SECOND AMENDATORY AGREEMENT

THIS SECOND AMENDATORY AGREEMENT is entered into as of the date indicated on the signature page, by and between the **CITY AND COUNTY OF DENVER**, a Colorado municipal corporation ("City"), Party of the First Part, and **UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH ("UCAR")**, a nonprofit corporation authorized to conduct business in the state of Colorado (the "Consultant"), Party of the Second Part;

WITNESSETH

WHEREAS, the parties entered into an Agreement dated June 28, 2015 and a subsequent amendment dated September 28, 2018 ("Existing Agreement") in which the Consultant agreed to provide consulting services for weather forecasting and pavement treatment recommendations for runways, taxiways, ramp areas and roadways at **DEN**; and

WHEREAS, UCAR has been partnering with DEN since 2008 and provides weather information specific to DEN and surface predictions by use of the Maintenance Decision Support System (MDSS) product and are the only provider of the MDSS product; and

WHEREAS, the MDSS utilizes weather observations and numerical model predictions from multiple sources to produce routes specific or runway-specific analyses and forecasts of environmental conditions for DEN; and

WHEREAS, UCAR created a custom version of the Federal Highway Administration (FHWA) MDSS for Colorado with a specific focus on DEN runway operations; and

WHEREAS, Extending the contract will enable DEN to continue mitigating the challenges the airport encounters during future snow seasons; and

WHEREAS, the parties desire to amend the Existing Agreement by increasing the length of the term of the agreement and maximum contract amount; and

NOW, THEREFORE, for and in consideration of the premises and other good and valuable consideration, the parties hereto agree as follows:

1. **SECTION 2 SCOPE OF WORK** is amended with the addition of the following section-

"**C. Weather Forecast System**

The Weathernet system is a key piece of forecasting technology that the City shall require UCAR to provide. Providing the Weathernet system is a material part of this Contract. Weathernet provides a text forecast four times per day and will be available 24 hours for additional support. Weathernet may also provide incident meteorological support on-site during very high-impact situations. During the non-

winter months, Weathernet will provide twice per day forecast updates but will still be available 24 hours a day to provide support over the phone or via email."

2. **Section 5 TERM** is hereby amended by deleting Section 5 in its entirety and replacing it with the following:

"**5. TERM:** The Term of this Agreement shall commence on January 1, 2016 and shall terminate on December 31, 2024, unless sooner terminated."

3. **Section 4. A. MAXIMUM CONTRACT LIABILITY; FUNDING** is hereby amended by deleting Section 4. A. and replacing it with the following:

"A. Any other provision of this Agreement notwithstanding, in no event shall the City be liable for payment for services rendered and expenses incurred by the Consultant under the terms of this Agreement for any amount in excess of the sum of One Million Twenty One Thousand Four Hundred Forty-Nine Dollars and Zero Cents ($1,021,449.00). The Maximum Contract Liability may only be increased by amendment to this Agreement."

4. The Attached **Exhibit A Scope of Work** is here by added with an effective date of 1/1/22 at which time it shall replace the existing Scope of Work.

This Second Amendatory Agreement shall not be effective or binding on the City until fully executed by all signatories of the City and County of Denver.

[END OF PAGE]

EXHIBIT A

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

OFFICE OF THE DIRECTOR

March 15, 2021

Mike Carlson C.M., ACE
Aviation Operations Manager
City and County of Denver
Denver International Airport
Airport Operations / Airport Office Building
10th Floor
8500 Pena Boulevard, Denver, CO

Dear Mr. Carlson:

I am pleased to submit for your consideration NCAR proposal #2020-0777 entitled, "Denver International Airport MDSS Demonstration, Research and Development." Mr. Seth Linden is NCAR's Principal Investigator on this project. The total cost reimbursable amount requested for NCAR is $419,719. Please note that UCAR/NCAR participation in this project is contingent upon mutually agreed upon terms and conditions.

Should City and County of Denver choose to award the proposal, funds for NCAR (DUNS# 078339587) should be provided by direct agreement with the University Corporation for Atmospheric Research. Arrangements can be made with:

Ms. Amy Smith
Manager, UCAR Contracts
University Corporation for Atmospheric Research
3090 Center Green Drive
Boulder, CO 80301-2252
Telephone (303) 497-8872
Email: fedaward@ucar.edu

Please refer to the NCAR proposal number on all correspondence with UCAR.

Should you have questions regarding the proposal, please contact Mr. Linden at linden@ucar.edu or, on administrative matters, contact the NCAR Budget and Planning Office, Ms. Andrea Martinez at andreaem@ucar.edu.

Sincerely,

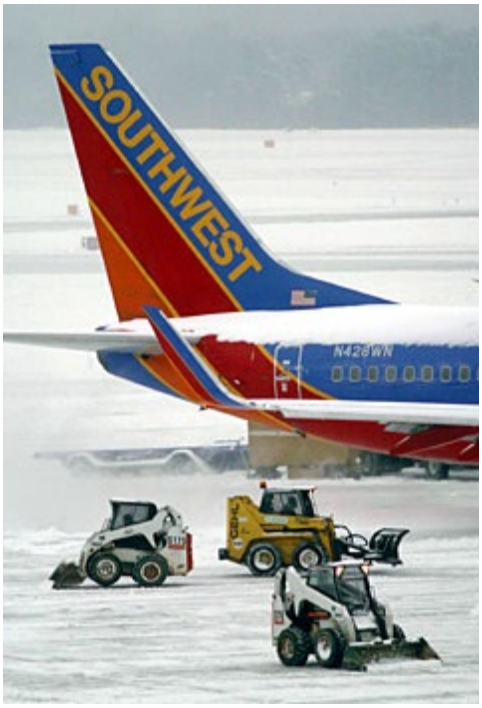
Andrea Martinez

Andrea Martinez
Contract Management Analyst

Enclosure
cc: NCAR B&P
T. Campbell, RAL

EXHIBIT A
Denver International Airport MDSS Demonstration, Research and Development

STATEMENT OF WORK FOR THE PROVISION OF MAINTENANCE DECISION SUPPORT SYSTEM (MDSS) RESEARCH AND DEVELOPMENT TO THE CITY AND COUNTY OF DENVER/DENVER INTERNATIONAL AIRPORT (DEN)



Prepared by the
University Corporation for Atmospheric Research

Effective Date: January 1, 2022

I. Background

In an effort to mitigate the challenges associated with winter maintenance decisions, the Federal Highway Administration (FHWA) initiated a program in 2001 aimed at developing a winter road Maintenance Decision Support System (MDSS). The primary goal of the MDSS program was to construct a functional prototype MDSS that could provide objective guidance to winter road maintenance decision-makers concerning the appropriate treatment strategies to employ to control roadway snow and ice during adverse winter weather events.

The FHWA MDSS prototype utilizes current weather observations and numerical model predictions from multiple sources to produce route-specific or runway-specific analyses and forecasts of environmental conditions. Output from this process is used to drive an energy balance model to generate predictions of pavement conditions along each route of interest. Together, environmental and road condition information is used to construct recommended treatments, which are based on standard rules of practice for effective deicing and anti-icing operations. An interactive mobile compatible display is used to visualize graphic and text-based treatment recommendations, as well as diagnostic and prognostic atmosphere and road condition data.

The broad needs met by the current MDSS include the following:

- Centralized Weather Support
- Enhanced Strategic Planning Capability
- Improved Tactical Response Capability
- Improved Adverse Road Weather Notification
- Operation-Specific Decision Support

The National Center for Atmospheric Research (NCAR), which is operated by the University Corporation for Atmospheric Research (UCAR), created a custom version of the FHWA MDSS for Colorado with a specific focus on Denver International Airport (DEN) runway operations. Over the winters of 2013-2015, 2016-2018 and 2019-2021, UCAR and the City and County of Denver, which operates DEN, entered into an agreement for the provision of MDSS services and support to DEN. This project will be enhancing the MDSS DEN system with better display technology, new custom models and also some new work related to runway friction and snowfall prediction. This document describes a continuation of the DEN MDSS efforts for the next three years (2022 – 2024).

II. Deliverables and Services

UCAR shall provide deliverables consistent with the following MDSS technical documents.

Table 1. MDSS Project Related Documents

Document and/or Web Sites	Source
Maintenance Decision Support System (MDSS) Project, FHWA. http://ral.ucar.edu/projects/mdss/den-mdss/	National Center for Atmospheric Research
Maintenance Decision Support System (MDSS) Release-6.6 Draft Technical Description, Dated 10 March 2015. Available upon request.	National Center for Atmospheric Research

a. MDSS Elements and Parameters

The MDSS system shall provide a set of guidance products for airport operation maintenance managers and crews that provides a forecast of weather and pavement conditions and treatment recommendations customized for specific runways, taxiways, and ramp areas, as well as roadways of interest. UCAR will ensure that MDSS is delivering the same types of forecast products as it has been over the last nine years. Refer to the previous SOW for a detailed list of forecast variables and products.

b. UCAR shall provide to Denver International Airport an MDSS system tailored for the airport's operations.

The MDSS shall have core components including, but not limited to, a fuzzy logic-based weather forecast system, a pavement condition and treatment module, and a data server, which will be operated centrally at UCAR in Boulder, Colorado. The weather forecast system will use advanced data fusion technology developed at UCAR called the Dynamic Integrated foreCast system (DICast™®). The MDSS web server at UCAR will communicate (via the Internet) with the display application, which is available to all DEN maintenance personnel. Weather data from DEN's sensors (atmospheric and surface condition data within the airport environment), as well as other key data, will be provided to UCAR via the Meteorological Assimilation Data Ingest System (MADIS) program or acquired directly from DEN via common data transmission methods (e.g., ftp).

MDSS Update Rate:

72-hr weather and pavement condition predictions will be updated and made available every hour.

MDSS Temporal Resolution:

Weather and road pavement forecast data will be provided at 1-hr resolution out to 72 hrs.

c. MDSS Operations

Field Demonstration Period:

UCAR, a TBD human-in-the-loop weather forecast provider (a subcontractor to this work) and DEN staff shall interact as necessary throughout the demonstration period to discuss MDSS operations, configuration, and enhancement plans throughout each of the next three years. These activities may include face-to-face meetings, conducting telecons, or communicating via email.

A best effort will be made to ensure that the MDSS operates 24-hours per day, 7-days per week during this period. UCAR personnel will be available on an on-call basis between 0900 and 1700 MST, Monday through Friday if a critical failure occurs.

UCAR will provide DEN with point of contact information (e.g., cell phone numbers) prior to the start of MDSS operations.

UCAR staff will also be available to respond to comments and questions about the MDSS during normal working hours.

Weather Forecast Advisories

TBD human-in-the-loop weather forecast provider staff will provide text-based summaries via e-mail of the predicted weather and road conditions to designated DEN staff members. TBD staff will also be available to clarify the weather situation and can be reached using the point of contact information provided by UCAR. Throughout the winter seasons (October through April), TBD will provide a text forecast four times per day and will be available 24 hours per day for additional support. TBD may also provide incident meteorological support on-site during very high-impact winter weather situations. During the non-winter months (May through September), TBD will provide twice per day forecast updates but will still be available 24 hours per day to provide support over the phone or via email.

DEN Winter Maintenance Runways/Routes

The MDSS will be configured to provide weather and pavement condition forecasts and treatment recommendations (i.e., forecast data regarding the state of the atmosphere, surface, and subsurface, which will be made available in real-time) for each DEN instrumented runway and/or roadway of interest. DEN representatives, working with UCAR personnel, will select the runways and routes to be used in the MDSS. The runways and routes within DEN's area of responsibility will be characterized using general

characteristics (pavement type, subsurface characteristics, etc.). Separate winter maintenance treatment plans will be generated by the MDSS for each of the chosen runways and routes.

d. MDSS Research and Enhancements

Specific Enhancements in 2022: Enhance the new mobile display

During the previous contract, UCAR created a new mobile compatible MDSS display. The new display relies on updated, industry standard GUI software that works well with both desktops and mobile devices. It uses a new backend database that organizes and stores all of the data necessary for the web-server. The web-server also uses industry standard software and is the interface between the GUI and the data in the data-base. The display is a web-based (browser-based) application supporting mobile devices and desktop computers. In 2022, UCAR will enhance the display by adding a map layer. The map layer will show color coded DEN runways based on the worst alert condition over the next 24-hours. Users will have the ability to click on the map and then see the overall alerts for that runway and adjacent runways and then interrogate the weather and road forecast for a selected runway. If time and budget allows, further enhancements will be made to speed up the display, specifically the interaction between the GUI and the web-server layer. Other minor improvements, as requested and specified by DEN users may be made to the display if budget allows. The work includes but is not limited to:

- Create base-maps for DEN airport runways and other regions within the MDSS display
- Add new code to web-server layer to return correct, color-coded map objects
- Add new code to display layer to allow users to click on maps and then see the alert view

Specific Enhancements in 2022: Add ECMWF model data to MDSS

UCAR will acquire European Centre for Medium-Range Weather Forecasts (ECMWF) model data from the ECMWF center and utilize it in the MDSS system. The ECMWF global model is regarded as the best global weather model in the world based on performance statistics. The ECMWF model typically outperforms other global model in terms of forecast accuracy, especially at longer lead-times. By utilizing the ECMWF model data, it is anticipated that the MDSS forecast will be improved in the 2-3 day time horizon. The ECMWF model will be integrated with the other numerical weather prediction (NWP) models that make up the backend weather forecast engine (DICast) for MDSS and this will enhance the MDSS final forecast.

UCAR will purchase the ECMWF raw model data through a required, paid subscription from 2022 through 2024 (3 years). UCAR will then process the model data and incorporate it into the MDSS forecast engine (DICast). The work includes:

- The system will use the ECMWF High-Resolution model data (HRES data)
  - The model data resolution is 0.1 degrees (9km grid spacing)
- The system will use the 00 UTC and 12 UTC model runs (new model data twice per day)
- The system will use model data that has lead-times from 0 to 90 hours out
  - The model data is at 1-hour temporal resolution through 90 hours out
- The work includes:
  - UCAR will setup a paid subscription of the model data from ECMWF
  - Setup retrieval of raw model data from ECMWF
  - Decode the ECMWF raw data into site specific data for DICast
  - Set up and configure all DICast related processes to get the model data through the system
    - Create DICast variables from the raw mode data
    - Bias correct model data
  - Integrate the processed model data into the final DICast forecast
  - Re-configure DICast static model weights used for the precipitation forecast to incorporate the ECMWF model

<u>Specific Enhancements in 2023</u>: Customize NCAR WRF model for Colorado

UCAR will setup a custom Weather Research and Forecasting (WRF) model over Colorado for MDSS. The WRF model will be integrated with the other NWP models that make up the backend weather forecast engine (DICast) for MDSS and this will enhance the MDSS final forecast. It may also be used independently to help predict banded precipitation events or other hard to predict weather features over Colorado.

During the previous contract, NCAR started the work to setup up an initial research version of the WRF over Colorado. The work was put on hold due to COVID-19. This describes the continuation of the work in 2023.

The WRF model technology originated at UCAR/NCAR in 2000 and serves as the core NWP model for many high-resolution modeling efforts around the United States. NCAR has the ability to setup custom WRF model data runs for specific regions and has prior experience doing this for winter-weather in Colorado.

NCAR will setup the latest version of WRF (3.7 or higher). The WRF will be configured to cover Colorado with a 2km spatial domain resolution. This may require a larger grid over the western U.S. at 6km resolution that serves as the boundary conditions for the 2km Colorado domain. NCAR will use a WRF configuration that is more specific to predicting winter-weather and snowfall in Colorado. The WRF model will run 4 times per day,

initialized every 6 hours and will produce 1-hour output out to 72 hours into the future. The work includes:

- The WRF will be configured with a 6km outer-domain over the Western U.S. with a 2km domain over Colorado
- The WRF will produce new forecasts every 6 hours (4 times per day), initialized at 00, 06, 12, 18 UTC each day
- The WRF forecast will go from 0 to 72 hours out at 1-hour time resolution
- All standard weather forecast variables will be produced including but not limited to:
    - Air temperature
    - Dewpoint temperature
    - Wind speed and Wind Direction at the surface
    - Cloud cover
    - Precipitation: liquid rate, snowfall rate, total liquid accumulation, total snow accumulation
    - Virtual radar (dBZ forecast)
- Subtasks include:
    - Continue initial setup and configuration of the WRF on UCAR super-computer: cheyenne
    - Install WRF on a new computer / server (a new NCAR/RAL machine that will be purchased)
    - Transfer WRF model output back to MDSS backend machine
    - Decode the WRF raw data into site specific data for DICast
    - Set up and configure all DICast related software to process the WRF model data
        - Create DICast variables from the raw model data
        - Bias correct the WRF model data
    - Integrate the processed model data into the final DICast forecast
    - Re-configure DICast static model weights used for precipitation forecast to incorporate the WRF forecast

<u>Specific Enhancements in 2023</u>: Add Runway Crosswind Potential Index

UCAR will add a new variable to the output of MDSS: the runway crosswind potential index. The runway crosswind potential index is an alert category (0 to 3) based on the cross-wind speed intensity impacting the runways. Crosswinds are the wind-speed component perpendicular to the runway and can prevent planes from landing if the cross-wind is too strong. UCAR will setup and configure a runway cross-wind algorithm for all of the DEN runway sites. The crosswind potential index will be added to the output of DICast used in MDSS. A crosswind potential graphic will then be added to the MDSS mobile display so it can be viewed by DEN maintenance personnel. The work includes:

- Create configuration file with DEN runway end point geo-coordinates (latitude / longitude points on each end of the runways)

- Produce crosswind-speed values and crosswind-speed potential in the derived-variables application in DICast
- Add crosswind potential output to the backend data-base
- Create new crosswind potential graphics for display
- Modify mobile display to show cross-wind potential graphics

***Specific Enhancements in 2024*: Runway Friction Prediction**

UCAR will setup a Runway Friction Prediction System (RFCPS) for Denver International Airport. The RFCPS combines machine learning models with a backend weather forecast to predict runway friction values and runway closure alerts from 0-6 hour out at 15-minute lead-times. The RFCPS predicts runway friction values (Mu values between 0-1) and then applies rules of practice to predict runway closure alerts.

The friction prediction work for DEN will rely on research performed by UCAR for Minneapolis St. Paul International Airport (MSP) that involved creating an initial version of the RFCPS. The RFCPS system relies on modified MDSS output and machine learning models to predict runway friction and the onset and duration of runway closures for Minneapolis–Saint Paul International Airport.

Initially, the latest RFCPS system, which just relies on MDSS output, will be setup for DEN. This involves configuring all the runway sites (end-points and mid-points), producing 15-minute interpolated forecast data, setting up the existing friction models and setting up the applications to produce real-time output.

After the initial prototype system is setup for DEN, UCAR will work towards creating a tuned RFCPS system specific to DEN. The goal is to create new friction prediction machine learning models for the DEN runways. This involves gathering historical runway friction measurements and relating the friction observations to atmospheric and pavement observations near the runways. The runway friction observations will be gathered from the DEN Airport Operations. The pavement and atmospheric observations will be gathered from RWIS sites near the runways. The KDEN METAR (ASOS) site will also serve as a backup for acquiring atmospheric observations. All of the observation data will be quality-controlled and then used to build new machine learning models. If the new friction models show good performance, they will be used in the DEN RFCPS system.

Additionally, if near real-time friction observations are available from DEN, the RFCPS will use those observations to Forward Error Correct (FEC) the final friction forecasts. Finally, new output plots will be created showing the predicted friction values and runway closure alerts for the DEN runways. The new graphics will be made available through the MDSS mobile application or another mobile friendly web viewer.

The work includes, but is not limited, to:

- Setup initial RFCPS system for DEN
    - Configure runway location end-points and mid-points
    - Create 15-minute output required by RFCPS
    - Install machine learning models
    - Install output and plotting scripts
- Develop new friction prediction machine learning model specific to DEN runways
    - Acquire historical friction measurements from DEN maintenance personnel
    - Acquire historical atmospheric and pavement observations from RWIS sites near the airport runways
    - Relate the friction observations to the atmospheric and pavement observations for a given time and location
    - Apply quality control (QC) and prepare observations for machine-learning
    - Create new machine-learning models specific to DEN runways
    - Analyze new friction models to determine performance
- If near real-time friction observations are available, the friction data will be gathered, quality-controlled and used to FEC the final friction forecasts
    - Sub-hourly updates are created upon receiving real-time friction data
- Output plots showing predicted friction values and runway closure alerts will generated and made available via either the MDSS mobile application or another RFCPS viewer application

***Specific Enhancements in 2024*: Improve MDSS snowfall prediction**

The MDSS snowfall forecast is at the heart of the decision support products used by Denver International Airport. The snowfall forecast is one of the main drivers of the runway pavement conditions in terms of the road temperature prediction and how much snow and ice is expected to build up on the runways. Improving the MDSS snowfall forecast will improve all the important decision support output used by DEN.

The specific goal of this task is to create new snowfall accumulation variables that indicate the expected range of snowfall for a given lead-time. New forecast variables will be created that indicate the forecast low-end snowfall accumulation and another that indicates the high-end snowfall accumulation, together these new variables will give the range of expected snowfall for a given site and valid-time. A new algorithm will be created that examines the different snowfall forecasts from different input models and then develops low-end and high-end values based on statistical techniques. The standard total snowfall accumulation forecast will be used to QC the new variables.

If sufficient budget remains, a simple probabilistic snowfall accumulation forecast will be created using the input models. The idea would be to use something like Bayesian Model Averaging (BMA) to create a probabilistic range of expected snowfall accumulation. The final output would be the total snowfall accumulation range between the 25^{th} to the 75^{th} percentile (low to high end range of snowfall accumulation indicated by the probability).

The 25th percentile would be the low-end value and the 75th percentile would be the high end value.

Finally a new output plot will be created for the MDSS display that shows the low-end total snowfall accumulation, the standard total snowfall accumulation and the high-end total snowfall accumulation.

The work includes, but is not limited, to:

- Develop a new application or algorithm to ingest each of the input model's liquid precipitation forecast
    - These are the input models that are integrated in the DICast back-end weather engine to produce the final MDSS forecast
    - The algorithm will convert each model's liquid precipitation to a snowfall amount using the MDSS liquid to snow conversion algorithm
    - Low-end and high-end snowfall accumulation range will be calculated by comparing model snowfall forecast amounts to the final MDSS total snowfall accumulation
- Add new variables to the MDSS mobile display
    - Create a new plot that shows low-end total accumulation, standard total accumulation and high-end total accumulation
    - The new plots will be displayed in the MDSS mobile application

e. Budget information

Yearly budget totals may be adjusted upon mutual agreement between the Parties. Any adjustments cannot exceed the Contract Maximum Liability.

UCAR

UCAR Proposal Budget Detail

Proposal #	2020-0777
Proposal Title:	Denver International Airport MDSS Demonstration, Research and Development
UCAR Entity:	NCAR
Period of Performance:	01-01-2022 - 12-31-2024
Principal Investigator	Seth Linden

			Unit / Rate		Effort Year 1	Effort Year 2	Effort Year 3	Year 1 City and County of Denver	Year 2 City and County of Denver	Year 3 City and County of Denver	Cumulative Grand Total
Salaries	**Regular Salaries**	Proj Scientist II	Hours		0.00	224.00	0.00	0	13,059	0	**13,059**
		Soft EngProg III	Hours		60.00	30.00	60.00	3,592	1,850	3,811	**9,253**
		Soft EngProg II	Hours		24.00	0.00	203.00	984	0	8,831	**9,815**
		Soft EngProg III	Hours		24.00	16.00	200.00	1,314	902	11,612	**13,828**
		Soft EngProg III	Hours		32.00	20.00	120.00	1,870	1,204	7,438	**10,512**
		Soft EngProg III	Hours		158.00	162.00	116.00	9,347	9,871	7,280	**26,498**
		Soft EngProg IV	Hours		20.00	30.00	20.00	1,698	2,623	1,801	**6,122**
	Subtotal Salaries							**18,805**	**29,509**	**40,773**	**89,087**
Fringe Benefits		Regular Benefits @	54.50 %					10,248	16,083	22,223	**48,554**
	Subtotal Fringe Benefits							**10,248**	**16,083**	**22,223**	**48,554**
	Total Salaries and Benefits							**29,053**	**45,592**	**62,996**	**137,641**
Purchased Services		Subcontract						24,910	25,000	25,000	**74,910**
		Other - Purchase raw ECMWF data for 3 years						26,400	0	0	**26,400**
	Subtotal Purchased Services							**51,310**	**25,000**	**25,000**	**101,310**
Travel		Domestic - AMS						0	0	4,991	**4,991**
	Subtotal Travel							**0**	**0**	**4,991**	**4,991**
	Modified Total Direct Costs (MTDC)							**80,363**	**70,592**	**92,987**	**243,942**
Indirect Costs		NCAR Indirect Cost Rate (MTDC)	56.60 %					45,485	39,955	52,631	**138,071**
	Total Indirect Costs							**45,485**	**39,955**	**52,631**	**138,071**
MTDC Costs that Include Indirect Costs	**Computing Service Center**	Computing Service Center	$7.67 / hr					2,438	3,697	5,514	**11,649**
	Subtotal MTDC Costs that Include Indirect Costs							**2,438**	**3,697**	**5,514**	**11,649**
	Total MTDC + Applied Indirect Costs							**128,286**	**114,244**	**151,132**	**393,662**

UCAR

UCAR Proposal Budget Detail

			Unit / Rate		Effort Year 1	Effort Year 2	Effort Year 3	Year 1 City and County of Denver	Year 2 City and County of Denver	Year 3 City and County of Denver	Cumulative Grand Total
Management Fee		UCAR Management Fee	3.00 %					3,849	3,427	4,534	**11,810**
Exclusions from MTDC	**Equipment**	New Dell computer for running WRF.						0	12,357	0	**12,357**
	Balance of Purchased Services >$25K/fiscal year	Subcontract						0	600	1,290	**1,890**
	Subtotal Exclusions from MTDC							**0**	**12,957**	**1,290**	**14,247**
	Total Funding To UCAR							**132,135**	**130,628**	**156,956**	**419,719**

Contract Control Number: PLANE-202157610-02 / Alfresco 201522205-02
Contractor Name: UNIVERSITY CORPORATION FOR ATMOSPHRC RESEARCH (UCAR)

IN WITNESS WHEREOF, the parties have set their hands and affixed their seals at Denver, Colorado as of:

SEAL

CITY AND COUNTY OF DENVER:

ATTEST:

By: _____

_____

APPROVED AS TO FORM:

Attorney for the City and County of Denver

By: _____

REGISTERED AND COUNTERSIGNED:

By: _____

By: _____

Contract Control Number: PLANE-202157610-02 / Alfresco 201522205-02
Contractor Name: UNIVERSITY CORPORATION FOR ATMOSPHRC RESEARCH (UCAR)

By: DocuSigned by: Amy Smith BCF55DD7D6B340E... _____

Name: Amy Smith _____
(please print)

Title: Interim Contracts Director _____
(please print)

ATTEST: [if required]

By: _____

Name: _____
(please print)

Title: _____
(please print)