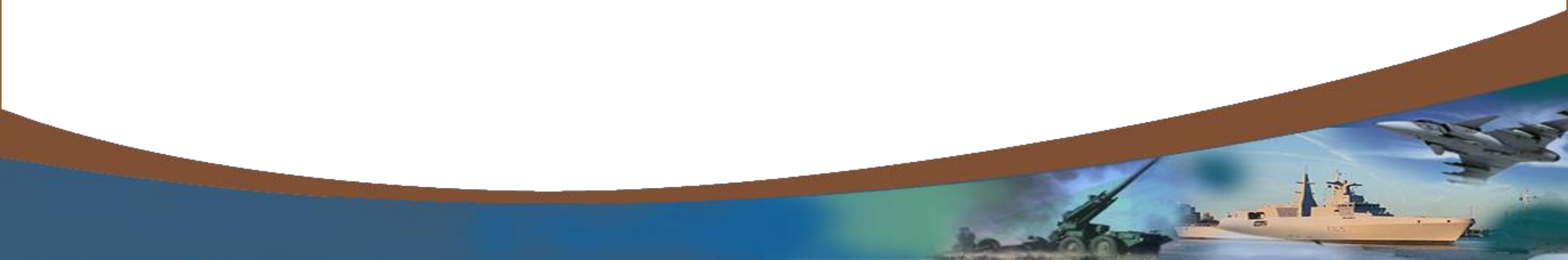
Acoustic Target Classification
(Computer Aided Classification)

Outline

1. Problem description
2. Target Detection
3. Acoustic analysis methods
4. Acoustic classification
5. Classification libraries
6. Applications and trends

Presented by Philip la Grange

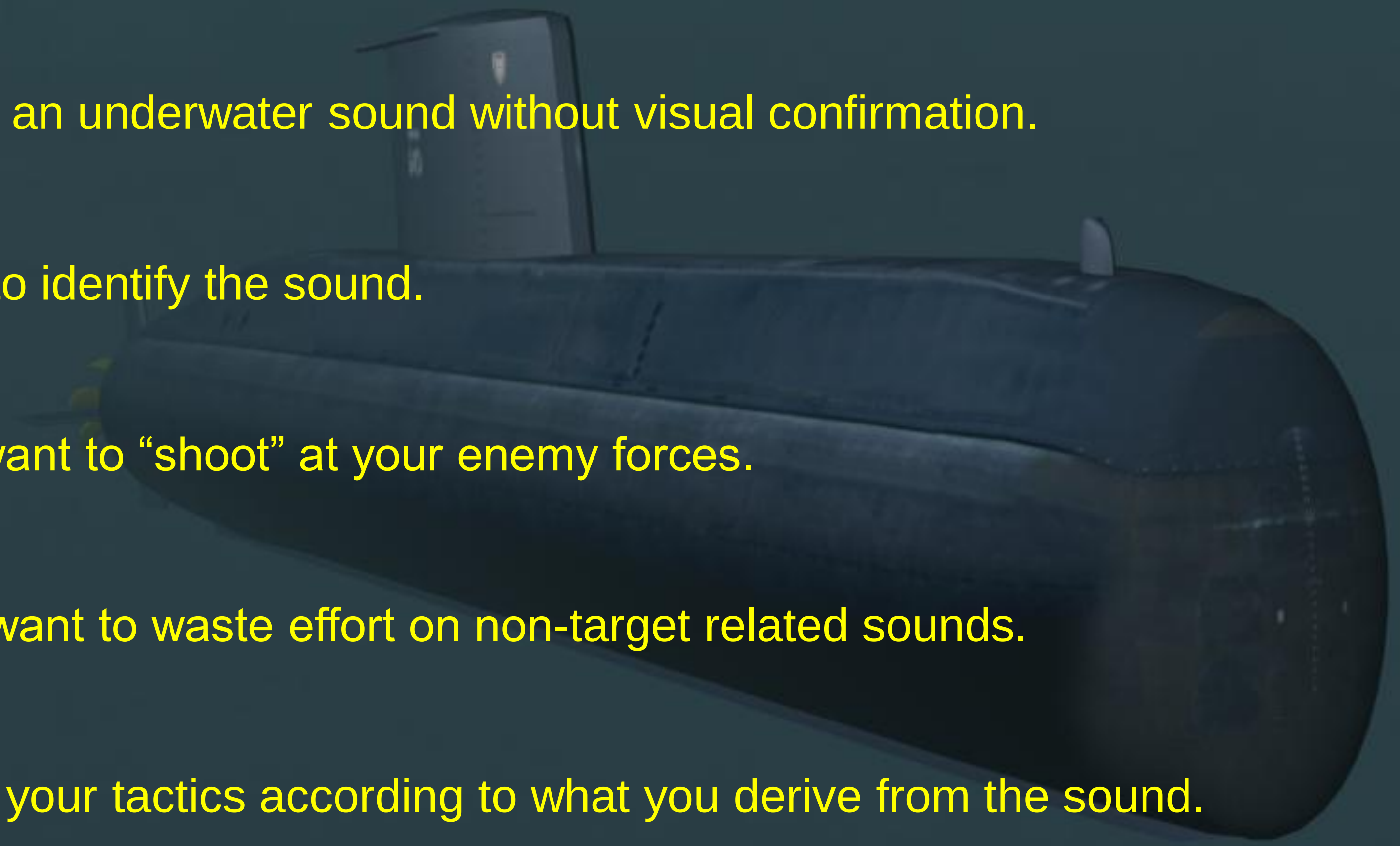


Acoustic Target Classification
(Computer Aided Classification)

Biological sounds

1. .
2. .
3. .
4. .

Problem Description



Detect an underwater sound without visual confirmation.

Need to identify the sound.

Only want to “shoot” at your enemy forces.

Don’t want to waste effort on non-target related sounds.

Adjust your tactics according to what you derive from the sound.

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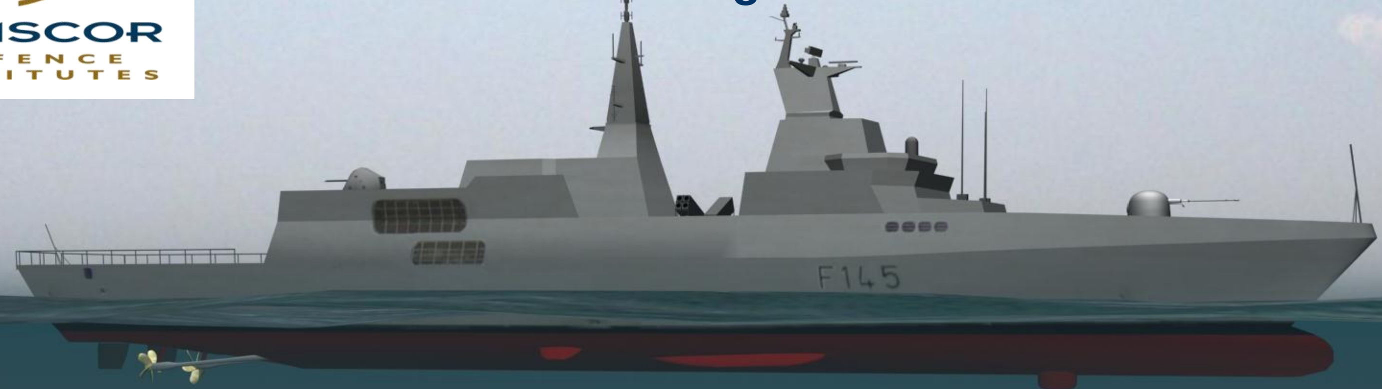
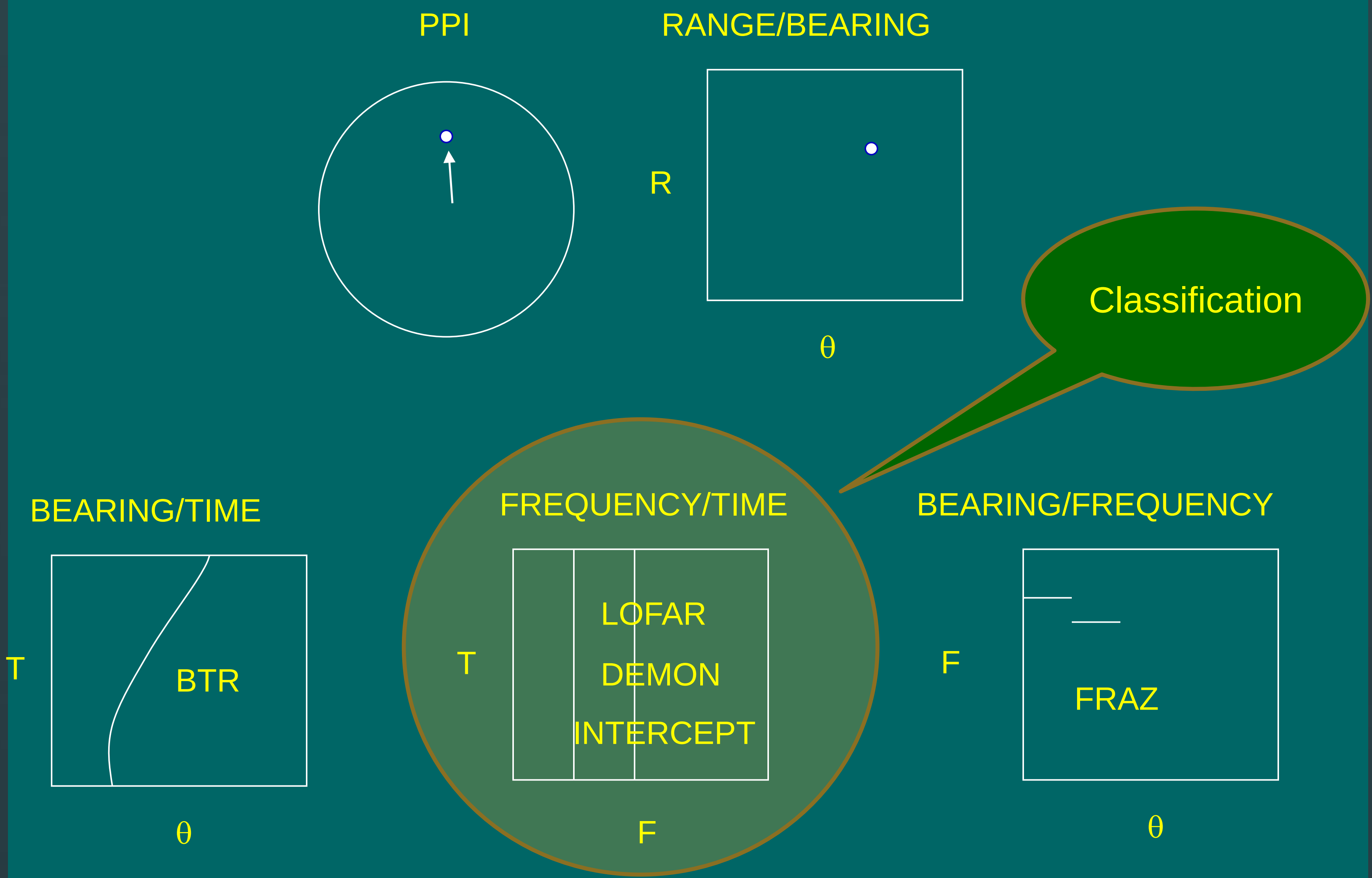
IMT

Target detection

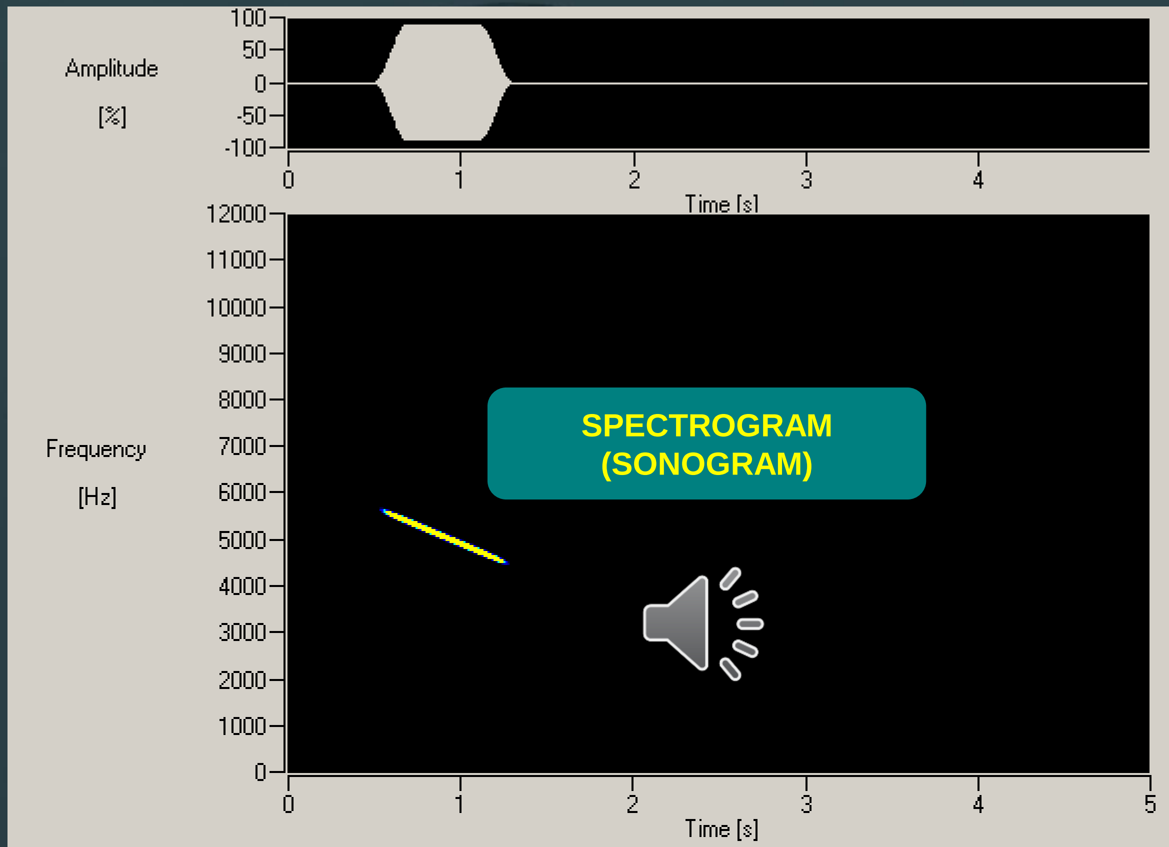


Typical sonar detection systems

Military sonar displays



Introduction to spectrograms
a "chirp"
a FM pulse



TRANSIENT SOUNDS

SOUND PATTERN BECOMES AN IMAGE

AMPLITUDE INFORMATION LIES IN THE COLOR

Sonar sound analysis

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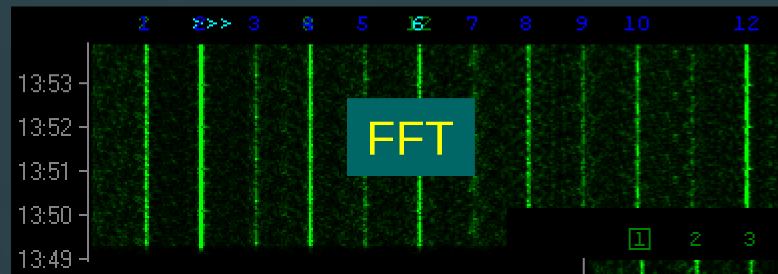
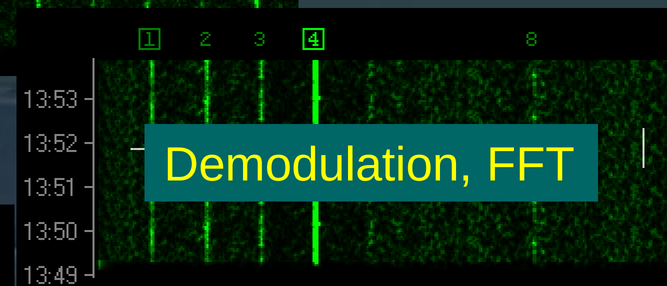
IMT

Acoustic Analysis

LOFAR analysis

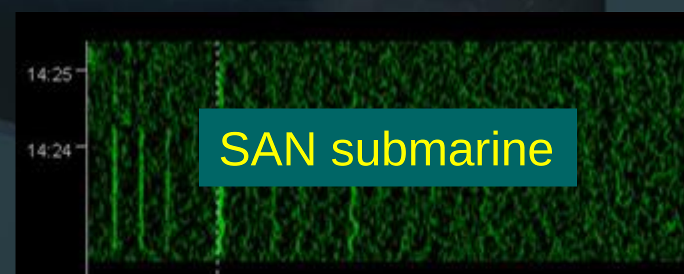


DEMON analysis (envelope, rotation)



INTERCEPT analysis (pulse)

TRANSIENT analysis (short duration)



Post analysis of slow waterfall diagrams

Analysis of short spectrograms

Acoustic Classification

Propeller parameters

(NOB,NOS,RPM)

Engine parameters

(NOC,RPM,STROKE)

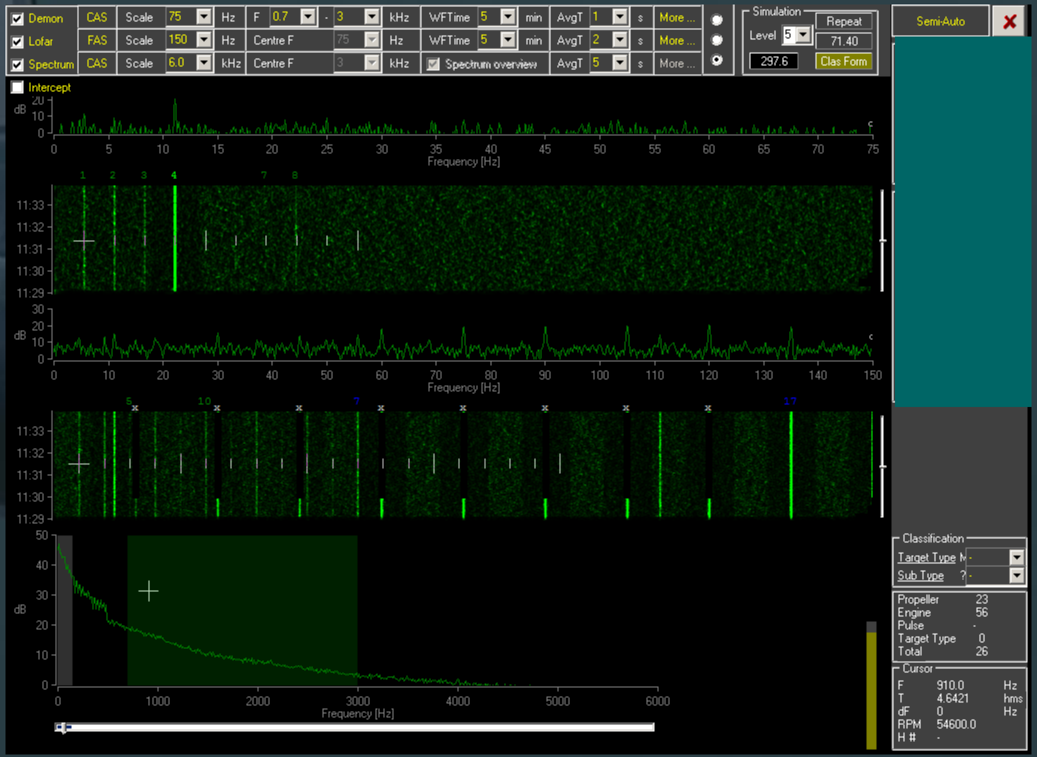
(Gearbox ratio)

Sonar transmission parameters

(typical pulse parameters)

Other transient sounds

Self noise identification



Acoustic Classification

Exact classification vs. generic classification.

```
Score=052 Type12=Merchant Vessel/Turbine
Score=040 Type7=Merchant Vessel/Medium/Gearbc
Score=039 Type6=Merchant Vessel/Large/Gearbox
Score=039 Type15=Warship/Medium
Score=038 Type5=Merchant Vessel/Very Large/Moc
Score=037 Type14=Warship/Major/Turbine
Score=033 Type21=Warship/Auxiliary Ship/SAN
```

"Exact" target parameters required in library

Must have encountered the target

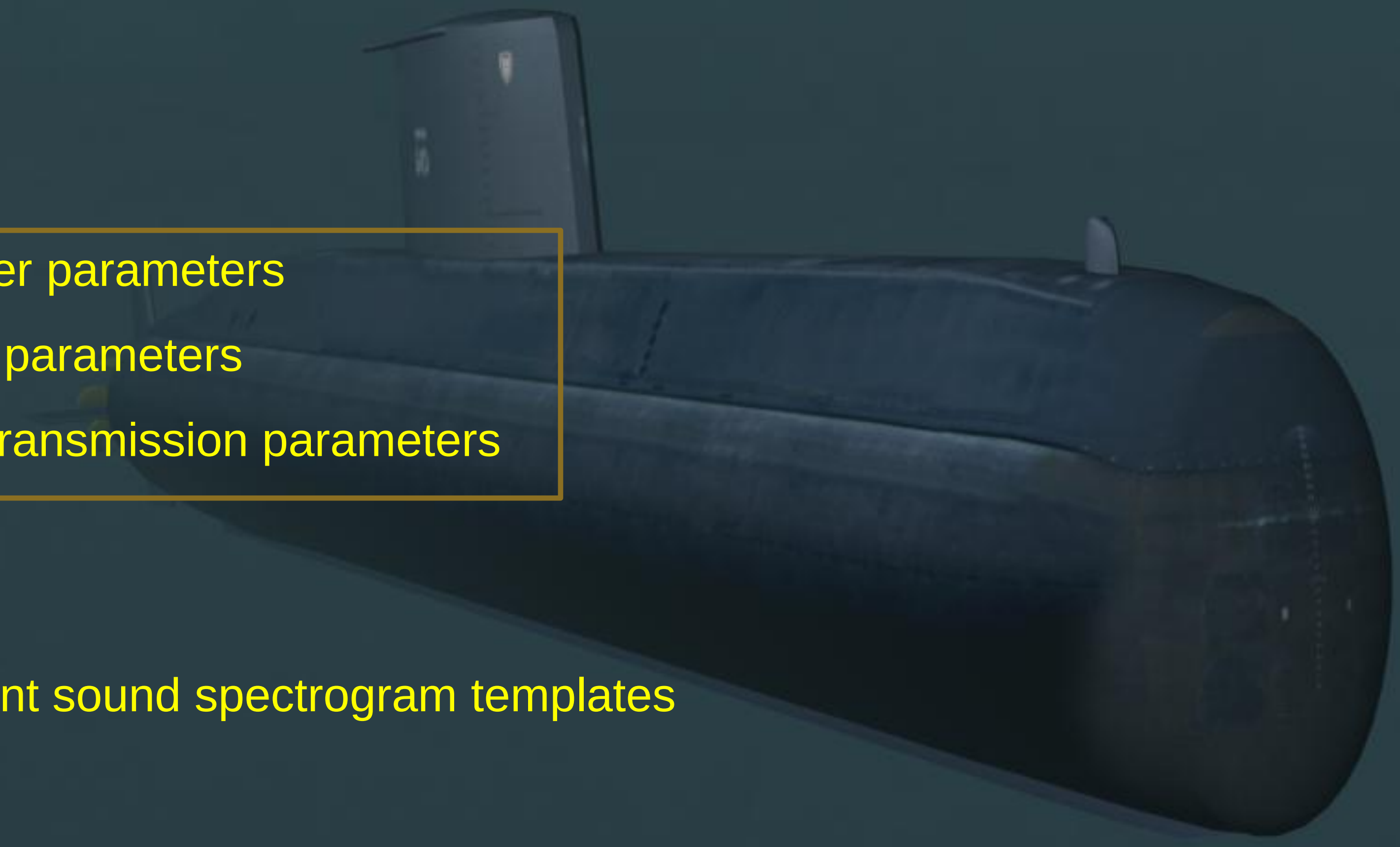
"Rules"

e.g. RPM>500 = Fishing vessel

RPM>XXX = Torpedo

Intelligent rules

Classification Libraries



Propeller parameters

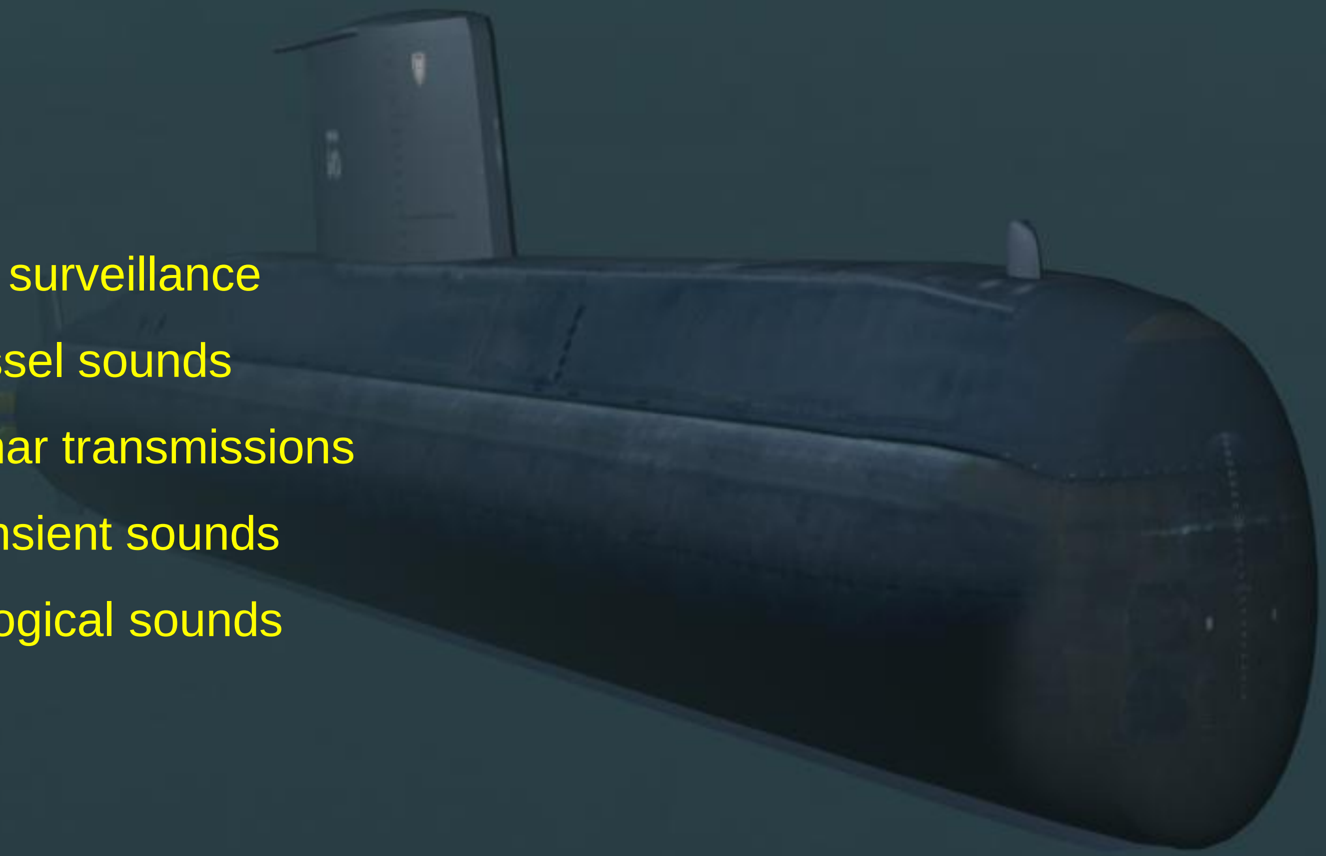
Engine parameters

Sonar transmission parameters

Transient sound spectrogram templates

Biological sound spectrogram templates

Applications (underwater)



Underwater surveillance

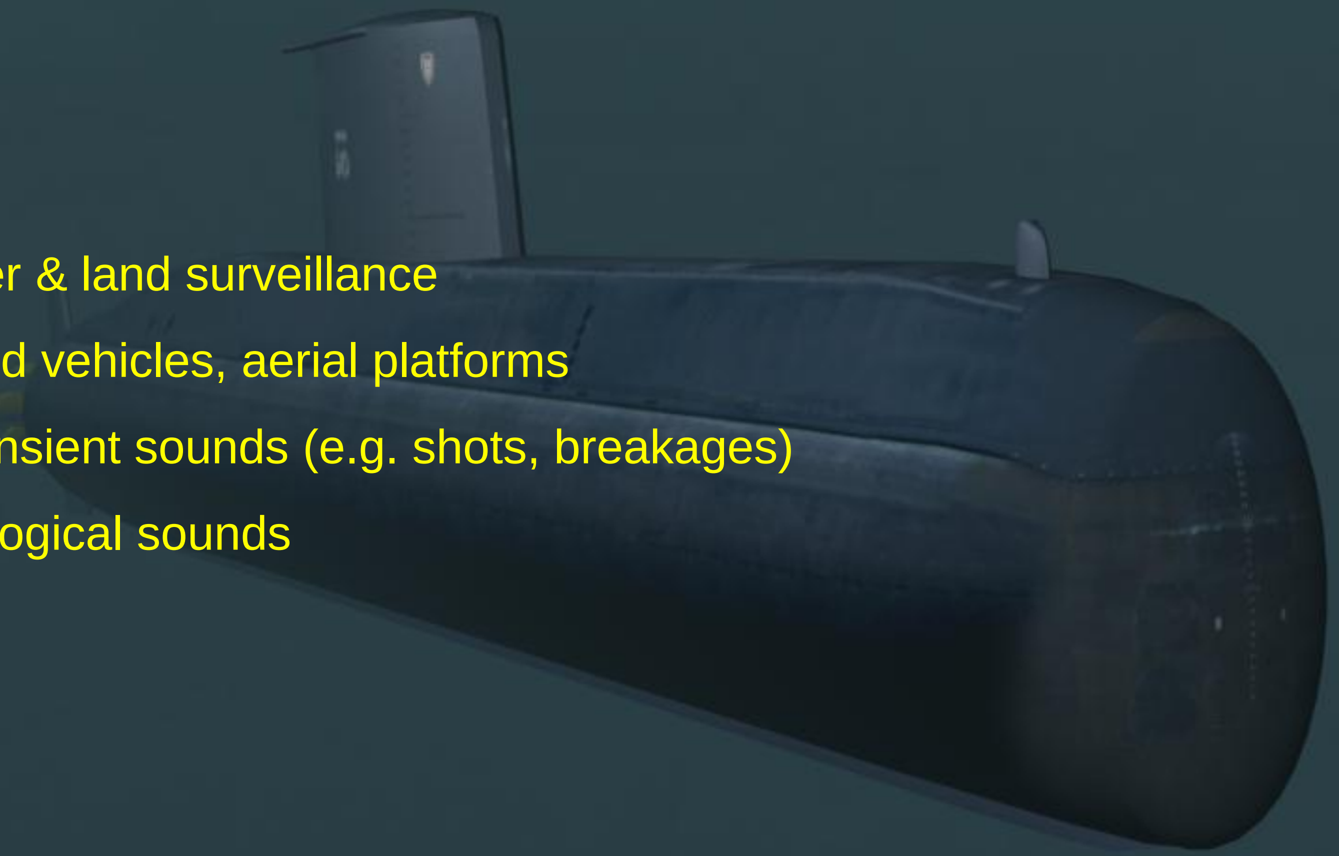
Classify vessel sounds

Classify sonar transmissions

Classify transient sounds

Identify biological sounds

Applications (above water)



Above water & land surveillance

Classify land vehicles, aerial platforms

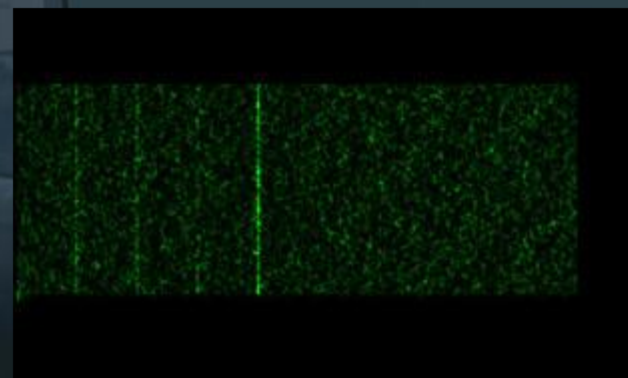
Classify transient sounds (e.g. shots, breakages)

Identify biological sounds

Results

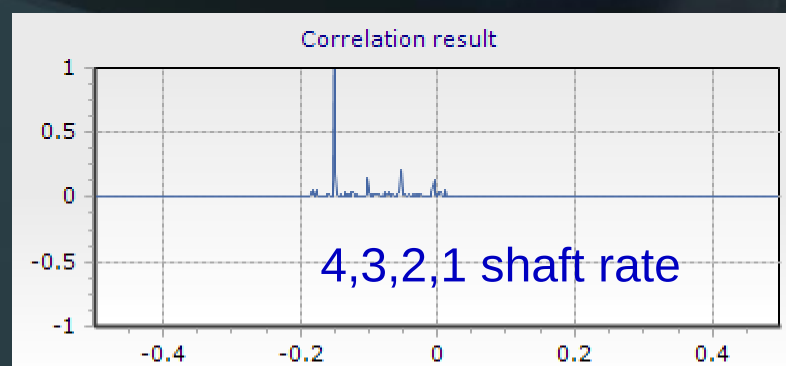
Spectrogram analysis

(picture, 5 min - no sound)



Number of blades = 4

Shaft rate = XXX rpm



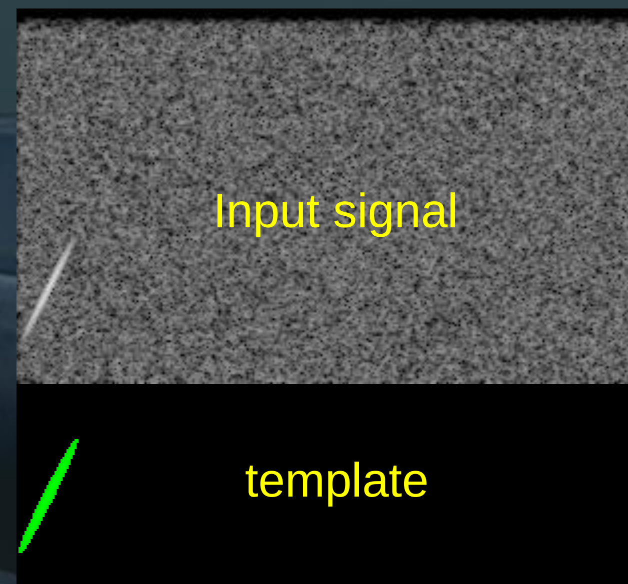
Results

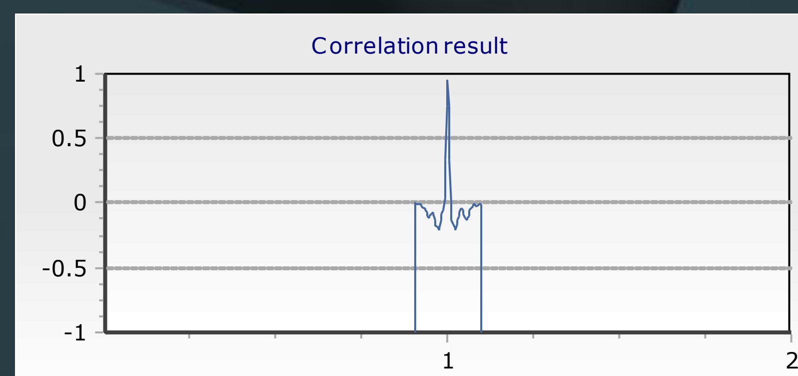
Spectrogram analysis

(picture, no sound)

Spectrogram correlation advantages

- Work in high noise
- Maximize processing gain
- Attractive side lobes

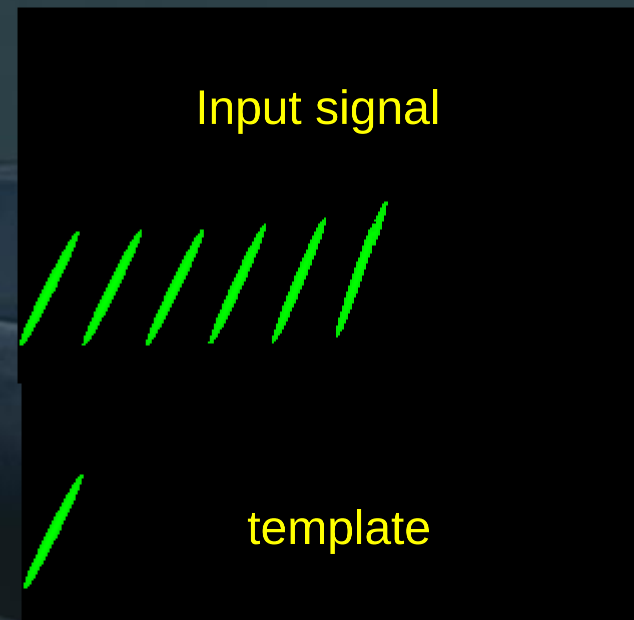




Results

Spectrogram analysis

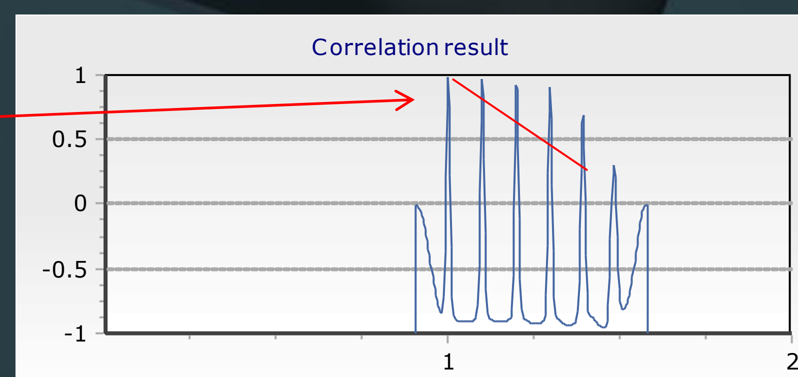
(picture, no sound)



Spectrogram correlation advantages

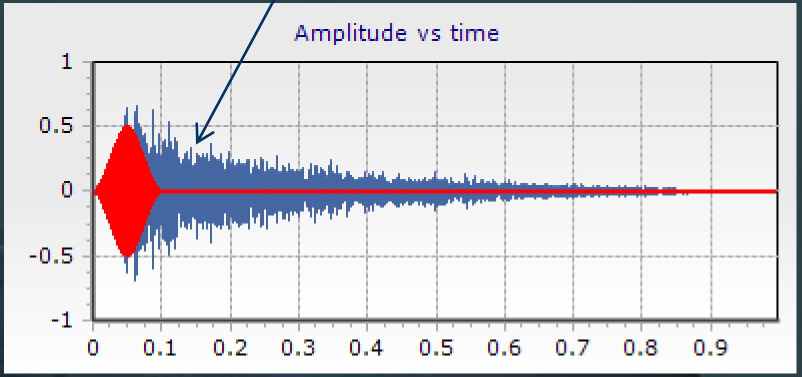
• Can tolerate small variations (do not need an exact replica in database)
Very useful for biological sounds

• compare to matched filtering



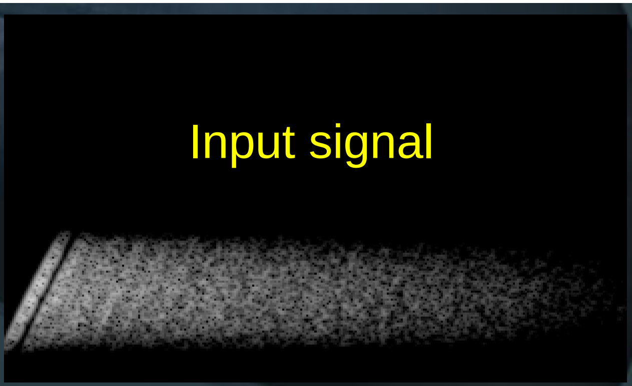
Results

Input signal



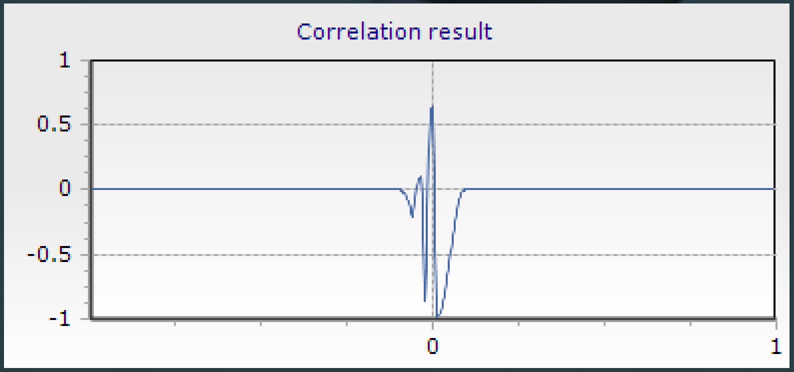
Spectrogram analysis

(picture, no sound)

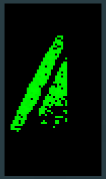


Spectrogram correlation advantages

- Tolerate multi-path
- Reverberation / echo removal
- Image processing benefits



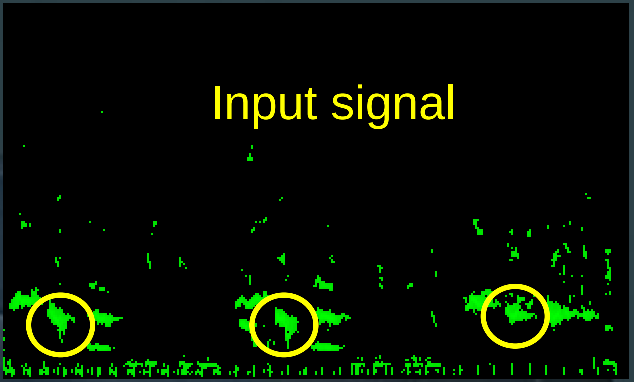
Input signal analysed

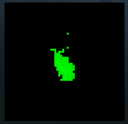


Results

Spectrogram analysis

(picture, no sound)

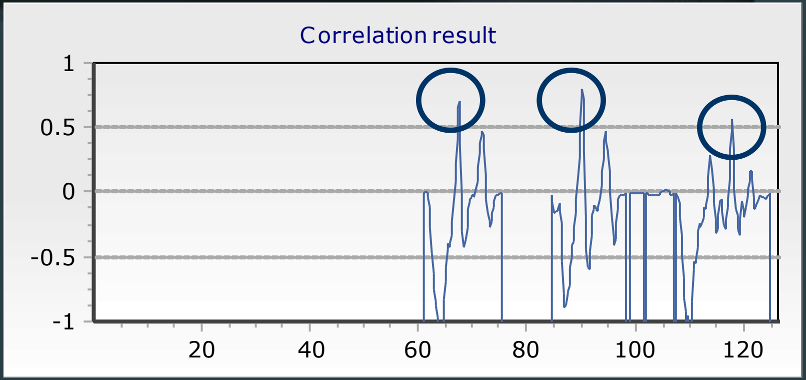




template

Spectrogram correlation advantages

- 2nd syllable of humpback whale
- more appropriate than matched filter

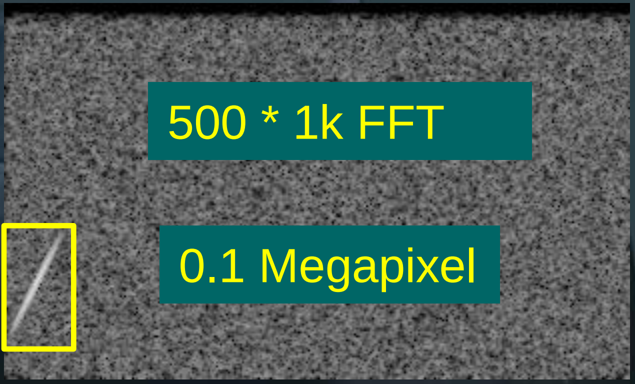


Results

Spectrogram analysis

(picture, no sound)

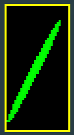
N2=250



1 second = 100 pixels = M

Spectrogram correlation advantages

- Post-processing speed
- x10 (1/10th of image)



(x40)

- Classification library search
- “pictures” that do not interfere

STFFT: 100 * N log (N) = 1M complex = 2M

Matrix correlation = M * (M * N2) = 2M

Time correlation = $(F_s)^2$ = 2G

F domain convolution (2s) = 4M complex = 8M

Summary

- Overview of acoustic classification with traditional processing
- Difference between exact and rule based classification
- Potential to post (mission) process traditional Lofargrams & Demongrams without access to the raw data (amplitude is in the image)
- Ability to improve both detection and classification of known pulses with spectrogram correlation
- Ability to identify (classify) a wide range of transient sounds by spectrogram pattern matching rapidly in a very large database
- New opportunities for smart waveform design and extensive use of available bandwidth

End

Questions ?