भारत इलेक्ट्रॉनिक्स
BHARAT ELECTRONICS
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DEVELOPMENT OF MULTI-TARGET TRACKER FOR SURVEILLANCE RADAR USING MATLAB

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Outline

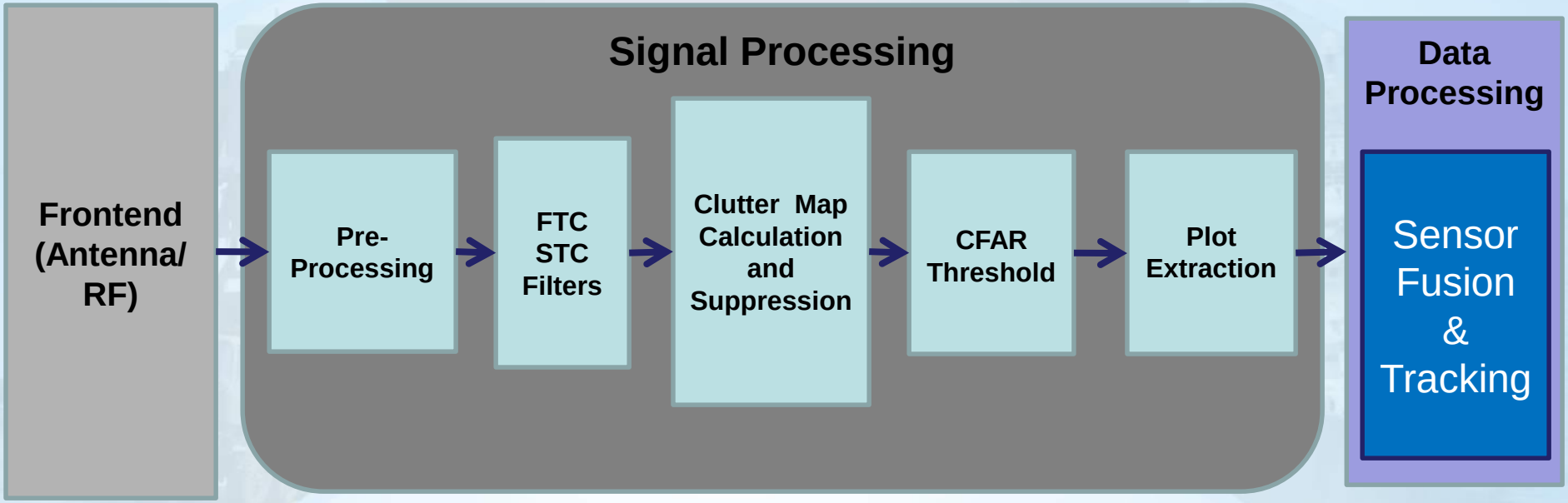
- Introduction about BEL
- Requirements
- Approach
  - Tools used :MATLAB Sensor Fusion Tracking Toolbox (SFTT) , CODER
  - Method employed : Development Phase I - IV
- Results
  - Comparison with different approaches
  - Comparison with Original Equipment Manufacture (OEM)system
- Key takeaways
- Looking forward for…

ABOUT BEL

- BEL is PSUs under the Ministry of Defence, India.
- BEL design, develop and manufactures a wide range of products in the following fields
  - Radars
  - Electronic Warfare System
  - Defence Communication
  - Tank Electronics
  - Opto Electronics and Semiconductors
  - Missile System and Tank Electronics
  - EVM and VVPAT and many more…
- Major customers of BEL comprise of Indian Army, Navy, Air Force, Paramilitary, Coast Guard and many more.



RADAR PROJECT SCHEMATIC



STC : Sensitivity Time Control
FTC : Fast Time Control
CFAR :Constant False Alarm Rate

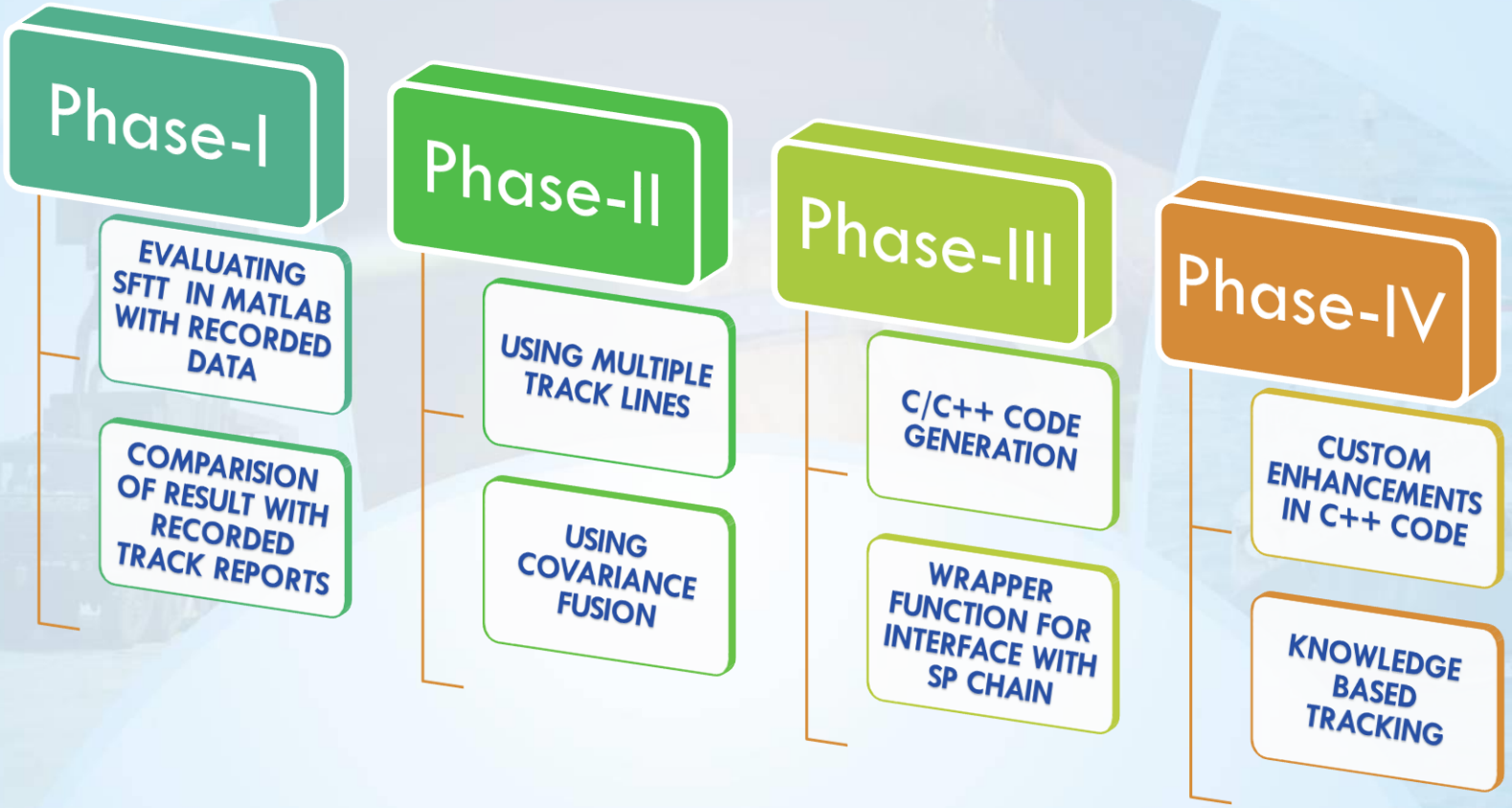
REQUIREMENTS

- Development of **field deployable multi-target tracking module** using **Sensor Fusion Tracking Toolbox** and **MATLAB coder**.
- Evaluation of performance in **Coastal Surveillance** scenario.

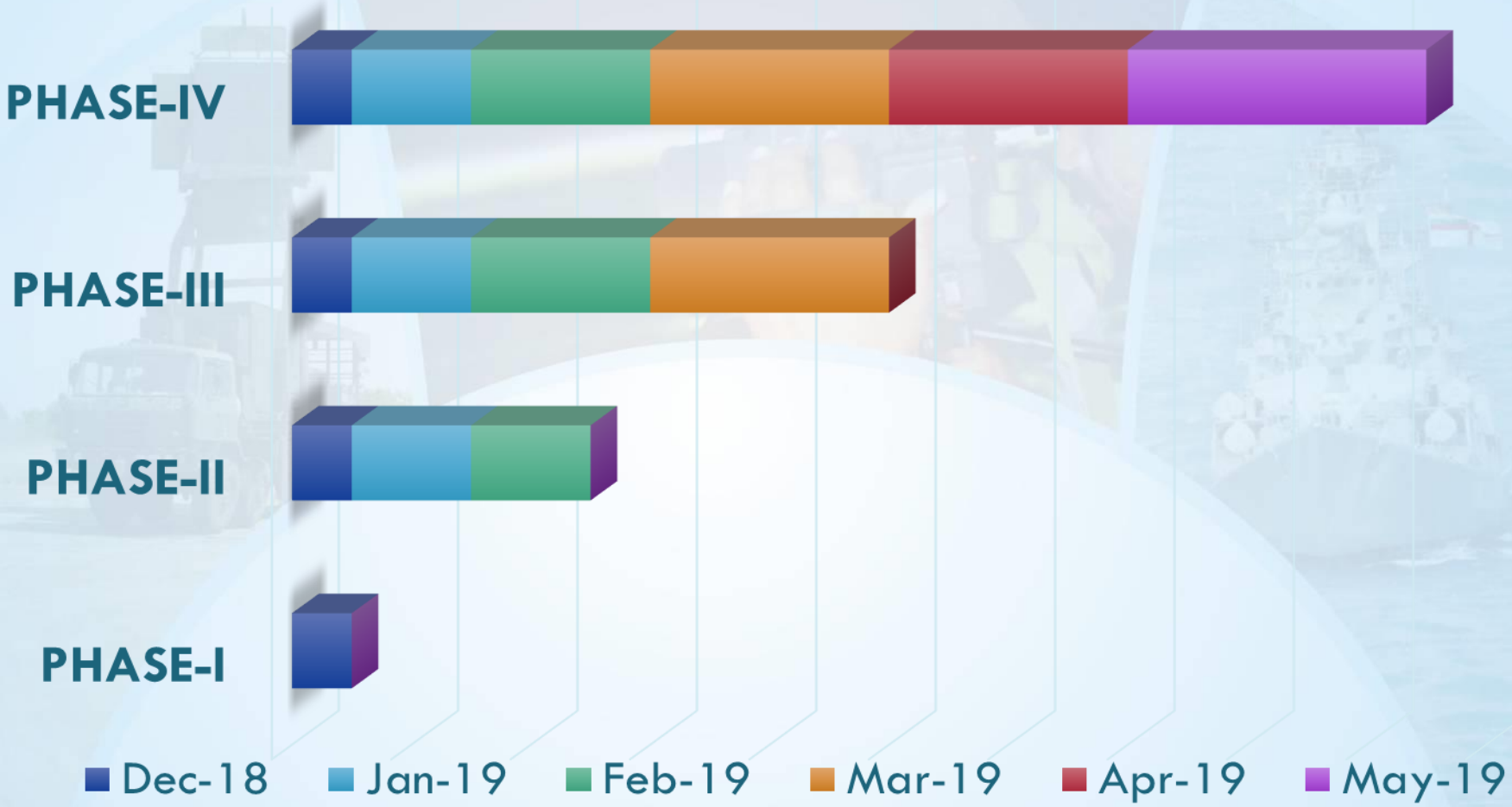
CHALLENGES

- **Small target tracking** amidst sea clutter
- **Reduced false track initiation** in high clutter conditions
- **Faster track initiation** & better **maintenance**
- Attribute extraction for **target classification**
- **Deployable** code generation **without dependencies** on external libraries

APPROACH


Phase-I
EVALUATING SFTT IN MATLAB WITH RECORDED DATA
COMPARISION OF RESULT WITH RECORDED TRACK REPORTS
Phase-II
USING MULTIPLE TRACK LINES
USING COVARIANCE FUSION
Phase-III
C/C++ CODE GENERATION
WRAPPER FUNCTION FOR INTERFACE WITH SP CHAIN
Phase-IV
CUSTOM ENHANCEMENTS IN C++ CODE
KNOWLEDGE BASED TRACKING

DEVELOPMENT OF MULTI_TARGET_TRACKER FOR CSS - TIMELINE



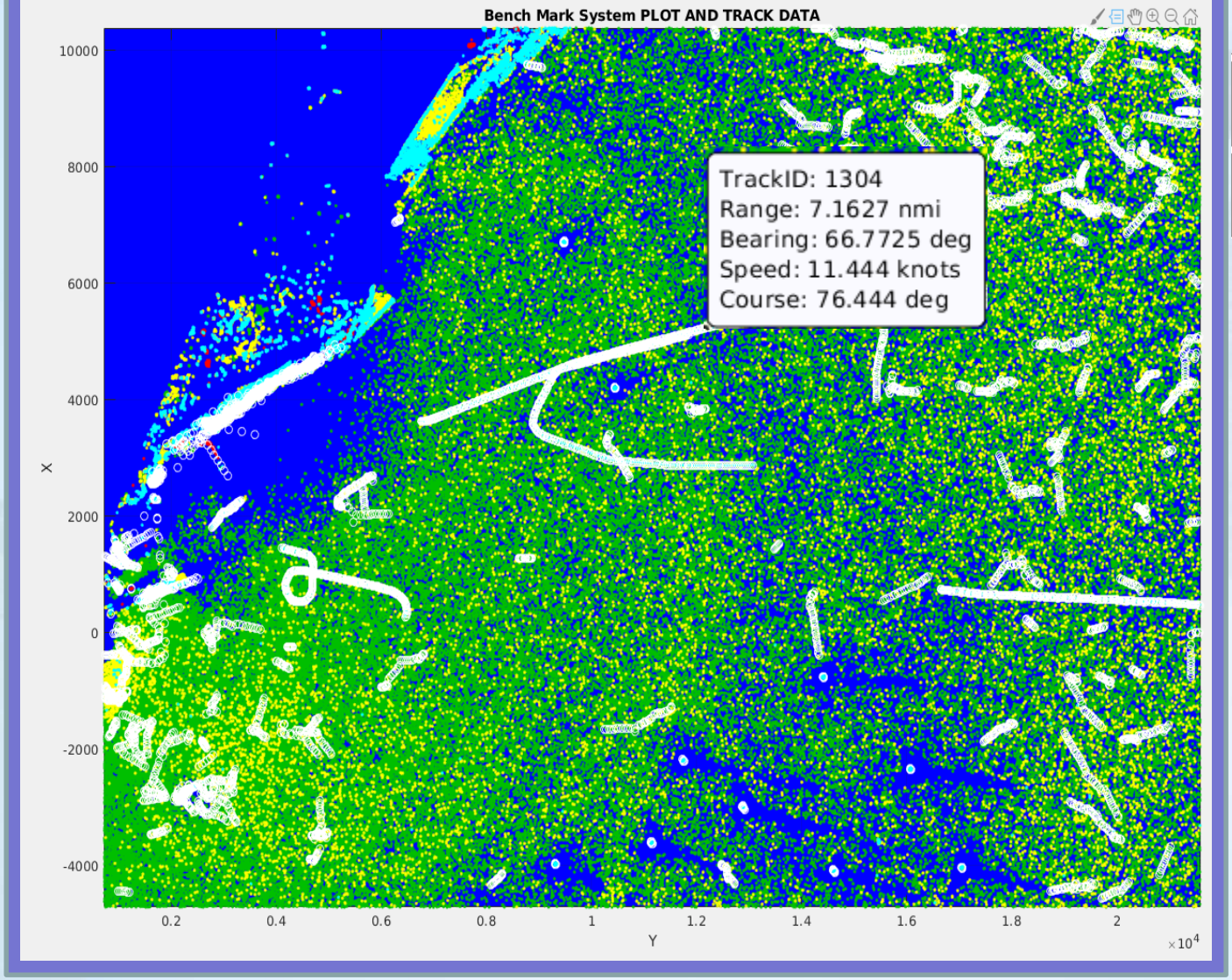
DEVELOPMENT PHASE - I

- Evaluating performance of **trackerGNN** and **trackerTOMHT** modules in **Matlab-SFTT with field recorded data(detections).**
  - Tuning tracker initiation , filter and maintenance parameters
  - Evaluating performance w.r.t track kinematics accuracy and maintenance , by changing assignment methods, cost matrix computation, etc.

```
tracker =
trackerGNN('FilterInitializationFcn',...
@initcaekf,...
'MaxNumTracks',1000,...
'Assignment','Jonker-Volgenant',...
'AssignmentThreshold',50,...
'TrackLogic','History',...
'DeletionThreshold',[6 8], ...
'ConfirmationThreshold',[8 10] ,...
'HasCostMatrixInput',true);
```

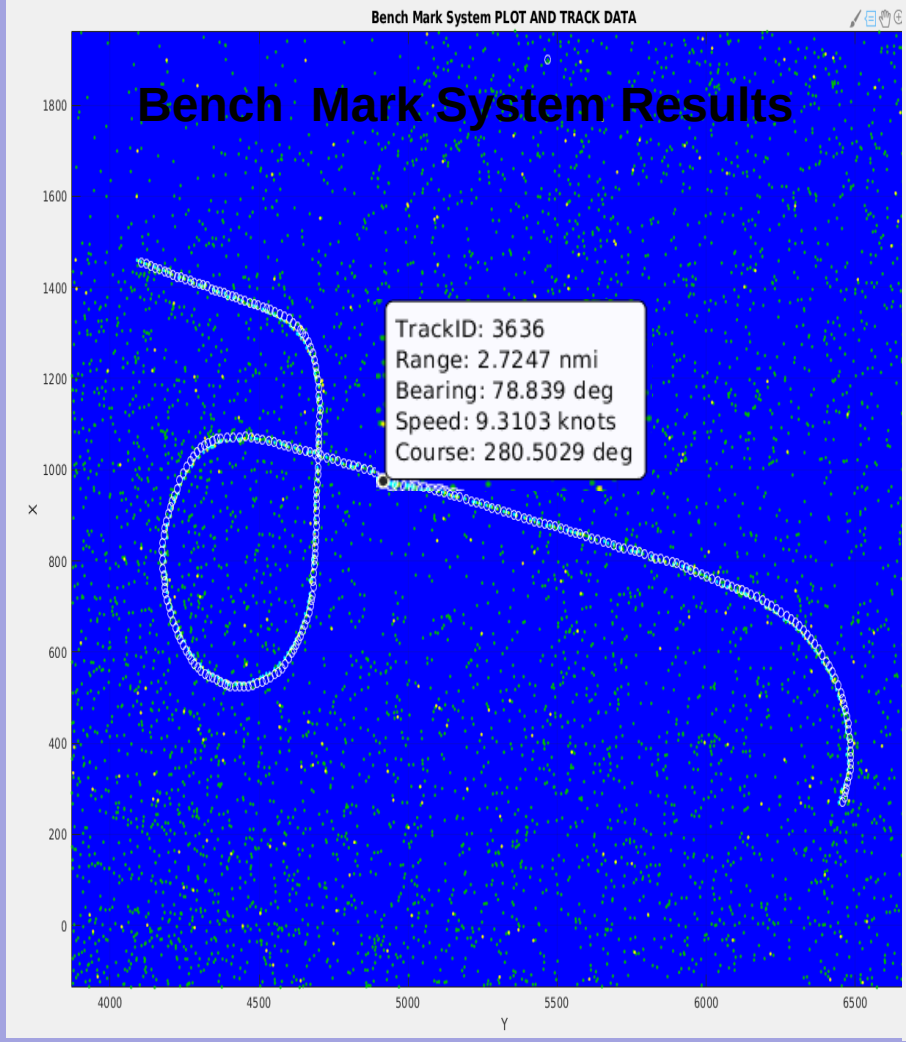
```
tracker =
trackerTOMHT('FilterInitializationFcn',...
@custcaekf, ...
'ConfirmationThreshold', 25,...
'MaxNumSensors', 1, ...
'DeletionThreshold', -5, ...
'AssignmentThreshold',[0.5,0.7,1]*50,...
'MaxNumHypotheses', 2,...
'MaxNumTracks',1000,...
'MaxNumHypotheses',10,...
'NScanPruning','Hypothesis',...
'HasCostMatrixInput',true,...
'FalseAlarmRate',1e-5);
```

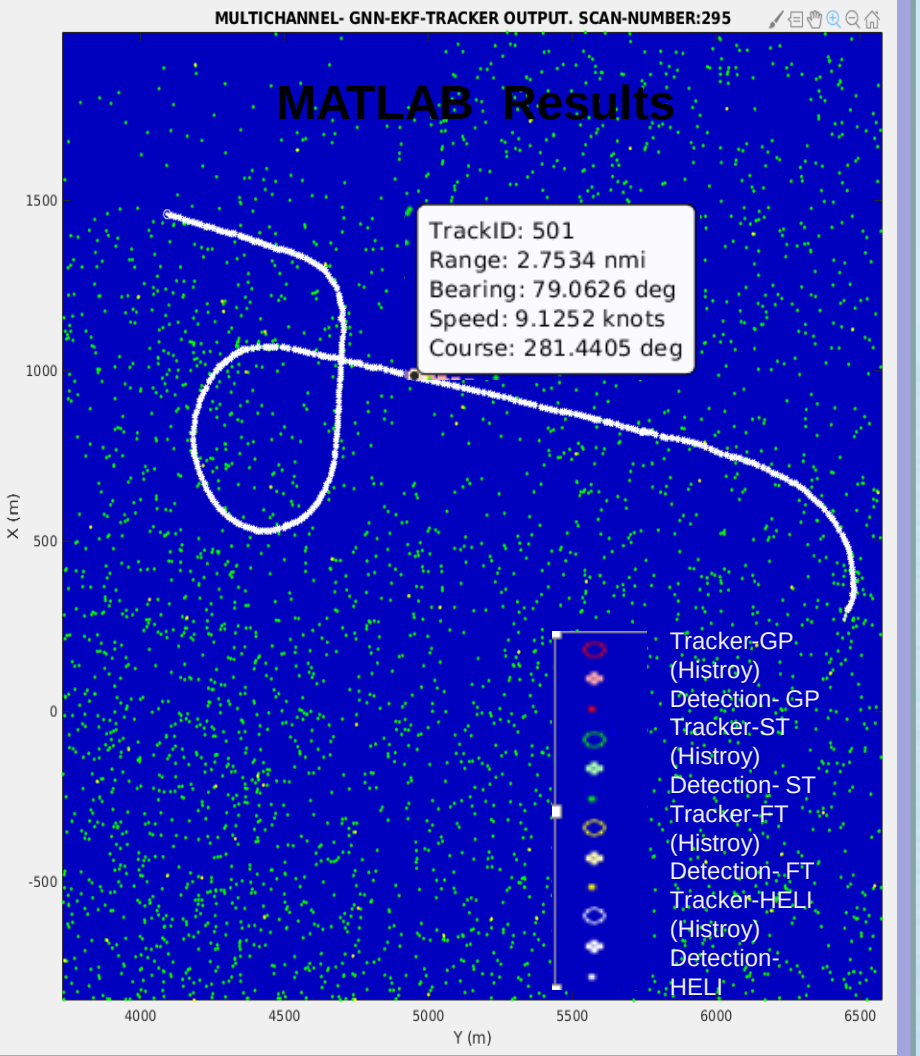
RECORDED DATA-295 SCANS



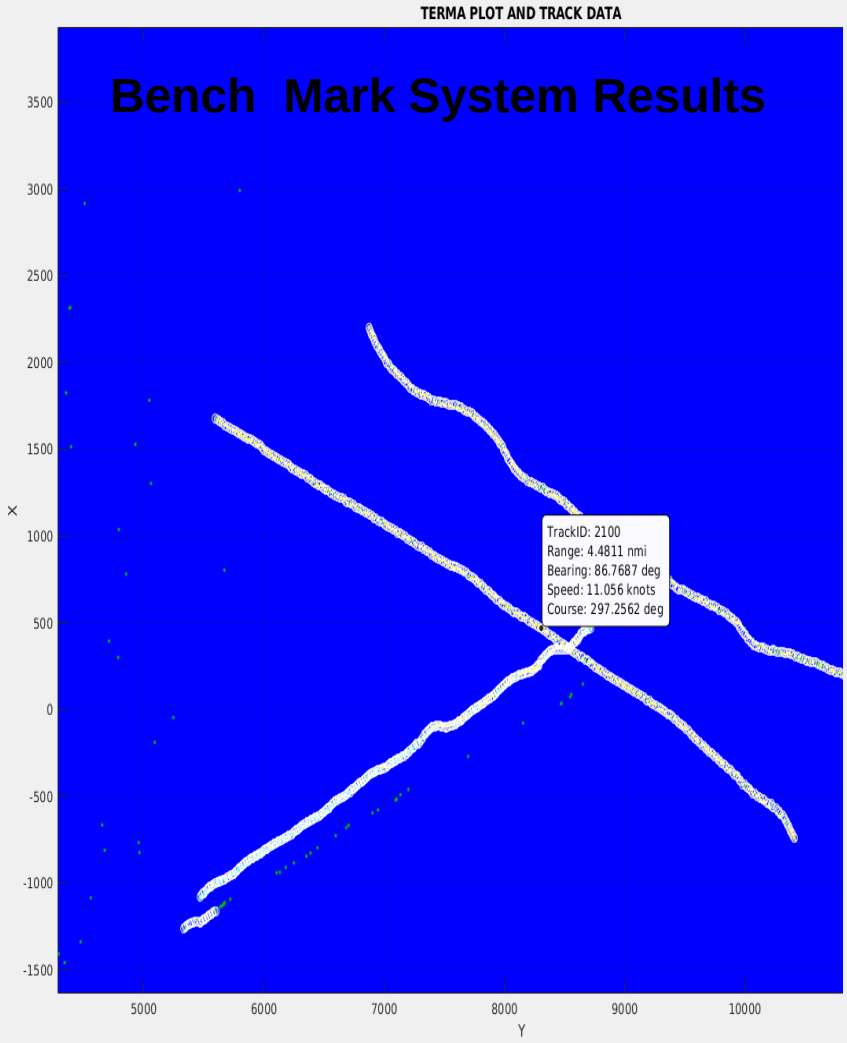
RADAR – POSITION
NAVIGATIONAL-TL PLOTS
SLOW-TL-PLOTS
FAST-TL-PLOTS
HELICOPTER-TL-PLOTS
TERMA- TRACKS

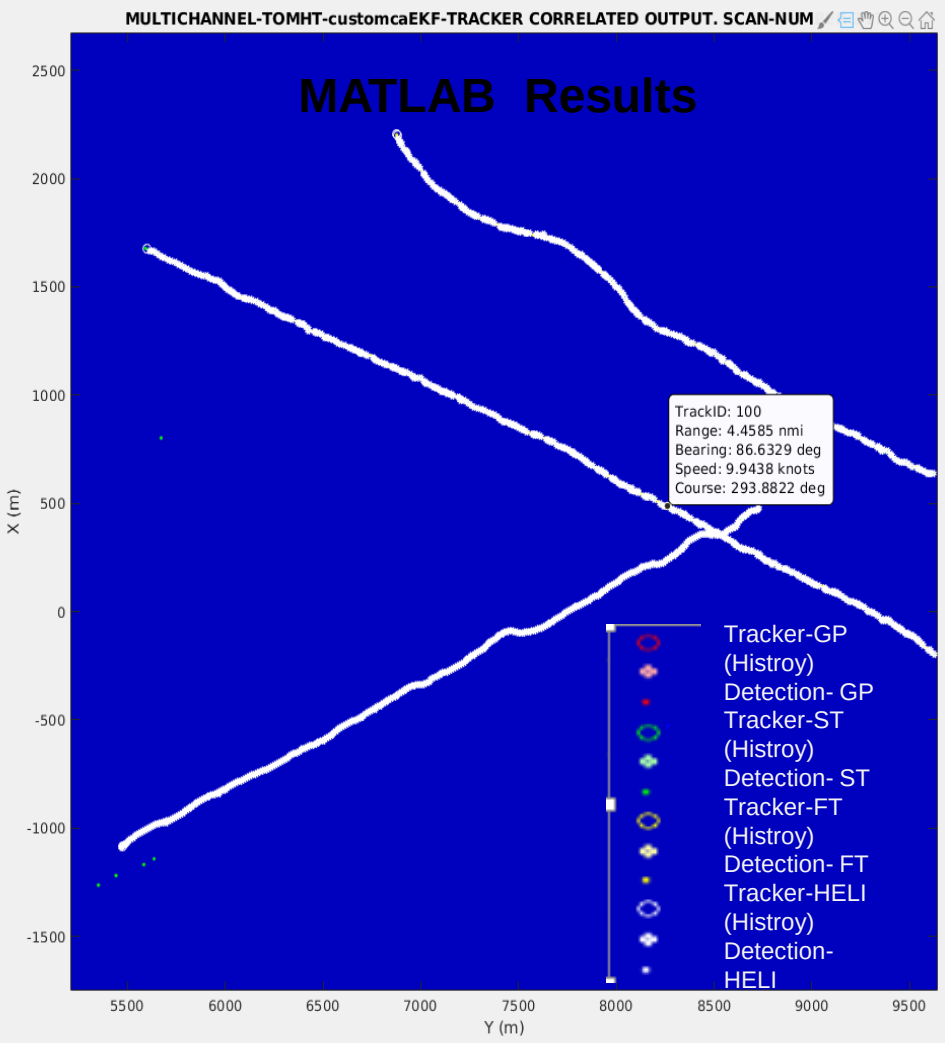
RESULTS USING MATLAB SFTT-GNN MULTIOBJECT TRACKER





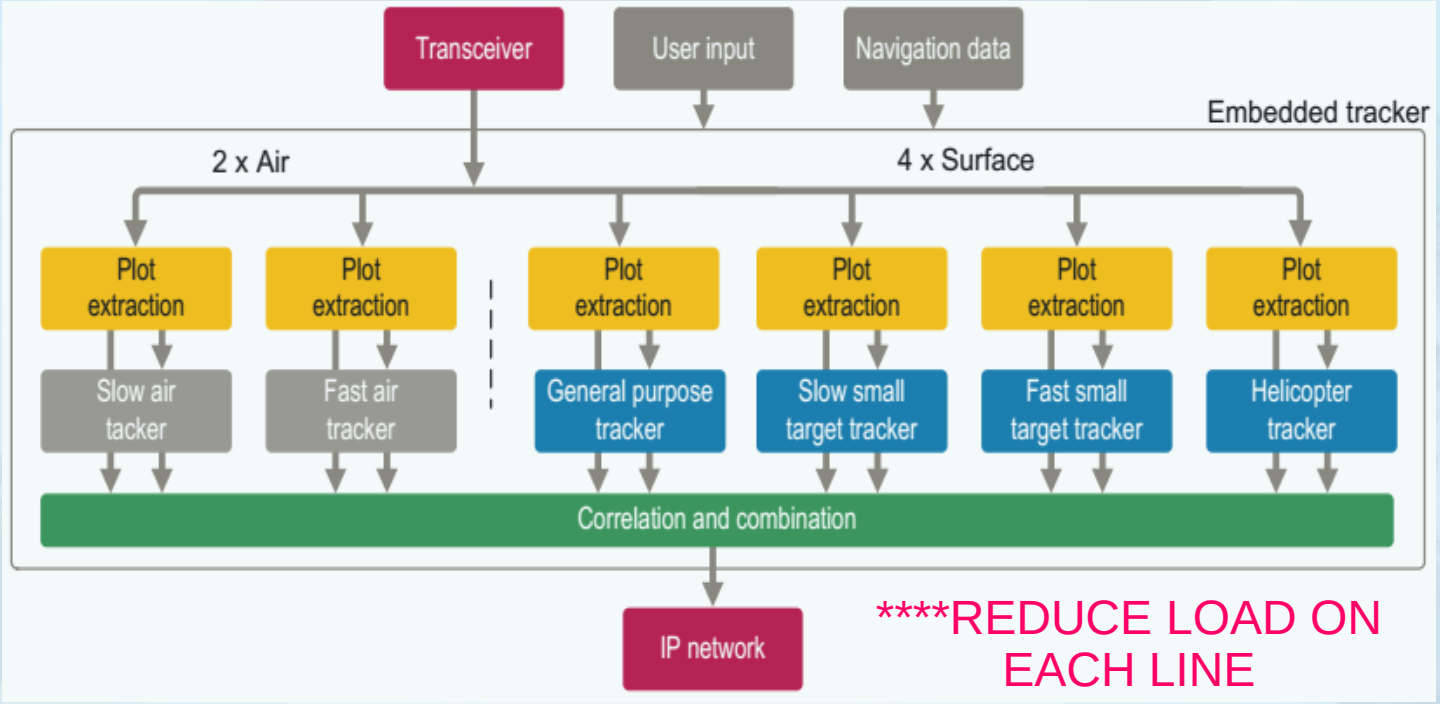
RESULTS USING MATLAB SFTT-TOMHT MULTIOBJECT TRACKER





DEVELOPMENT PHASE - II

- Use of **Multiple-Track Lines** for load reduction

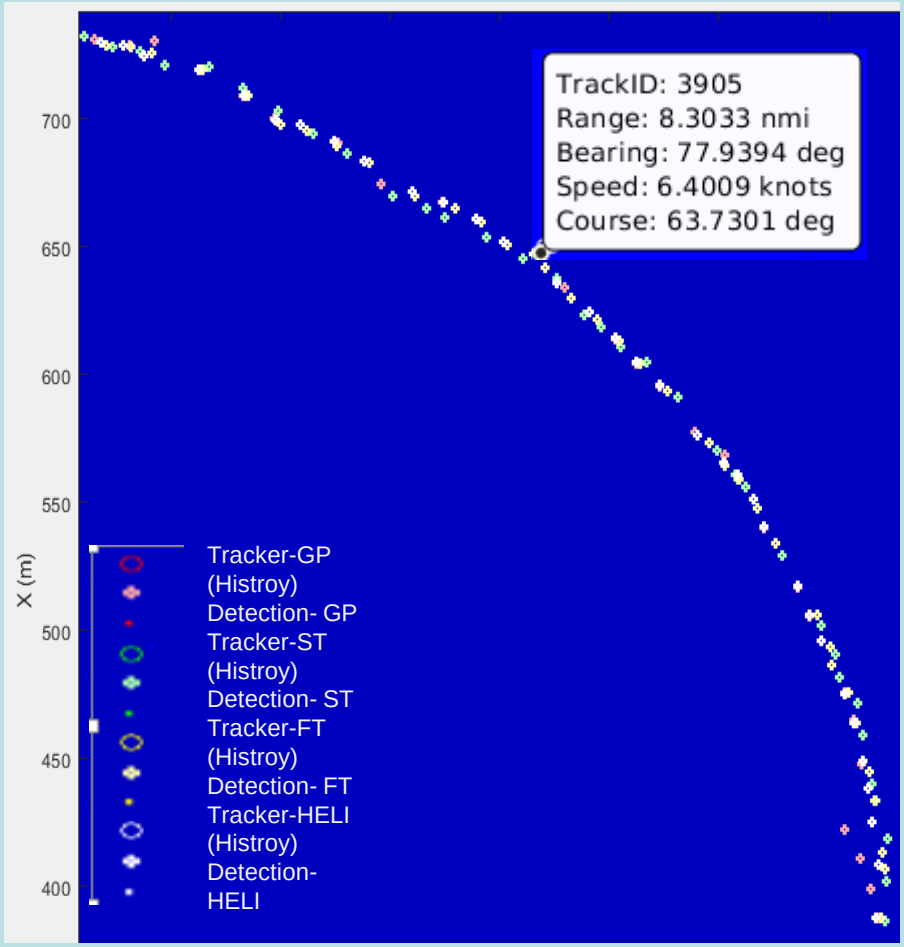


- Use of **covariance fusion** for correlating tracks from all track lines

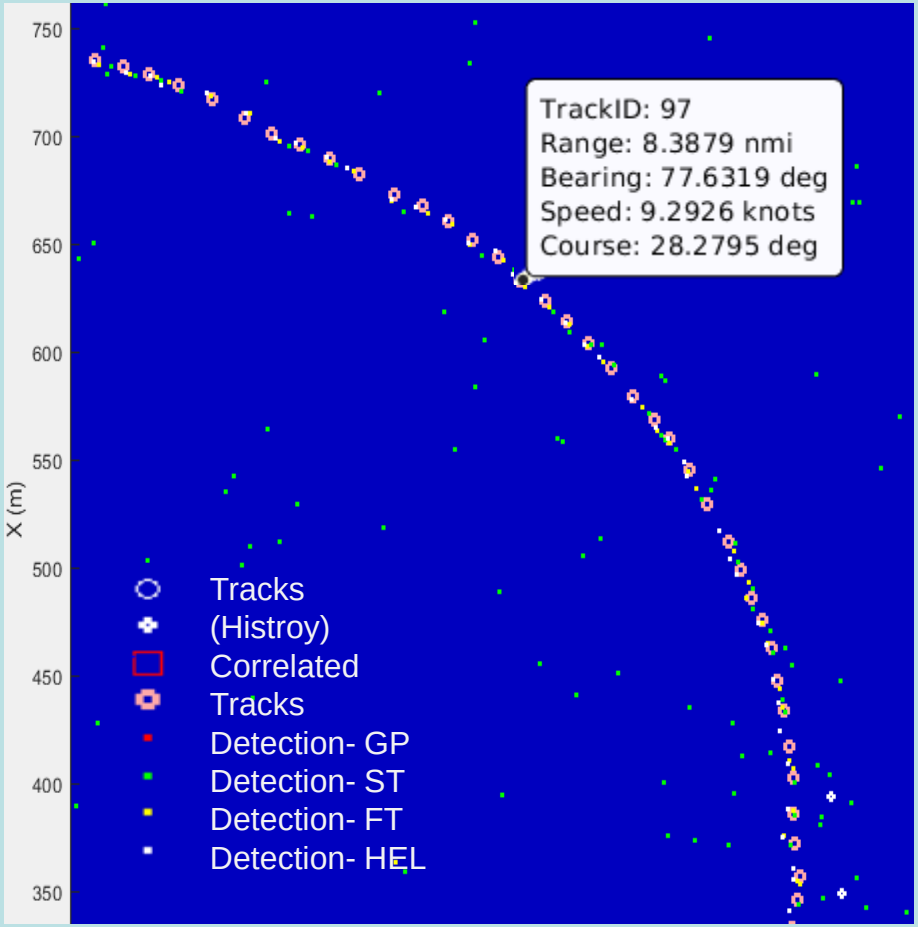
```
X(:,t) = confTracks{h}(fusionIDS{cTrk}(t)).State;
P(:,:,t) = confTracks{h}(fusionIDS{cTrk}(t)).StateCovariance;
[Xcorr,Pcorr] = fusexcov(X,P);  %Cross-covariance fusion
```

RESULTS (CONTD.)

WITHOUT COVARIANCE FUSION

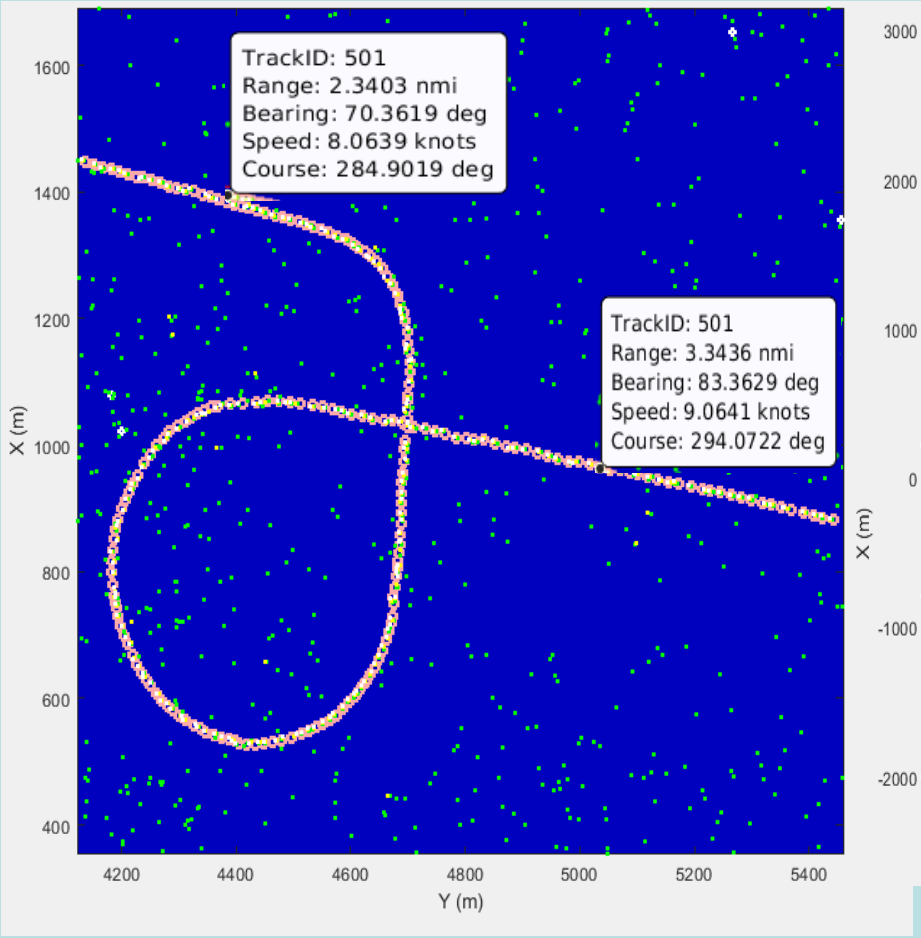


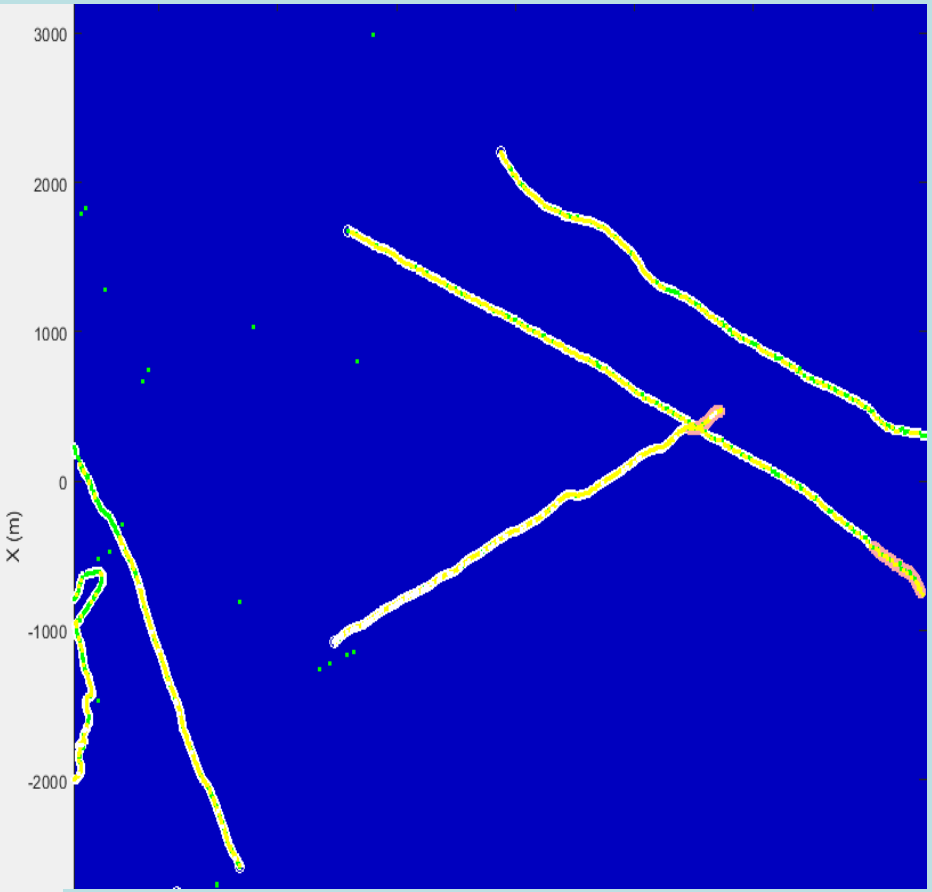
WITH COVARIANCE FUSION



TRACK MAINTENANCE FOR TWO DATASETS

Track is maintained even after long run (Track ID is maintained)





DEVELOPMENT PHASE - III

- **Deployable C++ code** generation using **MATLAB Coder**

```
load detectiondata.mat
compInputs  = {detections simTime};
tracker_kernel(compInputs{1},simTime);
codegen tracker_kernel -args compInputs;
```

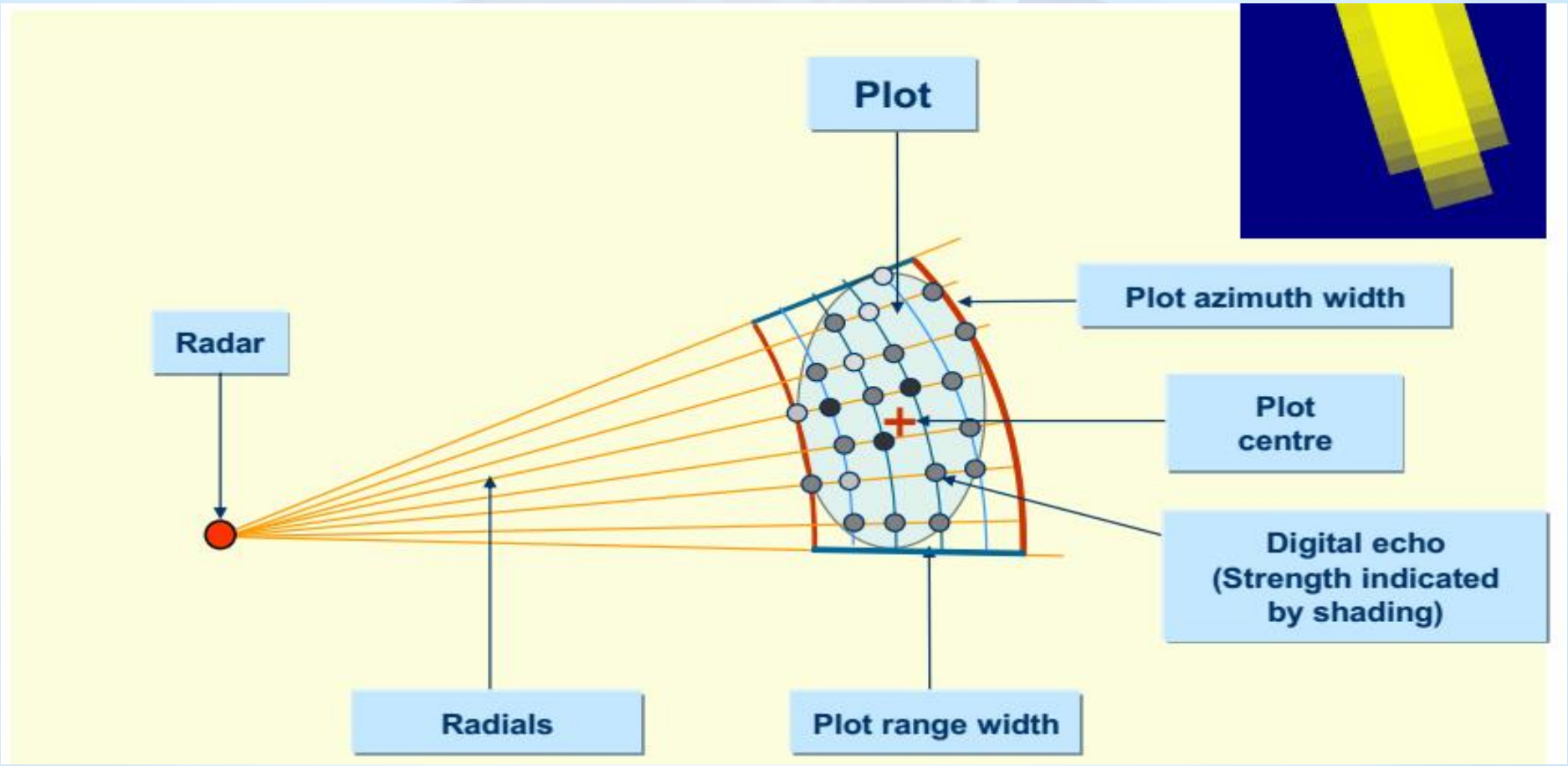
```
function [confirmedTracks, numTracks,~] =
tracker_kernel.m(detections,time)
    persistent tracker
    if isempty(tracker)
         tracker = trackerTOMHT('FilterInitializationFcn',
    @initcaEKF,...
          'MaxNumHypotheses', 5,...
          'MaxNumTracks',1000,...
          'MaxNumSensors',1,...
          'NScanPruning','Hypothesis');
    end
    [confirmedTracks,~,~,information] = tracker(detections,time);
    numTracks = tracker.NumTracks;
end
```

- **Wrapper function** is developed for **interfacing** the C++ Code with the signal processer chain .

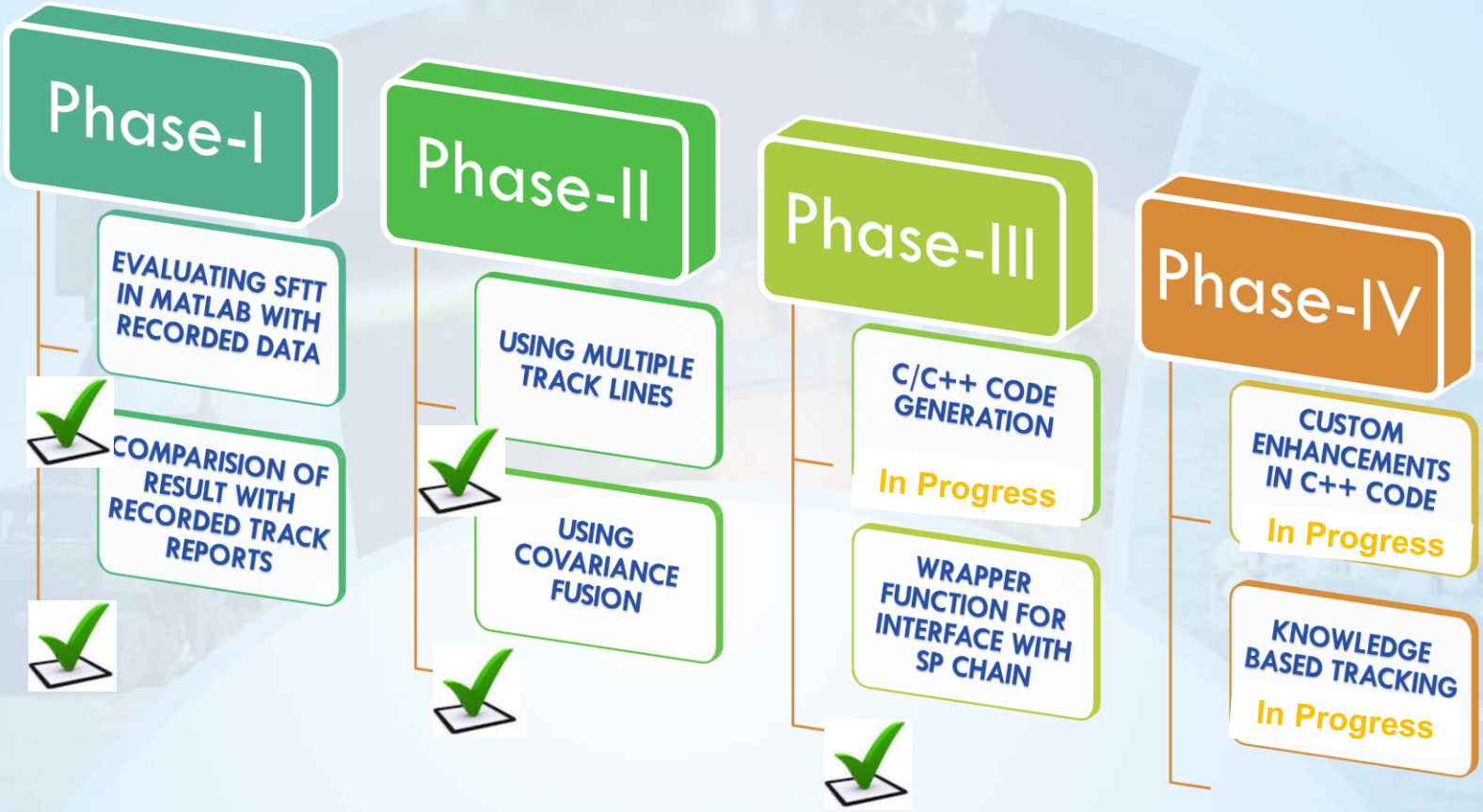
DEVELOPMENT PHASE - IV

- **Custom Enhancements** in C++ code for introducing **Knowledge based tracking methods such as:**
  - Utilization of **zones** and **map** information
  - Using plot attributes such **range spread** ,**azimuth spread** and **plot amplitude** for association
  - Adaptation in Confirmation , Association and Deletion Thresholds w.r.t variable clutter density
  - Optimizing memory allocations and introducing parallel processing architecture for multiple track lines with correlation.

PLOT ATTRIBUTES



STATUSF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BENEFITS OF USING MATLAB

- Object Oriented Approach
- The ability to auto-generate C code, using MATLAB Coder
- Wide variety of readily available packages and Toolbox
- Complex Tracker Algorithms are available out of the box.
- Easy to prove and evaluate the concepts
- Saves money and time
- User friendly

KEY TAKE AWAYS

- Using **MATLAB SFTT** for evaluating **Multi-Target Tracker** and **Estimation Filters**
- Using **cross-covariance fusion** for track-to-track **correlation**
- Using **MATLAB CODER** for **deployable** C++ code generation
- Employing **Knowledge based tracking** methods for improving track maintenance

LOOKING FORWARD FOR

- **Multi-sensor data fusion** (viz. Radar, AIS etc)
- **Attribute based Tracking** and data fusion
- **Target classification**
- **Deployable code generation** for these modules

“ Looking forward to a long and fruitful association ”

THANK YOU