

Three Dimensional (3D) Sensor Exploitation

Walter S. Kuklinski

781-271-5778 • wskuklin@mitre.org

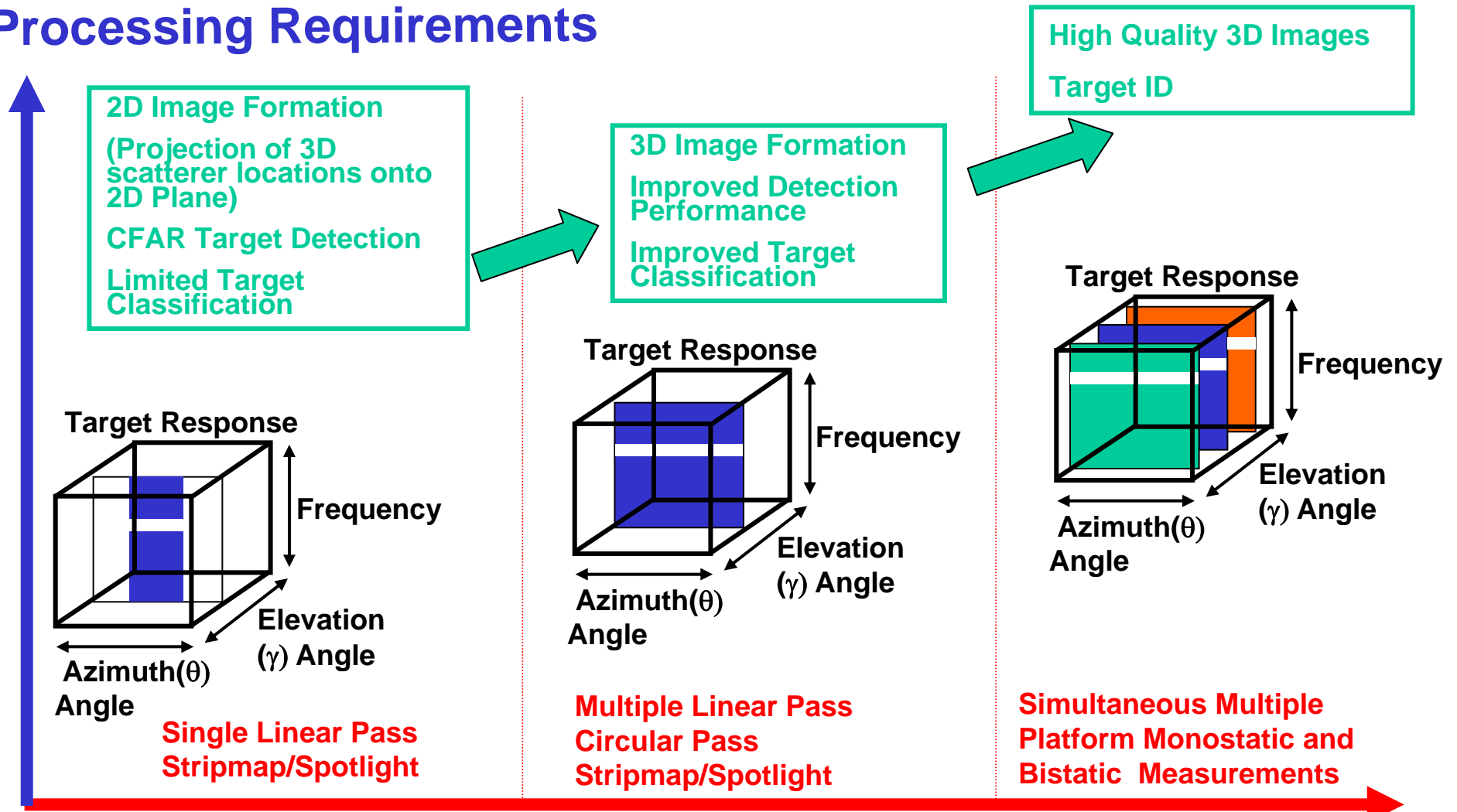


Problem

- **Non-cooperative target identification systems that use 2D images of 3D targets often fail to meet desired levels of performance in target detection and target classification.**
- **Existing single 3D imaging technologies and exploitation methods suffer from a variety of performance limiting characteristics.**
 - **LADAR: Effective range is highly weather dependent**
 - **Volumetric SAR and IFSAR: Require data collection over large viewing angles in both azimuth and elevation**
 - **Current image formation algorithms do not utilize scattering models that accurately represent “true” 3D target scattering responses.**
 - **HSI: Limited spatial resolution**
 - **Human 3D Data Exploitation Procedures: The amount of data contained in 3D images of dense target scenes can readily overwhelm even well-trained observers, requiring the development of 3D ATR algorithms.**

Background

Processing Requirements

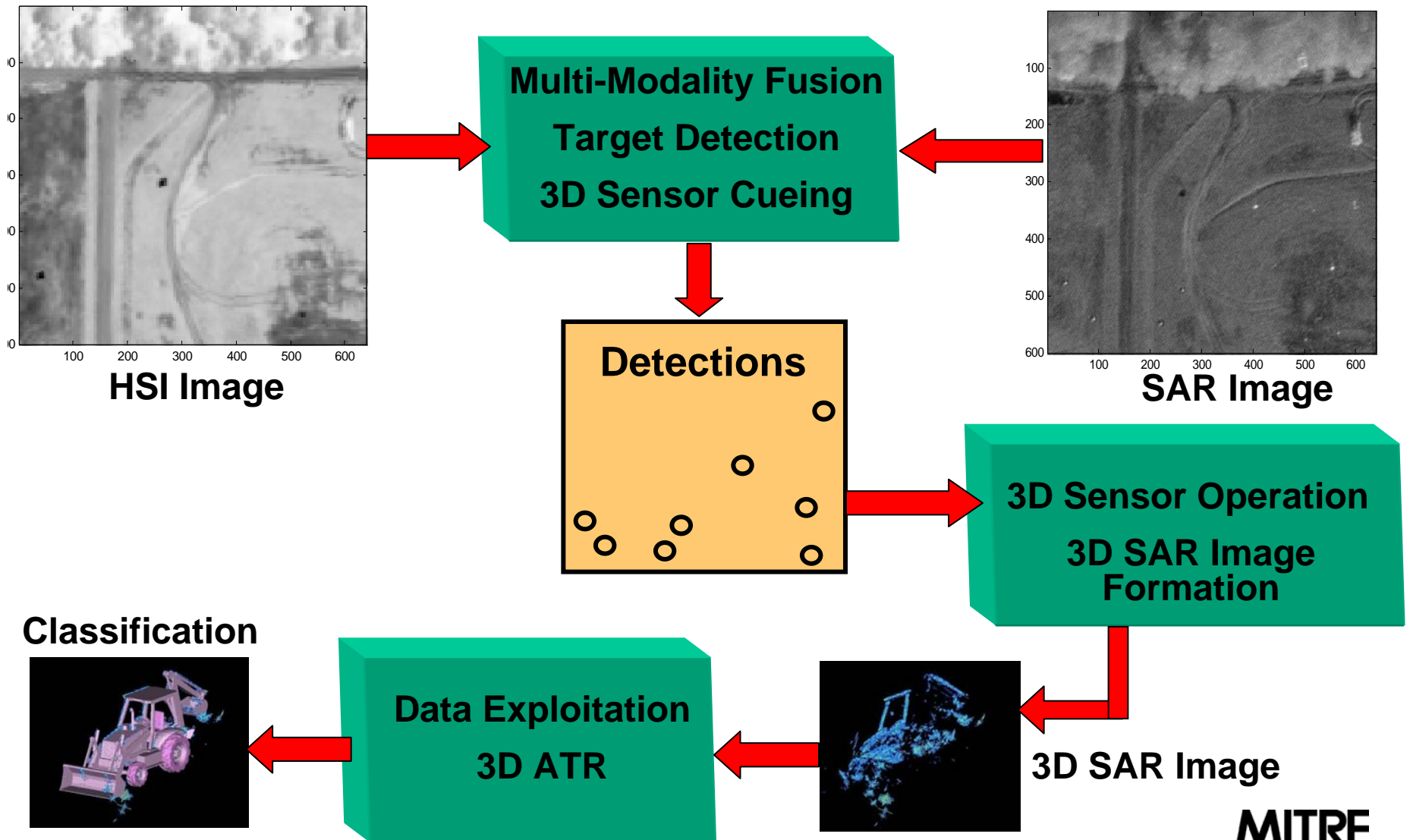


Data Collection Geometry

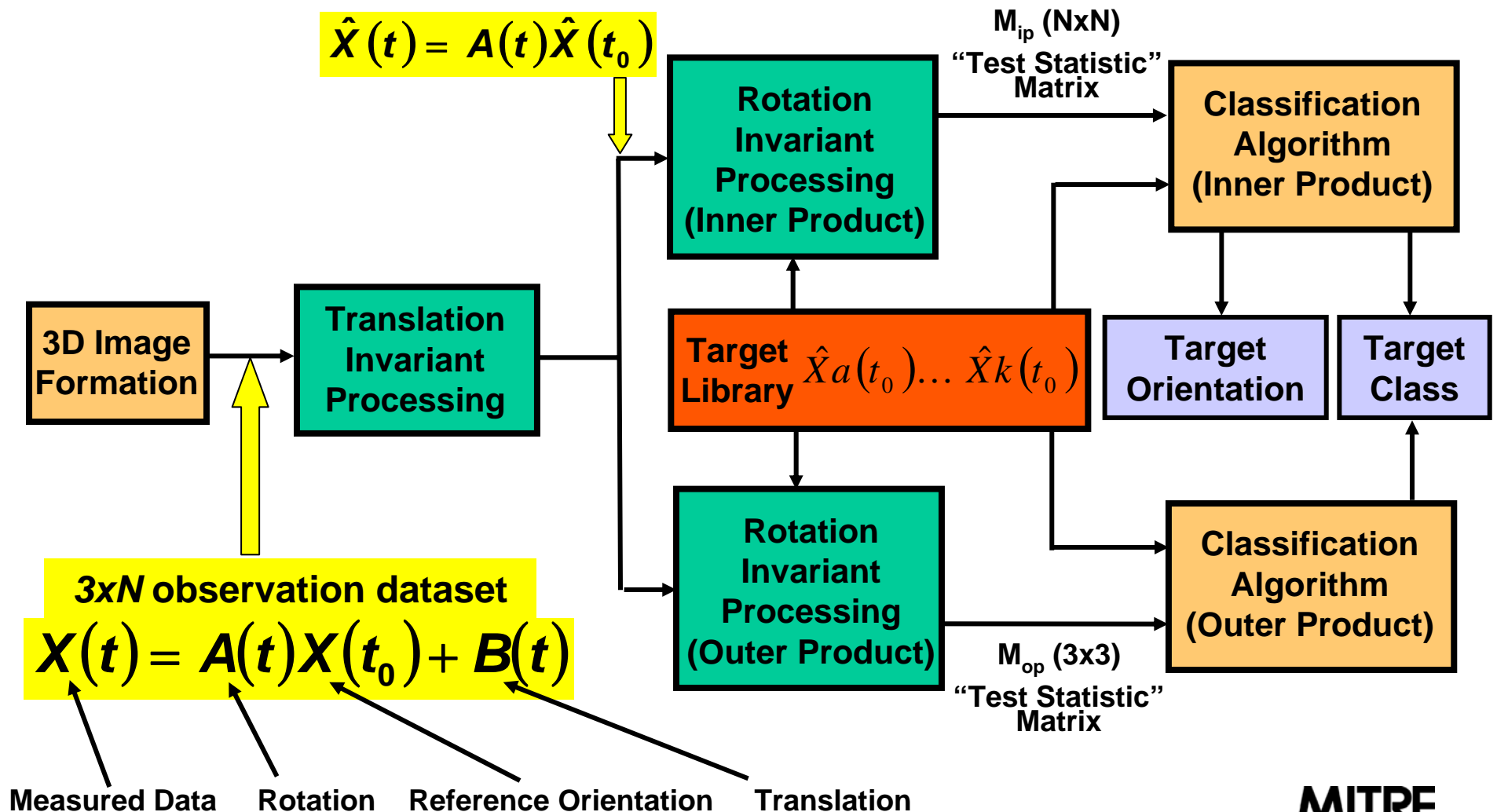
Objective

- **Use a systems-level approach to design, analyze, and implement algorithms for collaborative 3D sensor target identification and target engagement**
 - **Develop optimal target detection algorithms based on fusion of multiple modality sensor data**
 - **Develop 3D SAR image formation algorithms that utilize prior information to produce useful 3D target images over broad ranges of obscuration, configuration variation, and environment complexity**
 - **Develop pose-invariant 3D automatic target recognition (ATR) algorithms**

Activities











Highlight: 3D Geometric Invariant ATR



Highlight: Simulation Study Classification Performance

$\sigma^2=.25, \delta=.7$ Classification

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | | |
|---|-----|---|-----|-----|---|-----|-----|-----|-----|---|
| 1 | .90 | - | - | - | - | - | - | - | .10 |  |
| 2 | - | 1 | - | - | - | - | - | - | - |  |
| 3 | - | - | .97 | - | - | - | - | - | .03 |  |
| 4 | - | - | - | .91 | - | - | - | - | .09 |  |
| 5 | - | - | - | - | 1 | - | - | - | - |  |
| 6 | - | - | - | - | - | .98 | - | - | .02 |  |
| 7 | - | - | - | - | - | - | .98 | - | .02 |  |
| 8 | - | - | - | - | - | - | - | .96 | .04 |  |

- Discriminant: $\|\hat{X}M_k^+ \hat{X}^T - I\| < \delta$
- 100 trials
- **NO INCORRECT CLASSIFICATIONS!**
 - Will not incorrectly classify targets unless data + noise happens to coincide with another target
 - Will classify as 'unknown' if noise corrupts measurement beyond tolerance

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Impacts

- **Multi-modal 3D sensor exploitation will provide robust all-weather ID capability that is resistant to camouflage, concealment and deception, and jamming.**
- **This MSR will establish MITRE as a center of excellence in 3D collaborative sensor processing.**
- **This MSR will advance the state of the art in 3D sensor processing and exploitation.**
 - **Provide 3D exploitation algorithms that will deliver improved ID information, enabling increased combat ID and situation awareness for the warfighter**
- **The project will establish methods to produce 3D ISR data products in an efficient manner and determine requirements for processing and exploitation of 3D products by the Air Force MC2C, the Army FCS, the Navy ESG, NGA, and other national systems.**

Future Plans

- We evaluated the performance of existing commercial geo-registration tools to register HSI, SAR, FOPEN SAR, and EO/IR data using IFSAR- and LIDAR-derived Digital Terrain Models.
- We have begun developing a more capable registration method based on a novel multiple hypothesis testing procedure.
 - Multiple modalities, HSI, SAR, and EO/IR can all be readily accommodated.

- We developed a new class of nonlinear, limited view 3D SAR image formation techniques.
- The utility of our DLS technique and GDLS techniques versus existing methods should be assessed in terms of target classification performance (3D ATR techniques).

- We have developed a full 3D Geometric Data Exploitation methodology.
 - The literature only reports 1D or 2D algorithms.
- Our GI ATR formalism includes articulation and provides a path to an operational ATR methodology.