PRN Codes For Future NavIC L1 civil Signal

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Presentation Outline

- Introduction
- PRN code design requirements for navigation system
- Proposed PRN codes for future NavIC L1 civil signal
- NavIC L1 civil PRN code selection criteria
- Correlation analysis of proposed codes
- Performance comparison of proposed codes with other GNSS codes at L1
- Conclusion

Introduction

- NavIC is introducing a new civil signal in L1 frequency band.

- This NavIC L1 civil signal will consist of a pilot and a data component, each with a separate PRN code

- The optimal code selection for NavIC L1 civil signal consists of –
  - Generation of a candidate code set,
  - Analyzing the codes performance against a set of criteria
  - Selection of optimal codes among the set.

- Code sets from various code Families were analyzed.

- Code Length
  - Correlation properties
  - Acquisition time

- Code Type
  - Family size and code length

- Code Rate
  - Determine bandwidth of signal

- Code Correlation Properties
  - Near zero cross correlation and out of chip correlation

- Ease of Hardware Implementation
  - The structure of code is simple and easy to achieve and change.

Proposed PRN codes for future NavIC L1 Civil Signal

PRN sequences based on quadratic residue of a prime are proposed for NavIC L1 civil signal.

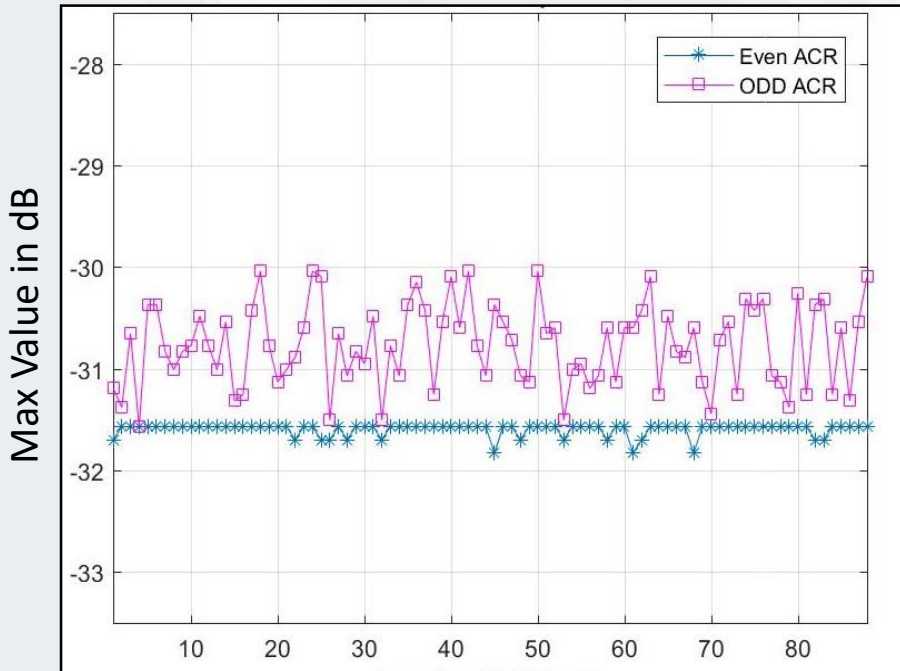| Signal component	Primary code length	Primary code period (msec.)	Secondary code length	Secondary code period (msec.)
L1 Data *	10230	10	-	-
L1 –Pilot	10230	10	1800	18000
***The L1 data component shall not contain a secondary code.**				

Concept of Tiered Code Architecture
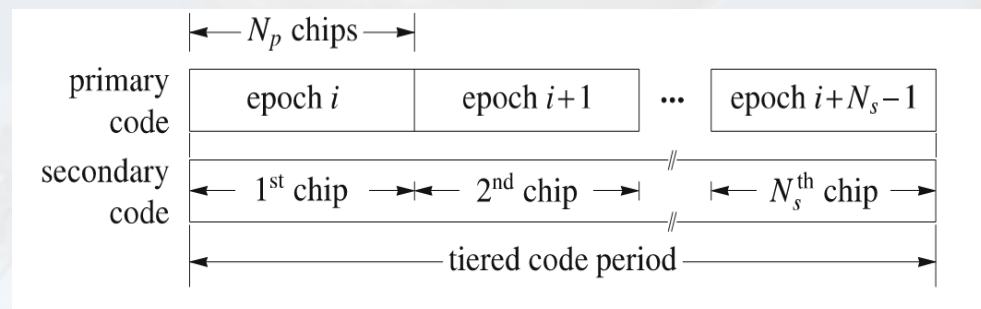
Selection criteria's that is used to select PRN codes for NavIC L1

- Balance property of codes

- Values of autocorrelation

- Intra System cross correlation

- Inter System cross correlation-Values of cross correlation with PRN codes of

  - GPS L1 C pilot and data signals

  - Beidou B1C signals

- Values of odd correlation
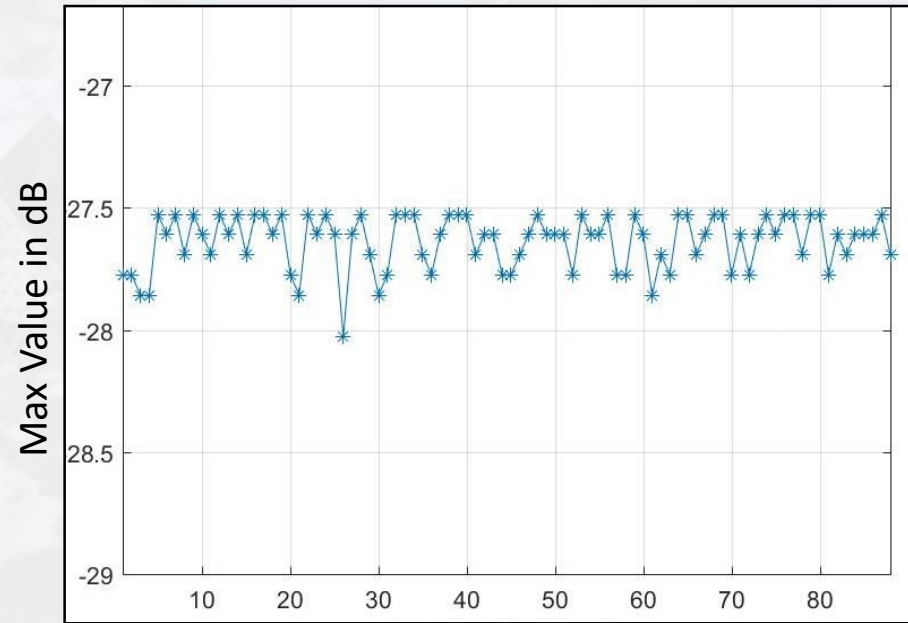
- Orthogonality of codes

Even and Odd ACR and CCR analysis of Proposed NavIC L1 Primary PRN Codes

Value of even and odd autocorrelation side lobe peaks (in dB)

Value of cross correlation peaks (in dB)
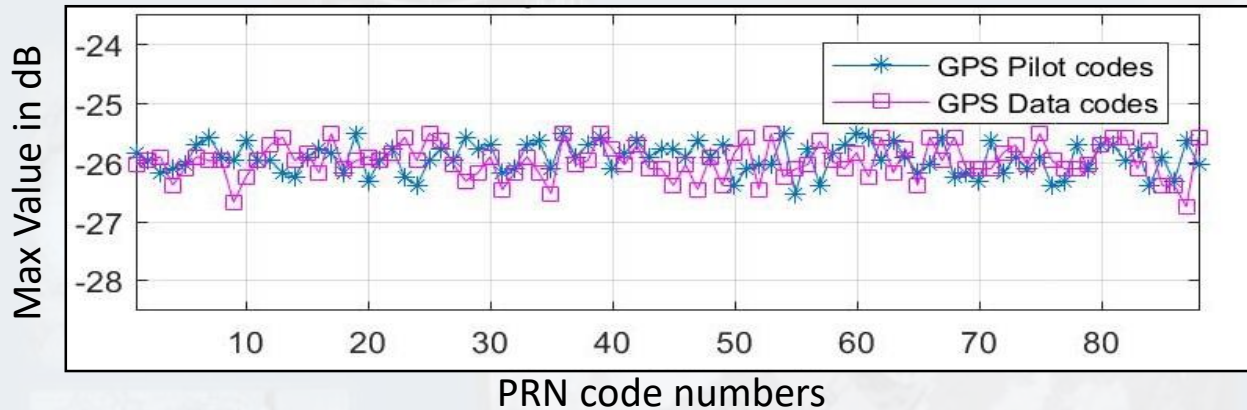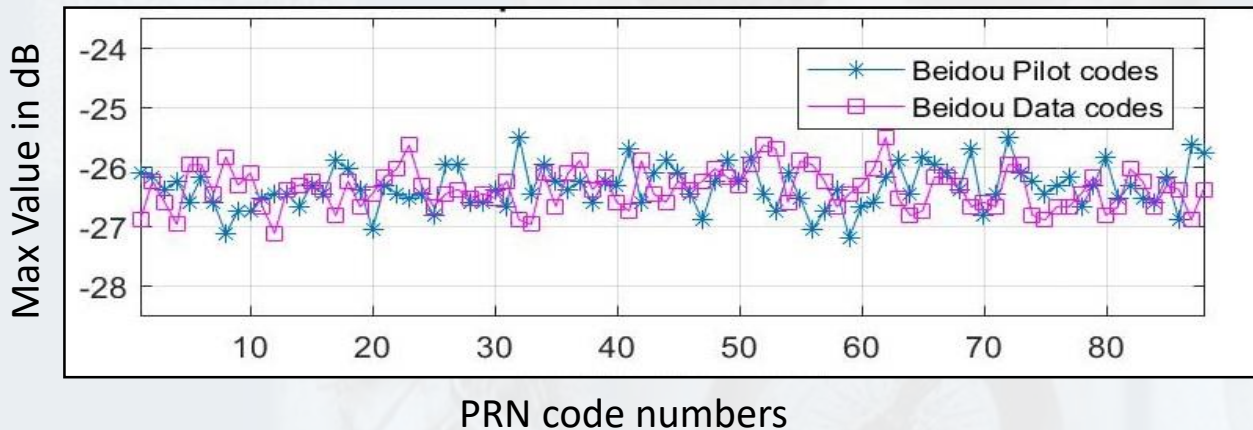

PRN code numbers

PRN code numbers

Total PRN codes Analyzed =88
Max value of ACR= **-31.57(Even ACR)**
-30.04(ODD ACR),-27.5 (CCR)

Inter System Cross Correlation analysis of Proposed NavIC L1 Primary PRN Codes

Max. value of cross correlation peaks with GPS L1C codes (in dB)

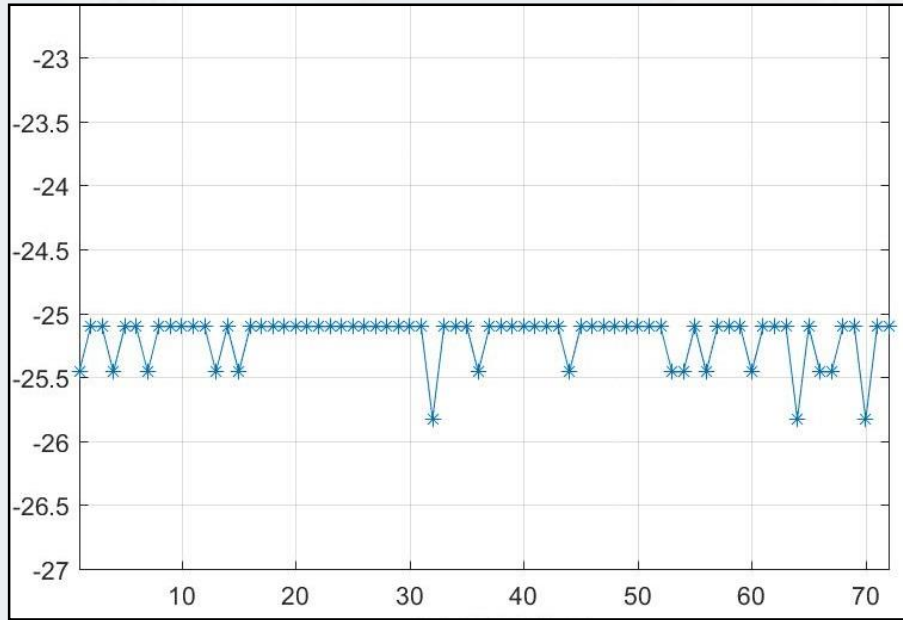Max. value of cross correlation peaks with Beidou B1C codes (in dB)

Total PRN codes Analyzed =88
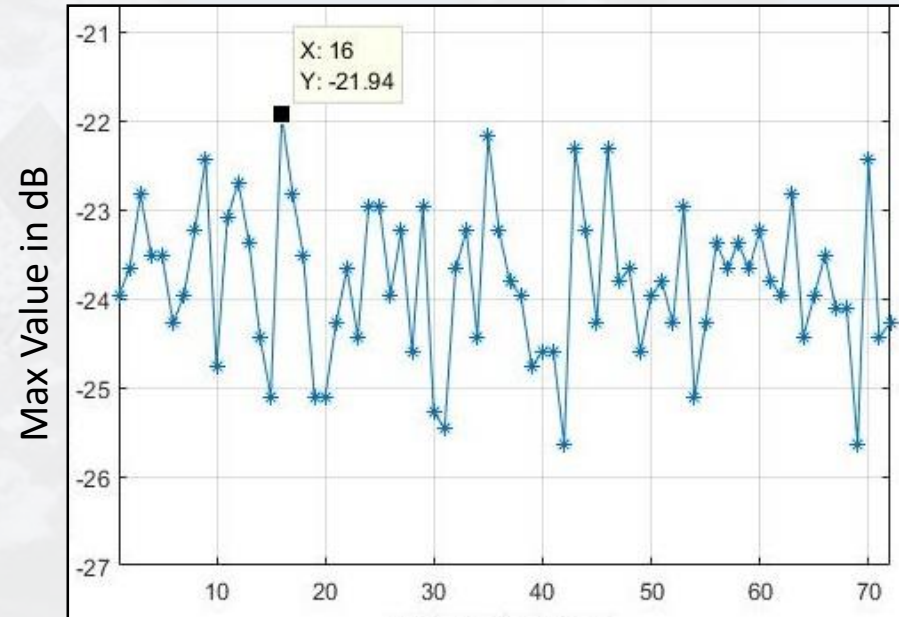PRN codes Correlated with 420 GPS L1C codes and 126 B1C codes
Max value of CCR= -25.2 dB

Even and Odd ACR analysis of Proposed NavIC L1 Secondary PRN Codes

Value of even autocorrelation side lobe peaks (in dB)

Value of odd autocorrelation side lobe peaks (in dB)
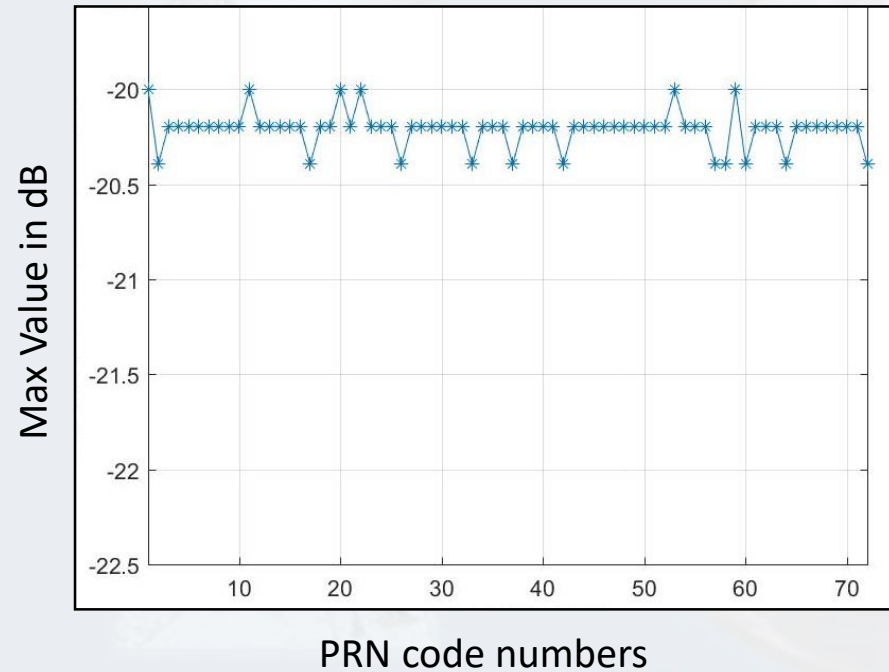

PRN code numbers

X: 16
Y: -21.94

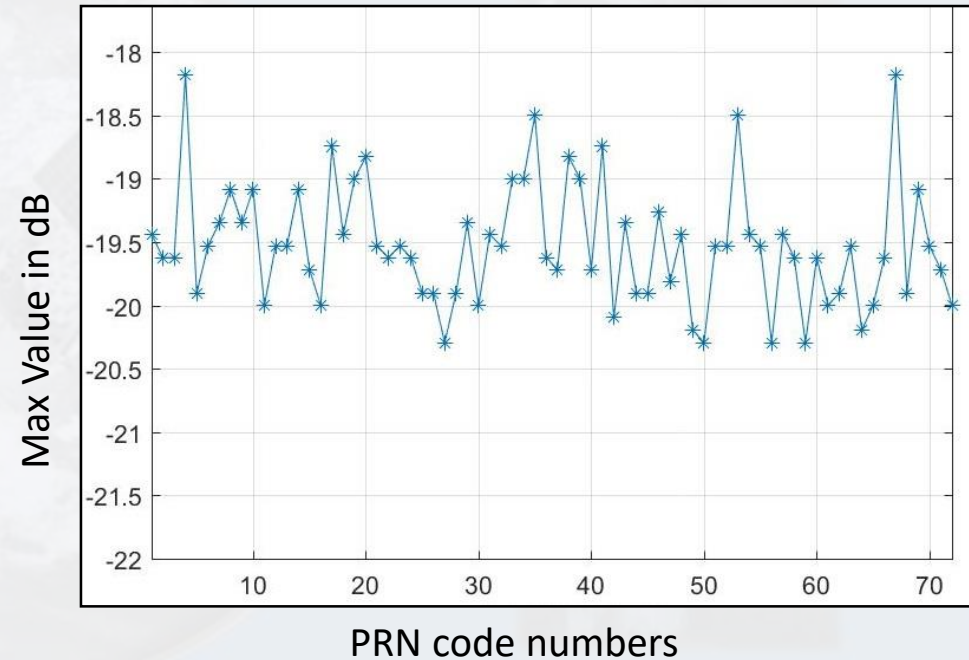PRN code numbers

Total PRN codes Analyzed =72
Code length=1800
Max value of ACR= -25.1(Even), -21.94(Odd)dB

Even and Odd CCR analysis of Proposed NavIC L1C secondary PRN Codes

Value of even cross correlation peaks

Max Value in dB

PRN code numbers

Value of odd cross correlation peaks

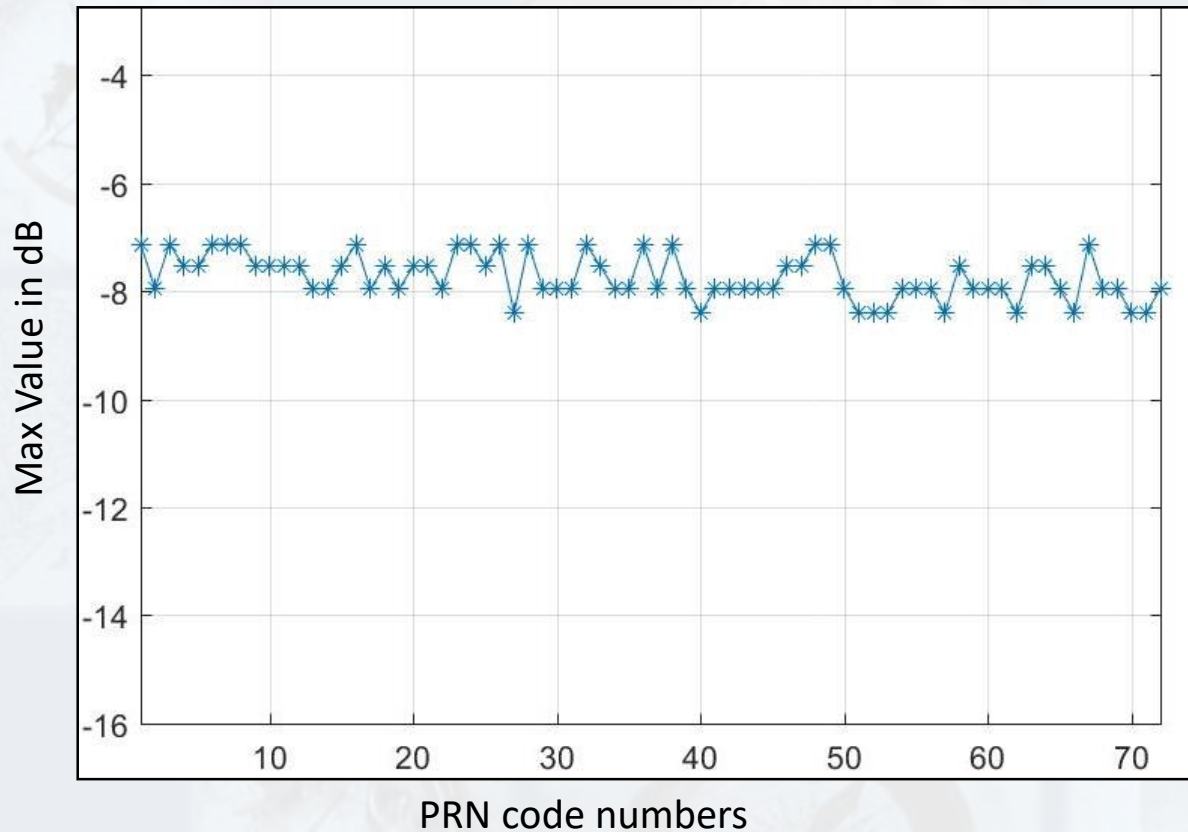Max Value in dB

PRN code numbers

Total PRN codes =72
Code length =1800
Max value of CCR= -20.00 dB

Partial CCR analysis of Proposed NavIC L1C secondary -PRN Codes

Value of segmented partial cross correlation peaks (in dB)

PRN code numbers

Total PRN codes Analyzed =72 PRN codes- length 1800 Each code partially correlated with 1 second sequence(100 chips) code segments of all other codes

Performance Comparison of Proposed Codes With Other GNSS Codes at L1

Code Type/ Properties	GPS L1-C Codes			Beidou B1C Codes			Proposed Codes for NavIC	
Type	Primary PRN		Secondary –overlay codes	Primary PRN		Secondary PRN	Primary PRN	Secondary PRN
length	10230		1800	10230		1800	10230	1800
Generation method	10223 PRN sequence with pad sequence insertion		Truncated M L-codes & Truncated Gold codes	10243 PRN sequence with cyclic truncation		3607 PRN sequence with cyclic truncation	PRN sequence based on Quadratic Residues of prime	PRN sequence based on Quadratic Residues of prime
Maximum ACR side lobe value (in dB)	Pilot -31.2	data -31.2 (Even) -28.03 (Odd)	-22.69 for t-gold codes -24.76 for ML codes	pilot -31.2	Data -31.19(Even) -31.19(Odd)	-25.11	-31.57(Even ACR) -30.04(Odd ACR)	-25.1 (Even ACR) -21.94(Odd ACR)
Maximum CCR Values (in dB)	-27.2 (even) Odd(-26.2)	-27.2	-19.6	-27.45	-27.29 (Even) Odd (-27.2)	-19.90	-27.528 (Even)	-20.0 dB Even -18.1 dB ODD CCR; -19.0 dB with GPS and Beidou
Partial Correlation Values (in dB)100 chip segment	--		-7.13	--		-7.68	--	-6.9dB

Conclusion

- Selection of PRN Codes for future civilian NavIC signal required a search over potential code families with desirable properties
- QR based PRN codes were proposed as candidate codes for NavIC L1.
- Selected codes have similar performance as other GNSS codes in same band
- The selected codes do not degrade the Inter-system cross correlation of other GNSS signals in the same band
- Proposed codes have reasonable odd correlation performance as well.

Thank You