CRF 2021 Rating Formulae

NOTE: CRF formulae, factors and ratings are subject to change each calendar year

12/14/20

			Notes
Base Rating		**R1= 0.06 * (L * S) / (.75*DSPS/64)^.33 + 0.3*L + 0.20*S + DC + LBRC + StabC**	1
Rated Length:		**L=Base Sailing Length (L1) + a length increment (DelL) for recent designs with broad sterns**	
		L = L1 + DelL	
	If LWL>=0.65*LOA,	L1 = 1.02*(LOA + 4* LWL) / 5	2
	If LWL<0.65*LOA,	L 1= 1.02*(LOA + 4*0.65*LOA) / 5	3
	If Age < 1990,	DelL = 0	
	If Age => 1990 & Bm10 / Bmax <= 0.75:	DelL = 0	4
	If Age => 1990 & Bm10 / Bmax > 0.75:	DelL = L1 * [15*{(Bm10 / Bmax) - 0.75} ^ 2.3]	
Rated S:		**S=Sq Root of upwind + downwind sail areas, adjusted for rig and shroud types**	5
		S = {Rig Type Factor*Shroud Type Factor*(RSAup + RSAdn) / 2} ^0.5	6
RSAup; Rated SA, Upwind;		RSAup = Jib + Main + Mizzen + Foresail	
		RSAup=RSAF + RSAM + RSAY + RSAG	
Rated Foretriangel Area, if LP% >1;	If LP% > 1.0:	RSAF = 0.55 * IG * J * {1 + 1.5 * ((LP% * J) - J)/(LP% * J)}	
Rated Foretriangel Area, if LP% <=1;	If LP% <= 1.0:	RSAF=0.55*.96*(IG62+j^2)^0.5*J*LP%	
Rated Mainsail Area, for Jib Headed Main;	If P> 0:	RSAM=.45*P*E	
Rated Mainsail Area for Gaff Headed Main;	If PG> 0:	RSAM=0.55*PG*E	
Rated Mizzen Area;	If PY> 0:	RSAY=0.5*PY*EY	
Rated Foresail Area, Schooner's;	If B1> 0:	RSAG=0.4*(P1+P3)/2*B1	
RSAdn; Rated SA, downwind;		RSAdn = Spin + Main + Mizzen + Foresail	
		RSAdn=SPIN + RSAM + RSAY + RSAG	
	If S-SPIN > A-SPIN:	SPIN=S-SPIN	
	If S-SPIN =< A-SPIN:	SPIN=A-SPIN	
		S-SPIN=0.95*(ISP^2+J^2)^0.5*1.8*SPL*0.8*1.05	7
		A-SPIN=0.95*(ISP^2+TSPJ^2)^0.5*1.75*TSP*0.75*1.0	8
Displacement	**DSPS**	**Declared value for boat weight as raced, without crew, in pounds**	9
Draft Correction	**DC**	**Based on the difference between a Base Draft (BD) and the Rated Draft (RD)**	10
		DC = 0.2 * L1 * ((RD/BD)^2.0 - 1)	
	Base Draft:	BD = -0.0006 * L1 ^ 2 + 0.192 * L1 + 1.16	11
	Rated Draft: If no centerboard:	RD = DM	12
	If Brd down draft (DMcb) > fixed draft:	RD = DM + 0.70 * (DMcb-DM)	13
Length/Beam Ratio Corr.	**LBRC**	**Based on the difference between a Base Length Beam Ratio and a Rated Length Beam Ratio**	14
		LBRC = 0.25 * L *{[RLBR / BLBR ^ 0.20 - 1.0}	
	Base LBR:	BLBR= 0.037*L1+1.66	15
	Rated LBR:	RLBR = L/Bmax	
Stability Correction	**StabC**	**Based on the difference between a base righting moment and a calculated righting moment.**	16
		Makes use of declared ballast weight, calculated hydrostatics, and a calculated default crew weight	
	If Rmtot > Rmbase:	**StabC = 0.10 * L1 * ((RMtot / RMbase)^1.6 -1.0)**	17
	If Rmtot =< Rmbase:	**StabC = 0.10 * L1 * ((RMtot / RMbase)^0.2 -1.0)**	18
		RMtot = RMhull + RMCrew	19
		RMhull = Disp * GMt * 0.0175	
		GMt = It/(DSPS/64) + VCB - VCG	
		VCB = -1*{((DSPS/64-Ballast/690) * .35 * Dh) + (Ballast/690 * (Dh + (Draft - Dh)/2)}/(DSPS/64)	
		Dh = (DSPS/64 - Ballast/690) / (LWL * Bmax * 0.9 * Cp * Cms)	
		Assumed canoe body Coefficient: Cp=0.55, Cms=.65	
		VCG = ((DSPS - Ballast) * CGnet + (Ballast * CGkeel)) / DSPS	
		CGnet = 0.60 * (L1/Dh) ^0.5	20
		CGkeel = Dh + (Dm-Dh)/2 * (Keel Factor +0.03) ^3	
	If Bm10/Bmax > 0.75:	RMcrew = (CrewCt -2) * 185 * ((Bm10+Bmax)/2 * 0.57 - 0.5 - 0.1*Dh)	21
	If Bm10/Bmax =< 0.75:	RMcrew = (CrewCt -2) * 185 * (Bmax * 0.45 - 0.5 - 0.1*Dh)	
		CrewCt = CrewWgt / 185	22
		CrewWgt = (DSPS/2240 / (0.01*LWL)^3)/254)^0.375 * (RmHull/(DSPS*Bmax)/0.006)^0.4 * LWL^1.5 * 7.6	23
		RMBase = 24.2*(BWL*L1^0.25)^2-7.25*(BWL*L1^.25)+2756	24
		BWL=Bmax^.92*(Dh*7.25/Bmax)^0.08	25
	If RmTot > RMBase;	StabC=0.10*L1*((RmTot/RmBase)^1.60-1)	
	If RmTot =< RMBase;	StabC=0.10*L1*((RmTot/RmBase)^0.20-1)	
CRF 2021 Rating	**Rating**	**R(ft) = R1 * Prop * DLF * SaDF * Keel * Spar * MAF**	26
		R(sec/mi) = 0.6* 3600 * {1/(Rft)^0.5 - 1/(100)^0.5} - 90	27
		R(GPH) = R(sec/mi) + 535	28
Prop Factor (Prop)	**Prop**	**Prop = assigned prop factor, based on installation type**	29
Disp/Length Factor	**DLF**	**Based on the difference between a base Disp/Length ratio and the actual Disp/Length ratio**	
	If DLFbase > 1.015;	**DLF = DLFbase + (1 + DLFbase - 1.015)^4.0 -1**	30
	If Base DLF=< 1.015;	**DLF = Base DLF**	
		Base DLF = {(350 - 2.9 * L) / ((Disp/2240) / (0.01 * L) ^ 3)} ^ 0.025	31
Sail Area/Disp Factor	**SaDF**	**Based on the difference between a base SA/Disp ratio and the actual SA/Disp ratio**	
	If SaDFbase > 1.0130;	**SaDF = Base SaDF + (1 + SaDFbase -1.015)^3.0 - 1**	32
	If SaDFbase =< 1.0130;	**SaDF = SaDFbase**	
		Base SaDF = ((S ^ 2 / (DSPS/64) ^ 0.67) / (0.18 * L1 + 19.5)) ^ 0.040	33
Keel Type Factor	**Keel**	**Keel =Assigned Keel Factor, based on keel type**	34
Spar Material Factor	**Spar**	**Spar=Assigned Spar Factor, based on spar construction material**	35
Moveable Appendage Factor	**MAF**	**MAF = Moveable Appendage Factor (for a keel Trim Tab, if fitted)**	36

Notes	Comments
1	The basic architecture of the 2017 reformulation of CRF was adapted from Nat Herreshoff's **Universal Rule** and from Olin Stephens' (et al) **International Offshore Rule**. Despite shortcomings exposed by agressive exploitation of loopholes over time, early versions of IOR did a quite good job of handicapping a variety boat boat sizes and types until it fell out of favor due to the humps, bumps and hollows that came to plague it in later years.
2	Effective sailing length 'L' is a primary driver of performance, and is taken as a weighted average of LOA and LWL, with LWL recognized as having a stronger effect on performance potential than LOA.
3	A cap on total overhang of 35% of LOA (typical of International Rule boats) limits any rating advantage stemming from overhang length and slope extremes (eg Sonder and Square Meter classes)
4	A declaration for Bm10 is only required for design dates after 1990. It addresses the added effective sailing length resulting from broad, powerful sterns in some contemporary designs.
5	The square root of sail area is taken to keep the rated units uniform in linear feet. For non-spinnaker ratings, RSAdn = RSAup
6	See table of assigned Rig and Shroud Type factors
7	CRF 2021 assumes a default SMW of 1.8*SPL in calculating symmetrical spinnaker area. Starting in 2022, calculations for S-SPIN will likley depend on actual measured SMW, beginning with newly built sails only.
8	CRF 2021 assumes a default AMG of 1.75*TPS in calculating asymmetrical spinnaker area. Starting in 2022, calculations for A-SPIN will likley depend on actual measured AMG, beginning with newly built sails only.
9	The declared DSPS is to be the estimated weight of the yacht as presented for racing, in pounds, excluding crew weight. For yachts that are primarily raced and daysailed, this is similar to 'light ship' (empty tanks, with minimal food and gear). For yachts that are equipped and provisioned for cruising while racing, this is similar to 'half load' (tanks half full, with ordinary food and gear) .
10	Rated draft deeper than base draft speeds up rating
11	Base Draft (BD) is based on a second order polynomial fit to draft vs length across the Classic fleet
12	DM=maximum fixed draft.
13	DMcb=max centerboard down draft. CRF 2021 rates centerboard boats for 70% of the added depth of the board extension below the fixed draft
14	Length/beam ratio higher than base (for a long, narrow hull) speeds up rating
15	Base Length/Beam Ratio (BLBR) is based on a second order polynomial fit to LOA/Bmax ratios across the Classic fleet

16	Stability is a primary driver of sailboat performance potential, but physically measureing it is not a reasonable or practical requirement for the Classic fleet. The next best thing is to influence ratings via stability that is calculated rather than measured. Higher calculated stability does result in a faster CRF rating, but the effect is modest given the limited data available.
17	Calculated stability that is higher than base stability speeds up rating
18	If ballast weight is uncertain or unknown, a value is assigned that is typically 0.4*DSPS
19	Calculated RM including effect of crew weight
20	Empirically derived approximatation
21	The crew moment arm for contemproary boats with broad beam aft is greater than it is for typical Classic hulls.
22	Crew count assumes an average crew weight of 185 pounds.
23	Calculated crew weight taken from a recognized IMS formulation
24	Base RM includes crew weight, and is based on a second order polynomial fit to Rmtot vs a function of Bmax and L across the Classic fleet
25	Empirically derived approximatation
26	The rating in decimal feet reflects speed potential via an implieded effective sailing Length.
27	Sec/mi, normalized to typical PHRF handicaps w/scratch R=100
28	Sec/mi, normalized to VPP GPH ratings, eg via ORCi or ORR
29	See table of assigned factors
30	Disp/length ratio lower (lighter) than base speeds up rating
31	The Base DLF is a linear function that reflects the Disp/L distributioin across the Classic fleet
32	SA/Disp ratio higher than base speeds up rating
33	The Base SaDF is a linear function that reflects the SA/Disp distributioin across the Classic fleet
34	See table of assigned keel typefactors. The factors used reflect the differences in appendage wetted area, aspect ratio, and center of gravity associated with the various keel types.
35	See table of assigned spar material factors. The factors used reflect differences in stability and pitch moment of inertia associated with the different mast material types and number of masts.
36	The factor used is taken from IOR.