UNIVERSITÀ DI PISA

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Low-Cost Fully-Software Waveforms for Tactical Communications

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DSPCoLa

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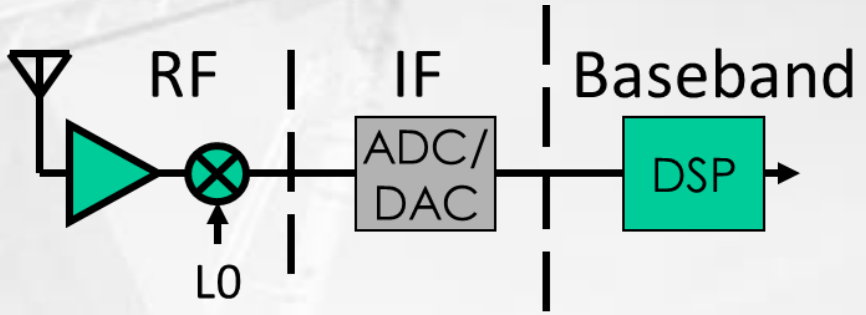
Motivation

- Flexibility
- Improve the interoperability
- Improve the waveform
- Didactic purpose
- Need to save resources (memory occupation and CPU consumption)
- Money saving

Low-cost Fully-Software approach

Motivation

- **Software-Defined Radio :**



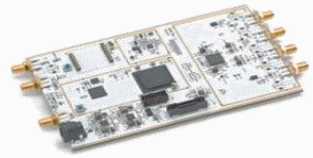
- **Fully-Software approach :**

- **SDR Platform :**

RTL-SDR
12€

USRP 1
600€

USRP B100
600€



USRP B200/B210
600/1000€

Lancers Laboratory

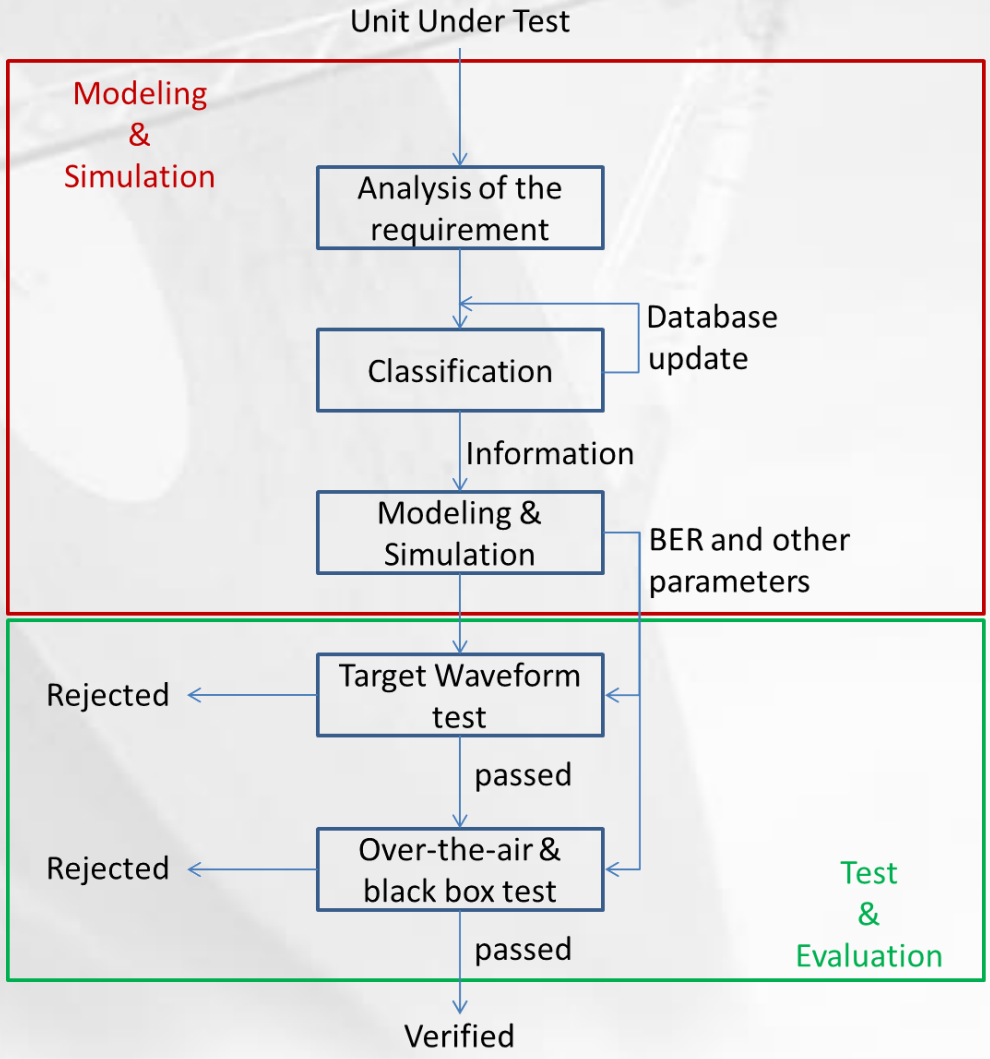
LANCERS

- **Born to perform T&E on SDR products, both platforms and waveforms:**
  - **Waveforms:**
    - Analysis of documentation, design and implementation
    - Evaluation of base waveforms
    - Evaluation of waveforms versus a legacy standard (interoperability)

Lancers Laboratory

- **Complete systems:**
  - Performance (Platform+WF)
  - Interoperability between different SDR platforms and with legacy platforms
  - Reconfigurability, power consumption, performance in co-sited environment, etc

Lancers Laboratory

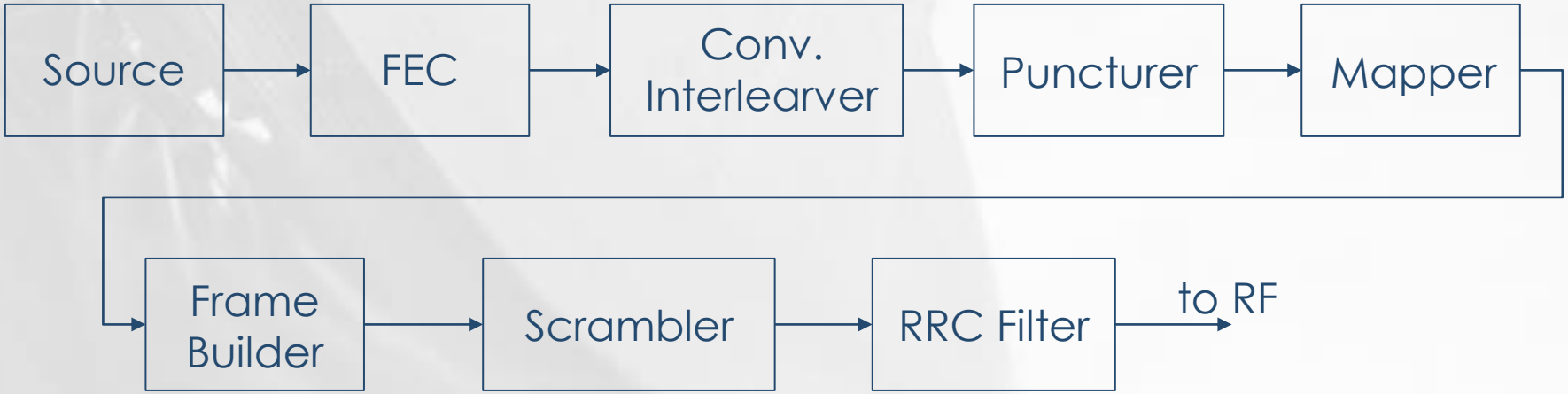


Developed waveforms:

- STANAG 4285
- MILSTD-188110A
- STANAG 4539
- MILSTD-188110B Appendix C

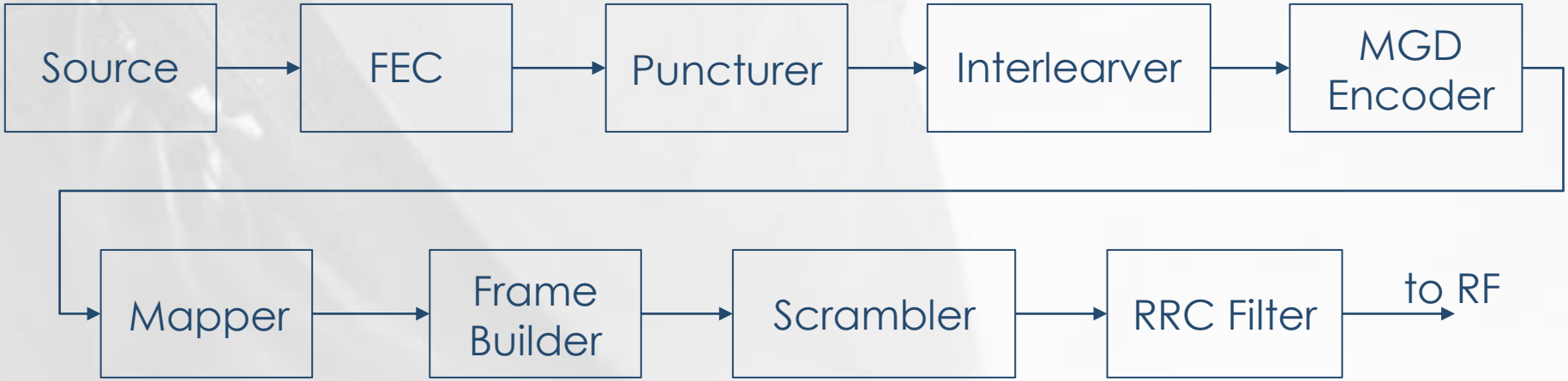
Waveform

- **STANAG 4285**
  - Bitrate: 75, 150, 300, 600, 1200, 2400, 3600 bps
  - FEC : Convolutional Code + repetition block code(optionally)
  - Interleaver : Convolutional interleaver(Zero,Short,Long)
  - Mapping : Phase-Shift Keying(BPSK,QPSK,8PSK)
  - Filter : Root-Raised Cosine (α=0.2)



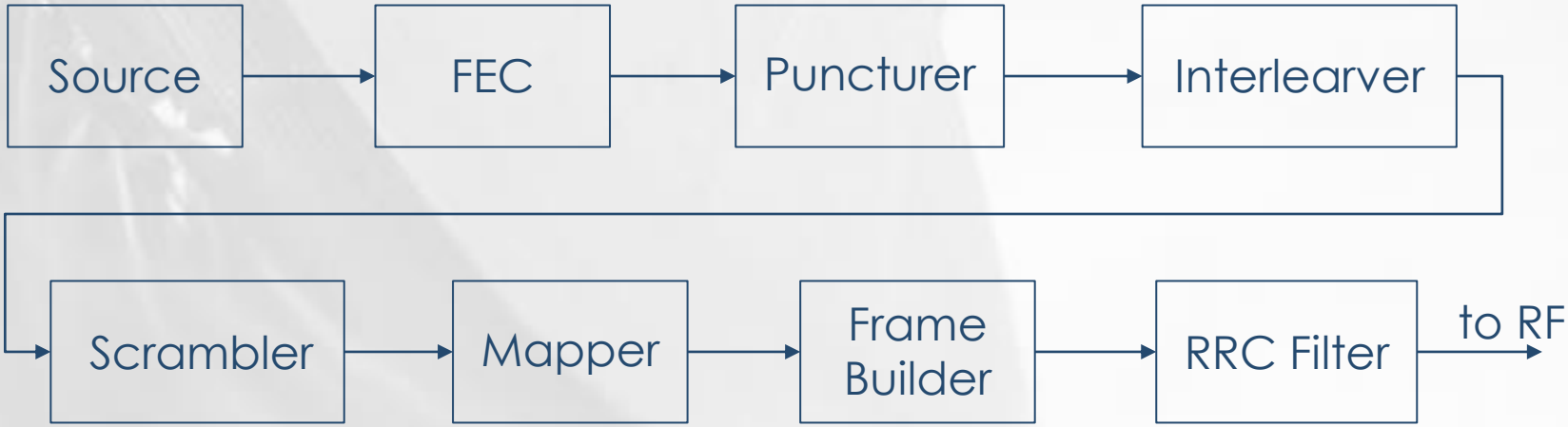
Waveform

- **MILSTD-188110A**
  - Bitrate: 75, 150, 300, 600, 1200, 2400, 3600 bps (F.F. or F.H.)
  - FEC : Convolutional Code + repetition block code(optionally)
  - Interleaver : Matrix block interleaver
  - Mapping : Phase-Shift Keying(BPSK,QPSK,8PSK)
  - Filter : Root-Raised Cosine (α=0.35)



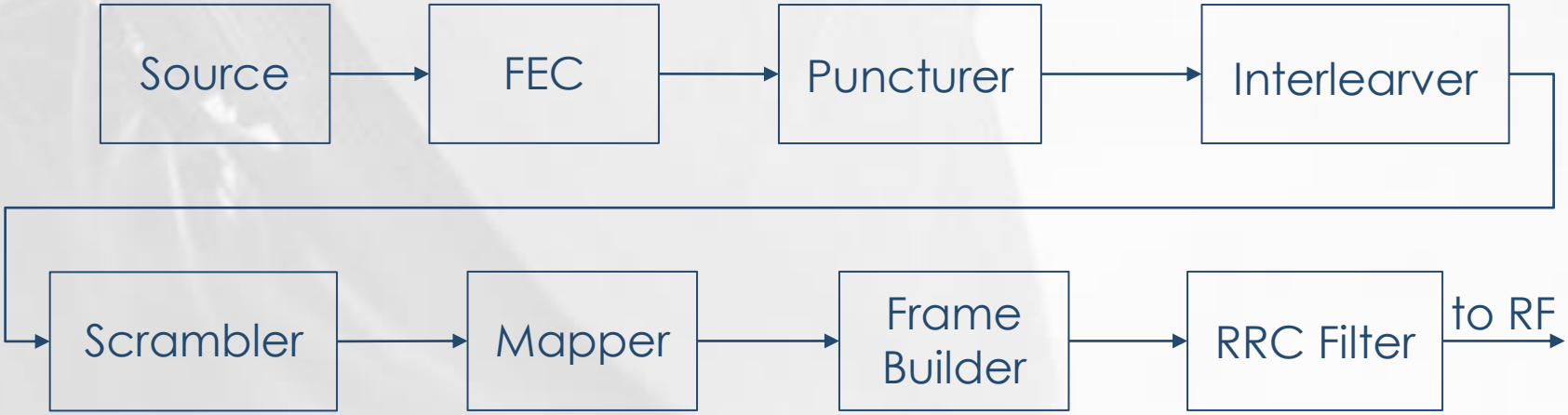
Waveform

- **STANAG 4539**
  - Bitrate: 3200, 4800, 6400, 8000, 9600, 12800 bps
  - FEC : Convolutional code and puncturing
  - Interleaver : Matrix block interleaver
  - Mapping : BPSK(3200), QPSK(4800), modified 16/32/64-QAM
  - Filter : Root-Raised Cosine (α=0.35)



Waveform

- **MILSTD-188110B Appendix C**
  - Bitrate: 3200, 4800, 6400, 8000, 9600,12800 bps
  - FEC : Convolutional code and puncturing
  - Interleaver : Matrix block interleaver
  - Mapping : BPSK(3200), QPSK(4800), modified 16/32/64-QAM
  - Filter : Root-Raised Cosine (α=0.35)



Framework

- **OSSIE: Open-Source SCA Implementation - Embedded**
  - SCA-Compliant SDR development effort:
    - SDR core framework based on the JTRS SCA(ver 2.2.2):
      - Based on OmniORB(robust high performance CORBA ORB for C++ and Python)
    - Tools for rapid development of SDR components and waveforms:
      - Desktop IDE based on Eclipse
      - Tools help the developer generating basic structure of components and waveforms
      - Tools provide code templates that allow the insertion of C++ code which performs the component function
    - An evolving library of pre-built components and waveforms

Framework

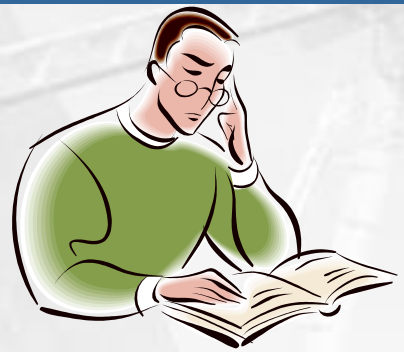
- **Improvement :**
  - Incrementation the collection of OSSIE component
  - Inclusion of new useful libraries such as newest version of liquid-dsp and fftw
  - Modification on USRP-UHD driver provided by Virginia-Tech
  - Realization of customized version of OS including improved OSSIE version and libraries

http://dspcola.iet.unipi.it/OSSIE

- **Bugs:**
  - Spurious in-band and out-band emission

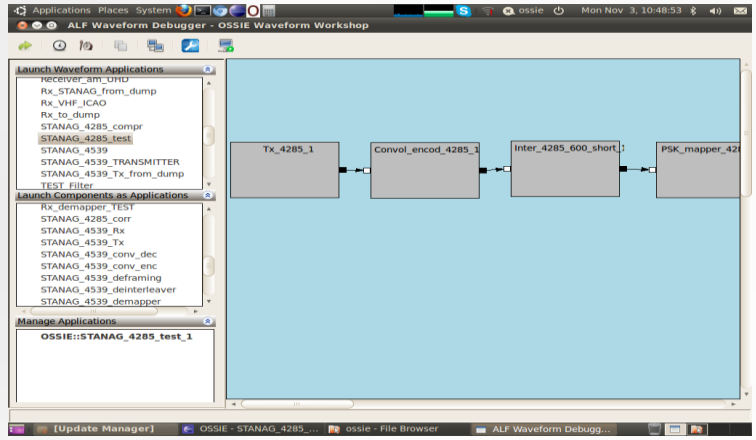
Result

- **Study of the waveform**



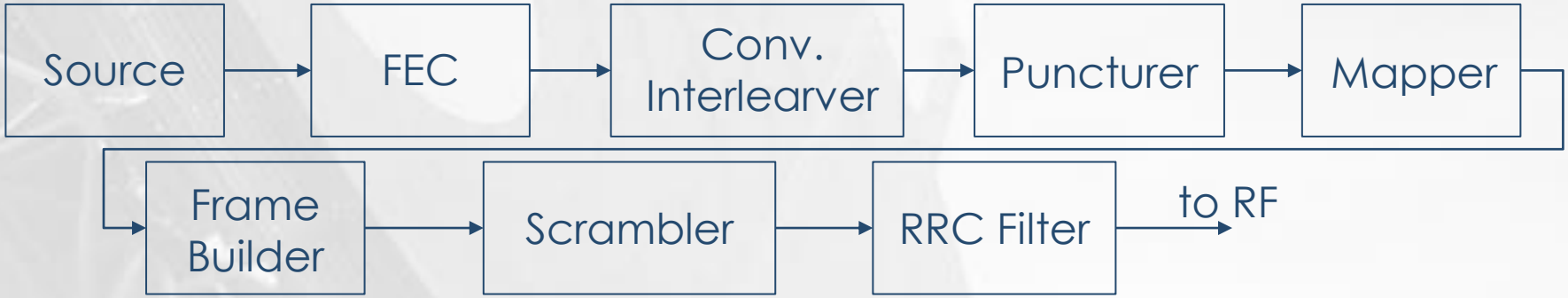
- **C++ indipendent implementation**

- **Ossie implementation:**
  - Creation of components
  - Waveform creation
  - Waveform improvement
  - Test "over the air"

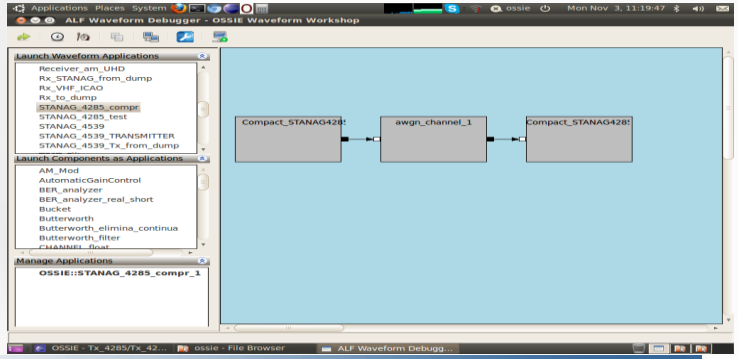


Result

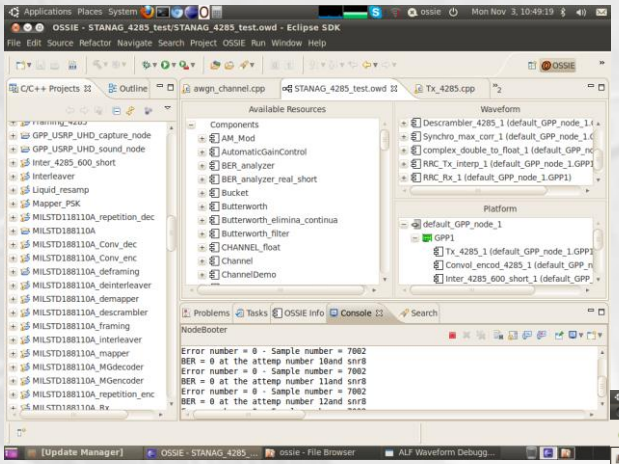
- **Reference WF: STANAG 4285**
  - Bitrate = 600 bps
  - Interleaver = Short
- **Fragmented WF (18 components)**



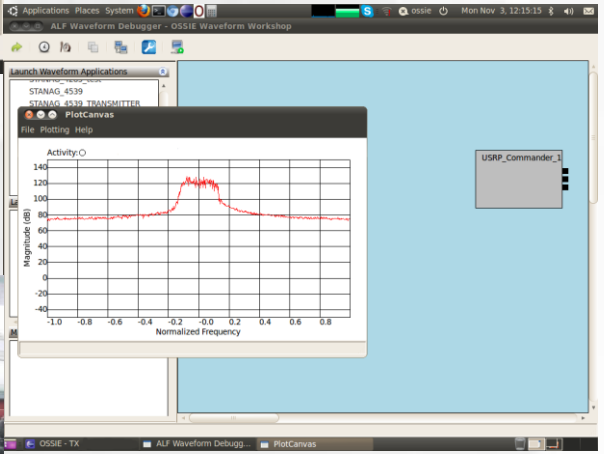
- **Compact WF (3 components)**



Result

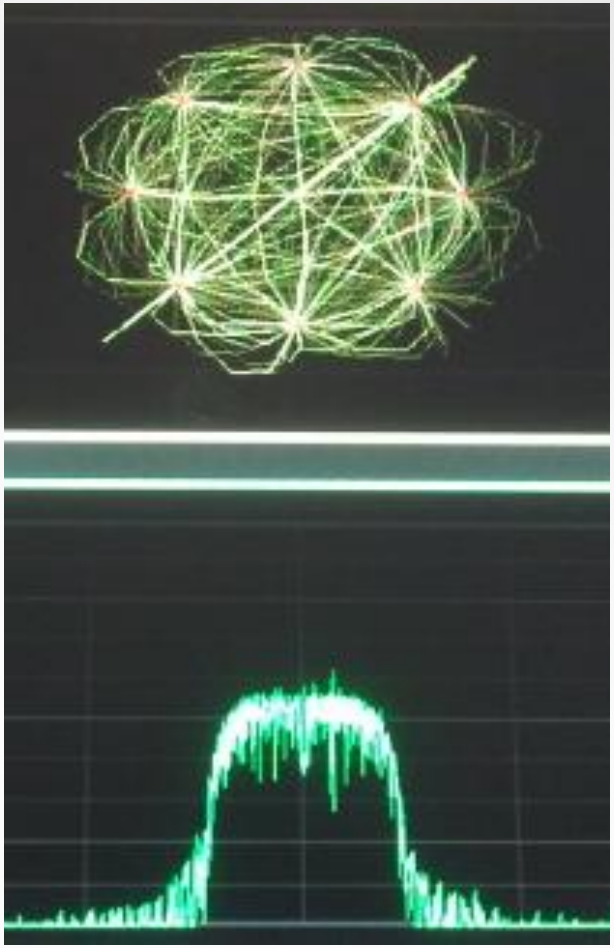


OSSIE
Simulation



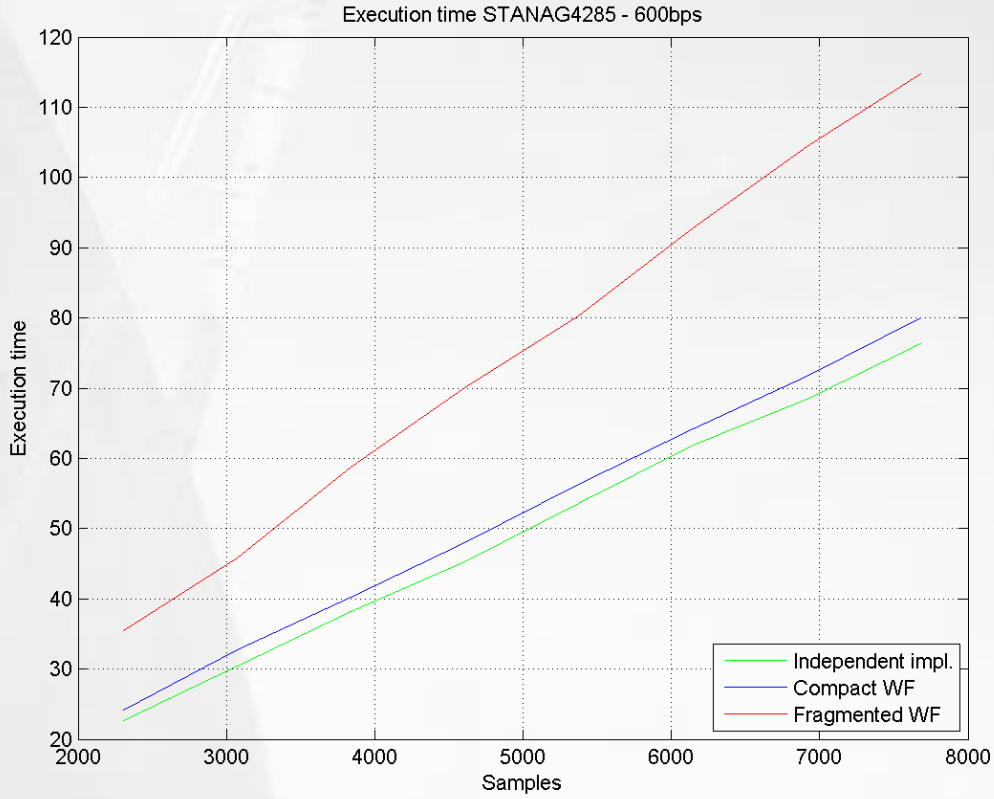
Test between
SDR platform

Test
"over the air"



Result

Samples	Indep	Compact	Fragment
2304	22.637	24.16	35.519
3072	30.422	32.682	45.847
3840	38.227	40.28	58.814
4608	45.234	48.051	70.033
5376	53.536	56.29	80.282
6144	61.938	64.152	92.8
6912	68.398	71.64	104.34
7680	76,395	79.99	114.79



Conclusion

- Efficiency of Fully-software approach
- Applicability to low-cost hardware
- Compact waveform shows better performance in terms of execution time than Fragmented waveform

Future work and improvements

- Improve code to increase the performance in terms of memory allocation and CPU consuption
- Including upper layers, such as TCP/IP and application layers
- Extend the implementation of several additional waveforms
- Evaluation of USRP frequency hopping capabilities
- Migration to RedHawk
- Interoperability test
- Test waveform on other SDR platfoms

Thanks

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