University Corporation for Atmospheric Research
Technology Transfer Strategic Plan

Why Technology Transfer is Important at NCAR and UCAR

Societal Impact

We believe that technology transfer is a fundamental part of our scientific mission; as scientists and engineers, we have a duty to see that our scientific and engineering advancements are applied to benefit human society.

Improve Science - two-way exchange

Science and innovation feed upon each other. UCAR will benefit - scientifically and financially - as our research is applied to the Earth system and humanity's role within that system.

Background

In 2018, UCAR undertook a technology transfer strategic planning process to assess what is and is not working in the area of technology transfer and to gather new ideas from a broad cross-section of stakeholders, including UCAR and NCAR leadership, employees, private sponsors, and licensees. The goal was to understand where the organization is today with technology transfer, where it needs to go, and what it needs to do to get there. As UCAR sets out on this path, it has been informed by the recommendations of the Innovation Council[1], expertise from across the organization brought together in 2017 by the UCAR President to assess the state of innovation at UCAR. The Innovation Council came up with the following working definition of innovation:

> *Moving from applied research to development of applications, tech transfer, commercialization, working with the private sector, or tangible near-term societal benefit/broader impacts.*

The Innovation Council noted roadblocks to innovation and proactively identified approaches that NCAR/UCAR should consider in order to foster a culture of innovation. See Innovation Council Recommendations, attached as Appendix A.

[1] The Innovation Council is a group of mid-career scientists and engineers from all the NCAR labs and UCP programs who were brought together by the UCAR President in 2017 to advise him on how we can make progress as an organization in recognizing, promoting, rewarding, and incentivizing innovation.

Likewise, one of the first actions the Technology Transfer Team (T3 Team[2] - a team from across the organization formed specifically to help advise the technology transfer strategic planning process) undertook was to create a definition of "technology transfer" that provides meaning and context for all our stakeholders. Technology transfer is:

> *The process of extending the scientific and engineering advancements and capabilities developed at NCAR/UCAR to public and private applications and industries.*

Not surprisingly, the two definitions overlap and help provide a roadmap for this Technology Transfer Strategic Plan.

Given that our organization's larger vision and mission are captured in UCAR's and NCAR's Strategic Plans, it is important to focus the Technology Transfer Strategic Plan around the objective of ***extending our discoveries in a tangible way***. The specific role of technology transfer is identified in the following goals, which are the result of UCAR's engagement with internal and external stakeholders:

- ➢ Promoting and creating a culture of innovation
- ➢ Building effective private sector connections and partnerships
- ➢ Capturing our impact: science that meets society's needs

This Technology Transfer Strategic Plan consists of two main sections:

Part One captures the current state of technology transfer at NCAR/UCAR, explains the strategic planning process and provides the data and results from the internal and external engagement phases;

Part Two lays out where we want to go, with the three goals and specific recommended initiatives.

Part One – Where we are now

1. Current State of Technology Transfer at NCAR/UCAR

Technology transfer at UCAR includes making sure that the public has access to research results and applications, with the goal that they be applied to help individuals, society, and the environment worldwide. As such, technology transfer spans a wide spectrum and may occur through publication, open source software and models; or it may require private research sponsorship and commercialization to transform it into an application or solution.

UCAR follows NCAR's imperative to efficiently move its technology to research communities and the public and private sectors for operational use. For this reason, much

[2] The Technology Transfer Team was created in 2018 to help lead the internal engagement for the Technology Transfer Strategic Plan. These were individuals from across the organization who responded to a "volunteer" position on this team.

of our intellectual property is openly distributed to commercial industry and other non-traditional traditional sponsors without charge or is individually licensed for operational use in conjunction with sponsored research funding. UCAR and NCAR do not formally capture the broad benefits of their research, and societal impacts are left to individual programs to measure and are often anecdotal.

Much of the algorithms and software systems developed by NCAR laboratories are collaborative efforts that are either made publicly available or licensed through open source licenses. The benefit of making such models freely available is that these models can become the standard throughout the world. The drawback is that we do not currently have a mechanism to identify how these models and open source technologies are being used, including their impact. In cases where we have collaborated with third parties (public and private) to move the models and software into operational environments, we are just beginning to understand the impact of our work in the world. A good example is the Weather Research and Forecasting (WRF) model, with public and private collaborations and new innovative applications created from its use. (See the WRF model case study, which is attached as Appendix A.)

Technology transfer and commercialization have never been resourced adequately at UCAR. There are no full-time employees devoted to managing the business opportunities, development, and licensing of technology. Since 2013, UCAR's Business Development and Partnerships group and the Office of General Counsel (OGC) have worked together to manage business opportunities and technology licensing. Prior to that, technology commercialization primarily operated out of the previous office of the Associate Vice President for Business Services, along with licensing expertise from the OGC. The matrixed management of technology transfer can be successful with agreed upon roles and responsibilities.

Technology commercialization

Technology transfer in a traditional sense — that is, licensing technologies for operational and commercial applications — at its most successful, has been a path that has led to more sponsored research opportunities and funding as well as external exposure of the technology and scientific work. At its least successful, it has been a path that has provided a limited monetary return. Since 1986, UCAR has used the UCAR Foundation (now known as the "UCAR Exchange")[3] as its separate legal entity to manage commercial licenses and help promote start-up companies. Annual royalties and license fees from commercialization are modest.[4] However, as with most universities, UCAR considers annual revenue from commercialization to be an important part of our technology transfer efforts.

UCAR provides royalty revenue from licenses to employees that are inventors on patents or are nominated as significant contributors for a specific technology commercialization

[3] In 2018, the UCAR Foundation changed its name to the UCAR Exchange.

[4] Licensing revenues for the past decade have amounted to $1,683,000.

effort. Consistent with the Bayh-Dole Act, the policy also provides that the entity (UCP and NCAR) receive a percentage of royalties to invest back into labs and programs.
UCAR policy provides for the following royalty-sharing mechanism:

$10,000 or less	Distribution
Inventor	100%
NCAR/UCP	0
UCAR Exchange	0

Above $10,000	Distribution
Inventor	10%
NCAR/UCP	70%
UCAR Exchange	20%

Over the past decade, technology commercialization through the UCAR Exchange has focused on two approaches: support of start-ups that are built around UCAR technology, and commercial licenses to industry.

Companies springing from NCAR innovation

In the past decade, three companies were created as spin-offs to exploit UCAR technology:

- Science and Technology in Atmospheric Research Institute (STAR) was established in 2005. STAR is a completely independent entity that conducts classified research outside of the UCAR/NCAR research envelope, but engages with NCAR through sponsored research projects. STAR provided a $200,000 donation to the Research Applications Laboratory as an unrestricted innovation fund in 2016.
- Advanced Radar Corporation (ARC) was founded in 2006. ARC was initially established to upgrade existing radars. It has since expanded into building new radars and integrated early warning systems. ARC was acquired by a diversified technology company in 2016.
- Global Weather Corporation (GWC) was founded in 2009 and has built a company around proprietary software created in NCAR's Research Applications Laboratory. The core software is DICast®, which enables GWC to provide precise weather, wind, solar, and road forecasting services to its customers, who utilize this service in a variety of industries.

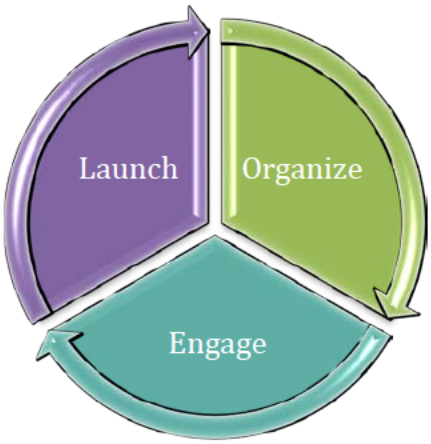
Each of these companies is based in Boulder and continues to contribute to our local community.

2. The Strategic Planning Process in 2018

Starting in early 2018, a small internal team from UCAR's Office of General Counsel and Business Development group met to lay out a vision for conducting Technology Transfer Strategic Planning. That vision included technology transfer as a way to:

- Promote an entrepreneurial culture within the organization
- Encourage science that meets society's needs
- Support talent development, retention and recruitment
- Grow more effective industry partnerships

UCAR chose a simple three-part process for the strategic planning effort, adopted from the Strategic Planning in Nonprofits (SPiN) process[5]:

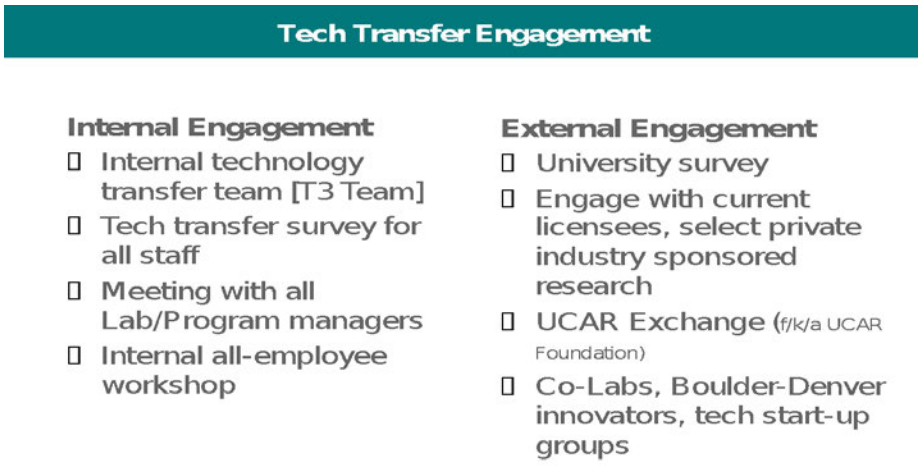


The three phases of the strategic planning process are: organize (prepare and assess); engage (listen, envision, draft); launch (execute and evaluate). A timeline (see Appendix B) was created so that the team could plan for and spend most of its time on the key part of the strategic planning process: engagement.

During the spring and summer of 2018, the ***engagement phase*** involved a two-fold approach: internal and external engagement with relevant stakeholders for each area. For internal engagement, we conducted an all-employee technology transfer survey, interviewed all lab/program directors, and recruited an internal technology transfer team (the T3 Team) to plan the all-employee workshop and act as technology transfer ambassadors. We held an employee workshop in July 2018 to understand what is working and what is not working and to gather more input and ideas for the strategic plan. For external engagement, we conducted a survey of a dozen universities and met with current

[5] Adapted from the Strategic Planning in Nonprofits (SPiN) process; © 2016 Washington Nonprofits. All rights reserved.

licensees and some private sector industry partners. Outcomes of these engagements are discussed below and detailed material is provided in the appendices.



Internal Engagement

Getting feedback from internal stakeholders was critical to understanding the current state of technology transfer and to helping us identify themes, create initiatives and objectives to accomplish the goals. Internal engagement involved three distinct efforts: an employee survey, an in-person interview with each lab and program director and an all- employee technology transfer strategic planning workshop.

Employee Survey

In March, a 21-question survey was posted for three weeks in the daily staff announcements that are available to all employees. Only a small percentage – around 5% of all employees and 8% of scientists and engineers – chose to participate in the survey. Not all participants completed every question.

Employees provided a surprisingly consistent message: that technology transfer is necessary for both UCAR as an organization as well as individual employees and labs, but that additional training and clearer guidelines are necessary. With regard to technology transfer at the organization level, a very strong majority, 81.5% of respondents, believe that NCAR and/or UCP have a responsibility to perform technology transfer. With regard to technology transfer at the individual level, 53.1% have had discussions or worked on technology transfer while at UCAR and 42.9% say that they have engaged in business development in order to bring new funding into their NCAR lab or UCP program. Employees understand the importance of technology transfer and a majority are already engaged.

However, employees also noted confusion with regard to current technology transfer efforts. Few respondents were able to describe how technology transfer works at their lab or program. When asked whether an employee's ability to engage in tech transfer *should* be considered in making hiring or advancement decisions, respondents answered "Yes" by more than a 2:1 margin.

In answers to several open-ended questions, employees consistently asked for basic training and clearer guidelines. Overall, the message from employees is that technology transfer is a necessary activity, but additional training, clearer resources, and customizable incentives are needed.

Lab and Program Director Meetings

In Spring 2018 we began meeting individually with each UCP program and NCAR lab director, which amounted to 14 separate interviews. The directors were asked 10 questions designed to determine the extent to which the institution, their specific program or lab, and their individual employees identify and explore the innovation and commercial potential of their research. The informal nature of the meetings and open-ended questions generated data that is less easily quantifiable than with the earlier employee survey, but the results can be broadly grouped into four categories: what has worked, what has not worked, culture, and engagement.

With regard to what has worked, the lab and program directors identified as some of our strengths our long-term relationships with industry; our ability to provide tailored solutions; our ability to respond to short-term industry needs through conferences, webinars and reports; the development of instrumentation and models that are used outside of the lab; the ability to attract scientific visitors; and our access to specialized computing resources.

In discussing what has not worked, the directors noted the small number of patent applications filed, the patent process, a basic understanding of intellectual property, losing projects due to incompatible contract terms between industry and a federally funded research organization, a failure to keep up with new technology, producing low quality code, and access to resources.

With regard to our culture, the directors identified a tendency to reinvent the wheel, the search for perfection, ambivalence toward deadlines, a sense that we are no longer at the leading edge, uncertainty surrounding funding, risk aversion, a lack of ladder track/promotion opportunities, a lack of leadership to enable technology transfer to flourish, and a lack of understanding as key barriers to future success. It was also noted by many directors that there was no support or encouragement for technology transfer from federal sponsors, so it becomes an afterthought.

Finally, the directors noted the need to solicit ideas, perhaps through the appointment of ambassadors to each lab or program; a sense that if technology transfer is to be taken

seriously, it must become a part of the UCAR management structure; clear communication around what exactly is expected from labs; promoting tech transfer to the same extent that other initiatives, such as diversity and inclusion are promoted; and providing them with tangible tools and resources.

As with the employee survey, the results of the director interviews were surprisingly consistent – that changing our culture and building on our strengths will require a visible and sustained commitment from senior leadership, the dedication of tangible resources, and ongoing education. The directors had ideas for changing the culture that are captured, along with the ideas from the employee workshop, in the initiatives below.

Employee Workshop

An all-employee workshop was held July 26, 2018, during which valuable input was gathered for the technology transfer effort at UCAR. Participants engaged in several group exercises designed to answer two questions: what is working? what is not working? and to solicit ideas and suggestions for improvement. From the workshop:

What is Working?	What is not Working?
Good research	Cross-lab collaboration
Our people	Education/understanding of patents, royalties, and licenses
Our relationships	Familiarity with private sector
UCAR reputation	Resource availability, including: education, funding, technical support and time.

The workshop participants developed detailed ideas and suggestions for our future success. Perhaps not surprisingly, those suggestions mirror the suggestions made by the directors during the in-person interviews, as well as suggestions received during the employee survey. They can be broadly grouped as: engagement by management, meaningful incentives to employees, creating connections beyond academia, funding and support, and, education. Discussions about how we can do a better job of making an impact with our research and concomitantly understanding and capturing how our research makes an impact rounded out the workshop input.

Three themes emerged from the workshop:

- The importance of relationships, connections, and partnerships
- The need for incentives and focused management
- More funding and support from leadership

These themes, along with all internal stakeholders' ideas for short- and long-term approaches to technology transfer are incorporated in the initiatives, recommendations, and objectives in Part Two, below.

External Engagement

There were two major sources of data from external stakeholders: UCAR's private sector sponsors and licensees, and a dozen of UCAR's member universities.

Private Sector Sponsors and Licensees

UCAR has a broad spectrum of nongovernment sponsors, including many private sector companies who fund research and license technologies for operational systems or to become part of commercial products and services. These sponsors and licensees are an integral part of UCAR's technology transfer ecosystem. As with the internal stakeholders, it was important for UCAR to understand what was working and not working in these relationships. To maintain independence, UCAR engaged an external consultant, and the findings are included in Appendix C. The consultant found that there were five general misperceptions between UCAR and its technology transfer partners:

- Perceived Financial Value – both from UCAR and the private company
- Basic vs. Applied Science Interest – NCAR would approach science from a more basic perspective
- Resource Availability – prioritization of time and attention to partner's needs
- Time Frame Expectation – different pace of work between the two entities
- Maturity of Output – lack of NCAR documentation on work performed

Difficulties that the private sector experiences in working or trying to work with UCAR and NCAR are that there is no consistent customer service relationship, communication and management structure are opaque, and there is a lack of understanding of the role and purpose of technology transfer within NCAR/UCAR. Private entities also noted a lack of clarity and certainty around NCAR/UCAR's future direction in terms of innovation and discovery.

The consultant also found that NCAR has a strong reputation and is considered the gold standard for science and research in weather and climate. Private companies appreciated direct scientist involvement both in terms of partnership initiation and continuity for future work.

University Survey

A UCAR team conducted phone and email interviews with atmospheric, Earth science, and related departments at 13 universities to discuss their technology transfer efforts and programs. The results of the university survey, including questions asked and university technology transfer performance across a variety of metrics are included in Appendix D.

Overall, many universities have sophisticated and well-staffed technology transfer programs. Specifically:

- Technology transfer is an institution-wide priority driven by interest from senior leadership
- Entrepreneurial resources are readily available to scientists at the university and they are encouraged to utilize them (e.g., through coaching sessions, workshops)
- Training resources are readily available
- Connections with alumni-led/created companies are leveraged
- Graduates are funneled to university-affiliated companies
- Strong incentive schemes exist for individual scientists and their labs in terms of revenue sharing
- Strong success metrics are available in patents, disclosures, and revenue

A common challenge cited is that funds for new technology transfer initiatives are sourced from existing licensing agreements, so when an agreement expires, an initiative may fall flat. Universities also cited a lack of business-savvy personnel that have marketplace skills and experience. A lack of dedicated staff to execute contracts quickly and respond to private sector pace creates missed opportunities. Some groups have a culture of negativity around working with the private sector. Some universities are so large that navigating the web of competing interests when engaging a company is too difficult.

There were no consistent patterns that provided a recipe for success. Some factors that contribute to success include size of staff, monetary resources, areas of expertise in market analysis, commercialization skills and, most importantly, a commitment from leadership.

There is a commonality of challenges throughout the universities, which can be summed up as lack of resources, such as time, money, and people to work on technology transfer.

Part Two – Where We Want to Go

Based on engagement with internal and external stakeholders over a six-month period (February–July 2018), common themes emerged to support UCAR's approach to technology transfer.

As one of its first activities, the T3 Team created a new definition of technology transfer, which was validated by the internal and external engagement and is being adopted as part of this strategic plan. That definition is:

The process of extending the scientific and engineering advancements and capabilities developed at NCAR/UCAR to public and private applications and industries.

The common themes that emerged during the research phase have led to the following three goals:

- Promoting/creating a culture of innovation
- Building effective private sector connections/partnerships
- Capturing our impact: science that meets society's needs

Goal #1: Promoting/Creating a Culture of Innovation

1. Make technology transfer a priority for scientists and engineers through recruitment, performance goals, promotion, training, and rewards.

- Training
    - Provide leadership (and Leadership Academy) training on technology transfer, private sector relationships, business development
    - Partner with local resources for specialized training on technology transfer
    - Provide a program with meaningful long- and short-term engagement opportunities with outside entrepreneurs and mentors (like UMatch with the business community)
- Modify the goals/competencies in the new performance evaluation system to create optional goals/competencies focused on technology transfer
- Modify job metrics to recognize involvement in innovation for all ladder track and project scientists, research engineers, software engineers, engineers, and other relevant job categories
- Rewards
    - Provide year-end, organization-wide awards for successful technology transfer efforts
    - Provide competitions and prizes to build excitement around new ideas and technology innovation

    - Revise royalty sharing for inventors and programs/labs so that programs/labs receive a larger share

2. Inspire with new methods and resources
   - Encourage cross-lab collaboration through "transfer" schemes where staff are embedded in another lab to work on related short-term projects
   - Provide direct funding to employees to seed new ideas, to attend meetings directly related to technology transfer, and to develop new business proposals with the private sector
   - Carve some percentage (e.g., 1%) out of all awarded funds to devote to technology transfer
   - Provide an annual lecture series focused on technology transfer

Goal #2: Developing Connections with the Private Sector

1. Create awareness of our capabilities
   - Create a means to gather a centralized, in-depth understanding of NCAR/UCP products and services (instrumentation, data, software, and modeling tools) and share internally and externally in meaningful ways:
     - web presence
     - marketing collateral
     - industry emails/newsletter
   - Develop market assessments for existing NCAR/UCP technologies
   - Utilize other third-party platforms (e.g., CO-LABS, NREL) to promote our technology

2. Create opportunities to work with the private sector
   - Identify industry needs that connect with expertise at NCAR/UCAR
   - Work with industry to better understand their needs and develop solutions to meet them
   - Establish an entrepreneur-in-residence program to connect NCAR/UCAR staff with local business expertise
   - Host private industry "Meetups"
   - Attend, exhibit, speak at relevant private industry conferences outside the traditional professional communities
   - Create sabbatical opportunities for industry personnel and NCAR personnel to get experience in the other sector

3. Manage relationships with the private sector
   - Dedicate a UCAR person to working with labs and programs on relationships
   - Implement a customer relationship management (CRM) tool to be used by coordinators in labs/programs

Goal #3: Capturing Our Impact: Science that Meets Society's Needs

1. Improve communication about the broader societal impact of our research by:

- Providing a web portal that links UCAR researchers with communications, content writing, and ways to provide anecdotes about the impact of our work
- Provide the same web portal to our private sector partners and licensees to provide stories and metrics about the impact of our work
- Provide a quarterly update on technology transfer efforts or innovative projects in each lab/program
- Identify new audiences to educate about our work
- Develop case studies
- Produce video vignettes

2. Work toward relevant internet access and presence that captures our impact

- Search engine optimization
    - Discover, understand and utilize tools that are already established to optimize accessibility of our products/tools
- Create or join shared platforms across the tech transfer community, including other labs and universities in the region, similar industries, vertical markets (e.g., aviation, agriculture) or areas of expertise

3. Formally and informally solicit industry/societal needs from companies, VCs, and government

4. Create an annual competition/award on our impact/societal impacts

5. Collaborate with universities, including member universities, to develop, gather data on, and highlight socially impactful technologies in our joint areas of research

Summary

The three goals presented here are ambitious and will require acceptance, coordination, and agreement from UCAR and NCAR leadership and adoption by all staff. The T3 Team and Innovation Council will continue to be important advisers and ambassadors for helping prioritize initiatives and carry them out. Further decisions about which specific initiatives to pursue, resources needed, and reasonable timelines will need to be developed, along with an approach to measuring progress. Other efforts that are under way at UCAR and NCAR, specifically strategic planning and work force development efforts, will also provide complimentary pathways to implement some of the initiatives within this plan. This strategic plan is meant to provide the background and framework to move forward. People and passion will bring it to life.

Appendix A

Case Study: Weather Research and Forecasting (WRF) Model (2016)[1]

Much of the algorithms and software systems developed by NCAR are collaborative efforts that are either placed in the public domain or licensed through open source licenses. The result of making such models freely available is that these models become the standard throughout the world. Commercial companies regularly use NCAR-based community models for their own endeavors, creating or improving product and service offerings for their customers.

Over 100 private sector companies have registered to use our Weather Research and Forecasting (WRF) model. NSF-funded research thus finds its way into private-sector offerings, silently creating new markets and jobs. UCAR has worked to encourage more widespread use by private companies. Since 2013, UCAR has met with over 100 commercial companies to encourage familiarization with NCAR community models, WRF in particular, and the ways in which their data can be used with the model. In addition to private companies, WRF models are regularly used by non-NSF Federal entities for operational uses, State governments, National Labs, Universities, and International Partners. Figure 1 depicts the broad reach of the open access community model.

WRF is the foundation for many research and operational models, and it serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometers. With one major release per year, including last year, WRF remains one of the most dependable, state-of-the art, forecasting models in the world. Based upon the number of registered users (from 67 in 2000 to more than 33,000 in 2015), WRF is also one of the most widely used regional models in the world.

These users are active. NCAR receives more than 325 WRF inquiries per month (10-12 per day); has 8,250 WRF newsletter subscribers; and attains more than 3,000 new registered users per year. A number of critical research and operational tools have sprung out of WRF. These include:

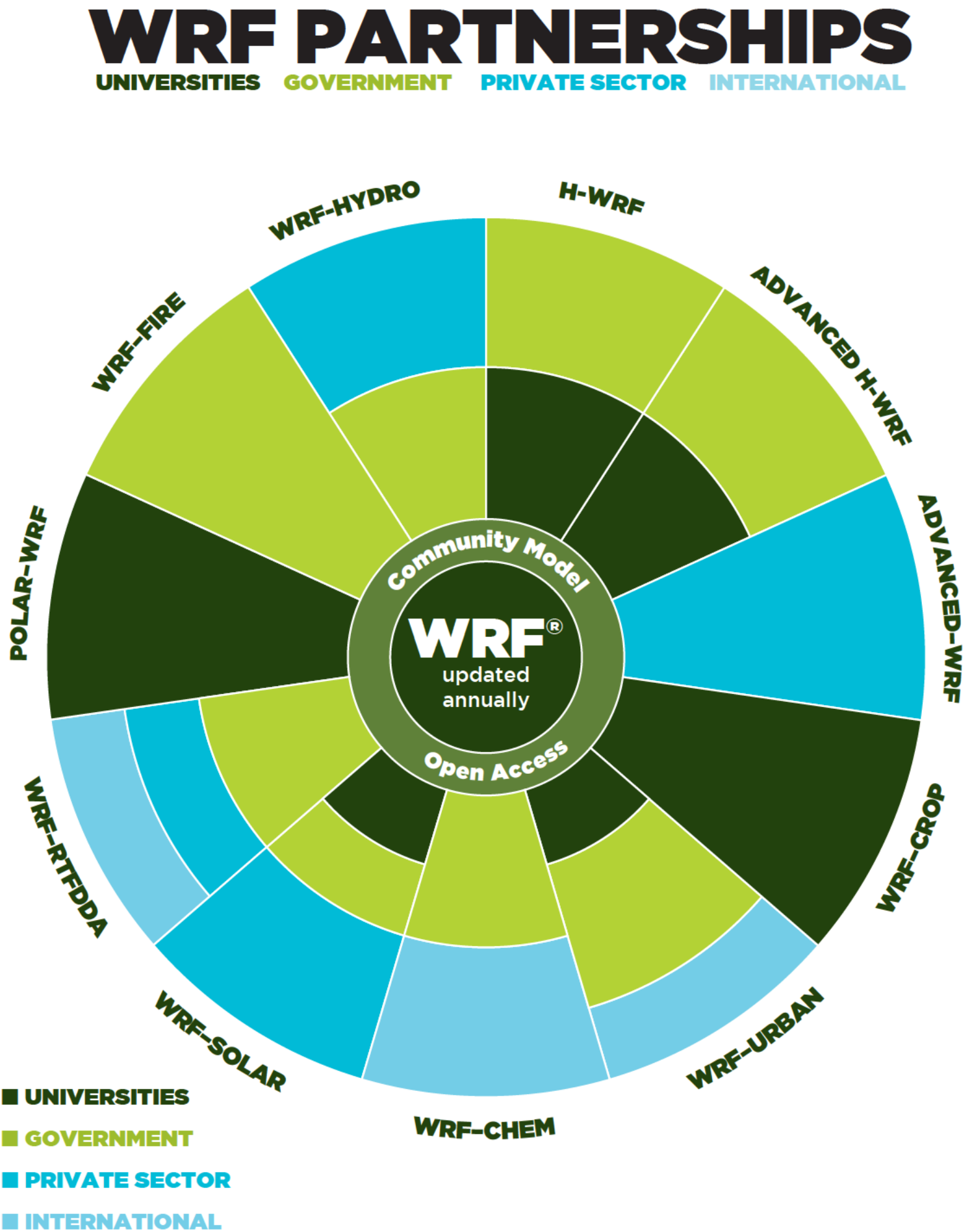
- H-WRF (hurricane forecasting tool)
- WRF-Chem (air chemistry forecasting tool)
- WRF-Crop (agriculture forecasting tool)
- Polar WRF (Antarctic and Arctic weather forecasting tool)
- WRF-Fire (forest fire forecasting tool)
- WRF-Hydro Modeling System (flood and drought forecasting tool)

[1] The data in the case study comes from the 2015-16 time period and does not reflect current numbers in 2019.

- Solar-WRF (solar electricity forecasting tool)
- WRF-RTFDDA (Real-Time Four Dimensional Data Assimilation forecasting tool to integrate new data sources)
- Advanced WRF (forecasting tool to harness Big Data opportunities)
- WRF-Urban (prediction tool for environmental conditions in urban settings)

NCAR plays two distinct and important roles in the success of bringing WRF solutions to society. First and foremost, NCAR (supported by government funding and collaboration) developed the model using state of the art science; and then, building on its strong partnership with Universities, created a platform by which anyone in the world can easily and freely access and manipulate the model based on their own needs. NCAR continuously improves the model and its accessibility. Second, NCAR researchers then work directly with universities, private companies, foreign entities, federal and state governments, and others to develop WRF applications that respond to their operational or commercial needs. It is both of these functions, the leadership in creation and sustainment of the model and the development of model applications based on various interdisciplinary opportunities, that foster the transition of NCAR science into society. The creation of such an effective, robust, and flexible model would not have been possible without a National Center, and by employing scientists to work with partners to make applications, NCAR can continuously provide feedback to make the model better, more usable, and more powerful.

Image 1


WRF PARTNERSHIPS
UNIVERSITIES GOVERNMENT PRIVATE SECTOR INTERNATIONAL
WRF-HYDRO
H-WRF
WRF-FIRE
ADVANCED H-WRF
POLAR-WRF
ADVANCED-WRF
Community Model
WRF®
updated
annually
Open Access
WRF-RTFDDA
WRF-CROP
WRF-SOLAR
WRF-URBAN
WRF-CHEM
UNIVERSITIES
GOVERNMENT
PRIVATE SECTOR
INTERNATIONAL

WRF Collaborations (sampling)
August 2016

WRF- Hydro
- NOAA/NWS (G)
- CUAHSI (U)

WRF-Crop
- Purdue University (U)

WRF-Solar
- NREL (G)
- Brookhaven NL (G)
- NOAA (G)
- Pennsylvania State University (U)
- Colorado State University (U)
- University of Hawaii (U)
- University of Washington (U)
- University of Buffalo (U)
- Long Island Power Authority (P)
- Sacramento Municipal Utility District (P)
- Southern California Edison (P)
- Hawaiian Electric System (P)
- New York Power Authority (G)
- Xcel Energy (P)
- California ISO (P)
- Schneider Electric (P)
- Atmospheric and Environmental Research (P)
- Global Weather Corporation (P)
- MDA Information Systems (P)

WRF-RTFDDA
- Army Test and Evaluation Command (G)
- Panasonic Aviation (P)
- China Electric Power Research Institute (I)

WRF-Fire
- State of Colorado (G)

WRF-Chem
- NASA (G)
- NOAA (G)
- University of Tel Aviv (I)

WRF-Urban
- Arizona State University (U)
- University of Tsukuba, Japan (U)
- University of Reading, UK (U)
- Institute of Urban Meteorology, Beijing, China (I)
- University of Guangzhou, China (I)
- National Natural Science Foundation of China, Beijing (I)
- National Exposure Research Lab, EPA (G)
- Center for Research on Energy, Environment and Technology, Madrid, Spain (I)

H-WRF
- University of Rhode Island (U)
- NOAA (G)

Advanced H-WRF
- University of Miami (U)
- University of Rhode Island (U)
- NOAA (G)
- USAF (G)

Advanced-WRF
- IBM (P)

Polar-WRF
- Oklahoma State University (U)

WRF-DA
- Central Weather Bureau (I)
- Met Office (I)
- USAF (G)
- IBM (P)
- York University, Toronto (I)
- Turkish State Meteorological Service (I)
- NOAA (G)
- NREL (G)

4 Groups:
U=Universities
P=Private Sector
G=Government
I=International

Appendix B

UCAR Technology Transfer Engagement and Strategic Planning Process - 2018

Vision:

- Promote/create an entrepreneurial culture
- Science meets society's needs
- Talent development, retention and recruitment
- More effective industry partnerships

Phase		Key Activity	Key Product	Timeline
Organize	Prepare	Convene Planning Team; Develop pathway, timeline, toolkit for strategic planning	Pathway Process Timeline List of Stakeholders Framework for engagement Volunteer job description for 6 employees to serve on T3 Decide on Team (T3)	December 2017 – March 2018
	Assess	Conduct SWOTs; Innovation Council recommendations; T3 Team survey and define WHY	Summary of strengths and weaknesses; Summary of collaborators and competitors; Why Technology Transfer	December 2017- April 2018
	Research and Data Gathering	Information and data gathering Engage external consultants, internal experts, Stakeholder mapping	Establish current state and exemplars of institutional models; T3 Team input	January – February 2018

Engage	Listen/Envision	Stakeholder engagement; Vision; Future State Exercises	Summary of stakeholder input; Vision; Strategic areas, opportunities; Ideas; Projects	March – May 2018
	Engage	Internal and external stakeholders engagement; Employee engagement workshop	Data gathering; Recommendations Vision SWOT	April – July 2018
	Draft Plan	Post workshop meeting Create an outline Draft Plan Draft Plan Review and input (round 2)	Draft plan; Strategic priorities; Action items Approval – UCAR Leadership; UCAR BOT; UCAR Exchange	July – December 2018 February 2019
Launch	Execute	Decide on plan for initiatives; Roles and responsibilities Align people and resources; Army of volunteers	Final Plan Execution plans Clearly defined roles and responsibilities	March – May 2019
	Evaluate	Set up system to collect relevant data and report periodically; Celebrate wins	Framework for reporting; Interactive website; Portals; Database	May 2019 and on-going

Appendix D

Survey of UCAR Member Universities on Technology Transfer Executive Summary

June 2018

As part of UCAR's Technology Transfer Strategic Planning process, we identified 13 institutions with portfolios in the Earth and atmospheric sciences to participate in a technology transfer (TT) survey.

Florida State University	University of California – Irvine
Oregon State University	University of Colorado – Boulder
Penn State University	University of Michigan
Scripps Institution of Oceanography	University of Oklahoma
SUNY/Albany	University of Utah
University of Arizona	University of Washington
	Woods Hole Oceanographic Institute

The responses show that institutions have different methods, resources, and priorities with regard to their TT programs. Each institution was asked the same set of questions (see Exhibit A). Following is a brief summary after each question.

How do you define Technology Transfer at your university/organization and is it a priority?
Many institutions take a broad view that TT is defined by making an impact through commercialization, education and software tools, and societal benefits. A majority of institutions answered that TT is a priority. Two noted that a change of leadership resulted in making TT a priority. Three replied that TT is not a priority.

How is it supported within your university/organization?
A majority responded that TT is supported within their institutions. They are engaging researchers and staff by building entrepreneurial resources for them. For example, the University of Colorado created a "Commercialization Academy" for interested faculty and researchers. Outreach to faculty, department chairs, deans and VPs was also a common approach. Concrete examples of how TT is promoted in the atmospheric and earth sciences departments include: establishing good relationships with the TT and sponsored research offices at their universities, promoting patents, working with alumni- and faculty-created companies, providing a pipeline of graduates to those companies, working across departments and labs, and striving for personal relationships in business.

How do you incentivize your staff?
There are a variety of different incentives. Some use patent filings as part of granting tenure or promotion. Some offer generous royalty splits, such as 45% of first 100k of royalty revenue and 40% afterward, and others offer options to use the revenue for their lab or match dollars for competitive commercialization grants.

How do you measure success in your TT program?
Some view success as having enough money to fund patents, which can lead to commercialization. Others use metrics such as increased invention disclosures, patent filings and licenses.

What are your current challenges in tech transfer?
The institutions have a variety of challenges. One challenge discussed was the failure to create a sustainable pipeline of new technologies. Some programs depend on existing patents to fund their programs. Once the patents expire, the programs have a hard time operating. Another challenge is that very few institutions have the luxury of large staffs to help with licensing, commercialization, venture accelerators, I-Corps and proof of concept programs. Many lack business-savvy personnel who have marketplace skills and experience. There are concerns about lack of dedicated staff to execute industry contracts and the challenge of meeting stakeholder expectations with regard to financial, time-to-market and other risks. This requires investments in teams and skills that aren't always understood or met. Additional challenges include: research is not focused on solving problems; culture of negativity when working with industry; navigating the many competing interests within a large university; and few inventions become grand slam products or services, and those that do often take much longer than expected.

Summary
There were no consistent patterns that provide a recipe for success. Some factors that contribute to success include: size of staff, monetary resources, areas of expertise in market analysis, commercialization skills and most importantly, a commitment from leadership. There is a commonality of challenges throughout the universities, which can be summed up as lack of resources, such as time, money, and people to work on TT.

Finally, we were able to compare these institutions' overall technology transfer performance with 2016 data available from the Association of University Technology Managers (AUTM), to which we added the UCAR data. See Exhibit B.

Exhibit A

Survey Questions

1. Technology Transfer

a. How do you define Technology Transfer at your university/organization?

b. Is technology transfer a priority in your culture? - [why, why not] If yes, how? or if no, how do you make it work?

c. How is it supported within your university?

d. (For atmospheric sciences, earth sciences, etc. departments) Is it supported, promoted within your [department]? How, give examples

e. How do you incentivize your staff? What mechanisms have you tried in the past?

2. Success

a. How do you measure success in your TT program?

b. What is the key ingredient to that success?

3. Challenges

a. What are your current challenges in tech transfer?

b. What areas are more challenging?

Exhibit B

Table of Technology Transfer Data - 2016*

YEAR	INSTITUTION	Tot Res Exp	Tot Lic/Opt Exe	Gross Lic Inc	Inv. Disc.	New Pat. App	Strtup
2016	Florida State Univ.	$172,212,052	9	$348,929	66	41	3
2016	Oregon State Univ.	$254,275,000	124	$4,168,295	70	38	5
2016	Penn State Univ.	$836,353,000	17	$7,832,756	154	150	6
2016	SUNY - The Research Foundation for the State University of New York	$920,270,746	70	$10,741,022	306	116	13
2016	Univ. of Arizona	$604,464,000	95	$2,015,807	250	138	14
2016	Univ. of California System	$4,408,000,000	278	$156,128,029	1679	1329	86
2016	Univ. of Colorado	$844,712,086	62	$3,102,715	275	312	7
2016	Univ. of Michigan	$1,393,105,207	173	$23,391,292	428	176	12
2016	Univ. of Oklahoma All Campuses	$175,944,748	7	$809,167	60	25	3
2016	Univ. of Utah - No information found in AUTM						
2016	Univ. of Washington/Wash. Res. Fdn.	$1,290,042,000	326	$19,628,870	363	181	21
2016	Woods Hole Oceanographic Inst.	$191,000,000	4	$429,639	33	7	1
2016	UCAR	$206,000,000	8	$94,745	4	4	0

TotResExp=Total Research Expenditures

Tot Lic/Opt Exe= Total Licenses /Options Executed

***AUTM Statistics Access for Technology Transfer Database 2016**