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

e-Meeting, 17th April – 26th April 2023

**Agenda item: 8.8.3**

**Source: Intel**

**Title: Report from [Post121][314][UAV] Flight path reporting**

**WID: NR\_UAV-Core**

**Document for: Discussion and Decision**

# 1 Introduction

This is to discuss the following:

* [POST121][314][UAV] Flight path reporting (Intel)

Scope: Discuss the flight path reporting related details such as: the trigger for reporting the flight path information in UAI, whether there is a need to differentiate initial and updated flight path plan, flight path report signalling in HO preparation and in CN to RAN signalling, the maximum number of waypoints, etc.

Intended outcome: set of agreeable proposals

Deadline: Long (TBD: tentative April 5)

**Agreements so far related to flightpath reporting:**

*Meeting 119e:*

3 As in LTE, flight path plan reporting will be introduced. Location list of waypoints (3D location information) and timestamp is adopted as the basic content of flight path report. FFS if timestamp is mandatory or optional for NR. FFS if further enhancements are needed

*Meeting 120:*

Agreements:

1. A waypoint is a planned location for the UE along the flight path and is described via the existing parameter type LocationCoordinates defined in TS 37.355.
2. A timestamp provides the UTC time associated with estimated time of arrival to a waypoint as baseline. FFS on granularity
3. No requirements are placed on spatial distribution of waypoints
4. A UE indicates whether flight plan information is available within the RRCReconfigurationComplete, RRCReestablishmentComplete, RRCResumeComplete, or RRCSetupComplete message. Flight path reporting uses at the UE Information request/response procedure as baseline.
5. UE indicates to the network a new flight path is available in the UE (whether it is initial or update). Then, reuse the normal request/response procedure of flight path report.
6. UAI message can also be used to indicate the UE has flight path availability.
7. FFS whether and what triggering conditions are specified for flight update. FFS The maximum number of waypoints within flight path plan is left FFS.

*Meeting 121:*

**Agreements**:

1. The granularity of flightpath timestamp is 1s.
2. Timestamp in flightpath is encoded using AbsoluteTimeInfo-r16 IE

# 2 Discussion

## 2.1 Flight path triggering

During meeting #120, flightpath update indication is agreed via UAI message. This section is to discuss how the UE triggers this indication (if any). From companies’ contributions, there are few options proposed to trigger flightpath update indication as summarized below. There are also concerns about having too many triggering from the UAV if no trigger condition is defined and the network may not care the updated flightpath. Therefore, summary of proposed options is provided below. Please indicate your preference, as well as all acceptable options.

* Option 1: Network configures one or more threshold(s). FFS on the kind of threshold(s) (e.g. time, distance, number of waypoints) that triggers the flightpath update indication in UAI. [2,5,14,15,19]
* Option 2: Prohibit timer applies to flightpath update indication [6]
* Option 3: Any change compared to last reported flightpath (i.e. as long as it is difference from last reported flightpath) will trigger flight path update indication in UAI [13]
* Option 4: Up to UE implementation to trigger [6,8,18]

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| **Question 1: Which of the option(s) to trigger flightpath update indication in UAI is/are your preference/ acceptable?**   * **Option 1: Network configures one or more threshold(s). FFS on the kind of threshold(s) (e.g. time, distance, number of waypoints) that triggers the flightpath update indication in UAI. [2,5,14,15,19,11]** * **Option 2: Prohibit timer applies to flightpath update indication [6]** * **Option 3: Any change compared to last reported flightpath (i.e. as long as it is difference from last reported flightpath) will trigger flight path update indication in UAI [13]** * **Option 4: Up to UE implementation to trigger [6,8,18]** | | |
| **Company** | **All acceptable options** | **Comments** |
| Ericsson | Option-1 | Network can configure the change in terms of a threshold. FFS if absolute or relative. For example, provide an absolute number of changed waypoints or a difference (relative) in the number of changed waypoints as the trigger.  Option-3 at least from the description looks like it is up to UE to decide and can be merged with UE implementation i.e., Option-4.  In our view network should be in control on any signaling of flightpath from UE to network as only network can know whether it has any use for the flight path information or not. |
| CATT | Option-4 | The motivation to introduce limitation should be clarified firstly. From the current understanding, there may be two aspects: uplink signalling load and malicious attack. If the intention is to limit the uplink signalling load, it is not convinced since there is no any limitation had been introduced to limit UAI message before. If the intention is to avoid malicious attack, this issue should be handled by CN instead of AS solution in the current 5G system. To step back, the UAI message in 5.7.4 of 38.331 is already under the control of gNB (Before the UAI message, the *RRCReconfiguration* can be used to achieve this point). |
| ZTE | Option 2 and option 4 | From network point of view, we need a mechanism to prevent frequent flight path update indication. We believe prohibit timer can prevent UAV UE from doing this.  On option 1, we think it is difficulty for network to determine what kind of update is necessary and what is not. E.g. it is hard to say 3 waypoints change is more significant than 1 waypoint change (it depends on the actual flight path). So we prefer to leave to UE implementation. With the help of prohibit timer, we believe UE vendor will be careful on the update indication. |
| Xiaomi | Option 1 | For option 1, whether and when UE report the flightpath update indication is in the control of network.  For option 2, flight path information cannot be updated as soon as possible. In effect, both option 3 and option 4 is the method which is up to UE implementation. For flight path reporting, it may be better that it is in the control of network. |
| Samsung | Option 1, 2 | Support option 1 and 2.  First, if we leave the triggering of flightpath update indication to UE implementation, it can be triggered too frequently, which leads to unnecessary overhead on both UE and network. Thus, there should be some method to prevent too frequent update.  Second, from the gNB perspective, the update of flight path information can be useful only when it is relevant to mobility support for that UE. Thus, it seems reasonable to allow the gNB to configure the triggering condition (e.g, time/distance/number thresholds) of the update indication. Thus, we support option 1.  Also, we believe that the prohibit timer can be used together to prevent too frequent UAI transmission as in the legacy operation. |
| Lenovo | Option 3 | Currently in UAI message, most of reports are initiated upon the change of the content or preference or status etc., for example   * delay budget report * IDC assistance information * preference on DRX parameters * preference on the maximum aggregated bandwidth * preference on the maximum number of secondary component carriers * preference on the maximum number of MIMO layers * assistance information to transition out of RRC\_CONNECTED state * configured grant assistance information * indication of its preference in being provisioned with reference time information * MUSIM assistance information for gap preference * indication of fulfilment of the RRM measurement relaxation criterion * relaxing its RLM measurements * relaxing its BFD measurements in serving cells * service link propagation delay difference   We think upon change to initiate flight path reporting is totally reuse the legacy mechanism, which is simple and enough. We have not observed threshold mechanism to restrict initiation of the report in current UAI message. And we do not think flight path reporting is frequently changed. So we do not prefer option 1.  For option 2, we are open if it is necessary. |
| vivo | Option 4/3 | From our understanding, the UAV may not change its flight path frequently. Basically, they may change their flight path plan when an obstacle appears. And UAV itself can decide whether the changed flight plan needs to be sent to the network. So, we think it is sufficient to left it to UE implementation. For option 1, the benefit is unclear but the complexity is obvious.  Besides, from spec point of view, we don’t see the difference between option 3 and option 4. |
| LGE | Option 4 | Flight path indiciation mechanisms(option 1,2, and 3) seem to be kind of optimization for invalid UE behaviours like continuous UAI. But the UAI message can be controlled by the network. We can leave it to UE implementation. |
| NEC | Option 4 | Determination of triggering flight path update indication is out of RAN2’s scope. |
| Sharp | Option 1 with comments | The flight path update can be controlled by the network in some cases. We think some indications from network are useful. For example, the network can indicate whether the flightpath update is triggered when only time information is changed since the time information is optional. Option 1 can be changed to more generic: “Network configures one or more threshold(s)/indications” |
| Apple | Option 4 | We suppose the intention to let network control the trigger condition for reporting the updated flight path is to reduce signaling overhead. From our understanding, the whole procedure is already under network control thus there is no need to introduce extra control merely for updated reporting.  In addition, it would be a complex discussion on the trigger condition, to cover all possible updates. |

Summary: TBD

## 2.2 Flight path available indication (configuration, initial and updated)

Some companies discuss whether flightpath update indication should be configured by the network before UE can send the indication in UAI. Please provide your view below:

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| **Question 2: Do you prefer flightpath update indication in UAI is configurable by the network?**   * **Option 1: configurable by the network** * **Option 2: not configurable [8]** | | |
| **Company** | **Answer** | **Comments** |
| Ericsson | Option-1 |  |
| CATT | Option 1 | If we are on the same page of the wording “configurable” in the question, since the legacy UE Assistance Information procedure is under control of gNB(See 5.7.4.2 in 38.331 h30 version). Option 2 seems to change the legacy UAI procedure which the motivation is not clear to us right now. |
| ZTE | Option 1 | Network should be able to determine whether an UAV UE is allowed to indicate flight path update, as the legacy UAI mechanism. |
| Xiaomi | Option 1 |  |
| Samsung | Option 1 | See our comment to Question 1 above. |
| Lenovo | Option 1 | Network should be able to configure whether an UAV UE can report the flight path update indication |
| vivo | Option 1 |  |
| LGE | Option 1 |  |
| NEC | Option 1 | This should be under NW control. |
| Sharp | Option 1 |  |
| Apple | See comments | The reason why we proposed no further control from network is this UAV message carries a mere indication for update, but not a real report on updated information. If the updated flight info is carried in UAI, it’s natural to have corresponding network configuration for it. But the actual report uses UEInformationRequest/UEInformationResponse procedure, it seems cumbersome to have double control here (one for update indication and one for real report).  Anyway seeing the responses above, we are fine to go with majority view. |

Summary: TBD

How is the “flightpath update indication” implemented via the *UEAssistanceInformation* message? Summary of companies’ proposals is provided below. Please indicate all acceptable options:

* Option 1: Single indication is used for both initial and updated flightpath available (i.e. same flag is used for initial and updated flight path indication) [5,8]
* Option 2: Different indications are used to provide initial or future reporting of the flightpath information, (i.e.one flag is used for initial, and one flag is used to indicate the flightpath update available indication)
* Option 3: Different indications are used to report when flight path info is available and the reason that cause the reporting, i.e. one flag for flight path available, one flag for update cause (e.g. initial, available of new flightpath) [15]
* Option 4: UE can also report when flightpath is unavailable. FFS if this is done via same or different IE as the flight path related information discussed in previous options [7]

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| **Question 3: How is the “flightpath update indication” implemented via the *UEAssistanceInformation* message?**   * **Option 1: Single indication is used for both initial and updated flightpath available (i.e. same flag is used for initial and updated flight path indication) [5,8]** * **Option 2: Different indications are used to provide initial or future reporting of the flightpath information, (i.e.one flag is used for initial, and one flag is used to indicate the flightpath update available indication)** * **Option 3: Different indications are used to report when flight path info is available and the reason that cause the reporting, i.e. one flag for flight path available, one flag for update cause (e.g. initial, available of new flightpath) [15, 11]** * **Option 4: UE can also report when flightpath is unavailable. FFS if this is done via same or different IE as the flight path related information discussed in previous options [7]** | | |
| **Company** | **Preference/ acceptable options** | **Comments** |
| Ericsson | Option-3 | There is an opportunity to improve the LTE design by providing the network with more information.  The update need not be limited to initial/availability of a new fight path. Information on the validity of previously reported waypoints should also be considered i.e., either invalid or still valid and updated.  For Option-4, if no update is available, the UE need not report. It is redundant to send a report with something being unavailable. |
| CATT | Option1 | Since the report is from UE to gNB, and the gNB implement is not captured in the spec, it is doubt that the necessary to distinguish the initial and updated flightpath available. |
| ZTE | Option 1 | First of all, we think these options are related to the answer to question 5 (whether delta flightpath reporting is supported). If delta reporting is not supported, there is no need to have separate flags for initial and update, because the NW anyway will retrieve a complete flight path and replace previous one.  Further, It is hard for network to determine whether an update is necessary only according to an simple indicator. And it may be difficult to define “initial flightpath” and “updated flightpath”. Without a clear definition, an UAV UE implementation may always indicate “initial flightpath” to network. Thus it is useless to have different indications in UAI. |
| Xiaomi | Option 1 and Option 4 | When initial and updated flight path available, different indications/flags are not needed. A single indication (same flag) is used to inform the network that a new flight path is available and the old flight path is unavailable, if any.  When flightpath is unavailable, UE should report to network to indicate the old flight path is unavailable. The same indication in option 1 can be used. If network requests UE to report flight path, UE will not report the flight path to network when flight path is unavailable in UE. |
| Samsung | Option 1, 4 | Support option 1. If there is any previously reported flight path, the network can regard the flag as update flag. No need to have different flags for initial and update separately.  For option 3, we can’t see the need to introduce additional indicators to indicate the reason of the FPP update. Prefer to stick to previous agreement i.e. single bit seems sufficient and if NW provides some triggering conditions, then UE can indicate it via UAI if conditions are fulfilled.  Support option 4. It seems reasonable for the UE to report when flightpath becomes unavailable. We are open to discuss the details on how to indicate it. E.g., implicit indication (absence of *flightpathInfoAvailable* flag) or explicit indication (a new indicator for unavailability). |
| Lenovo | Option 1 | We think gNB can determine whether it is update flight path report by gNB implementation |
| vivo | Option 1 | One common indication is enough as the network can distinguish. |
| LGE | Option 1 | We don't think a separate indication is necessary. Subsequent actions on the network do not depend on whether the indication is availability or update. That is, the network needs to retrieve the flight path information for whatever the indication is. |
| NEC | Option 1 | In our understanding, the updated flightpath plan is based on the initial one. Network is able to know whether the available flightpath plan is an initial one or not (the network may have retrieved flightpath before, using UE information request/response), so we don’t see the need to have different indications. |
| Sharp | Option 1 | We are also open to discuss Option 3 if network would like to know more information to decide whether to request the updated flightpath. |
| Apple | Option 1 | For unavailable flight path report, there are two alternatives to enable it.   * Alt 1: UE indicates an explicit “cancel” indication in UAI message * Alt 2: Absence of the flight path info in UEInformationResponse message   We actually think both alternatives are feasible but Alt 2 a little bit. Going with Option 1, the indication of flight path availability can cover the “flight cancel” case. |

Summary: TBD

Regarding maximum number of waypoints that can be reported by the UAV, in LTE, maximum number is 20. Some companies suggested to make this number configurable by the network. Other companies indicate that there may be some need to extend the maximum number of waypoints if flightpath information is forward to target gNB during handover. Please indicate all acceptable options.

* Option 1: maximum number of waypoints is configurable by network [7,15]
* Option 2: maximum number of waypoints is set to 20 same as in LTE [4,6,17,18]
* Option 3: suggest a different maximum number of waypoints

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| **Question 4: What is the maximum number of waypoints should flight path reporting support?**   * **Option 1: maximum number of waypoints is configurable by network [7,15]** * **Option 2: maximum number of waypoints is set to 20 same as in LTE [4,6,17,18, 13]** * **Option 3: suggest a different maximum number of waypoints (please specify)** | | |
| **Company** | **Preference/ acceptable options** | **Comments** |
| Ericsson | Option-1/2 | A maximum value should be captured in the RRC specification. The network, however, can configure how many at most can be reported by the UE. LTE maximum 20 can be taken as baseline. |
| CATT | Option2 | The maximum number of waypoints depends on the need for NR UAV. Since the performance requirement (e.g. accuracy) for NR UAV is the same as LTE UAV. It is nature to follow the LTE in the current release. |
| ZTE | Option 2 | We prefer follow LTE. |
| Xiaomi | Option-1/2 | We also prefer follow LTE.  In 36.331, for each flight path reporting, the maximum number of way points UE can include in the flight path information report (i.e. *maxWayPointNumber-r15*) is configured by network via *FlightPathInfoReportConfig*. And the maximum value of *maxWayPointNumber-r15* (i.e *maxWayPoint-r15*) is 20.    **We wonder know whether the question applies to *maxWayPointNumber* or *maxWayPoint.***  **If it applies to *maxWayPointNumber*, we support option1. If it applies to *maxWayPoint*, we support option 2.** |
| Samsung | Option 2 | We prefer to keep the maximum number of waypoints as in LTE (i.e., 20). |
| Lenovo | Option 2 | We prefer to keep the maximum number of waypoints as in LTE (i.e., 20). |
| vivo | Option 2 | The maximum number of waypoints in LTE can be the baseline. If we support flight path transfer during HO in NR, we can further discuss whether to extend the number. |
| LGE | Option 2 | Prefer to follow LTE |
| NEC | Option 2 | We prefer to align with LTE. Anyway an updated plan can be send further. |
| Sharp | Option 2 | LTE method can be reused. |
| Apple | Option 2 |  |

Summary: TBD

## 2.3 Delta support of flight path reporting

In [2,7,15,29,20], it is proposed to support delta flightpath reporting. The main argument is that there is no need to report the entire flightpath if only part of it has changed. On the other hand, other papers [5,8] propose not to support delta flight path reporting. The argument is when flightpath changes, it most likely changes the entire path. For example, UAV starts the flight path at a later time. Please indicate your preference and supporting comments below:

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| **Question 5: Do you support delta flightpath reporting?** | | |
| **Company** | **Support/ not support** | **Comments** |
| Ericsson | Support | There is an opportunity to improve the LTE design by providing the network with more relevant information for e.g., UE only reports new information.  The update need not be limited to initial/availability of a new fight path. Information on the validity of previously reported waypoints would be important. |
| CATT | Not support | Share the same view as rapp. The requirement to save uplink reporting load for NR UAV is not convinced to us right now. |
| ZTE | Not support | We agree that when flight path changes, it is most likely the whole path is changed. Thus it is unnecessary to introduce such complexity in flight path update reporting. And currently, there is no delta reporting mechanism in uplink reporting in NR. |
| Xiaomi | Support | To reduce signaling overhead, delta flight path information can be supported for flight path update and the new flight path information is the delta of the flight path information reported in last time. |
| Samsung | See our comments | The entire path report can be the baseline, but we are open to discuss the partial update to reduce signalling overhead.  In some cases (e.g., removing passed waypoints, change only in time stamp …), we can reduce the signalling overhead quite a lot without having complex delta-configuration mechanism.  For examples: In case of ‘removing passed waypoint’, the UE can just indicate the number of waypoints to remove ‘N’. Then, the network can remove ‘N’ waypoints from the front of the previously reported list. In case of ‘change only in time stamp’, we can just allow the location information of waypoints to be optional only for the update case. |
| Lenovo | Not support | Agree with Rapp, CATT and ZTE |
| vivo | Not support | Agree with Rapp. |
| LGE | Not support | Agree with ZTE. It is also more complicated to compare the delta flight path with the previous report in the network side. |
| NEC | Not support. | We think it’s too complicated to distinguish partial update and entirely update. |
| Sharp | Not support | Delta signalling is complex. |
| Apple | Not support | For UL message, normally there is no delta reporting in NR. In UAI discussion, it was explicitly agreed that inside a feature, there is no delta reporting. This principle should also apply to UEInformationResponse message. That is to say, when UE creates the UEInformationResponse, it would be a message with full content. With this logic, network does not need to know if it is an update or initial one as network would directly make use of the newly reported info and discard the previous one if any. This actually simplifies the network implementation, i.e., avoiding the composing action when receiving a UL message with delta info. |

Summary: TBD

## 2.4 Flightpath information forwarding during handover

There are also some discussions regarding if flightpath information should be forwarded from source gNB to target gNB. Papers [17,20] suggest the support of flightpath information forwarding so network can perform mobility optimization for UAV as well as interference control. In addition, contribution [20] proposes to support UAV UE connected to 5GC (current LTE only supports UAV UE connected to EPC) to indicate *flightPathInfoAvailable.* There are 2 following proposals, please indicate your supporting proposal below:

* P1: flightpath information should be forwarded from source gNB to target gNB during handover.
* P2: *flightPathInfoAvailable* is added for UAV UE connected to 5GC (this change is in LTE)

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| **Question 6: Which of the following proposal(s) do you support?**   * **P1: flightpath information should be forwarded from source gNB to target gNB during handover.** * **P2: *flightPathInfoAvailable* is added for UAV UE connected to 5GC (this change is in LTE)** | | |
| **Company** | **Supporting proposal(s)** | **Comments** |
| Ericsson | Supportive | Should check with RAN3 on feasibility. |
| CATT | See comments | From technical point of view, both proposals are reasonable and acceptable. But there is no RAN2 spec impacts from our points of view till now (e.g., for P1 in RAN3 and P2 in SA). |
| ZTE | P1: support  P2: see comments | On P1: The traffic and delay used for reporting flightpath in target cell can be saved.  On P2: We may need to firstly clarify whether LTE/5GC is within the scope of UAV WID? If yes, we also agree with P2. |
| Xiaomi | P1 is ok | For P1, it should be checked with RAN3. For P2, agree with ZTE. |
| Samsung | Only P1 | Support P1. Flight path information is likely not to change after handover. Thus, the flightpath forwarding between source gNB and target gNB is useful to help mobility optimization.  For P2, it seems out of scope this WI. |
| Lenovo | Both proposals are ok | We support both proposals technically. But may need to confirm with RAN3 |
| vivo | Support P1. | If flightpath information can be forwarded from source gNB to target gNB during handover, the target gNB does not need to request flight path reporting from the UE, which can save the signalling overhead. Therefore, from signalling overhead perspective, we support proposal 1. The flight path information can be added in the inter-node message, so maybe it can be done in RAN2.  For P2, we think it is reasonable, but it seems not in the WID. |
| LGE | P1 is ok | Need to check with RAN3. |
| NEC | Support P1. | For the candidate cell selection by the target gNB, the flight path information will be useful. For example, if some candidate cells are overlapped, the target NB may select candidate cell(s) which is more suitable for the expected flight path (i.e., way point). |
| Sharp | P1 | And maybe check with RAN3. |
| Apple | Support P1 | Good to have P1. For P2, we are open for discussion. |

Summary: TBD

## 2.5 Other proposals

Please indicate if you have any other proposals related to flightpath update but not addressed in above questions.

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| **Company** | **Answer** |
| Ericsson | Additionally, in our view [11], some other critical information related to the flight path can also be reported, either in the flight path report or in a separate UE report. For example, we believe that information about default/emergency landing spots is important. Therefore, we propose RAN2 to discuss such enhancements |
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# 3 Conclusion

TBD

# References

1. RP-223545 Revised WID: NR Support for UAV (Uncrewed Aerial Vehicles) 3GPP TSG RAN Meeting #98e Electronic Meeting, Dec 12 - 16, 2022
2. R2-2301387 “Discussion on flight path reporting”, Samsung
3. R2-2301676 “Discussion on flight path reporting for NR UAV”, vivo
4. R2-2300992 “Flight path reporting”, Huawei, HiSilicon
5. R2-2300368 “Flight path update triggering for UAV”, Intel Corporation
6. R2-2301221 “On flight path reporting”, ZTE Corporation, Sanechips
7. R2-2301398 “Discussion on flight path reporting for NR UAV”, Xiaomi
8. R2-2300747 “Flight path reporting in UAV”, Apple
9. R2-2300480 “On Flight Path Plan (FPP) and Height-dependent Configurations”, Nokia, Nokia Shanghai Bell
10. R2-2300853 “Discussion on Flight Path Reporting”, NEC Europe Ltd
11. R2-2300905 “Flight path reporting”, Ericsson
12. R2-2300942 “Discussion on flight path reporting for NR UAV”, Sharp
13. R2-2300973 “Remaining issues of flight path reporting for NR UAV”, Lenovo
14. R2-2301228 “Flight path Reporting for NR UAV”, CMCC
15. R2-2301367 “Flight path notification and reporting for UAV”, InterDigital
16. R2-2301676 “Discussion on flight path reporting for NR UAV”, vivo
17. R2-2301810 “Discussion on flight path reporting for NR UAV”, China Telecom
18. R2-2301876 “Leftover Issues on Flight Path Reporting”, CATT
19. R2-2301883 “Consideration on flight path reporting of NR support for UAV”, DENSO CORPORATION
20. R2-2300584 “Flight path reporting enhancements”, Qualcomm