

Future Airborne and Shipborne Radars

This breakout built upon these presentations:

- **Science Drivers** for Future Airborne and Shipborne Radars
 - Michael Bell (CSU) focused on ship deployments
 - Paul Reasor (NOAA) discussed airborne radar - mostly for hurricane research
- **Feasibility Considerations**: Cost, Design, and Deployment Challenges (Brad Klotz, NCAR)

Objectives of the breakout:

- discuss the community needs and expectations for future radar systems on moving platforms (airborne/shipborne).
- link the scientific gaps, radar technology, and platform capabilities to help guide decisions on current and future radars.

This is a summary of three breakout discussions:

- Group 4 (~15 people): Facilitator and Note taker: Wen Chau Lee
- Group 3 (~25 people): Facilitator: Bart Geerts Note Taker: Brad Klotz
- Group 9 remote (2 people): Facilitator and Note taker: Vivek

3. Objectives & Guiding Questions

Title	The Future of Airborne and Shipborne Radar
Description	<ul style="list-style-type: none">- discuss the community needs and expectations for future radar systems on moving platforms (airborne/shipborne).- link the scientific gaps, radar technology, and platform capabilities to help guide decisions on current and future radars.
Topics and Objectives	<ul style="list-style-type: none">• What are some ways the community can adapt and develop radar facilities for long-term success in a changing radar landscape?• How can we find appropriate applications that combine the capabilities of new or existing technology with scientific needs?• How can we better utilize or implement different weather or

	<p>cloud radars on airborne or shipborne platforms in a way that addresses important science gaps?</p> <ul style="list-style-type: none"> • What is the vision for building current operations into more advanced CONOPS? • Discuss how to work with funding agencies to continue to support these important radar platforms • Discuss the importance of cross-collaboration with actionable ideas
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4. Discussion & Key Findings

Please use the following format for each comment made. Ensure that the comment and major theme are noted along with the person saying the comment. Summarize as best as possible.

<p>Summary of comments:</p> <p>The mission statement for this group should be focused on a joint approach across agencies that allows us to utilize new technology such as PAR while also harnessing the knowledge gained through mechanically scanning radars.</p> <p><u>Old vs new:</u></p> <ul style="list-style-type: none"> - Current, proven technologies still have a purpose. Especially the remote places (oceans, Arctic ...) need more sampling <ul style="list-style-type: none"> - extend platform diversity (e.g., SEA-POL on multiple ships) - although installation on new aircraft may be very time-consuming/costly (make radars more modular) - There is room for incremental innovations that can be deployed at a reasonable cost <u>and</u> advance the science - Complex new technology can be transformational but TRL1→10 timeline (TMRR) may be too long. <ul style="list-style-type: none"> - aircraft/ships have the extra complication of regulatory compliance (certification) - phased development approach: TMRR phase would allow an iterative cycle that connects scientific and design needs; this creates an environment for software development and understanding performance of a system

- Understanding risks of new radars is really important as we move forward. NCAR can be facilitators of the distributed applications; From an operations standpoint, NCAR has been doing airborne research for decades, NCAR stands at the forefront of the development and exploration aspects; How do we operate the research aspects of the airborne platforms? Is this more of the exploratory endeavor?
- explore cost reduction strategies, e.g. by building in contingencies: changing our requirements and applications of airborne systems that still achieve scientific capabilities; This is vital for improving capabilities using the new technologies
- AI can fill some science gaps, but radar measurements are still needed

Agency collaboration on complex airborne/shipborne radars:

- Agency collaboration and use of a broader federal fleet to support radar platforms would be highly desirable, as these systems are complex and costly to maintain (e.g., NCAR and NOAA). A model similar to UNOLS could be considered.
- There has long been interest in coordinating aviation resources across agencies, but the mission requirements of the main players (NSF, NASA, NOAA) differ significantly. What would coordination between agencies look like?

Cross-collaboration on software/applications:

- understanding changes in airborne processing software, the importance of automated applications for operational support, the ML/AI component seems to be a very fruitful avenue for this effort;
 - example: single point of failure with NOAA HRD software development
- How does this affect the new aircraft, will real-time processing be a problem?
- Things like starlink might not support upload and data transmission effectively
- Robust communications are important and require active involvement across agencies and industry

Airborne radars for CAL/VAL of spaceborne radars:

- transformational development: Doppler radar in space
- how do we utilize satellite radars for cross calibration and intercomparison with satellite products;
- NASA's fleet of aircraft that can fly above the deepest storms will be retired - no replacement?
- Maybe AI has a role to play in this intercomparison
 - but there is a gap in coverage for vertical winds that may prevent training for ML algorithms

Issues related to a moving platform:

- rapid (electronic) scanning is even more desirable on a moving platform:

attitude changes should be slow compared to radar sampling rate

- Corrections for INE and potential changes in navigation; Maybe there is some room and motivation for PAR.
- Pros and cons of mechanically scanning vs. PAR were discussed? Comment was the PAR does improve using adaptive positioning of the aircraft because it is adjusting to the radar itself rather than the aircraft itself - although accurate information about the plane position and 3D movement remains for corrections

Access to legacy airborne radar data, transferability of data:

- Where do we stand on development on distributed architecture?
- We want a vehicle to continue the effort for understanding the resources available, utilizing those resources appropriately, collaborating between agencies to understand the needs and roles across scales.

Working across communication applications, and distributed platforms:

- NCAR and NOAA will be working on airborne analysis for various future applications - this addresses some key aspects about the future of airborne weather radar

Recommendation for NSF/Community: The APAR experience and transition from parabolic to PAR, added complexity of the platform, NCAR understands the complexity, broader university consortium to participate in the development along with cross-agency collaboration; exploring and shaping the next gen radar system for both operational platforms but also focusing on small feasibility studies on a constellation of observational capabilities;

NCAR serves as the vehicle to facilitate the interaction between these groups; Broaden the mission beyond the specific platform but allow pathways for accessing new technologies with thoughtful integration; We acknowledge the complexity but we want to create the means for NCAR to facilitate the research and link to operational applications. Create a sustainable infrastructure for the future of radar but over a more quickly moving time frame; Addresses the issue of deployability over a quick, responsive time scale.

Major Theme:

Questions raised:

Commenter:

5. Outcomes & Consensus

- **Group Consensus:** List any clear consensus from the group
 - We discussed the importance of software usage across platforms
 - We discussed the importance of distributed facilities in an effort to provide combined knowledge between agencies

- **Gaps & Opportunities:** List any ideas that show potential but need more support or investigation

6. Final Summary