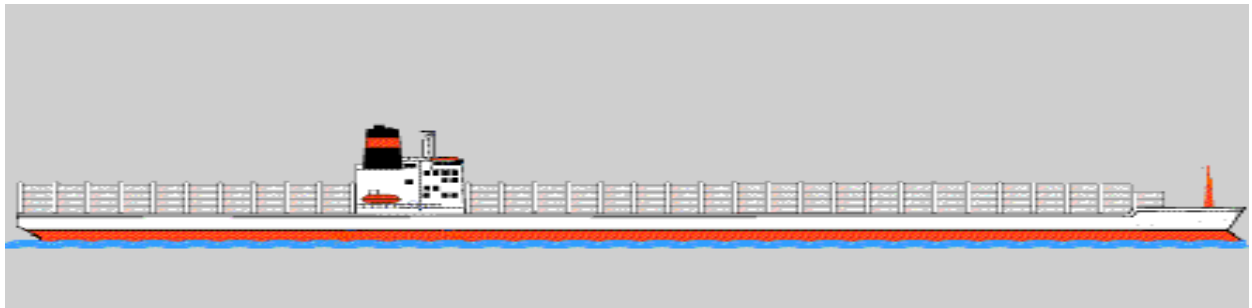




ESP 2000
Stellar Marine
Speed Pilot



Overview

Description

The ESP 2000 Speed Pilot is a vessel speed control system that provides precision control of vessel speed to improve cost per mile. Speed, load, current and weather conditions all affect the cost per mile. Depending on the cost per mile and the vessel position related to the schedule, the ESP will adjust engine RPMs to maximize progress and minimize fuel.

Designed specifically for high speed container vessels, the ESP 2000 uses two basic principles to reduce costs:

1. use the lowest speed necessary to maintain the schedule, and
2. burn the least amount of fuel necessary to maintain the required speed.

Since vessel speed is the largest controllable factor affecting fuel costs, and the relationship between speed and fuel follows the cube curve, relatively minor adjustments in speed will result in large fuel savings.

Testing

An ESP 2000, installed on a major European carrier, was subject to detailed evaluation and testing to obtain precise and reliable data. This report describes the test methods used and provides detailed observations and analysis of the test results.

Vessel Specifications

M/V Test Vessel:	4,400 TEU Container Ship
Length:	279.12 m
Gross Tonnage:	56,248 t
Main Engine:	12 RTA 84C, 41,260 kW @ 90 RPM
Propeller:	6 blades, diameter 8.5 m
Pitch:	8.666 m

Summary

Based on historical data obtained from the Test Company, the Test Vessel, with the ESP 2000 installed, burned 7.12% less fuel than its Sister Ship on trips from Suez to Singapore during 2000. The Test Vessel also burned 11.42% less fuel during the year 2000 than during the prior year on the same run. Furthermore, during Trip 1 - Suez to Singapore, the Test Vessel burned the least amount of fuel ever on this run by itself or its Sister Ship. While other factors such as weather and bottom paint affected these savings, the ESP 2000 clearly played a major role in reducing fuel costs.

The crew of the Test Vessel showed confidence in the ESP 2000 by allowing the ESP to control speed for more than 99 percent of the voyage in three trips that were analysed. The captain and crew did not intervene with ESP control until the last 1 percent of the trip when the Test Vessel was slowed for arrival.

Tests run on a trip from Antwerp to Port Said show that fuel savings of 6.7% can be achieved by using the ESP 2000 in Set Speed mode as opposed to running the Test Vessel using existing systems and methods. This fuel saving is possible because the precision of the ESP 2000 enables it to run slower and arrive closer to the scheduled arrival time.

The precision of the ESP 2000 was further verified by tests that showed:

- RPM control ± 0.1 RPM
- Speed control ± 0.1 knot
- Noon to Noon distance ± 0.1 mile
- Distance calculation ± 1 percent

Throughout the testing, the ESP 2000 was proven to improve voyage planning by allowing the captain to enter trip data (distance, arrival time, min. RPM and max. RPM), and having the ESP 2000 adjust for load and sea conditions. This minimized the need to run faster for voyage contingencies, which in turn saved fuel.

Test 1 – Historical Comparison

Purpose

To compare the performance of the Test Vessel operating with the ESP 2000 to its Sister Ship operating without an ESP 2000.

To compare the performance of the Test Vessel operating with the ESP 2000 to its performance during a prior year operating without an ESP 2000.

Description

Historical data was obtained from the Test Company. Yearly average totals were calculated for each vessel for the 6 trips made from Suez to Singapore.

Data

Chart 1 – Comparison of Test Vessel to Reference (Sister Ship) *before* ESP 2000 Installation

Vessel	Yearly Averages 1999 – Suez to Singapore					
	Draft	Displace	Hours	Distance	Speed	Fuel
Ref.	12.8	77317	221.0	4935	22.4	1227.9
Test	12.6	75797	223.3	4942	22.0	1245.1
Diff(%)	1.56	1.97	1.04	0.12	1.79	*1.40

*The Test Vessel burned 1.4% more fuel than its Sister Ship in 1999.

Test 1 – Historical Comparison (continued)

Chart 2 – Comparison of Test Vessel to Reference (Sister Ship) *after* ESP 2000 Installation

Vessel	Yearly Averages 2000 – Suez to Singapore					
	Draft	Displace	Hours	Distance	Speed	Fuel
Ref.	12.8	76946	226.8	4921	21.7	1187.4
Test	12.7	76582	226.4	4927	21.8	1102.9
Diff(%)	0.78	0.47	0.18	0.12	0.46	*7.12

*With the ESP installed, the Test Vessel burned 7.12% less fuel than its Sister Ship.

Chart 3 – Comparison of Test Vessel *before* and *after* ESP 2000 Installation

Year	Yearly Averages – Suez to Singapore					
	Draft	Displace	Hours	Distance	Speed	Fuel
1999	12.6	75797	223.3	4942	22.0	1245.1
*2000	12.7	76582	226.4	4927	21.8	1102.9
Diff(%)	0.79	1.04	1.39	0.30	0.91	**11.42

*The ESP 2000 was installed on the Test Vessel in Feb 2000.

**The Test Vessel burned 11.42% less fuel during the year 2000 than during the prior year

Test 1 – Historical Comparison (continued)

Chart 4 – Comparison of Sister Ship to prior year

Year	Yearly Averages – Suez to Singapore					
	Draft	Displace	Hours	Distance	Speed	Fuel
1999	12.8	77317	221.0	4935	22.4	1227.9
2000	12.8	76946	226.8	4921	21.7	1187.4
Diff(%)	0.00	0.48	2.62	0.28	3.12	*3.30

*The Sister Ship burned 3.3% less fuel during the year 2000 than the prior year.

Results and Observations

1. The Test Vessel burned 1.4% more fuel than its Sister Ship in 1999. In 2000, with the ESP installed, the Test Vessel burned 7.12% less fuel than its Sister Ship.
2. The Test Vessel burned 11.42% less fuel during the year 2000 than during the prior year. The Sister Ship burned 3.3% less fuel during the year 2000 than the prior year. The general improvement for both vessels during the year 2000 can be attributed in part to weather. The Test Vessel also received fresh bottom paint in Feb 2000, which might account for some of the savings.

Test 2 – Voyage Control

Purpose

To evaluate the ESP 2000's ability to manage a voyage, by arriving on time using the slowest possible sea speed, with minimal intervention from the crew.

Description

Three different trips were analysed where the ESP 2000 was in control for the majority of the trip. The Captain and crew were able to make adjustments to arrival time, distance to destination, max RPM, and min RPM at any time. They were also able to go to manual control for arrival whenever they wanted. Throughout the voyage, the ESP made all the necessary adjustments for current, weather, and load.

Data

Trip 1 - Suez to Singapore

<i>Mode of Speed Control</i>	<i>Total Hours</i>	<i>Distance</i>		<i>Average Speed</i>
		<i>Total</i>	<i>Percent</i>	
ESP 2000	227.50	4900	99.19	21.54
Manual*	2.47	40	0.81	16.19
Trip Totals	229.97	4940	100.00	21.48

* Captain takes control for arrival 2.47 hours before required arrival time with 40 miles to go. Vessel meets with pilot on time.

Test 2 – Voyage Control continued

Trip 2 - Suez to La Harve

<i>Mode of Speed Control</i>	<i>Total Hours</i>	<i>Distance</i>		<i>Average Speed</i>
		<i>Total</i>	<i>Percent</i>	
ESP 2000	137.00	3069	99.45	22.40
Manual*	1.17	17	0.55	14.53
Trip Totals	138.17	3086	100.00	22.33

* Captain takes control for arrival 1.17 hours before required arrival time with 17 miles to go. Vessel meets with pilot on time.

Trip 3 - Antwerp to Suez

<i>Mode of Speed Control</i>	<i>Total Hours</i>	<i>Distance</i>		<i>Average Speed</i>
		<i>Total</i>	<i>Percent</i>	
ESP 2000	139.00	3227	99.57	23.22
Manual*	1.50	14	0.43	9.33
Trip Totals	140.50	3241	100.00	23.07

* Captain takes control for arrival 1.5 hours before desired arrival time with 14 miles to go. Desired arrival time was 2 hours before Suez deadline for first convoy.

Results and Observations

1. The ESP 2000 remained in control of vessel speed for more than 99 percent of each of the 3 trips. The captain and crew did not intervene with ESP control until the last 1 percent of the trip when the Test Vessel was slowed for arrival.
2. For each of the 3 trips, the Test Vessel arrived at the desired arrival time, rather than too early, which saved fuel. In fact, during Trip 1 - Suez to Singapore, the Test Vessel burned the least amount of fuel ever on this run by itself or its Sister Ship.

Test 3 – Set Speed Mode

Purpose

To estimate the fuel savings that can be achieved by running the vessel in Set Speed mode.

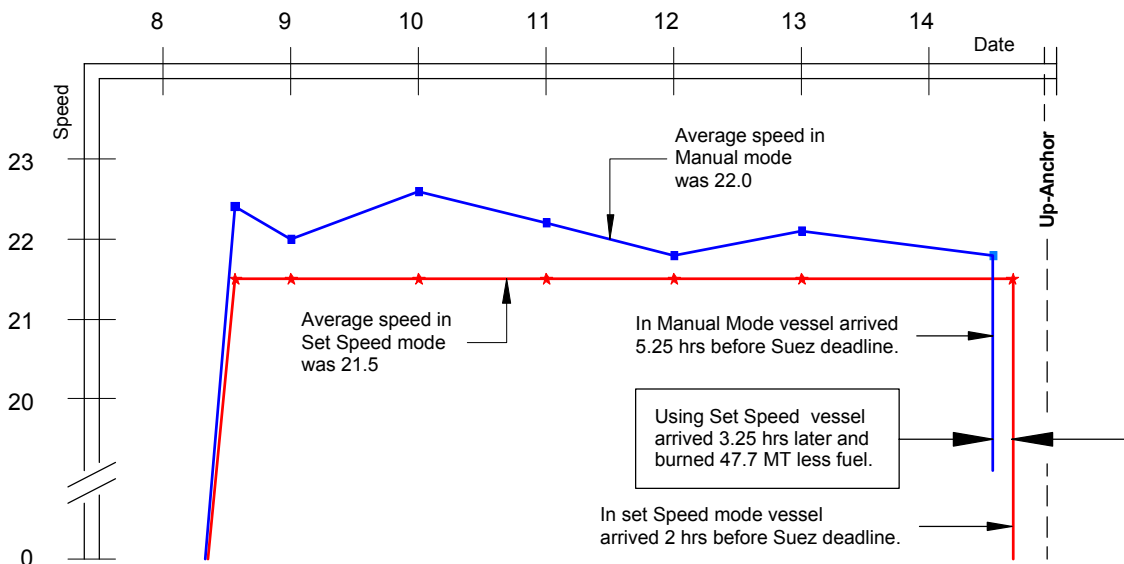
Description

Testing for fuel savings in this mode is difficult because a 'blind' test is required to ensure that the crew operates the vessel in a normal manner. The following approach was used:

- Two sets of data were generated from 2 trips of the vessel with similar load, crew, weather and current conditions.
- During the first trip from Antwerp to Port Said, the crew operated the vessel using existing tools to determine required speed.
- During the second trip, 6 days selected from Suez to Singapore, the crew engaged the ESP 2000 in Set Speed mode with a speed of 21.5 knots.
- Data from the second trip was used to estimate fuel burn for the first trip assuming it was run in Set Speed mode.
- Arrival times and fuel consumption were then compared.

Alternatively, a cube curve calculation can be used to estimate the fuel burn for a given set speed.

Data



Set Speed Test Data – Test Vessel Trip from Antwerp to Port Said
 (times and dates are GMT)

Dock to Full Away (not included in totals)

Date	Distance		Hours		Speed		Fuel Burn	
	Manual	Set Speed	Manual	Set Speed	Manual	Set Speed	Manual	Set Speed
May 8a	104.4	104.4	6.6	6.6	16.54	16.54	15.68	15.68
May 8b	290.7	279.5	13	13	22.41	21.50	66.01	58.10
May 9	525.9	516.0	24	24	21.94	21.50	117.30	106.80
May 10	540.0	516.0	24	24	22.59	21.50	118.01	109.00
May 11	529.4	516.0	24	24	22.16	21.50	119.73	107.40
May 12	521.6	516.0	24	24	21.84	21.50	117.14	108.00
May 13	528.1	516.0	24	24	22.1	21.50	117.14	105.10
May 14	260.7	336.9	12.3	15.7	21.74	21.50	56.86	70.04
Ttl/Avg	3196.40	3196.40	145.30	148.70	22.00	21.50	712.19	664.44

In Set Speed mode, fuel burn was 47.75 MT less. A saving of 6.7 %.

In Manual mode, vessel arrived 10.25 hrs before up-anchor.
 In Set Speed mode, vessel arrived 7 hrs before up-anchor.
 Note: goal was 6 hrs

Indicates average speed full away

Fuel burn in Manual mode is actual measured value in MT/DAY

Test 3 – Set Speed Mode (continued)

Results and Observations

1. During a 7 day trip from Antwerp to Port Said, fuel savings of 6.7 % could be achieved by using the ESP 2000 in Set Speed mode as opposed to running using existing systems and methods. This fuel saving is possible because the precision of the ESP 2000 enables it to run slower and arrive closer to the scheduled arrival time.
2. Using the cube curve formula where manual speed is 22.0 and manual fuel burn is 712.19, estimated fuel burn for a Set Speed of 21.5 equals 664.7 MT (note: a fuel burn of 664.49 MT was generated in the Set Speed test).
3. The ESP 2000 worked equally well on voyage segments where normal adjustment of a vessel's arrival time was to anchor or run dead slow. Anchoring or running slow at the end of a voyage did not make up for the fuel used to maintain higher speeds during the early part of a voyage.

Test 4 – RPM Control

Purpose

To determine how precisely the ESP 2000 can hold the RPM at a set value.

Description

RPM Mode was run for 1 to 3 hours and verified by using the shaft revolutions counter to determine the actual RPM.

During testing, sea conditions were force 0.

Data

<i>Date</i>	<i>RPM Engaged</i>	<i>Hours</i>	<i>Average RPM</i>	<i>RPM Range (low to high)</i>	
May 17	80.0	2	80.0	79.9	80.1
May 17	80.0	1	80.0	79.9	80.1
May 18	76.0	3	76.0	76.0	76.1
May 18	76.0	1.5	76.0	76.0	76.0

Note: The ESP 2000 air control system has a resolution of 1 mbar.

Results and Observations

1. The ESP 2000 was able to hold RPM to within ± 0.1 of an RPM.
2. The ABB was able to hold RPM to within ± 1 of an RPM.

NOTE: During a voyage to Lisbon on February 13, 2000, the vessel was operating in light ballast, conditions at force 6, with RPMs varying ± 4 . The ESP 2000 was able to maintain the RPM (averaged over 1 minute) to ± 0.1 of requested setting and dampen the oscillations by 20 percent.

Test 5 – Speed Control

Purpose

To determine how precisely the ESP 2000 can hold a ground speed.

Description

Tests were run on May 16. Vessel speed was 21.90 knots before testing. The ESP 2000 was then engaged in Set Speed mode with a speed of 21.50 knots. During the next half-hour (pre-test period), the ESP stabilized to the requested speed. Three consecutive one-hour tests were then run where average speeds were recorded. The results were compared with those from navigation equipment on the bridge.

Data

<i>Test Period</i>	<i>Hours</i>	<i>Speed Engaged</i>	<i>Beg. RPM</i>	<i>End. RPM</i>	<i>Average Speed</i>
Pre-test	.5	21.5	80.8	81.4	21.60
1	1	21.5	81.4	80.9	21.55
2	1	21.5	80.9	81.1	21.50
3	1	21.5	81.1	79.4	21.52
Total	3				21.52

Notes:

1. RPM varied between 79.3 and 81.4 throughout the test periods.
2. Speed varied from 21.4 to 21.6 knots over the test.
3. Changes in RPM reflect outside influences such as changes in weather and currents. RPM dropped to 79.4 by the end of the test as a result of an increasing favourable current.

Results and Observations

1. The ESP 2000 can be set to 0.1 knot and was able to maintain better than 0.1 knot accuracy averaged over 1-hour periods.
2. The ESP 2000 was able to compensate for changes in conditions.

Test 6 – Distance Control – Noon to Noon Repeatability

Purpose

To determine how precisely the ESP 2000 can control ground speed to cover repeatable distance over consecutive 24-hour periods.

Description

This test was run during a trip from Suez to La Harve from June 21 to June 25. Four consecutive 24-hour tests were run where average speeds and miles made good were recorded.

Data

<i>Test Date</i>	<i>Hours</i>	<i>Speed Engaged</i>	<i>Average Speed</i>	<i>Miles Made Good</i>
June 22	24	22.3	22.3	534.8
June 23	24	22.3	22.3	534.8
June 24	24	22.3	22.3	534.8
June 25	24	22.3	22.3	534.8

Note: On June 25, speeds ranged from 21.1 to 23.4 knots because of currents in the Strait of Gibraltar. Speeds varied when RPM limits were encountered.

Results and Observations

1. The ESP 2000 can be set to 0.1 knot and was able to maintain better than 0.1 knot accuracy averaged over 24-hour periods.
2. The ESP 2000 was able to compensate for changes in conditions such as currents by calculating variances and correcting when conditions were more favourable.

Test 7 – Distance Calculation

Purpose

To evaluate the ability of the ESP 2000 to calculate distance from speed. This ability is essential for a distance oriented speed log like the ESP 2000.

Description

Tests were run on March 27 and May 22. The dates and geographic positions were chosen because they represent a fixed course for the entire day. The actual distance is calculated from lat./long., and assumes that the vessel did not deviate from its course at all.

Data

<i>Date</i>		<i>Position</i>		<i>Distance</i>		<i>Diff. %</i>
		<i>Lat.</i>	<i>Long.</i>	<i>Actual</i>	<i>ESP</i>	
Mar 27	From	552.15N	8822.16E			
	To	547.60N	7934.60E	524.7	526.6	0.4
May 22	From	551.67N	8745.99E			
	To	552.98N	7910.37E	512.2	514.8	0.5

Results and Observations

1. The ESP 2000 was able to calculate distance with an error of less than one percent.
2. This precision enables the ESP 2000 to keep the vessel at the required ground speed to arrive on time, thereby saving considerable amounts of fuel.

Test 8 – Track Measuring

Purpose

To evaluate the ability of the ESP 2000 to measure distance repeatedly.

Description

Distance was measured dock to dock for 3 trips of the Test Vessel from Singapore to Hongkong.

Data

<i>Trip</i>	<i>Distance</i>	<i>Difference (%)</i>
1	1439.1	0.04
2	1438.2	0.02
3	1438.1	0.03
Average	1438.47	

Results and Observations

1. The combined errors of the ESP 2000 and the Autopilot were 0.04 percent or less. This works out to an error of less than 1 mile per 1000.