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NATS Safeguarding Office

Technical Safeguarding Assessment

For Mona & Morgan
Wind Farm Developments

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Contents

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1. Scope

This report is a bespoke technical assessment of the impact of two proposed windfarms on the Communication, Navigation and Surveillance, CNS, equipment operated by the Isle of Man Airport.

Details of the proposed turbines and the CNS equipment to be assessed were provided by the airport.

No attempt has been made to estimate the operational significance of any technical impact identified. It is felt this can only properly be determined by specialists at the airport who are actively engaged in providing the required air traffic service.

2. Development Details

The proposed Mona and Morgan windfarms are large offshore developments to be located in the Irish Sea to the South-East of the Isle of Man.

The turbine locations have not been finalised, however is not expected that the precise locations of the turbines within the overall development boundaries will change the conclusions of the report significantly.

Where required to undertake an assessment a set of representative turbine locations have been used; these are detailed in Appendix B and shown in the diagram below. For the purposes of any assessment covered by this report the turbines are all assumed to be 207m to hub and 367m to tip.

Figure 1 – Representative Turbine Locations

3. Assessments Required

Details of the equipment to be assessed were provided via email by the airport and include:

- An ATCR33SE Primary Radar
- Three Air-ground-air Radio Sites
- A distributed MLAT System comprising 19 locations
- The instrument landing systems for runways 26 and 08

The diagrams below show the locations of the equipment to be assessed.

Figure 2 – On-airfield CNS equipment

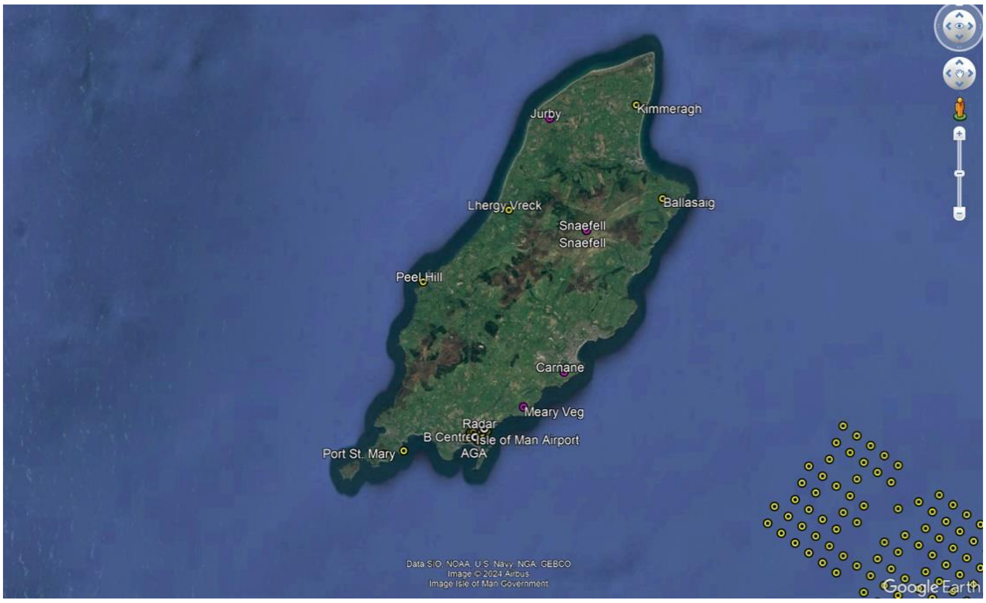

Figure 3 – Remote CNS equipment

3.1. RADAR Technical Assessment

3.1.1. False Tracks

Using the theory as described in Appendix A and the turbine specific propagation profiles it has been determined that the terrain screening available will not adequately attenuate the signal, and therefore all the proposed turbines would return sufficient power to cause false primary plots to be generated. Not every turbine will generate a false plot every scan however they are likely to be of sufficient frequency that they lead to the creation of false PSR tracks that would be displayed to controllers.

3.1.2. Track Seduction

Alongside these turbine-generated false tracks the underlying false plots can also lead to a phenomenon known as track seduction which is when a mature aircraft track overflying the area appears to deviate from its actual path because the radar mistakenly attributes one or more of the false plots to the aircraft track.

3.1.3. Probability of detection

A reduction in the radar's probability of detection is also anticipated in the airspace directly above the turbines as the radar clutter suppression algorithms raise thresholds and track processing struggles to handle the mix of real/false plots. The extent of this area will depend on the radar's internal cell sizes and will extend beyond the windfarms themselves as once real aircraft tracks are lost they may take multiple scans to re-establish upon leaving the affected area.

3.1.4. Shadowing

For turbines of this scale there will be a shadow cast behind the turbine where plot detection and accuracy is likely to be degraded. At this range the shadow zone will not extend far beyond the turbine and be limited to very low altitude and therefore shadowing is not deemed to be a significant factor.

3.2. Navigational Aid Assessment

The components of the instrument landing system; two localisers, two glide paths, a DME and an NDB were assessed against the criteria from ICAO EUR Doc 015. This document provides restricted areas for turbine development in the vicinity of these types of equipment.

For the DME the restricted area only runs out to 3km, and all of the turbines are comfortably outside this.

For the NDB the criteria are even less restrictive and again all the proposed turbines lie outside both the range and slope restrictions.

The localisers and glide path criteria extend significantly further however the turbines are still comfortably clear of the restricted areas as shown below.

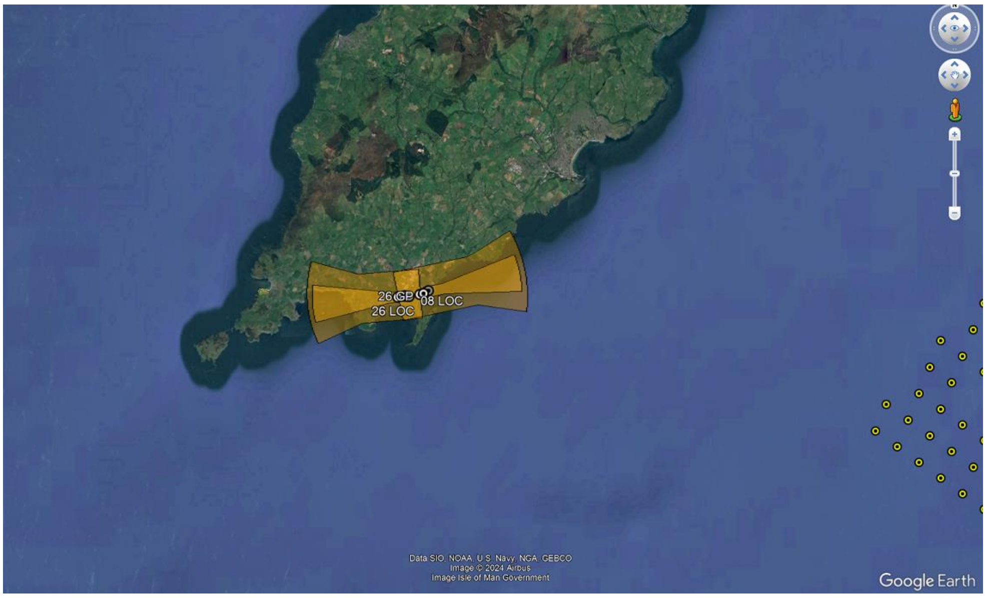

Figure 3 – Localisers and glide path restricted area criteria

3.3. Radio Communication Assessment

CAP-670 Appendix A to GEN 02 provides the basis for air-ground radio assessments of turbines in the United Kingdom. The CAP-670 methodology involves two phases; an initial zonal assessment based on turbine classification and, if required, a more detailed carrier to interference ratio assessment.

The CAP-670 turbine classifications range from "Small" to "Large Industrial" based on turbine characteristics such as hub and tip height.

Unfortunately the largest turbine class tops out at 158m to tip which is less than half the size of the turbines being proposed and therefore the published red/amber/green volumes of the zonal assessment are not applicable.

It is possible to assume "Amber" and to scale the more detailed carrier to interference, C/I, ratio assessment by using the formula provided to calculate a bi-static RCS outside the range provided in CAP670 tables 4 and 5.

Modelling 172 turbines is very computationally intensive and as these will not likely be the final locations this would not yield a definitive result in any case.

It was therefore decided to model the best (Mona T16) and worst (Morgan T11) case turbine to get a feel for the likely volume of impact with the caveat that the cumulative effect of multiple turbines may inflate these volumes somewhat.

Simulating a receiver at 1,000ft yielded shadows directly behind the turbines and potential degradation at longer ranges out to the maximum range of the radio.

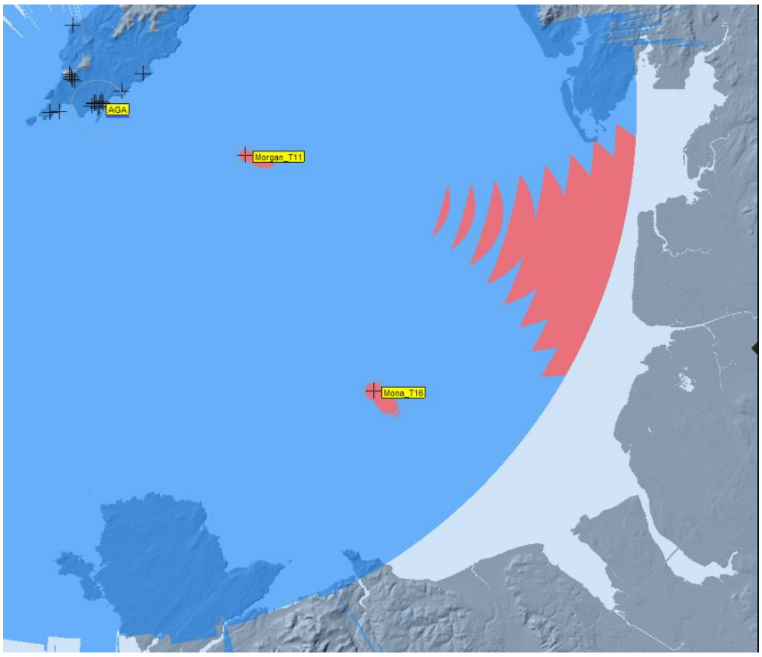

Figure 4 – AGA C/I <23dB at 1,000ft

At 2,000ft the shadows are smaller and the long-range effects reduced to the fringes of cover where radio contact is likely intermittent anyway.

Figure 5 – AGA C/I <23dB at 2,000ft

By 3,000ft the shadow zone from each turbine has reduced further and no impact is predicted other than directly in the vicinity of each turbine.

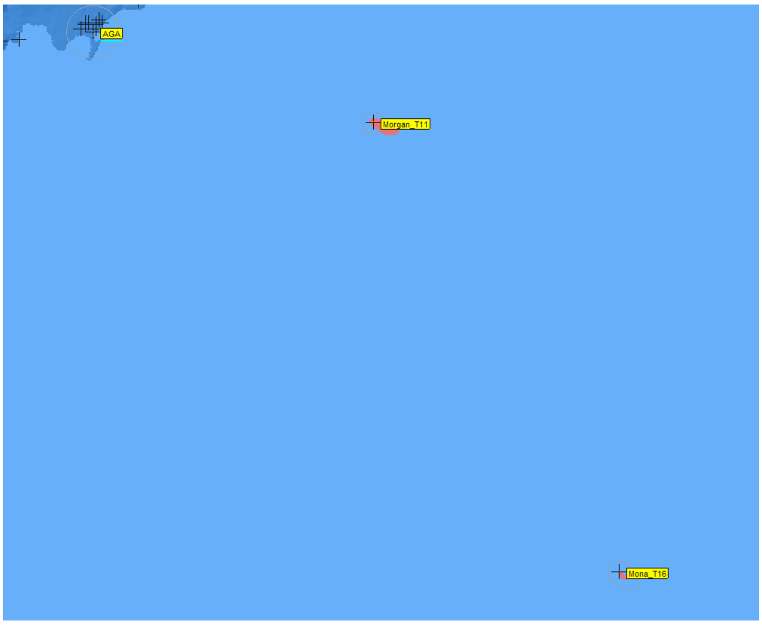

Figure 6 – AGA C/I <23dB at 3,000ft

By 5,000ft the Mona T16 impact disappears entirely although the impact from Morgan T11 can theoretically be seen in simulations up to 9,000ft.

3.4. MLAT Assessment

The distributed nature of the MLAT means that by design it is more resilient to distributed obstructions such as those proposed however there is very little formal guidance published on this topic.

The Eurocontrol "How to assess the potential impact of Wind Turbines Surveillance Sensors" guidelines document is silent on this topic but does have specific sections on SSR shadowing that can be read across to MLAT performance.

In Annex D the guidelines justify an SSR protection range of 16km (i.e. turbines out-with 16km do not constitute a problem) based on a predicted 3dB shadow zone of 1600m x 45m being operationally tolerable. Their analysis based on 1030MHz and a 6m diameter turbine tower.

To simulate the MLAT and larger offshore turbines 1090MHz was used alongside an 8m diameter turbine tower. The results vary with the distance between remote unit, RU, and turbine but the horizontal extent was always within the range of 2670m x 56m to 2900m x 58m.

The shadow zones for the 3 RU down the East coast of the island are shown below

Figure 7 – MLAT Shadow zones from Meary Veg, Carnane and Ballasaig

In order for the MLAT to be degraded the shadow zones from a sufficient number of RU's need to overlap such that the overall system cannot resolve the aircraft's position.

As can be seen from the following plot, based on the representative Morgan layout, the shadows rarely overlap and this situation would only be improved by including the coverage from additional RU's.

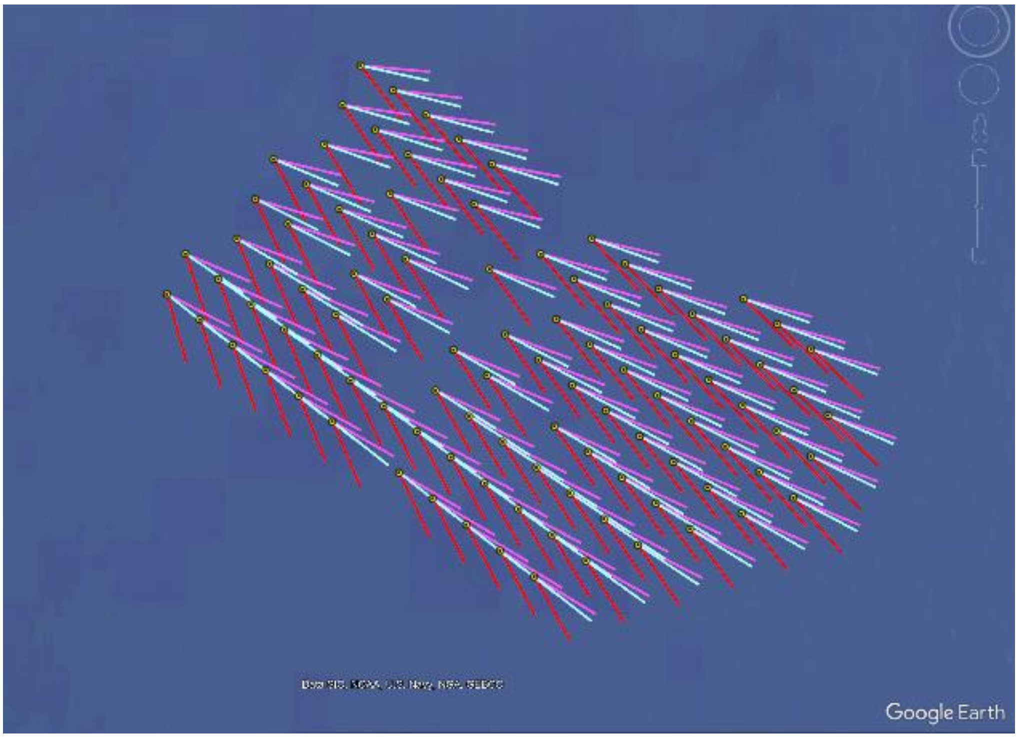

Figure 8 – Morgan MLAT Shadow zones from Meary Veg, Carnane and Ballasaig

In summary the turbines will cause shadows on individual RU's leading to holes in their coverage however as a whole the MLAT network should be relatively tolerant to obstructions of this nature. Any effects that are seen will be limited to the area in and around the turbines at low level altitudes equivalent to the heights of the turbines themselves.

4. Conclusions

4.1. Navigational Aids

No impact is expecting on any of the airport's navigational aids.

4.2. Surveillance

On the primary radar, false plots and detection problems will significantly degrade performance in the volume directly above the area around where the turbines are located. A less severe performance impact may also be felt over a wider area where track re-establishment issues manifest themselves.

On the MLAT the turbines will cause shadows on individual RU's leading to holes in their coverage however as a whole the MLAT network should be relatively tolerant to obstructions of this nature. Any effects that are seen will be limited to the area in and around the turbines at low level altitudes equivalent to the heights of the turbines themselves.

4.3. Communications

Current guidance does not extend to turbines of this size however existing assessment techniques can scaled and conclusions drawn. Using the CAP670 C/I technique it appears there could be degradation in AGA signal quality in the area around and behind the turbines at low altitude but that this reduces as the height above the turbines increases.

Appendix A – Background RADAR Theory

Primary RADAR False Plots

When RADAR transmits a pulse of energy with a power of P_t the power density, P, at a range of r is given by the equation:

$$P = \frac{G_t P_t}{4\pi r^2}$$

Where G_t is the gain of the RADAR's antenna in the direction in question.

If an object at this point in space has a RADAR cross section of σ, this can be treated as if the object re-radiates the pulse with a gain of σ and therefore the power density of the reflected signal at the RADAR is given by the equation:

$$P_a = \frac{\sigma P}{4\pi r^2} = \frac{\sigma G_t P_t}{(4\pi)^2 r^4}$$

The RADAR's ability to collect this power and feed it to its receiver is a function of its antenna's effective area, A_e, and is given by the equation:

$$P_r = P_a A_e = \frac{P_a G_r \lambda^2}{4\pi} = \frac{\sigma G_t G_r \lambda^2 P_t}{(4\pi)^3 r^4}$$

Where G_t is the RADAR antenna's receive gain in the direction of the object and λ is the RADAR's wavelength.

In a real world environment this equation must be augmented to include losses due to a variety of factors both internal to the RADAR system as well as external losses due to terrain and atmospheric absorption.

*For simplicity these losses are generally combined in a single variable **L**.*

$$P_r = \frac{\sigma G_t G_r \lambda^2 P_t}{(4\pi)^3 r^4 L}$$

Secondary RADAR Reflections

When modelling the impact on SSR the probability that an indirect signal reflected from a wind turbine has the signal strength to be confused for a real interrogation or reply can determined from a similar equation:

$$P_r = \frac{\sigma G_t G_r \lambda^2 P_t}{(4\pi)^3 r_t^2 r_r^2 L}$$

Where r_t and r_r are the range from RADAR-to-turbine and turbine-to-aircraft respectively. This equation can be rearranged to give the radius from the turbine within which an aircraft must be for reflections to become a problem.

$$r_r = \sqrt{\frac{\lambda^2}{(4\pi)^3}} \sqrt{\frac{\sigma G_t G_r P_t}{r_t^2 P_r L}}$$

Shadowing

When turbines lie directly between a RADAR and an aircraft not only do they have the potential to absorb or deflect enough power such that the signal is of insufficient level to be detected on arrival.

It is also possible that azimuth determination, whether this done via sliding window or monopulse, can be distorted giving rise to inaccurate position reporting.

Terrain and Propagation Modelling

All terrain and propagation modelling is carried out by a software tool called HTZ Communications (version 2024.2). All calculations of propagation losses are carried out with HTZ Communications configured to use the ITU-R 526 propagation model.

Appendix B – Turbine Locations

Morgan

A 100 turbine layout provided to NATS in 2021 has been used

1	53.9116	-3.9681	26	53.9321	-3.9270	51	53.9700	-3.9266	76	53.9991	-3.9058
2	53.9203	-3.9885	27	53.9408	-3.9473	52	53.9787	-3.9470	77	54.0078	-3.9263
3	53.929	-4.0089	28	53.9495	-3.9677	53	53.9874	-3.9674	78	54.0165	-3.9467
4	53.9378	-4.0292	29	53.9582	-3.9881	54	53.9961	-3.9878	79	54.0252	-3.9671
5	53.9465	-4.0496	30	53.9669	-4.0085	55	54.0222	-4.0490	80	54.0426	-4.0080
6	53.9639	-4.0904	31	53.9757	-4.0289	56	54.0309	-4.0695	81	54.0513	-4.0284
7	53.9726	-4.1108	32	54.0018	-4.0901	57	54.0396	-4.0899	82	54.0600	-4.0489
8	53.9813	-4.1312	33	54.0105	-4.1106	58	54.0483	-4.1104	83	54.0687	-4.0693
9	53.9900	-4.1516	34	54.0192	-4.1310	59	54.0570	-4.1308	84	54.0774	-4.0898
10	53.9987	-4.1720	35	54.0279	-4.1514	60	53.9410	-3.8143	85	53.9701	-3.7934
11	54.0074	-4.1924	36	53.9293	-3.8758	61	53.9497	-3.8346	86	53.9788	-3.8138
12	53.9175	-3.9374	37	53.9380	-3.8962	62	53.9584	-3.8550	87	53.9875	-3.8342
13	53.9262	-3.9577	38	53.9467	-3.9166	63	53.9671	-3.8754	88	53.9963	-3.8546
14	53.9349	-3.9781	39	53.9554	-3.9370	64	53.9759	-3.8958	89	54.0050	-3.8750
15	53.9436	-3.9985	40	53.9641	-3.9573	65	53.9846	-3.9162	90	54.0137	-3.8955
16	53.9524	-4.0189	41	53.9815	-3.9982	66	53.9933	-3.9366	91	54.0224	-3.9159
17	53.9611	-4.0393	42	53.9902	-4.0186	67	54.0020	-3.9570	92	54.0311	-3.9363
18	53.9698	-4.0597	43	54.0077	-4.0594	68	54.0194	-3.9979	93	54.0572	-3.9976
19	53.9785	-4.0801	44	54.0164	-4.0798	69	54.0455	-4.0592	94	54.0659	-4.0181
20	53.9872	-4.1005	45	54.0338	-4.1207	70	54.0629	-4.1001	95	54.0746	-4.0385
21	53.9959	-4.1209	46	54.0424	-4.1411	71	53.9556	-3.8038	96	54.0833	-4.0590
22	54.0046	-4.1413	47	53.9351	-3.8451	72	53.9643	-3.8242	97	54.0920	-4.0795
23	54.0133	-4.1617	48	53.9439	-3.8654	73	53.9730	-3.8446	98	53.9934	-3.8034
24	54.0220	-4.1822	49	53.9526	-3.8858	74	53.9817	-3.8650	99	54.0021	-3.8238
25	53.9234	-3.9066	50	53.9613	-3.9062	75	53.9904	-3.8854	100	54.0108	-3.8442

Mona

A 72 turbine layout provided to the airport by the developer specifically for this assessment has been used

1	53.8071	-4.0352	26	53.6343	-4.0310	51	53.7359	-3.9745
2	53.8069	-4.0124	27	53.6375	-4.0538	52	53.7538	-3.9748
3	53.8066	-3.9897	28	53.6512	-4.0541	53	53.7718	-3.9750
4	53.8063	-3.9669	29	53.6648	-4.0544	54	53.7898	-3.9753
5	53.8060	-3.9441	30	53.6784	-4.0548	55	53.6408	-3.9290
6	53.7942	-3.9211	31	53.6920	-4.0551	56	53.6587	-3.9293
7	53.7661	-3.8749	32	53.7056	-4.0555	57	53.6767	-3.9295
8	53.7490	-3.8469	33	53.7192	-4.0558	58	53.6947	-3.9298
9	53.7348	-3.8285	34	53.7332	-4.0562	59	53.7127	-3.9300
10	53.7197	-3.8282	35	53.7615	-4.0569	60	53.7306	-3.9303
11	53.6920	-3.8277	36	53.7769	-4.0572	61	53.7486	-3.9305
12	53.6780	-3.8204	37	53.7905	-4.0548	62	53.7666	-3.9308
13	53.6639	-3.8117	38	53.6511	-4.0176	63	53.6355	-3.8848
14	53.6498	-3.8039	39	53.6691	-4.0178	64	53.6535	-3.8850
15	53.6362	-3.8036	40	53.6871	-4.0181	65	53.6715	-3.8853
16	53.6118	-3.8032	41	53.7051	-4.0183	66	53.6895	-3.8855
17	53.6121	-3.8264	42	53.7231	-4.0186	67	53.7075	-3.8858
18	53.6125	-3.8491	43	53.7410	-4.0188	68	53.7254	-3.8860
19	53.6128	-3.8717	44	53.7590	-4.0191	69	53.7434	-3.8863
20	53.6146	-3.8945	45	53.7770	-4.0193	70	53.6303	-3.8405
21	53.6179	-3.9172	46	53.6460	-3.9733	71	53.6483	-3.8408
22	53.6212	-3.9400	47	53.6639	-3.9735	72	53.6663	-3.8410
23	53.6245	-3.9627	48	53.6819	-3.9738			
24	53.6277	-3.9855	49	53.6999	-3.9741			
25	53.6310	-4.0082	50	53.7179	-3.9743			