**3GPP TSG-RAN WG2 Meeting #121bis-e** **R2-23xx**

**eMeeting, 17-26 April, 2023**

**Agenda item:** 8.8.2

**Work Item:** NR\_UAV-Core

**Source:** Qualcomm Incorporated (Moderator)

**Title:** Report of [POST121][313][UAV] Height-dependent configuration

**Document for:** Discussion/Decision

# Introduction

During RAN2#121, based on email discussion report [Post120][312][UAV] (see R2-2300479) and report of offline [AT121][305][UAV] (see R2-2302210), following was agreed:

**Agreements:**

1. Support configuring height-dependent more-than-one configurations targeting measurement and measurement reporting enhancement. UE applies corresponding configuration based on the UE height. The proposed solutions should aim at avoiding RAN4 impacts. FFS how this would be configured (i.e. different MO configurations or different parameters FFS Exact parameters and details.

To progress further, following email discussion was setup.

* [POST121][313][UAV] Height-dependent configuration (Qualcomm)

Scope: Discuss the details how the network configures and how the UE applies height-dependent configurations (i.e. which IEs/parameters can be modified, what is the expected UE behavior, etc.)

Intended outcome: set of agreeable proposals

Deadline: Long

This document is the report of the above email discussion.

# Discussion

## Which parameters need height-dependent configuration?

The first discussion point is intended to gather inputs on which parameters need height-dependent configuration. In other words, which configuration/parameters should be allowed for the UE to choose the value (form configurations provided by network) based on UE height. Note that, based on discussion during [Post120][312][UAV], for the proposed parameter needing different values/configurations each for a specific height region, following questions should be answered:

1. What happens with UE’s filters, variables, etc. when the switch between configurations happens? Is the behavior different than the one already specified e.g. for cell change?
2. Is there a mismatch between what the NW is aware of and the actual configuration the UE uses?
3. The benefit of multiple configurations versus H1/H2 reporting to the NW and waiting for the new configuration
4. Can the NW know and properly configure the LOS/NLOS boundary?

Additionally, based on the RAN2#121 discussion, moderator would like to add the following question:

1. Is there potential RAN4 impact?

**Q1: Which configuration(s)/parameter(s) need ability to be configured with different configurations/values, each for a specific height region?**

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| **Company** | **Which configuration(s)/parameter(s) need to support ability to be configured with different configurations/values, each for a specific height region?** | **For the proposed configuration/parameter, any comments to address the following questions:**  **a) What happens with UE’s filters, variables, etc. when the switch between configurations happens? Is the behavior different than the one already specified e.g. for cell change?**  **b) Is there a mismatch between what the NW is aware of and the actual configuration the UE uses?**  **c) The benefit of multiple configurations versus H1/H2 reporting to the NW and waiting for the new configuration**  **d) Can the NW know and properly configure the LOS/NLOS boundary?**  **e) Is there potential RAN4 impact?** |
| Ericsson | We prefer to alter reporting related parameters. For example, reporting interval, number of measurement reports, maximum number of non-serving cells to be included in the report. | 1. Should not impact. Only number of reports need to be accounted based on height specifically, e,g if event triggers below a height but UE’s height increases, and UE needs to follow the new count. 2. Network may not be aware of exact height of UE but that should not be an issue. For example, below a height, UE reports with certain interval and certain n of reports or cells. Network will simply receive accordingly and may even dedice the height based on the report content. 3. Interference can be limited immediately when UE crosses a height. Reconfiguration may be cumbersome and chronically late.   Not foreseen |
| ZTE | SSB-ToMeasure | We prefer to to introduce height-based SSB-ToMeasure such that UAV UE can be configured to perform measurement on different subset of SSBs in different height region. The benefits are as following:   1. It is possible for network to exclude side lobes of downtilted beams when UAV UE is flying above a threshold, especially the side lobes of downtilted beams from far away cells. The side lobes from far away cells are assumed as a negative factor on UAV Ue’s mobility performance. 2. It is beneficial for UE power saving by excluding the downtilted beam when UAV UE is flying above a height threshold. When UAV UE fly above a height threshold, it is assumed more cells will be detected. In such radio environment, to exclude the downtilted beam can reduce the measurement on beams as well as the size of measurement report.   Reply on the questions for height-based SSB-ToMeasure:   1. The UE action upon the autonomous SSB-ToMeasure switch is similar to measurement reconfiguration triggered by the NW (i.e. reception of RRCReconfiguration message with MeasConfig from the NW). There is no special impact. 2. The UE applies the height dependent configuration just as NW expected. If height information is also included in measurement report, the NW can be aware of which configuration is used for the reporting. Thus we don’t think there is mismatch between what NW is aware of and the actual configuration the UE uses. 3. Comparing the H1/H2 reporting and waiting for new configuration from NW, the height-based SSB-ToMeasure solution can save both signaling overhead and signaling delay. Then it is further beneficial for interference reduction in LOS environment. 4. For the proposed height-based SSB-ToMeasure solution, we don’t think it is related to LOS/NLOS boundary.   The network can configure the height-based SSB-ToMeasure according to network planning, i.e. which beam is uptilted and which is downtilted. Further, the network can actually “learn” how to configure it according to the beam level measurement results from other UEs.   1. For the proposed height-based SSB-ToMeasure, we assume the same SMTC is used, i.e. no additional SMTC is needed. There is no potential RAN4 impact for this height-based SSB-ToMeasure solution. |
| LGE | 1) allowed/excluded cell  2) radio resources, e.g., SSB and CSI-RS | a) Upon switching of the parameter(s), it would be simpler if UE behaves as if it receives a new reconfiguration message. Optimization can be left for later releases.  b) Height dependent parameters are configured by network, and UE reports its height based on network configuration. That is, everything is under network control and corresponding network awareness. Therefore, no mismatch issues are foreseen.  c) Considering UAV is moving fast, the height-dependent solution is beneficial to adjust the suitable parameter timely. Although, the network can re-configure UE based on the H1 and H2 event, it takes more time to reconfigure parameters and incurs frequent signalling between the UE and the network.  d) A simple bisection of areas to LON/NLOS is not suitable in real fields in particular for urban area, where environmental diversity is very high.  e) As long as the parameter switching is similar to execution of reconfiguration, we do not see any non-trivial RAN4 impact. |
| NEC | Measurements object related parameters:   * Exclude-listed cells * allow-listed cells * ssb-ToMeasure   Measurement report related parameters:   * A4 threshold * NumberOfTriggeringCells | We don’t think all details can be included in this reply, some quick comments:   * We prefer to select configuration(s)/parameter(s) which brings no RAN4 impact. * Comparing with H1/H2 reporting to the NW and waiting for the new configuration, configurations can be applied with less latency by this “height-dependent” way. * There may be mismatch, solutions can be further discussed if there are critical impact. |
| Huawei, HiSilicon | TTT  NumberOfTriggeringCells  Height state scale factors | RAN2 has agreed height-dependent multiple configuration. We believe that NumberOfTriggeringCells and TTT parameter can be height-dependent. Besides, we think that height state scale factors can be defined for these height-dependent parameters. Similar to the IE SpeedsStateScaleFactors, height state scale factor can be applied when the UE is in a medium or high height state and used for scaling a height-dependent parameter. Compared to configure each parameter for different height separately, use height state scale factor can unified all height-dependent parameter very well. It can save a lot of radio resources. We assume, for example, that TTT and NumberOfTriggeringCells are height dependent. The NW needs to configure multiple sets of these two parameters for the legacy mechanism, e.g., TTT value1 for 100m, TTT value2 for 200m, TTT value3 for 300m, and N1 for 100m, N2 for 200m, and N3 for 300m. However, if the height state scale factor is applied, the NW only needs to configure TTT value0 and N0 and scaling factors 1, 2 and 3 for 100, 200 and 300 meters, respectively. The UE autonomously scales the TTT and N by multiplying the scaling factors according to the altitude. The result can be round up or round down if the parameters are integer. As we can see, the more parameters that are height-dependent, the more radio resources can be saved by using height-state scale factors.  We need to consider how to handle the running parameters or configurations, i.e., TTT and cellsTriggeredList if the measurement configuration has changed. For the TTT, the UE should maintain the running TTT, rather than reset the TTT, in order to send the MR immediately. For the cellsTriggeredList, if the NumberOfTriggeringCells is changed, we need to specify the UE behaviour. According to the 38.331, the UE will remove the cell in the cellsTriggeredList if the NumberOfTriggeringCells is re-configured because the measurement reporting entry needs to be removed when the ReportConfig is re-configured. However, the late report issue already existed when the NumberOfTriggeringCells was introduced in NR. The late report issue will be heavier if the UE removes the cell in the cellsTriggeredList when the NumberOfTriggeringCells is re-configured. Furthermore, the case is also different, the UE change the NumberOfTriggeringCells on its own rather than the NW re-configure the ReportConfig. Thus, the UE should also maintain the current cellsTriggeredList rather than remove the cell in the cellsTriggeredList in order to send the MR immediately too.  As for the mismatch between the UE and network, the UE can add the height into the Measurement Report when the parameter is scaled.  For question c, it can save the configuration time compared to waiting for the configuration after eventH1 or eventH2 triggers.  Whether the NW knows the LoS and NLoS boundary depends on the operator. Because the operator can measure the boundary when they distribute the base station.  There is no RAN4 impact. |

Summary: TBD

## How to configure, e.g. different MO (measurement object) or different parameters/values (within a single MO)?

Next question is whether different configurations for different height ranges is provided to the UE as different MO configurations or done at parameter level. But before that, it is worthwhile to clarify on some comments that were raised during RAN2#121.

One of the comments raised during RAN2#121 indicated there may be restriction in current specifications that there cannot be more than one measurement objects for the same frequency with different associated parameters, e.g. different offsets and/ or exclude-lists .

For LTE, TS 36.331 has the following text:

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| 5.5.1       Introduction <<skip>>  5.   **Measurement gaps:**Periods that the UE may use to perform measurements, i.e. no (UL, DL) transmissions are scheduled.  E-UTRAN only configures a single measurement object for a given frequency (except for WLAN and except for CBR measurements), i.e. it is not possible to configure two or more measurement objects for the same frequency with different associated parameters, e.g. different offsets and/ or exclude-lists. E-UTRAN may configure multiple instances of the same event e.g. by configuring two reporting configurations with different thresholds.  The UE maintains a single measurement object list, a single reporting configuration list, and a single measurement identities list. The measurement object list includes measurement objects, that are specified per RAT type, possibly including intra-frequency object(s) (i.e. the object(s) corresponding to the serving frequency(ies)), inter-frequency object(s) and inter-RAT objects. Similarly, the reporting configuration list includes E-UTRA and inter-RAT reporting configurations. Any measurement object can be linked to any reporting configuration of the same RAT type. Some reporting configurations may not be linked to a measurement object. Likewise, some measurement objects may not be linked to a reporting configuration. |

However, the paragraph with such restriction is not included in TS 38.331:

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| 5.5.1       Introduction <<skip>>  **5.   Measurement gaps:**Periods that the UE may use to perform measurements.  A UE in RRC\_CONNECTED maintains a measurement object list, a reporting configuration list, and a measurement identities list according to signalling and procedures in this specification. The measurement object list possibly includes NR measurement object(s), CLI measurement object(s), inter-RAT objects, and L2 U2N Relay objects. Similarly, the reporting configuration list includes NR, inter-RAT, and L2 U2N Relay reporting configurations. Any measurement object can be linked to any reporting configuration of the same RAT type. Some reporting configurations may not be linked to a measurement object. Likewise, some measurement objects may not be linked to a reporting configuration. |

Additionally, following field descriptions refer to the possible scenario of multiple MeasObjectNR with the same SSB frequency:

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| ***MeasObjectNR*field descriptions** |
| ***associatedMeasGapSSB***  Indicates the associated measurement gap for SSB measuring identified by *ssb-ConfigMobility* in this measurement object. When multiple *MeasObjectNR* with the same SSB frequency are configured, the network configures the same measurement gap ID in this field for each *MeasObjectNR*. If this field is absent, the associated measurement gap is the gap configured via *gapFR1*, *gapFR2*, or *gapUE*. |
| ***associatedMeasGapSSB2***  Indicates the associated additional measurement gap for SSB measuring identified by *ssb-ConfigMobility* in this measurement object for NTN deployments. When multiple *MeasObjectNR* with the same SSB frequency are configured, the network configures the same measurement gap ID in this field for each *MeasObjectNR*. If this field is absent, the associated measurement gap is the gap indicated by *associatedMeasGapSSB*. |

On the other hand, following is captured in TS 38.331:

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| 5.5.2       Measurement configuration**5.5.2.1            General** The network applies the procedure as follows:  -     to ensure that, whenever the UE has a *measConfig*associated with a CG, it includes a *measObject* for the SpCell and for each NR SCell of the CG to be measured;  -     to configure at most one measurement identity across all CGs using a reporting configuration with the *reportType* set to *reportCGI;*  -     to configure at most one measurement identity per the node hosting PDCP entity using a reporting configuration with the*ul-DelayValueConfig;*  -     to configure at most one measurement identity per the node hosting PDCP entity using a reporting configuration with the*ul-ExcessDelayConfig;*  -to ensure that, in the *measConfig* associated with a CG:  -     for all SSB based measurements there is at most one measurement object with the same *ssbFrequency*;  *-*an *smtc1* included in any measurement object with the same *ssbFrequency* has the same value and that an *smtc2* included in any measurement object with the same *ssbFrequency* has the same value and that an *smtc3list* included in any measurement object with the same *ssbFrequency* has the same value and that an *smtc4list* included in any measurement object with the same *ssbFrequency* has the same value;  -     to ensure that all measurement objects configured in this specification and in TS 36.331 [10] with the same *ssbFrequency* have the same *ssbSubcarrierSpacing*;  -     to ensure that, if a measurement object associated with the MCG has the same *ssbFrequency* as a measurement object associated with the SCG:  -     for that *ssbFrequency*, the measurement window according to the *smtc1* configured by the MCG includes the measurement window according to the *smtc1* configured by the SCG, or vice-versa, with an accuracy of the maximum receive timing difference specified in TS 38.133 [14].  -     if both measurement objects are used for RSSI measurements, bits in *measurementSlots* in both objects corresponding to the same slot are set to the same value. Also, the *endSymbol* is the same in both objects.  -     to ensure that, if a measurement object has the same *ssbFrequency* as a measurement object configured in TS 36.331 [10]:  -     for that *ssbFrequency*, the measurement window according to the *smtc* configured in TS 36.331 [10] includes the measurement window according to the *smtc1* configured in TS 38.331, or vice-versa, with an accuracy of the maximum receive timing difference specified in TS 38.133 [14].  -     if both measurement objects are used for RSSI measurements, bits in *measurementSlots* in both objects corresponding to the same slot are set to the same value. Also, the *endSymbol* is the same in both objects.  -     when the UE is in NE-DC, NR-DC, or NR standalone, to configure at most one measurement identity across all CGs using a reporting configuration with the *reportType* set to *reportSFTD*;  <<skip>> |

**Observation 1: In NR, currently it is possible to configure more than one measurement objects for a given frequency (but not in the same CG).**

Another comment raised was there may be different RAN4 requirements for the UE with one measurement object vs multiple measurement objects. Given that multiple measurement objects (regardless of for the same or different frequency) is already supported in NR, moderator understands no additional RAN4 requirements in terms of number of MO need to be introduced due to more-than-one configurations targeting different heights as those existing requirements apply accordingly for one or multiple measurement objects.

**Observation 2: No additional RAN4 requirements in terms of number of MO are expected due to more-than-one configurations targeting different heights.**

Note that the above observation does not concern with how the UE measures height but focuses solely on the number of measurement objects.

**Q2: Comments on the above observations, if any.**

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| **Company** | **Comment** |
| Ericsson | In one cell group, UE can be configured with only one MO per SSB frequency. This seems the baseline case for aerial operation. This seems to suggest it is easier to do the height dependency in parameter level, either within an MO or within ReportConfig, or both. |
| ZTE | Agree with observation 1. We also noticed that for SSB based measurements network can configure at most one measurement object per SSB frequency.  On observation 2, we think there is no additional RAN4 requirement in terms of different MO or different parameter values, since these MO or parameter values are applied in different height region and in different time. Autonomous switching between different MOs or parameter values is similar to a measurement reconfiguration triggered by network. |
| NEC | Agree with Observation 1. But what we are considering is slightly different from this “more than one measurement objects” case. At lease UE do not need to apply configurations for different height regions simultaneously.  For Observation 2, our view is we should target at no RAN4 impact parameters/configurations |
| Huawei, HiSilicon | We agree with the observations. |

Summary: TBD

Now, to the question above: whether to configure -

* (a) different measurement objects such that when UE moves to a different (configured) height range, a new measurement object is applicable. Or,
* (b) different parameters/fields (within the same MO), where different values (or value ranges) of the parameter/field applies to different height or height range. Or,
* (c) other option (explain in comments).

**Q3. How to configure height-dependent more-than-one configurations? E.g. different MO or different fields/values within same MO? Or other options.**

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| **Company** | **How to configure height-dependent more-than-one configurations? (a) different MO, (b) different fields/values, (c) Other option.** | **Comments and examples** |
| Ericsson | Our suggestion is to go for b) if height dependent configuration related to MO is seen useful. |  |
| ZTE | b) different fields/values | On (a) different MO:  We think this options brings unnecessary spec impact considering the limitations in current spec (Observation 1 in Q2). In addition, we don’t think it is necessary to have such flexibility to configured a whole different MO.  On the contrary, to have different fields/values (b) is much easier to analysis pros and cons, and the impact on spec can be limited within expected scope. |
| LGE | (b) different fields/values | In (a), there would be a lot of duplicated configuration parameters across measurement objects for the same frequency. |
| NEC | FFS | We need more details before making this decision. i.e., the definition of different MO, are they link to the same or different MeasID? From UE perspective, the switch is occurred between different MeasID or between different MO for one MeasID?  Also, we don’t need to exclude more-than-one report configurations at this stage. |
| Huawei, HiSilicon | b | We do not think different MOs for different heights are needed because not all the parameters included in the MO are height-dependent. If we choose the granularity of MO, it is redundant for the UE and wasteful of radio resources. Thus, we prefer solution b. The NW can configure the exact parameters in a single MO. Meanwhile, we think the height state scale factor that we proposed in Q1 is also applicable for the parameters that can be height-dependent. |

Summary: TBD

## Expected UE behaviour when the applicable value changes due to change of height

Suppose the UE crosses a height region and the configuration/value of a parameter in the new region is as follows:

1. No change compared to the value before entering the height region
2. Not configured in the new height region
3. Different value compared to the value before entering the height region

Note that in LTE, the case of change in configuration parameter based on UE detected state exists, where the UE applies different TTT value based on its speed. The detailed UE behaviour is not specified and left up to UE. See TS 36.331 5.5.6.2.

For the case of no change of configured values, there are following options for the UE, and what UE should do may be different depending on the scenario or type of the parameter.

* Continue to perform related operations as the configured value is unchanged, or
* Reset the current action (whatever that is) since a new value/configuration means new operation even though the value is same.

**Q4: Comments on expected UE behaviour if the configuration/value of parameter in the new region is not changed compared to the value before entering the height region. And whether anything need to be specified or can be left to UE implementation.**

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| **Company** | **Comment** |
| Ericsson | It can be handled by the specification that no unnecessary UE actions are needed. E.g. by the ASN1 structure, or by field descriptions. |
| ZTE | First of all, the question needs to be clarified: if the configuration/value of parameters is not changed in the new region compared to the value before entering the region, why it is configured?  For height-based SSB-ToMeasure, we think the answer to this question could be: the UE behavior related to beam measurement and cell level quality derivation will not be impacted. |
| LGE | Since there is no change of parameter values, UE continues to perform the related operations, e.g., measurement/measurement report. No special handling is needed. |
| NEC | UE should reset and switch to the new value/configuration whatever that is. Anyway NW can avoid configuring completely same configurations for different height, which makes no sense. |
| Huawei, HiSilicon | The UE does not need to change any configurations or modify any running parameters, e.g., TTT or cellsTriggeredList if the configured parameters or configurations are not changed. But we need to specify the UE behaviours when the configured parameters or configurations change. As we mentioned in Q1, we need to consider how to handle the running parameters or configurations, especially the cellsTriggeredList, if the measurement configuration has changed. For the cellsTriggeredList, if the NumberOfTriggeringCells is changed, we need to specify the UW behaviour. According to the 38.331, the UE will remove the cell in the cellsTriggeredList if the NumberOfTriggeringCells is re-configured because the measurement reporting entry needs to be removed when the ReportConfig is re-configured. However, the late report issue already existed when the NumberOfTriggeringCells was introduced in NR. The late report issue will be heavier if the UE removes the cell in the cellsTriggeredList when the NumberOfTriggeringCells is re-configured. Furthermore, the case is also different, the UE change the NumberOfTriggeringCells on its own rather than the NW re-configure the ReportConfig. Thus, the UE should maintain the current cellsTriggeredList rather than remove the cell in the cellsTriggeredList in order to send the Measurement Report immediately. |

Summary: TBD

For the case that the value is not configured in the new height region, moderator’s view is the UE should stop the current related action and treat as if the parameter/configuration is released.

**Q5: Comments on expected UE behaviour if the configuration/ parameter in the new region is not configured. And whether anything need to be specified or can be left to UE implementation.**

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| **Company** | **Comment** |
| Ericsson | Depend on the parameter whether this would be a valid configuration or not.  Should be discussed case by case. |
| ZTE | For height-based SSB-ToMeasure, if there is no configuration for a specific height region, the UE just follow the legacy configuration/value. |
| LGE | Upon entering a new height region, it is clear that UE should stop following old parameters for the previous height range but start following the new parameter values applicable for the new height region. No tricky issue is foreseen and no risky optimization is needed. How to realize this is up to state-3 details including ANS.1 implementation. |
| NEC | It seems not a UAV specific issue. NW should ensure the mandatory configurations exist. |
| Huawei, HiSilicon | The UE should follow the last configuration or parameter if the corresponding configuration or parameter has not been configured in the new region. A UAV's flight path is continuous, and the radio environment is similar if the height is close. For example, if the NW configures NumberOfTriggeringCells as 3 for 100m-200m but not configures it over 200m, the UE should follow the configuration in the range 100m-200m when it climbs to 220m because the radio environment is similar between 200m and 220m. |

Summary: TBD

For the case where the value in new height region is different compared to the value before entering the height region, the UE action may depend on scenario or type of the parameter.

E.g., if the changed parameter is a timer value, and,

* the new value is such that the timer would not have expired, then the expiration time should be updated based on new value (considering the actual start time); ongoing operations may continue but the expiry of the timer is extended or shortened according to the new value.
* the timer would have expired with the new value (shorter value), then treat it as if the timer just expired.

Such details can be left to UE implementation, similar to what was done in LTE for different TTT value for different UE speed.

**Q6: Comments on expected UE behaviour if the configuration/value of parameter in the new region is changed compared to the value before entering the height region. And whether anything need to be specified or can be left to UE implementation.**

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| **Company** | **Comment** |
| Ericsson | Depends on the exact parameter. It may be ok to leave some changes to UE implementation but where feasible, explicit specification is preferred to limit varieties in UE behaviour. |
| ZTE | For height-based SSB-ToMeasure, UE just applies the corresponding configuration/value of parameter in new region, and then performs measurement as the current spec handling. Spec needs to capture this and nothing else is foreseen. |
| LGE | Upon entering a new height region, it is clear that UE should stop following old parameters for the previous height range but start following the new parameter values applicable for the new height region. No tricky issue is foreseen and no risky optimization is needed. How to realize this is up to state-3 details including ANS.1 implementation. |
| NEC | For non-timer-based parameters, we think it just like receiving new RRC reconfigurations and some current procedures can be reused, i.e., measurement object removal/addition/modification. |
| Huawei, HiSilicon | See our comments in Q4 |

Summary: TBD

## Any other items?

Please list any other aspects related to the discussion on height-dependent configuration that is not covered by above questions.

**Q7: Any other items?**

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| **Company** | **Comments** |
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# Summary

TBD