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Design experience of new generation river-sea cargo vessels

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UNECE
Inland Transport Committee

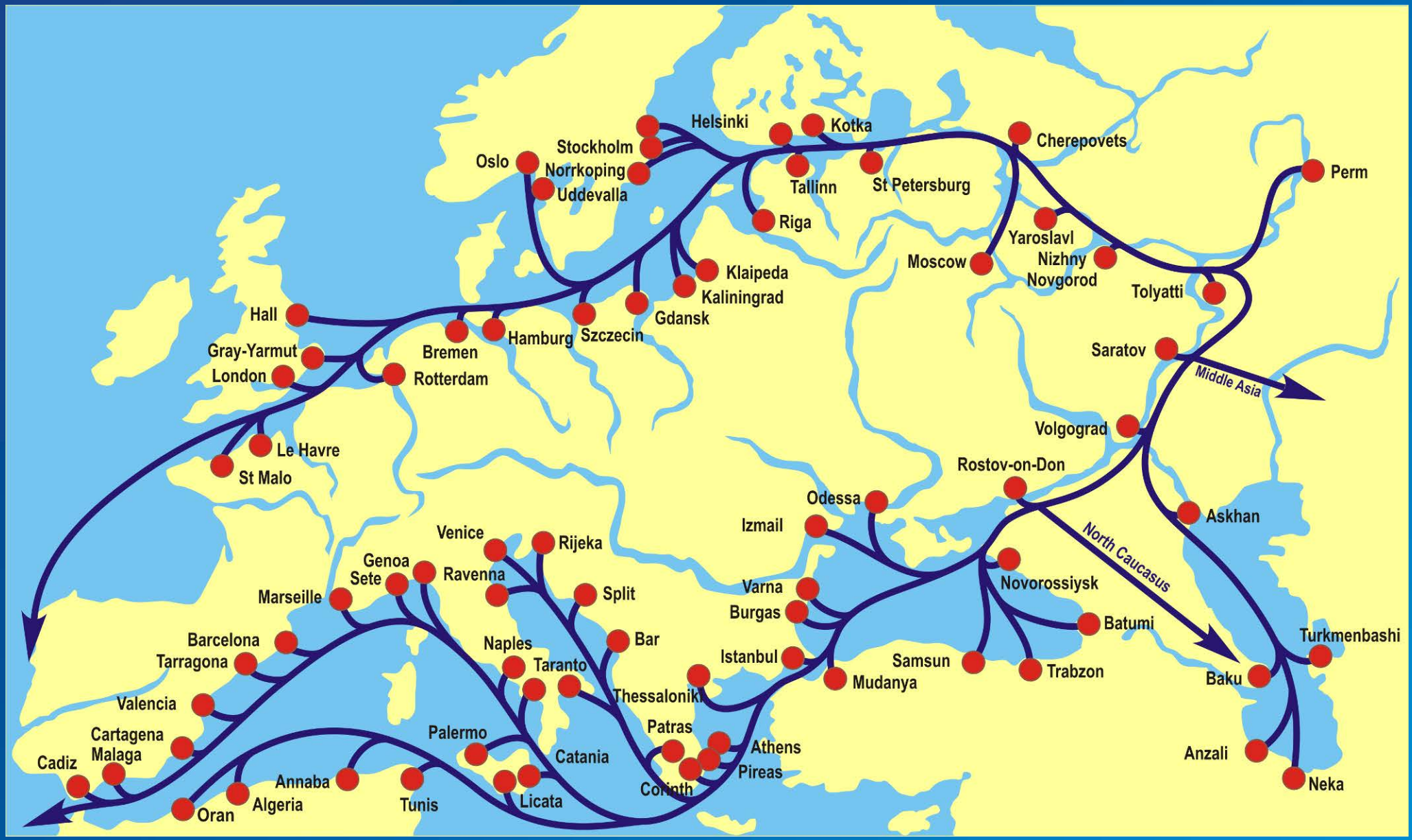
Working Party on the Standardization of Technical and Safety Requirements in Inland Navigation (50th session)
February 15th - 17th, 2017, Palais des Nations - Geneva, Switzerland

Russian inland waterways

EUROPEAN PART:

Cities	103
Reservoirs	14
Hydro-systems	17
Islands	4
Channels	6
Gulfs	3
Rapid	1
Bridges	33
Lakes	5
Rivers	20

Coasters and river-sea vessels routes in Europe



River and river – sea perspectives

River transport market is growing; its efficiency is bigger than for car and rail way transportations. OSC “Russian Railways” charge rates growth provides new clients inflow for river transportation. Besides Russian rail way transport transfer capability has known limit, and it becomes reached in some causes. Especially this takes place in summer seasons when additional passenger trains are provided for south directions.

Though even big river shipping companies have faced difficult or will face them in the nearest time. Cargo transportation structure changes, so carriers need for fleet update. Only very big companies are able to effect such changes.

More than 80% of vessels which are assumed for building for Russian shipowners also are of river-sea type, and changing of this parity in nearest years is not expected.

River – sea shipping in Russia

In addition to foreign transportations, river-sea navigation vessels (RSV) provide execution of the most important task of north regions supply

Roads cargo transfer from RSV to marine vessels, which is widely applied in the south and the north-west OF Russian Federation is another modern direction of RSV usage.

In world marine practice (USA, England, Denmark, Norway, Egypt, etc.) such operations are named as scheme of “ship-to-ship" or STS operations

The STS scheme of oil reloading from river-sea going vessels to marine vessels with use of storage tankers gives an opportunity to form larger cargo parties for marine tankers with displacement of 100-150 thousand tons. Regulations for road reloading complexes are developed in order to provide safety of STS operations. These Regulation required strict fulfillment of the Russian ecological legislation and usage of worldwide experience that reduces to a minimum risks of environmental contamination.

Sulfur, grain and mineral fertilizers also are trans-loaded through road reloading complexes. The steady export channel of Russian products which is bringing stable income in the budget of Russian Federation.

Dynamics of cargo river-sea vessels quantity

Register class notation	2007 units	2010 units	2016 units	Withdrawal, units
RS R1	320	304	231	-89
RS R2	265	231	229	-36
RS R2-RSN	584	471	397	-187
RS R3-RSN	272	182	115	-157
RRR M-SP	369	347	212	-157
RRR M-PR	372	347	351	-21
RRR O-PR	312	237	190	-122
Total	2494	2119	1725	-769

Age of transport vessels in accordance with Russian River Register database as on October 2016

Fleet type	Age group					Total
	< 10 years	10-20 years	21-30 years	31-40 years	> 40 years	
Distribution in accordance with age groups						
Self-propelled dry-cargo, units	15	3	124	248	467	857
Non-self-propelled dry-cargo, units	94	70	1041	1802	1183	4190
Self-propelled tanker, units	18	3	65	195	371	652
Non-self-propelled tanker, units	17	50	210	241	174	692
Passenger, units	192	89	189	364	502	1336
Tug-pusher, units	39	9	471	1192	1019	2730
Craft, units	61	49	380	439	787	1716
Total, units	436	273	2480	4481	4503	12173
Age structure of fleet						
Self-propelled dry-cargo, %	1,75	0,35	14,47	28,94	54,49	100
Non-self-propelled dry-cargo, %	2,24	1,67	24,84	43,01	28,23	100
Self-propelled tanker, %	2,76	0,46	9,97	29,91	56,9	100
Non-self-propelled tanker, %	2,46	7,23	30,35	34,83	25,14	100
Passenger, %	14,37	6,66	14,15	27,25	37,57	100
Tug-pusher, %	1,43	0,33	17,25	43,65	37,33	100
Craft, %	3,55	2,86	22,14	25,58	45,86	100
Total, %	3,58	2,24	20,37	36,81	36,99	100

Source: Russian River Register

What do you do?

Design of new vessel projects for transportation of different cargoes in European part of Russian inland waterways and building of such vessels is strategically important problem in view of Russian export/import relations development and strengthening Russian geopolitical position.

Most of all there are required dry-cargo vessels and tankers which have to change old “Volgo-Don” and “Volgoneft” vessels on the lines which are oriented for transportation of raw cargoes from Russian river ports to trans-shipping complexes at Gulf of Finland and Kerch Straits. New vessels have to differ in quality from existing ones which ideology was developed in 50-s of last century in such directions as high efficiency, ecology and reliability. This designs have to “solve” problem moments such transport queues under Neva bridges and under Rostov bridge.

Transition to qualitatively new level of transportation organization for water transport is needed.

What differs new generation?

Certainly, for ship owners new ships should be the best in the class. Clearly, that for achievement of the greatest economic benefit of operation of the cargo ship, it is necessary, that the vessel had the greatest possible carrying capacity.

For RSV, main dimension are limited by conditions of internal waterways.

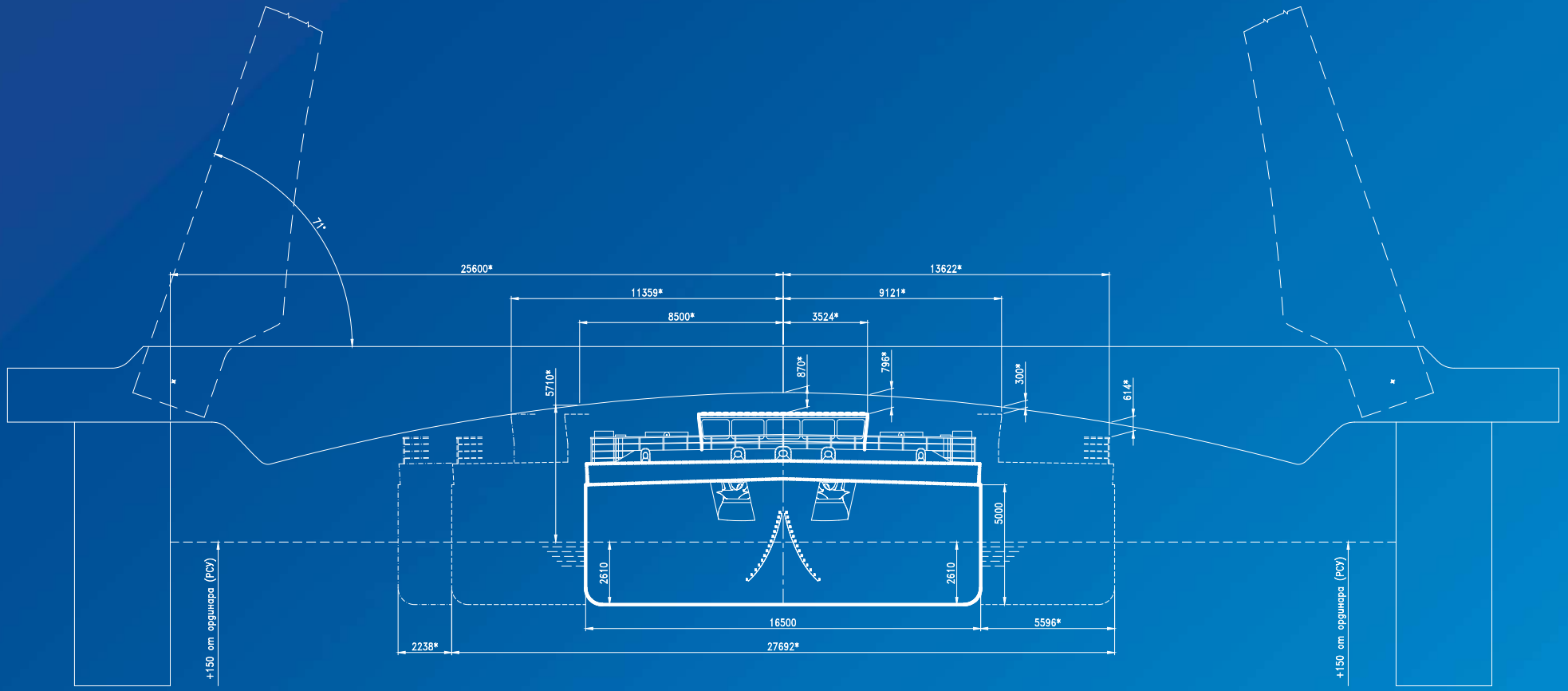
Foundation of new concepts

To our opinion, new generation of RSV for Russian inland waterways will be characterized by the following features:

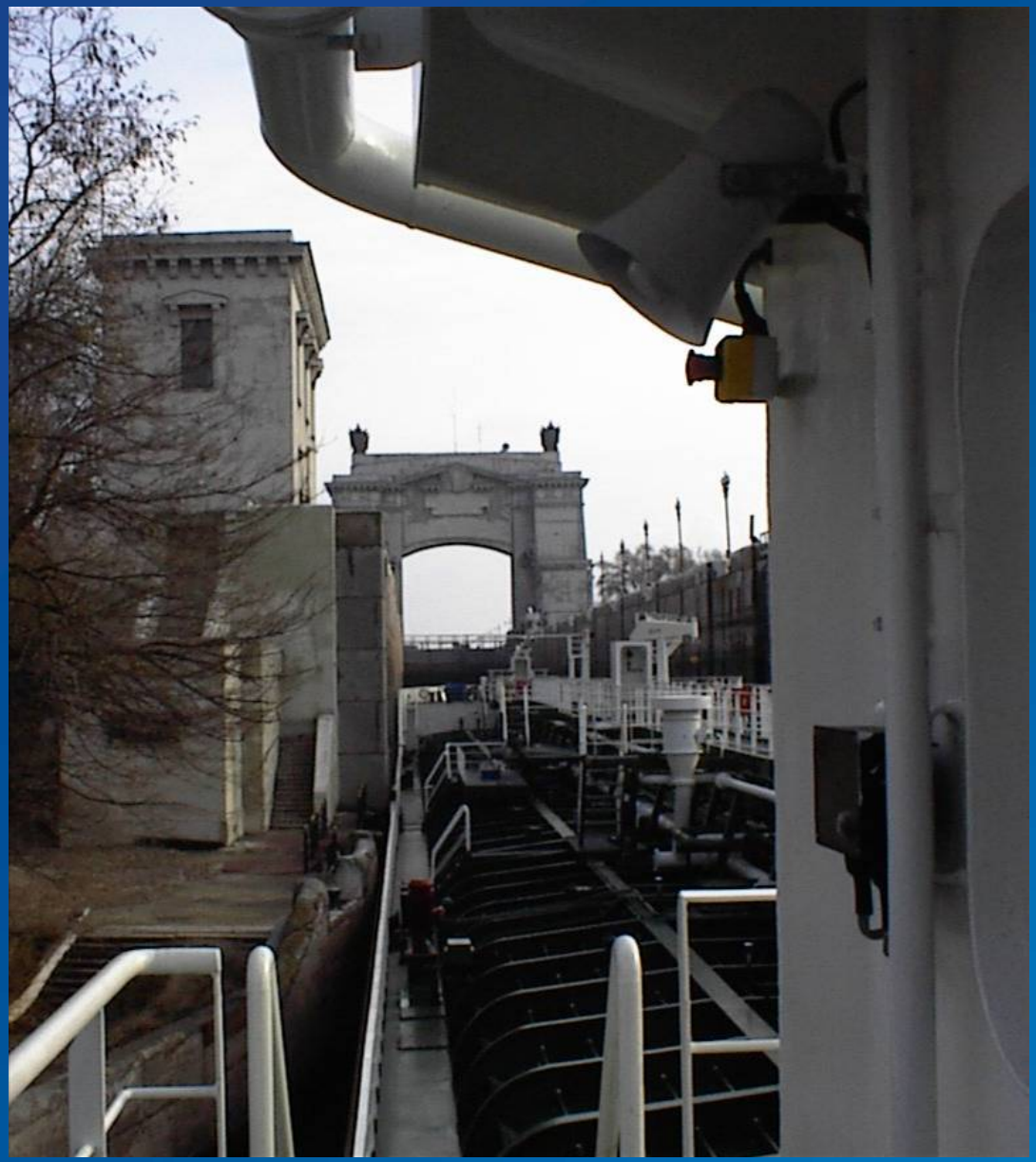
1. Due to main dimensions. Way restrictions of operational region are determinative

Vessel's class		Overall length L_{M}, m	Overall breadth B_{M}, m	Draught d, m	Air draught $H_{\text{НГ}}$, m
«Volgo-Balt Max»		185	16.95-20.1	2.90-3.80	13.2
«Volgo-Don Max»		140	17.0	3.20-3.70	13.2
«BBK Max»		132	13.63	2.90-3.80	11.9
«Danube Max»	Danube - Passau	135	13.40	2.00-2.50	6.7
	Upstream Passau*	135	11.45	1.70-2.00	6.03
*including pass-through to Northern Sea (Danube-Main- Rhine system)					

Scheme for dimensions defining for vessel's transverse section depending on the sizes of the bridge span



“Volgo-Don max” class tanker passes the lock with minimal permissible clearance



New vessel of Marine Engineering Bureau (MEB). RSD44 project passes under the Blagoveshchensk bridge in St. Petersburg

Hull form

There is quite natural question - what is the limit of block coefficient increase for a vessel of the mixed the river - sea navigation?

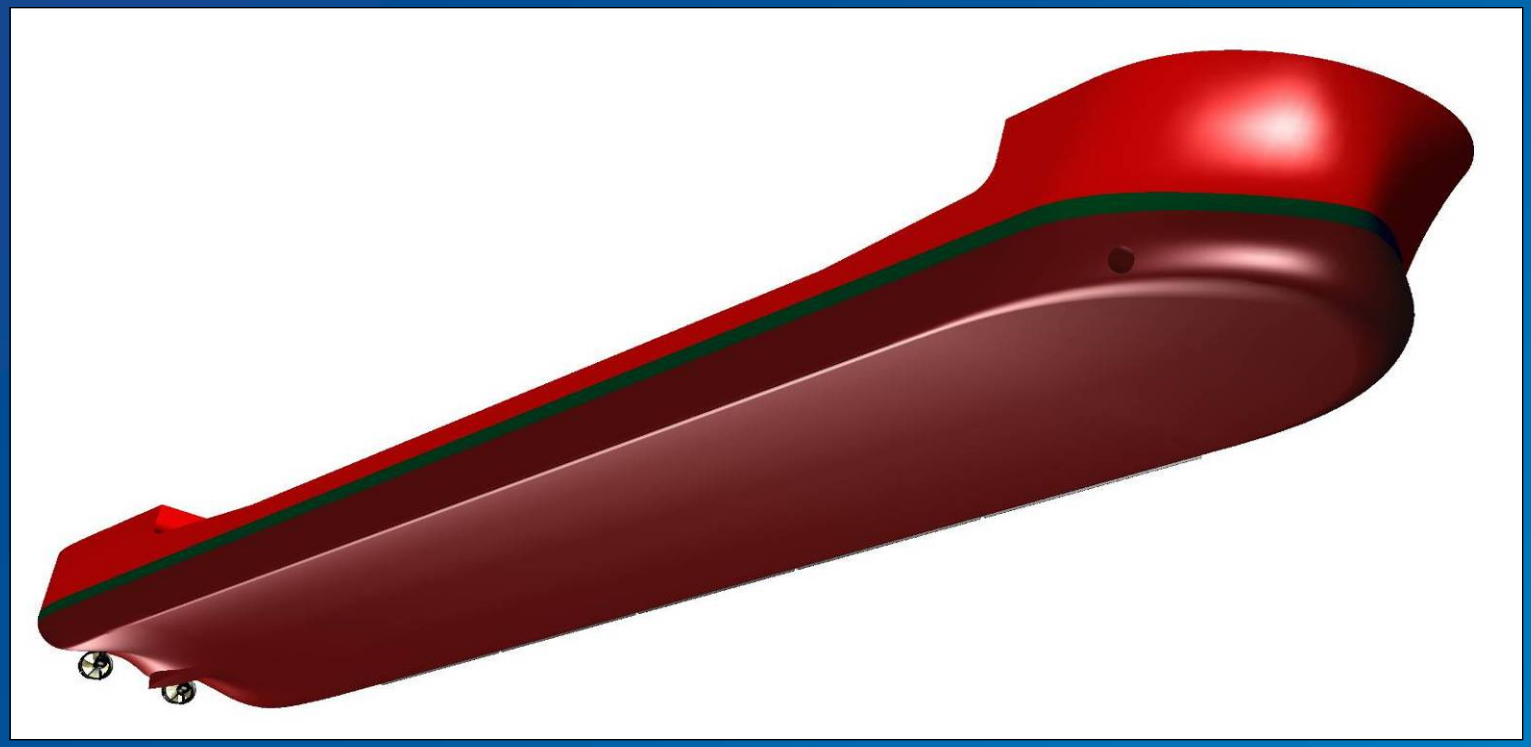
The task was solved in structure of research work on creation of shape of perspective ships of the internal waterways and mixed navigation in frameworks of Research Program «Development of Merchant Marine for 2009-2016».

The theoretical case of a vessel with block coefficient 0,93 had been specially developed. The bulbous bow form, transom aft, with half - tunnels and a skeg were applied.

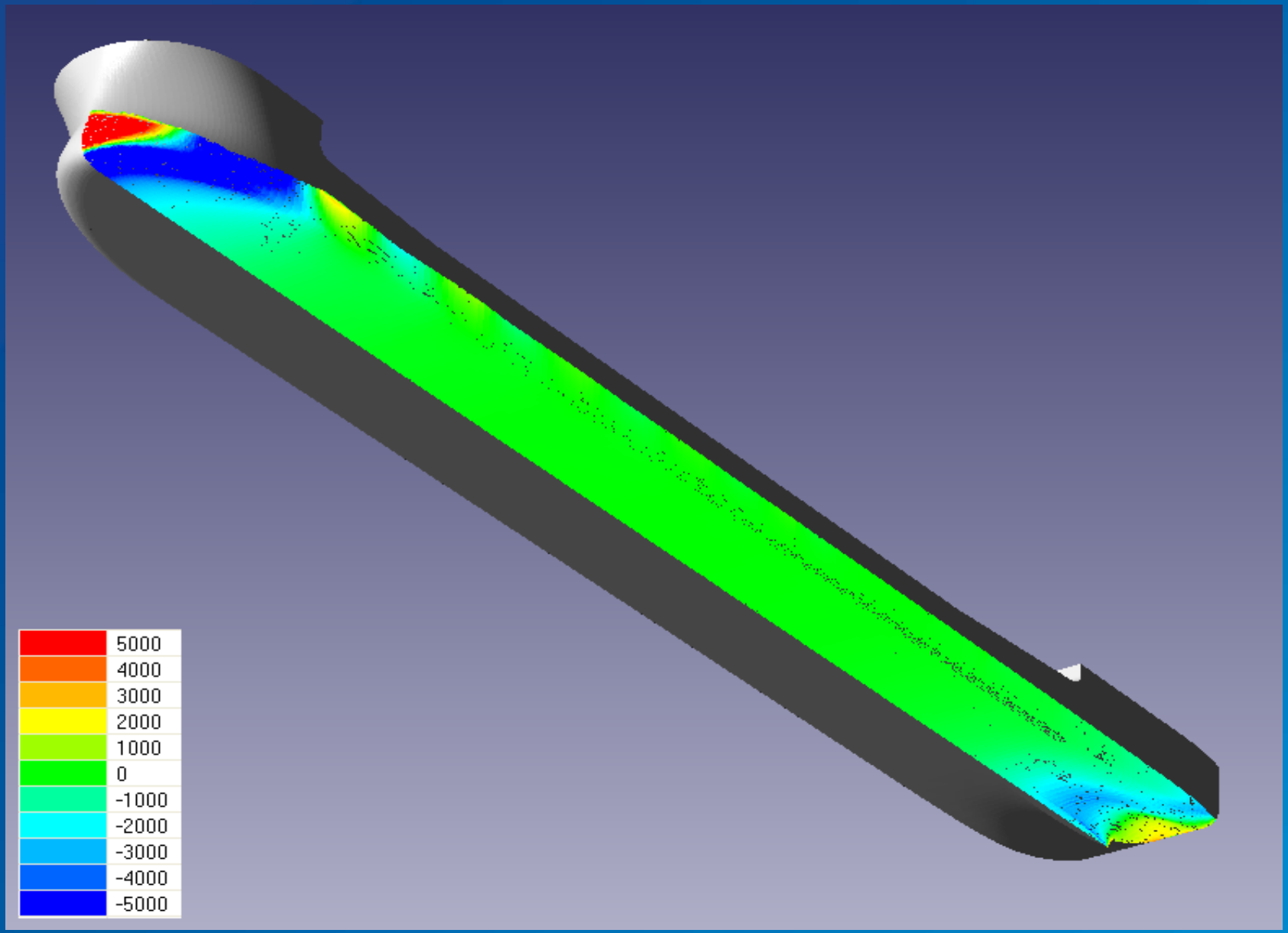
3D model of vessel hull with appendages was prepared for numerical investigation of towage characteristics on still water and wave.

For CFD calculations validation model towing test carried out in the deep-water tank of Krylov State Research Center with model's scale 1:16.

General view of virtual and test models

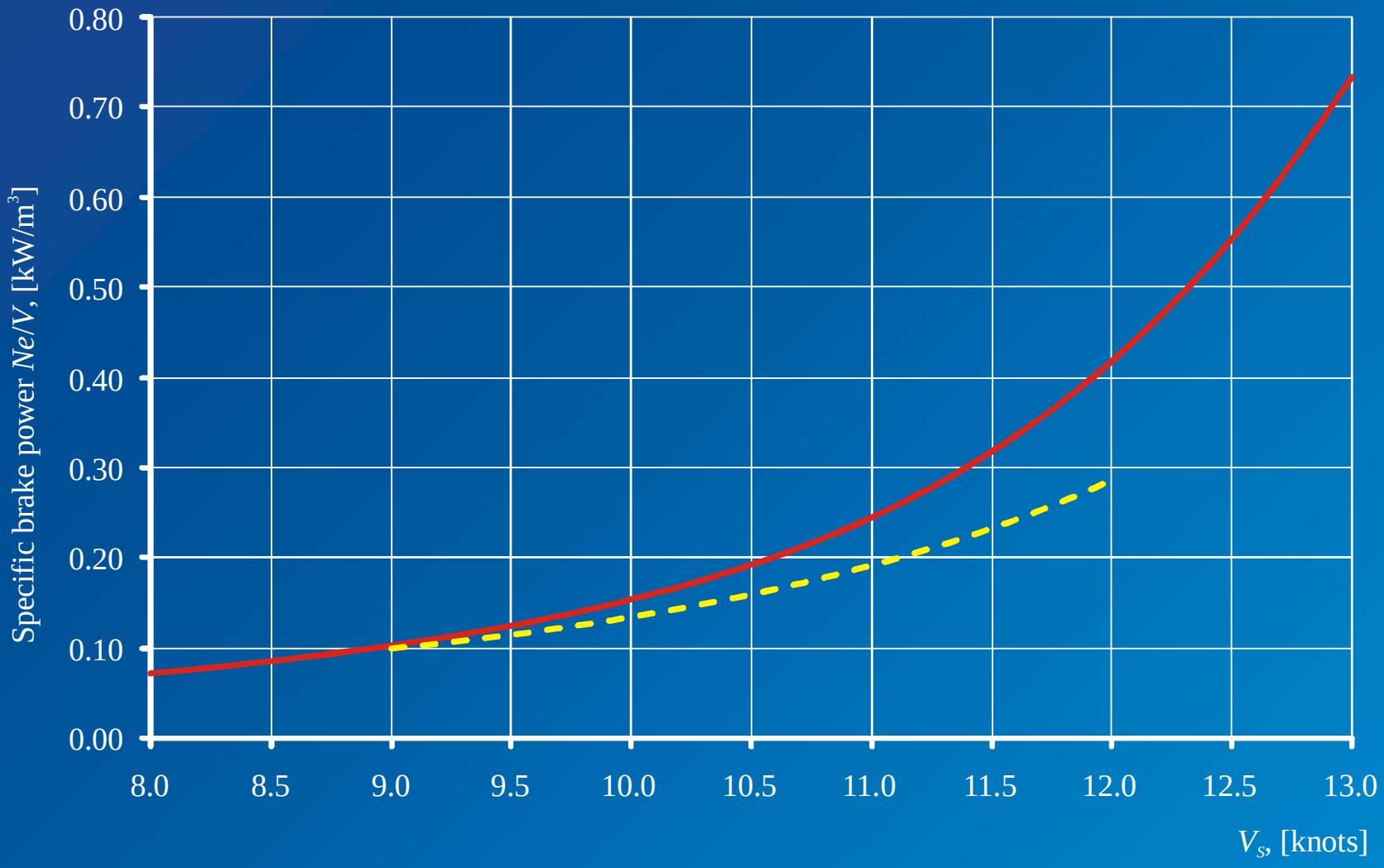


Distribution of pressure without hydrostatic component (Pa). Fore view. Speed 10 kn



Waves generation during model towing

Comparison of specific effective power for ships with “normal” hull form and extremely high block coefficient Cb



Results of model tests

- Comparing experimental relation of residual resistance factor C_R due to Fn for normal (C_B = 0.90) and fat (C_B = 0.93) forms also showed that for cargo loading C_R value is very close for both vessels.
- In accordance with tow tank model tests for full loaded condition fat vessel has towage power P_E only for 4% bigger than usual vessel with C_B = 0.90. In ballast condition P_E value for fat tanker is higher then for normal vessel; at speed of 10.5 kn difference is ~80 kW (about 13%).
- The main conclusion of researches – raising of Block Coefficient (for range of values 0,88…0,93) have a little influences on required power on typical for ships of mixed river sea navigation speed of 10.5 knots.
- These results are very important; it means that Block Coefficient for river-sea vessels may be increased up to 0.93 As it has been realized by Marine Engineering Bureau in RST27, RST54, RSD59, RST12 projects.

Results of sea trials

Photo: Sergey Morozov

Sea trials have shown an excellent maneuverability of the vessel and good performance. A vessel of project RST27, having record block coefficient of the hull form 0.93, has shown speed of 11.7 knots on a measured line at power on shaft of 2100 kW (0.875 from maximum main engines power) and at bow draught of 3.2 m, aft 3.3 m.

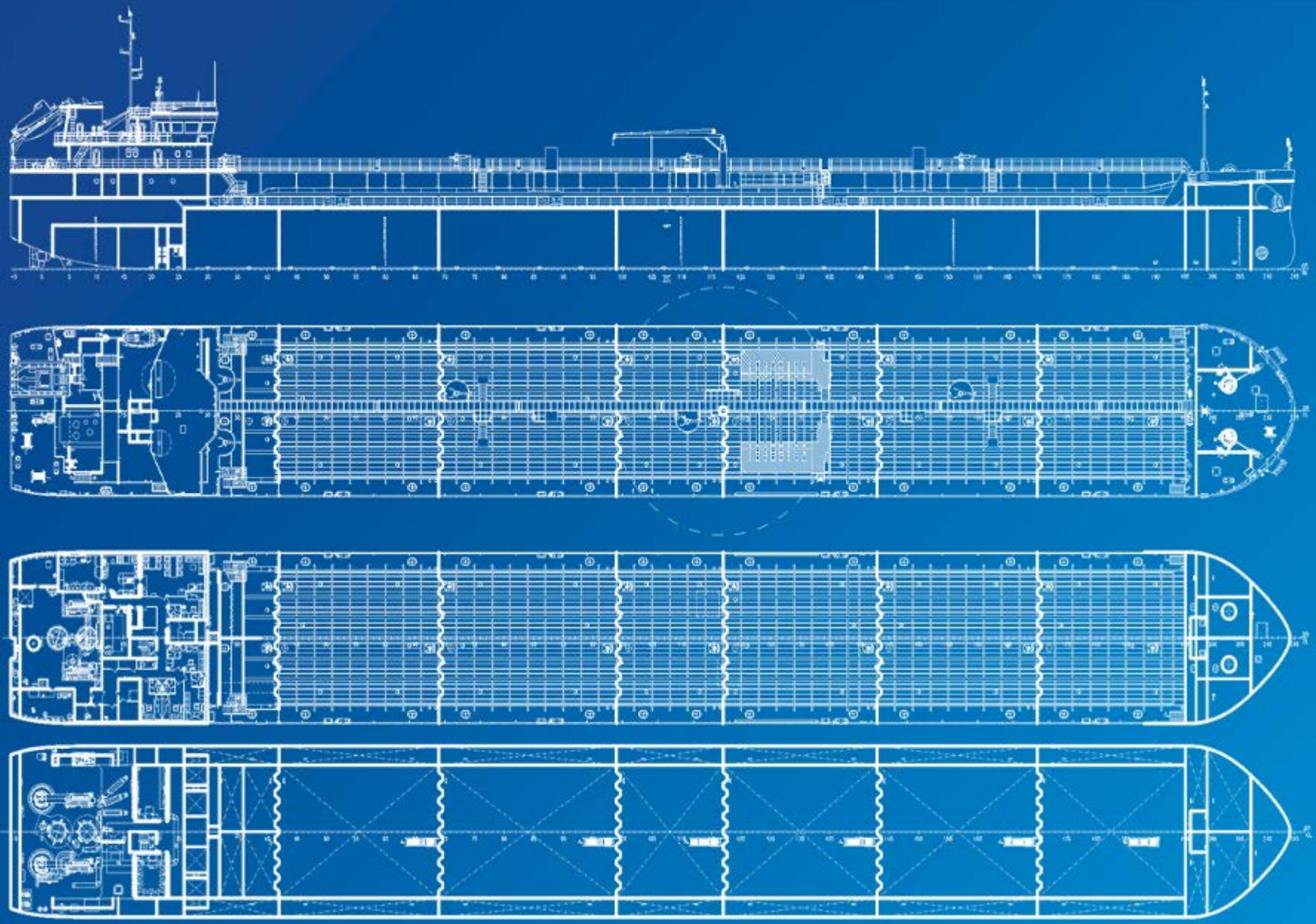
Is proved the chosen main engines power and the advanced forecastle and aft superstructures have provided seaworthiness in conditions with height 7.0 m of wave 3 % probability.

Our conclusions about *Cb*

- **Effect of raised values of Block Coefficient (in the range 0.88…0.93) is insignificant for typical for river-sea ships operational speed of 10 kn**.
- This conclusion is very important; it means that Block Coefficient for river-sea ships may be increased up to 0.93.
- Finding theoretical results let Marine Engineering Bureau create new project of the "fat" river-sea going tanker (RST27); tanker's deadweight is of 5520 t at the river draught of 3.60 m. One may compare with RST22 tanker which has river deadweight about 4700 t while classes of both tankers are equal.

“Extra-full” tanker of “Volgo-Don max” class of RST27 MEB project, put into operation in 2012-2017 35 vessels, 8 more are under construction, including 1 modernized tanker of RST27M project

General arrangement of RST27 vessel with block coefficient 0,93



Features of new generation tankers of RST27 project

The concept of tankers of RST27 project is formulated as follows: the tanker with full use of limited dimensions of Volgo-Don Channel, greatest possible block coefficient from positions of propulsion efficiency, with increased carrying capacity in the river and the raised strength standard of ship's hull for sea operation, the raised tank capacity at minimally possible hull depth, raised maneuverability in constrained conditions, in locks, channels and on shallow waters.

Ships should operate in conditions of the Azov, Caspian Seas and Volgo-Don Channel so positioned it as «Volgo-Don max» class tankers.

“Armada” type tanker – 31 vessels have been delivered since 2002 (005RST01, RST22, RST22M)

Comparison of characteristics of river-sea tankers

Vessel of RST27 project has the maximal deadweight in the river, and the difference with nearest modern "competitor", a vessel of project RST25, makes about 200 t. In comparison with “Volgoneft" type tankers deadweight in the river already is more by 528 tons, and in the sea by 2141 t.

Besides "Volgoneft" use diesel fuel, and modern ship - heavy fuel which cost practically twice is less. The tanker of project RST27 has the weight parameter insignificantly distinguished from tankers of projects RST25 and 550A that speaks about rational designing case designs. To all other, tankers of project RST27 can be maintained in areas R2 (with a wave in height up to 7,0 m) and have the much greater block coefficient of the hull form (parameters of deadweight at various draughts).

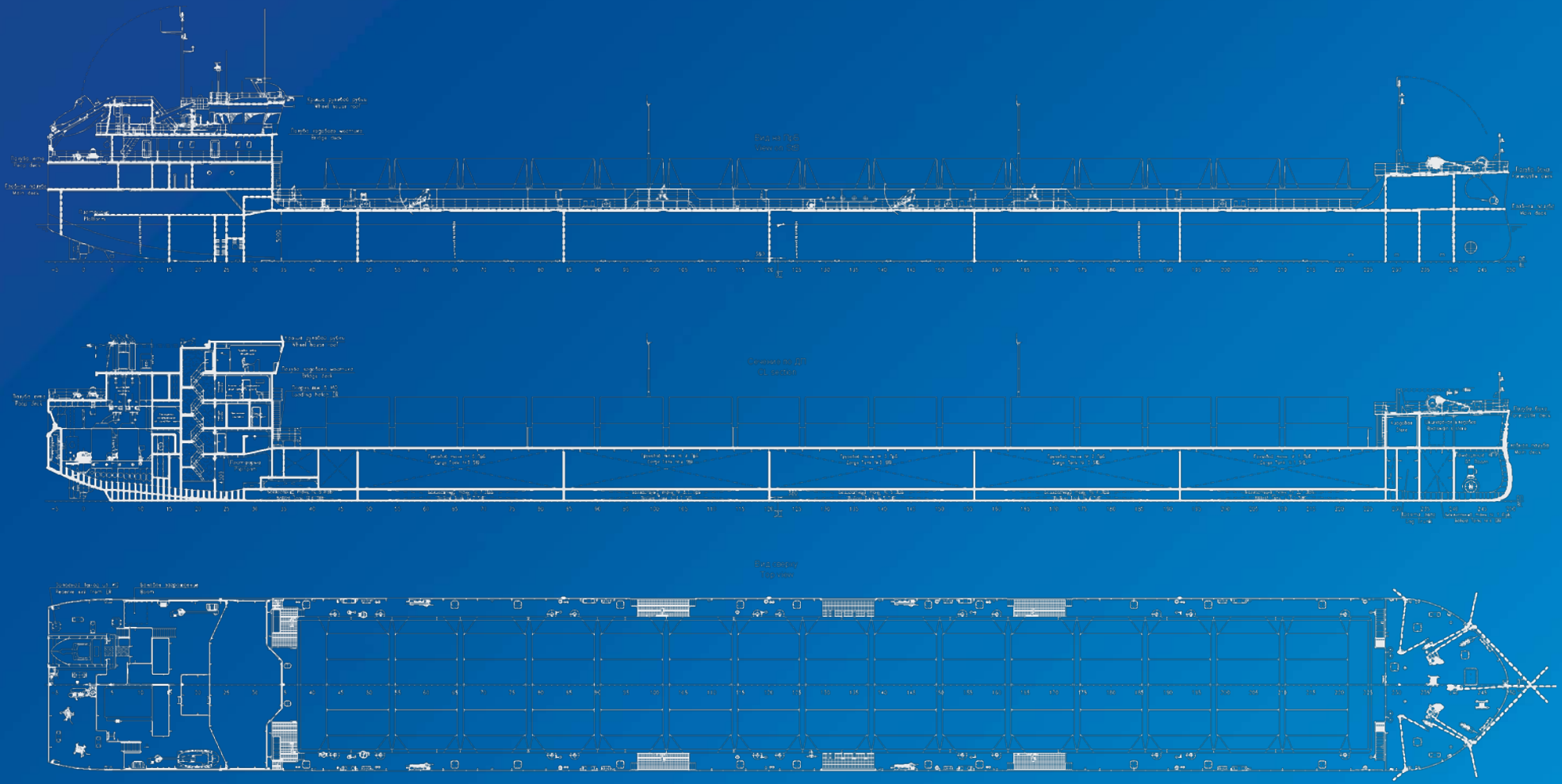
Tanker of RST25 project – 7 have been built since 2010, 2 vessels are under construction

Photo: Pavel Yemelyanov

Combined (tanker – dry-cargo) vessel of RST54 project – 7 have been built since 2014

Photos: Alexander Konov, Pavel Pheklistov

General arrangement of RST54 vessel with block coefficient 0,93

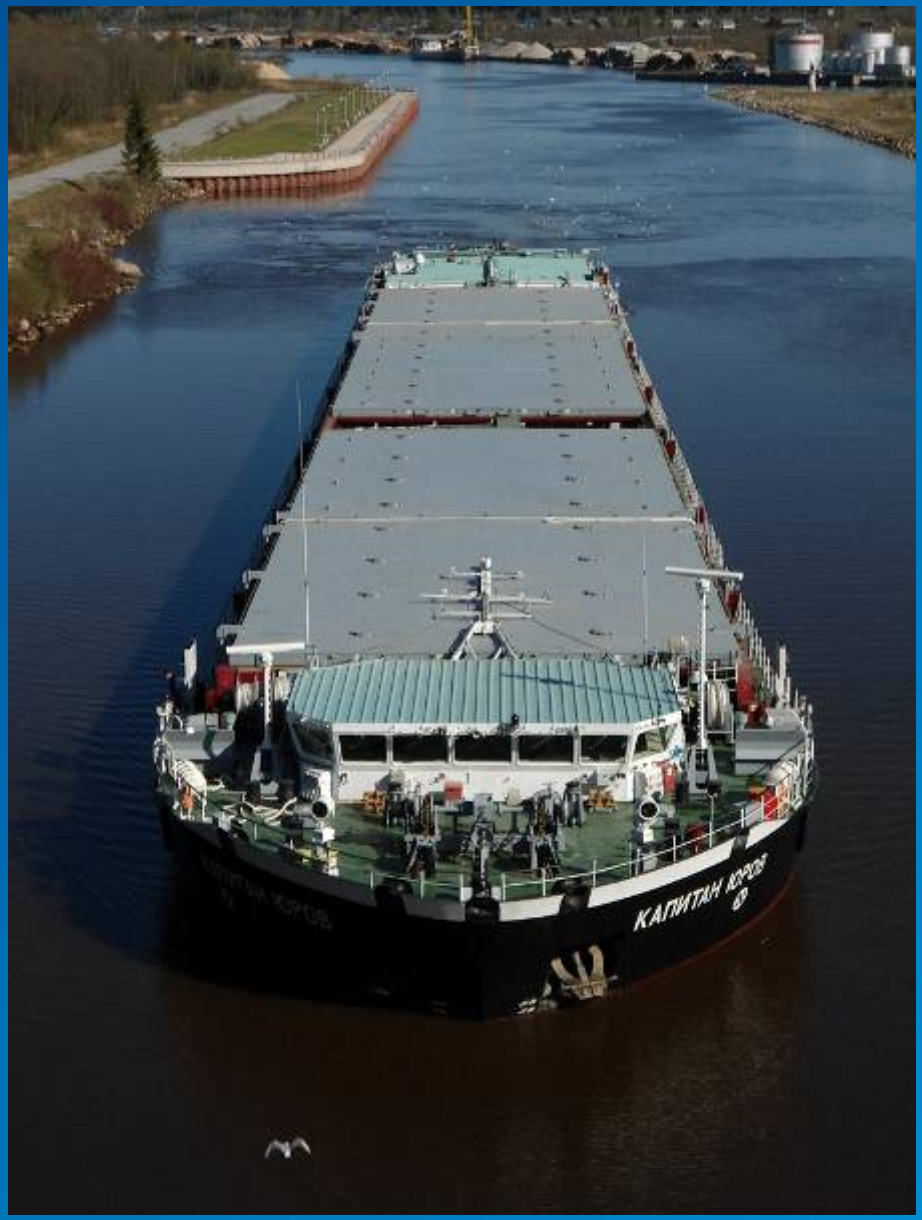


5499 DWT dry-cargo vessel of 005RSD03 project «Karelia» type

Dry-cargo vessel of RSD49 project – 11 vessels built in 2012-2017, 1 in progress

Photo: Pavel Pheklistov

Dry-cargo vessel of RSD44 project with low air draught – 10 built in 2011-2012



General view of new PV08 river passenger vessel

Photo: Pavel Pheklistov

General view of high comfortable river passenger vessel of new PV09 project

High comfortable river passenger vessel of new PV09 project

General view of new river-sea passenger vessel of PV300VD project

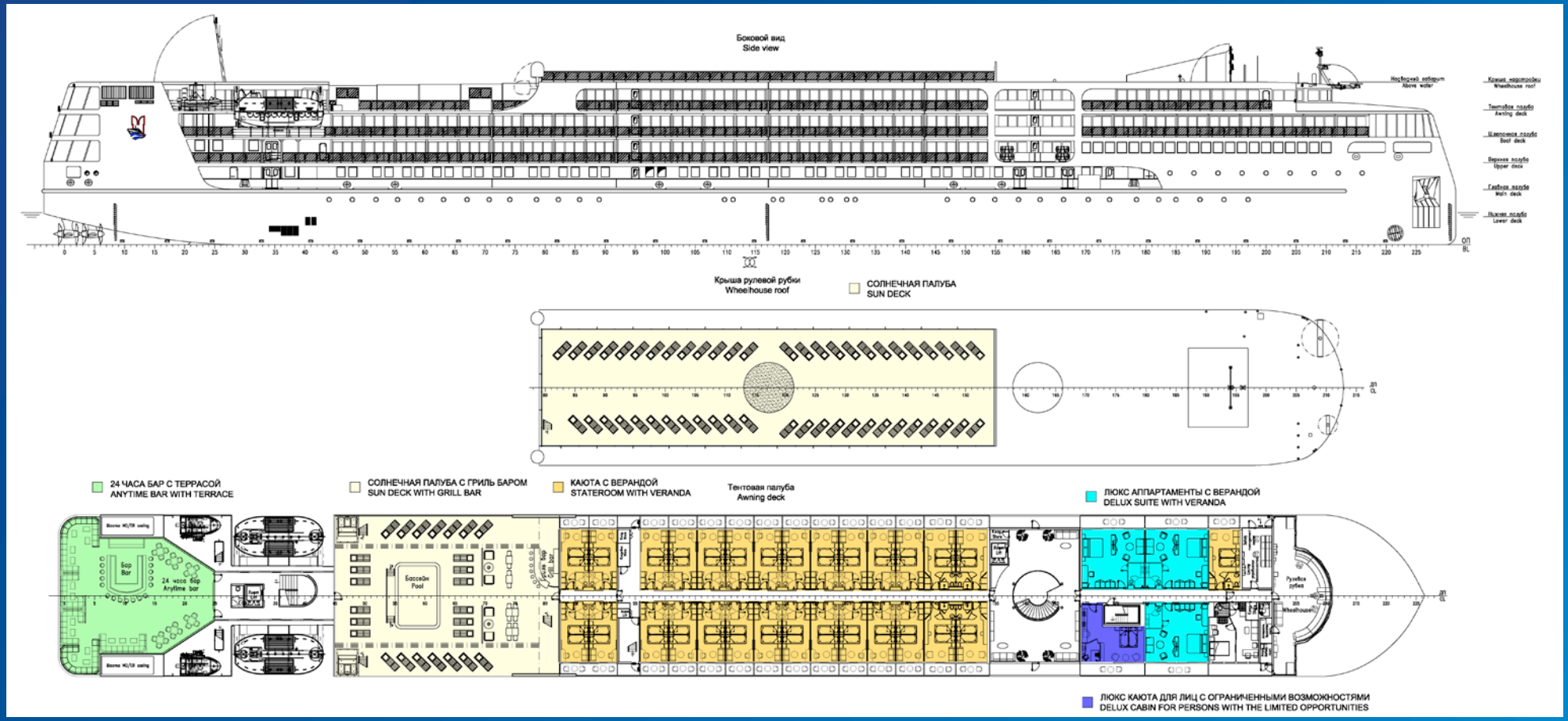
Main characteristics of PV300VD river-sea passenger vessel

Parameter	Value
Main dimension	
Length overall, m	141.15
Length DWL (scantling), m	141.00
Breadth overall (with fenders), m	16.82
Breadth (scantling), m	16.60
Depth, m	5.50
L x B x H	141.00 x 16.82 x 5.50 = 13 044
Draught on DWL (project), m	3.20
Number of deckhouse tiers	4
Endurace, days:	
by fuel stores	15
by provision stores	10
by fresh water stores (fresh water treatment plant with capacity of 150 m^3/day)	unlimited
Passenger capacity	310
The total number of double cabins, of which:	155
- deluxe apartments with balcony	7
- deluxe cabins with balcony	3
- cabins for people with disabilities	2
- cabins with balcony	133
- standard cabins	8
- standard cabins for people with disabilities	2

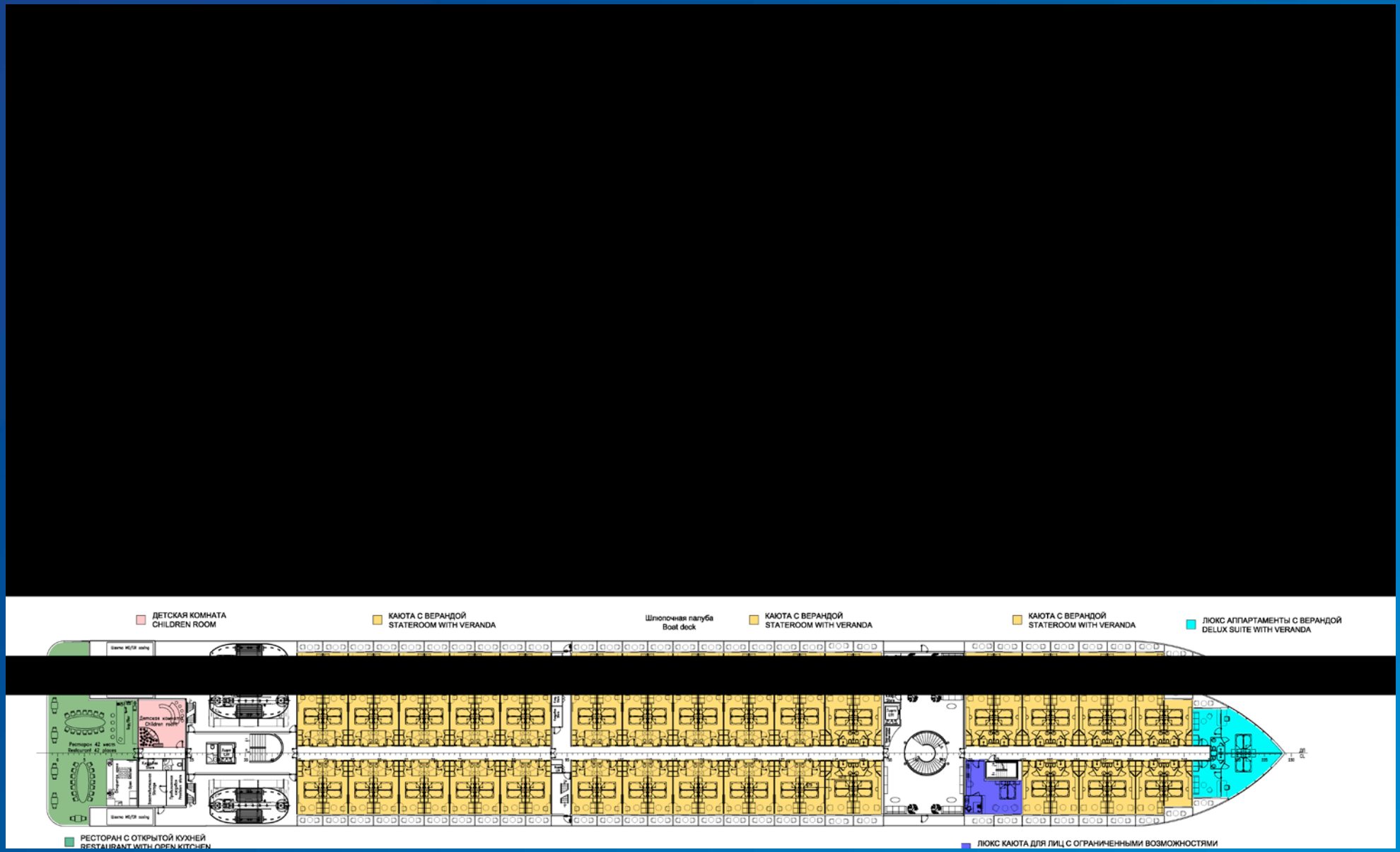
Main characteristics of PV300VD river-sea passenger vessel

Parameter	Value
Area of cabins, m² (without balconies):	
- deluxe apartments with balcony	36-43 (33-35)
- deluxe cabins with balcony	26 (21)
- cabins for people with disabilities	33 (27)
- cabins with balcony	19-21 (16-18)
- standard cabins	16
- standard cabins for people with disabilities	21
Restaurant, places	310
Restaurant with open kitchen, places	42
Music saloon with bar, places	210-300
Day-and-night bar with terrace, places	80
Sun deck with grill-bar (bar/sun deck), places	48 / 100
Children room, m²	27
Fitness center	Training room; SPA saloon with sauna, jacuzzi and massage;Hairdresser saloon
Passenger lifts	2 x 6 pers.
Cargo lifts	4
Russian River Register class	✠ M-SP 3.5 (Ice 30) A
Main diesel-generators power, ekW	4 x 1140
Rudder-propellers, kW	3 x 1000
Bow thruster, kW	1 x 600
Emergency diesel-generator, kW	1 x 214
Crew and handling staff, pers.	90
Speed, km/h	22.5
Rescue / Duty motorboat, pers.	2 x 150 / 2 x 6
Evacuation systems with inflatable liferafts	6 x 50 pers.

General arrangement of new river-sea passenger vessel of PV300VD project



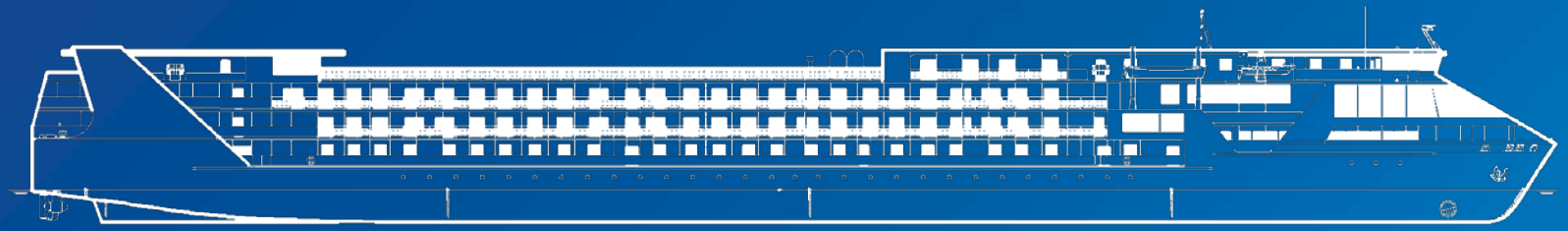
General arrangement of new river-sea passenger vessel of PV300VD project



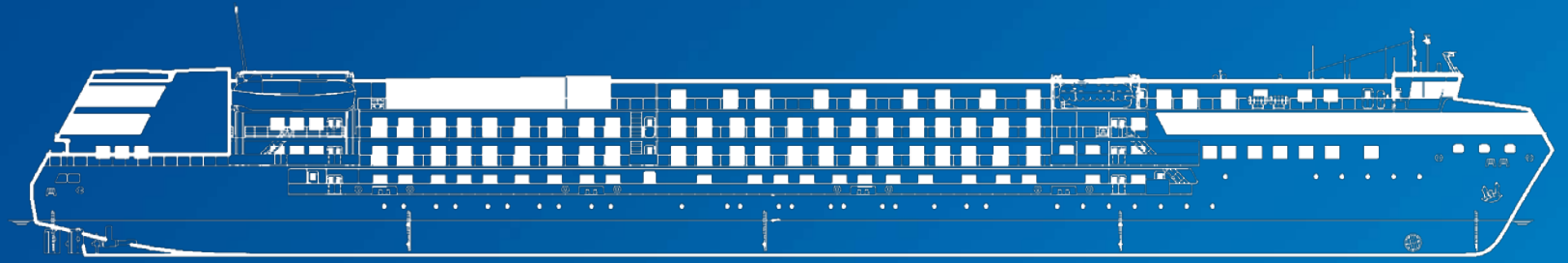
Design stages of PV300VD passenger vessel

Change of side views of river and river-sea passenger vessels

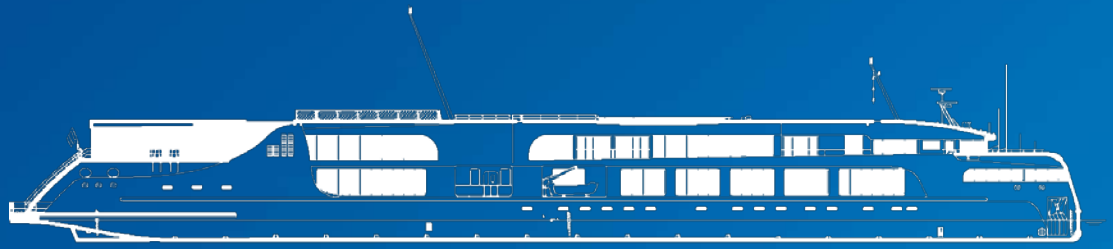
PV300
(2011)



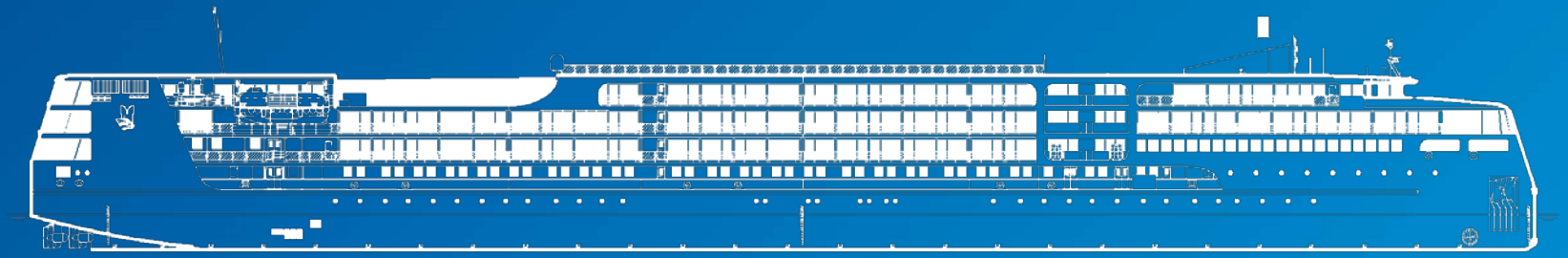
PV300VD
(2012-2013)



PV09
(2014)



PV300VD
(2016)



Passenger vessel of PV08 project.
General view of Panorama suite

Passenger vessel of PV08 project.
Sun deck

Self-propelled river-sea cargo vessels which were built at leading shipyards in 2000-2016

Shipyards	Years																	Total
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Krasnoe Sormovo	4	2	4	6	6	5	6	7	7	6	7	9	10	2	4	3	3	91
Oka (Navashino)						3	2	1	1	1	3	8	8	7		3	3	40
Volgograd	2	1	3	4	5	4	3	6	3	1	1							33
Onega						3	3	2	3	3	4							18
Kherson						1	1	2	2	2	1	1	1	4	1			16
Okean (Nikolayev)						1	4	4										9
Neva (Schlusselburg)													2	5	1		1	9
Lotos (Astrakhan)															2		2	4
Zelenodolsk								1	1					2				4
Nobel (Rubinsk)					1								2	1				4
Yaroslavl							1								3			4
Verkhnekamskiy										1				1				2
Don Cassens (Aksay)														1	1			2
Kostroma														1	1			2
Total	**6**	**3**	**7**	**10**	**12**	**17**	**20**	**23**	**17**	**14**	**16**	**18**	**23**	**24**	**13**	**6**	**9**	**238**

Sailing areas of main projects of XXI Century Russian river-sea vessels

Type, project	RRR class			RS class			
	M-SP / RS 3,5	M-PR / RS 3,0	O-PR / RS 2,0	R3-RSN / RS 3,5	R2-RSN / RS 6,0	R2	R1
New dry-cargo vessels							
Neva-Leader, RSD49*	-	-	-	-	-	10	-
Geroi Stalingrada, RSD44*	-	10	-	-	-	-	-
Saxona, DCV27*	-	-	-	-	-	-	1
Scala, DCV26*	-	-	-	-	-	-	1
Sparta, DCV25*	-	-	-	-	-	-	1
St. Nickolay, RSD20*	-	-	-	-	-	1	-
Khazar, RSD19	-	-	-	-	-	-	4
UCF, RSD18*	-	-	-	-	-	5	-
Euro-cruiser, RSD17*	-	-	-	-	-	-	5
Azov XL, RSD12	-	-	-	-	-	4	-
Ommax, RSD08	-	-	-	-	1	-	-
Tanais, 007RSD07*	-	-	-	-	-	1	-
Chelsea, 005RSD06, RSD11*	-	-	-	-	9	-	-
Palmali Trader, 006RSD05*	-	-	-	-	-	8	-
Caspian Express, 003RSD04*, 003RSD04/ALB02, 003RSD04/ALB03	-	-	-	-	-	9	3
Kareliya, 005RSD03*	-	-	-	-	-	12	-
Nadezhda, 006RSD02*	-	-	-	-	1	-	-
Leda, RSD58*	-	-	-	-	1	-	-
ALB05	-	-	-	-	-	1	-
Rusich, 00101	-	-	-	-	-	-	13
Valday, 01010	-	-	-	-	-	-	4
Yuzhniy Bug, 17620	-	-	-	-	-	-	9
Total dry-cargo vessels	**-**	**10**	**-**	**-**	**12**	**51**	**41**

Sailing areas of main projects of XXI Century Russian river-sea vessels

Type, project	RRR class			RS class			
	M-SP / RS 3,5	M-PR / RS 3,0	O-PR / RS 2,0	R3-RSN / RS 3,5	R2-RSN / RS 6,0	R2	R1
New tankers							
BF Tanker, RST54*	-	7	-	-	-	-	-
VF Tanker, RST27*	-	-	-	-	-	35	-
Gloster, RST26*	-	-	-	-	-	1	-
New Volgoneft, RST25*	-	-	-	-	7	-	-
New Armada, RST22, RST22M*	-	-	-	-	-	9	12
Armada, 005RST01*	-	-	-	-	-	10	-
Roschem, RST14*	-	-	-	-	3	-	-
Aston Trader, RST09*	-	-	-	-	3	-	-
Narva, RST05*	1	-	-	-	-	1	-
Eco Mariner, 001RST02*	-	-	-	1	-	-	-
ALB06	-	-	-	-	-	1	-
00201L	-	-	-	-	-	-	2
00210, 00215, 00230	-	-	-	-	-	-	7
00216	-	-	-	-	3	-	-
19612	-	-	-	-	-	-	5
19614	-	-	-	-	25	-	-
19619	-	-	-	-	-	-	11
19900	-	-	-	-	-	6	-
17103	-	-	-	-	-	2	-
15790	-	-	-	-	1	-	-
52	-	-	-	-	3	-	-
507AT	1	-	-	-	-	-	-
HCR / VHX (China)	-	-	-	-	17	2	-
Total tankers	**2**	**7**	**-**	**1**	**62**	**67**	**37**
Total	**2**	**17**	**-**	**1**	**74**	**118**	**78**

Note. * – Marine Engineering Bureau project

Perspective new river-sea dry-cargo vessel of RSD59 MEB project

Perspective new river-sea tanker of RST12C MEB project (R2-RSN 4,5 / RS 4,5)

Perspective new integrated vessel of RSD67+RDB67 MEB project

Appliance of LPG as main fuel on RST27, RST12C tankers

Thank you for attention!