University-Led Stratospheric Operations and Observations: Past and Future

Zero-pressure balloon filling in Lauder, New Zealand, 1998

Super-pressure balloon launch in Wanaka, New Zealand, 2015

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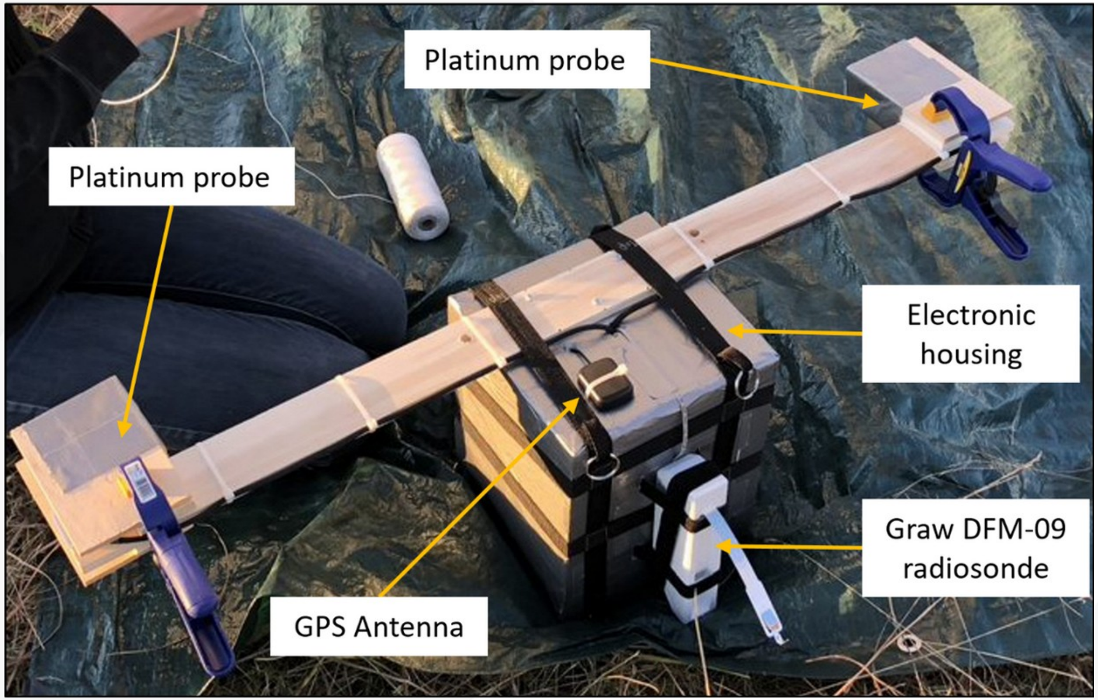
Universities: An Enduring Role in the Stratosphere

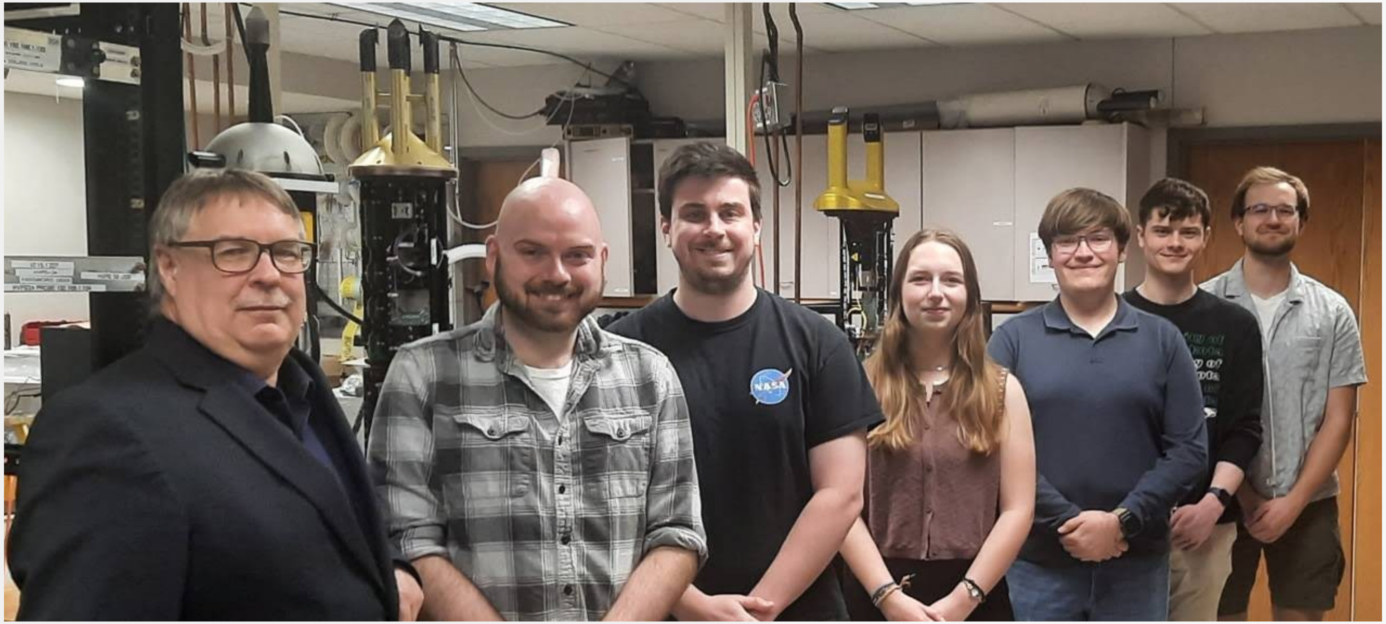
- Academic institutions have served as both training grounds for operators and proving grounds for novel instrumentation.
  - **Proving Ground:** Novel payloads matured on academic platforms before wider deployment.
  - **Training Ground:** Students become the next generation of stratospheric operators, engineers, and scientists.
  - **Science Engine:** Campaigns deliver observations of stratospheric composition and dynamics not otherwise possible.

Proving Ground: Thermosonde Instrument Design

- The thermosonde instrument, based on NASA designs, measures high-resolution temperature differences that can be used to calculate C_n^2.
- Major Components
  - 2 μm Diameter Platinum Wires
  - Graw DFM-09 Radiosonde (XDATA protocol)
  - Raspberry Pi Signal Processing Components
  - GPS Receiver
- Two thin-wire probes for Wheatstone Bridge legs.
  - Difference in resistance between the wires creates voltage difference at the bridge.
  - Voltage difference is a function of the difference in temperature between the probes.



Training Ground: Experimental Learning



People in top imaged from left to right: David Delene, Shawn Wagner (Research Scientist), Christian Nairy (Ph.D.), Jenna Post (Undergrad), Jacob Halmos (Undergrad), Bryce Rickbeil (Undergrad), and Conrad Slad (Undergrad). People in left image from bottom/left to top/right: David Delene, Liz Cardoza (undergrad), Summer Coleman (Grad), Ashley Vos (Undergrad), Paramvir Singh (Undergrad), Benjamin Guida (Undergrad), and Tree (Kevin) Norby (Graduate).

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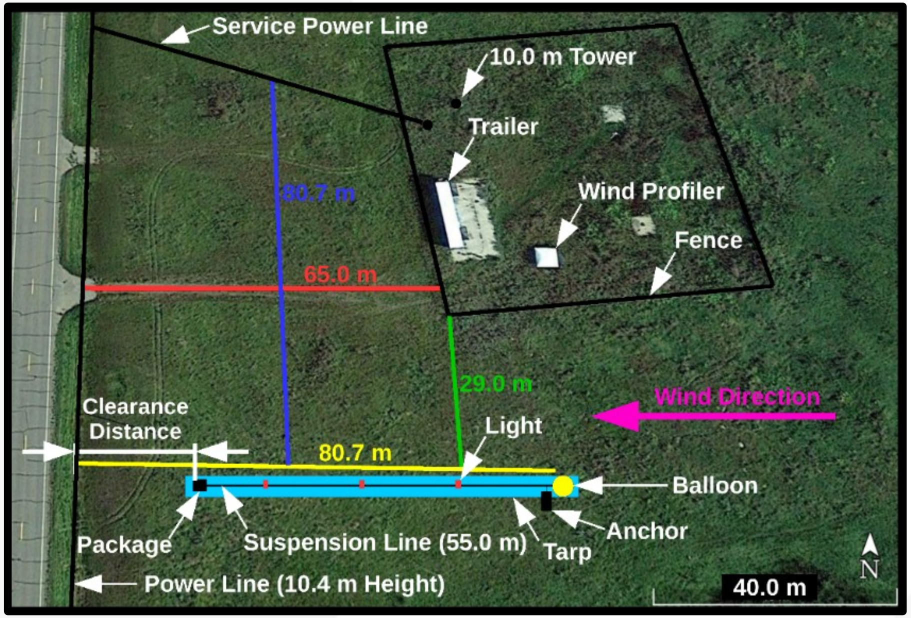
Science Engine: Balloon Flight Operations

- Thermosonde package suspended 55 m beneath a balloon.
  - Long tether used to reduce the effect of thermal balloon wakes on the measurements.
- High altitude balloon carries instrument through the atmosphere and descends after balloon burst.
- Initial flights testing conducted at the University of North Dakota Glacial Ridge Atmospheric Observatory.



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A Legacy Spanning a Century

- **Early Era:**
  - Balloon-borne cosmic-ray experiments probe high-energy physics.
  - Universities pioneer high-altitude scientific ballooning.
- **Sounding-rocket Era:**
  - Student-built instruments fly on early rocket platforms.
- **Modern Era:**
  - Campaigns quantify stratosphere–troposphere exchange.
- **My Own PhD Research**
  - Balloon-borne, in-situ aerosol measurements.

Why Now: Four Trends Are Converging

- Platform maturity and cheaper access are meeting smarter payloads and data pipelines.
  - **Persistent Platforms:** HAPS, stratospheric UAS, super-pressure balloons aloft for days to months.
  - **Miniaturized Payloads:** Capable sensing within a student team's reach.
  - **Machine-learning-enabled processing:** Large flight datasets become usable science faster.
  - **Low-cost Launch Infrastructure:** Frequent, iterative academic missions.

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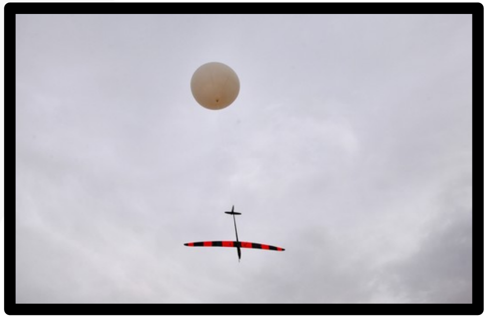
New Capabilities: The Convergence Unlocks

- **Persistent Telecommunications Relays:**
  - High-altitude communication nodes over wide areas.
- **Wide-area Surveillance:**
  - Sustained station-keeping over large regions.
- **Novel Scientific Observation:**
  - Composition and dynamics prior platforms could not sustain.
- Each application requires an educated workforce to operate, which is what universities supply.



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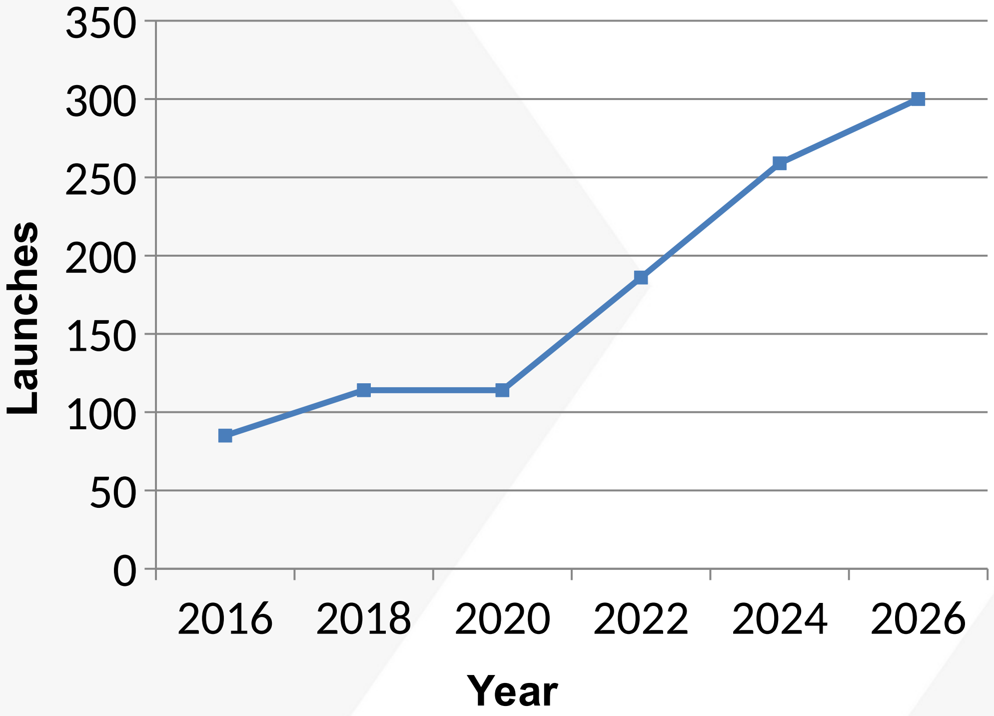
A Timely Science Driver: Rising Launch Cadence

- Growing rocket launch cadence deposits material directly in the stratosphere.
  - Each launch injects combustion products and particles
  - A composition change we should be measuring.
  - In-situ balloon and UAS platforms are well suited to capture this signal.



Data Source:
https://planet4589.org/space/stats/launches.html

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Lessons Learned at the University of North Dakota

- **Instrument Readiness Drives the Schedule**

  Preparation time is typically underestimated.

- **Students are the Mission**

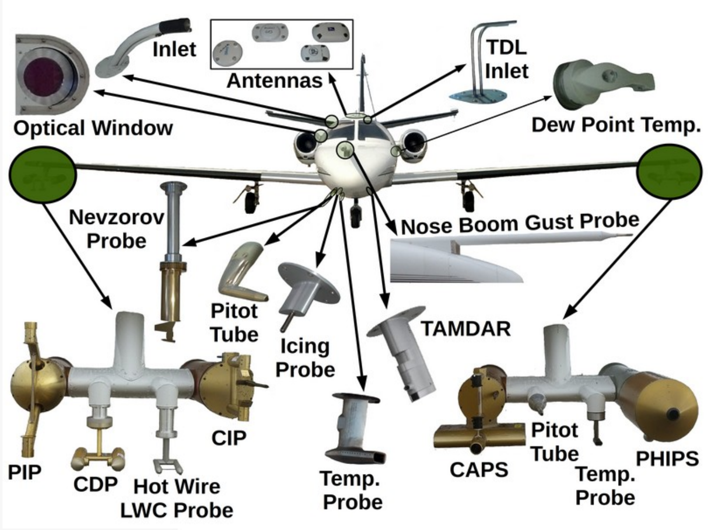
  Campaigns double as workforce training.

- **Data Pipelines before Flight, not After**

  Build workflows ahead of time.

- **Partnerships de-risk Operations**

  University–industry–government ties fill gaps no single lab covers alone.



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Gaps that Constrain University Participation

- **Launch and Recovery Access**
  - Limited affordable, schedulable infrastructure.
- **Sustained Funding**
  - Short grant cycles fit poorly with multi-year platform and workforce development.
- **Regulatory Pathways**
  - Airspace and operational approvals for persistent UAS/HAPS.
- **Shared Instrumentation**
  - Few community payload and calibration resources.

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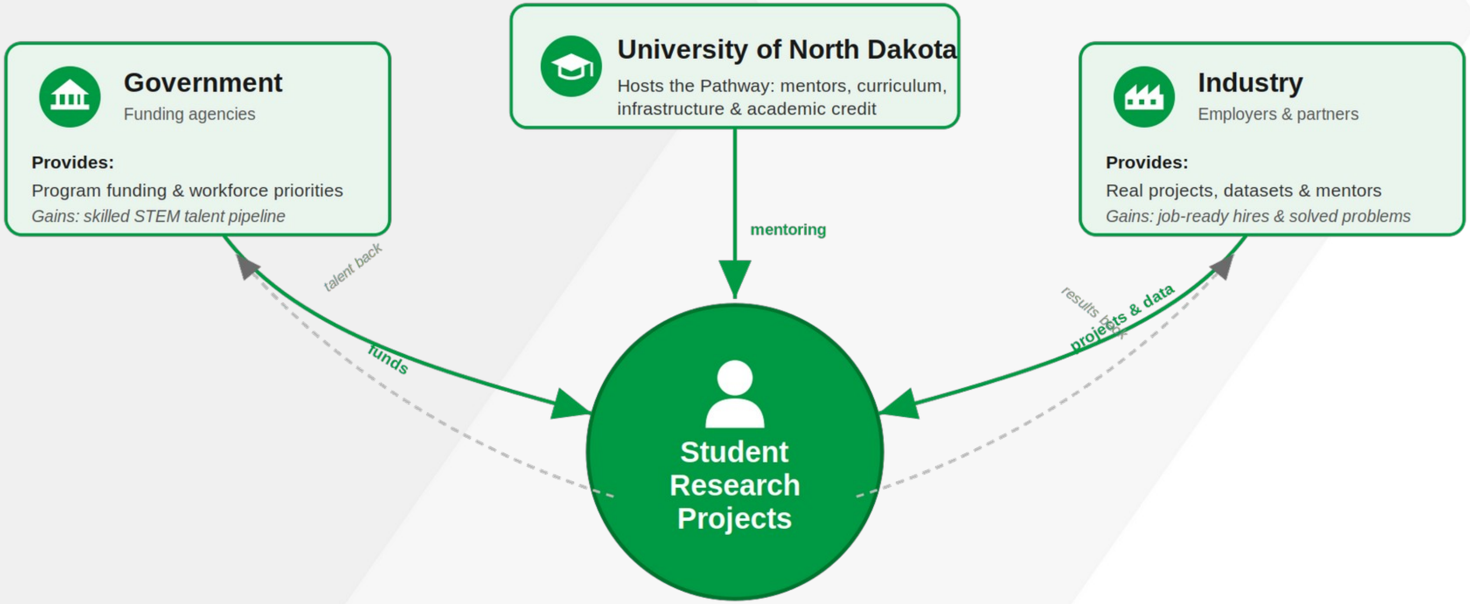
A Framework for Academic Engagement

- **Build Shared Infrastructure:**
  - Community launch, recovery, and calibration resources.
- **Fund the Full Life-cycle:**
  - Multi-year support aligned to platforms and the students who operate them.
- **Formalize Partnerships:**
  - Standing university–industry–government structures.

Improving University–Government–Industry Ties

- **Universities:** Curricula built around real operations.
- **Government:** Sustained, multi-year funding.
- **Industry:** Pull-through of student talent into the workforce.



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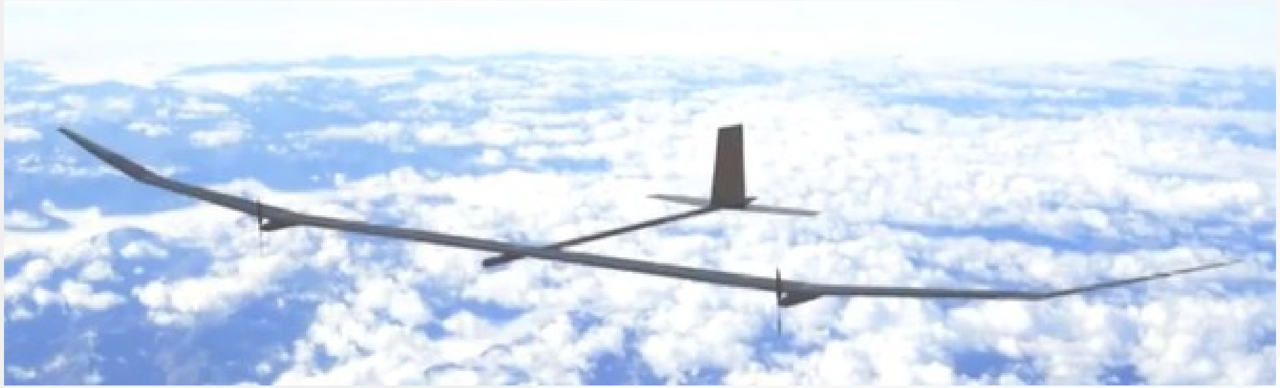
Conclusions: The Next Decade Is Academia's to Shape

- Universities have always trained the operators and proven the instruments, which is the legacy.
- Convergence of persistent platforms, miniaturized payloads, Machine Learning, and low-cost launch lets Universities do far more.
- Realizing current opportunities requires aligning funding, infrastructure, and partnerships.



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