



IMPROVE STEERING COMMITTEE MEETING 2021

FLOW CONTROL WITH VARIABLE SPEED PUMP

ILIA POTANIN

11/26/2021

UCDAVIS

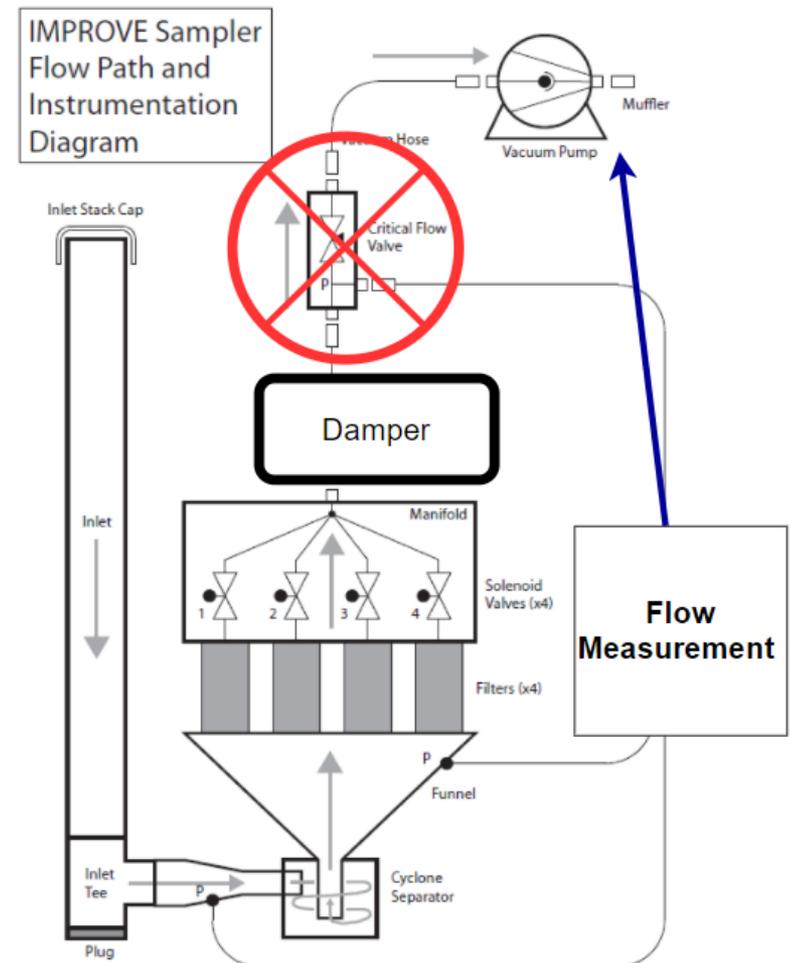
Recap

Goals:

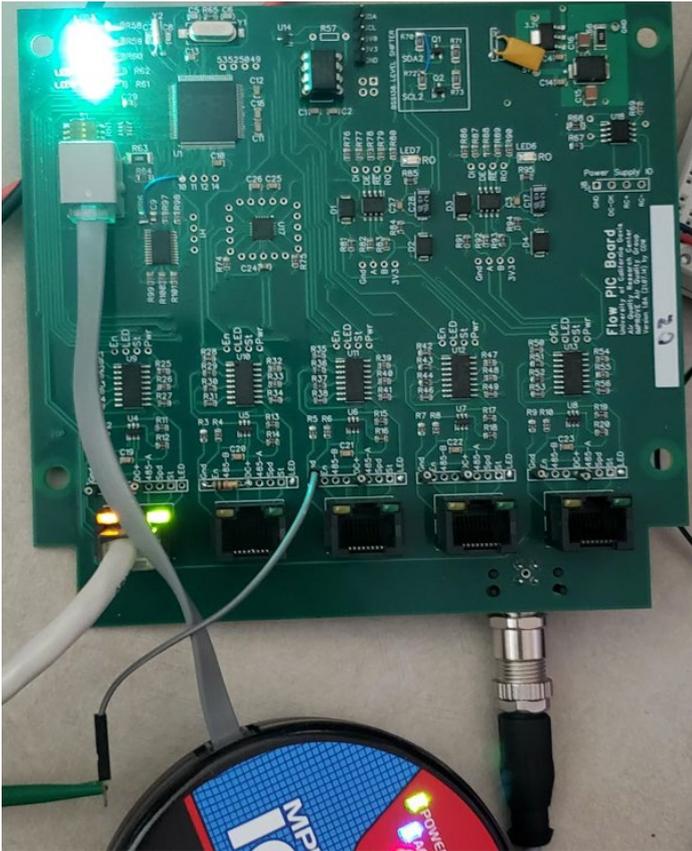
- Regulate flow rate to compensate for:
 - Flow rate drop due to filter loading
 - Air density changes due to temperature
- Reduce power consumption of sampler
- Pump noise is lower at slower speeds

Method:

- Use cyclone pressure drop to calculate flow rate deviation from nominal
- Feed error signal to variable speed vacuum pump
- Add damping volume between pump and sampler



Developments 2020-2021: Electronics



Developed Interface Board between Controller and Pump Driver

5 Pre-Production units ordered. (chip shortage is leading to delays)

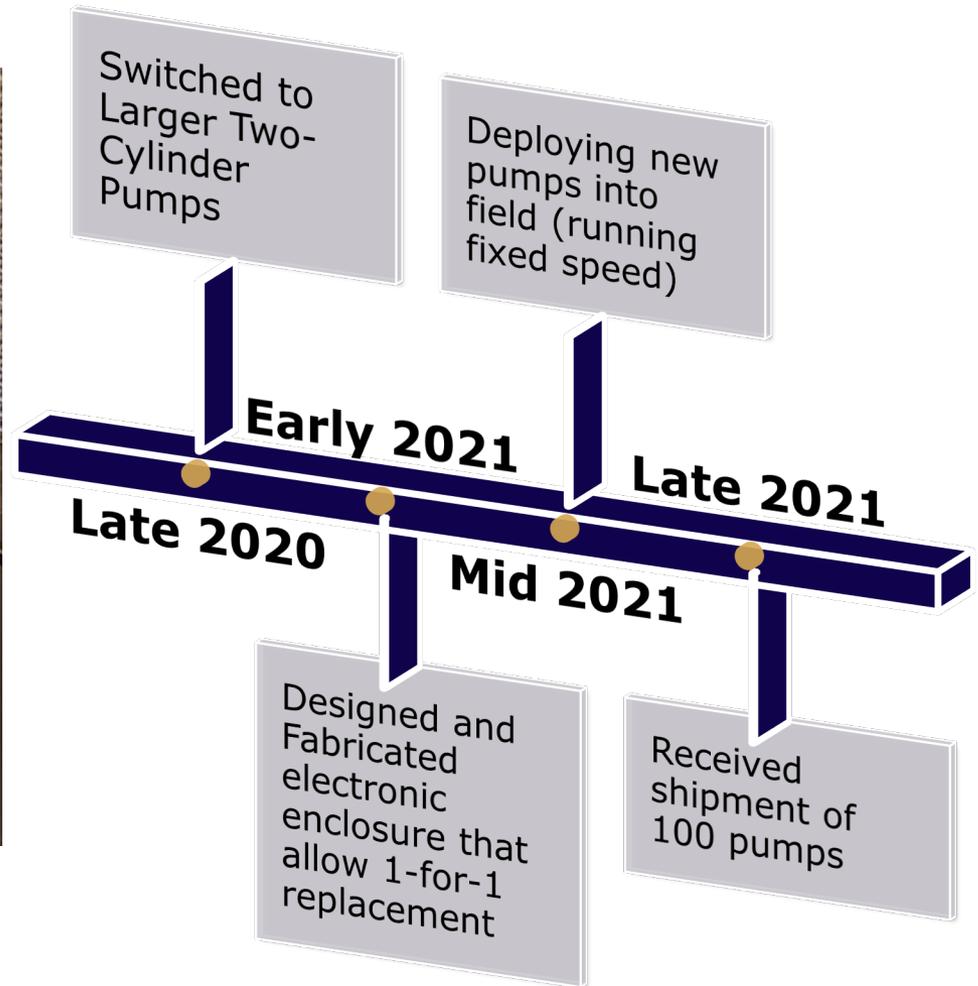
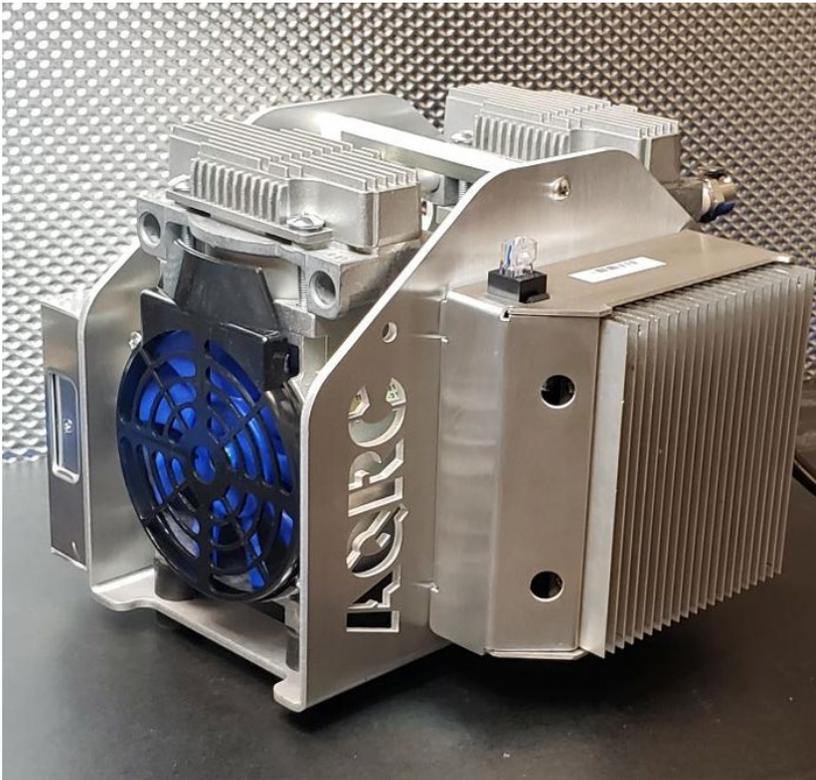
Mid 2021:

Early 2021:

Late 2021:

Updated board design to include ESD protection and RS485 Serial

Developments 2020-2021: Mechanical



Developments 2020-2021: Software

- **Modified controller software to integrate pump speed adjustment during sampling**
- **Added software ability to detect clogging filters**
 - If configured, sampling will stop when flow rate drops below threshold
- **Added database and software support for running custom sampling schedules**
 - Special schedule can trigger sampler to start a run remotely

Active vs Passive Flow Control Testing

2020 March to October at “Cobalt” site (Near UC Davis Student Farms):

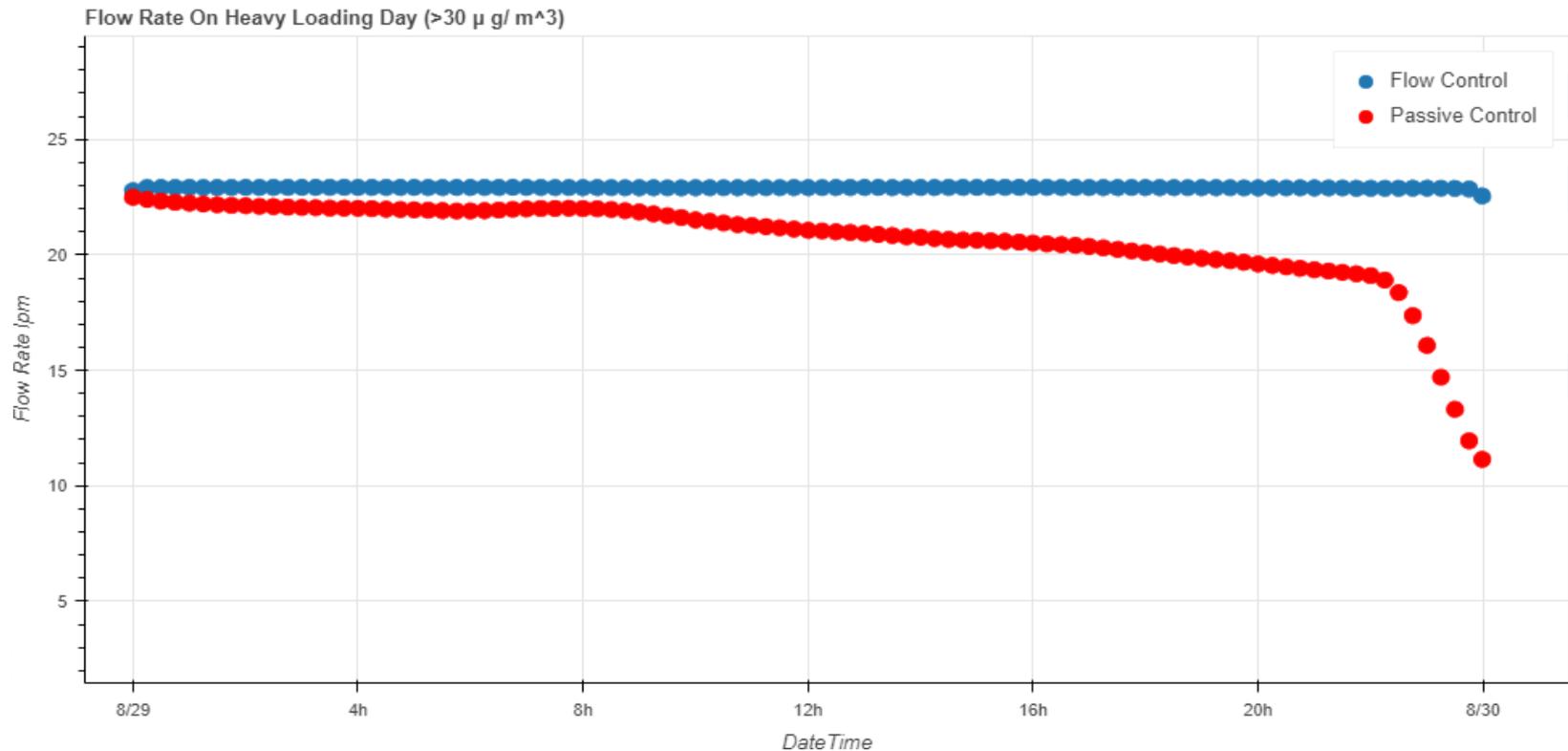
- 10 PM_{2.5} modules: 5 Active flow control, 5 Passive flow control
- Running Regular IMPROVE schedule
- 6.8% SD in concentration measurement within each group.
- Suspect local PM sources of neighboring farm caused poor agreement between modules

2021 August to Present on Ghausi hall roof on campus

- 8 PM_{2.5} modules: 4 Active flow control, 4 Passive flow control
- Running Regular IMPROVE schedule
- 2.5% SD for concentration measurement within each group
- 1% SD relative difference between two.
- No clear concentration bias between groups. Need more data.

Flow Control Testing: Early Results

- Passive flow control had 1.4% lower flow rate across all tests
- Average Flow was 7.5% lower at $>25\mu\text{g}/\text{m}^3$ (shown below)



Looking Forward

- **Plan to Order 300 pumps in 2022 to replace failing existing pumps**
- **Deploy active flow control modules to sites with collocated modules in 2022**
- **Long-term: Need to develop a flow measurement method for PM₁₀ modules without choked flow. Some early prototypes were made but were expensive or difficult to calibrate.**