The FESTER field trial

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ABSTRACT

An overview is given of the First European – South African Transmission ExpeRiment (FESTER), which took place in South Africa, over the False Bay area, centered around Simon's Town. The experiment lasted from April 2015 through February 2016 and involved continuous observations as well as periodic observations that took place during four Intensive Observation Periods (IOPs) of 2 weeks each, which were spread over the year. The continuous observations aimed at a characterization of the electro-optical propagation environment, and included standard meteorology, aerosol, refraction and turbulence measurements. The periodic observations aimed at assessing the performance of electro-optical sensors in VIS / SWIR / MWIR and LWIR wavebands by following a boat sailing outbound and inbound tracks. In addition, dynamic aspects of electro-optical signatures, i.e., the changes induced by variations in the environment and/or target orientation, were studied. The present paper provides an overview of the trial, and presents a few first results.

Keywords: Field trial, sensor performance, electro-optical propagation, dynamic signatures

1. INTRODUCTION

The military operational theatre has changed significantly over the last decades. In the post-cold war era, international missions, law enforcement, humanitarian aid and peace keeping operations require flexible military organizations with the ability to operate efficiently in any geographical region and in any environment. Efficient operations require the capability to achieve reliable operational situational awareness, which in turn relies heavily on the most optimal deployment of sensor systems.

The performance of sensor systems is affected by the environment. In some cases, the impact of the environment is evident: rain, snow and fog limit the effective range of electro-optical sensors. In other cases, the relation with the environment is more subtle: temperature and humidity gradients in the atmosphere may cause ducting conditions allowing radars sometimes to see beyond the horizon, and sometimes to have a shorter range. To further complicate matters, the environment impacts differently on various sensors and sensor bands. Conditions that severely limit the performance of radars may be beneficial for electro-optical systems and vice versa.[1]

With the shift in focus from blue to brown waters, the Navy has entered the coastal zone. Here, the need for detailed environmental data is amplified due to the high spatial and temporal variability in the conditions. In addition, the scale of the operational theatre is often reduced (amphibious operations, interception of drug traffickers, harbor protection, …),

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which augments the need for spatial detail. The presence of a nearby coast impacts on the meteorological conditions that are often perturbed by small-scale disturbances such as a complex coast line or the occurrence of sea breezes.[2] Also, the aerosol loading of the atmosphere becomes more complex as not only marine aerosols generated from wave-wind interactions are present, but also aerosols of other types that are generated from secondary production processes or produced on the nearby land and advected into the operational area. The result is a highly variable aerosol extinction, that in turn results in highly variable effects on the propagation conditions in the coastal zone.[3]

Situational awareness can only be achieved with reliable sensor information. The commander must know up to what range his sensor systems are able to pick up a threat under the given environmental conditions. Vice versa, he also needs to know at what range his platform is visible to the threat sensors. The adverse impact of the environment on sensor performance requires an answer to the question "if I do not see the threat, does that mean that the threat is not there, or are my sensors not able to pick up the threat?" Such answers can be provided by Tactical Decision Aids (TDAs) that assess sensor performance as function of environmental conditions, for example the Electro-Optical System Transmission And Ranging (EOSTAR) model.[4]

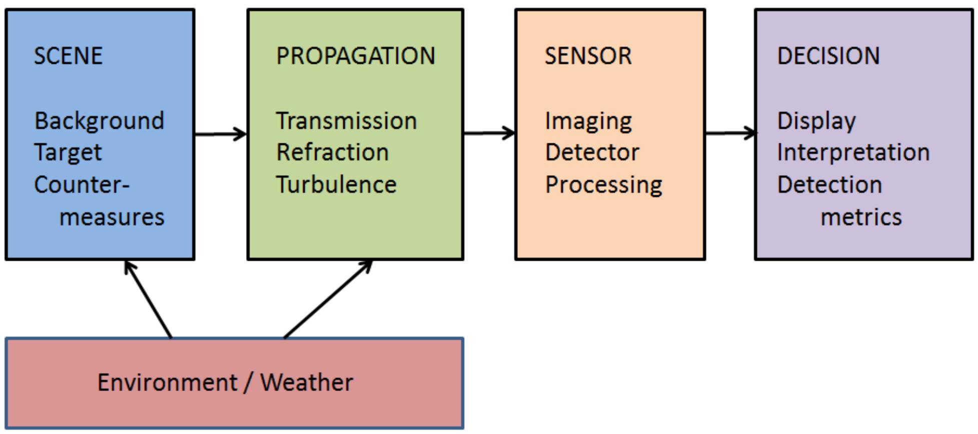

Figure 1: Block scheme of the observation chain

To perform its task, the EO-TDA must aim at providing a description of the observation chain, which is summarized in Figure 1. The first block represents the target in its environment (background, possible countermeasures), the second block describes the signal transfer function between the object of interest and the sensor, the third block translates the optically received signal to an electronic / digital signal, and the final block transforms the signal to information that assists the human operator in his decision process, yielding the final output in terms of information relevant to the detection, recognition and identification (DRI) or vulnerability process. Environmental effects directly influence the contrasts in the scene as well as the propagation.

The validation of TDAs such as EOSTAR require comprehensive field trials that simultaneously monitor the performance of the sensors and the environmental conditions that drive the physical processes impacting on the scene and the propagation conditions. While the authors of this paper have all been involved in such trials (e.g., Stein and Seiffer[5]) none of these have taken place in the southern hemisphere, which may present new environmental conditions compared to previous test sites. Furthermore, it is important that a suitable infrastructure is available at the test site, to accommodate experimentalists and their equipment and to ensure safe operation. All of this was provided by selecting False Bay, South Africa, as the location for the First European – South African Transmission ExpeRiment (FESTER). In addition, the electro-optical propagation conditions over the False Bay area had already been extensively characterized during the False-bay ATMOSpheric Experiment (FATMOSE) in 2009-2010.[6] This provided a solid basis for understanding the environment and the lessons learned from FATMOSE provided key guidelines for the setup of instrumentation, as well as the spatial and temporal resolutions required in the measurements.

The FESTER experiment was jointly organized by the South African Institute for Maritime Technology (IMT), the Netherlands Organization for applied scientific research (TNO), and the German Fraunhofer Institute for Optronics, System Technologies and Image Exploitation (IOSB). The other partners in the project were the South African Council for Scientific and Industrial Research (CSIR), department Defence, Peace, Safety and Security (DPSS), the Norwegian Defense Research Establishment (FFI) and the German Wehrtechnische Dienststelle für Waffen und Munition (WTD91).

The main objective of the FESTER trial was to provide data for the validation of EO-TDAs, in particular EOSTAR.[4] Secondary trial goals consisted of (1) measuring EO dynamic signatures and wakes for development and testing of signature models; (2) characterizing optical turbulence effects in terms of scintillation, beam wander and blur; (3) assessing the spatial and temporal scales of environmental inhomogeneity as reflected in changes in meteorological parameters, aerosol concentrations, and turbulence; (4) evaluating the differences and similarities in the propagation conditions for the electro-optical and radiofrequency domains.[7]

As the FATMOSE trial had suggested that the inhomogeneity in sea surface temperature impacts heavily on the propagation conditions over False bay, the FESTER trial was extended with an oceanographic component. The oceanographic experiment focused on an underwater characterization of the northwestern part of False Bay, as part of a larger academic cooperative effort of characterizing the False Bay underwater environment.

2. DESCRIPTION OF EXPERIMENTAL PROGRAM

2.1 General

The FESTER campaign took place from April 2015 through February 2016 near Cape Town, South Africa (Figure 2, left panel). The center location of the trial was the Institute for Maritime Technology (IMT) in Simon's Town (red dot in the right panel of Figure 2), and the area of interest spanned the Northern and Northwestern parts of False Bay. Apart from the IMT, additional FESTER locations included a sea-facing apartment in St. James (SJ in Fig. 2), the National Sea Rescue Institute (NSRI) station in Strandfontein (SF in Fig.2), and the Roman Rock lighthouse (RR in Fig.2, see also Fig. 3). The old Signal School on the mountain ridge to the west of IMT provided an elevated (approximately 200 m above sea level) viewing point of the bay. Finally, an important asset was the Sea Lab (Fig. 3), a boat owned and operated by IMT.

The experiment consisted of two components: continuous monitoring and intensive observation periods (IOP). The continuous monitoring took place over the full FESTER timeframe, with instrumentation at IMT, Roman Rock, Strandfontein, St. James and along the propagation path from IMT to St. James. These instruments are further discussed in section 2.2 and served mostly for the characterization of the (propagation) environment.

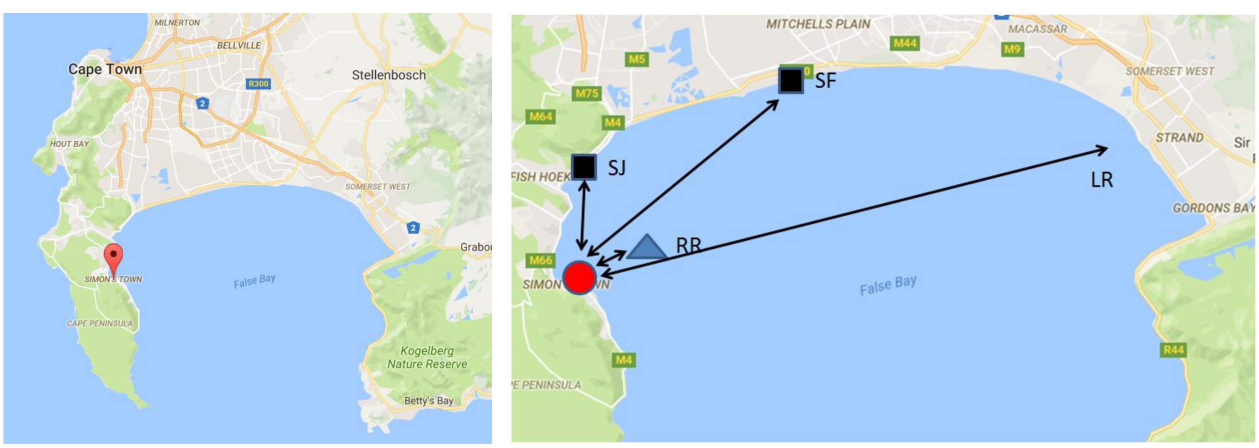

Figure 2: FESTER trial area. Left panel: global area, the city of Simon's Town is indicated by the marker. Right panel: detailed area, IMT is indicated by the red circle, RR = Roman Rock, SJ = St. James, SF = Strandfontein, LR = Long radial. Arrows indicate propagation links and/or generic boat tracks.

Figure 3: FESTER locations and assets. From left to right: the IMT building, Roman Rock lighthouse and Sea Lab.

The IOPs consisted of four timeframes of 2 weeks each, that were spaced regularly over the year in order to capture the seasonal variability of the False Bay climate. IOP1 took place from 1 to 14 June 2015, IOP2 from 31 August to 13 September 2015, IOP3 from 16 to 29 November 2015, and IOP4 from 15 to 26 February 2016. The IOPs included the deployment of the electro-optical sensor and radar systems and Sea Lab operations. The Sea Lab sailed along two radials. One of these ran from IMT to St. James (figure 2), and served mainly for dynamic signature measurements and the characterization of upper air and oceanographic conditions. The second radial was denoted the long radial (LR in figure 2) and ran (south)east from the IMT towards the other side of the Bay. This radial served for evaluating sensor performance in terms of contrast, resolution and detection ranges.

The remainder of this section discusses the individual instrumentation deployed and the measurement set-up. Since the present paper is an overview, the description is necessarily limited in detail. Individual reports on specific experiments and analyses will provide full details of instrumentation, settings, and operations.

2.2 Continuous monitoring

The objective of the continuous monitoring experiments was to provide a year-long dataset that characterizes the False Bay environment in terms of propagation, meteorological and oceanographic parameters. For the propagation conditions, transmission, refraction and turbulence were taken into account separately.

Table 1 provides an overview of the instrumentation deployed for turbulence monitoring. The main instrumentation to measure turbulence consisted of four Scintec boundary layer scintillometers (BLS). A BLS2000 system was operated over the 8.7 path from IMT to St. James, and three BLS900 systems were deployed over the 1.8 km path from IMT to Roman Rock, with average heights over the water of 7, 15 and 21 meters, respectively. The package was complemented by a Sonic anemometer installed at Roman Rock.

Table 1. Turbulence package deployed for continuous observations.

Name	Equipment	Output	Deployment	Owner
Scintec BLS900	Scintillometer	C_n^2, C_T^2	1st Floor IMT ↔ RR	IMT
Scintec BLS900	Scintillometer	C_n^2, C_T^2	2nd Floor IMT ↔ RR	IOSB
Scintec BLS900	Scintillometer	C_n^2, C_T^2	Upper roof IMT ↔ RR	DPSS
Scintec BLS2000	Scintillometer	C_n^2, C_T^2	Lower roof IMT ↔ SJ	IOSB
Gill HS-90	Ultrasonic anemometer	C_n^2, C_T^2	Roman Rock (RR)	IOSB
MSRT	Transmissometer	TRA, SI	2nd Floor IMT ↔ SJ	TNO
'Hubble'	Imaging MWIR &VIS	N, blur, SI	Upper roof IMT ↔ SF	IOSB

Symbols/Abbreviations: T = Air temperature; TRA = Transmission; SI = Scintillation index; N = Refractive index; C_n^2 and C_T^2 denote the structure constant for refractive index and temperature, respectively.

Transmission measurements were made over the 8.7 path between IMT and the apartment at St. James, using the Multi-Spectral Radiometer Transmissometer (MSRT) developed and built by TNO.[8,9] This instruments provided the transmission in 6 wavelengths bands centered at 0.45, 0.61, 0.91, 1.53, 2.32 and 4 µm. The mid-wave infrared (MWIR) band at 4 µm was only operative during the IOPs. The MSRT was operated in dual mode that combined a long integration time of 21 seconds for transmission measurements with a 10 ms integration time for scintillation measurements.

Finally, turbulence observations were made over the 15.7 km path between IMT and the NSRI station in Strandfontein. Three halogen lights were mounted in a chevron arrangement at the NSRI station. Their light was collected by a 2m telescope located at the upper roof of IMT (the "Hubble"), and fed onto imaging sensors operating in the MWIR and visible (VIS) bands.

Table 2 presents the remaining sensor suite that made up the continuous observations. The aerosol package consisted of in-situ optical particles counters (OPC) located in the parking lot in front of the IMT-building (left corner in left panel of figure 3), facing southeast towards the open waters of the bay. The OPCs provided a diameter range of 0.21 to 45 µm in 91 channels. The in-situ distributions were complemented by vertical profiles as measured by a lidar ceilometer and column extinction measured by a sun photometer, both located at the IMT roof. Furthermore, the MSRT provided path-integrated aerosol properties along the path from IMT to St. James.[9]

Table 2. Additional sensors deployed for continuous observations.

Name	Equipment	Output	Deployment	Owner
PMS CSASP-100HV	Optical particle counter	Aerosol size distr.	In front of IMT	TNO
PMS CSASP-200	Optical particle counter	Aerosol size distr.	In front of IMT	TNO
Vaisala CL-51	Lidar ceilometer	Aerosol profile, cloud height	Upper roof IMT	DPSS
Cimel	Sun photometer	Aerosol column, solar/sky irradiance	Upper roof IMT	DPSS
MSRT	Transmissometer	Pat-integr. Aerosol	2nd Floor IMT ↔ SJ	TNO
Name	**Equipment**	**Output**	**Deployment**	**Owner**
Aimar 200WX	Weather station	P, U, Q, T	Roman Rock (RR)	IMT
Gill HS-90	Ultrasonic anemometer	P, U, Q, T	Roman Rock (RR)	IOSB
Davis Vantage Pro2	Weather station	P, U, Q, T, rain, irr	Upper roof IMT	IMT
Campbell	Weather station	P, U, Q, T, rain	Lower IMT roof	IOSB
Aimar 200WX	Weather station	P, U, Q, T	Sea Lab	IMT
SPAR Buoy	Weather station on buoy	P, U, T	Middle of path IMT ↔ SJ	IMT
Name	**Equipment**	**Output**	**Deployment**	**Owner**
Teledyne RDI ADCP	Wave and current profiler	Current, waves	1.7 km along IMT ↔ SJ	IMT
Nortek AWAC	Wave and current profiler	Current, waves	4.3 km along IMT ↔ SJ	IMT
Nortek Aquadopp (Z-Cell)	Current profiler	Current, waves	7.2 km along IMT ↔ SJ	IMT

Symbols/Abbreviations: P = Pressure, U = Wind; Q: Humidity; T = Air temperature; irr = solar irradiance.

The continuous oceanographic observations were made by three sensors, regularly spaced along the path from IMT to Kalk Bay. All sensors were moored to the bottom of the Bay and provided the profiles of the water currents from the bottom up to the surface. In addition, all sensors provided the full directional wave field that was summarized in terms of wave height and wave period.

2.3 Intensive Observation Periods (IOPs)

The IOPs were the timeframes when the sensor systems were deployed and their performance was evaluated as function of the environmental conditions, using the Sea Lab as a target. The IOPs thus provided the core data for the primary objective of FESTER, i.e., the validation of Tactical Decision Aids. The IOPs also provided the data for the secondary objective of understanding the dynamic aspects of electro-optical signatures. Tables 3, 4 and 5 provide an overview of the instrumentation deployed during the IOPs.

Table 3. Equipment installed on Sea Lab during IOPs.

Name	Equipment	Output	Owner
Bar target	Standard black-white bar pattern	Contrast as function spatial frequency	IMT
LED lights (2x)	High-intensity, narrow beam light	Resolved target separation distance	IMT
Heat sources (2x)	High-temperature blackbody	Point source intensity	IOSB
Vaisala WXT520	Weather station	P, U, Q, T, rain	IMT
Aimar 200WX	Weather station	P, U, T	IMT
GPS, AIS	Positioning and location tools	Position, trajectory	IMT
Metal plates (6x)	3 and 6 mm steel with insulation	Dynamic IR signature	IMT
Pyrgeometer (2x)	Irradiance measurement	Incident sky radiance on metal plates	TNO
Pyranometer (2x)	Irradiance measurement	Incident solar radiance on metal plates	TNO
iButtons (12x)	Temperature sensors and loggers	Plate and hull temperatures	TNO (1) IMT
Heitronics	LWIR radiometer	Sea surface temperature	IMT
Allsop Helikite	Kite with weather sensors	Vertical profiles of P, U, Q, T	IMT
CTD Probe	Underwater characterization	T_{sea}	IMT
Surfboard	Towed sensor platform	Air-sea interchange temperatures	IMT

Symbols/Abbreviations: P = Pressure, U = Wind; Q: Humidity; T = Air temperature; T_{sea} = seawater temperature.
Remark: numbers between brackets in column 'owner' signal the specific IOP that the instrument was deployed.

Table 4: Additional equipment installed at IMT during IOPs.

Name	Equipment	Output	Owner
Radiosonde	Balloon with weather sensors	Vertical profiles of P, U, Q, T	WTD91 (4)

Symbols/Abbreviations: P = Pressure, U = Wind; Q: Humidity; T = Air temperature.
Remark: numbers between brackets in column 'owner' signal the specific IOP that the instrument was deployed.

Table 5. Imaging sensors and radar deployed during the IOPs.

Name	Band	Characteristics	Deployment	Owner
FLIR SC7300L	LWIR	CMT 320x256, 2.75 x 2.2° FOV, 0.15 mrad IFOV	Upper roof IMT	IMT
FLIR/CEDIP	MWIR	InSb 320x256, 2.75 x 2.2° FOV, 0.15 mrad IFOV	Upper roof IMT	IMT
CEDIP	SWIR	CMT 320x256, 2.75 x 2.2° FOV, 0.15 mrad IFOV	Upper roof IMT	IMT
JAI AG080	NIR	CCD, FOV (HxV) 0.18 x 0.14°, 3.1 μrad IFOV	Upper roof IMT	IMT
JAI CB-200GE	VIS	CCD, FOV (HxV) 0.27 x 0.20°, 2.9 μrad IFOV	Upper roof IMT	IMT
InfraTec LWIR	LWIR	CMT, 640x512, 2.8° FOV	Upper roof IMT	IOSB
InfraTec MWIR	LWIR	CMT, 640x512, 2.8° FOV	Upper roof IMT	IOSB
AIM640C	MWIR	CMT, 640x512, 1° FOV	Upper roof IMT	IOSB
FLIR SC7000	MWIR, SWIR	InSb, 640x512, 2.8° FOV	Upper roof IMT	IOSB
FLIR AC6555SC	LWIR	640x480, 5.25° FOV	1st floor IMT, old Signal School	TNO (1)
FLIR SC7750L	LWIR	InSb, 640x512, 2.93 x 2.35° FOV, 0.08 mrad IFOV	ground floor IMT, old Signal School	TNO (3)
FLIR SC7600	MWIR	InSb, 640x512, 2.75 x 2.2° FOV, 0.075 mrad IFOV	ground floor IMT, old Signal School	TNO (3)
Sony DXC-9100P	VIS	CCD, 782x582, 3.03 x 2.27° FOV	ground floor IMT, old Signal School	TNO (3)
Telops Hyper-Cam	LWIR, MWIR	320 x 256, 6.4 x 5.1° FOV	In front of IMT	FFI (3)
SimRad 4G radar	9.4 GHz	2.6 – 5.2° beam width	In front of IMT	FFI (3)

Remarks: (a) numbers between brackets in column 'owner' signal the specific IOP that the instrument was deployed; (b) The location "in front of IMT" is a few meters below the ground floor of IMT.

Figure 4: FESTER instrumentation. Left panel: helikite, Middle panel: surfboard; Right panel: metal plates on Sea Lab.

The characterization of the environment was intensified during the IOPs with emphasis on the spatial and temporal inhomogeneities in the air and the water, and this for the transect from IMT to St. James. For the water component, a Conductivity Temperature and Depth profiler (CTD-probe) was deployed from the Sea Lab at five (increased to seven during IOP3 and IOP4) waypoints along the transect. This allowed retrieval of water temperature profiles over a 8 km spatial range within a few hours. The sea surface temperature was measured separately by a longwave infrared (LWIR) radiometer mounted on a rod extending from the bow of the Sea Lab. In addition, the seawater temperature just below the surface was measured by a sensor mounted on a "surfboard" (middle panel of figure 4) that was towed alongside the Sea Lab, in-front of the wake. The surfboard also measured the air temperature just above the surface (0.5 m); because the surfboard structure is rather small and thus induces less flow distortion in the water and air than Sea Lab, it is hoped that the temperatures measured on the surfboard provide a good indication of the air-sea interchange temperatures.

The Sea Lab also deployed a helikite (left panel of figure 4) at the midpoint of the transect IMT – St. James. This provided an unique insight in the vertical structure of first 100 – 200 meters of the atmosphere above the water and a rare opportunity to test the validity of meteorological theories, which in turn are used in the calculations of turbulence quantities. During IOP4, the vertical structure was also measured by three (classic) radiosonde releases per day, but these profiles are vertically less resolved than those obtained with the helikite and (depending on wind) covered a larger spatial area, not necessarily over the water surface of False Bay. On the other hand, the radiosondes provided information up to 15 km height.

The main task for Sea Lab consisted of serving as a target for the multitude of electro-optical sensors deployed during the various IOPs. Table 5 provides an overview of the sensors, which covered the full electro-optical band from the visible (VIS) via the near-infrared (NIR), short-wave infrared (SWIR), mid-wave infrared (MWIR) to the far infrared (LWIR). The sensors were positioned at various heights at the IMT building (from ground level to the upper roof). During IOP1 and IOP3, sensors were also deployed from an elevated viewing point (200 m above the water), the Old Signal School on the mountain behind IMT. During IOP3, FFI deployed two hyperspectral camera's (MWIR and LWIR). These cameras are unique, because they provide spectral information for each pixel separately.

Signature measurements were primarily made when Sea Lab sailed the 8.7 km track from IMT to St. James. For improved realism, each side of Sea Lab was equipped with two metal plates, 3 and 6 mm thick, insulated at the back and coated with grey paint (right panel of figure 4). The in-situ temperatures of the metal plates and other representatives spaces on Sea Lab were continuously measured with iButtons. Pyrgeometers and pyranometers were installed next to the vertical plates; the sensors were mounted vertically with respect to the plates as to measure the radiation incident on the plates.

Dynamic aspects of the signatures were created by changing the solar and sky irradiance of the metal plates. To this end, Sea Lab made stops at specific waypoints along the transect IMT – St. James. The ship was then oriented towards the sensor systems, which could then monitor the heating or cooling of the plates as equilibrium set in. When the equilibrium was established, Sea Lab would turn and present its other side to the sensors. The sensors could then record the dynamic signature changes as a new equilibrium was established.

The signature measurements were completed with recordings of the sea and sky backgrounds, and the wake of Sea Lab as it sailed at various speeds. The elevated sensor position at the Old Signal School was primarily created for this element. Furthermore, a side experiment consisted of tracking the Sea Lab as it sailed along, and moved in front of or behind other traffic.

The longer tracks of Sea Lab towards the other side of False Bay (LR in figure 1, typical range up to 30 km) served to establish sensor performance. Three individual experiments were performed. In the first experiment, the sensors measured the (apparent) intensity of two high-temperature black bodies that were mounted aft on Sea Lab as the boat sailed away from IMT. Since the intrinsic radiant intensities of the black bodies is known, the apparent radiance provides information on the propagation conditions and can be used to test the predictions of Tactical Decision Aids.

The other experiments focused on the spatial resolution of the imaging systems. To this end, a traditional black/white bar chart was mounted on Sea Lab, which allowed to measure contrast as function of spatial resolution as Sea Lab sailed away from IMT. Furthermore, two LED lights were mounted on a horizontal rod with a known separation distance. The LEDs were high-intensity and provided a narrow beam. As Sea Lab sailed away, the maximum distance could be determined at which the two LEDs were still resolved by the imaging sensors.

A radar was deployed during IOP3 and recorded the signal intensity returned from Sea Lab as it sailed out from IMT on the long radial. These measurements reveal the propagation conditions (refraction, propagation factors) in the radiofrequency domain, which can be compared to the propagation conditions in the electro-optical domain. This then reveals the similarities and differences of the two sensor types.

3. FIRST AND REPRESENTATIVE RESULTS

The FESTER campaign has yielded a wealth of data and it is not obvious to select a few representative results. We have chosen a few examples that demonstrate the uniqueness of the dataset acquired during FESTER. For example, the left panel figure 5 shows the results of our efforts to characterize the inhomogeneity of the environment. The figure shows the variation in seawater temperatures along the transect IMT – St James as observed during one particular run of Sea Lab. Although not shown, the temperatures of the sea surface and air just above the water (surfboard, radiometer and weather stations) were also recorded during this run. The right panel of figure 5 shows the vertical profile of air temperature as obtained with the helikite at the midpoint of the transect. In all, the data provides insight in the variability of the air-sea temperature difference, which is relevant for the turbulence intensity as reflected in the structure parameter C_n^2.

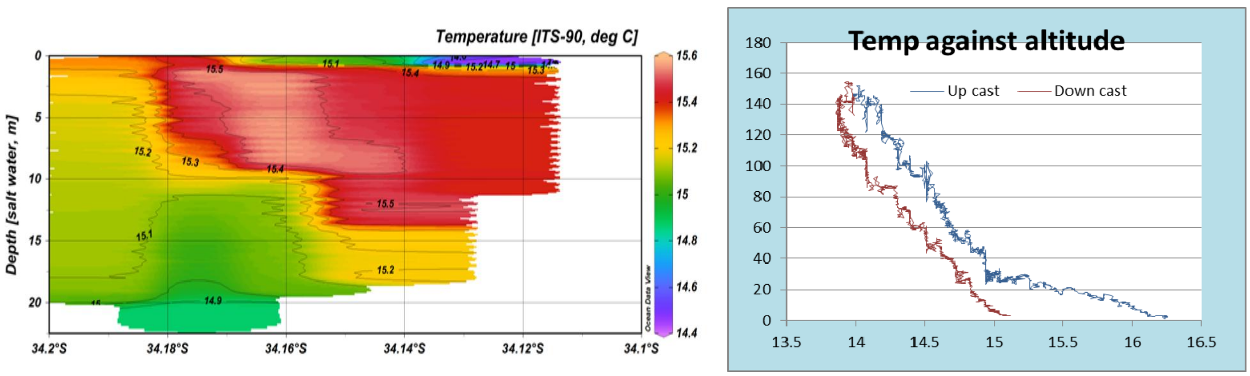

Figure 5: Left panel: sea water temperatures along path from IMT to St. James; Right panel: Vertical profile of air temperature acquired with the helikite.

To illustrate the importance of air-sea temperature differences, figure 6 shows the results of C_n^2 measurements for a specific day. The bright red, blue and green curves show the (path-averaged) C_n^2 values retrieved from the three scintillometers on the 1.8 km path from IMT to St. James. The curves demonstrate that the turbulent intensity decreases as the path is higher above the water. This is a direct consequence of the changes in air temperature with height, which can (in principle) be quantified by the information provided by the helikite.

The plot also shows the (in-situ) C_n^2 value as retrieved from the sonic anemometer at the top of the lighthouse, and the path-averaged values obtained with the BLS2000 along the longer 8.7 km path from IMT to St. James. For the second

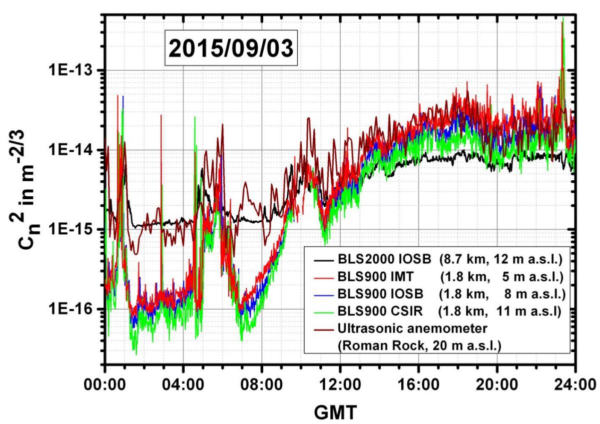

Figure 6: Variations in turbulence intensity (C_n^2) on 3 September 2015 (IOP2)

half of the day all five curves show similar behaviour, which suggest that the False Bay environment was rather homogeneous at that time. However, for the first part of the day the sonic and the BLS2000 show a markedly different behaviour from the three BLS900 systems. This reflects the spatial inhomogeneity of the environment and suggests that a specific event took place along the path from IMT to Roman Rock, which affected the lowest air layers of the atmosphere. This will be analysed further.

Figure 7: Snapshots of a time series showing the variation in metal plate temperature

Figure 7 shows an example of the dynamic signature experiments. The figure shows three snapshots from a time series of observations with the IOSB MWIR camera. Prior to the recording, Sea Lab had allowed the metal plates to warm up in the sun until equilibrium was reached. Sea Lab then turned, which brought the metal plates in the shade where they started to cool. Although the images were recorded in autogain mode and the radiant intensities have not yet been normalized, the snapshots clearly show the cooling of the metal plates. The images also demonstrate that the thinner plate cools more rapidly than the thicker plate. Time series like these provide time constants for the reaction of materials to changing environmental conditions, which can be induced by ship movements (turns, speed), but also by the environment itself (clouds moving in front of sun).

4. CONCLUDING REMARKS

The First European – South African Transmission ExpeRiment (FESTER) took place over the False Bay area near Cape Town, South Africa, from April 2015 through February 2016. The primary objective of the field trial was to collect data for the validation of Electro-Optical Tactical Decision Aids (EO-TDAs), with secondary objectives focusing on signature modeling and the characterization of the (inhomogeneous) propagation environment. The experiment included continuous measurements, mostly focusing on the propagation environment, and four two-week Intensive Observation Periods (IOPs), focusing on sensor performance. The IOPs were spaced over the year to capture the seasonal variations over False Bay.

The data collection in FESTER was successful, with minimal equipment failure and corresponding lacks in data, and no malfunction of the most critical instrumentation. FESTER yielded information on sensor performance in all electro-optical bands (VIS to LWIR) as well as in the X-band of the radiofrequency domain. This information was primarily gathered from outbound tracks of the vessel Sea Lab over the Bay, when sensors focused on bar targets, LED lights and black bodies.

On a closer range, electro-optical signature measurements were made. The experiments focused on dynamic aspects, created by changes in irradiance induced by turning of the boat, as well as wakes. Sea and sky backgrounds were recorded to allow for contrast calculations.

The characterization of the propagation environment included path-averaged transmission, refraction and turbulence measurements over a 8.7 km over-water link from the IMT institute to St. James, complemented by in-situ measurements at IMT and Roman Rock lighthouse. In addition, aerosol information was recorded in-situ and over horizontal and vertical paths. The characterization of the environment was completed by an extensive set of standard meteorological parameters.

The inhomogeneity of the atmospheric and oceanic environments was assessed by a series of spatially and temporally resolved measurements, including profiles of seawater and air temperatures. These measurements allow testing standard micrometeorological approaches to characterize the propagation environment, which eventually may lead to improvements of these modules for application in EO-TDAs.

In conclusion, the FESTER effort has resulted in a rather unique and extensive dataset that allows evaluating the performance of EO Tactical Decision Aids and its underlying modules.

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