10 YEARS

NFPA

# Fluid Power =VEHICLE Challenge

NFPA Education and Technology Foundation

**FINAL PRESENTATION & DESIGN REVIEW**
**DREXEL UNIVERSITY**
**ADVISOR: JUSTIN ALLISON**
**DATE: 4/6/2026**

Drexel UNIVERSITY

**Now Speaking: Chris Holland**

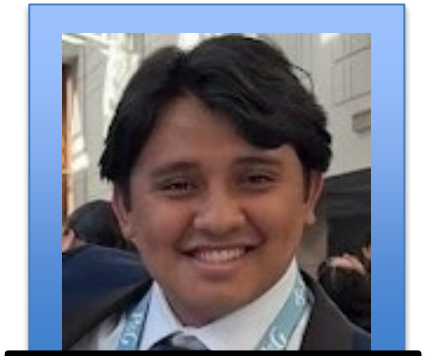
# MEET THE TEAM

**Nick Zafiriadis**
Hydraulics Lead

**Ian Siwinski**
Transmission Lead

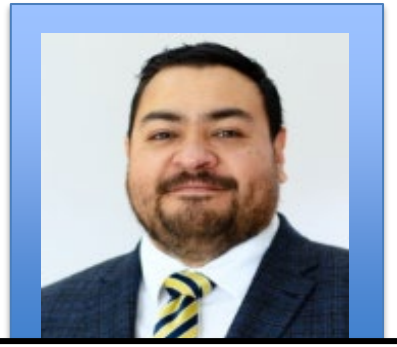
**Jimmy MacDonald**
CAD Lead & Hydraulics

**Reese Wheeler**
Electronics Lead



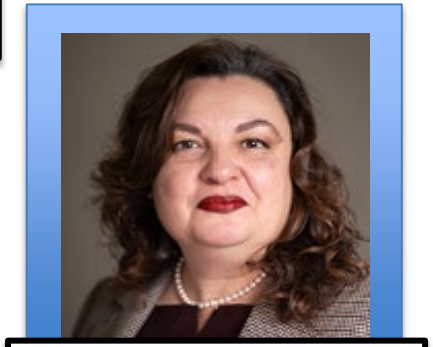
**Cesar Rosales Retana**

**Matthew Roche**
Team Lead & Hydraulics

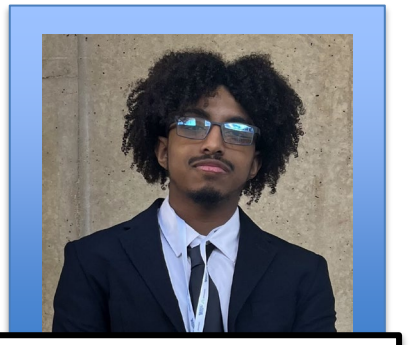


**Advisor**
**Dr. De La Fuente**

Drexel UNIVERSITY



**Co-Advisor**
**Dr. Ciobanescu**



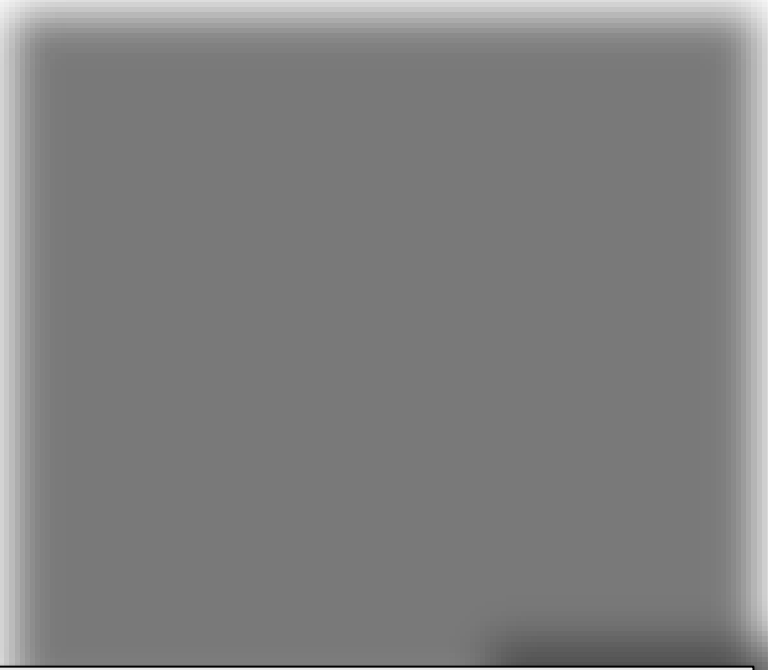
**Chris Holland**

**Now Speaking: Chris Holland**

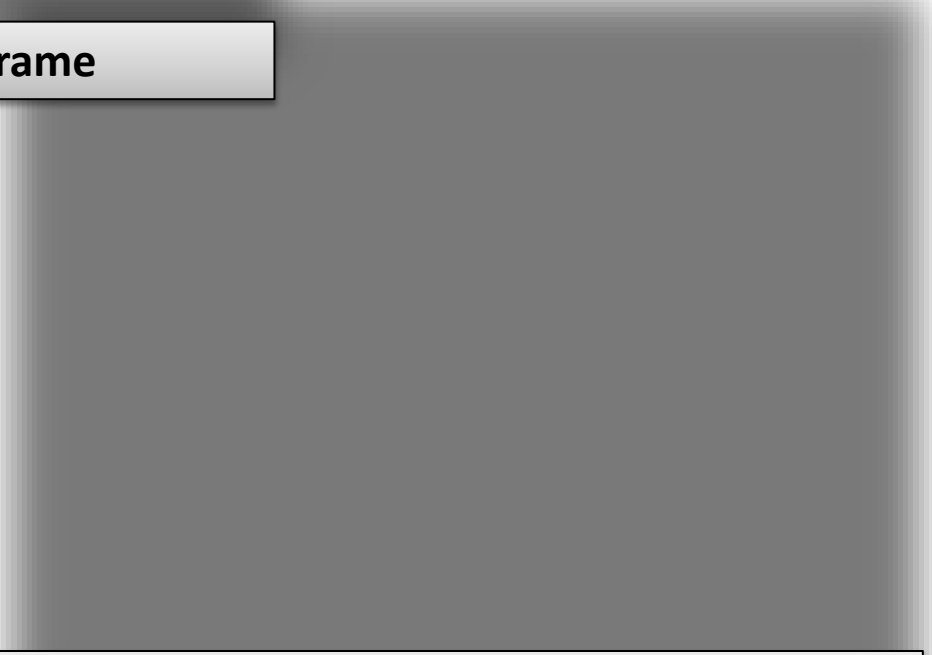
# Frame Selection

Miami Sun Traditional 24":

- Stable platform for riding.
- Large mounting area for a clean layout and design freedom
- 7-speed compatibility
- Dual braking system
- Frame weight ~ 50 lbs



Pre Fabrication Frame



Post Fabrication Frame

**Now Speaking: Chris Holland**

# Transmission Selections (Part 1)

- 0.39 CID Danfoss Gear Pump
- Existing 36T Pedal sprocket
- Industrial 17T Pump sprocket
- ANSI 40 Roller Chain
- Chain Tensioner to relieve interference

| Pump CiD | Pedal RPM | Gear Ratio (Pedal/Pump size) | Pedal Lever Length | Max Pump Torque |
|---|---|---|---|---|
| 0.39 | 85 | 2.11 | 7 | 186 |
| Pedal Torque | Lbs. of Push | Average Push on Pedal | Pump RPM | Pump GPM |
| 392 | 56 | 27.00 | 179.35 | 0.30 |

**Type: Gear Pump**
**Rotation: Clockwise**
**Weight: 5.3 lbs.**
**Max. Flow: 6.3 GPM**

**Now Speaking: Ian Siwinski**

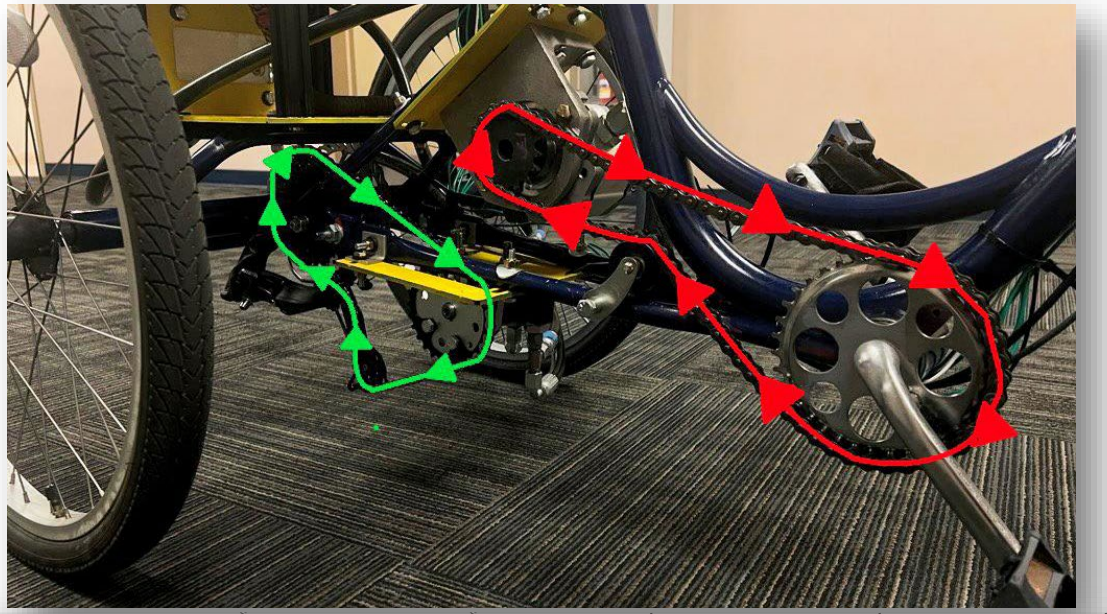
# Transmission Selections (Motor)

- Young Powertech YMM
  0.79 CID Orbital motor
- Min. RPM < 40
- Max. RPM > 1940
- Max. PSI ~ 2900
- More efficient at lower speeds
- Provides higher torque at low RPM
- Operates in recommended ranges

**Now Speaking: Ian Siwinski**

# Transmission Selections (Part 3)

- YMM 0.79 CID
- Custom 16mm bore shaft hub w/ 28T chainring
- ½" x 3/32" single-speed narrow chain
- 7-speed cassette (34T-13T)
- Shimano Altus Derailleur
- Rear axle Disc Brake

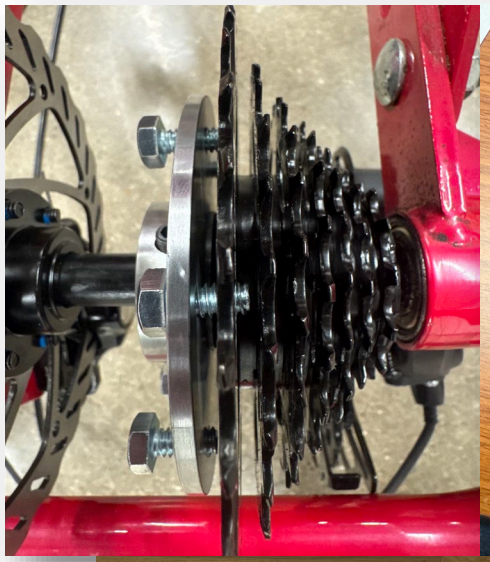


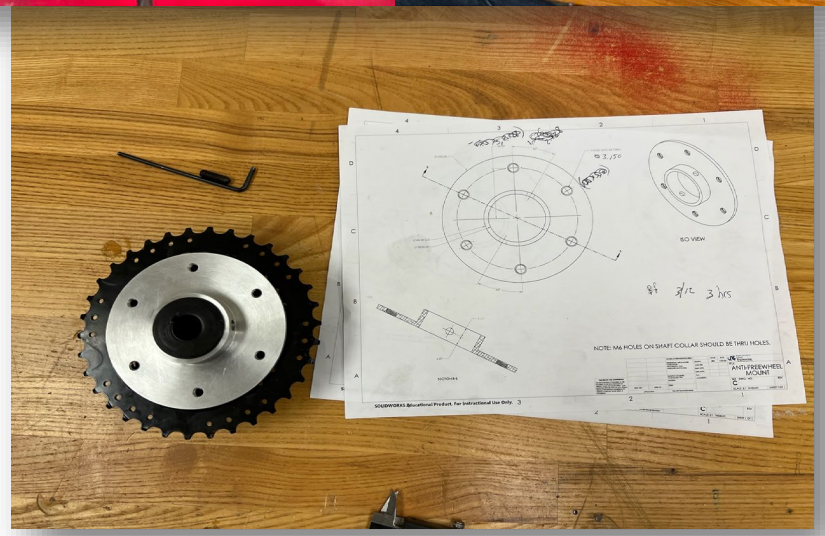
| Motor CIR | Max PSI | Gear Ratio (Wheel/Motor Size) | Max Motor Torque | Max lbs. of pull | Average lbs. of pull | Max. Pedaling MPH |
|---|---|---|---|---|---|---|
| 0.79 | 3000 | 1.21 | 377 | 38 | 29 | 5.21 |
| 0.79 | 3000 | 1.00 | 377 | 31 | 24 | 6.32 |
| 0.79 | 3000 | 0.86 | 377 | 27 | 21 | 7.38 |
| 0.79 | 3000 | 0.75 | 377 | 24 | 18 | 8.43 |
| 0.79 | 3000 | 0.64 | 377 | 20 | 15 | 9.84 |
| 0.79 | 3000 | 0.54 | 377 | 17 | 13 | 11.81 |
| 0.79 | 3000 | 0.46 | 377 | 14 | 11 | 13.62 |
| Pedal RPM | Pre-Charge | | | | | |
| 85 | 2000 | | | | | |

**Now Speaking: Ian Siwinski**

# Fabrication: Transmission

- Utilized SolidWorks for alignment
- Mounting re-design required for pedaling space and reducing interference
- Designed machined noninvasive anti-freewheel hub for regen mode
- Tuned derailleur for proper gear shifting during differing operating loads

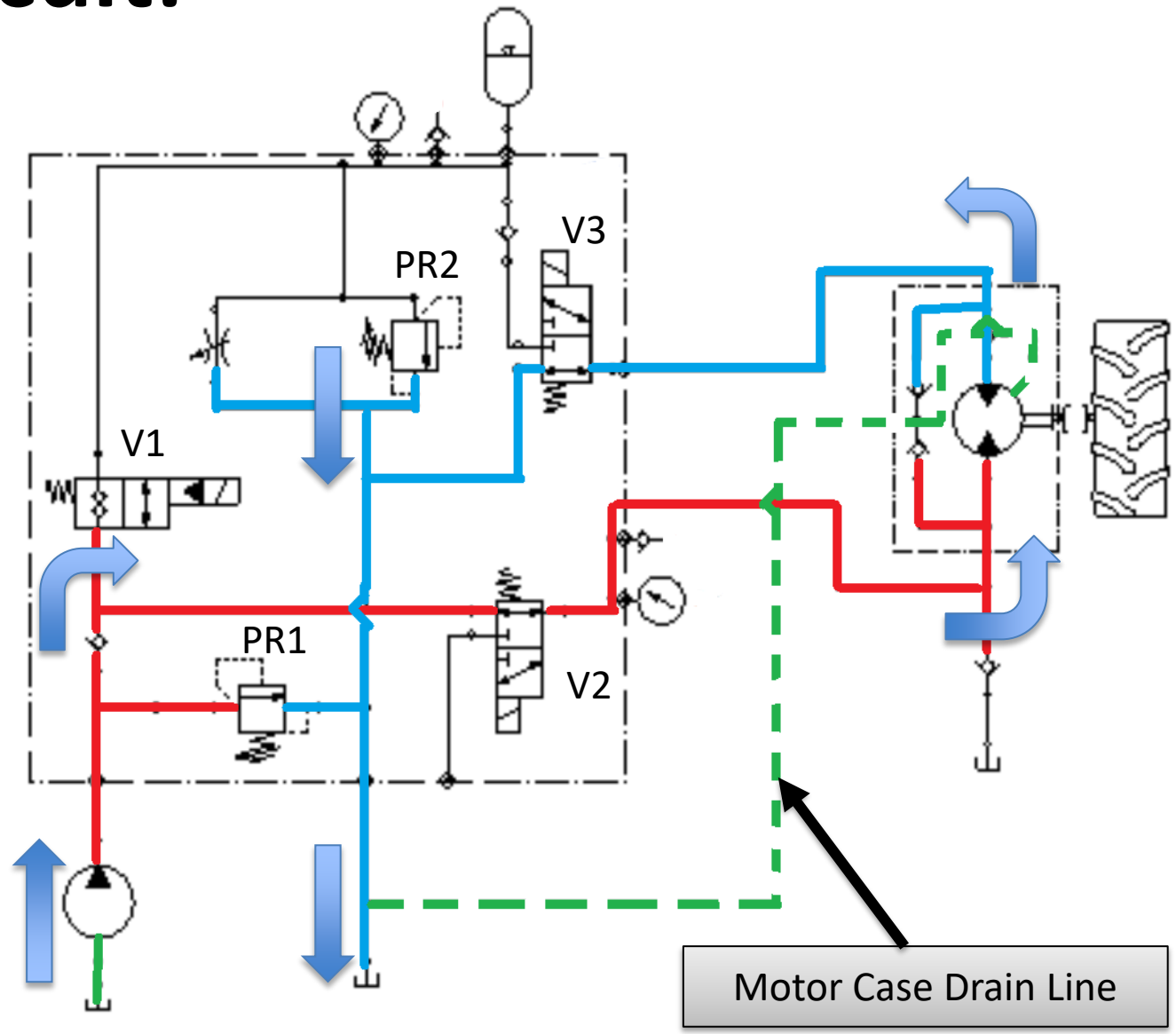




**Now Speaking: Ian Siwinski**

# Hydraulic Circuit: Drive Mode

Color Code Key
Blue = Return
Red = High Pressure
Green = Suction
Green Doted = Drain

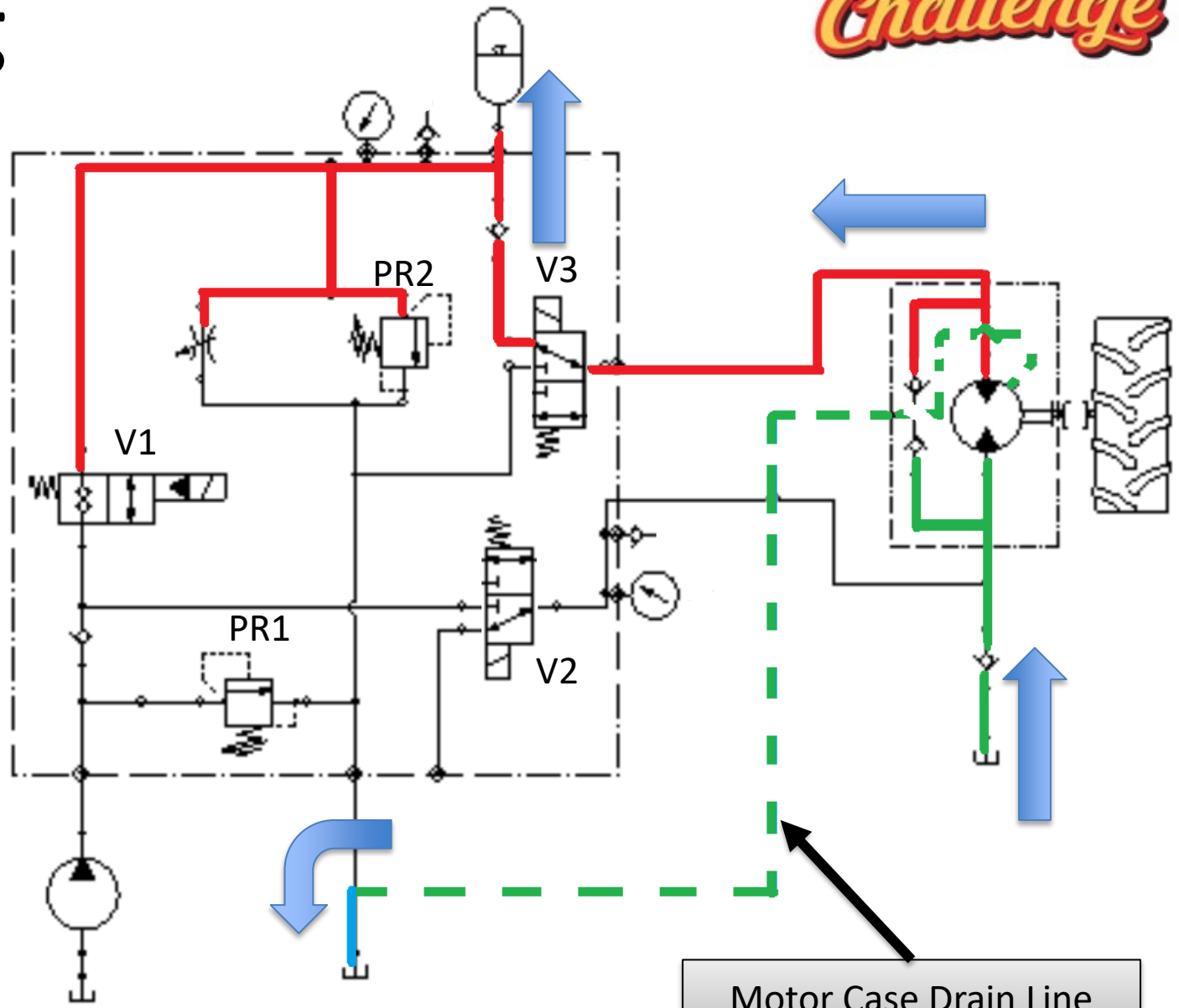



**Now Speaking: Nick Zafiriadis**

# Hydraulic Circuit: Regenerative Braking

- Kinetic energy is converted into hydraulic potential energy
- Motor “acts as a pump” to pressurize accumulator
- Stored energy can be used in "Boost" Mode

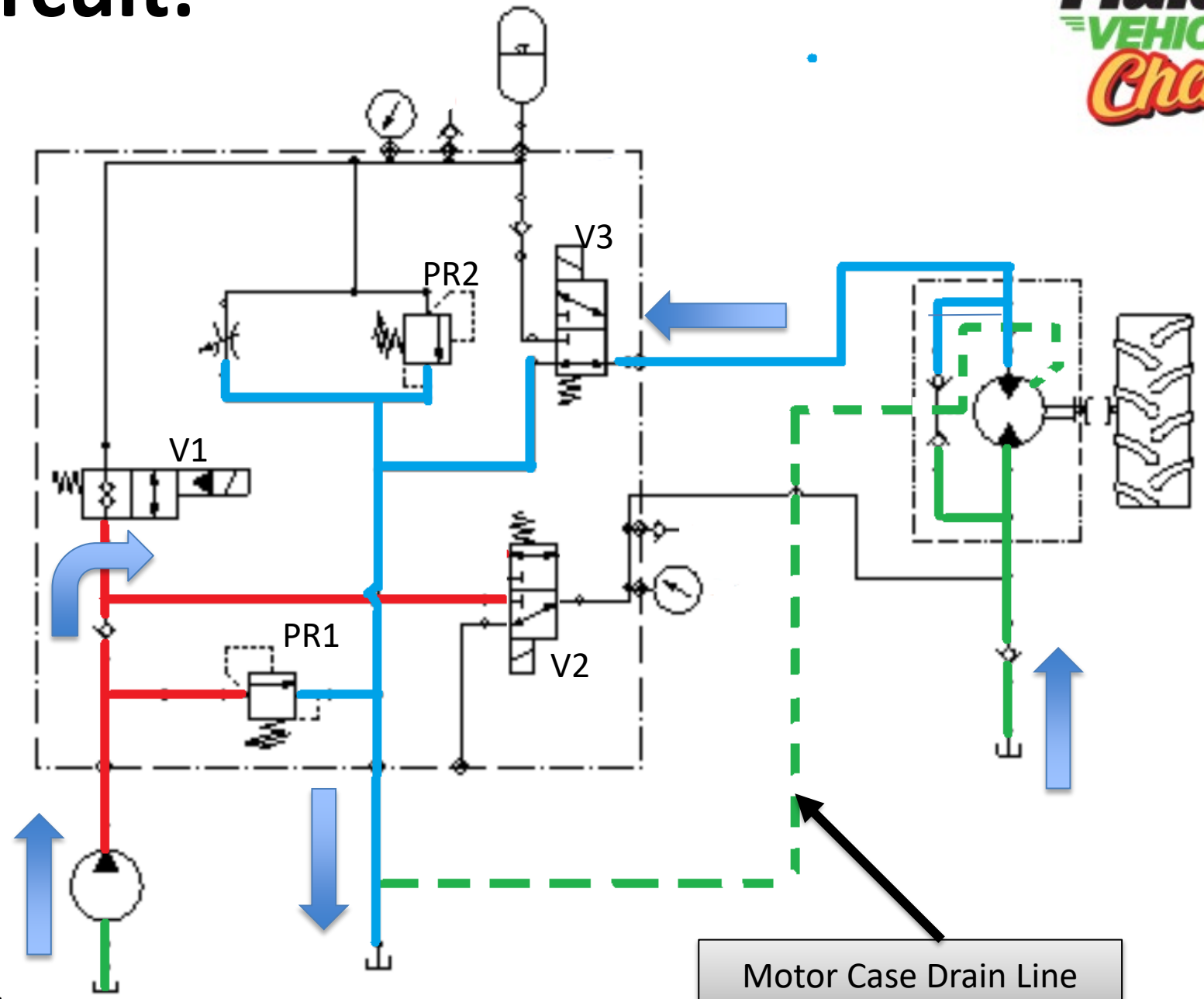
Color Code Key
Blue = Return
Red = High Pressure
Green = Suction
Green Doted = Drain




**Now Speaking: Nick Zafiriadis**

# Hydraulic Circuit: Cruise

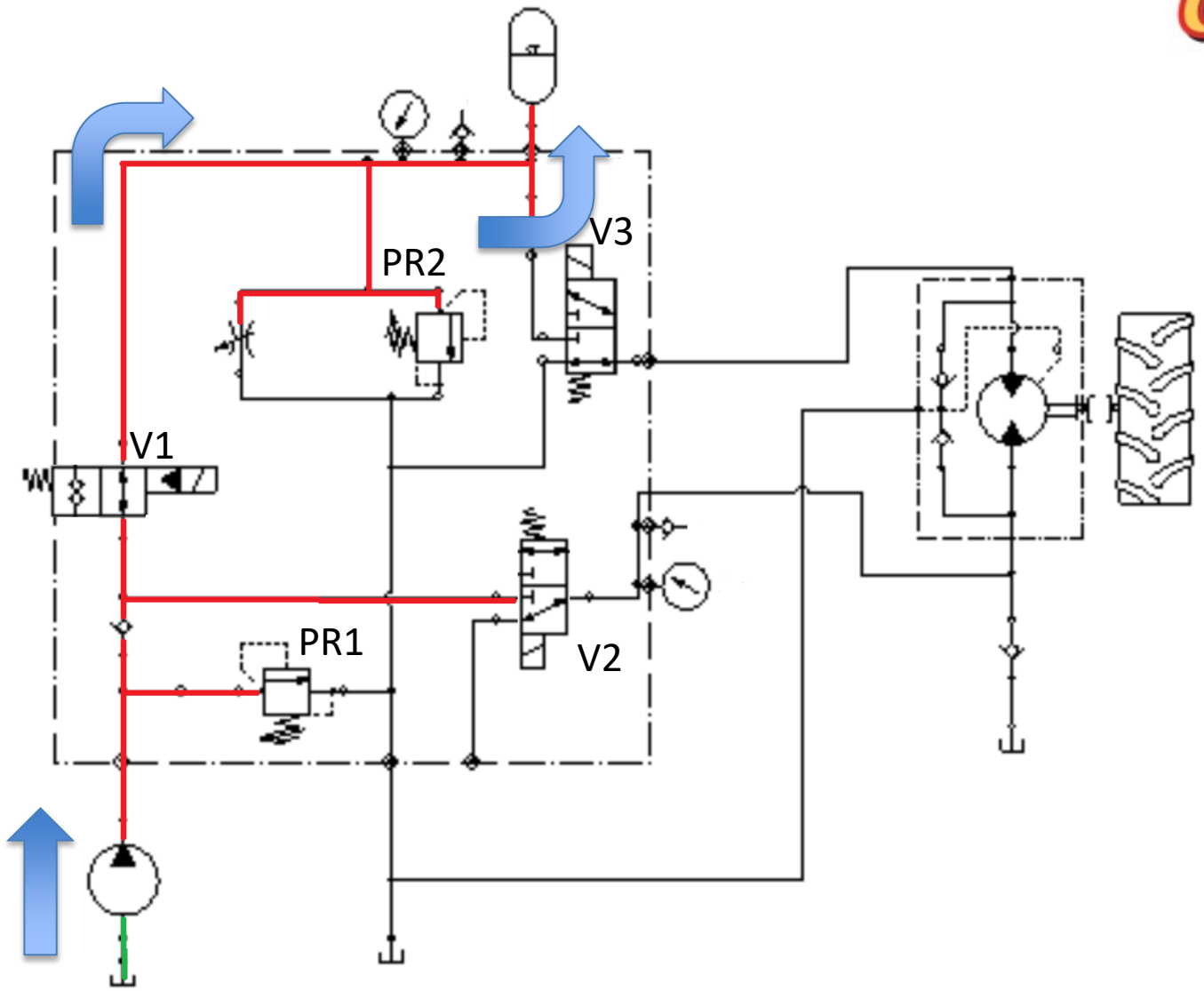
Color Code Key
Blue = Return
Red = High Pressure
Green = Suction
Green Doted = Drain




**Now Speaking: Nick Zafiriadis**

# Hydraulic Circuit: Direct Charge

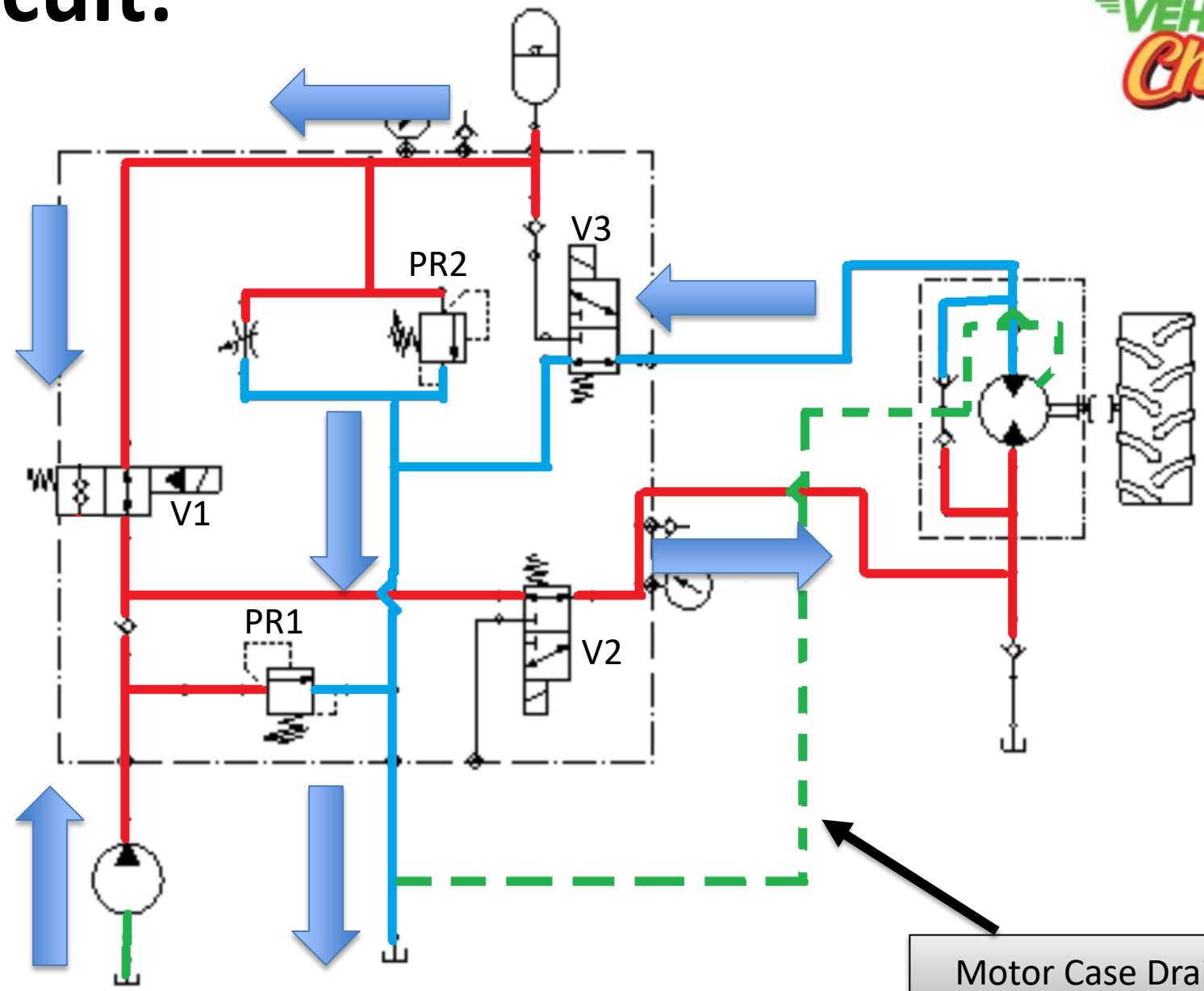
Color Code Key
Blue = Return
Red = High Pressure
Green = Suction
Green Doted = Drain




**Now Speaking: Nick Zafiriadis**

# Hydraulic Circuit: Boost

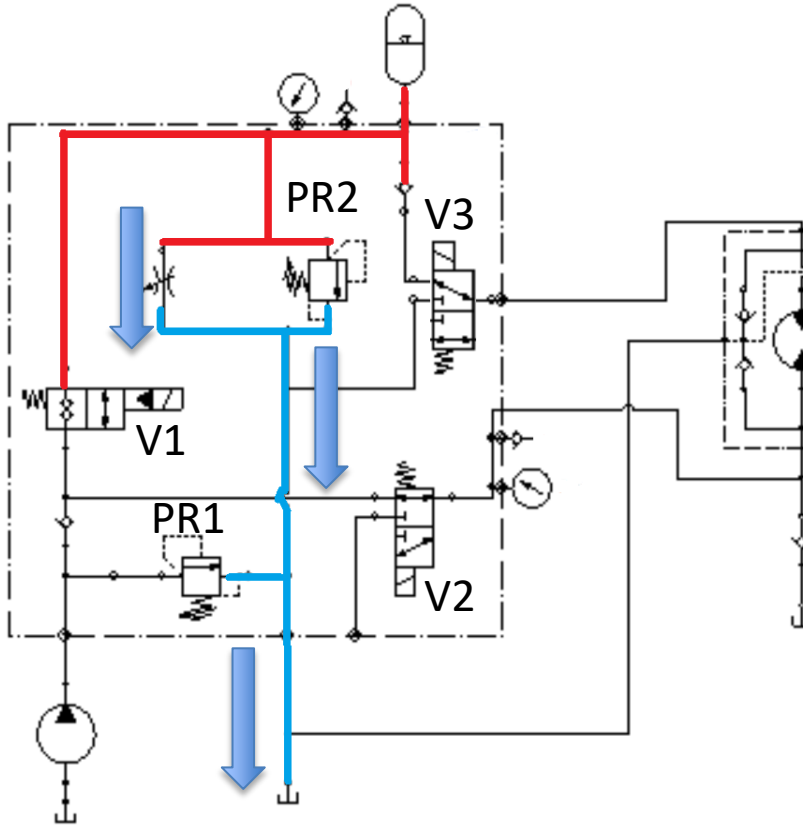
Color Code Key
Blue = Return
Red = High Pressure
Green = Suction
Green Doted = Drain



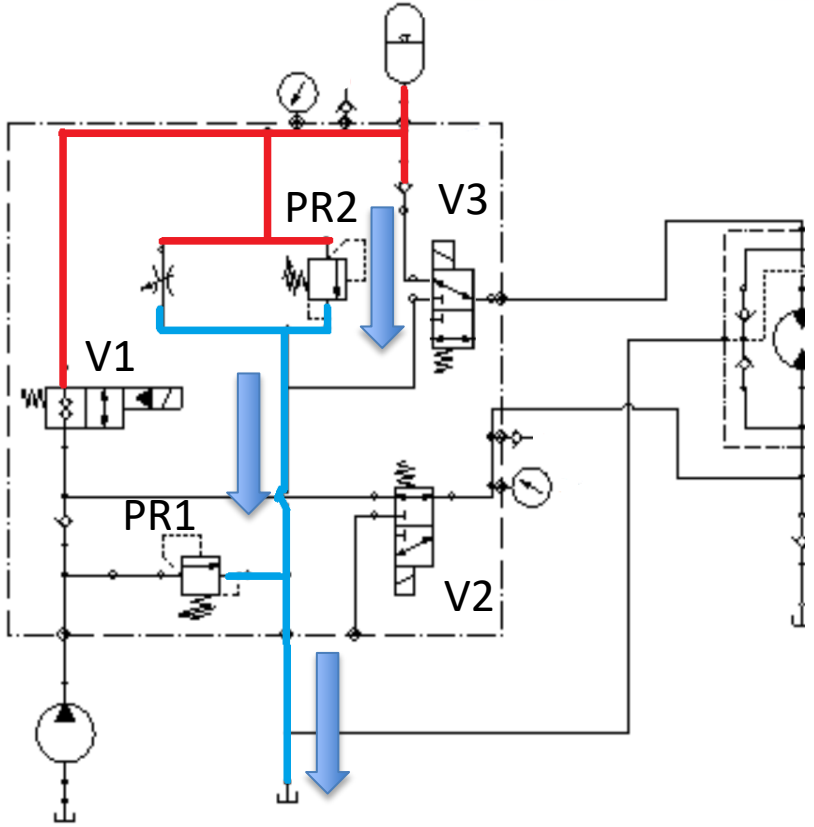

Motor Case Drain Line

**Now Speaking: Nick Zafiriadis**

# Hydraulic Circuit: Direct Discharge and Emergency Discharge



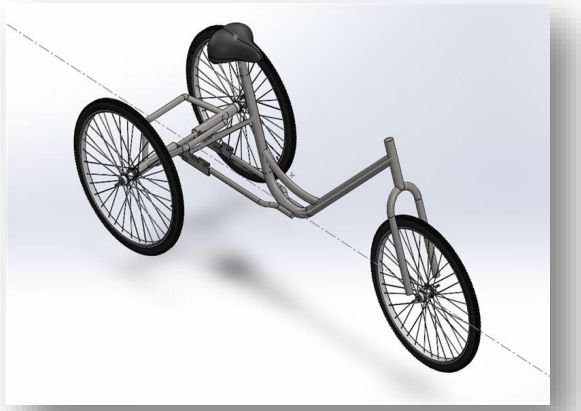
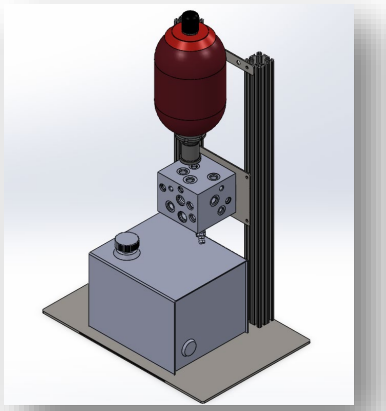
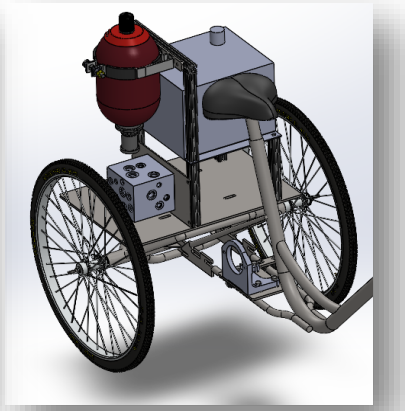
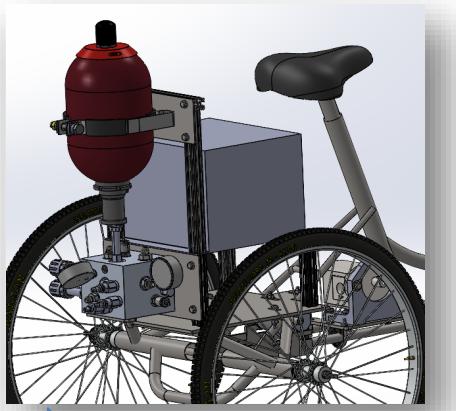

Color Code Key
Blue = Return
Red = High Pressure
Green = Suction
Green Dot = Drain



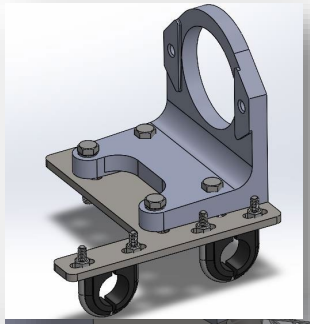
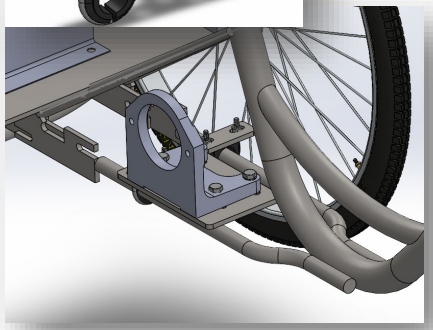
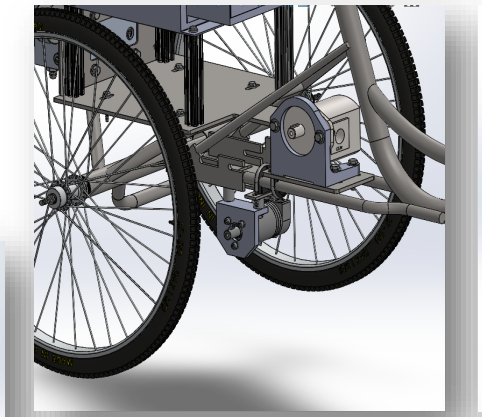
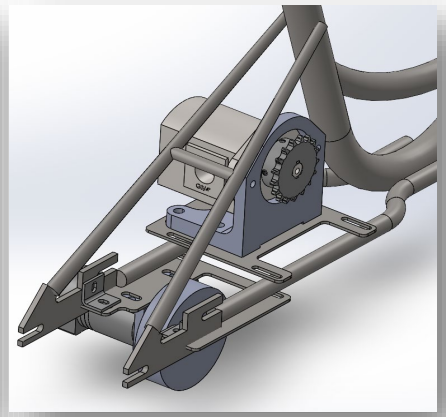

**Now Speaking: Nick Zafiriadis**

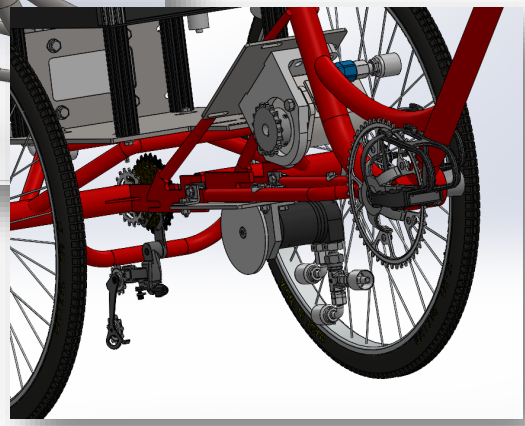
# CAD Modeling

Hydraulics Design Flow


**Start** → **Iteration** → **Finish**

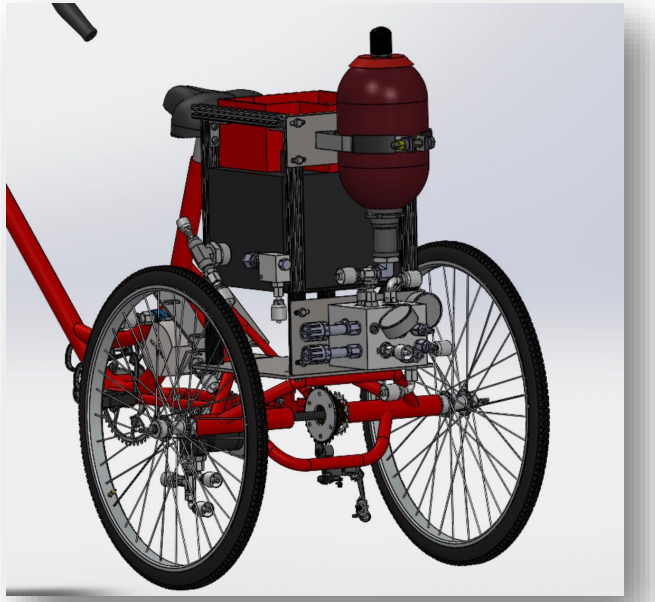


Transmission Design Flow

**Now Speaking: Jimmy MacDonald**

# Fabrication: Hydraulics

- Accurate CAD model verifies part clearances; generates BOM for assembly
- Aluminum extrusion cage helps elevate the reservoir to provide additional head pressure to system
- Accumulator/manifold rearmost allows for more hydraulic connection possibilities
- Pump mounted above motor to allow for maximum motor sprocket clearance; avoids rider's foot hitting pump



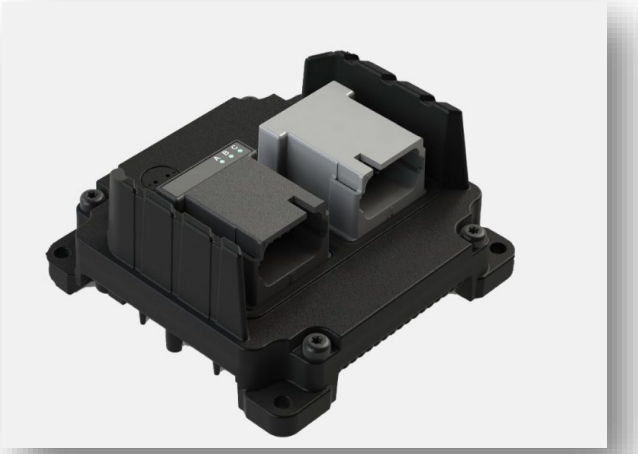
**Now Speaking: Jimmy MacDonald**

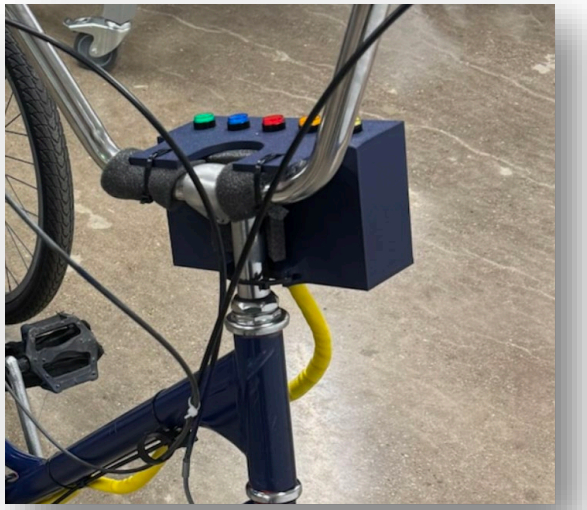
# Fabrication: Hosing

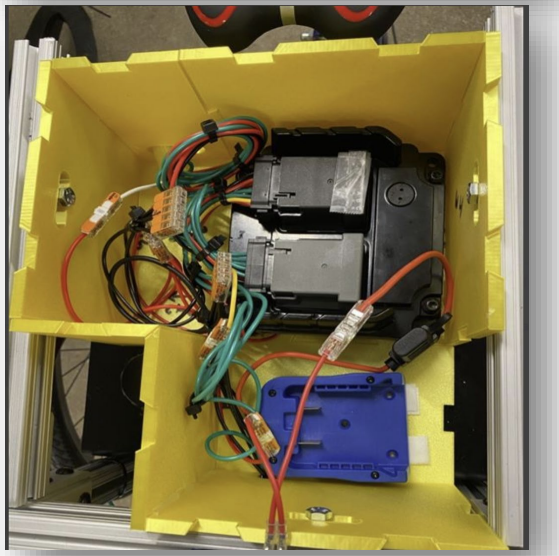
- Airline Hydraulics donated fittings and hoses
- SAE-6 Hosing for most lines (3/8”)
- SAE-8 for suction and accumulator lines (1/2”)
- SAE-4 for motor case drain (1/4”)
- All hose connection fittings are JIC

**Now Speaking: Matt Roche**

# Electrical



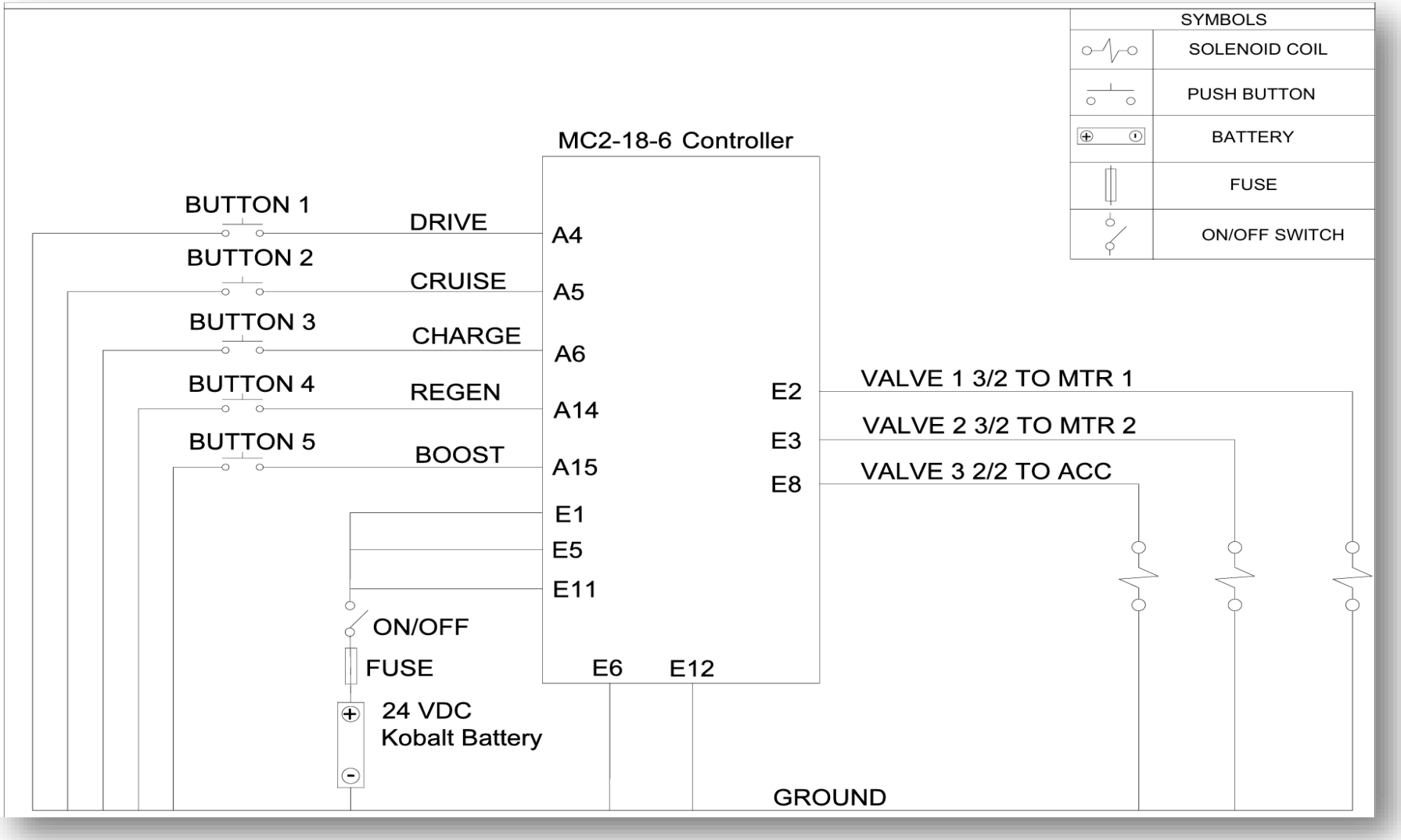


- 5 push buttons
- Buttons wired normally open
- 24VDC battery
- Each button press is read by the PLC and selects the corresponding solenoid valves
- Electrical wiring housed in a custom 3D printed enclosure (mounted on top of the reservoir)
- Handlebar-mounted button box

**Now Speaking: Reese Wheeler**

# Electrical Diagram



# Final Design

**Now Speaking: Matthew Roche**

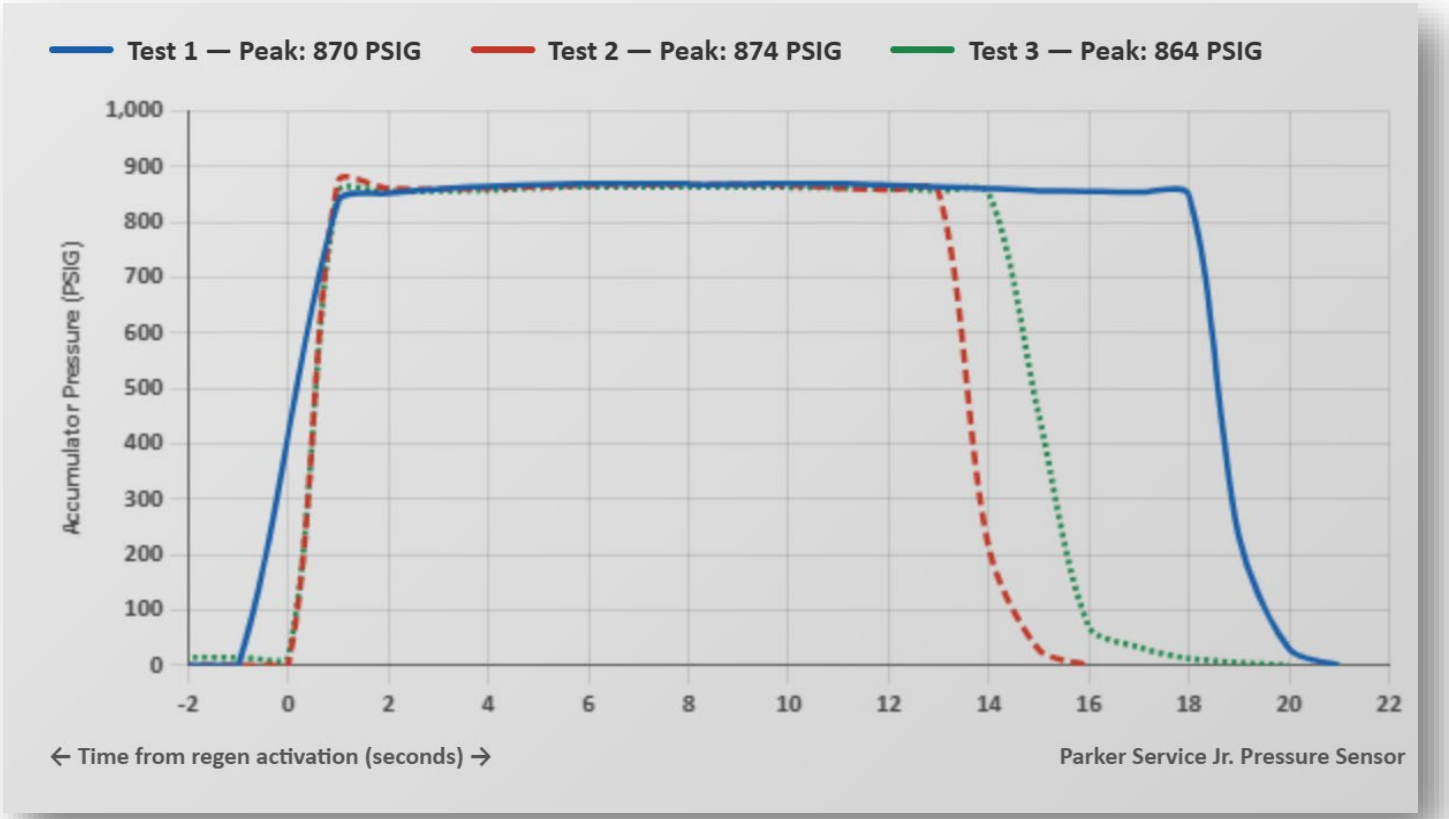
# Vehicle Testing

- Successfully tested all operating modes
- Adjusted pre-charge of accumulator from 1200 to 900 psi
- Evaluated multiple sprocket configurations on the pump side for best riding experience (13-17T)
- 7-speed derailleur tuned for reliable shifting; demanded pinpoint accurate alignment with the motor sprocket and 7-speed

**Now Speaking: Matthew Roche**

# Regenerative Braking Test Data

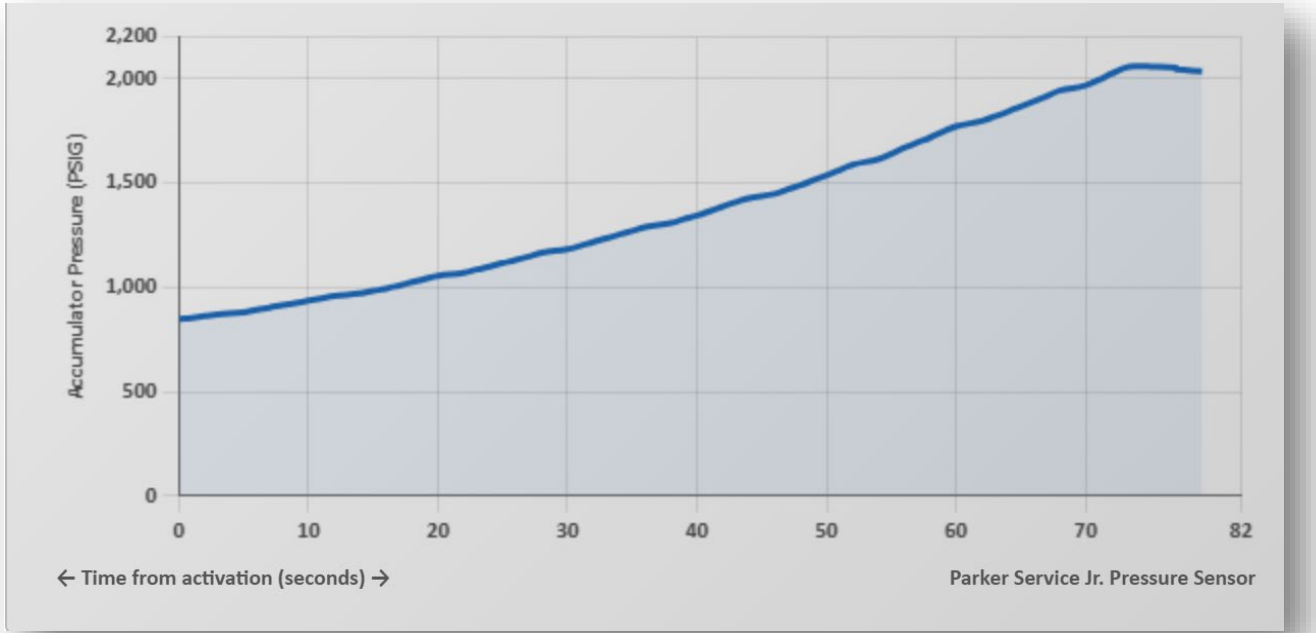
- Regen failed at a pre-charge of 1,200 psi
- Pre-charge reduced to 900 psi, had successful runs
- Tests showed pressure peaked at ~ 870 psi




**Now Speaking: Matthew Roche**

# Direct Charge Test

- Tested to verify accumulator could be pre-loaded before sprint race
- ~80 seconds to charge bike to 2,000 psi; varies based on rider stamina




**Now Speaking: Matthew Roche**

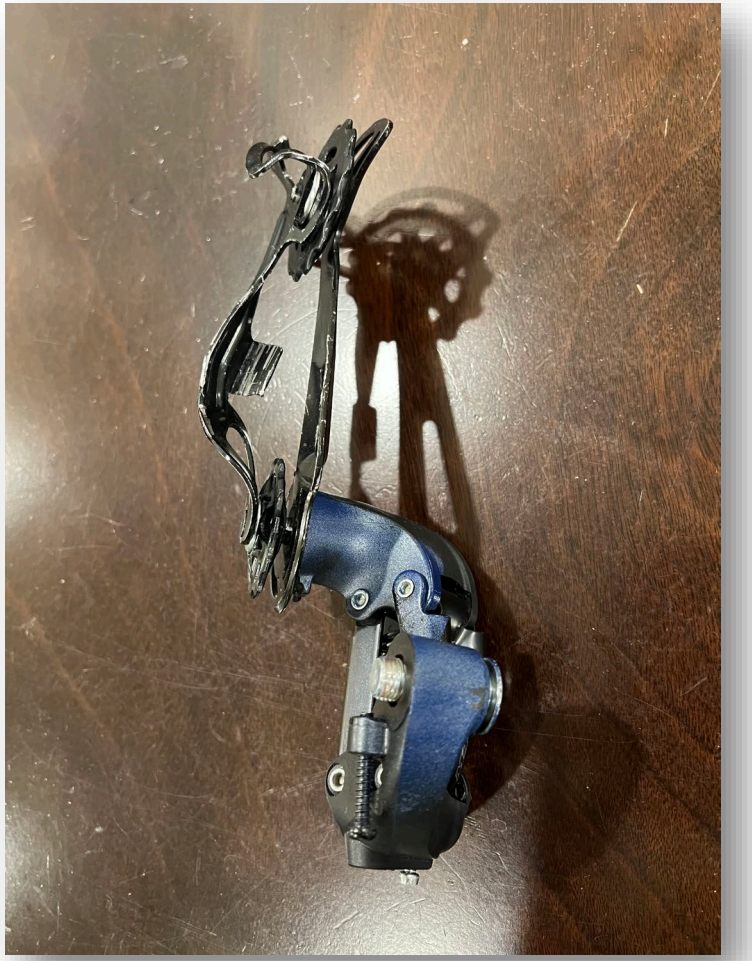
# Vehicle Improvements

- 7 speed included for variable motor/pump gear ratios
- Reservoir raised for added head pressure on pump
- Elevated mounting of pump to increase rider pedaling area
- Chain guide for pump chain to reduce rubbing; extra filing done on frame for even less interference
- Flipped accumulator for easier access to test ports
- Modified button box to hold wiring components for a cleaner looking vehicle
- Tuned accumulator pre-charge from 1200 to 900 psi to improve usable volume of accumulator

**Now Speaking: Cesar Rosales Retana**

# LESSONS LEARNED

- The value of collaborative design analysis and revision
- A "perfect" design is not always the appropriate/achievable choice
- Communication is imperative for a good design
- Designing around lead times is essential
- Read spec sheets thoroughly
- Do *not* use derailleur guide sprocket for tensioner during regen



**Now Speaking: Cesar Rosales Retana**

# ACKNOWLEDGEMENTS


- Thank you to all the sponsorships that help us in providing meaningful input and supplying a variety of components
- Special thanks to **Steve Gluck, Justin Allison, Ernie Parker, Rob Panzarella, Joe Kelly, Tim Hofmann, Carlo Pecorari, Ben Quade** and **Professor Juan de la Fuente Valadez** for all your support, as well as **Mary Pluta** along with the **Drexel COE** for giving us the opportunity to compete


**Now Speaking: Cesar Rosales Retana**

# QUESTIONS?


**Now Speaking: Cesar Rosales Retana**