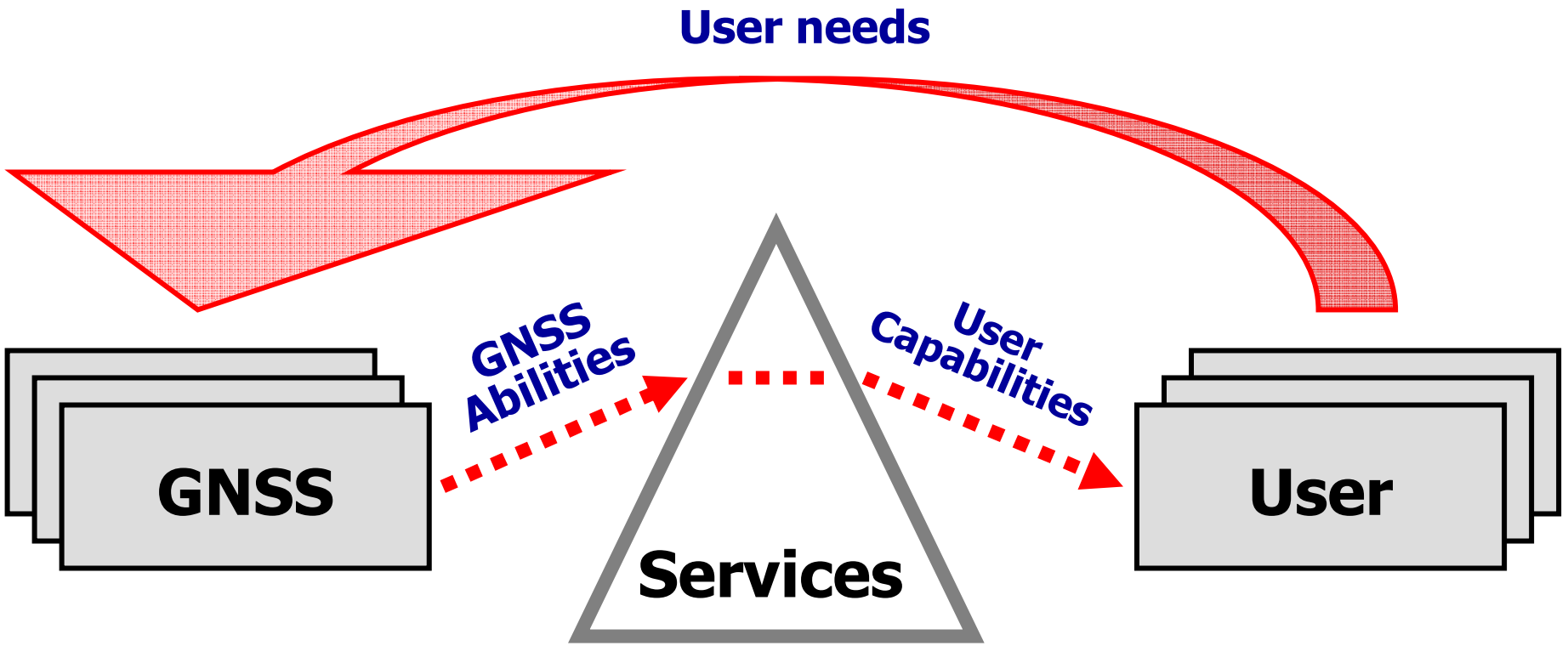
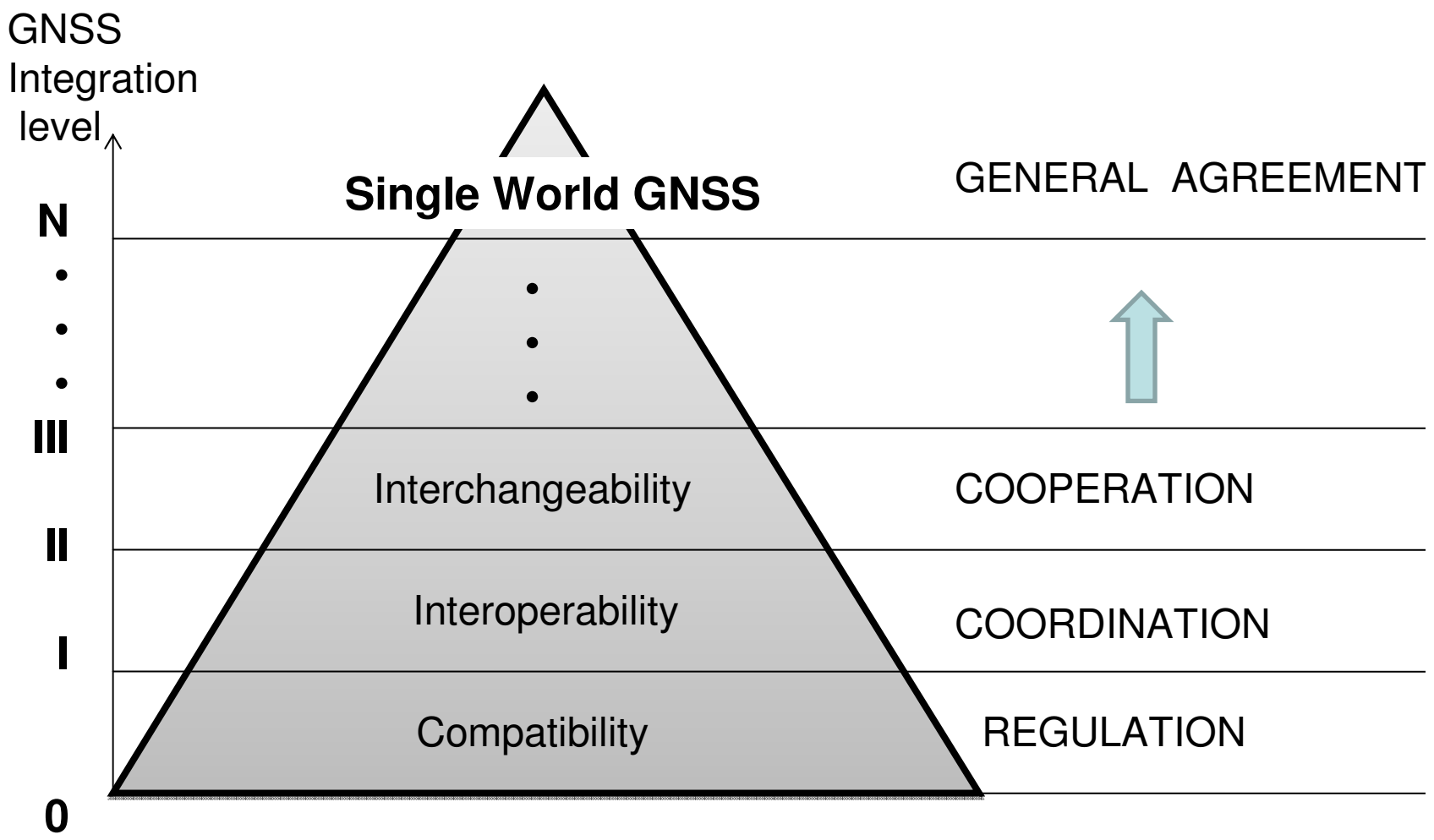
The Russian Federation View on GNSS Compatibility and Interoperability

Approach Logic



System abilities are projected to user capabilities

Levels of GNSS Integration (Harmonization)



Why reconsider definitions?

Benefits of the proposed approach:

- Universal approach applicable to both existing and future systems
- Not directly dependent on the technical solutions
- Allows to coordinate compatibility and interoperability issues both bilaterally and multilaterally taking into account international regulations such as ITU and others

Compatibility

- The basic principle of compatibility is
  - **«Do Not Harm!»**
- *Compatibility* refers to the ability of global and regional navigation satellite systems and their augmentations to be used together or separately without causing mutual interference

"Compatibility" is applicable to systems, not services

Compatibility (2)

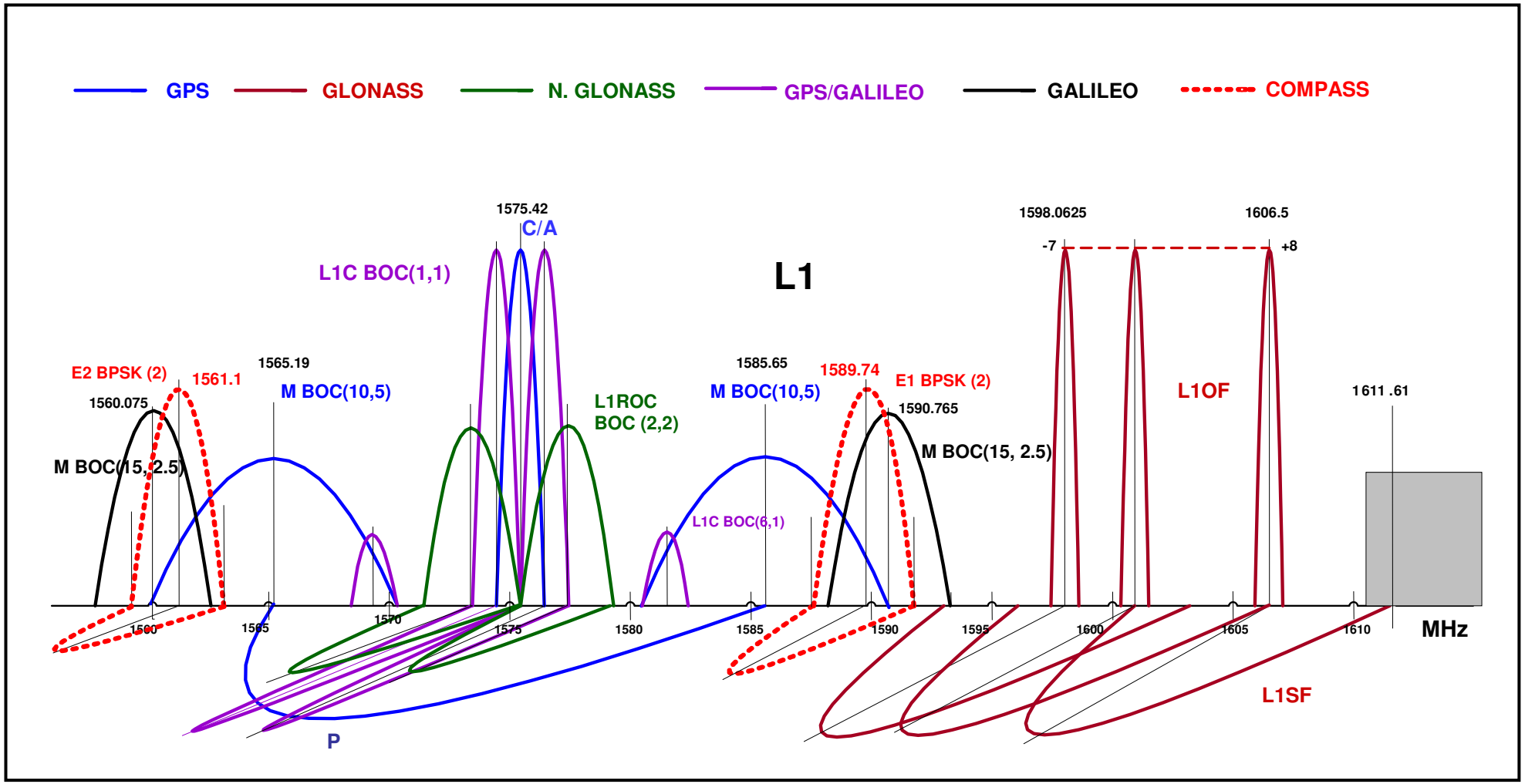
(ii) Compatibility principle (as of Bangalore):

- *"(ii) Compatibility should also involve spectral separation between each system's authorized service signals and other systems' signals"*

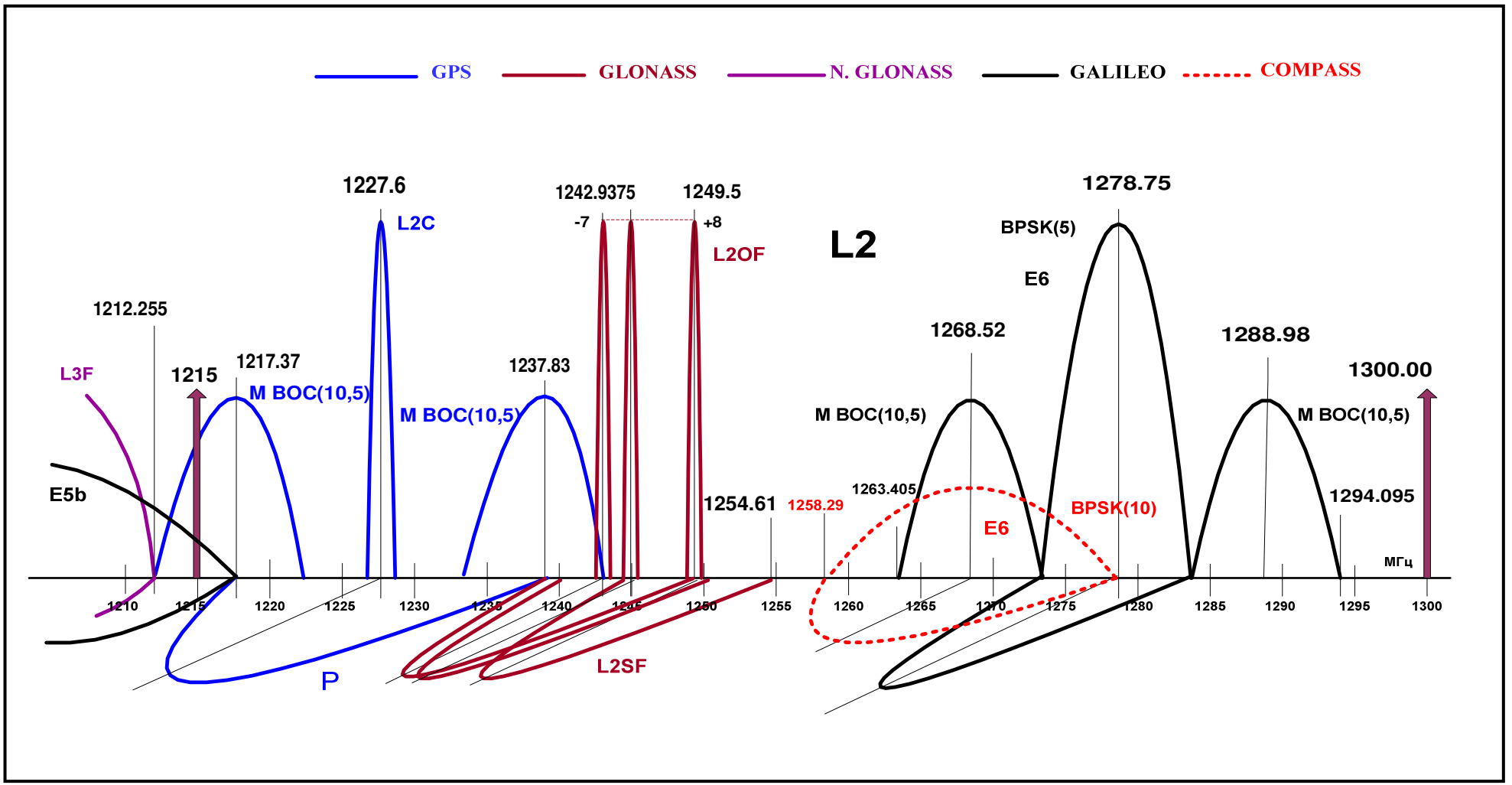
***DOUBTS*:**

- Frequency spectrums are unlimited. What is the separation level?
- Now there are some cases of spectral crossing between authorized service signals (ASS) (systems: GPS, GLONASS, GALILEO, COMPASS; bands: L1, L2, L5/L3)
- Request of separation applies sizeable restrictions on new systems and modernization of existing systems
- Path of frequency band declared for ASS one of system can not to use the other systems
- Signal modernization will find difficulty in spectral crossing intervals

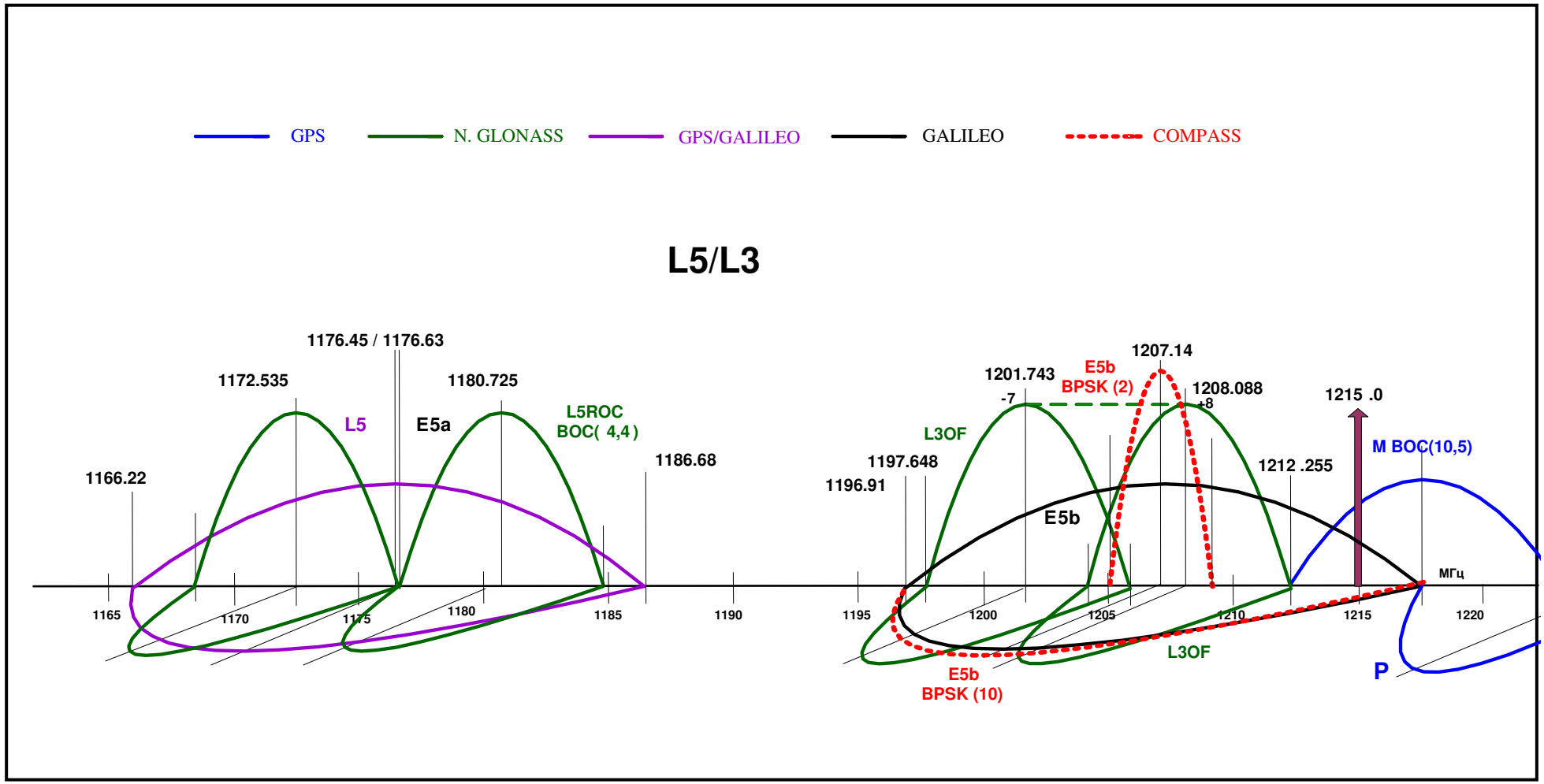
Compatibility (3)



Compatibility (4)



Compatibility (5)



Possible solution

Compatibility refers to the ability of global and regional navigation satellite systems and their augmentations to be used together or separately without causing mutual interference

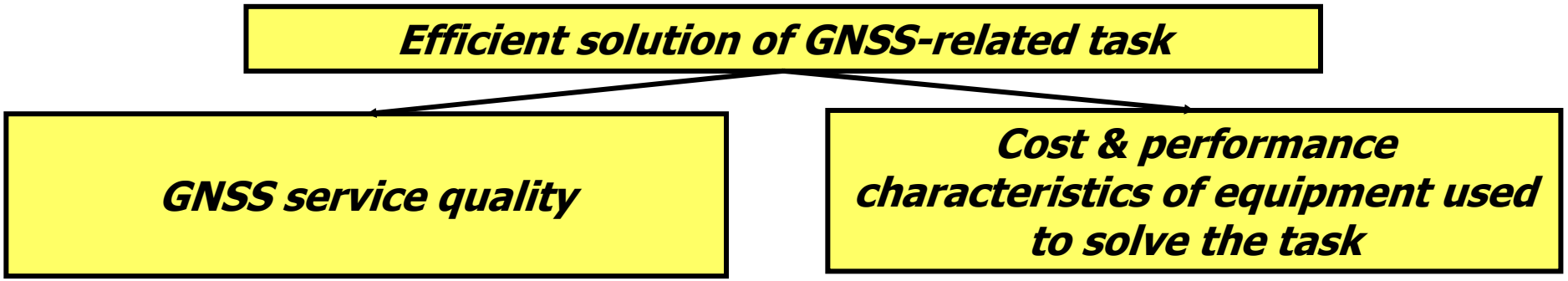
- Radiofrequency compatibility is the basis for system compatibility. ITU provides radiofrequency compatibility within the framework of agreed procedures and criteria.
- Any additional solutions to improve compatibility should be encouraged within the framework of the ITU.

GNSS Interoperability

- The basic principle of interoperability is

  «Better Together Than Separate»

- *Interoperability* referred to the ability of global and regional navigation satellite systems to be used together to provide better capabilities at the user level than would be achieved by relying solely on signals of one system



Quantitative Evaluation of GNSS Interoperability

- **Parameters of solution quality (P = performance):**
  - positioning accuracy
  - availability, particularly in cities and mountainous areas
  - reliability of service (robustness in conditions of interference,…)
  - responsiveness (time to establish connection)
  - …
- **Cost & performance characteristics (C = cost):**
  - cost
  - power consumption
  - weight
  - dimensions
  - …

A quantitative evaluation of GNSS interoperability:
increase of important for a given user efficient GNSS solution characteristics when several GNSS are used

Initial Data

$P_{К}^{j}$ = **j** th component of performance when **К** th GNSS is used;

$P_{К,С}^{j}$ = **j** *th* component of performance when both **Кth** and **Сth** GNSS are used;

$C_{К}^{i}$ = **j** th component of cost when **К** th GNSS is used;

$C_{К,С}^{i}$ = **j** *th* component of cost when both **Кth** and **Сth** GNSS are used.

Hereafter: **j = 1 … J**

J – number of performance components

i = 1 … I

I – number of cost components

$1 < К < N$; $1 < С < N$; $К \neq С$;

N – number of available GNSS

Quantitative evaluation of GNSS Interoperability Algorithm

1. Evaluation of absolute and relative change in cost and performance characteristics when several GNSS are used:

$$\Delta P^{j}_{к,с} = P^{j}_{к,с} - P^{j}_{к} \qquad q^{j}_{к,с} = \frac{\Delta P^{j}_{к,с}}{\Delta P^{j}_{к}} \times 100\%$$

$$\Delta C^{i}_{к,с} = C^{i}_{кс} - C^{i}_{к} \qquad s^{i}_{к,с} = \frac{\Delta C^{i}_{к,с}}{\Delta C^{i}_{к}} \times 100\%$$

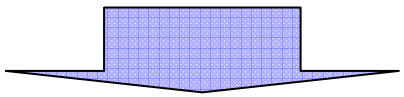
2. Determination of significant for a given **m**th user cost and performance components and evaluation of surplus $Q_{к,с}$ when both **к**th and **с**th GNSS are used:

$$Q_{кс} = F\left\{ \alpha_j \times \Delta P^{j}_{к,с};\ \beta_j \times \Delta C^{i}_{к,с} \right\}_{j,i},$$

where $\alpha_j, \beta_j = \begin{cases} \textbf{1 – for non-significant components;} \\ \textbf{0 – for significant components.} \end{cases}$

Interoperability Logic

- Consumer
- Performance and Cost characteristics
- Quantitative evaluation of GNSS interoperability algorithm
- Priorities in Performance and Cost characteristics for users. Aims. Criteria
- GNSS technical solutions able to meet consumers' demand
- Evaluation of GNSS interoperability
- Recommendations to GNSS providers



GNSS Interoperability Evaluation Example

- Signals:
  - GLONASS-K (w/o L1C, with full set of new signals in L1, L2, L3)
  - GPS-III (w/ L1C)
  - Galileo (w/ L1C)
- Almost the same availability and accuracy parameters
- For example, 3 consumer types are considered:
  - mass consumer with one-frequency L1 receiver (individual autonomous receiver)
  - mass consumer with two-frequency (L1,L2) receiver with external power (individual vehicle navigation)
  - consumer with high passenger safety requirements (aviation, marine fleet, railway)

Evaluation Data Source Table

		GPS	GPS+GAL			GPS+ГЛОНАСС		
Mass consumer	P_1 - accuracy	2 m	1,8 m	P_1 = 0,10	α_1 = 1	1,8 m	P_1 = 0,10	α_1 = 1
	P_2 - availability	60 %	90%	P_2 = 0,67	α_2 = 1	90%	P_2 = 0,67	α_2 = 1
	P_3 - reliability of service	70 %	70%	P_3 = 0,15	α_3 = 1	80 %	P_3 = 0,20	α_3 = 1
	P_4 -responsiveness	5 s	5 s	P_4 = 0,50	α_4 = 1	6 s	P_4 = 0,55	α_4 = 0
	C_1 - price	50 $	50 $	C_1 = 1,50	β_1 = 1	80 $	C_1 = 1,80	β_1 = 1
	C_2 - weigh	70 g	70 g	C_2 = 1,10	β_2 = 0	90 g	C_2 = 1,30	β_2 = 0
	C_3 - dimensions	30 mm	30 mm	C_3 = 1,70	β_3 = 0	35 mm	C_3 = 1,80	β_3 = 0
	C_4 - power consumption	100 mW	100 mW	C_4 = 1,50	β_4 = 0	120 mW	C_4 = 1,65	β_4 = 0
			Efficiency surplus					

GNSS interoperability evaluation example

GNSS Interoperability Evaluation

- **mass individual consumer :**
  - Galileo/GPS interoperability measure according to minimum receiver price criterion is 1,2 times higher than the same for GPS/GLONASS. However, GPS/GLONASS interoperability measure according to robustness criterion is 1,3 times higher than the same for GPS/Galileo
- **mass vehicle navigation consumer:**
  - GLONASS/GPS and GALILEO/GLONASS interoperability measure according to availability in cities criteria is almost the same
- **consumer with high passenger safety requirements (aviation, marine fleet, railway)**
  - GLONASS/GPS interoperability measure according to reliability criterion is 1,35 times higher than the same for GPS/GALILEO

Recommendation to WG-A outputs

- Continue to refine definitions of different GNSS integration levels
- Elaborate possible ways and procedures of system collaboration on different integration levels
- Adjust methods of quantitative evaluation of GNSS compatibility and interoperability
- Conduct two WG-A interim sessions (February, June in 2009) before ICG-4 to converge approaches