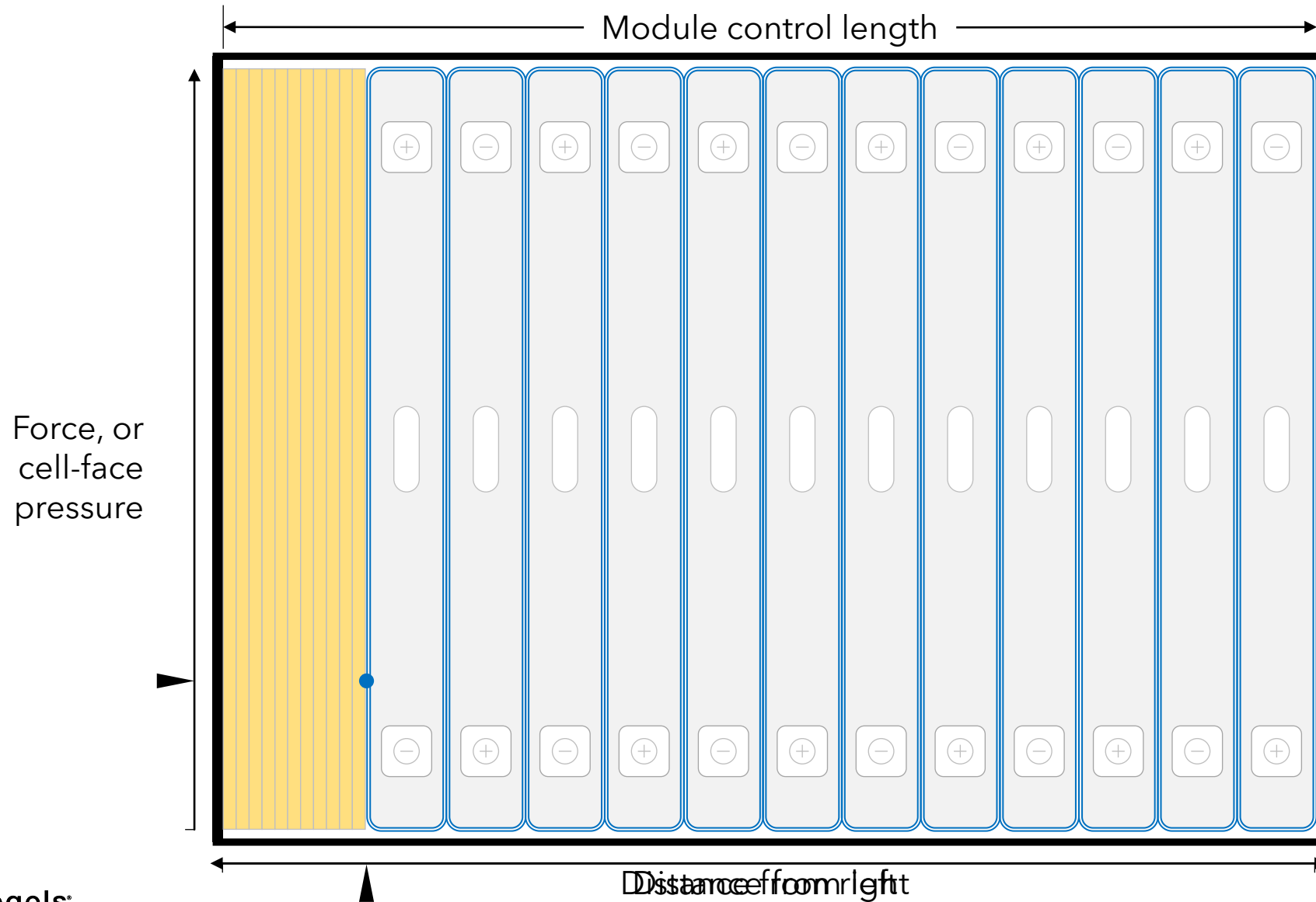


# Visualizing C2C Barrier Response

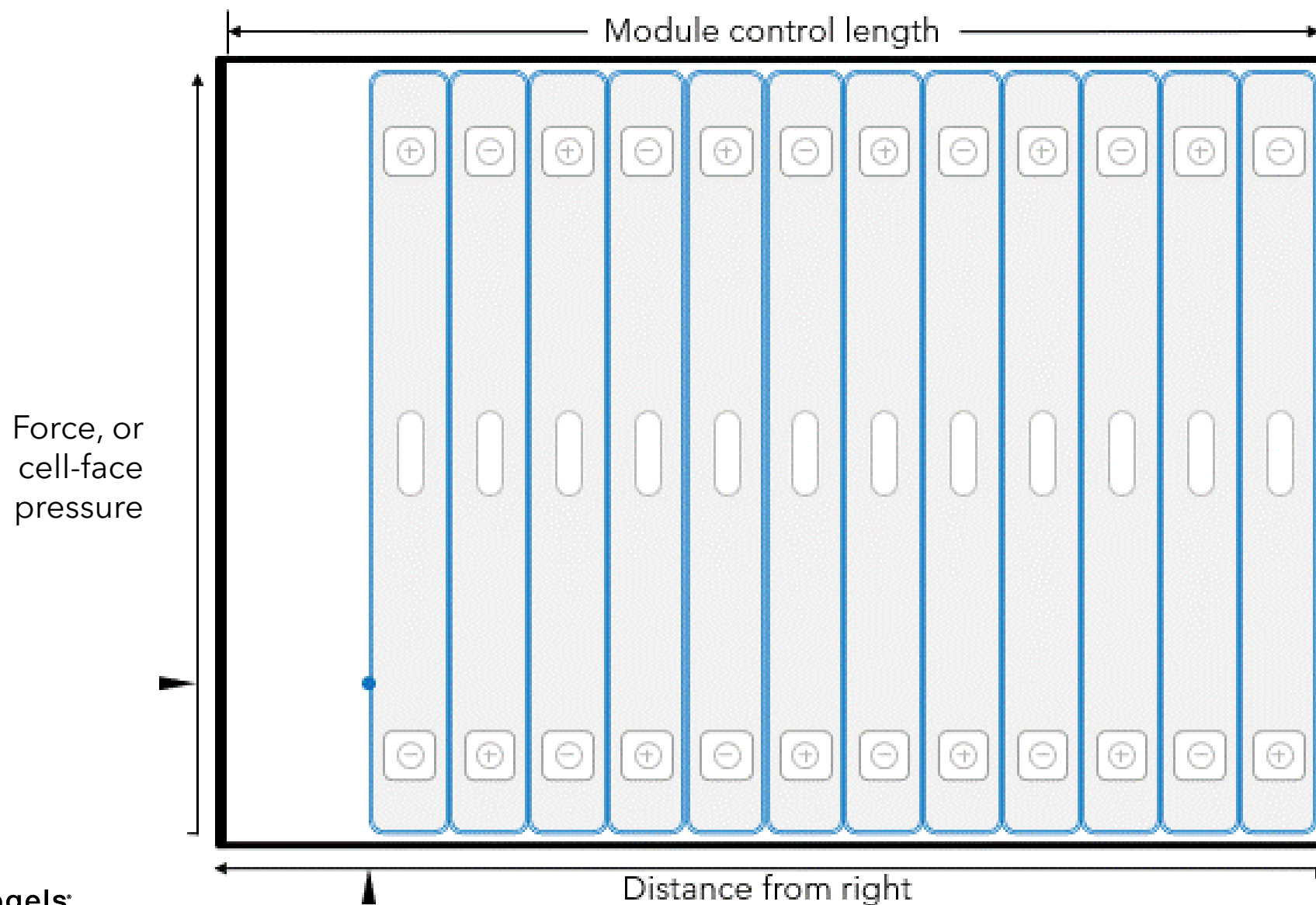




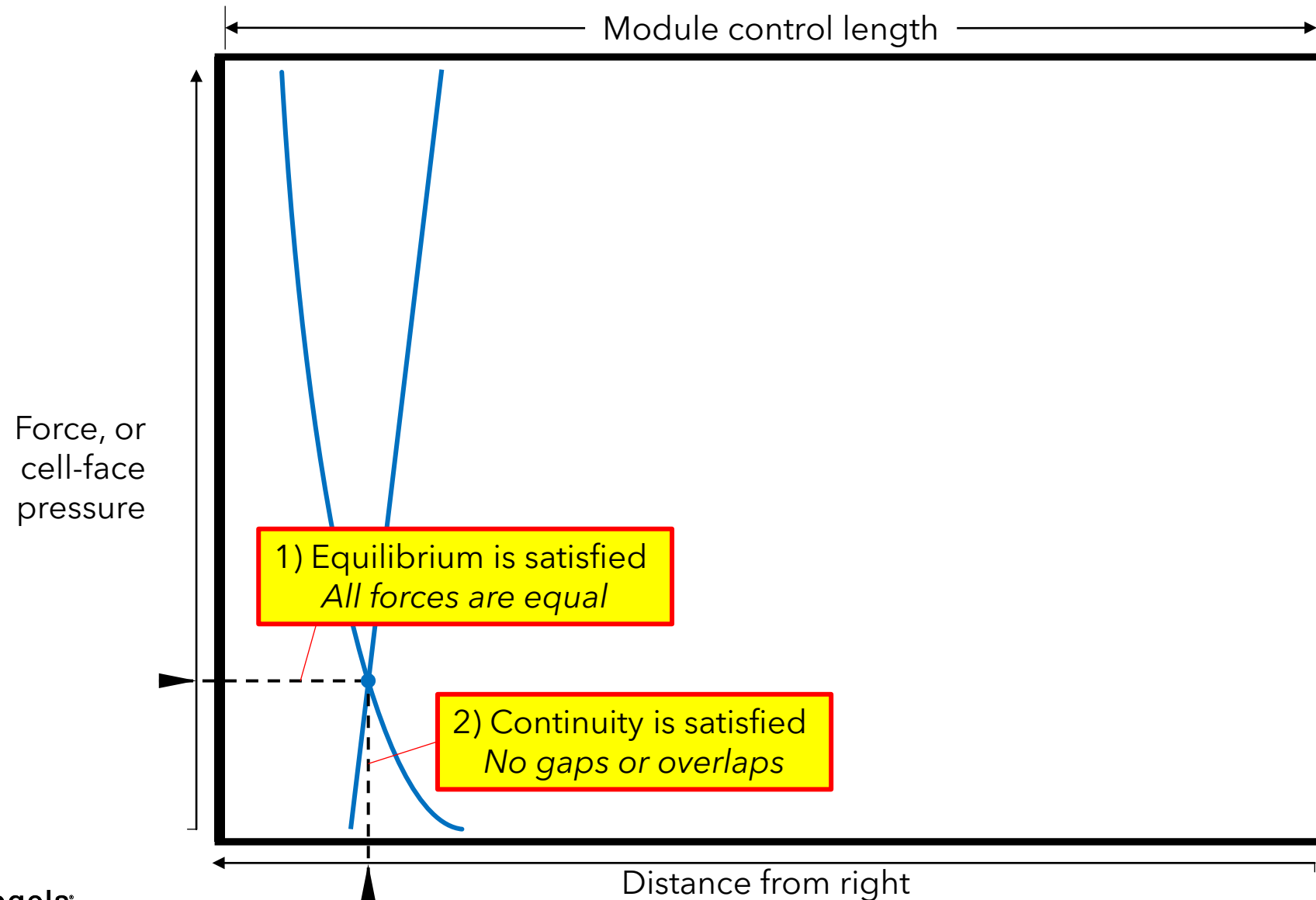
# Cell Response Is Described By Its Compressive Modulus



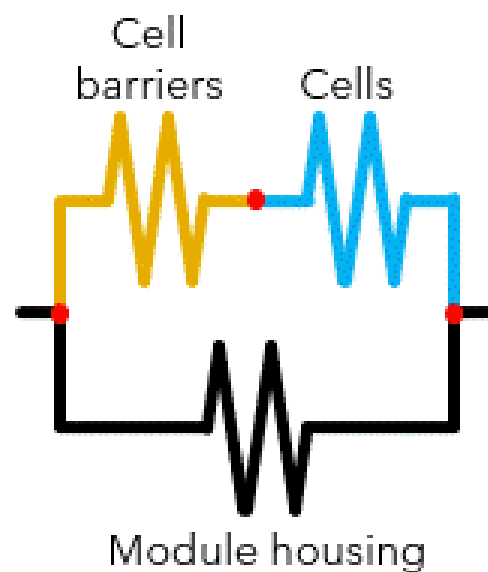
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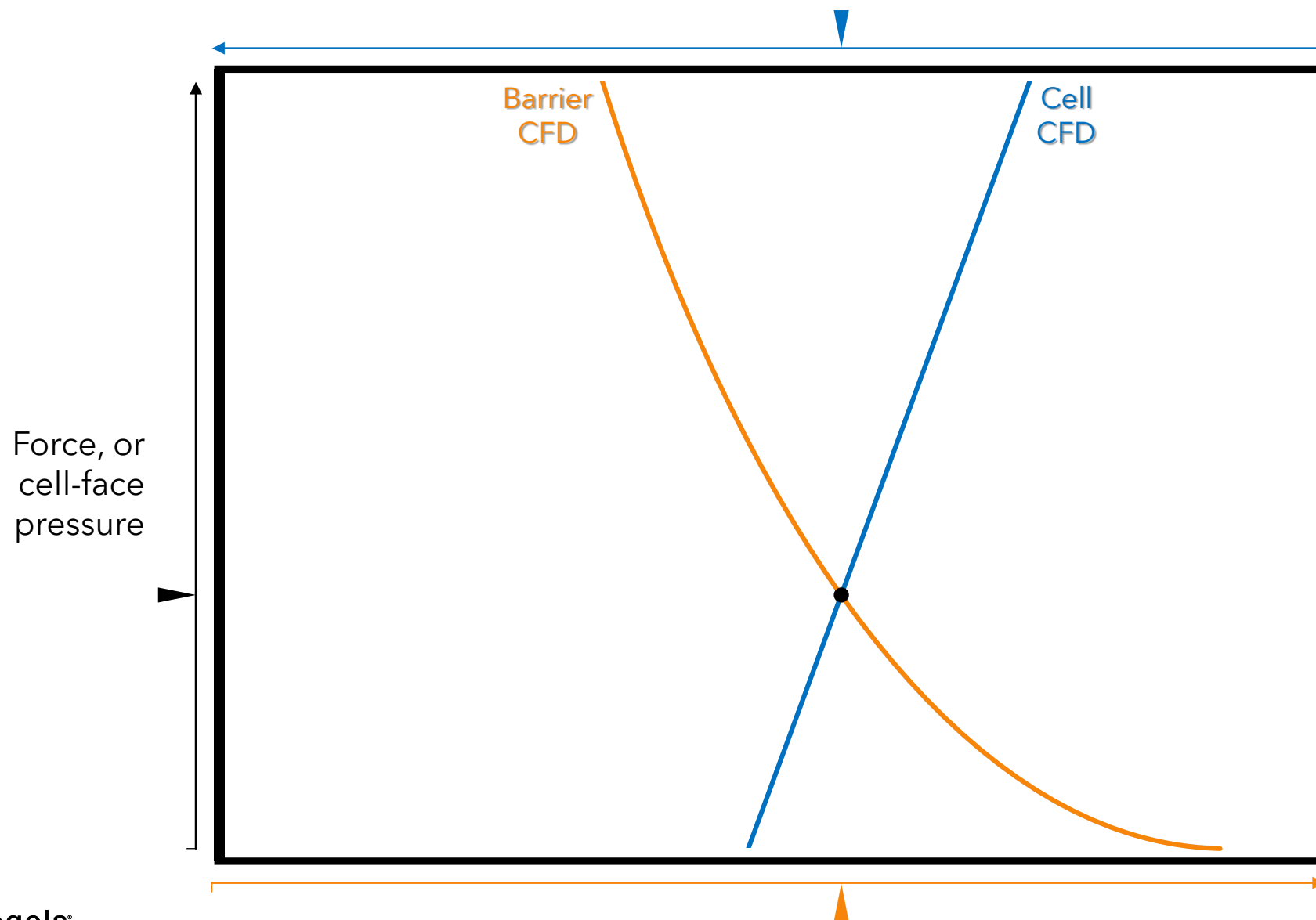
# Satisfying Equilibrium and Continuity



# Cells + Cell Barriers Act as a ~~Two-Spring~~ Three-Spring System

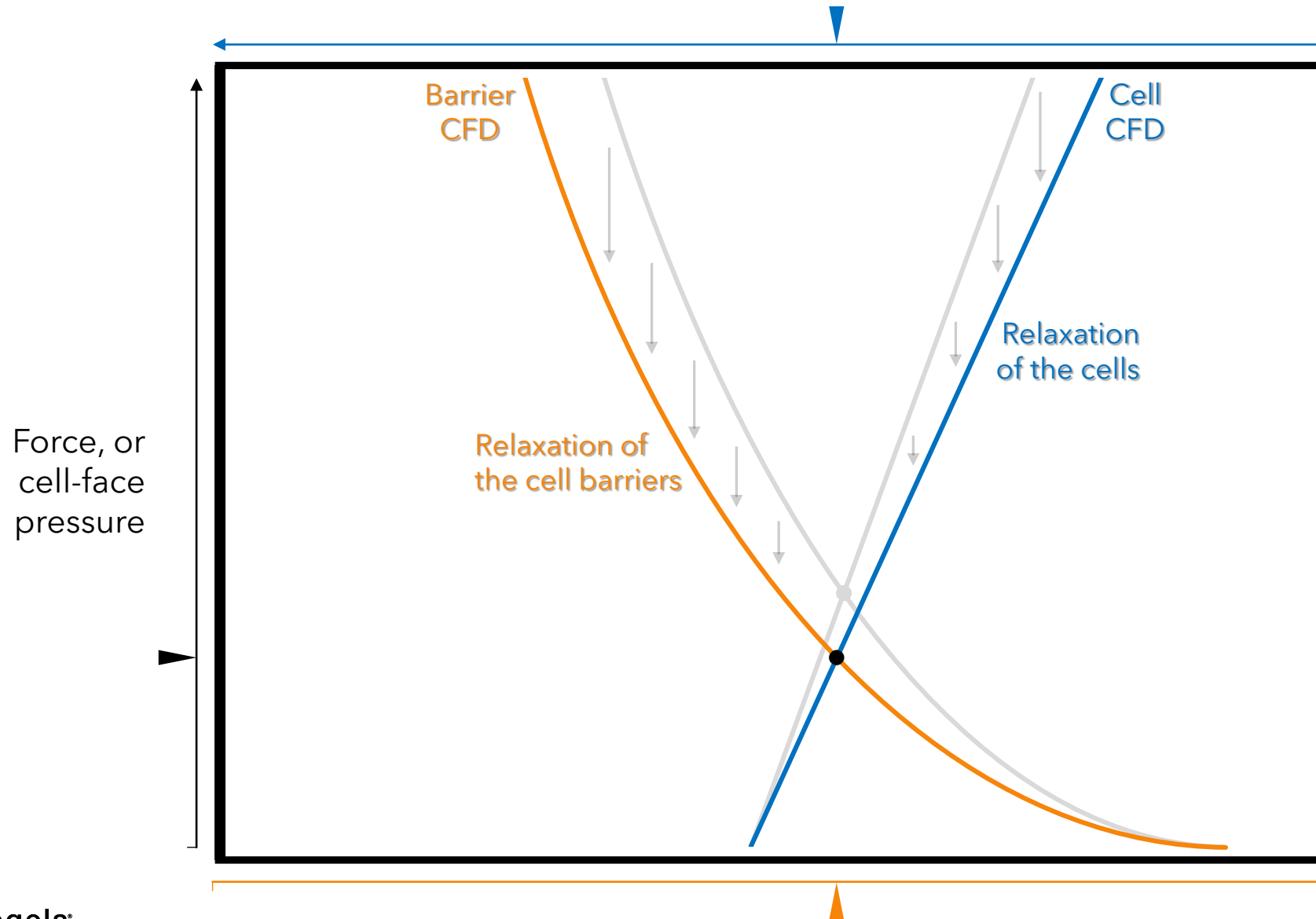


# ASY - Assembly

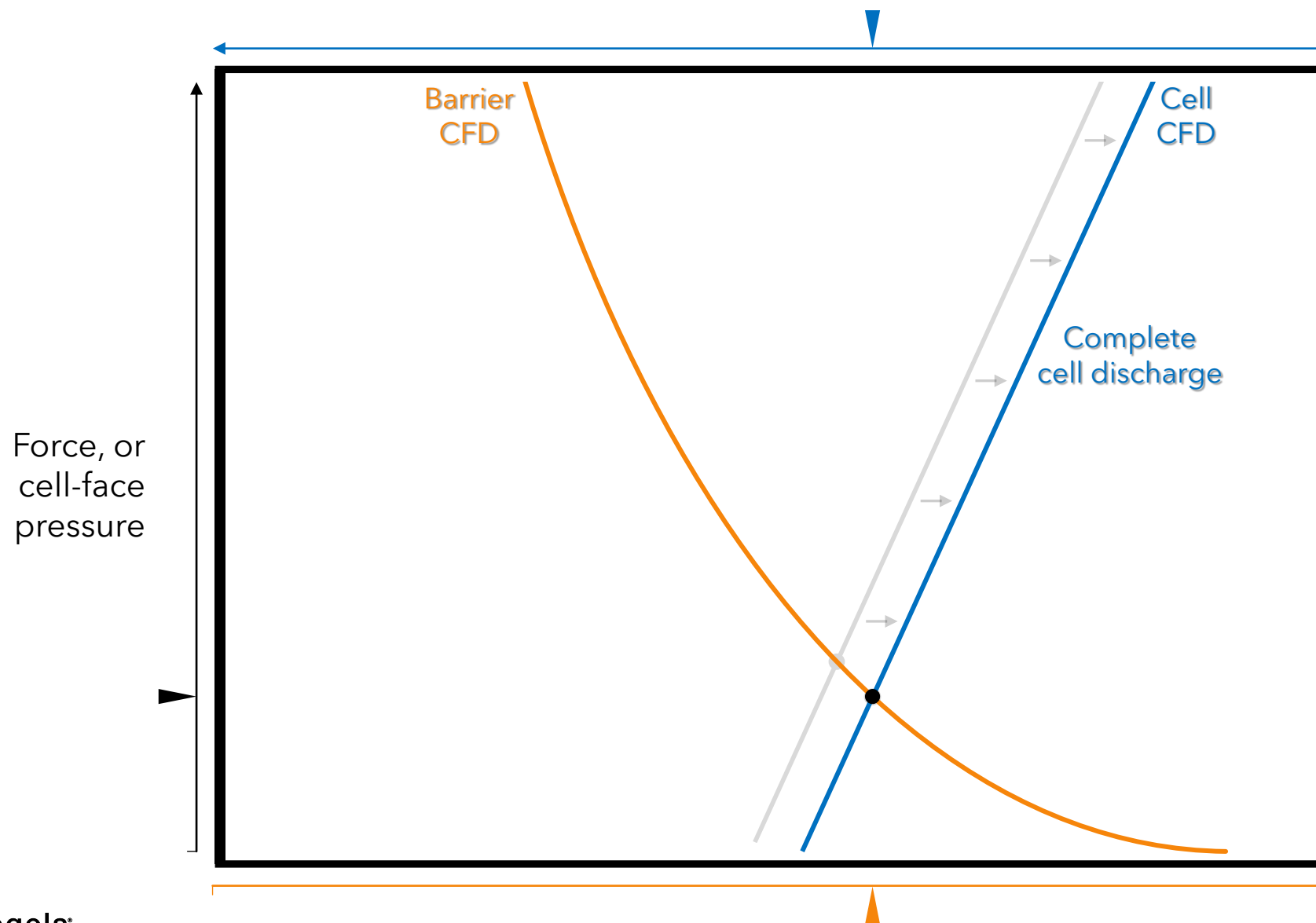




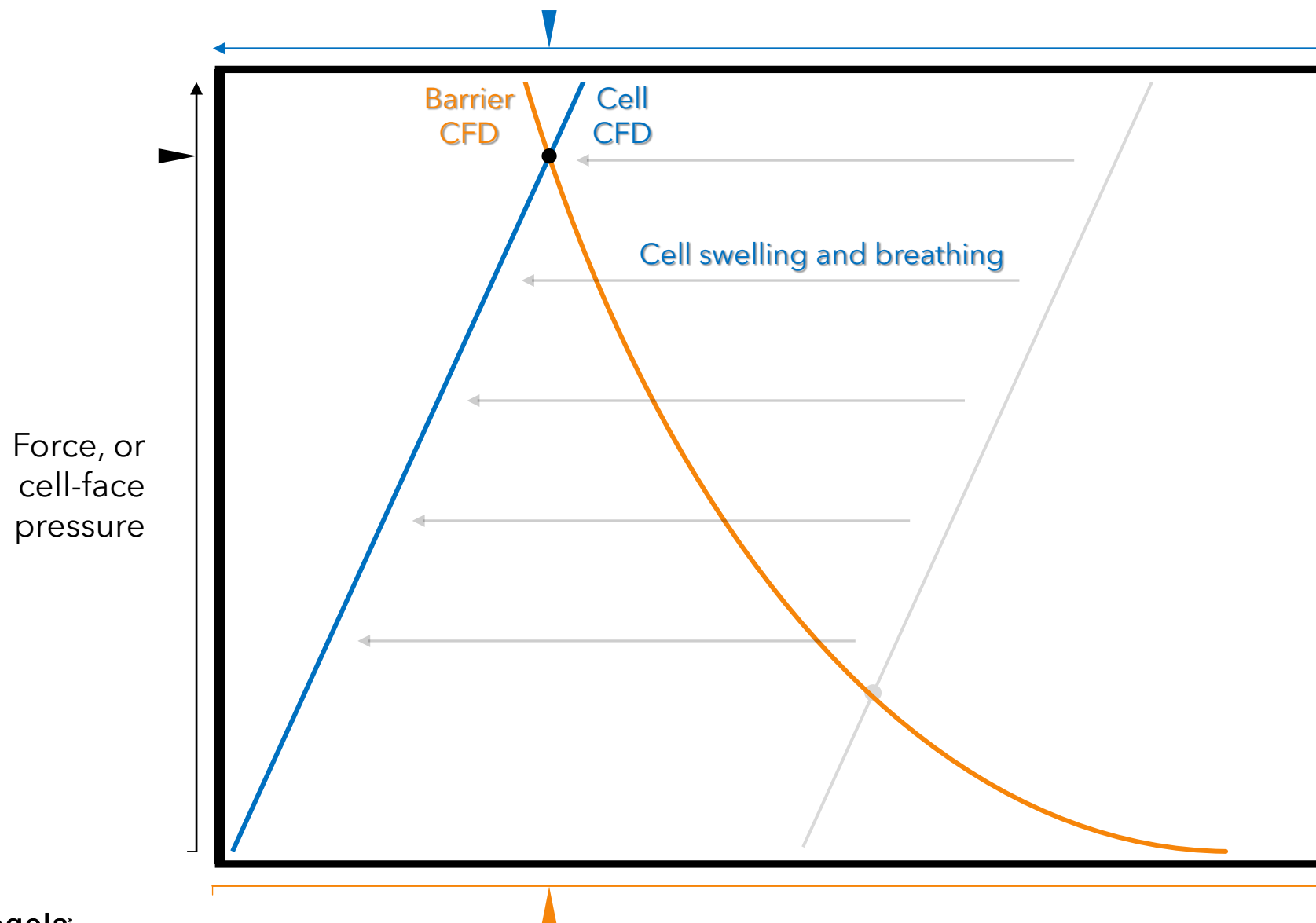
# BOL<sub>1</sub> - Post-Assembly Relaxed State (30% SOC)



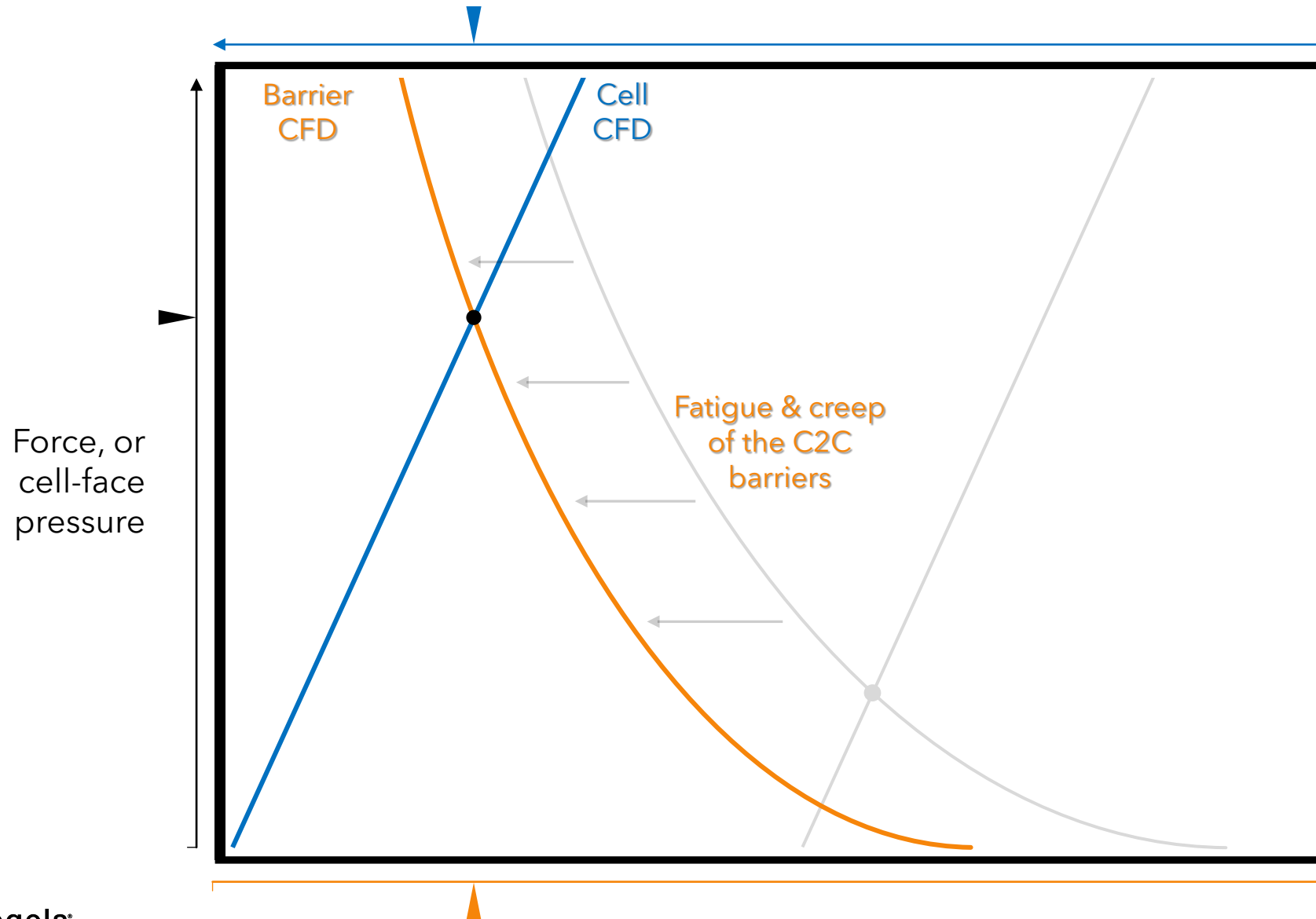
# BOL<sub>2</sub> - Relaxed and Fully Discharged (0% SOC)



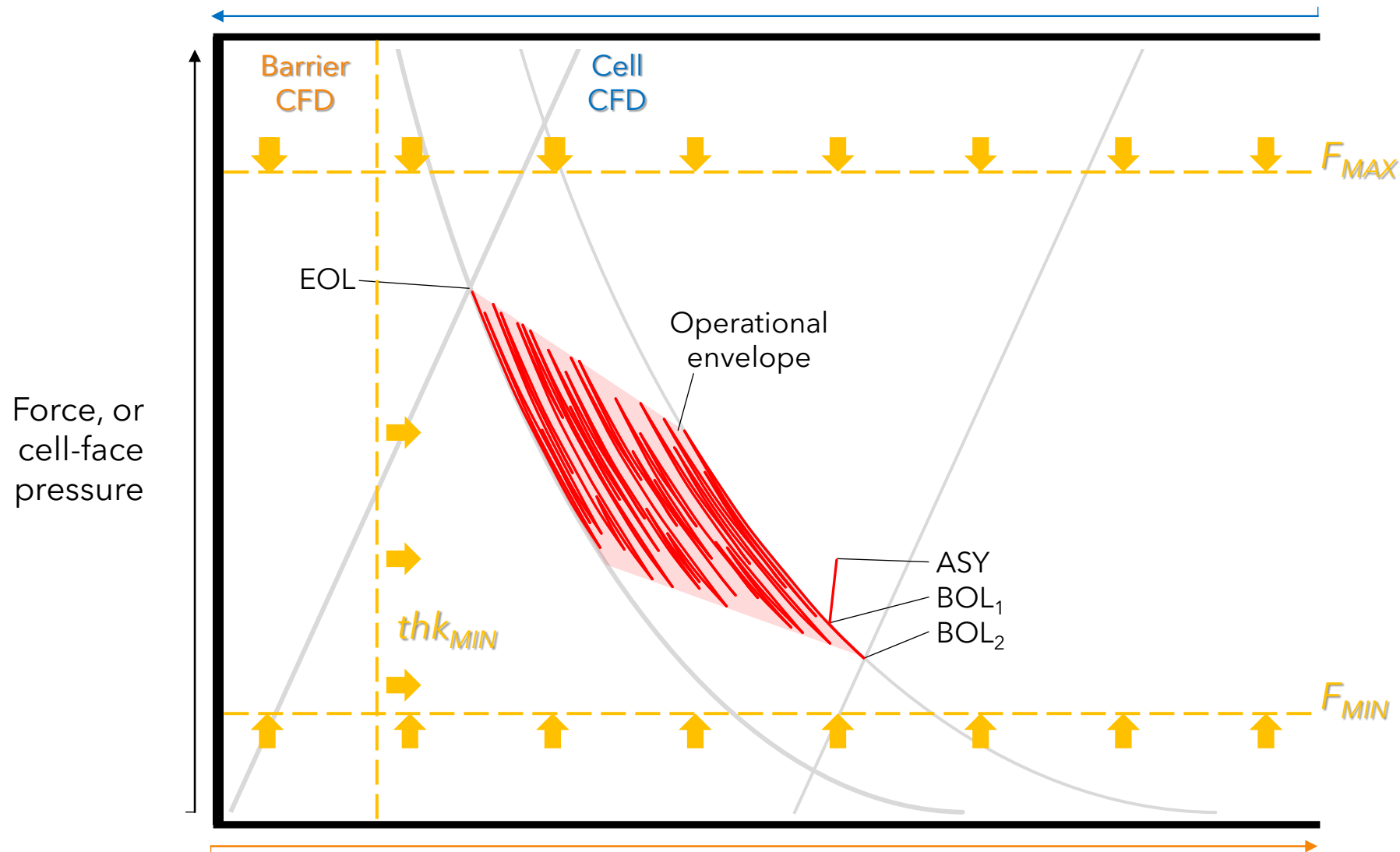
# EOL - Cells Swell and Breathe (100% SOC)



# EOL - Effects of Fatigue, Creep, and Compression Set

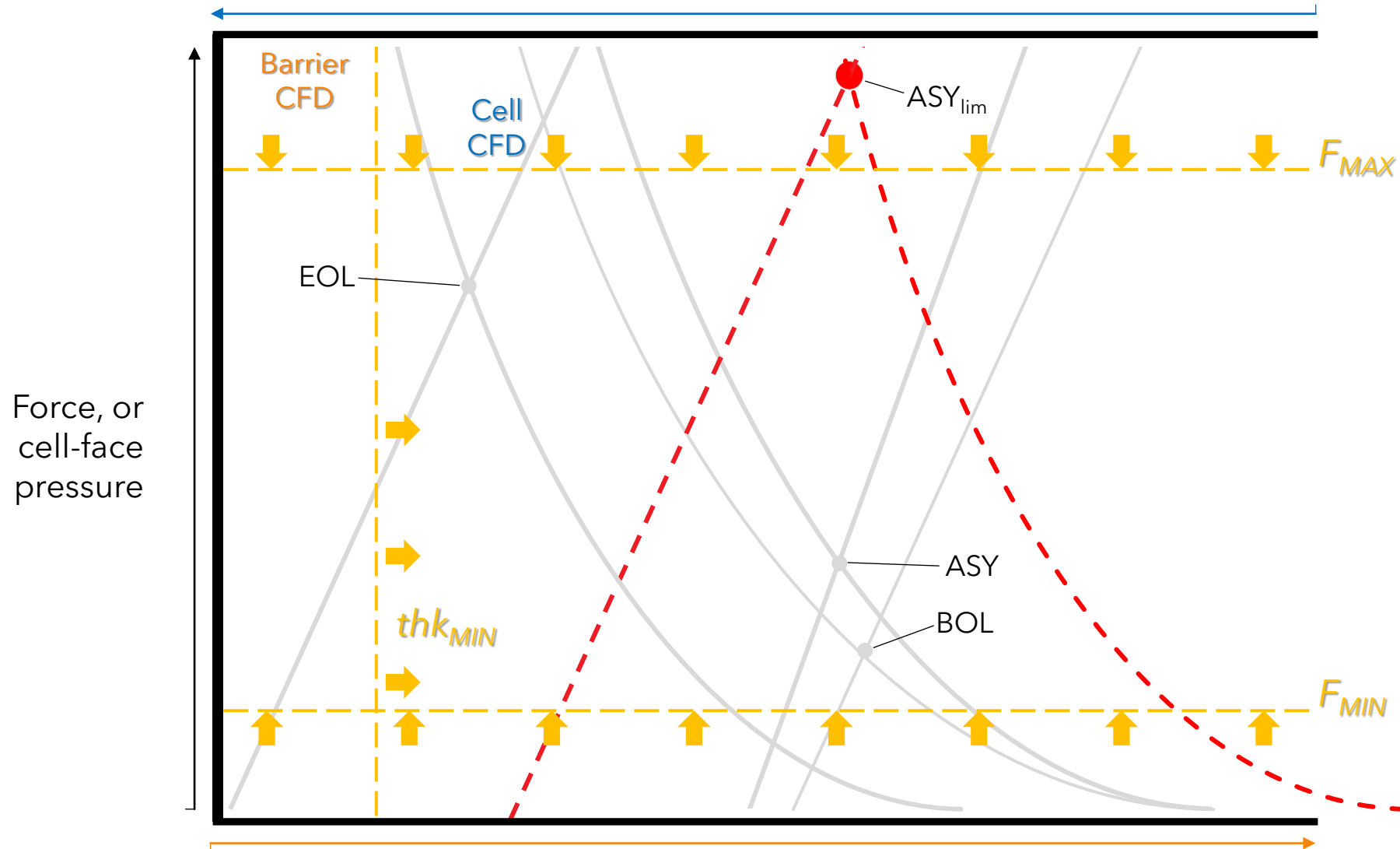


# The Module's Mechanical History Can Be Told with One Graph

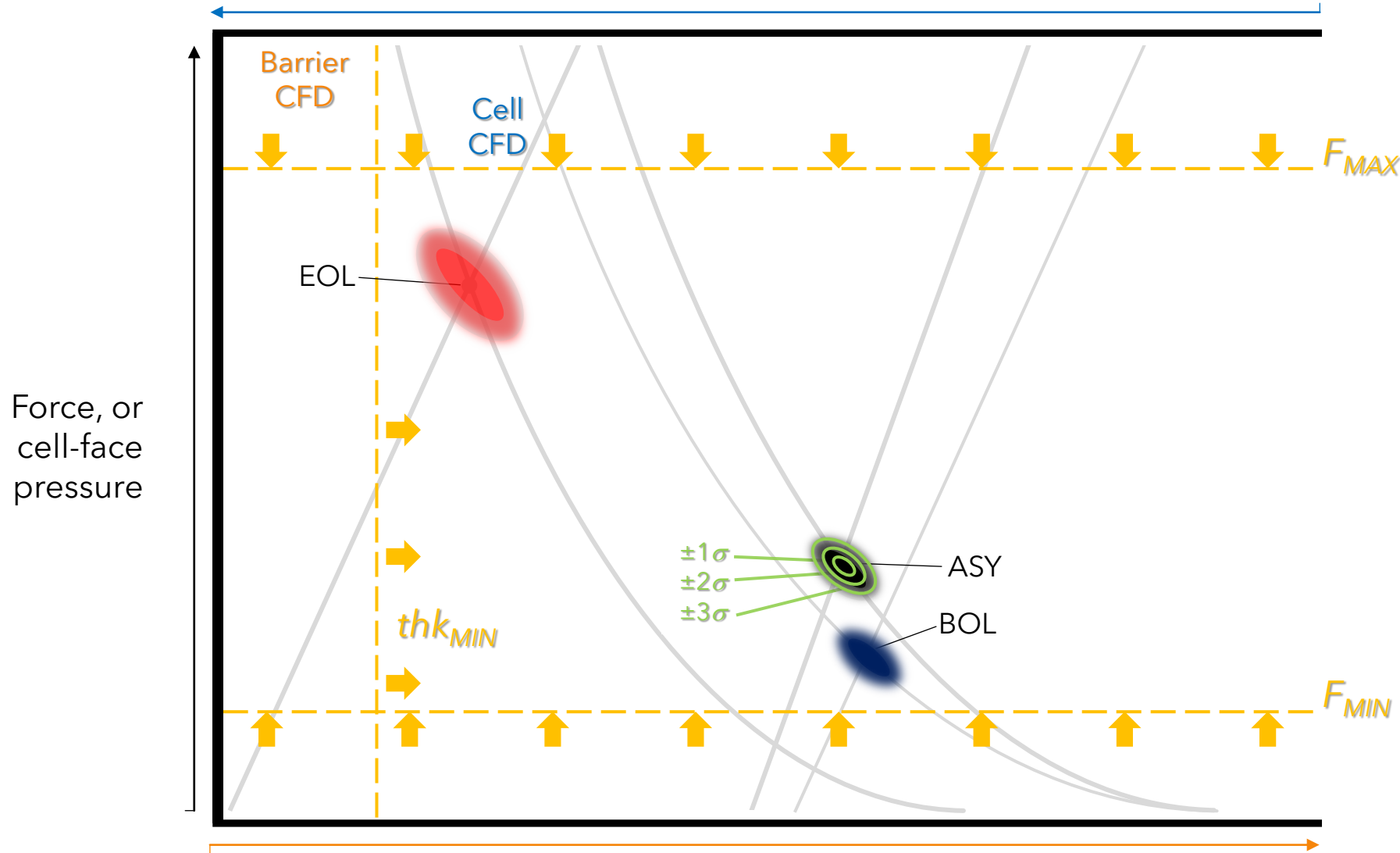




# Mechanical Outcomes Can Be Visualized with One Graph



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- Parametric model delivers variation control over every spring in our “3-Spring” System
- Calculate new equilibrium condition for small variations in geometry and stiffnesses
  - Controlled by specified standard deviations ( $C_v$ ) for each model component
- Iterate thousands of times to create a “cloud” of likely outcomes



# Continue the Conversation Hall 10, Booth G81

**Tyler Gurian**

*Senior Program Engineer, EV Thermal Barrier*

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