

# What we want:



COWNET and DOWNET CIFS

**Inexpensive**  
**Low-Risk**  
**Quickly-Developable**  
**High-Impact**  
**Broad-Impact**

## Improvements to Observing Capabilities

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# What we really really want:

Even more targetable,  
Even more affordable,  
Long-Wavelength,  
Even finer scale,  
Fast,  
Dual-Polarization,  
Vector-Winds



### What we have:

1995 Research S-Band Paradigm  
One big super-high capability radar

Extremely valuable tool for ~25 years

Targetable, Affordable,  
Long-Wavelength,  
Fine-Scale, Fast,  
Dual-Polarization,  
Vector-Winds



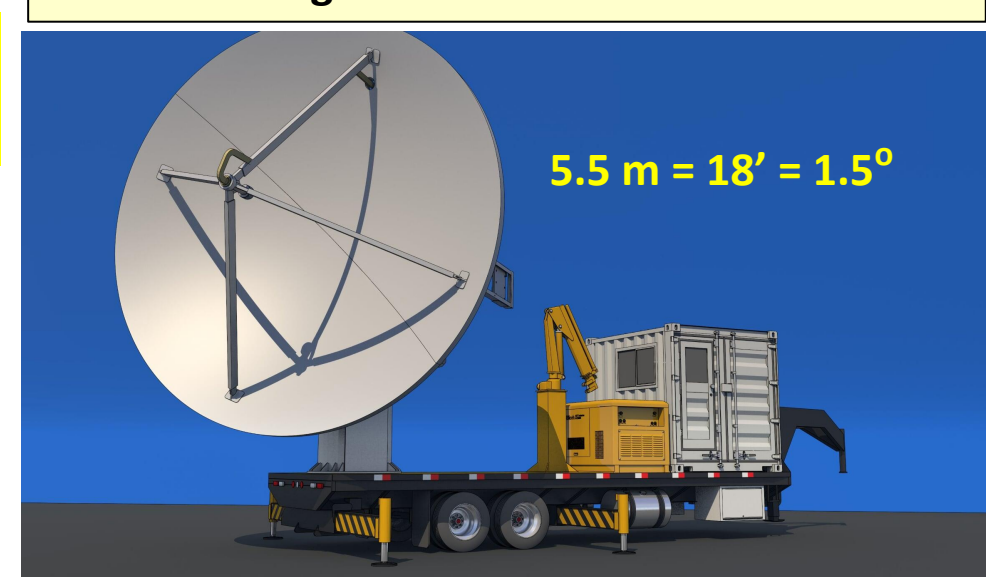
- Expensive to deploy: < \$1M
- Expensive to maintain: \$\$\$\$ / year
- Single-point of failure
- Long set up time (so not so targetable)

### What we need:

**Inexpensive**  
**Low-Risk**  
**Quickly-Developed**  
**Solution**

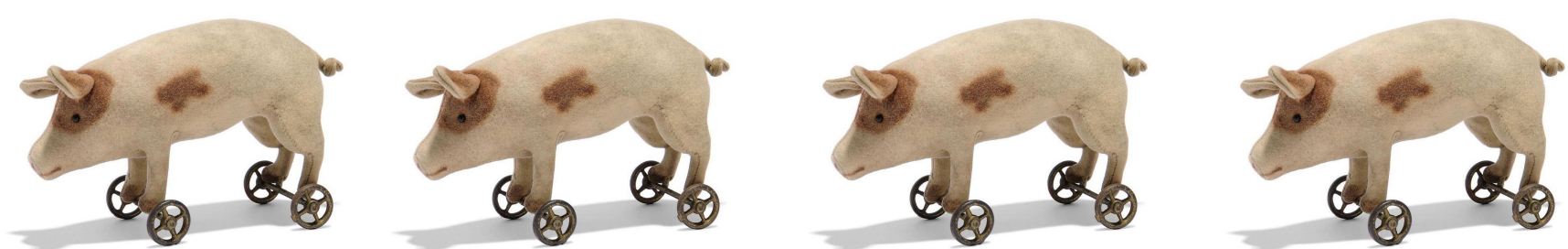


SOW: S-Band 2x 1 MW Transmitters  
1.5° degree beam 5.5 m antenna

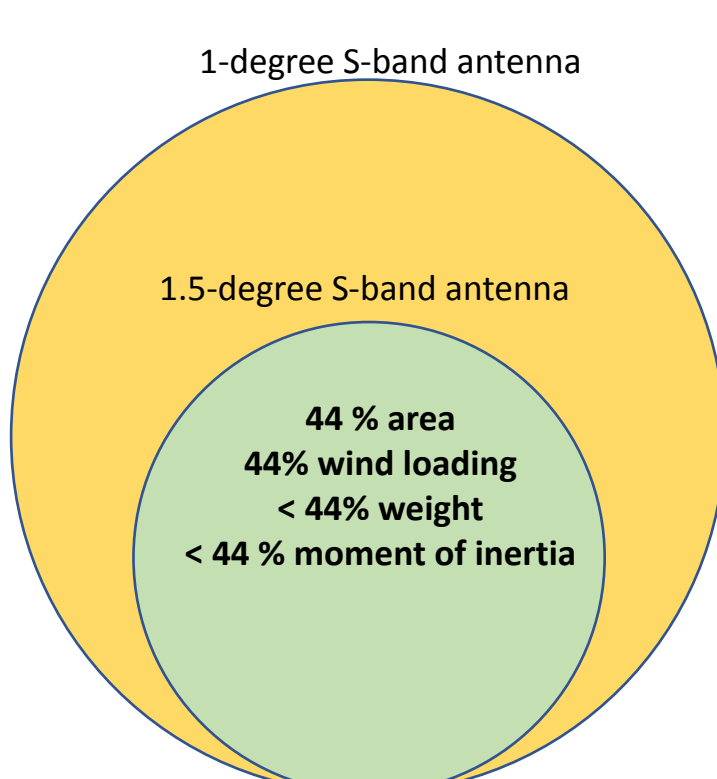
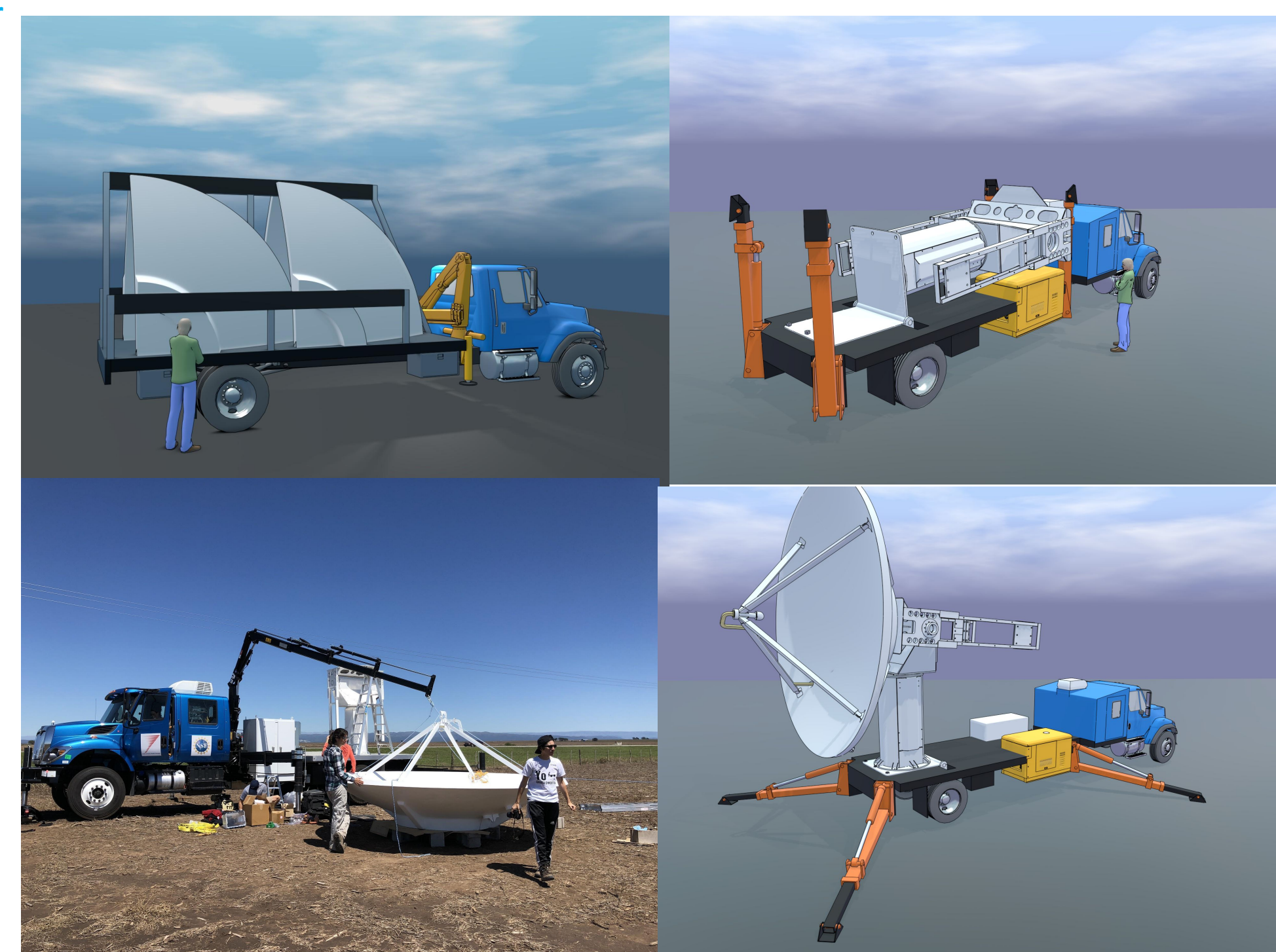


x4  
4 dual-pol, dual-frequency,  
radars in a S-band multiple-Doppler network

## S-Band On Wheels Network (SOW)



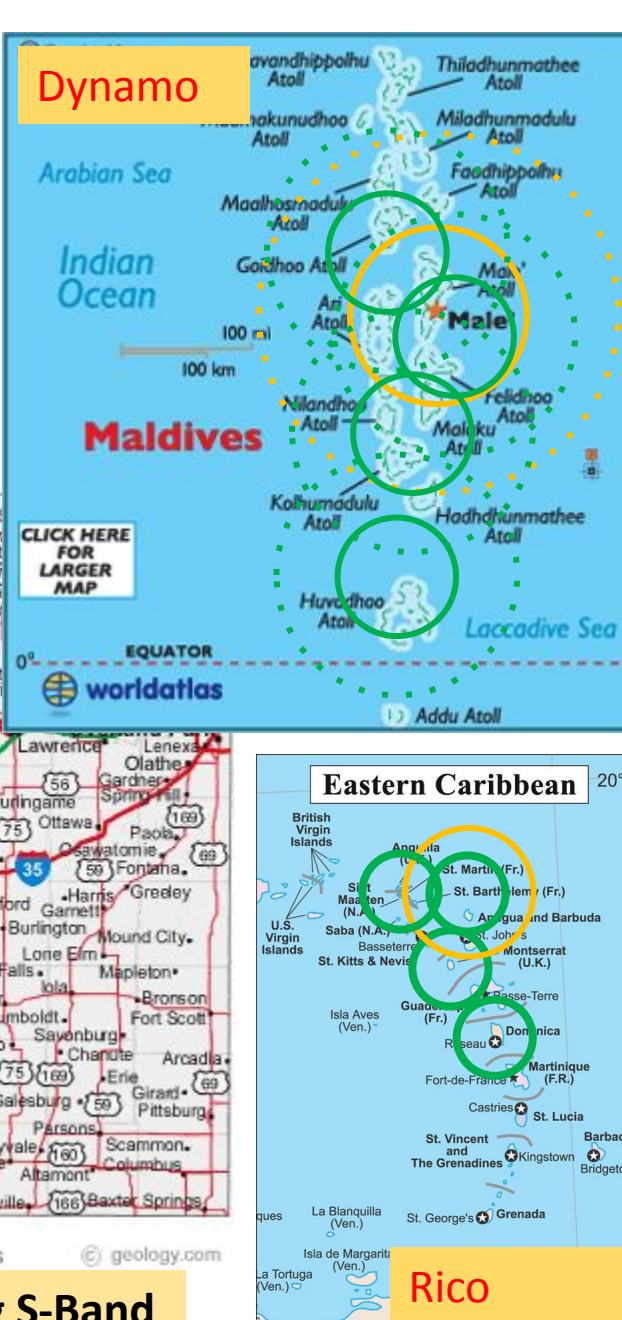
- More flexible coverage configurations: (triangle, linear, overlapping or spread out) (Single S-band radar coverage is rigidly a circle)
- 1, 2, 3, ... N could be requested for small, medium, and large projects
- Multiple-Doppler vectors from coordinated scanning network
- ~< 1/4 cost to deploy whole network compared to big S-band
  - No big pedestal, dish, trailers, power to maintain ... quicker
- 1-Day set up and tear down time, each.
- Same or better scientific capability in nearly all deployments
  - equal or better spatial resolution
  - 2x scan rates with dual-frequency
  - better sensitivity with 2x 1MW transmitters
- but only 2/3 resolution far out to sea



Size Matters for Adaptability and Cost

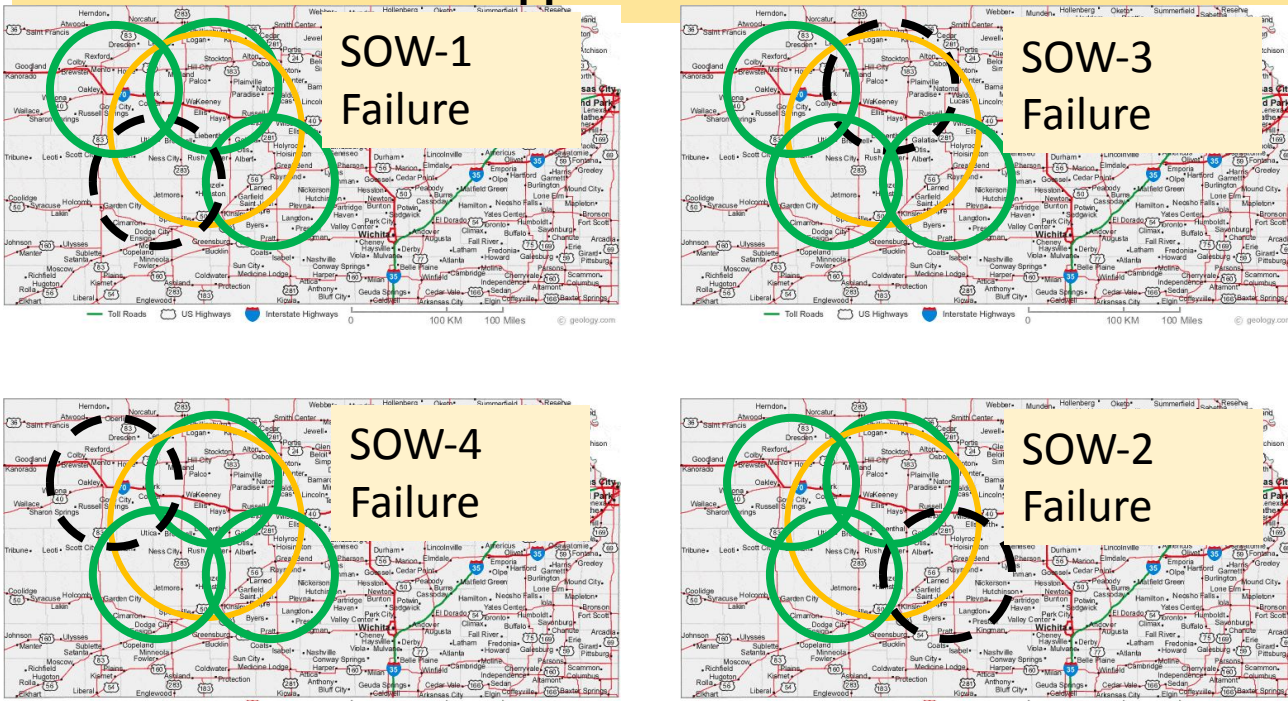
### Size Doesn't Matter for Science Resolution at Targets Matters

SOWs closer to targets than 1-degree radar. Resolution is comparable ... or better ... throughout domain  
Volumetric resolution 1.5 degrees @ 44 km ~ 1.0 degrees @ 100  
Horizontal resolution 1.5 degrees @ 65 km ~ 1.0 degrees @ 100

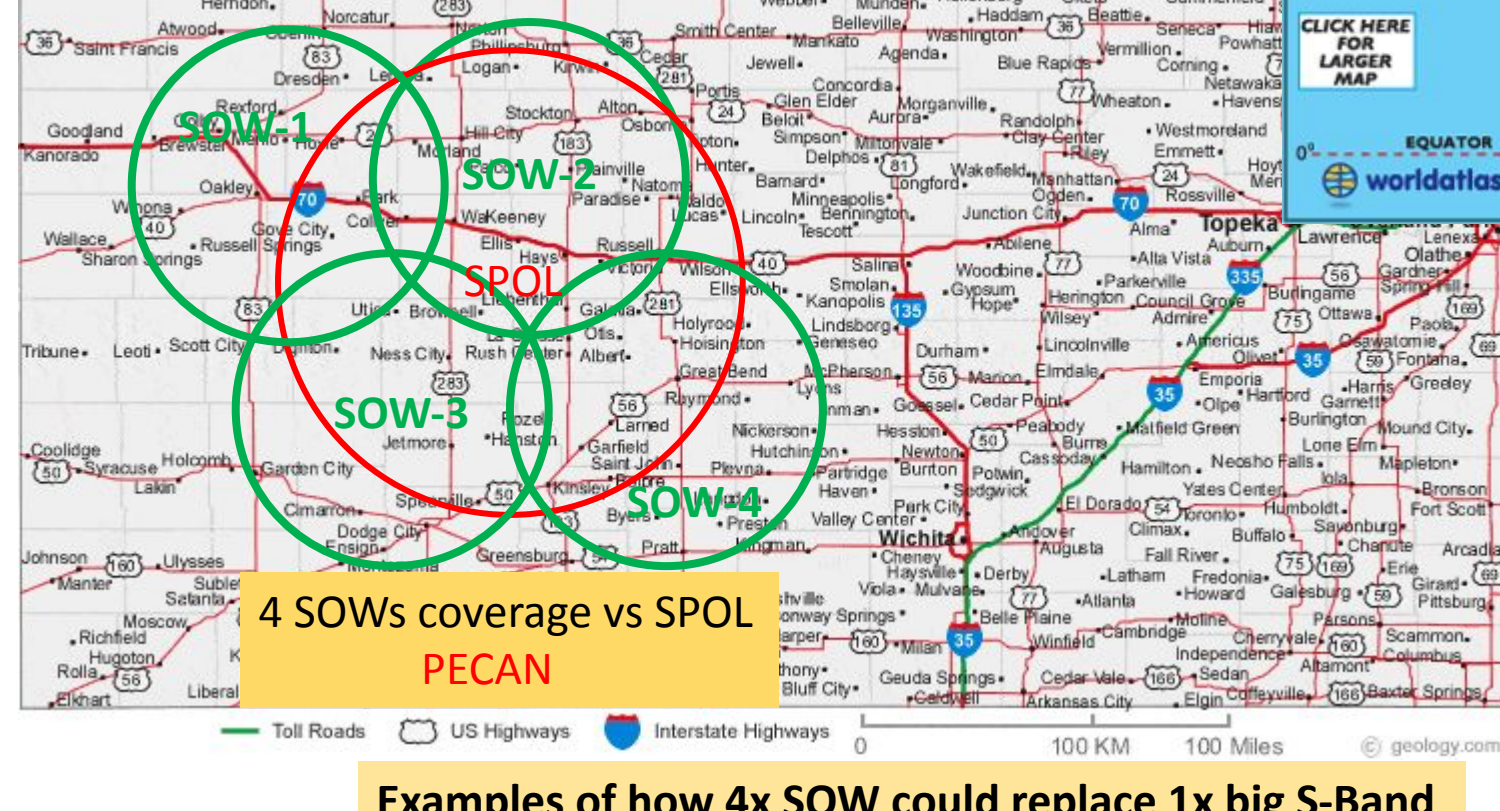


### More Failure-Tolerant Network

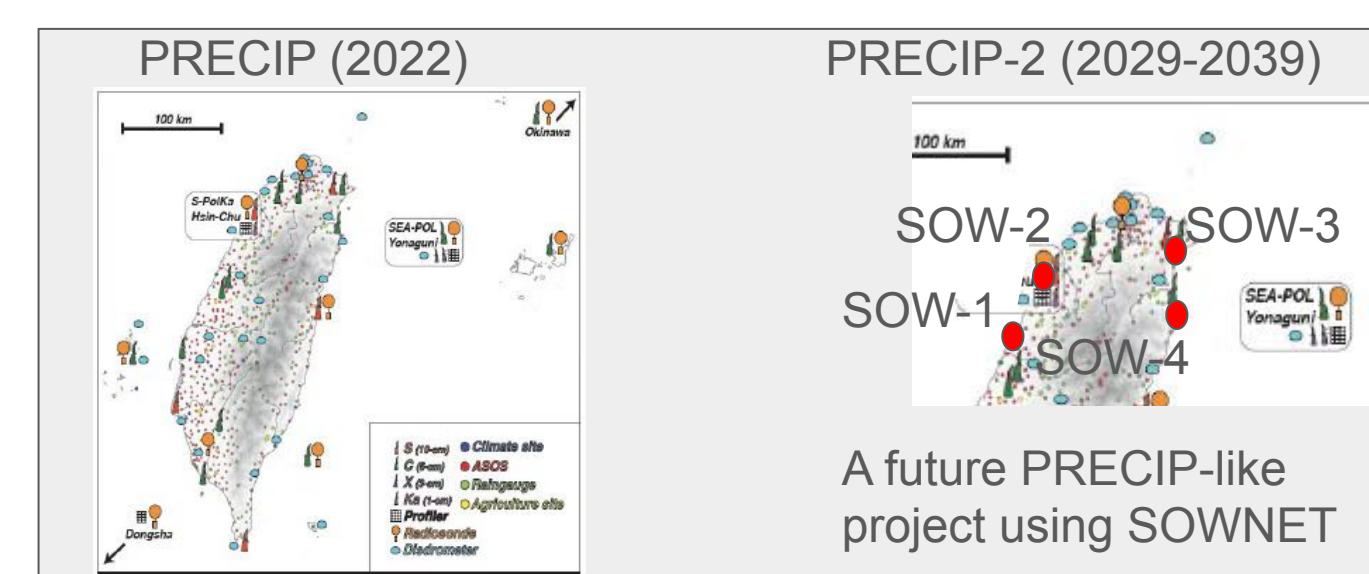
If one radar fails, rest of network is still up and providing dual-Doppler over broad area



### Network of 1.5° S-Band SOW



Examples of how 4x SOW could replace 1x big S-Band



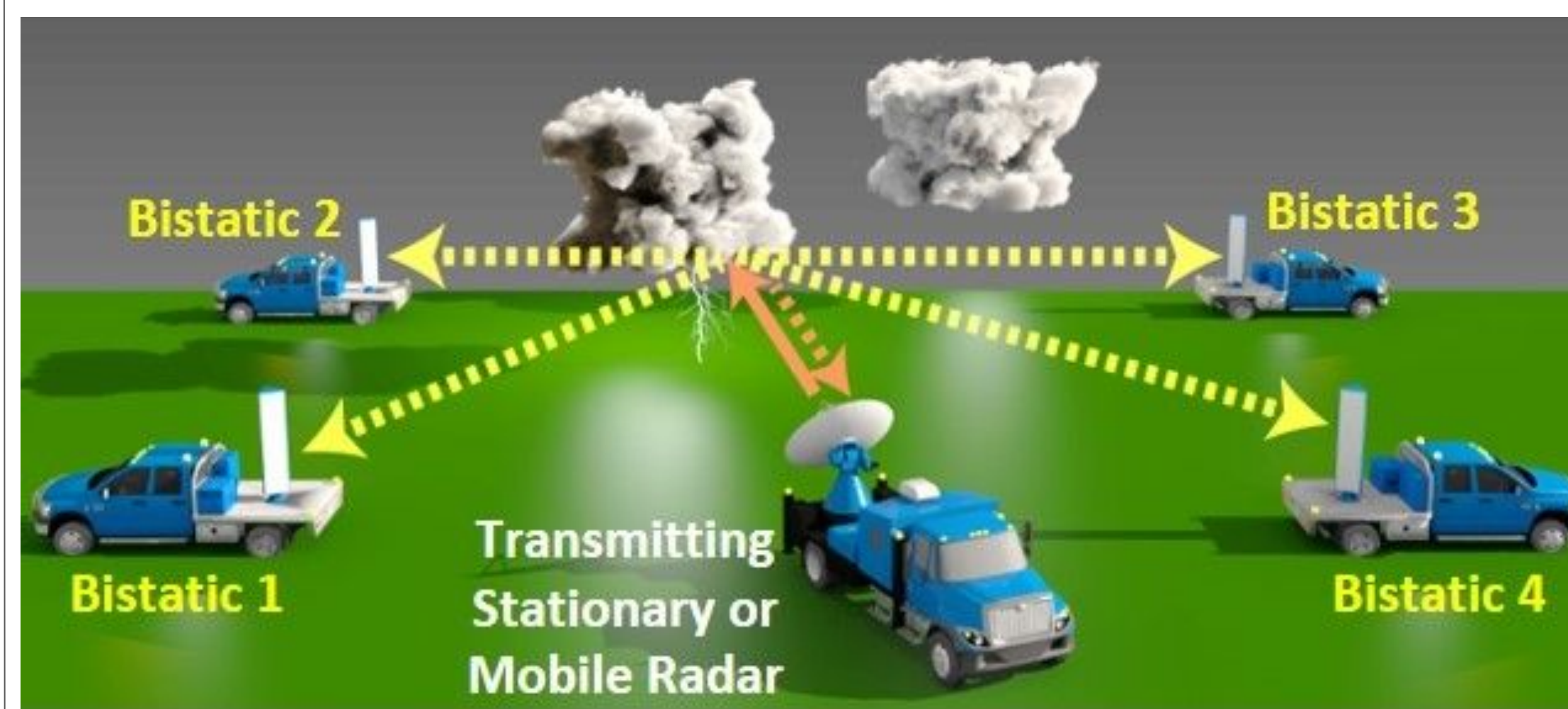
Awards: 2020462, 2113207, 2431370, 2431455, 2508611, 2410917, 2524109

## Bistatic Adaptable Radar Network (BARN)

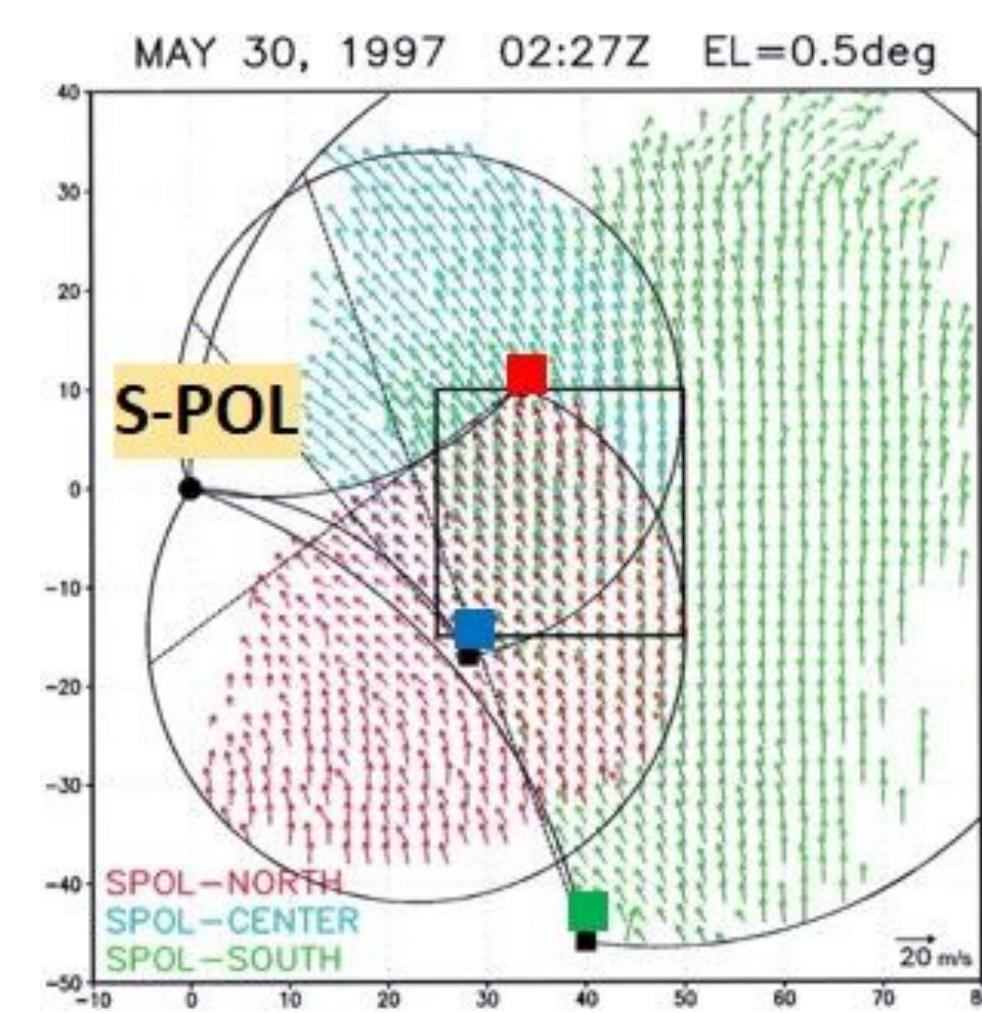
Using DOW / COW / SOW network (Or any radar network)

Most of what used to be "hard" about bistatics is now easy

- Faster computers
- Full time series recording
- 10-20 receiver networks feasible, extremely overdetermined solutions to vector wind field



Bistatic multiple-Doppler networks can employ stationary or mobile DOW/COW type radars and an array of very inexpensive, small, pick-up truck based passive receivers to retrieve real-time vector winds in non-interpolated (spatially or temporally) native observational coordinates.



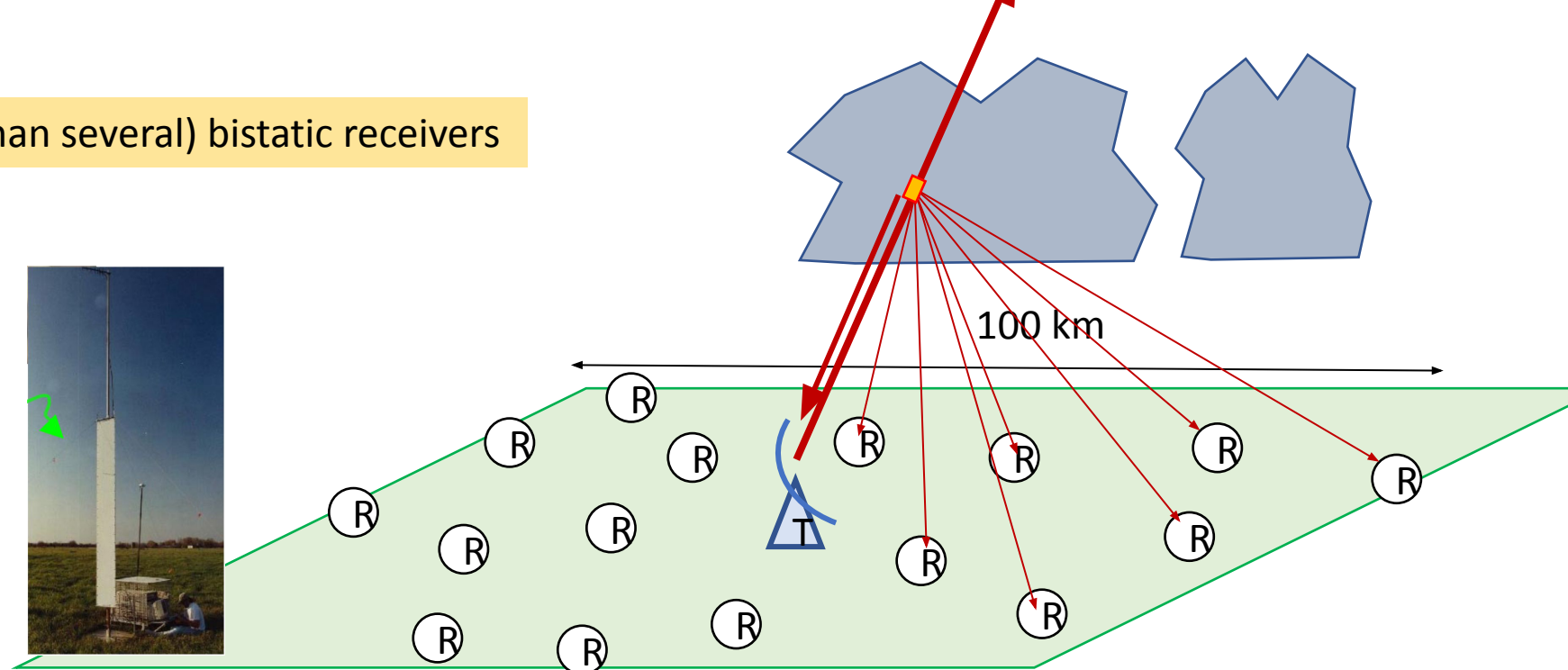
An example from a prototyping experiment shows vector winds calculated using a stationary radar (S-POL 1997) and three different passive bistatic receivers.

The key features of BARN are:

- BARN enables multiple-Doppler vector wind measurements over targeted regions.
- While SOWNET is providing moderate-resolution multiple-Doppler measurements, BARN provides finer-scale and/or customized measurements over smaller domains.
- BARN units will be configured with different SOWs, COW, or DOWs. Only the receiver front ends and antennas are frequency-specific.
- BARN units will be stationary, deployed for the duration of a project, or mobile.
- Stationary BARN units will be unattended, low power, and logistically similar to deployable weather stations.
- Highly redundant BARN units provide extreme reliability of multiple-Doppler operations.
- BARN units are < 1/10 the cost of scanning transmitting radars.
- BARN receiving antennas designed with different characteristics. These will include previously-used low-gain systems optimized to sample broad areas of precipitation, but unable to observe clear-air non-precipitating regions., Medium-gain systems, perhaps slowly scanning or switching, which can obtain vector wind measurement in the non-precipitating boundary layer will be designed. Different configurations will be optimized for different observational needs.

With >> faster computer power than 1990's bistatic networks, can use extremely over-determined voting/variational/etc. methods

Lots (more than several) bistatic receivers



Schematic of a single transmitter, highly multiple remote bistatic receiver network. Radiation is backscattered towards transmitting radar (T), and obliquely scattered towards several or more bistatic receivers (R). The remote receivers each have multiple antennas focusing with moderate gain at higher and lower elevations, or at different dual-Doppler lobes.

Highly overdetermined bistatic multiple-Doppler solutions reduce error in vector windfields, increase coverage in low-reflectivity clear-air regions, and through variational or "voting" methods, produce solutions with minimized contamination from side lobes.

Bistatic receivers can be optimally located and/or pointed to enhance coverage of high-value areas (e.g. airports, focusing topography, land/sea or land use boundaries, even, if receivers are mobile, convergence lines, fronts, and other atmospheric boundaries).

$$\begin{bmatrix} U \\ V \\ W_p \end{bmatrix} = \frac{1}{\delta} \begin{bmatrix} \alpha_1 & \beta_1 & \gamma_1 \\ \alpha_2 & \beta_2 & \gamma_2 \\ \alpha_3 & \beta_3 & \gamma_3 \\ \vdots & \vdots & \vdots \\ \alpha_n & \beta_n & \gamma_n \\ \alpha_t & \beta_t & \gamma_t \end{bmatrix} \begin{bmatrix} VR_1 \\ VR_2 \\ \vdots \\ VR_n \\ VR_t \end{bmatrix}$$

Eq 1. Calculation of vector winds from overdetermined bistatic network.  $\alpha \beta \gamma$  terms are functions of observing geometry.  $VR_1$  to  $VR_n$  are the Doppler velocities measured by 1 through n receivers and  $VR_t$  is the Doppler velocity measured by the transmitting radar.  $U, V,$  and  $W_p$  are the vector winds in the horizontal ( $U, V$ ) and vertical ( $W_p$ ) directions, solved for by minimizing errors. The number of unique bistatic Doppler measurements can be >20.

Fig. 8. Schematic of horizontal divergence and vorticity calculations calculated on a gate-by-gate, non-interpolated basis, using the native bistatic coordinate system.

## Ground-DORA



Old ELDORA Antennas



Tip Up  
+  
Rotate One Panel



Add Truck



Spin really Fast: 1 Hz

## Ground-DORA