1) Title of the tutorial

Micro-Doppler Signatures: Principles, Analysis and Emerging Applications

2) Instructors name and affiliation

- Dr Carmine Clemente, University of Strathclyde, Glasgow, UK
- Dr Francesco Fioranelli, TU Delft, Delft, The Netherlands

3) a 300 word abstract describing the proposed topic and including an outline of the contents

The micro-Doppler analysis is the study of the time varying Doppler effect from multiple scattering centres with different dynamics. Over the past few years the potentials of micro-Doppler signature analysis has been demonstrated in areas such as enhanced target detection, characterization and tracking. The advantage of micro-Doppler resides in the distinctive Doppler modulations from different targets components that allow unique features to be obtained.
This topic is highly relevant to the conference as micro-Doppler can play a significative role in modern radar systems in both civilian and defence applications. For instance, thanks to the enhancement in computational capabilities, the exploitation of micro-Doppler analysis is possible in a plethora of applications such as condition monitoring, urban surveillance, healthcare, automotive and manufacturing.

Contents Outline:

- Introduction: the introduction to the basic Doppler principle, definition of the micro-Doppler phenomenon, sampling, demodulation and data representation.
- Time-Frequency Analysis: Wide-band and Narrowband Spectrogram, Gabor Uncertainty principle and Energy distributions.
- Canonical Cases- Rigid Bodies: Basic principles of kinematic motion of rigid bodies. Micro-Doppler from vibrating, rotating and helicopters.
- Non Rigid Bodies: Modelling and simulation approaches, human gait and trotting of a German shepherd.
- Signature Extraction Techniques: Extraction of the micro-Doppler from clutter and from the main body return.
- Algorithms for Feature Extraction for Micro-Doppler Based ATR: Target recognition based on micro-Doppler. Principles of feature extraction and example of features extraction techniques applied to micro-Doppler.
- Advanced emerging applications: Micro-Doppler for UAV classification, m-D Based ballistic threats discrimination, micro-Doppler in Industry 4.0 and AgriTech, hand gesture recognition and vital sign monitoring.
- Real time recording and visualization of real radar data: Demonstration of real time data acquisition Tips for experimental campaigns
- Questions and answers.

4) Target audience and assumed knowledge

a. **Target Audience:** Audience from Master level onward, particularly suitable for people from Academia or Industry approaching the field of radar Micro-Doppler;
b. **Assumed Knowledge:** Fundamentals of radar systems and radar signal processing;