Review of OLS Data and Impacts on RNAV Approach Procedures

Bonriki International Airport (TRW), Funafuti International Airport (FUN), Cassidy International Airport (CXI)
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Bonriki International Airport (TRW), Funafuti International Airport (FUN), Cassidy International Airport (CXI)

Prepared for
Pacific Aviation Investment Program (PAIP)

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<th>Revision Date</th>
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<td>Craig Ridgley Aviation Director</td>
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30 April 2013
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Procedure Design Mapping
1.0 Introduction

In accordance with the PAIP development objective to improve aviation infrastructure safety and security compliance, it is expected that the participating airports will undergo aerodrome certification as a result of the improvements financed under PAIP. Under this process, a survey of Obstacle Limitation Surfaces (OLS) was carried out at the three subject airports: Tarawa (Bonriki) International Airport (TRW), Funafuti International Airport (FUN), and Cassidy International Airport (CIX).

Also included in the process is a review of existing RNAV (GNSS) Instrument Approach Procedures to ensure that all published procedures are in compliance with current standards. All three subject sites have RNAV (GNSS) Approaches to both runway ends, for a total of six approach procedures to be reviewed. The procedures have been reviewed only against the new obstacle data provided and current criteria standards. Specifically, the Visual Segment Surface (VSS) has been assessed for all approaches. PANS-OPS criteria states “Straight-in instrument approach procedures published before 15 March 2007 shall be protected in the visual segment by means of the VSS after the periodical review of the procedure, but not later than 15 March 2012.” Based on the information available and direction following directions received in discussions with the New Zealand CAA, this review concludes assessment of the VSS for procedures which did not have obstacle data available in these areas, but does not constitute a complete periodic review.

This report contains the summary of findings of the review of the six approaches at the three airport sites. Any changes recommended, either to the published procedure or operational changes at the airport, are indicated. Recommended changes should be reviewed by the local CAA and amendments published as required.

1.1 Scope of Work

The details of the instrument procedure review component of the project are described in sections E and F of Part B of the terms of reference. They state:

e) As part of “control of the quality of the process” a review of each instrument procedure at the Tarawa, Bonriki and Funafuti Airports is to be completed. This will involve:

   i) A complete planned systemic review according to ICAO standards and recommended practices on the existing airspace procedures.

   ii) Review of all instrument procedures at the airports above, following and adhering to all ICAO practices/guidelines, to include (but not limited to) all procedure design processes reviewed against PANSOPS criteria changes to ensure compliance, updated with new obstacle/surveyed data, terrain, procedure design documentation, calculations, verification and validation methods, safety and efficiency recommendations, any deficiencies noted and qualify the acquisition/processing of source information/data.

There are 4 procedures for each airport to be reviewed and reported on (12 procedures in total to be reviewed) plus likely updates to each of the three airports published data as a result of the review findings and recommendations.

f) Develop a full Procedure Design Report (PDR) will be issued outlining the results of the airspace procedure review in part (e) above.

In undertaking this assignment, the Consultant will be expected to review existing OLS, RNAV, GPS and GNSS Approaches for Bonriki International Airport, Kiribati and Funafuti International Airport, Tuvalu. In addition, the Consultant will be directed by the relevant government airport operator and will be expected to liaise closely with relevant stakeholders, such as the airlines currently servicing the airports.

Based on the information provided by AECOM, the scope of work is amended from the terms of reference text as follows:

- Cassidy International Airport (Kiribati) is included in the airports to be reviewed. Bonriki and Tarawa, described separately, are in fact the same airport.

- There are a total of two RNAV approaches at each site, one to each runway end, for a total of six approaches. The conventional (NDB) approaches are not included as part of this review.
The original procedure design files of the existing procedures were not made available for review. As a result, certain assumptions and/or background data was not available for review and verification. In these instances, independent determinations of procedure design elements were compared with the published procedures; where there were any discrepancies, the more conservative assumptions were favoured.

For clarity with regards to the wording of the Terms of Reference, RNAV, GPS, and GNSS all refer to the same type of approach. OLS refers to the obstacle limitation surfaces associated with airport certification, but is not in itself a type of approach.

1.2 Assumptions Based on Data Not Provided

As the original design file was not provided for review, the following assumptions have been made relating to the construction of assessment areas and obstacle clearance:

- The coordinates of the existing waypoints were not provided. The review was conducted under the assumption that each segment length is 5.00 nautical miles with the exception of the missed approach, whose waypoint location is the Intermediate Fix for the approach in the opposite direction. The existing procedures have been flight checked, and will be re-checked, confirming that the waypoints are appropriately placed. Waypoint locations will not change as a result of this review.

- The original obstacle assumption for open water regions is unknown. No specific figure is given for assuming obstacle heights in open water areas; rather, criteria states that the tallest transient obstacle likely to be present in that area should be considered. The obstacle allowance based on the published procedure is assessed for each segment to determine if it is sufficient.

- Terrain data was not provided. Terrain modelling from the Shuttle Radar Topography Mission (SRTM) was used to develop contour mapping. Reports on data accuracy from the US Geological Survey indicate a root mean square error of 3.4m, with lower error over relatively flat terrain. An additional 4m allowance has been assumed.

- Obstacle information is not provided outside the survey area associated with the obstacle limitation surfaces. A portion of the final and missed approach segments include areas outside the surveyed zone. A man-made obstacle and/or vegetation allowance of 20m is assumed as a conservative estimate of un-surveyed obstacles in these areas. This value is higher than any surveyed trees in the OLS area and is believed to be sufficient to account for all other vegetation in the area. The existing aerodrome and procedure charts indicate the presence of additional obstacles in some cases. These obstacles are considered in the assessments; as their exact position is not known, they are assumed to fall within the primary area of the associated flight segment and full obstacle clearance amounts are provided above them. The absence of any additional obstacles above this limit will be confirmed during a flight check.

1.3 Summary of Required Actions

Based on a review of the information provided and an independent assessment of the current published procedures, the following actions are required to ensure ongoing compliance with PANS-OPS criteria:

- Tarawa (Bonriki International): Trees noted as obstacles T199, T200, and T261 in the OLS survey should be removed as soon as practical, along with any other trees in the area that may grow to penetrate the VSS in the future. Special notice of obstacles T199 and T200 should be provided by NOTAM until they are removed.

- Tarawa (Bonriki International): Obstacle A1 should be removed as soon as practical. Notification of this obstacle should be provided by NOTAM until it is removed.

- Funafuti International: The notation regarding obstacle assessment in the VSS can be removed on republication of the AIP supplement.

- Funafuti International: RNAV (GNSS) RWY 03 Approach chart should be amended as follows:
  - LNAV OCA/H revised to read 420 (407).
  - Threshold elevation should be amended to 13 feet. Airport elevation should be amended to read 11 feet.
  - Changes to profile view to include:
- Glideslope angle amended to 3°.
- Procedure altitude at the FAF amended to 1660.
- Start of descent from 2500 amended to D2.6 from FAF.

- Funafuti International: RNAV (GNSS) RWY 03 Approach chart should be amended as follows:
  - Threshold elevation should be amended to 12 feet. Airport elevation should be amended to read 11 feet.
  - LNAV OCA/H should be amended to read 420 (408) for all categories.
  - Changes to profile view to include:
    - Glideslope angle amended to 3°.
    - Procedure altitude at the FAF amended to 1660.
    - Start of descent from 2500 amended to D2.6 from FAF.

- Christmas Island (Cassidy International): Tree 506 should be removed. The height of Mast 001 must be confirmed; if it penetrates the VSS and is greater than 17m, a special note should be provided on the approach chart and serious consideration should be given to its removal.

- Christmas Island (Cassidy International): GPS RWY 08 Approach chart should be amended as follows:
  - Threshold elevation should be amended to 8 feet. Airport elevation should be amended to read 9 feet.
  - A procedure altitude of 1660 feet should be indicated at the FAF with a descent angle of 3° shown.
  - The chart should be republished in its entirety incorporating the correct minima values. Differing values can lead to pilot error. In addition, with republication the title should be changed to RNAV (GNSS) RWY 08 in accordance with current procedure naming conventions.

- Christmas Island (Cassidy International): GPS RWY 26 Approach chart should be amended as follows:
  - Threshold elevation should be amended to 8 feet. Airport elevation should be amended to read 9 feet.
  - A procedure altitude of 1660 feet should be indicated at the FAF with a descent angle of 3° shown.
  - The chart should be republished in its entirety incorporating the correct minima values. Differing values can lead to pilot error. In addition, with republication the title should be changed to RNAV (GNSS) RWY 08 in accordance with current procedure naming conventions.

- A flight check should be carried out on all procedures to validate amendments.
2.0 Tarawa/Bonriki International RNAV (GNSS) RWY 09

2.1 Current Chart

![Diagram of Tarawa/Bonriki International RNAV (GNSS) RWY 09](image)
2.2 Criteria

The current procedure is reviewed in accordance with ICAO PANS-OPS Doc 8168, Volume II, Fifth Edition, Amendment 4, which is current at the time of review.

2.3 Terrain and Obstacle Data

Terrain data is derived from the US National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM). This project provides digital terrain models of almost the entire earth surface. The 90% relative height error for the Pacific Islands region is 6.2m (with a tendency to overstate height). An allowance of 7m is provided to account for this error when terrain data is used.

Obstacle data was provided for the Annex 14 OLS area as part of the obstacle survey conducted. The location of these obstacles is shown below, plotted onto the terrain data previously described. For clarity, obstacles less than 15m were removed from plotting as they will not be controlling obstacles nor factor in assessment of the Visual Segment Surface.

Figure 2-1: Surveyed obstacles over 15m

Obstacle data further from the runway was not available as part of this review. An allowance of 20m has been assumed for all areas for vegetation and most man-made structures. The existing chart indicates several obstacles in the area, the highest being 197 feet. Their exact location is unknown, but plotted in the approximate area based on the chart and conservatively assumed to fall within protection areas where it may be possible.

With the height of known obstacles, terrain plus allowances do not form the controlling obstacle for any segment of the procedure.

2.4 Aerodrome Data

Basic aerodrome data was provided as part of the OLS survey:

<table>
<thead>
<tr>
<th>Location</th>
<th>Coordinates</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>THR09</td>
<td>1°22'57.943&quot; N 173°08'17.101&quot; E</td>
<td>7.22ft</td>
</tr>
<tr>
<td>THR27</td>
<td>1°22'50.038&quot; N 173°09'19.108&quot; E</td>
<td>9.38ft</td>
</tr>
<tr>
<td>ARP</td>
<td>1° 22'52.177&quot; N 173° 08'46.580&quot; E</td>
<td>4.25ft</td>
</tr>
</tbody>
</table>
2.5 Waypoint Data

Existing waypoint coordinates were not provided. It is not the intent of this review to amend waypoint locations, and previous flight checks provide sufficient comfort that the waypoints are located in accordance with the charted information. For construction purposes, each segment (except the missed approach segment) is assumed to be exactly 5.00 nautical miles, with the right and left initial segments at exactly 90° offset from the final approach course. The missed approach point is co-located with the IF of the approach in the other direction.

2.6 Hold at the IAF/IF

The minimum indicated hold altitude is 1200 feet. This is equivalent to the Minimum Sector Altitude (MSA) and provides for obstacle heights up to 200 feet. The highest obstacle in the area is 197 feet as indicated on the chart, though its exact coordinates are unknown.

2.7 Initial Segments

Both initial segments are indicated with an altitude of 2500 feet. This altitude is a procedure altitude to provide a longer stabilized descent; the obstacle clearance altitude is 1200 feet as indicated in the MSA section on the chart. PANS-OPS requires only a procedure altitude indicated at the FAF, so the higher procedure altitude is not required under PANS-OPS criteria. While not a PANS-OPS requirement, the chart is not in contravention to any criteria and does not need to be modified.

The North initial segment (beginning at NADAN) has no known obstacles, and is entirely over open water. The MSA provides the initial segment obstacle clearance of 300m/1000 feet above obstacles up to 200 feet; this is a reasonable assumption.

The South initial segment (beginning at SABRA) has several obstacles, though their exact location was not provided. One charted obstacle, with a height of 148 feet is believed to fall within the primary area. The highest known obstacle in the area is 197 feet; it likely does not fall within the initial segment area, however even if it does, sufficient obstacle clearance is provided.

2.8 Intermediate Segment

The intermediate segment is indicated with an obstacle clearance altitude of 700 feet. The highest known obstacle in the area, at 197 feet, appears to fall within the secondary area of the intermediate segment. 150m/500 foot obstacle clearance is required; even under the assumption that the obstacle falls within the primary area the 700 foot intermediate altitude is correct.

2.9 Final Segment (LNAV)

Though their exact location is not known, the existing approach chart indicates obstacles with heights of 118, 125, and 164 feet. Based on the location of the land relative to the protection areas, these obstacles must fall significantly within the secondary area, if covered by the protection area at all. The published OCA of 380 feet allows for obstacles up to 130 feet in the primary area and up to about 250 feet in the conservatively estimated locations of the chart obstacles. This provides sufficient obstacle clearance even under conservative assumptions of charted obstacle locations; however a lower OCA cannot be recommended without knowing the exact locations of these obstacles.

2.10 Final Segment (Baro-VNAV)

The position of the obstacles within the FAS is not known. The existing OCA of 380 feet provides for obstacles up to 130 feet in the horizontal segment of the primary area. Since the charted obstacles must be in the secondary area based on the location of land, this appears to be a conservative assumption, however a lower OCA cannot be recommended without knowing the location of these obstacles. Since the aerodrome does not comply with Annex 14 Obstacle Free Zone requirements, the lowest possible OCA is 90/300 feet above the airport elevation. Since this would equate to 320 feet, there is not significant potential reduction of OCA even if obstacles were removed or fell under the assessment surfaces.
2.11 **Visual Segment Surface (VSS)**

The VSS is a surface which begins at the end of the runway strip, extending laterally at a splay of 15°, and rising at a slope of 1.12° less than the published nominal glide path procedure. It extends up to the point at which it reaches the published OCA. Obstacles less than 15m above the threshold elevation can be ignored; however any penetration of the VSS means that procedures cannot be published without aeronautical study.

*Figure 2-2: Obstacles in the VSS*

Based on the information in the OLS, two trees penetrate the VSS. Obstacle T200, a tree with a height of 21m, and T199, a tree with a height of 18.8m (both trees are located immediately adjacent to each other just south of the runway), are located just inside the start of the VSS. A third tree, T261 - 16.7m violates the VSS but can be discounted because it is less than 15m above the threshold elevation. Nonetheless, this tree will eventually violate the VSS as it grows.

These three trees should be removed as soon as possible, along with any other trees of similar height in the area that will eventually grow to a height that will penetrate the VSS. The determination of whether to suspend authorization of the approach until these obstacles are removed is the responsibility of the state. Based strictly on PANS-OPS criteria, if these were located even a few metres closer to the threshold, they would not penetrate the VSS (though they would then be a runway strip obstacle and would still need to be removed). The location of these trees relative to the runway means that by the time they are encountered the pilot will have either lined up correctly to land (in which case they will be approximately 100m to the right) or if the aircraft is not correctly lined up, will have already initiated a missed approach (in which case the aircraft will be high enough to clear them).

While these trees must be removed, the safety impact of revoking the approaches in the intervening period is likely greater than any safety improvements gained by eliminating the instrument approach. A reasonable compromise is to publish the presence of these obstacles by NOTAM until such time that they are removed.

**Recommendation:** Trees noted as obstacles T199, T200, and T261 in the OLS survey should be removed as soon as practical, along with any other trees in the area that may grow to penetrate the VSS in the future. Special notice of obstacles T199 and T200 should be provided by NOTAM until they are removed.
2.12 Missed Approach
There are no obstacles in the missed approach segment that require an increase in OCA or climb gradient.

2.13 Missed Approach Hold
The minimum holding altitude is indicated at 1200 feet. This is equivalent to the MSA and provides for obstacles up to 200 feet. The missed approach hold primary area and first buffer area are entirely over water.

2.14 Circling
Assessment of circling areas is made challenging by lack of detailed obstacle data in these areas; known obstacles and their approximate locations are used to develop minimum clearance altitudes. These are compared against current published altitudes to determine if an increase is necessary. However where a decrease is shown as possible, it cannot be recommended as insufficient data is provided.

<table>
<thead>
<tr>
<th>Category</th>
<th>Obstacle</th>
<th>Height</th>
<th>MOC</th>
<th>Required OCA</th>
<th>Published OCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Tower - East side of Island**</td>
<td>131ft</td>
<td>295ft</td>
<td>430 ft</td>
<td>450 ft</td>
</tr>
<tr>
<td>B</td>
<td>Tower - East side of Island**</td>
<td>131ft</td>
<td>295ft</td>
<td>500 ft*</td>
<td>510 ft</td>
</tr>
<tr>
<td>C</td>
<td>Tower - South of FAF**</td>
<td>164ft</td>
<td>394ft</td>
<td>600 ft*</td>
<td>600 ft</td>
</tr>
<tr>
<td>D</td>
<td>Tower - South of FAF**</td>
<td>164ft</td>
<td>394ft</td>
<td>700 ft*</td>
<td>700 ft</td>
</tr>
</tbody>
</table>

*Minimum OCA for category type
**Exact location unknown

All published circling altitudes meet or exceed minimum requirements. No reduction in altitudes is recommended as insufficient obstacle data is available and the original design file was not provided.

2.15 Segment Headings
Magnetic Declination as of April 2013 is 9.05°E (changing by 0.03°W per year) as calculated by the US National Oceanographic and Atmospheric Administration. This equals the value indicated on the chart. The table below summarizes the True and Magnetic headings of the segments.

<table>
<thead>
<tr>
<th>Segment(s)</th>
<th>HDG (True)</th>
<th>HDG (Magnetic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate, Final, Missed Approach</td>
<td>097°</td>
<td>088°</td>
</tr>
<tr>
<td>Initial (North)</td>
<td>187°</td>
<td>178°</td>
</tr>
<tr>
<td>Initial (South)</td>
<td>007°</td>
<td>358°</td>
</tr>
<tr>
<td>Missed Approach Hold inbound track</td>
<td>277°</td>
<td>268°</td>
</tr>
</tbody>
</table>

All segment headings as published are correct.

2.16 Procedure Altitudes
The procedure altitude provided at the FAF is 1660 ft. With a threshold crossing height of 50 feet, the altitude at the threshold is 58 feet. At a nominal descent angle of 3°, the amount of descent in 5.00 nm is 1592 feet, providing an altitude of 1650 feet at the FAF. The existing procedure altitude, while it could be published at 1650 feet, is appropriate. The very minor difference does not justify revision of the chart.

From the procedure altitude at the FAF to the initial procedure altitude (2500 feet) the distance at a slope of 3° is 2.64 nautical miles. The distance shown on the chart (2.6) is correct when rounded.
2.17 Summary of Amendments or Further Actions Recommended

Trees noted as obstacles T199, T200, and T261 in the OLS survey should be removed as soon as practical, along with any other trees in the area that may grow to penetrate the VSS in the future. Special notice of obstacles T199 and T200 should be provided by NOTAM until they are removed.

No changes are required to the procedure as published.
3.0 Tarawa/Bonriki International RNAV (GNSS) RWY 27

3.1 Current Chart
3.2 Criteria

The current procedure is reviewed in accordance with ICAO PANS-OPS Doc 8168, Volume II, Fifth Edition, Amendment 4, which is current at the time of review.

3.3 Terrain and Obstacle Data

Terrain data is derived from the US National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM). This project provides digital terrain models of almost the entire earth surface. The 90% relative height error for the Pacific Islands region is 6.2m (with a tendency to overstate height). An allowance of 7m is provided to account for this error when terrain data is used.

Obstacle data was provided for the Annex 14 OLS area as part of the obstacle survey conducted. The location of these obstacles is shown below, plotted onto the terrain data previously described. For clarity, obstacles less than 15m were removed from plotting as they will not be controlling obstacles nor factor in assessment of the Visual Segment Surface.

Figure 3-1: Surveyed obstacles over 15m

Obstacle data further from the runway was not available as part of this review. An allowance of 20m has been assumed for all areas for vegetation and most man-made structures. The existing chart indicates several obstacles in the area, the highest being 197 feet. Their exact location is unknown, but plotted in the approximate area based on the chart and conservatively assumed to fall within protection areas where it may be possible.

With the height of known obstacles, terrain plus allowances do not form the controlling obstacle for any segment of the procedure.

3.4 Aerodrome Data

Basic aerodrome data was provided as part of the OLS survey:

<table>
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<td>4.25ft</td>
</tr>
</tbody>
</table>
3.5 **Waypoint Data**

Existing waypoint coordinates were not provided. It is not the intent of this review to amend waypoint locations, and previous flight checks provide sufficient comfort that the waypoints are located in accordance with the charted information. For construction purposes, each segment (except the missed approach segment) is assumed to be exactly 5.00 nautical miles, with the right and left initial segments at exactly 90° offset from the final approach course. The missed approach point is co-located with the IF of the approach in the other direction.

3.6 **Hold at the IAF/IF**

The minimum indicated hold altitude is 1200 feet. This is equivalent to the Minimum Sector Altitude (MSA) and provides for obstacle heights up to 200 feet. The primary and first buffer area of the hold are entirely over water. The 200 foot allowance is more than sufficient to account for transient obstacles.

3.7 **Initial Segments**

Both initial segments are indicated with an altitude of 2500 feet. This altitude is a procedure altitude to provide a longer stabilized descent; the obstacle clearance altitude is 1200 feet as indicated in the MSA section on the chart. PANS-OPS requires only a procedure altitude indicated at the FAF, so the higher procedure altitude is not required under PANS-OPS criteria. While not a PANS-OPS requirement, the chart is not in contravention to any criteria and does not need to be modified.

Both initial segments are entirely over water with no known obstacles. The 200 foot allowance that the MSA provides is more than sufficient for any transient obstacles in the area.

3.8 **Intermediate Segment**

The intermediate segment is indicated with an obstacle clearance altitude of 700 feet. The intermediate segment is entirely over water with no known obstacles. The 200 foot allowance that the MSA provides is more than sufficient for any transient obstacles in the area.

3.9 **Final Segment (LNAV)**

The chart indicates an obstacle with a height of 131 feet in the vicinity of the final approach segment. This obstacle could not be located on aerial imagery, so its exact location is not clear. For conservative purposes, it is assumed to be located in the primary area, though it may be located in the secondary area. The highest area of terrain in the final primary area is less than 10m (a few areas shown as higher than this fall within the OLS survey area and can be confirmed as lower than suggested by the SRTM data). With allowances, the assumed possible height is 9m (terrain) + 7m (error allowance) + 20m (vegetation allowance) for total assumed height of 36m. This is lower than the 131 foot obstacle.

An MOC of 75m (246 feet) is provided over the obstacle, providing a final segment OCA of 377 feet (rounded up to 380 feet). The current published LNAV minimum is 400 feet. Without additional obstacle data, a recommendation of reducing this value cannot be made.
3.10 Final Segment (Baro-VNAV)

The position of the obstacles within the FAS is not known. The existing OCA of 380 feet provides for obstacles up to 130 feet (134 feet if using a 75m allowance) in the horizontal segment of the primary area. Since it is unclear whether the charted obstacle is in the primary or secondary area, a lower OCA cannot be recommended without knowing the location of these obstacles. Since the aerodrome does not comply with Annex 14 Obstacle Free Zone requirements, the lowest possible OCA is 90m/300 feet above the airport elevation. Since this would equate to 320 feet, there is not significant potential reduction of OCA even if obstacles were removed or fell under the assessment surfaces.

3.11 Visual Segment Surface (VSS)

The VSS is a surface which begins at the end of the runway strip, extending laterally at a splay of 15°, and rising at a slope of 1.12° less than the published nominal glide path procedure. It extends up to the point at which it reaches the published OCA. Obstacles less than 15m above the threshold elevation can be ignored; however any penetration of the VSS means that procedures cannot be published without aeronautical study.
Only one surveyed obstacle greater than 15m exists near this area. It is noted as obstacle "A1", though what type of obstacle is not clear, and is 15.9m above the threshold elevation. Strictly speaking, this obstacle does not penetrate the VSS as it is located just prior to the start of the surface. However, this is still an obstruction and should be removed as soon as practical.

**Recommendation:** Though just outside the boundary of the VSS, obstacle A1 should be removed as soon as practical. Notification of this obstacle should be provided by NOTAM until it is removed.

### 3.12 Missed Approach

There are no obstacles in the missed approach segment that require an increase in OCA or climb gradient.

### 3.13 Missed Approach Hold

The minimum holding altitude is indicated at 1200 feet. This is equivalent to the MSA and provides for obstacles up to 200 feet. The highest obstacle in the primary area is also the highest known obstacle in the entire region, at 197 feet.

### 3.14 Circling

Assessment of circling areas is made challenging by lack of detailed obstacle data in these areas; known obstacles and their approximate locations are used to develop minimum clearance altitudes. These are compared against current published altitudes to determine if an increase is necessary. However where a decrease is shown as possible, it cannot be recommended as insufficient data is provided.

<table>
<thead>
<tr>
<th>Category</th>
<th>Obstacle</th>
<th>Height</th>
<th>MOC</th>
<th>Required OCA</th>
<th>Published OCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Tower - East side of Island**</td>
<td>131 ft</td>
<td>295 ft</td>
<td>430 ft</td>
<td>450 ft</td>
</tr>
<tr>
<td>B</td>
<td>Tower - East side of Island**</td>
<td>131 ft</td>
<td>295 ft</td>
<td>500 ft*</td>
<td>510 ft</td>
</tr>
<tr>
<td>C</td>
<td>Tower - South of FAF**</td>
<td>164 ft</td>
<td>394 ft</td>
<td>600 ft*</td>
<td>600 ft</td>
</tr>
<tr>
<td>D</td>
<td>Tower - South of FAF**</td>
<td>164 ft</td>
<td>394 ft</td>
<td>700 ft*</td>
<td>700 ft</td>
</tr>
</tbody>
</table>

*Minimum OCA for category type

**Exact location unknown
All published circling altitudes meet or exceed minimum requirements. No reduction in altitudes is recommended as insufficient obstacle data is available and the original design file was not provided.

### 3.15 Segment Headings

Magnetic Declination as of April 2013 is 9.05°E (changing by 0.03°W per year) as calculated by the US National Oceanographic and Atmospheric Administration. This equals the value indicated on the chart. The table below summarizes the True and Magnetic headings of the segments.

<table>
<thead>
<tr>
<th>Segment(s)</th>
<th>HDG (True)</th>
<th>HDG (Magnetic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate, Final, Missed Approach</td>
<td>277°</td>
<td>268°</td>
</tr>
<tr>
<td>Initial (North)</td>
<td>187°</td>
<td>178°</td>
</tr>
<tr>
<td>Initial (South)</td>
<td>007°</td>
<td>358°</td>
</tr>
<tr>
<td>Missed Approach Hold Inbound Track</td>
<td>097°</td>
<td>088°</td>
</tr>
</tbody>
</table>

All segment headings as published are correct.

### 3.16 Procedure Altitudes

The procedure altitude provided at the FAF is 1660 ft. With a threshold crossing height of 50 feet, the altitude at the threshold is 59 feet. At a nominal descent angle of 3°, the amount of descent in 5.00 nm is 1592 feet, providing an altitude of 1651 feet at the FAF. The existing procedure altitude is appropriate.

From the procedure altitude at the FAF to the initial procedure altitude (2500 feet) the distance at a slope of 3° is 2.64 nautical miles. The distance shown on the chart (2.6) is correct when rounded.

### 3.17 Summary of Amendments or Further Actions recommended

Obstacle A1 should be removed as soon as practical. Notification of this obstacle should be provided by NOTAM until it is removed.

No changes are required to the procedure as published.
4.0 Funafuti International RNAV (GNSS) RWY 03

4.1 Current Chart

Use Funafuti QNH

DISTANCE to WPT      TAFAO 4 3 2 1 FUS73 4 3 2 1 RW03
Advisory Altitude 5%        3050 2750 2450 2150 1850 1550 1250 950 650 350 MDA MDA
Category             A    B    C    D
LNAV                  400(391) - 1500   400(391) - 2400
Course                470(461) - 1900   510(501) - 2800   600(591) - 3700   700(691) - 4600
4.2 Criteria

The current procedure is reviewed in accordance with ICAO PANS-OPS Doc 8168, Volume II, Fifth Edition, Amendment 4, which is current at the time of review.

4.3 Terrain and Obstacle Data

Terrain data is derived from the US National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM). This project provides digital terrain models of almost the entire earth surface. The 90% relative height error for the Pacific Islands region is 6.2m (with a tendency to overstate height). An allowance of 7m is provided to account for this error when terrain data is used.

Obstacle data was provided for the Annex 14 OLS area as part of the obstacle survey conducted. The location of these obstacles is shown below, plotted onto the terrain data previously described. For clarity, obstacles less than 15m above threshold elevation were removed from plotting as they will not be controlling obstacles nor factor in assessment of the Visual Segment Surface.

Figure 4-1 - Surveyed obstacles over 15m

Obstacle data further from the runway was not available as part of this review. An allowance of 20m has been assumed for all areas for vegetation and most man-made structures. The existing charts do not indicate any additional obstacles to be considered. Without access to full obstacle data or the original design file, reductions in segment altitudes cannot be recommended.

4.4 Aerodrome Data

Basic aerodrome data was provided as part of the OLS survey:

<table>
<thead>
<tr>
<th>Location</th>
<th>Coordinates</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>THR03</td>
<td>8° 31' 44.637&quot; S 179° 11' 31.240&quot; E</td>
<td>13 ft</td>
</tr>
<tr>
<td>THR21</td>
<td>8° 31' 08.102&quot; S 179° 12' 05.548&quot; E</td>
<td>12 ft</td>
</tr>
<tr>
<td>ARP</td>
<td>8° 31' 28.824&quot; S 179° 11' 43.900&quot; E</td>
<td>10.6 ft</td>
</tr>
</tbody>
</table>

**Recommendation:** approach chart should be amended to reflect the higher elevation of 11ft for ARP elevation and 13 ft for THR elevation (current chart reads 9 feet for both).
4.5 **Waypoint Data**

Existing waypoint coordinates were not provided. It is not the intent of this review to amend waypoint locations, and previous flight checks provide sufficient comfort that the waypoints are located in accordance with the charted information. For construction purposes, each segment (except the missed approach segment) is assumed to be exactly 5.00 nautical miles, with the right and left initial segments at exactly 90° offset from the final approach course. The missed approach point is co-located with the IF of the approach in the other direction.

4.6 **Hold at the IAF/IF**

The minimum indicated hold altitude is 2500 feet. This is equivalent to the procedure height of the initial segments and is 1300 feet above the MSA for the region. It provides for obstacles up to 1500 feet, none of which could reasonably be expected to exist in the area.

4.7 **Initial Segments**

Both initial segments are indicated with an altitude of 2500 feet. This altitude is a procedure altitude to provide a longer stabilized descent; the obstacle clearance altitude is 1200 feet as indicated in the MSA section on the chart. PANS-OPS requires only a procedure altitude indicated at the FAF, so the higher procedure altitude is not required under PANS-OPS criteria. While not a PANS-OPS requirement, the chart is not in contravention to any criteria and does not need to be modified.

Both initial segments are entirely over water with no known obstacles (the Initial segment from waypoint KAUPA transitions to the intermediate segment before reaching land). The 200 foot allowance that the MSA provides is more than sufficient for any transient obstacles in the area.

4.8 **Intermediate Segment**

The intermediate segment is indicated with an obstacle clearance altitude of 700 feet. As with the hold, the primary area encompass a significant area of terrain, though all terrain is less than 20m (66 ft). This provides for up to 134 feet for man-made obstacles; no obstacle data is available in this area and the absence of obstacles above this level will be confirmed on flight check.

4.9 **Final Segment (LNAV)**

The controlling (known) obstacle is Tower T293, located in the missed approach area before the Start of Climb, with a height of 48.35m or 159 feet. An MOC of 75m (246 feet) is provided over the obstacle, providing a final segment OCA of 405 feet (rounded up to 420 feet). The current published LNAV minimum is 400 feet. The chart must be amended to reflect this increased OCA.
4.10 Visual Segment Surface (VSS)

The VSS is a surface which begins at the end of the runway strip, extending laterally at a splay of 15°, and rising at a slope of 1.12° less than the published nominal glidepath procedure. It extends up to the point at which it reaches the published OCA. Obstacles less than 15m above the threshold elevation can be ignored; however any penetration of the VSS means that procedures cannot be published without aeronautical study.

Only one surveyed obstacle greater than 15m exists near this area. It is the tree noted as T275; it is located 376m from the start of the VSS, with a height of 19.44m (0.5m above threshold elevation). The height of the surface at this point is sufficiently above the tree - no penetrations of the VSS exist in this area.

**Recommendation:** The AIP amendment that the chart is published with has the notation "Obstacle data in the VSS areas for Funafuti International is not available thus obstacle protection in the visual segments cannot be guaranteed." Obstacle data has been compiled and reviewed and no penetrations exist on either end (see report for Runway 21). This notation can be removed on the subsequent amendment.

4.11 Missed Approach

The controlling obstacle in the missed approach is the same obstacle as for the final segment, as it is located before the start of climb.

4.12 Missed Approach Hold

The minimum holding altitude is indicated at 2500 feet. This is equivalent the procedure altitudes at the initial segments, and provides for obstacles up to 1500 feet. The missed approach hold primary area and first buffer area are located entirely over water. The obstacle allowance is more than sufficient for any transient obstacles that may be present in these areas.
4.13 Circling

Assessment of circling areas is made challenging by lack of detailed obstacle data in these areas; known obstacles and their approximate locations are used to develop minimum clearance altitudes. These are compared against current published altitudes to determine if an increase is necessary. However where a decrease is shown as possible, it cannot be recommended as insufficient data is provided.

<table>
<thead>
<tr>
<th>Category</th>
<th>Obstacle</th>
<th>Height</th>
<th>MOC</th>
<th>Required OCA</th>
<th>Published OCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Tower T293</td>
<td>48.35m / 159 ft</td>
<td>90m / 295ft</td>
<td>454 ft</td>
<td>470 ft</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>120m / 394ft</td>
<td>500 ft*</td>
<td>510 ft</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td>600 ft*</td>
<td>600 ft</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td>700 ft*</td>
<td>700 ft</td>
<td></td>
</tr>
</tbody>
</table>

*Minimum OCA for aircraft category

All published circling altitudes meet or exceed minimum requirements.

4.14 Segment Headings

Magnetic Declination as of April 2013 is 10.38°E (changing by 0.02°W per year) as calculated by the US National Oceanographic and Atmospheric Administration. This equals the value indicated on the chart (when rounded).

The table below summarizes the True and Magnetic headings of the segments.

<table>
<thead>
<tr>
<th>Segment(s)</th>
<th>HDG (True)</th>
<th>HDG (Magnetic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate, Final, Missed</td>
<td>043°</td>
<td>033°</td>
</tr>
<tr>
<td>Approach</td>
<td>133°</td>
<td>123°</td>
</tr>
<tr>
<td>Initial (via KAUPA)</td>
<td>313°</td>
<td>303°</td>
</tr>
<tr>
<td>Initial (via SEMUT)</td>
<td>223°</td>
<td>213°</td>
</tr>
<tr>
<td>Missed Approach Hold Inbound</td>
<td>223°</td>
<td>213°</td>
</tr>
</tbody>
</table>

All segment headings as published are correct.

4.15 Procedure Altitudes

The procedure altitude provided at the FAF is 1550 ft. With a threshold crossing height of 50 feet, the altitude at the threshold is 63 feet. At a nominal descent angle of 2.9°, the amount of descent in 5.00 nm is 1540 feet, providing an altitude of 1600 feet at the FAF. The existing procedure altitude is too low. However, the optimum descent angle is 3° and there is no obvious reason why a lower angle should be provided. At 3°, the procedure altitude at the FAF would be 1660 feet.

From the procedure altitude at the FAF to the initial procedure altitude (2500 feet) the distance at a slope of 2.9° is 2.92 nautical miles. The distance shown on the chart (3.2) is too high. In conjunction with changes to the procedure altitude at the FAF and the glideslope (to 3°) the distance from the FAF to begin descent from 2500 should be amended to 2.6nm.

**Recommendation:** The following changes should be made on the profile section of the chart:

- Glideslope angle amended to 3°.
- Procedure altitude at the FAF amended to 1660.
- Start of descent from 2500 amended to D2.6 from FAF.
4.16 Summary of Amendments or Further Actions Recommended

- Threshold elevation should be amended to **13 feet**. Airport elevation should be amended to read **11 feet**.
- LNAV OCA/H should be amended to read **420 (407)** for all categories
- Changes to profile view to include:
  - Glideslope angle amended to **3°**.
  - Procedure altitude at the FAF amended to 1660.
  - Start of descent from 2500 amended to D2.6 from FAF.
- Notation regarding obstacles in the VSS can be removed on republication of the AIP supplement.
5.0 Funafuti International RNAV (GNSS) RWY 21

5.1 Current Chart

<table>
<thead>
<tr>
<th>DISTANCE to VFR</th>
<th>KW21</th>
<th>12</th>
<th>23</th>
<th>34</th>
<th>45</th>
<th>123</th>
<th>215</th>
<th>345</th>
<th>456</th>
<th>567</th>
<th>678</th>
<th>789</th>
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<tr>
<td>Advisory Altitude</td>
<td>450</td>
<td>950</td>
<td>1250</td>
<td>1550</td>
<td>1850</td>
<td>2150</td>
<td>2450</td>
<td>2750</td>
<td>3050</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INAV</td>
<td>420(441) - 1600</td>
<td>420(441) - 2400</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clarity</td>
<td>470(451) - 1900</td>
<td>510(501) - 2800</td>
<td>600(591) - 3700</td>
<td>700(691) - 4600</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.2 Criteria

The current procedure is reviewed in accordance with ICAO PANS-OPS Doc 8168, Volume II, Fifth Edition, Amendment 4, which is current at the time of review.

5.3 Terrain and Obstacle Data

Terrain data is derived from the US National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM). This project provides digital terrain models of almost the entire earth surface. The 90% relative height error for the Pacific Islands region is 6.2m (with a tendency to overstate height). An allowance of 7m is provided to account for this error when terrain data is used.

Obstacle data was provided for the Annex 14 OLS area as part of the obstacle survey conducted. The location of these obstacles is shown below, plotted onto the terrain data previously described. For clarity, obstacles less than 15m above threshold elevation were removed from plotting as they will not be controlling obstacles nor factor in assessment of the Visual Segment Surface.

Figure 5-1: Surveyed obstacles over 15m

Obstacle data further from the runway was not available as part of this review. An allowance of 20m has been assumed for all areas for vegetation and most man-made structures. The existing charts do not indicate any additional obstacles to be considered. Without access to full obstacle data or the original design file, reductions in segment altitudes cannot be recommended.

5.4 Aerodrome Data

Basic aerodrome data was provided as part of the OLS survey:

<table>
<thead>
<tr>
<th>Location</th>
<th>Coordinates</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>THR03</td>
<td>8° 31’ 44.637” S 179° 11’ 31.240” E</td>
<td>13 ft</td>
</tr>
<tr>
<td>THR21</td>
<td>8° 31’ 08.102” S 179° 12’ 05.548” E</td>
<td>12 ft</td>
</tr>
<tr>
<td>ARP</td>
<td>8° 31’ 28.824” S 179° 11’ 43.900” E</td>
<td>10.6 ft</td>
</tr>
</tbody>
</table>

Recommendation: The approach chart must be amended to reflect the higher elevation of 11ft for ARP elevation and 12 feet for THR elevation (current chart reads 9 feet for both).
5.5 Waypoint Data

Existing waypoint coordinates were not provided. It is not the intent of this review to amend waypoint locations, and previous flight checks provide sufficient comfort that the waypoints are located in accordance with the charted information. For construction purposes, each segment (except the missed approach segment) is assumed to be exactly 5.00 nautical miles, with the right and left initial segments at exactly 90° offset from the final approach course. The missed approach point is co-located with the IF of the approach in the other direction.

5.6 Hold at the IAF/IF

The minimum holding altitude is indicated at 2500 feet. This is equivalent the procedure altitudes at the initial segments, and provides for obstacles up to 1500 feet. The missed approach hold primary area and first buffer area are located entirely over water. The obstacle allowance is more than sufficient for any transient obstacles that may be present in these areas.

5.7 Initial Segments

Both initial segments are indicated with an altitude of 2500 feet. This altitude is a procedure altitude to provide a longer stabilized descent; the obstacle clearance altitude is 1200 feet as indicated in the MSA section on the chart. PANS-OPS requires only a procedure altitude indicated at the FAF, so the higher procedure altitude is not required under PANS-OPS criteria. While not a PANS-OPS requirement, the chart is not in contravention to any criteria and does not need to be modified.

Both initial segments are entirely over water with no known obstacles. The 200 foot allowance that the MSA provides is more than sufficient for any transient obstacles in the area.

5.8 Intermediate Segment

The intermediate segment is indicated with an obstacle clearance altitude of 700 feet. The intermediate segment is located entirely over water with no known obstacles. The 200 foot allowance is sufficient for any transient obstacles in the area.

5.9 Final Segment (LNAV)

The controlling (known) obstacle is Tower T293, located in the missed approach area before the Start of Climb, with a height of 48.35m or 159 feet. An MOC of 75m (246 feet) is provided over the obstacle, providing a final segment OCA of 405 feet (rounded up to 420 feet). This is equal to the current published minimum. The height above threshold must be amended to reflect the revised THR elevation.
5.10 Visual Segment Surface (VSS)

The VSS is a surface which begins at the end of the runway strip, extending laterally at a splay of 15°, and rising at a slope of 1.12° less than the published nominal glidepath procedure. It extends up to the point at which it reaches the published OCA. Obstacles less than 15m above the threshold elevation can be ignored; however any penetration of the VSS means that procedures cannot be published without aeronautical study.

The VSS is located almost entirely over water with no obstacles greater than 15m present. No penetration of the VSS exists.

**Recommendation:** The AIP amendment that the chart is published with has the notation "Obstacle data in the VSS areas for Funafuti International is not available thus obstacle protection in the visual segments cannot be guaranteed." Obstacle data has been compiled and reviewed and no penetrations exist on either end (see report for Runway 21). This notation can be removed on the subsequent amendment.

5.11 Missed Approach

The controlling obstacle in the missed approach is the same obstacle as for the final segment, as it is located before the start of climb.

5.12 Missed Approach Hold

The minimum indicated hold altitude is 2500 feet. This is equivalent to the procedure height of the initial segments and is 1300 feet above the MSA for the region. It provides for obstacles up to 1500 feet, none of which could reasonably be expected to exist in the area.
5.13  Circling

Assessment of circling areas is made challenging by lack of detailed obstacle data in these areas; known obstacles and their approximate locations are used to develop minimum clearance altitudes. These are compared against current published altitudes to determine if an increase is necessary. However where a decrease is shown as possible, it cannot be recommended as insufficient data is provided.

<table>
<thead>
<tr>
<th>Category</th>
<th>Obstacle</th>
<th>Height</th>
<th>MOC</th>
<th>Required OCA</th>
<th>Published OCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Tower T293</td>
<td>48.35m / 159 ft</td>
<td>90m / 295ft</td>
<td>454 ft</td>
<td>470 ft</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td>500 ft*</td>
<td>510 ft</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td>600 ft*</td>
<td>600 ft</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td>700 ft*</td>
<td>700 ft</td>
</tr>
</tbody>
</table>

*Minimum OCA for aircraft category

All published circling altitudes meet or exceed minimum requirements. No reduction in altitudes is recommended as insufficient obstacle data is available and the original design file was not provided.

5.14  Segment Headings

Magnetic Declination as of April 2013 is 10.38°E (changing by 0.02°W per year) as calculated by the US National Oceanographic and Atmospheric Administration. This equals the value indicated on the chart (when rounded). The table below summarizes the True and Magnetic headings of the segments.

<table>
<thead>
<tr>
<th>Segment(s)</th>
<th>HDG (True)</th>
<th>HDG (Magnetic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate, Final, Missed Approach</td>
<td>223°</td>
<td>213°</td>
</tr>
<tr>
<td>Initial (via VASAF)</td>
<td>133°</td>
<td>123°</td>
</tr>
<tr>
<td>Initial (via BIKEN)</td>
<td>313°</td>
<td>303°</td>
</tr>
<tr>
<td>Missed Approach Hold Inbound Track</td>
<td>043°</td>
<td>033°</td>
</tr>
</tbody>
</table>

All segment headings as published are correct.

5.15  Procedure Altitudes

The procedure altitude provided at the FAF is 1550 ft. With a threshold crossing height of 50 feet, the altitude at the threshold is 62 feet. At a nominal descent angle of 2.9°, the amount of descent in 5.00 nm is 1540 feet, providing an altitude of 1600 feet at the FAF. The existing procedure altitude is too low. However, the optimum descent angle is 3° and there is no obvious reason why a lower angle should be provided. At 3°, the procedure altitude at the FAF would be 1660 feet.

From the procedure altitude at the FAF to the initial procedure altitude (2500 feet) the distance at a slope of 2.9° is 2.92 nautical miles. The distance shown on the chart (3.2) is too high. In conjunction with changes to the procedure altitude at the FAF and the glideslope (to 3°) the distance from the FAF to begin descent from 2500 should be amended to 2.6nm.

Recommendation: The following changes should be made on the profile section of the chart:
- Glideslope angle amended to 3°.
- Procedure altitude at the FAF amended to 1660.
- Start of descent from 2500 amended to D2.6 from FAF.
5.16 Summary of Amendments or Further Actions Recommended

- Threshold elevation should be amended to **12 feet**. Airport elevation should be amended to read **11 feet**.
- LNAV OCA/H should be amended to read **420 (408)** for all categories.
- Changes to profile view to include:
  - Glideslope angle amended to 3\(^\circ\).
  - Procedure altitude at the FAF amended to 1660.
  - Start of descent from 2500 amended to D2.6 from FAF.
- Notation regarding obstacles in the VSS can be removed on republication of the AIP supplement.
6.0  Christmas Island (Cassidy International) GPS RWY 08

6.1  Current Chart

CHRISTMAS ISLAND (CASSIDY INTL)
CAT A,B,C,D
GPS RWY 08

MISSING APCH: Climb direct to F26 1500

<table>
<thead>
<tr>
<th>TRACK MILES</th>
<th>F00</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>FF08</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>RW08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisory Altitude 5%</td>
<td>3050</td>
<td>2750</td>
<td>2450</td>
<td>2150</td>
<td>1850</td>
<td>1550</td>
<td>1250</td>
<td>950</td>
<td>650</td>
<td>MDA</td>
<td>MDA</td>
</tr>
<tr>
<td>Category</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>GPS</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>400 (395) - 2400</td>
</tr>
<tr>
<td>Circling</td>
<td>450 (445)</td>
<td>1900</td>
<td>500 (495)</td>
<td>2800</td>
<td>600 (595)</td>
<td>3700</td>
<td>700 (695)</td>
<td>4600</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Alternate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>800 - 5</td>
<td></td>
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</tr>
</tbody>
</table>

Published 15/12/99
Effective 25 MAR 99

WGS 84 coordinates

KIRIBATI
6.2 Current Minima Amendment

The following amendment is published as an AIP Supplement effective 15 FEB 2007:

<table>
<thead>
<tr>
<th>Category</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>420 (415)</td>
<td>1600</td>
<td>420 (415)</td>
<td>2400</td>
</tr>
<tr>
<td>Circling</td>
<td>470 (465)</td>
<td>1900</td>
<td>500 (495)</td>
<td>2800</td>
</tr>
<tr>
<td>Alternate</td>
<td></td>
<td></td>
<td>600 (595)</td>
<td>3700</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>700 (695)</td>
<td>4600</td>
</tr>
</tbody>
</table>

6.3 Criteria

The current procedure is reviewed in accordance with ICAO PANS-OPS Doc 8168, Volume II, Fifth Edition, Amendment 4, which is current at the time of review.

6.4 Terrain and Obstacle Data

Terrain data is derived from the US National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM). This project provides digital terrain models of almost the entire earth surface. The 90% relative height error for the Pacific Islands region is 6.2m (with a tendency to overstate height). An allowance of 7m is provided to account for this error when terrain data is used.

Obstacle data was provided for the Annex 14 OLS area as part of the obstacle survey conducted. The location of these obstacles is shown below, plotted onto the terrain data previously described. For clarity, obstacles less than 15m above threshold elevation were removed from plotting as they will not be controlling obstacles nor factor in assessment of the Visual Segment Surface.

Figure 6-1: Surveyed obstacles over 15m and estimated position of mast

Obstacle data further from the runway was not available as part of this review. An allowance of 20m has been assumed for all areas for vegetation and most man-made structures. The existing charts do not indicate any additional obstacles to be considered. Without access to full obstacle data or the original design file, reductions in segment altitudes cannot be recommended.
The AIP supplement indicates a mast located 650m northwest of the threshold to RWY08. The exact location is uncertain. With an elevation of 51.45m (169 feet) it is taller than any of the other charted obstacles. An additional obstacle, with a height of 150 feet, is shown on the chart approximately halfway between the FAF and the runway. Its location is approximated and assumed to lie in the primary area.

6.5 Aerodrome Data

Basic aerodrome data was provided as part of the OLS survey:

<table>
<thead>
<tr>
<th>Location</th>
<th>Coordinates</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>THR26</td>
<td>1° 59' 10.566&quot; N 157° 20' 25.662&quot; W</td>
<td>8.4ft</td>
</tr>
<tr>
<td>THR08</td>
<td>1° 59' 10.580&quot; N 157° 21' 33.712&quot; W</td>
<td>7.6ft</td>
</tr>
<tr>
<td>ARP</td>
<td>1° 59' 11.661&quot; N 157° 21'06.890&quot; W</td>
<td>9.4ft</td>
</tr>
</tbody>
</table>

Recommendation: Threshold elevation should be amended to 8 feet. Airport elevation should be amended to read 9 feet.

6.6 Waypoint Data

Existing waypoint coordinates were not provided. It is not the intent of this review to amend waypoint locations, and previous flight checks provide sufficient comfort that the waypoints are located in accordance with the charted information. For construction purposes, each segment (except the missed approach segment) is assumed to be exactly 5.00 nautical miles, with the right and left initial segments at exactly 90° offset from the final approach course. The missed approach point is co-located with the IF of the approach in the other direction.

6.7 Hold at the IAF/IF

The minimum holding altitude is indicated at 1500 feet. This is equivalent to the MSA and provides for obstacles up to 500 feet. This height provides for obstacles up to 500 feet in height. No obstacles are known to exist up to this level and terrain throughout the area does not exceed 20m (66ft); however in the absence of additional obstacle data a reduction in altitude cannot be recommended.

6.8 Initial Segments

Both initial segments are indicated with an altitude of 1500 feet. Each initial segment covers a small area of terrain, and provides an allowance of up to 500 feet for obstacles. It is unlikely that obstacles exist to this height, but in the absence of additional obstacle data a reduction in altitude cannot be recommended.

6.9 Intermediate Segment

The intermediate segment is indicated with an obstacle clearance altitude of 700 feet. This provides an allowance for obstacles of up to 200 feet. No obstacles are noted to that height, but in the absence of additional obstacle data a reduction in altitude cannot be recommended (nor would it be required).

6.10 Final Segment (LNAV)

The controlling (known) obstacle is the mast noted in the AIP supplement. Its exact location is unknown but assumed to rest within the primary area. With a height of 51.45m, plus MOC of 75m, the final OCA/H is 127m (415 feet) - rounded to 420 feet. This matches the revised minima published in the AIP supplement.

6.11 Visual Segment Surface (VSS)

The VSS is a surface which begins at the end of the runway strip, extending laterally at a splay of 15°, and rising at a slope of 1.12° less than the published nominal glidepath procedure. It extends up to the point at which it reaches the published OCA. Obstacles less than 15m above the threshold elevation can be ignored; however any penetration of the VSS means that procedures cannot be published without aeronautical study.
The most significant obstacle in the VSS is Mast 001, with a height of 37.63m, at a distance of 658m from the start of the VSS. The height of this obstacle is uncertain; it is listed alternatively as 37.63m in data tables but as 7.35m in the Type A chart. If it is the former, it penetrates significantly into the VSS, to a degree that cannot be overcome by raising the promulgated descent slope.

The other obstacle that penetrates the VSS is Tree T506. It has a height of 30.61m and is located 843m from the start of the VSS. The surface height at this point is 29.99m. The penetration is minor, however the tree should be removed.

**Recommendation:** Tree 506 should be removed. The height of Mast 001 must be confirmed; if it penetrates the VSS and is greater than 17m, a special note should be provided on the approach chart and serious consideration should be given to its removal.

### 6.12 Missed Approach

There are no obstacles in the missed approach that require a higher OCA or a higher than standard climb gradient.

### 6.13 Missed Approach Hold

The minimum indicated hold altitude is 1500 feet. This is equivalent to the Minimum Sector Altitude (MSA) and provides for obstacle heights up to 500 feet. The primary area is fully over water and the first buffer area covers a small area of low terrain. The obstacle allowance is sufficient for any transient obstacles that may be present.

### 6.14 Circling

Assessment of circling areas is made challenging by lack of detailed obstacle data in these areas; known obstacles and their approximate locations are used to develop minimum clearance altitudes. These are compared against current published altitudes to determine if an increase is necessary. However where a decrease is shown as possible, it cannot be recommended as insufficient data is provided.

<table>
<thead>
<tr>
<th>Category</th>
<th>Obstacle</th>
<th>Height</th>
<th>MOC</th>
<th>Required OCA</th>
<th>Published OCA</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mast**</td>
<td>51.45m / 169 ft</td>
<td>90m / 295ft</td>
<td>464 ft</td>
<td>470 ft</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td>500 ft*</td>
<td></td>
<td>500 ft</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td>600 ft*</td>
<td></td>
<td>600 ft</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td>700 ft*</td>
<td></td>
<td>700 ft</td>
</tr>
</tbody>
</table>

*Minimum OCA for aircraft category
**Exact location unknown

All published circling altitudes are correct based on known obstacles.

### 6.15 Segment Headings

Magnetic Declination as of April 2013 is 9.02°E (changing by 0.01°E per year) as calculated by the US National Oceanographic and Atmospheric Administration. This equals the value indicated on the chart (when rounded).

The table below summarizes the True and Magnetic headings of the segments.

<table>
<thead>
<tr>
<th>Segment(s)</th>
<th>HDG (True)</th>
<th>HDG (Magnetic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate, Final, Missed Approach</td>
<td>090°</td>
<td>081°</td>
</tr>
<tr>
<td>Initial (via AF08N)</td>
<td>180°</td>
<td>171°</td>
</tr>
<tr>
<td>Initial (via AF08S)</td>
<td>000°</td>
<td>351°</td>
</tr>
<tr>
<td>Missed Approach Hold Inbound Track</td>
<td>270°</td>
<td>261°</td>
</tr>
</tbody>
</table>

All segment headings as published are correct.
6.16 Procedure Altitudes

Likely due to the age of the chart, procedure altitudes are not provided. A procedure altitude should be provided at the FAF to assist with stabilized descent. The optimum descent angle is 3°. At 3°, the procedure altitude at the FAF would be 1660 feet, given a threshold crossing height of 50 feet.

Recommendation: A procedure altitude of 1660 feet should be indicated at the FAF with a descent angle of 3° shown.

6.17 Summary of Amendments or Further Actions Recommended

- Threshold elevation should be amended to **8 feet**. Airport elevation should be amended to read **9 feet**.
- Tree 506 should be removed. The height of Mast 001 must be confirmed; if it penetrates the VSS and is greater than 17m, a special note should be provided on the approach chart and serious consideration should be given to its removal.
- A procedure altitude of 1660 feet should be indicated at the FAF with a descent angle of 3° shown.
- The chart should be republished in its entirety incorporating the correct minima values. Differing values can lead to pilot error. In addition, with republication the title should be changed to **RNAV (GNSS) RWY 08** in accordance with current procedure naming conventions.
7.0 Christmas Island (Cassidy International) GPS RWY 26

7.1 Current Chart

Christmas Island (Cassidy Intl) GPS RWY 26

ELEV 5
RWY 26 THRU ELEV 5

Current Chart

CHRISTMAS ISLAND (CASSIDY INTL)
CAT A, B, C, D
GPS RWY 26

HOLDING IF26
HOLDING IF08

Use Christmas G.N.H.

Minimum Sector Altitude 25NM A.R.P.

Missed Apch: Climb direct to IF08 1500

Track Miles

<table>
<thead>
<tr>
<th>Category</th>
<th>GPS</th>
<th>CIRCLING</th>
<th>ALTERNATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A MDA</td>
<td>400</td>
<td>(395) - 1900</td>
<td>800 - 5</td>
</tr>
<tr>
<td>B NDA</td>
<td>650</td>
<td>(495) - 2300</td>
<td></td>
</tr>
<tr>
<td>C 650</td>
<td>1250</td>
<td>3000</td>
<td></td>
</tr>
<tr>
<td>D 1550</td>
<td>1850</td>
<td>3700</td>
<td></td>
</tr>
<tr>
<td>2150</td>
<td>2750</td>
<td>4600</td>
<td></td>
</tr>
</tbody>
</table>

Published 23 DEC 99
Effective 25 MAR 99
7.2 Current Minima Amendment

The following amendment is published as an AIP Supplement effective 15 FEB 2007:

<table>
<thead>
<tr>
<th>Category</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>400 (395) – 1600</td>
<td>400 (395) – 2400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circling</td>
<td>470 (465) – 1900</td>
<td>500 (495) – 2800</td>
<td>600 (595) – 3700</td>
<td>700 (695) – 4600</td>
</tr>
<tr>
<td>Alternate</td>
<td>800 – 5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.3 Criteria

The current procedure is reviewed in accordance with ICAO PANS-OPS Doc 8168, Volume II, Fifth Edition, Amendment 4, which is current at the time of review.

7.4 Terrain and Obstacle Data

Terrain data is derived from the US National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission (SRTM). This project provides digital terrain models of almost the entire earth surface. The 90% relative height error for the Pacific Islands region is 6.2m (with a tendency to overstate height). An allowance of 7m is provided to account for this error when terrain data is used.

Obstacle data was provided for the Annex 14 OLS area as part of the obstacle survey conducted. The location of these obstacles is shown below, plotted onto the terrain data previously described. For clarity, obstacles less than 15m above threshold elevation were removed from plotting as they will not be controlling obstacles nor factor in assessment of the Visual Segment Surface.

Figure 7-1: Surveyed obstacles over 15m and estimated position of mast

Obstacle data further from the runway was not available as part of this review. An allowance of 20m has been assumed for all areas for vegetation and most man-made structures. The existing charts do not indicate any additional obstacles to be considered. Without access to full obstacle data or the original design file, reductions in segment altitudes cannot be recommended.

The AIP supplement indicates a mast located 650m northwest of the threshold to RWY08. The exact location is uncertain. With an elevation of 51.45m (169 feet) it is taller than any of the other charted obstacles. An additional obstacle, with a height of 150 feet, is shown on the chart approximately halfway between the FAF and the runway. Its location is approximated and assumed to lie in the primary area.
7.5 Aerodrome Data

Basic aerodrome data was provided as part of the OLS survey:

<table>
<thead>
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<th>Location</th>
<th>Coordinates</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>THR26</td>
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<tr>
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<td>1° 59’ 10.580” N 157° 21’ 33.712” W</td>
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<td>1° 59’ 11.661” N 157° 21’06.890” W</td>
<td>9.4ft</td>
</tr>
</tbody>
</table>

**Recommendation**: Threshold elevation should be amended to 8 feet. Airport elevation should be amended to read 9 feet.

7.6 Waypoint Data

Existing waypoint coordinates were not provided. It is not the intent of this review to amend waypoint locations, and previous flight checks provide sufficient comfort that the waypoints are located in accordance with the charted information. For construction purposes, each segment (except the missed approach segment) is assumed to be exactly 5.00 nautical miles, with the right and left initial segments at exactly 90° offset from the final approach course. The missed approach point is co-located with the IF of the approach in the other direction.

7.7 Hold at the IAF/IF

The minimum indicated hold altitude is 1500 feet. This is equivalent to the Minimum Sector Altitude (MSA) and provides for obstacle heights up to 500 feet. The primary area is fully over water and the first buffer area covers a small area of low terrain. The obstacle allowance is sufficient for any transient obstacles that may be present.

7.8 Initial Segments

Both initial segments are indicated with an altitude of 1500 feet. Each initial segment is completely over water and no obstacles are known to exist in these areas. With MOC of 1000 feet, this altitude provides an allowance of up to 500 feet for obstacles. This is more than sufficient to account for any transient obstacles in the area.

7.9 Intermediate Segment

The intermediate segment is indicated with an obstacle clearance altitude of 700 feet. This provides an allowance for obstacles of up to 200 feet. The intermediate segment is located entirely over water and no obstacles are known to exist in this area. The obstacle allowance is sufficient for any transient obstacles in the area.

7.10 Final Segment (LNAV)

The controlling obstacle is the mast noted in the AIP supplement. While it is located in the missed approach segment, it is conservatively assumed to be located before the start of climb. The mast has a height of 48.35m or 159 feet. An MOC of 75m (246 feet) is provided over the obstacle, providing a final segment OCA of 405 feet (rounded up to 420 feet). This is equal to the current published minimum. The height above threshold must be amended to reflect the revised THR elevation.

7.11 Visual Segment Surface (VSS)

The VSS is a surface which begins at the end of the runway strip, extending laterally at a splay of 15°, and rising at a slope of 1.12° less than the published nominal glidepath procedure. It extends up to the point at which it reaches the published OCA. Obstacles less than 15m above the threshold elevation can be ignored; however any penetration of the VSS means that procedures cannot be published without aeronautical study.

There are no obstacles penetrating the VSS who have a height greater than 15m.
7.12 Missed Approach

The controlling obstacle is the mast noted in the AIP. As it is located before the start of climb, it is also the controlling obstacle for the final segment as noted. There are no other obstacles that require a higher OCA or missed approach climb gradient.

7.13 Missed Approach Hold

The minimum holding altitude is indicated at 1500 feet. This is equivalent to the MSA and provides for obstacles up to 500 feet. This height provides for obstacles up to 500 feet in height. No obstacles are known to exist up to this level and terrain throughout the area does not exceed 20m (66 ft); however in the absence of additional obstacle data a reduction in altitude cannot be recommended.

7.14 Circling

Assessment of circling areas is made challenging by lack of detailed obstacle data in these areas; known obstacles and their approximate locations are used to develop minimum clearance altitudes. These are compared against current published altitudes to determine if an increase is necessary. However where a decrease is shown as possible, it cannot be recommended as insufficient data is provided.

<table>
<thead>
<tr>
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<th>Obstacle</th>
<th>Height</th>
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<th>Required OCA</th>
<th>Published OCA</th>
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</thead>
<tbody>
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<td>A</td>
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<td>51.45m / 169 ft</td>
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<td>464 ft</td>
<td>470 ft</td>
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<td></td>
<td></td>
<td></td>
<td>500 ft*</td>
<td>500 ft</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td>600 ft*</td>
<td>600 ft</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td>700 ft*</td>
<td>700 ft</td>
</tr>
</tbody>
</table>

*Minimum OCA for aircraft category
**Exact location unknown

All published circling altitudes are correct based on known obstacles.

7.15 Segment Headings

Magnetic Declination as of April 2013 is 9.02°E (changing by 0.01°E per year) as calculated by the US National Oceanographic and Atmospheric Administration. This equals the value indicated on the chart (when rounded). The table below summarizes the True and Magnetic headings of the segments.

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<thead>
<tr>
<th>Segment(s)</th>
<th>HDG (True)</th>
<th>HDG (Magnetic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate, Final, Missed Approach</td>
<td>270°</td>
<td>261°</td>
</tr>
<tr>
<td>Initial (via AF26N)</td>
<td>180°</td>
<td>171°</td>
</tr>
<tr>
<td>Initial (via AF26S)</td>
<td>000°</td>
<td>351°</td>
</tr>
<tr>
<td>Missed Approach Hold Inbound Track</td>
<td>090°</td>
<td>081°</td>
</tr>
</tbody>
</table>

All segment headings as published are correct.

7.16 Procedure Altitudes

Likely due to the age of the chart, procedure altitudes are not provided. A procedure altitude should be provided at the FAF to assist with stabilized descent. The optimum descent angle is 3°. At 3°, the procedure altitude at the FAF would be 1660 feet, given a threshold crossing height of 50 feet.

**Recommendation:** A procedure altitude of 1660 feet should be indicated at the FAF with a descent angle of 3° shown.
7.17 Summary of Amendments or Further Actions Recommended

- Threshold elevation should be amended to 8 feet. Airport elevation should be amended to read 9 feet.
- A procedure altitude of 1660 feet should be indicated at the FAF with a descent angle of 3° shown.
- The chart should be republished in its entirety incorporating the correct minima values. Differing values can lead to pilot error. In addition, with republication the title should be changed to RNAV (GNSS) RWY 08 in accordance with current procedure naming conventions.
Appendix A

Calculations Common to all Procedures
Appendix A  Calculations Common to all Procedures

As all six procedures are designed based on the same altitudes and atmospheric conditions, construction of all procedures are identical. The following images are extracts of calculation sheets used to derive construction parameters for the turn at the IF, start of climb, and holding areas.

### PANS-OPS GNSS TURN CONSTRUCTION WORKSHEET

<table>
<thead>
<tr>
<th>Aircraft Category</th>
<th>Vat</th>
<th>Initial Apch. Range</th>
<th>Final Apch. Range</th>
<th>Max Speed for circling</th>
<th>Max Speed for Missed Apch.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&lt;169</td>
<td>165-280</td>
<td>130-185</td>
<td>185</td>
<td>185</td>
</tr>
<tr>
<td>B</td>
<td>169-223</td>
<td>220-335</td>
<td>155-240</td>
<td>250</td>
<td>240</td>
</tr>
<tr>
<td>D</td>
<td>261-306</td>
<td>345-465</td>
<td>240-345</td>
<td>380</td>
<td>345</td>
</tr>
<tr>
<td>H</td>
<td>N/A</td>
<td>130-220</td>
<td>110/165</td>
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<td>130 or 165</td>
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</tbody>
</table>

### Turn Construction Variables

<table>
<thead>
<tr>
<th>Fix Name</th>
<th>IF</th>
<th>Speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fix Type</td>
<td>IF</td>
<td>Altitude (m)</td>
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<tr>
<td>WP Type</td>
<td>IF</td>
<td>Turn Angle (°)</td>
</tr>
<tr>
<td>ATT (km)</td>
<td>1.48</td>
<td>390</td>
</tr>
<tr>
<td>XTT (km)</td>
<td>1.85</td>
<td>765</td>
</tr>
<tr>
<td>Bank Angle (°)</td>
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<td>90</td>
</tr>
<tr>
<td>Bank est. time</td>
<td>5</td>
<td>250</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>6</td>
<td>415.31</td>
</tr>
</tbody>
</table>

### Basic Turn Parameters

| Rate of turn (°/s - max 3) | 2.271 |
| Radius of Turn (km) | 2.910 |
| TAS in km/s | 0.115 |

### Inside Turn Expansion

| Turn Anticipation Distance (DTA) (km) | 2.910 |
| Turn Expansion Splay | 45 |
| Earliest Turn Point (nominal D from WP, km) | 4.390 |

### Outside Turn Expansion

| Latest Turn Point (nominal D from WP, km) | 0.645 |

### Simplified Bounding Circle Method

| Spiral Radius at C1 (km) | 2.975 |
| Spiral Radius at C2 (km) | 3.527 |
| Spiral Radius at C3 (km) | 4.143 |

### Full Wind Spiral Method

<table>
<thead>
<tr>
<th>Tangent Angle (y)</th>
<th>E45</th>
<th>E90</th>
<th>E135</th>
<th>E180</th>
<th>E225</th>
<th>E270</th>
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<tr>
<td></td>
<td>7.75</td>
<td>0.308</td>
<td>0.616</td>
<td>0.925</td>
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<td>1.541</td>
</tr>
</tbody>
</table>

### MISSED APPROACH CALCULATIONS (GNSS)

| Final OCA/H (ft) | 420 |
| Aircraft Category | D |
| Minimum Distance SOC to MAHWP (m) | 20372 |

### Start of Climb (SOC) Calculations

| SOC (m from MAPT) | 2431.40 |
| Fix Tolerance | 556 |
| Trans. Distance | 312.57 |
| Reaction Time | 1562.83 |
| Override IAS if speed is restricted | 375.08 |
| TAS with wind | 356.08 |
| TAS (m/s) | 104.19 |
# PANS-OPS RACETRACK/HOLDING WORKSHEET

**Aerodrome:** PAIP  
**Procedure:** Multiple  
**RNAV Criteria**

<table>
<thead>
<tr>
<th>Line</th>
<th>Description</th>
<th>Parameter</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conversion Factor for IAS to TAS</td>
<td>K</td>
<td>1.0441</td>
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</tr>
<tr>
<td>2</td>
<td>True Airspeed (TAS)</td>
<td>V</td>
<td>485.52</td>
<td>km/h</td>
</tr>
<tr>
<td>3</td>
<td>TAS per second</td>
<td>v</td>
<td>0.1349</td>
<td>km/s</td>
</tr>
<tr>
<td>4</td>
<td>Rate of Turn (max 3°/s)</td>
<td>R</td>
<td>1.94</td>
<td>°/s</td>
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<tr>
<td>5</td>
<td>Radius of Turn</td>
<td>r</td>
<td>3.98</td>
<td>km</td>
</tr>
<tr>
<td>6</td>
<td>Altitude in thousands of meters</td>
<td>h</td>
<td>0.37</td>
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</tr>
<tr>
<td>7</td>
<td>Wind Speed at procedure altitude</td>
<td>w</td>
<td>91.38</td>
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<tr>
<td>8</td>
<td>Wind Speed per second</td>
<td>w'</td>
<td>0.0254</td>
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<tr>
<td>9</td>
<td>Wind Effect per 45 degrees of turn</td>
<td>E45</td>
<td>0.5879</td>
<td>km/°</td>
</tr>
<tr>
<td>10</td>
<td>Outbound timing in seconds</td>
<td>t</td>
<td>300</td>
<td>s</td>
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<tr>
<td>11</td>
<td>Nominal length of outbound leg</td>
<td>D</td>
<td>9.26</td>
<td>km</td>
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<tr>
<td>12</td>
<td>Distance a to b (bank est. fast reaction)</td>
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<td>Distance a to c (bank est. late reaction)</td>
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<td>Distance g to i2 and i4</td>
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<td>16</td>
<td>Wind effect at point b</td>
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<tr>
<td>17</td>
<td>Wind effect at point c</td>
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<td>Wind effect at point h</td>
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<td>Wind effect at points i2 and i4</td>
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<td>Wind effect at point j</td>
<td>Wj</td>
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<td>km</td>
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<tr>
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<td>Wind effect at points k and l</td>
<td>Wk, Wl</td>
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<td>km</td>
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<td>29</td>
<td>Wind effect at point m</td>
<td>Wm</td>
<td>12.24</td>
<td>km</td>
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<td>30</td>
<td>Wind effect at point n3</td>
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<td>Wind effect at point n4</td>
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<td>Distance XE (RNAV Calculation)</td>
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<td>33</td>
<td>Distance YE (RNAV Calculation)</td>
<td>YE</td>
<td>8.92</td>
<td>km</td>
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</tbody>
</table>
Appendix B

Procedure Design
Mapping
Appendix B  Procedure Design Mapping

The following maps showing the instrument design protection areas are included separately:

1) Tarawa (Bonriki International) RWY 09 - 1:50 000
2) Tarawa (Bonriki International) RWY 09 - 1:100 000 (showing holding areas)
3) Tarawa (Bonriki International) RWY 27 - 1:50 000
4) Tarawa (Bonriki International) RWY 27 - 1:100 000 (showing holding areas)
5) Funafuti International RWY 03 - 1:50 000
6) Funafuti International RWY 03 - 1:100 000 (showing holding areas)
7) Funafuti International RWY 21 - 1:50 000
8) Funafuti International RWY 21 - 1:100 000 (showing holding areas)
9) Christmas Island (Cassidy International) RWY 08 - 1:50 000
10) Christmas Island (Cassidy International) RWY 08 - 1:100 000 (showing holding areas)
11) Christmas Island (Cassidy International) RWY 26 - 1:50 000
12) Christmas Island (Cassidy International) RWY 26 - 1:100 000 (showing holding areas)
Terrain depicted in North-West area of map is computer artifact. Disregard in assessment.
Terrain depicted in North-West area of map is computer artifact. Disregard in assessment.
Terrain depicted in North-West area of map is computer artifact. Disregard in assessment.