Development & application for the sea trial analysis program (i-STAP) based on IMO guidelines under discussion

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November 27, 2014

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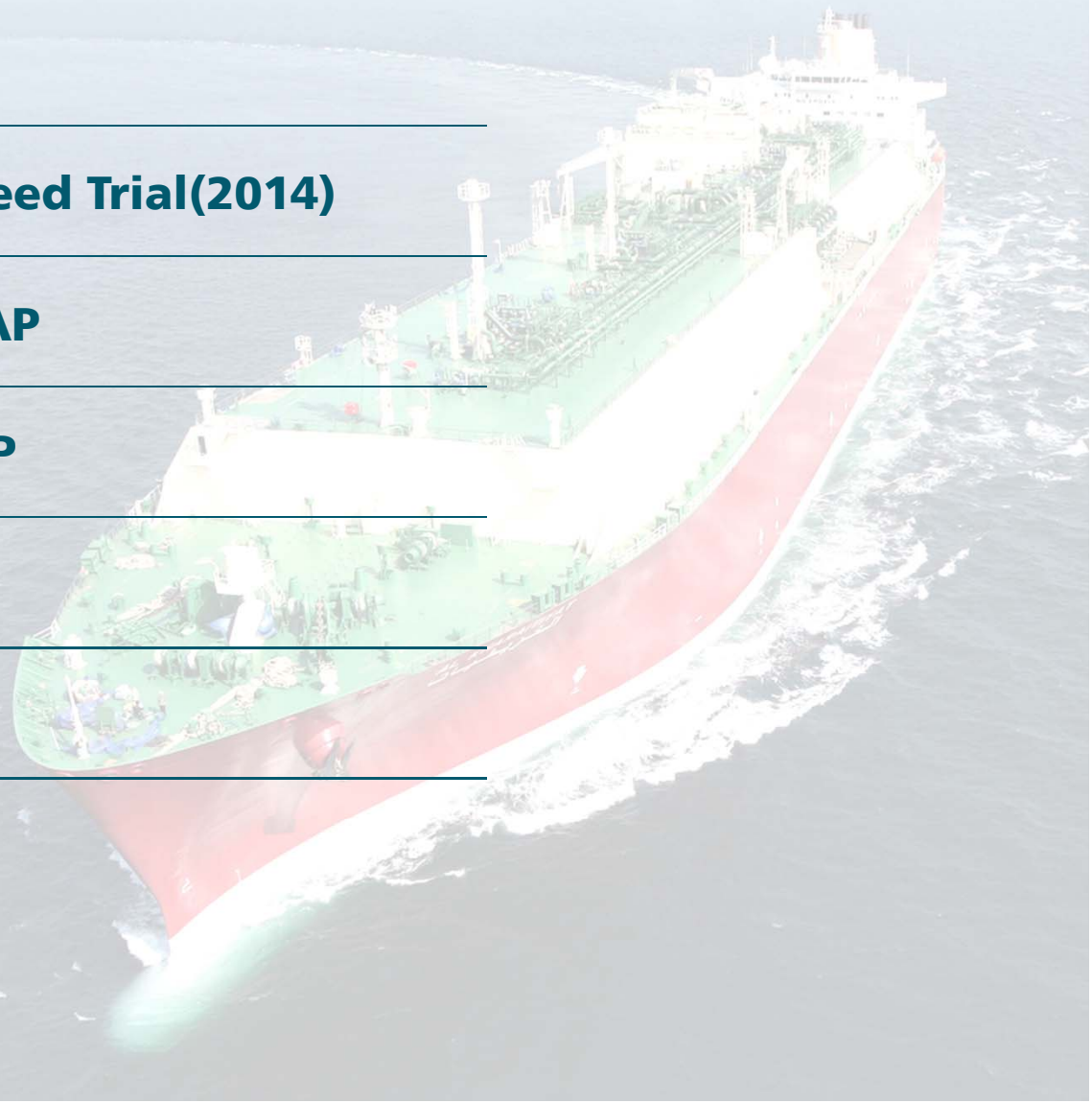
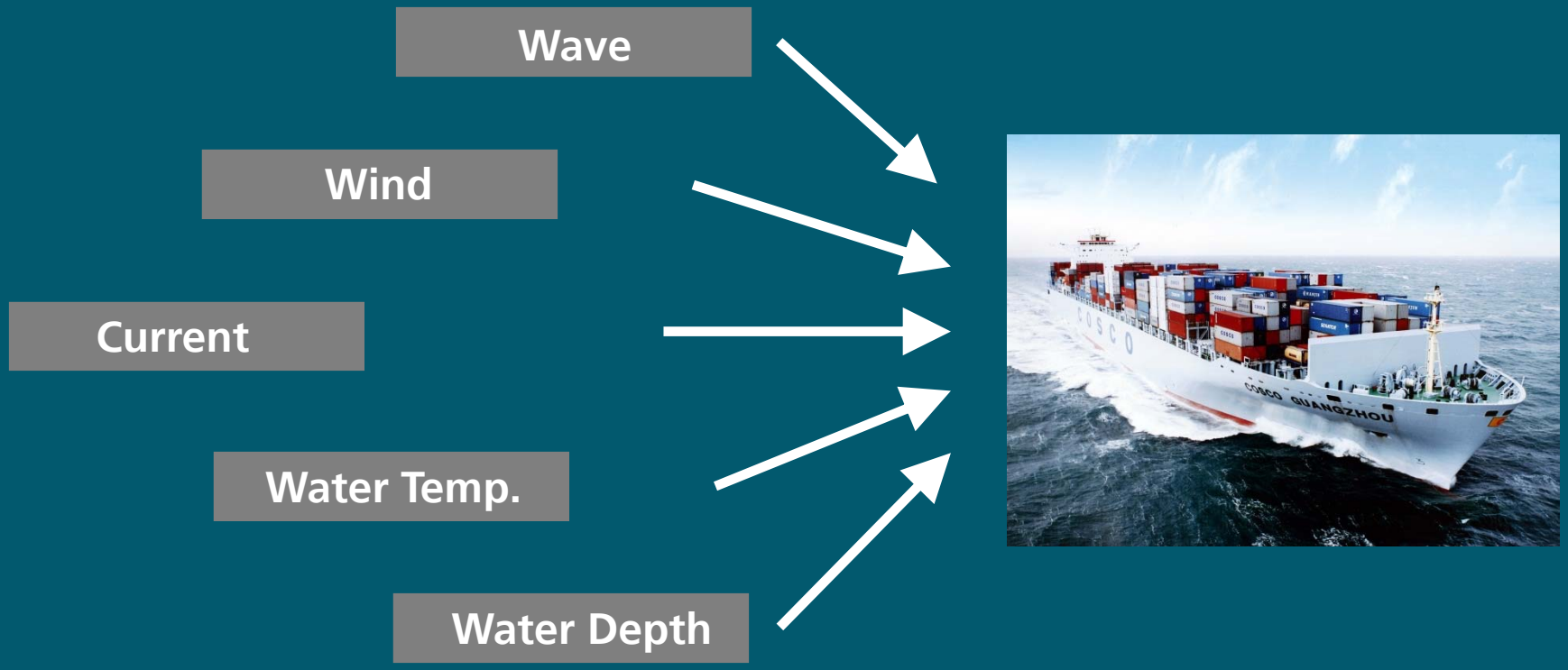


1. Background

- EEDI is most important issue for protection environments in international society.
- Validation of speed performance becomes important.
- Ship owner's mistrust for speed trial results.
- Clear and fair method for speed trial analysis is required.
- IMO ordered harmonization between ISO and ITTC.
- Revised ISO 15106 is in voting.
- Ship yards have to prepare for these trends.

Added Resistance Factors in Sea



- In real sea, a ship meets with various environmental conditions during speed trials(EEDI) and services(EEOI).

2. ISO Standards for Speed Trial(2014)

Correction Factor	ISO (2002)	ISO (2014)
Analysis Method	Taniguchi-Tamura	Direct Power
Wave	0	0
Wind	0	0
Steering	0	X
Drifting	0	X
Water Temperature	0	0
Water Depth	0	0
Tidal Current	0	0
Displacement	0	0

- ISO (2014) method is in voting until next month.
- Steering and drifting corrections are excluded.
- Many of correction method and procedure are changed for each factor.

3. Development of i-STAP

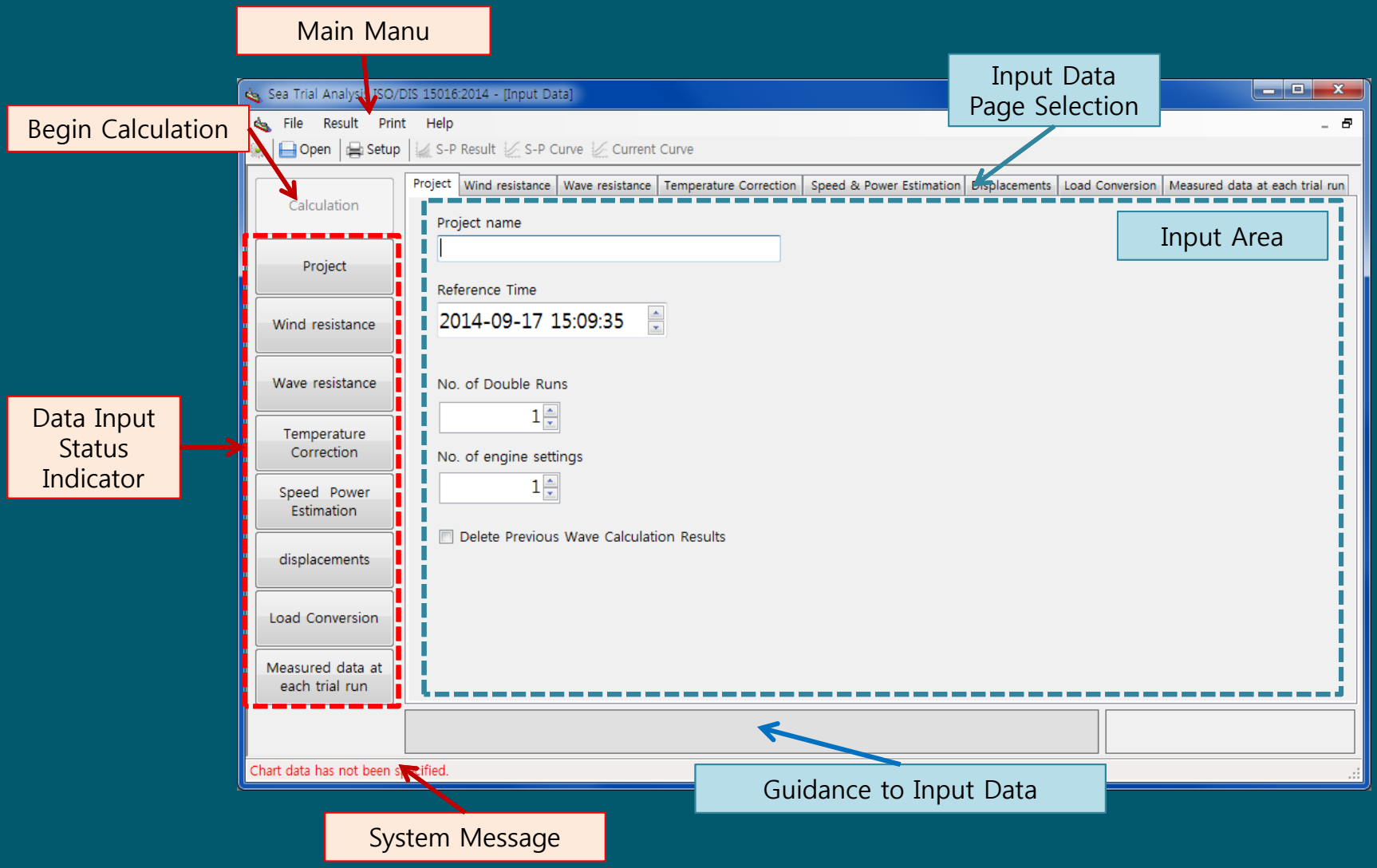
- i-STAP(ISO Speed Trial Analysis Program) in developing
- Until confirmation of revised ISO 15016
- Sponsored by KOSHIPA
- Programed by KRISO (Korea Research Institute of Ship & Ocean Engineering)
- Based on ISO 15016(2014) – in voting until Dec. 2014
- Korean ship yards joined

4. Introduction of i-STAP

Overview

- Fully support speed trial analysis as defined in ongoing amendments to ISO15016
  - Wind resistance with 3 options for wind resistance coefficients
  - 4 options of wave resistance
  - Water temperature and density correction
  - 2 options for current correction
  - 2 options for speed power correction
  - Shallow water correction
  - Displacement correction
  - Load conversion
- Ease of input using GUI with error checking and guidance
- Provide detailed calculation results for experts
- Output chart, summary report (pdf) and detail report (excel)
- Compatible with any PC running windows XP or later

Graphic User Interface

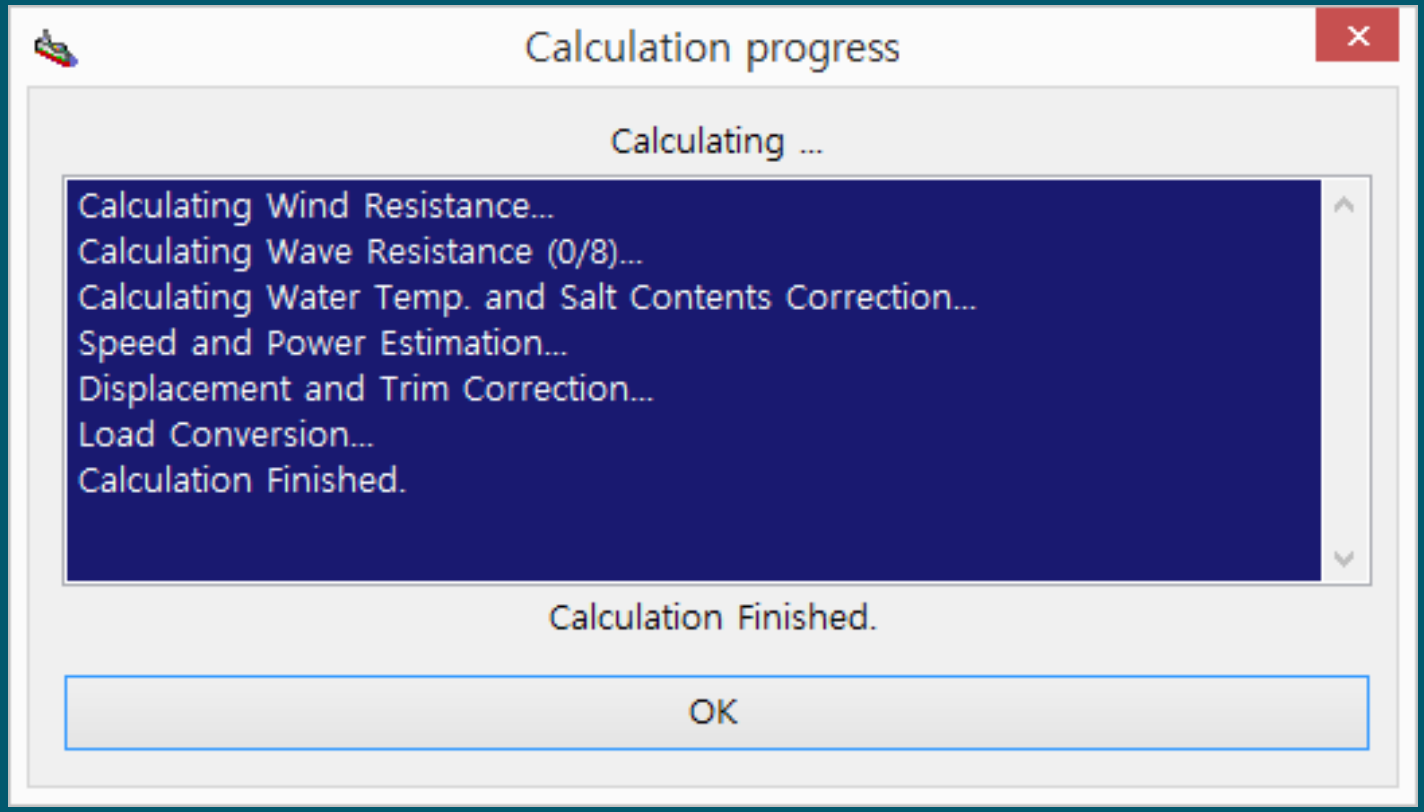


Data Input

- Input data is categorized into 8 logical groups.
  - Project
  - Wind resistance
  - Wave resistance
  - Temperature correction
  - Speed and power estimation
  - Displacement correction
  - Load conversion
  - Measured data at each trial run

Calculation

- **Log window**
  - **Shows progress**
  - **Error message**



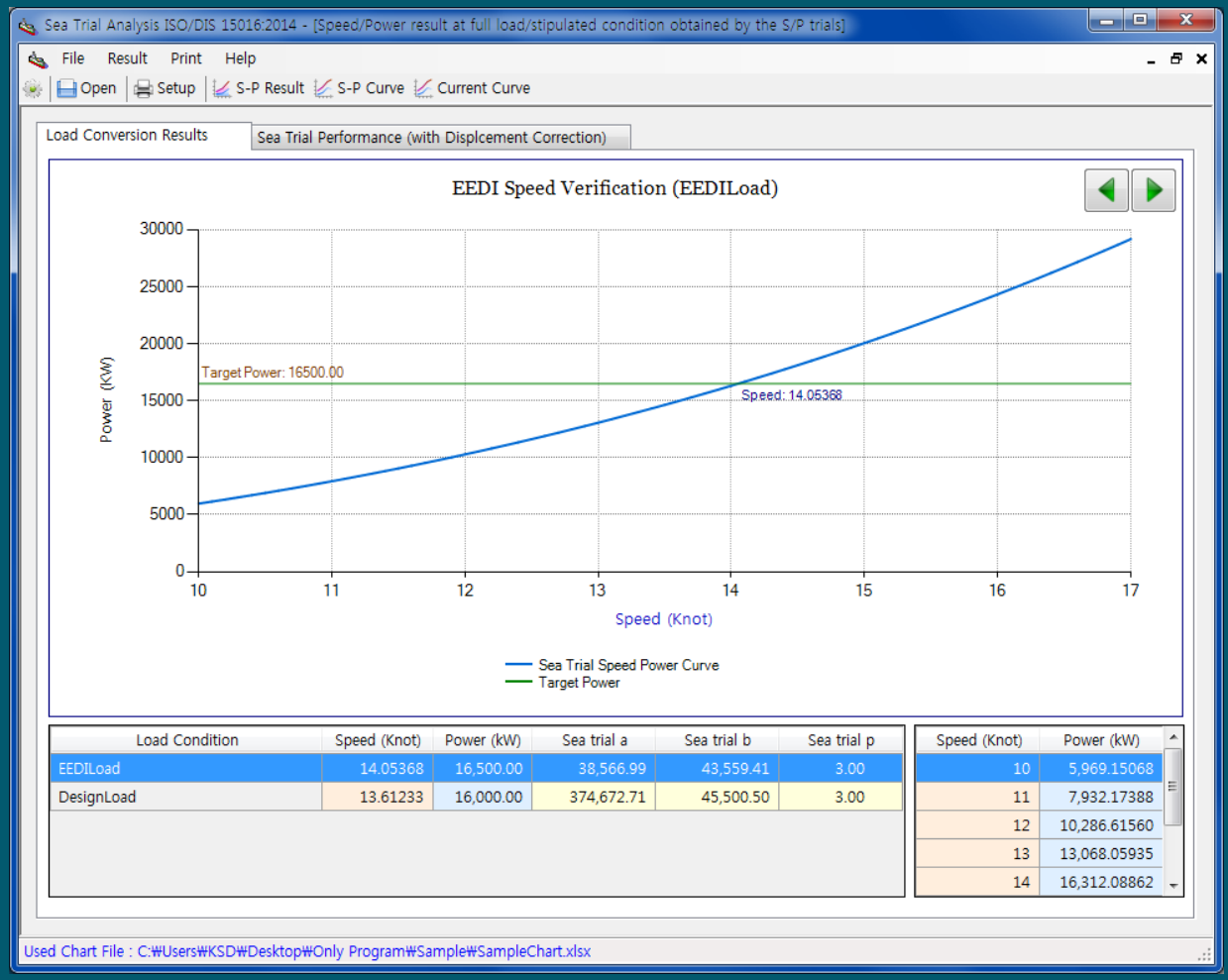
Output

- 3 kinds of outputs

  - Graphic output
  - PDF output for report
  - Excel file of detailed output

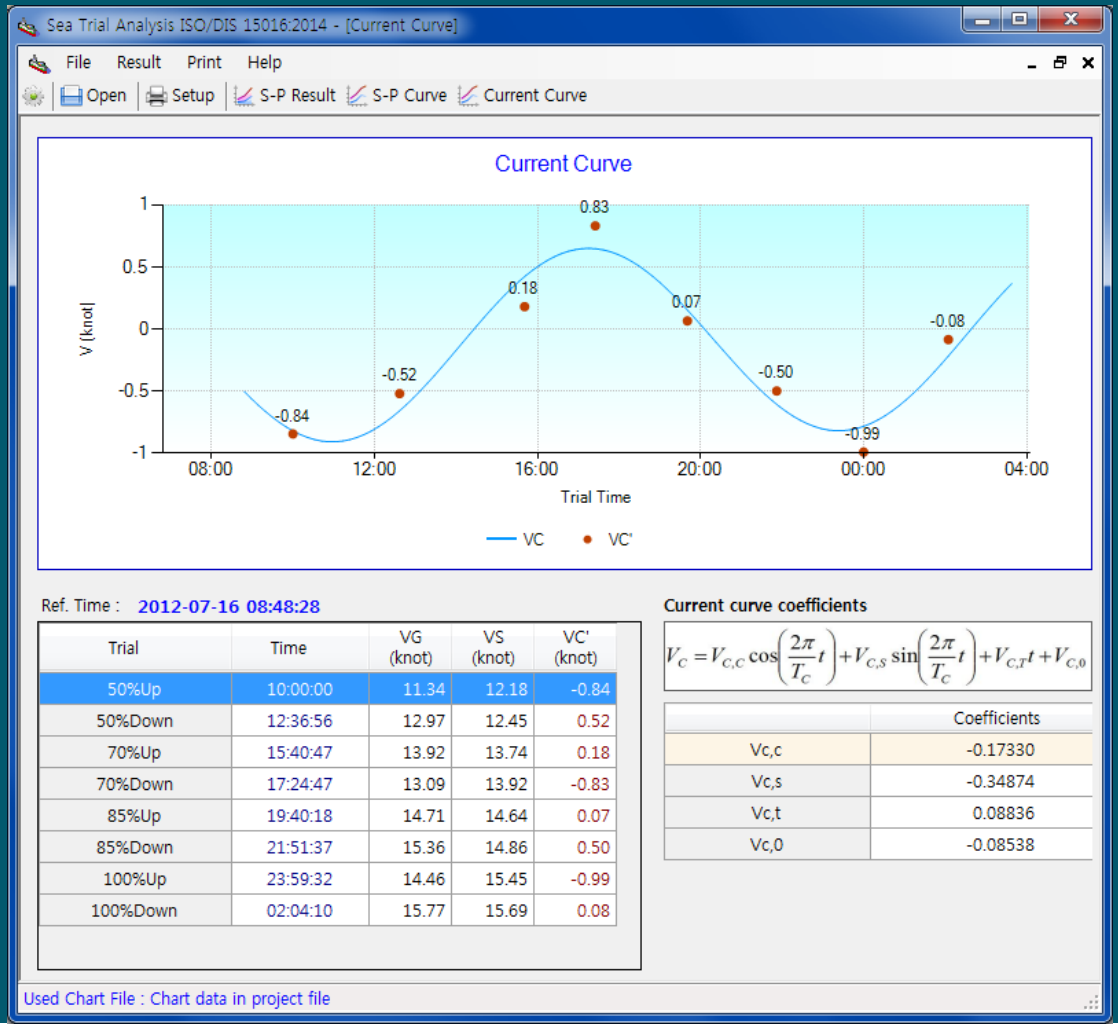
- **Graphic output**

- Load conversion results



- **Graphic output**

- Current correction result



Ref. Time : **2012-07-16 08:48:28**

Trial	Time	VG (knot)	VS (knot)	VC' (knot)
50%Up	10:00:00	11.34	12.18	-0.84
50%Down	12:36:56	12.97	12.45	0.52
70%Up	15:40:47	13.92	13.74	0.18
70%Down	17:24:47	13.09	13.92	-0.83
85%Up	19:40:18	14.71	14.64	0.07
85%Down	21:51:37	15.36	14.86	0.50
100%Up	23:59:32	14.46	15.45	-0.99
100%Down	02:04:10	15.77	15.69	0.08

Current curve coefficients

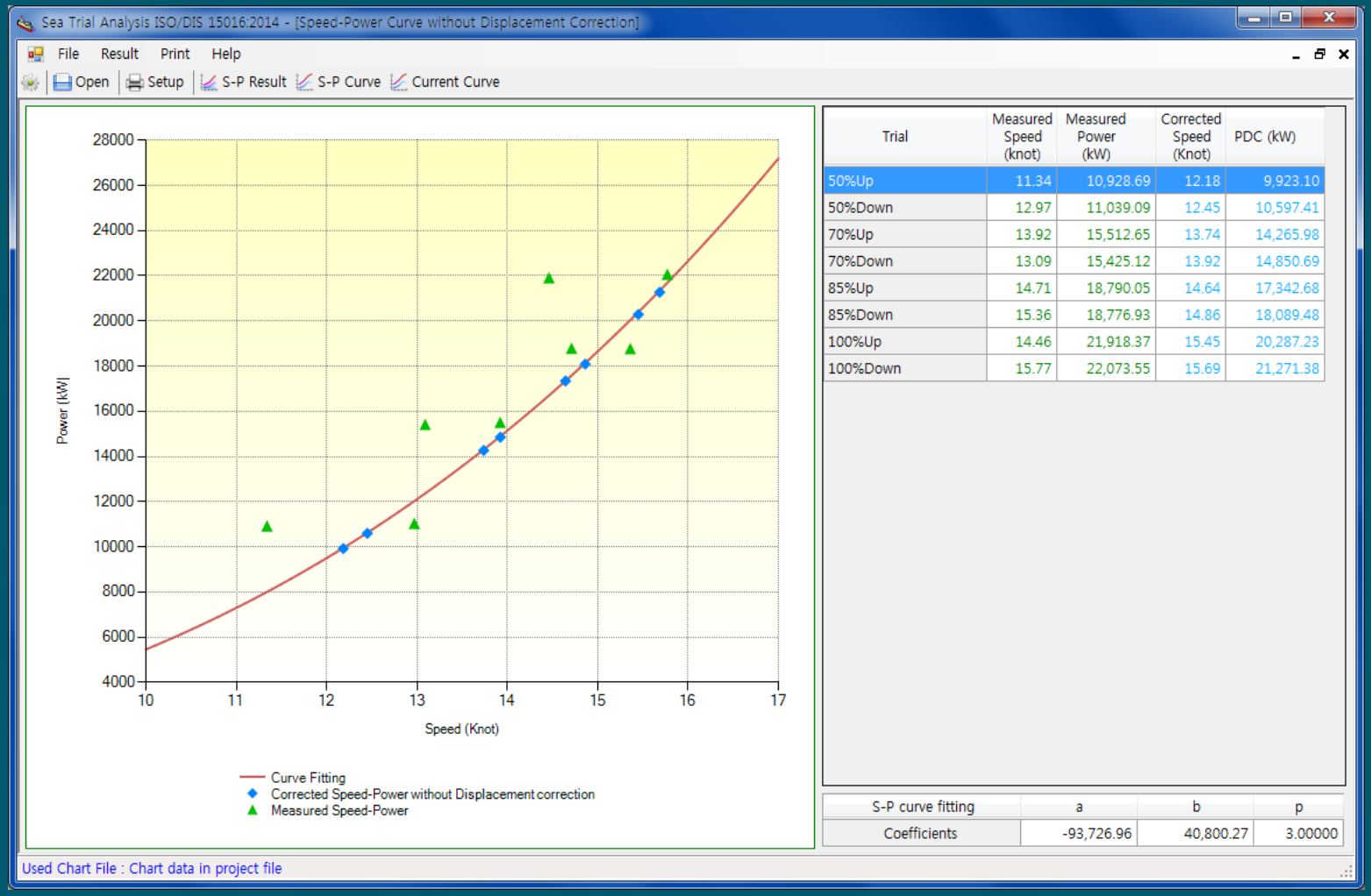
$$V_C = V_{C,C}\cos\left(\frac{2\pi}{T_C}t\right) + V_{C,S}\sin\left(\frac{2\pi}{T_C}t\right) + V_{C,T}t + V_{C,0}$$

	Coefficients
Vc,c	-0.17330
Vc,s	-0.34874
Vc,t	0.08836
Vc,0	-0.08538

Used Chart File : Chart data in project file

- **Graphic output**

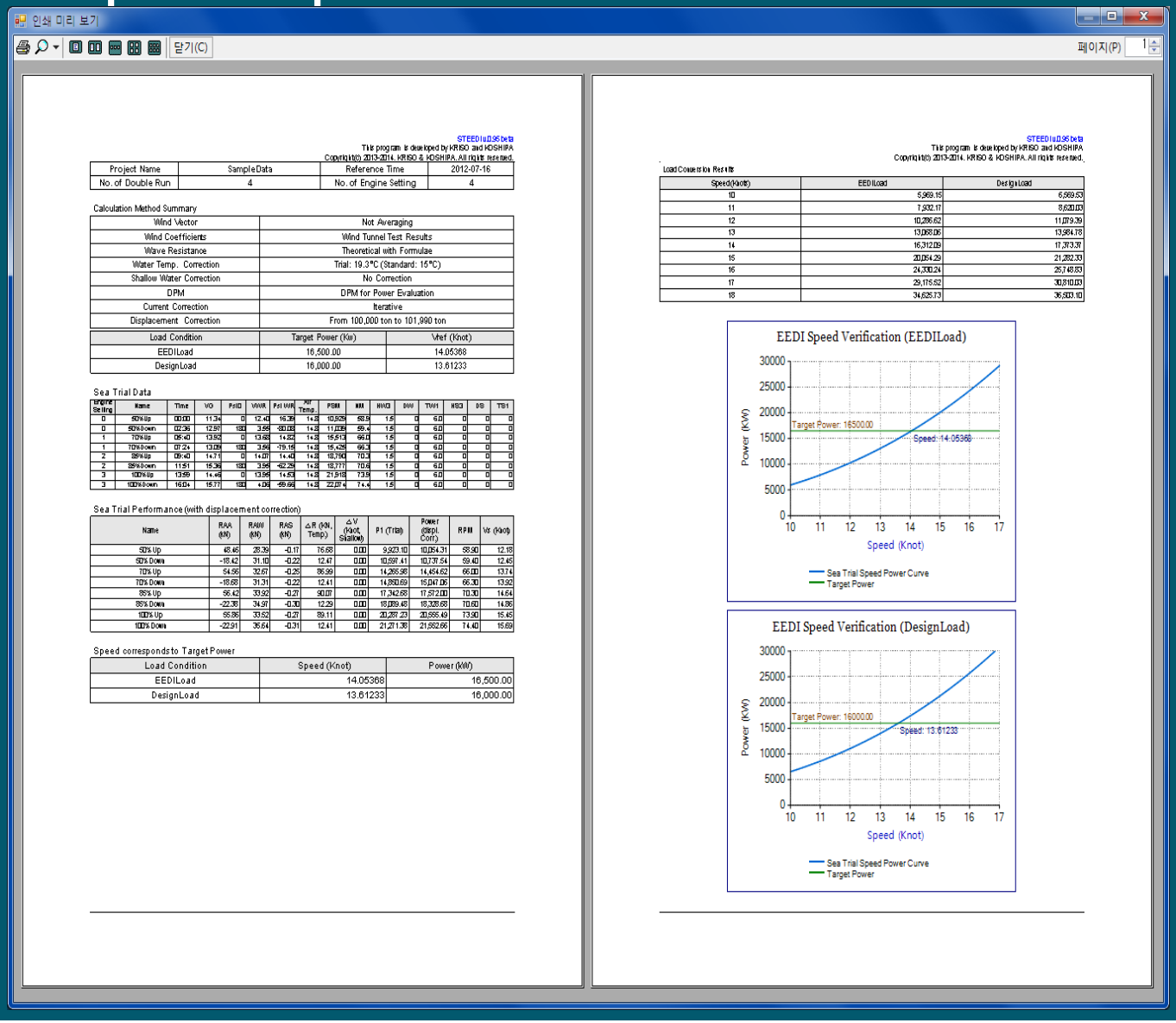
- Speed power curve



Trial	Measured Speed (knot)	Measured Power (kW)	Corrected Speed (Knot)	PDC (kW)
50%Up	11.34	10,928.69	12.18	9,923.10
50%Down	12.97	11,039.09	12.45	10,597.41
70%Up	13.92	15,512.65	13.74	14,265.98
70%Down	13.09	15,425.12	13.92	14,850.69
85%Up	14.71	18,790.05	14.64	17,342.68
85%Down	15.36	18,776.93	14.86	18,089.48
100%Up	14.46	21,918.37	15.45	20,287.23
100%Down	15.77	22,073.55	15.69	21,271.38

S-P curve fitting	a	b	p
Coefficients	-93,726.96	40,800.27	3.00000

▪ PDF output for report



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▪ Excel file of detailed output

Wind resistance calculation results:

	50%Up	50%Down	70%Up	70%Down	85%Up	85%Down	100%Up	100%Down
VG (m/s)	5.83	6.67	7.16	6.73	7.57	7.90	7.44	8.11
Psi0 (deg)	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00
VWR (m/s)	12.40	3.55	13.68	3.56	14.07	3.95	13.95	4.06
PsiWR (deg)	16.39	-80.08	14.82	-79.15	14.40	-62.29	14.53	-59.66
VWT (m/s)	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
PsiWT (deg)	29.99	29.98	29.99	29.97	30.00	29.97	29.99	30.03
VWTref (m/s)	5.74	5.74	5.74	5.74	5.74	5.74	5.74	5.74
VWRref (m/s)	11.18	3.33	12.47	3.36	12.86	4.10	12.74	4.26
PsiWRref (deg)	14.87	-59.34	13.31	-58.47	12.89	-44.43	13.02	-42.47
RhoA (kg/m3)	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
RhoStd (kg/m3)	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
CAA(Psi)	0.85	0.50	0.84	0.51	0.83	0.80	0.83	0.84
CAA(0)	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
RAA (kN)	48.46	-18.42	54.56	-18.68	56.42	-22.38	55.86	-22.91

Water temp. and salt contents calculation results:

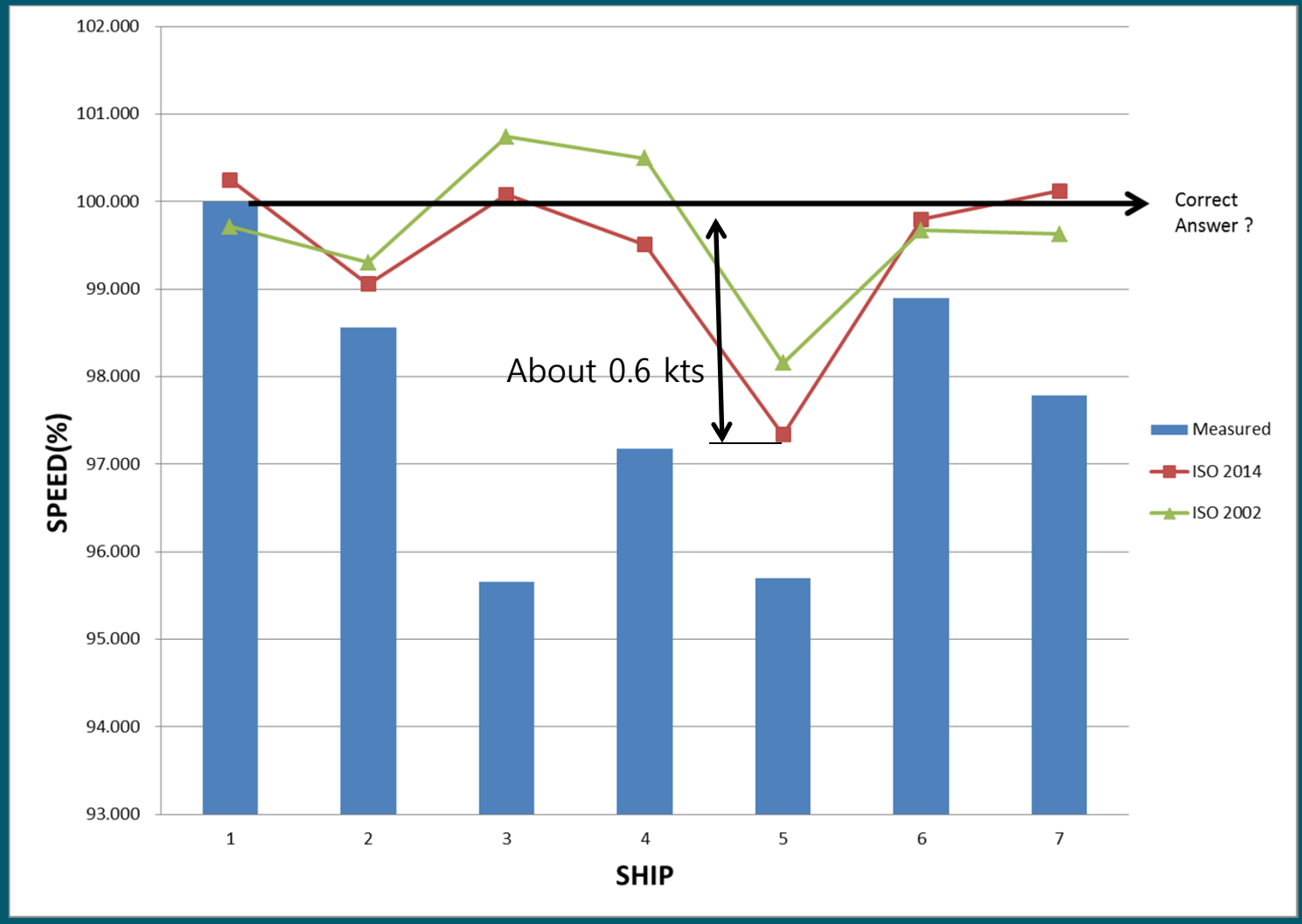
	50%Up	50%Down	70%Up	70%Down	85%Up	85%Down	100%Up	100%Down
VG (knot)	11.34	12.97	13.92	13.09	14.71	15.36	14.46	15.77
CF	1.43E-3	1.41E-3	1.40E-3	1.41E-3	1.39E-3	1.38E-3	1.39E-3	1.37E-3
CF0	1.45E-3	1.43E-3	1.41E-3	1.42E-3	1.40E-3	1.40E-3	1.41E-3	1.39E-3
RF (kN)	12.47	16.05	18.34	16.33	20.34	22.07	19.70	23.19
RT0 (kN)	8.73	11.42	13.15	11.63	14.69	16.02	14.19	16.88
RAS (kN)	-0.17	-0.22	-0.25	-0.22	-0.27	-0.30	-0.27	-0.31

Speed and power estimation results:

	50%Up	50%Down	70%Up	70%Down	85%Up	85%Down	100%Up	100%Down
Initial data:								
t	1900-01-00 01:11:32	1900-01-00 03:48:28	1900-01-00 06:52:19	1900-01-00 08:36:19	1900-01-00 10:51:50	1900-01-00 13:03:09	1900-01-00 15:11:04	1900-01-00 17:15:42
vs (knot)	12.16	12.16	13.51	13.51	15.04	15.04	15.12	15.12
PDM (kW)	10,600.83	10,707.92	15,047.27	14,962.37	18,226.35	18,213.62	21,260.82	21,411.34
DeltaR (kN)	76.68	12.47	86.99	12.41	90.07	12.29	89.11	12.41
DPM Load variation results:								
EtaD0	0.708	0.708	0.775	0.775	0.748	0.748	0.744	0.744
Xip	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xiv	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Xin	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nm (rpm)	58.90	59.40	66.00	66.30	70.30	70.60	73.90	74.40
PDC (kW)	9,923.32	10,597.78	14,267.69	14,851.12	17,295.29	18,086.59	20,329.76	21,281.66
Nc (rpm)	58.90	59.40	66.00	66.30	70.30	70.60	73.90	74.40
Iterative current correction results:								
vc' (knot)	-0.84	-0.52	0.18	0.83	0.07	-0.50	-0.99	-0.08
Speed power curve coefficients	a	-93,726.95576	b	41,928.27001	p	3.0		

5. Application Results

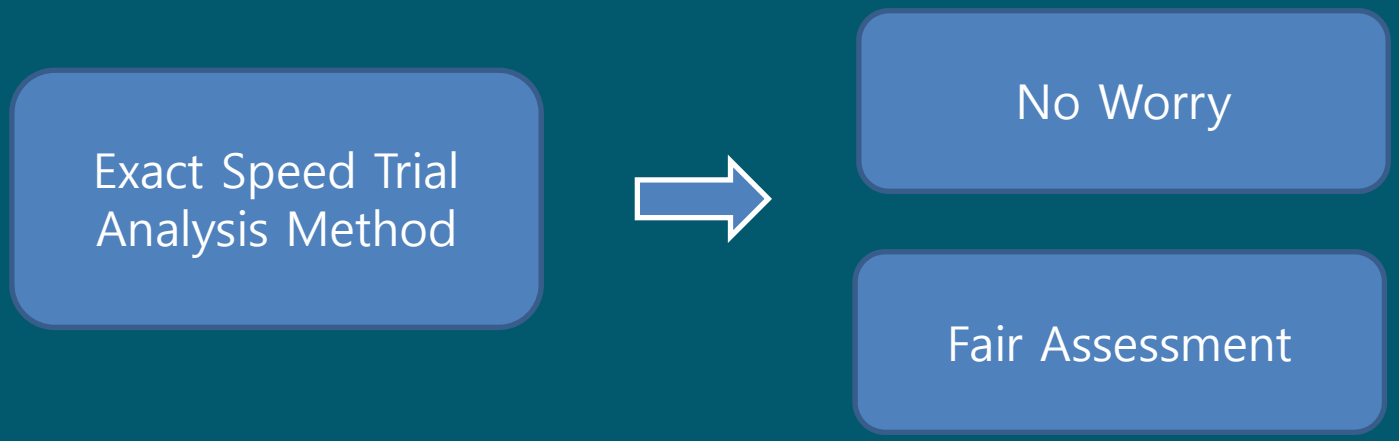
- Purpose of application
  - Validation of accuracy for ISO 2014
  - Comparison between 2002 version and 2014 version
- Selection of container carriers
  - More than 3 double runs for all sister ships
  - Including no correction ship carried out in very calm sea to consider correct answer
  - Using the normal options in speed trial analysis



- Some results doesn't converge to correct answer.
- Two method shows similar accuracy.
- There is possibility of arguments between builder and owner.

In view point of ship builders

- Why all results are different?
- The correction method is perfect to consider all added resistance?
- The speed performance depends on environmental condition and luck?
- Is it the best to wait until to meet very calm sea conditions on the sea?
- How explain the difference of speed performances between the sister ships to owners?
- How reduce the speed loss of non-compensation?



6. Conclusions

- i – STAP in developing based on ISO 15016(2014) is introduced. The program was developed user friendly using GUI.
- All reports are automatically produced when i-STAP is used.
- The revised ISO method was validated it's accuracy and compared with old ISO method. The accuracy of two methods is similar.
- But there is possibility of arguments for speed performance after sea trial between builder and owner because of inaccuracy of speed trial analysis method.
- For precise estimation of EEDI and EEOI, more improvements are necessary for correction method.

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