# Sparse OFDM Design for Interference and Ambiguity Mitigation in Multi-static ISAC

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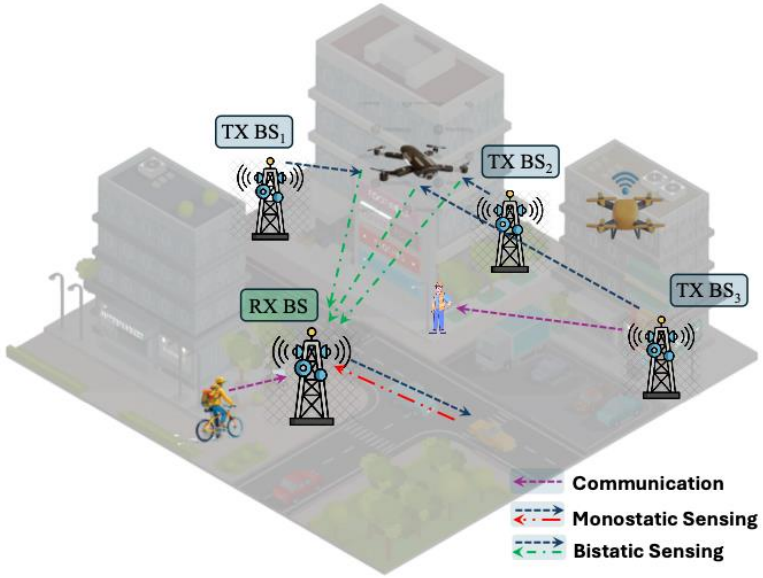
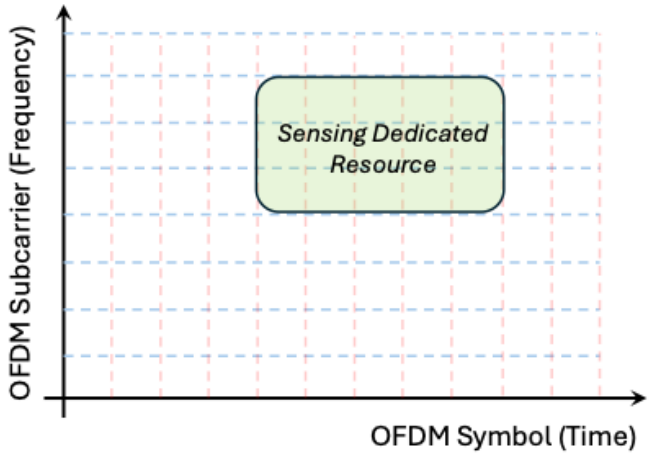
# The Multi-static ISAC Setup

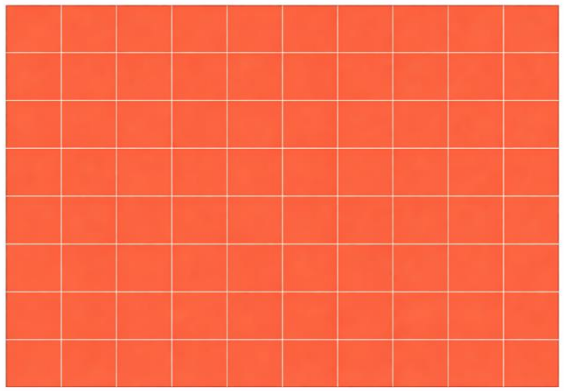
- Full/ Half-duplex BSs
- No direct TX to RX path (partitioning and beamforming)
- Sensing dedicated resource



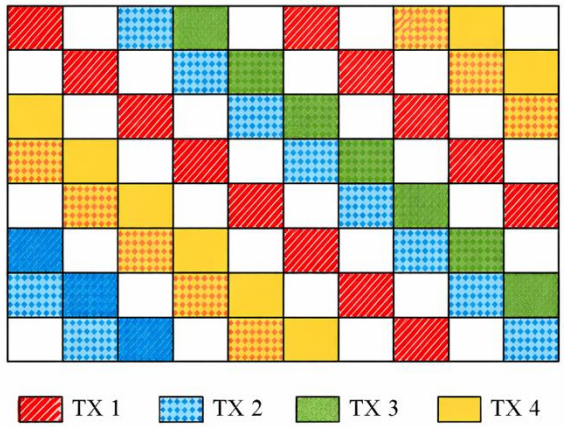
# The Dual challenge in Multi-static Sensing

**Challenge 1**: Fully Occupied grid



**Mechanism**: OFDM resource cells fully occupied by TXs
**Outcome**: Severe inter-BS interference

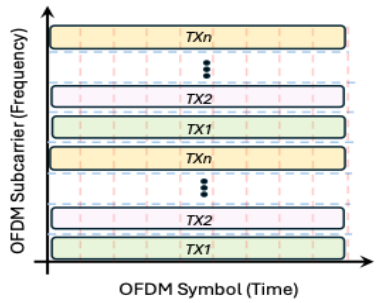
**Challenge 2**: Regular sparsity

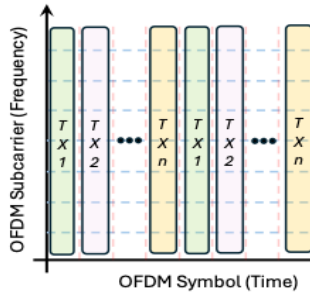


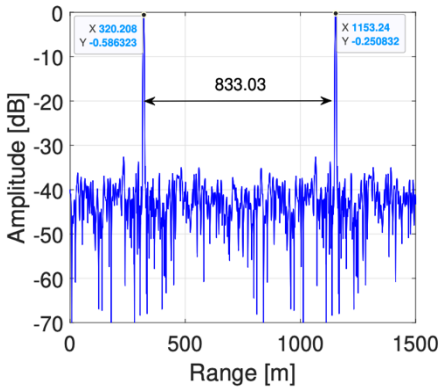

**Mechanism**: OFDM resource cells are sparse in regular pattern
**Outcome**: Range and Doppler ambiguities leading to ghost targets

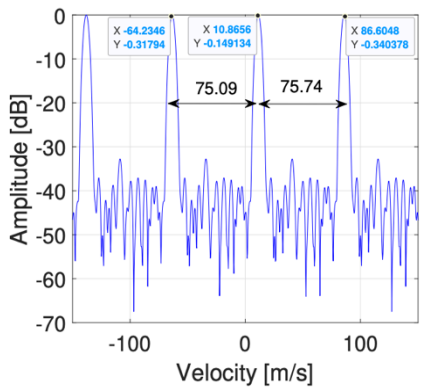
# Time Frequency Orthogonality

## Periodic Allocation

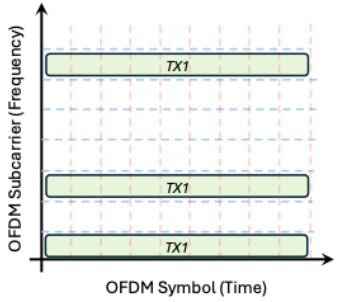


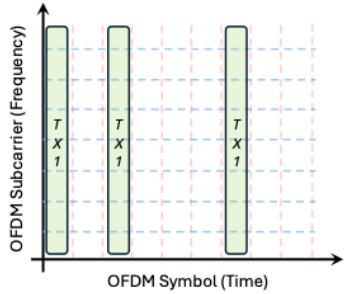



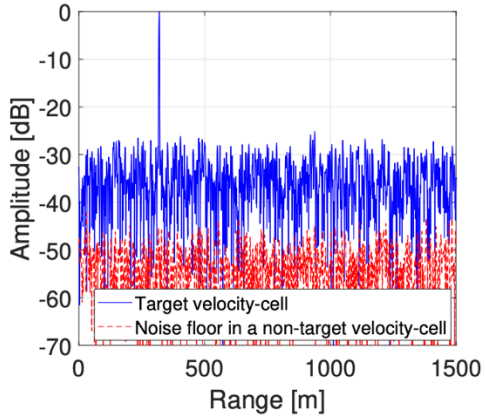



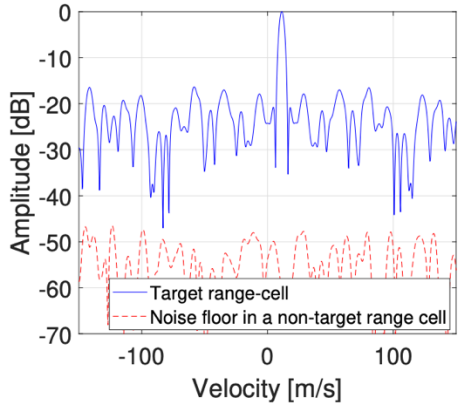




## Aperiodic Allocation



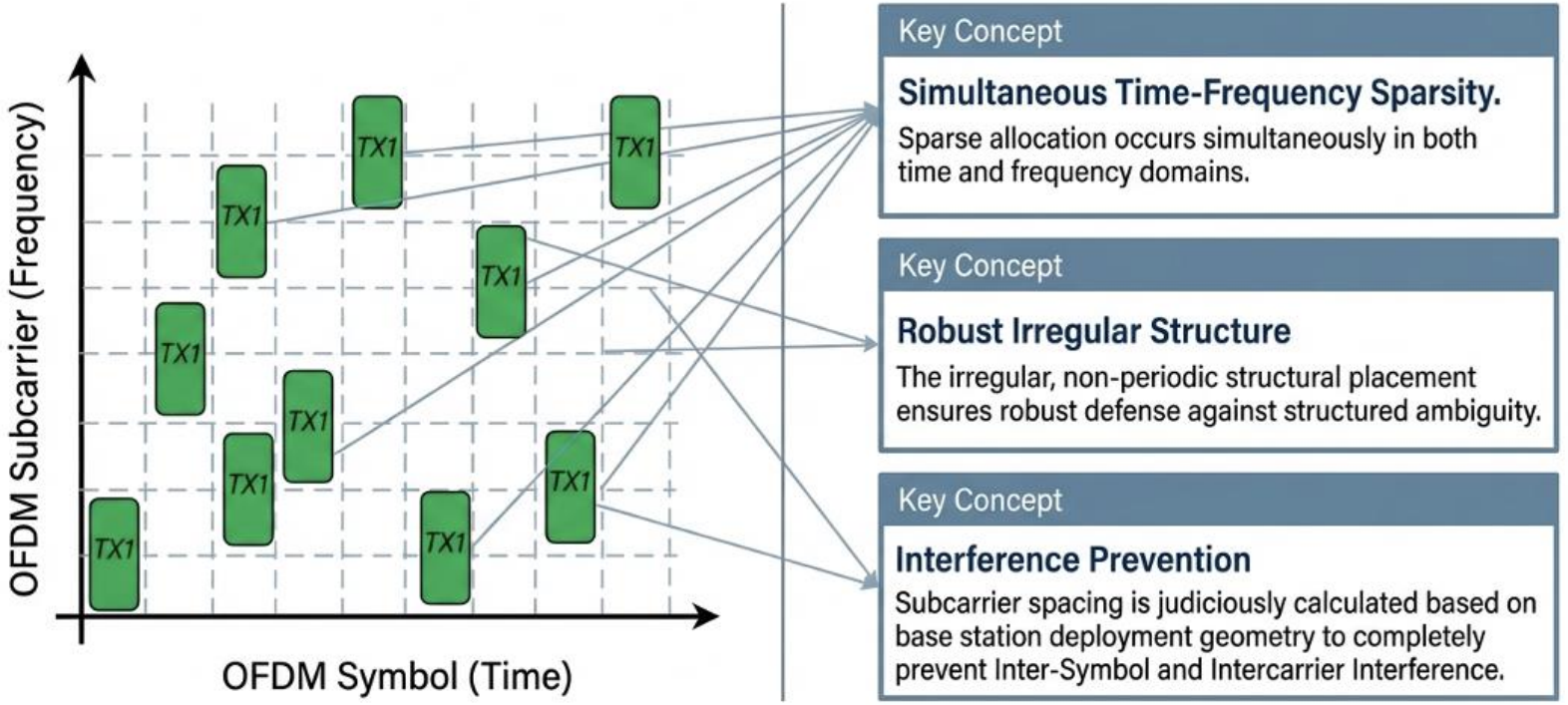



# Evaluating Sensing Approaches

| | Inter-BS Interference (IBI) Mitigation | Structural Ambiguity Mitigation |
|---|---|---|
| Standard Fully Occupied OFDM | Low | High |
| Periodic Sparse OFDM | High | Low |
| **Proposed: Irregular Sparse OFDM** | **High** | **High** |

Takeaway: Only an irregular, randomized sparse structure solves both interference and ambiguity simultaneously.

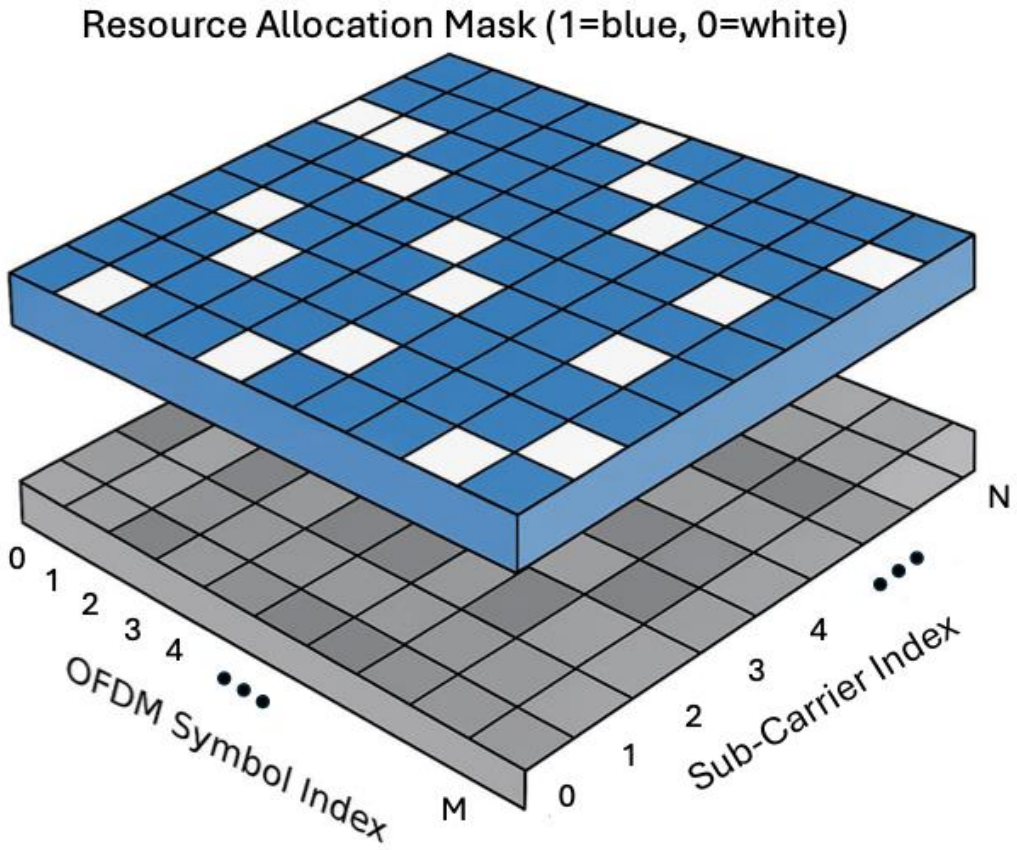
# Proposed Solution: Irregular Sparse OFDM



# Proposed Solution: Irregular Sparse OFDM

- Sparse allocation in time and frequency Irregular (non-periodic) structure
- Orthogonal resource masks
- For each time-frequency resource $(m, n)$, draw a random variable $\mathrm{Z}_{n,m} \sim U(1,2,\cdots,L)$ and assign mask

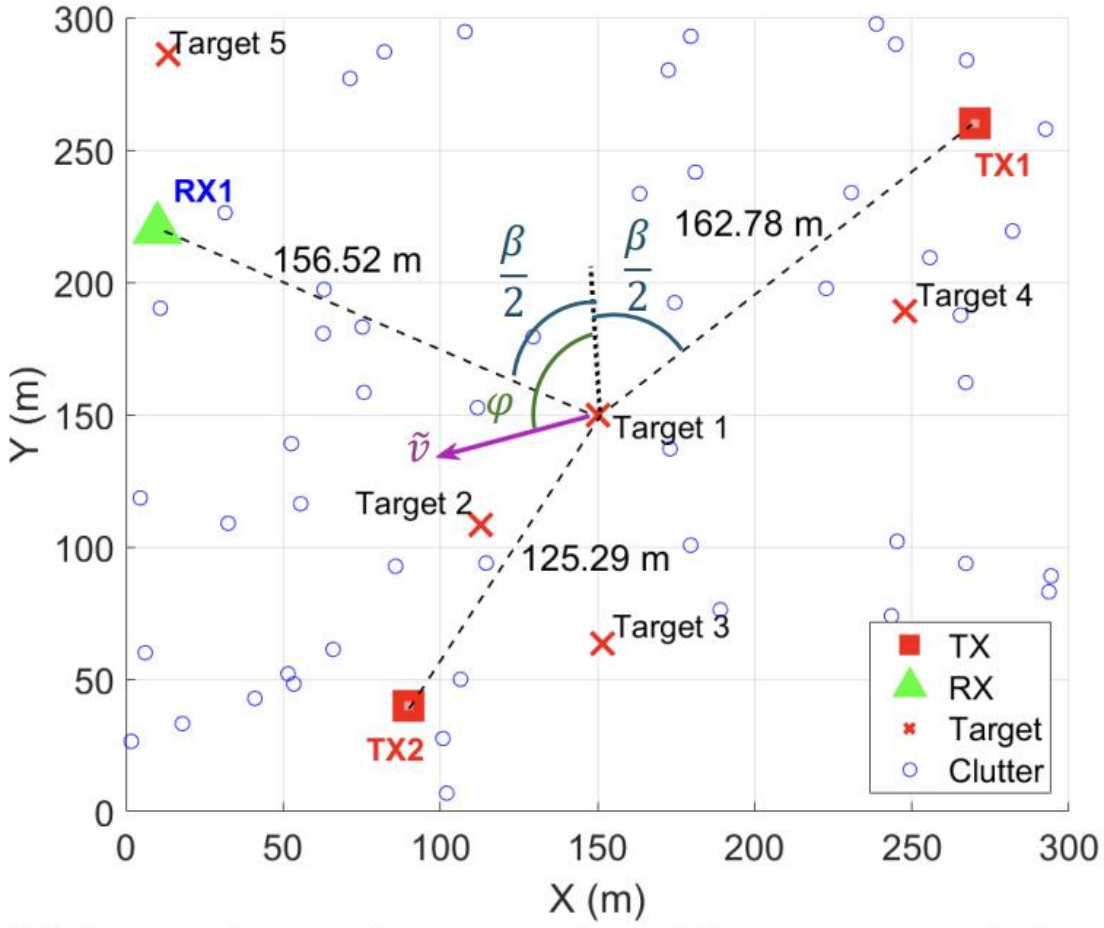
$$A_l(n,m) = \begin{cases} 1, \mathrm{Z}_{n,m} = l \\ 0, otherwise \end{cases}$$



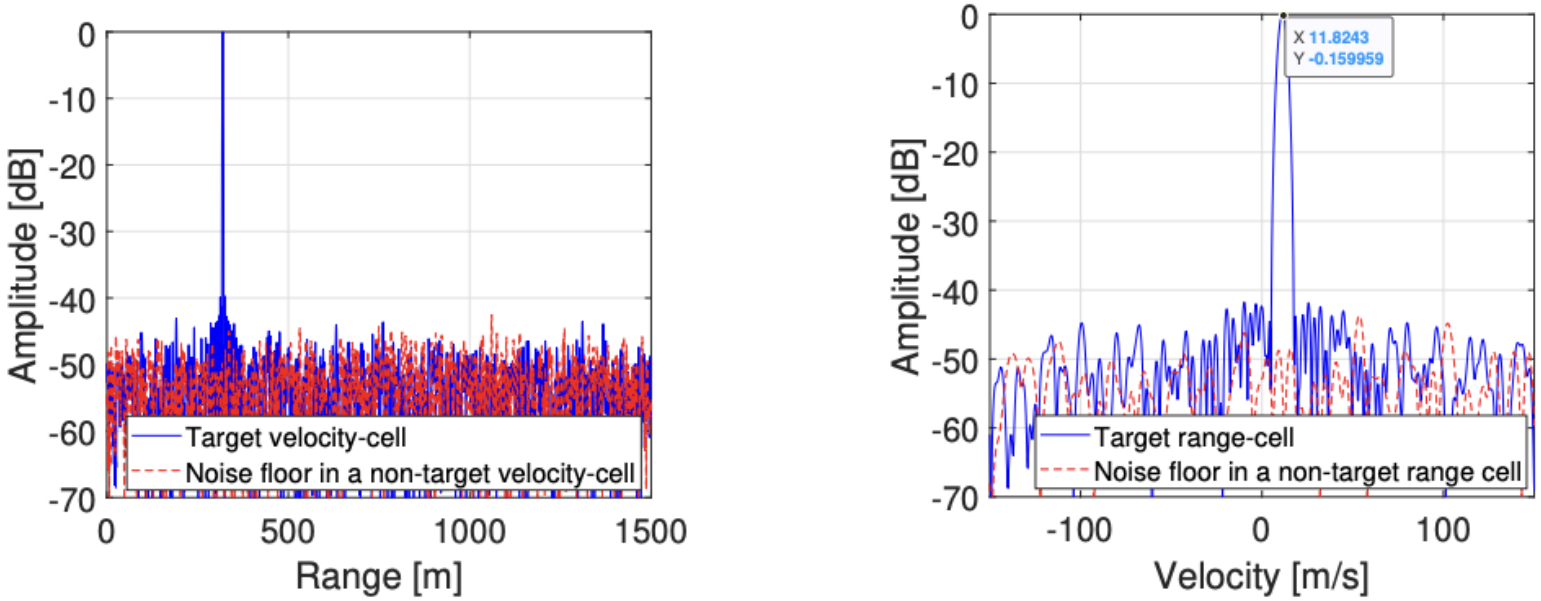
# Simulation Setup

TABLE II: OFDM Parameters

| Parameter | Value |
|---|---|
| Carrier frequency | $f_c = 4.7$ GHz |
| Subcarrier spacing | $\Delta f = 30$ kHz |
| Total bandwidth | BW $= 100$ MHz |
| Number of subcarriers | $N = 3276$ |
| Symbol duration | $T = 33.3\mu s$ |
| CP duration | $T_{\text{cp}} = 2.33\mu s$ |
| OFDM symbol duration | $T_{\text{sym}} = 35.66\mu s$ |
| Number of OFDM Symbols | $M = 280$ |
| Frame Duration | FD $= 10$ ms |

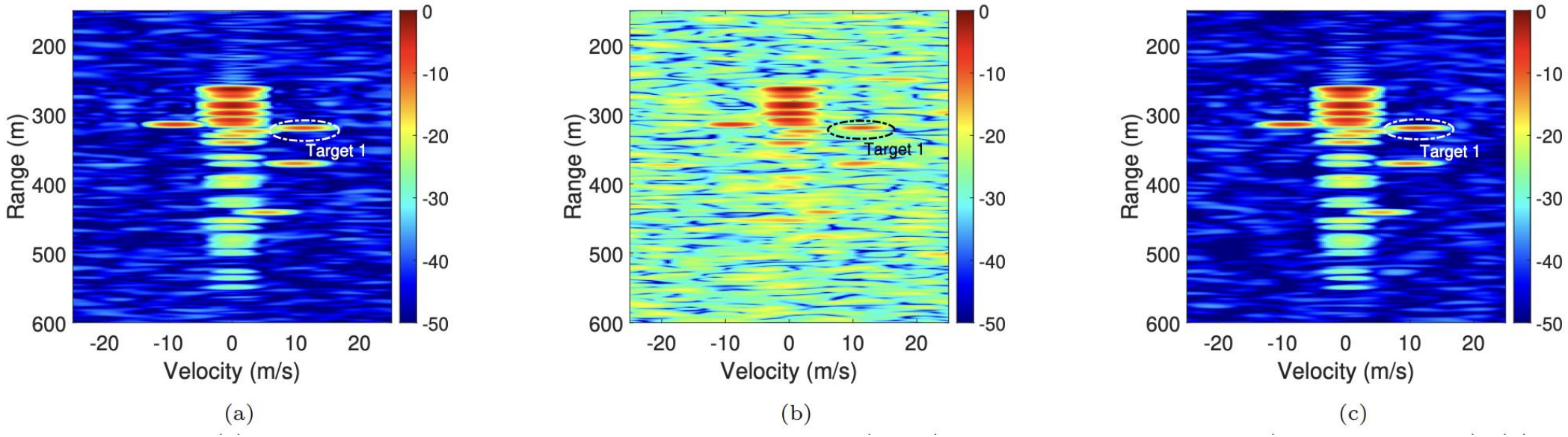


# Simulation Results



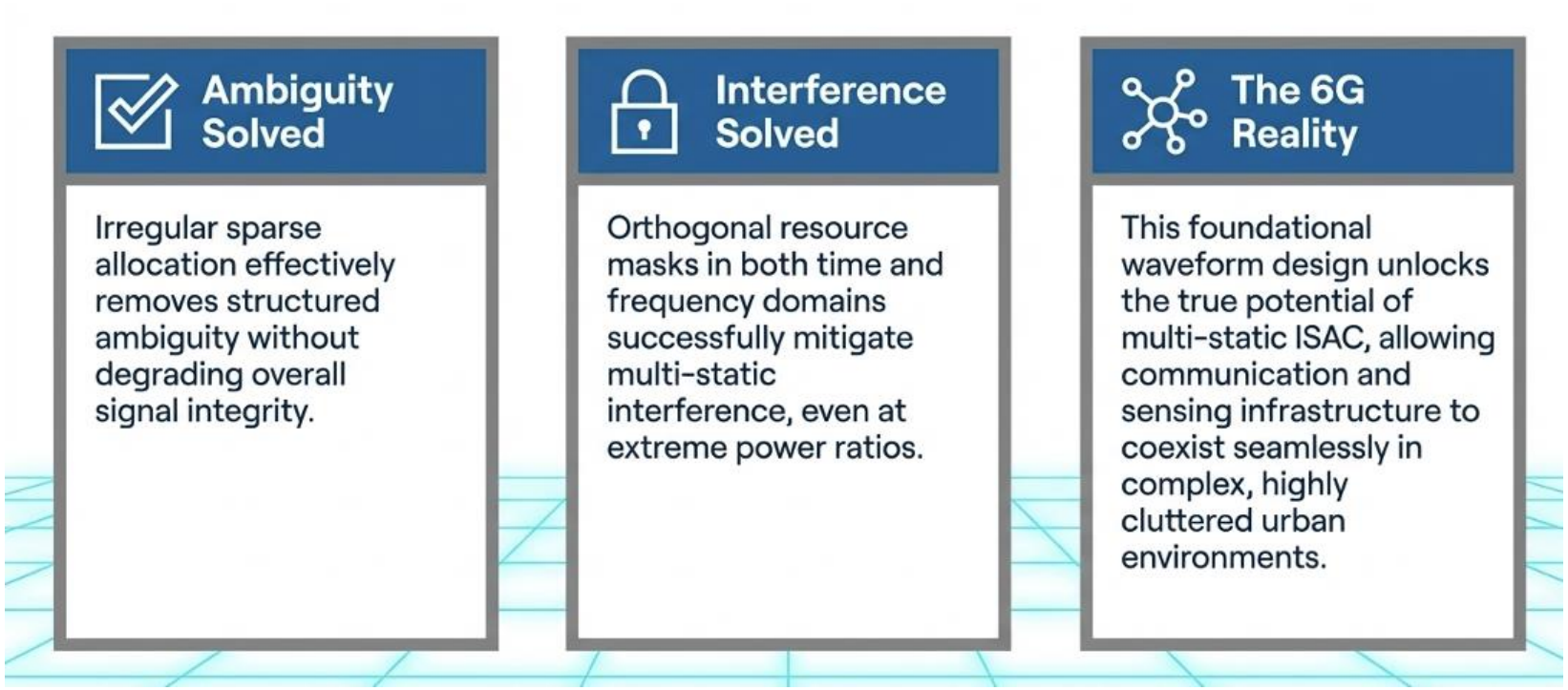

(a) Range profile for target velocity cell and (b) velocity profile for the target range cell with proposed aperiodic sparsity in both time and frequency domains with fully-orthogonal masks for two BSs

# Simulation Results




RVM with (a) fully occupied OFDM resource cells by two TX BSs (ρ = 0) with equal transmit power (0 dB power ratio), (b) fully occupied resource cells by two TX BSs (ρ = 0) with 20 dB transmit power ratio, (c) orthogonal masks in OFDM resource allocation for two TX BSs (ρ = 0.5) with 20 dB transmit power ratio

# Conclusion


Ambiguity Solved
Irregular sparse allocation effectively removes structured ambiguity without degrading overall signal integrity.
Interference Solved
Orthogonal resource masks in both time and frequency domains successfully mitigate multi-static interference, even at extreme power ratios.
The 6G Reality
This foundational waveform design unlocks the true potential of multi-static ISAC, allowing communication and sensing infrastructure to coexist seamlessly in complex, highly cluttered urban environments.