IMPROVEMENT OF INSTRUMENT APPROACH PROCEDURES

Friedman Memorial Airport
Hailey, Idaho

April 2013

Spohnheimer Consulting

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Issue

How can instrument approach procedures to Friedman Memorial Airport (identifier SUN, for Sun Valley) be improved for better arrival reliability?

Background

The SUN airport is located in a deep valley with numerous close-in mountains. As a result, instrument flight procedures used by pilots to transition from enroute altitudes to a point near the runway typically have high weather ceiling and large visibility requirements (known as minima), resulting in a high percentage of flight cancellations or diversions during inclement weather.

Until recently, it was thought the airport might be relocated into a more flat area to the south with better instrument procedures, but the Federal Aviation Administration (FAA) suspended its work on an Environmental Impact Statement. It is now known that the airport must remain in its present location for the short- to mid-term.

This brief feasibility study was chartered to examine the existing procedures and consider others that might improve airport arrival reliability. It implements the next step following the *SUN Reliability Analysis Summary* by T-O Engineers and Mead & Hunt in early 2012. The study considers modifications to existing procedures, creative application of ground facilities, and the use of navigational aids which the FAA may have deemed inappropriate for federal investment. The study is neither a Terminal Instrument Procedures design study nor a ground facility siting study, but recommends those activities be pursued where appropriate.

Facts Bearing on the Issue

Airport Location. The SUN airport is located in the Wood River Valley approximately one mile southeast of Hailey, ID. Its elevation is 5320' above mean sea level (MSL), and it is surrounded by mountain peaks on three sides with terrain elevations immediately adjacent the airport in the 6000-7000' range. Terrain at intermediate distances reaches 8000-9000'. Figure 1 shows Runway 13/31, which is 7550' long and 100' wide, and its immediately surrounding terrain.

Figure 1. SUN Runway 13/31 and Immediately Surrounding Terrain

Typical Operators. The SUN airport has several commercial scheduled air carriers (Horizon and Sky West), operating Bombardier Q400 and Embraer EMB120 aircraft, with the addition of CRJ-700 aircraft expected soon. Numerous high-end business jets and other private aircraft are based or operate at this airport.

Existing Intrument Procedures. The SUN airport is presently supported by five Instrument Approach Procedures (IAPs), all providing landing guidance from the south. Two are public procedures and can be flown by aircraft with standard climb capabilities; three are special procedures that require authorization and higher climb capabilities. One is also "private" in the sense that it was developed for specific aircraft or airlines. The procedures are included in Attachment 1 and summarized in Table 1. (For simplification, circling minima, if listed separately from other minima in the procedure, are not shown in the table.) Aircraft are categorized by weight and speed, with Category A typically being light, general aviation propeller-driven types, while Category C aircraft are typically used by air carriers at SUN, and by operators of business jets. For many years, public IAPs required no unique authorization, and assumed a standard climb rate (one-engine out for multi-engine commercial aircraft) for missed approaches of 200 feet per nautical mile (ft/NM). Special IAPs required authorization and crew training, and usually required aircraft with substantially better climb rates. In recent years, however, the FAA has allowed procedures requiring higher climb rates (e.g., up to 350 ft/NM) to be considered standard procedures.

The decision height/altitude and Visibility columns in Table 1 comprise the "minima", and are typically spoken (e.g., for the NDB IAP) as "2700 and five," where 2700 is a rounded value for the actual value of 2687'. This phrasing means that the base of the clouds must be at least 2700' above the field elevation (i.e., 8000' MSL) and the forward visibility must be at least 5 statute miles. Simply stated, if a pilot upon reaching this altitude while descending cannot see the airfield, a missed approach or "go-around" must be executed. (An exception to this general statement is the NDB/DME or GPS-A approach, which has a fly-visual segment.) A missed approach usually results in a diversion to another airport, unless the pilot elects to try again.

Table 1. Existing IAPs

IAP Name	Decision Altitude/Height (DA/H) feet	Visibility, NM	Type	Climb Gradient Required, ft/NM
RNAV (RNP) Y RWY 31 RNP 0.3	974 (1000) (Straight-in 31)	Cat A-C: 3	Special	330 to 14,000' MSL
RNAV (GPS) W RWY 31 LNAV MDA	1790 (1800) (Straight-in 31)	Cat A: 1 ¼ Cat B: 1 ½ Cat C: 3	Public	200
RNAV (GPS) X RWY 31	1610 (1700) (Straight-in 31)	Cat A: 1 ¼ Cat B: 1 ½ Cat C: 3	Special	414 to 7500' MSL
RNAV Z RWY 31 (GPS) (G4 and G5 only)	910 (1000) (Straight-in 31)	Cat C: 2	Special	385 to 10,000' MSL
NDB/DME OR GPS-A	2687 (2700) (Circling only)	Cat A-C: 5	Public	200

Previous Instrument Procedures. Since the 1980s, several technologies to provide landing guidance, in addition to the standard Instrument Landing System (ILS), have been tried by the US and international aviation communities. The general motivations have been increased flexibility from curved approaches, variable descent angles, and smaller protective areas required around the ground-based antenna systems.

One technology was the Microwave Landing System (MLS), which was installed for a few years at SUN to support landings from the north. This was a non-federal installation for Horizon, and its descent angle was very high at 6.00 degrees, but could be flown by aircraft types in use at the time. Its use was discontinued, and it will not be discussed further here.

A second newer technology is the Transponder Landing System (TLS), also a non-federal installation with Horizon as the intended operator. It existed for a few years at SUN to support landings from the south. Two special IAPs were developed for it, one by the FAA and the other by a private third party, and these are included in Attachment 2. The TLS was discontinued before it could be commissioned.

Procedure Design. Instrument flight procedures are designed using detailed criteria found in FAA Order 8260.3B, *United States Standard for Terminal Instrument Procedures (TERPS)*, and related smaller orders. Embedded in all procedures is the concept of Required Obstacle Clearance, which is established by defining various shaped and sized imaginary surfaces which cannot be penetrated by terrain or objects. The size and nature of the surfaces vary according to the accuracy of the underlying navigation method, as well as other parameters. An example of such a surface in both top and "end-on" views is shown in Figure 2.

For mountainous terrain airports, the general challenge is to locate approach and missed-approach paths to the airport for which a given surface (e.g., for an ILS Localizer or a GPS approach) is not penetrated by terrain or other objects, and can take the aircraft to the lowest descent point from which a missed approach climbout can be conducted with a specified climb capability. For procedures based on traditional ground-based navigational aids, the (usually) straight paths for approach and missed approach must be supported by the radiated signals. This in turn requires that a navaid must be capable of being installed to support the desired ground track(s). For satellite-based procedures, there is more flexibility in that essentially all 360 straight ground tracks can be supported, as well as some segmented tracks that approach curves.

Detailed efforts to locate best minima are beyond the scope of this report, but a feasibility approach has been taken to assess potential options as well as possible locations for any required ground-based navaids.

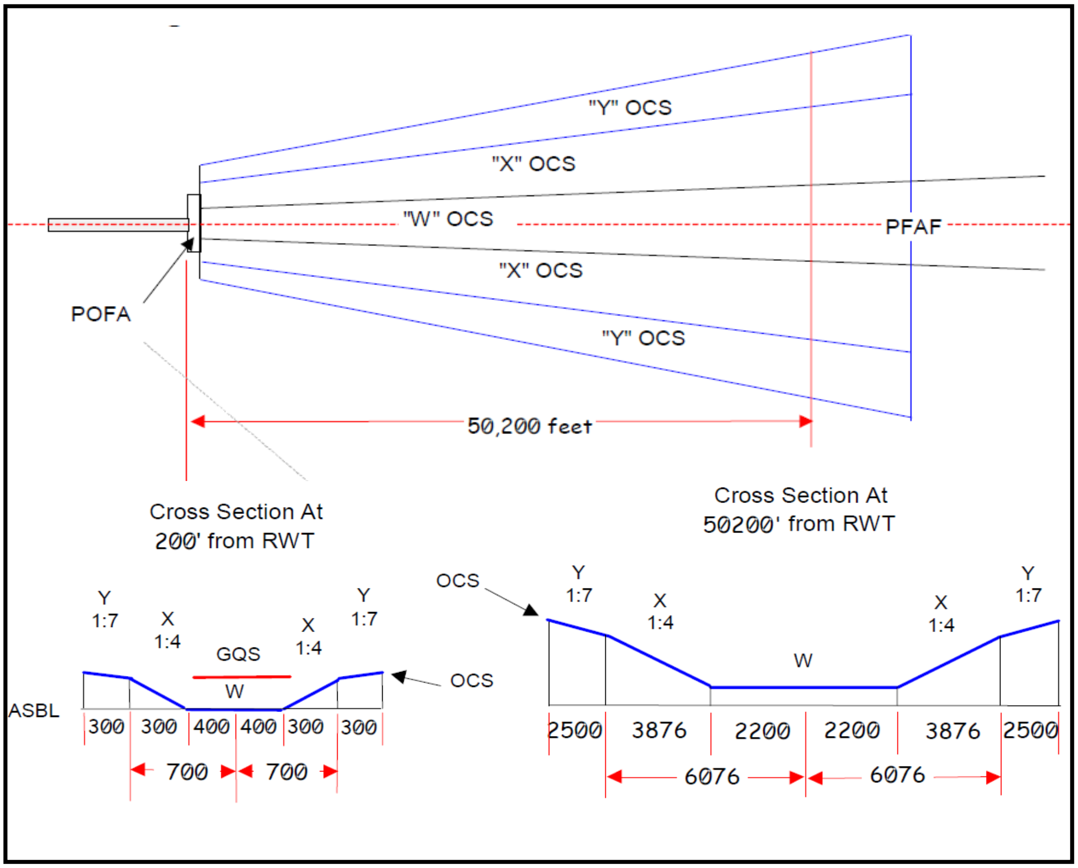

Figure 2. Example of a TERPS Obstacle Clearance Surface (ILS)

Analysis

Approaches from the North. None of the existing approach procedures provides an approach from the north, although the now-discontinued MLS approach did with a steep descent angle of 6.00 degrees. Given today's mix of scheduled carriers and other aircraft and current approvals for advanced navigation methods, a maximum descent angle of approximately 3.60 degrees, especially for public approaches, is appropriate. To begin such an approach, an aircraft must navigate to the starting point from the en route environment. For SUN, the high terrain north of the airport combined with the intervening topography and airport elevation result in a descent angle well above the desired maximum 3.60 degree value. Further advances in technology will be required to make less steep approaches from the north more viable. Until that time, they can be dismissed here without further analysis. (At least one of the SUN scheduled carriers may obtain approval for advanced navigation methods, which in turn may enable a more shallow descent angle (i.e., below 3.6 degrees) using navigation guidance through valleys.)

Approaches from the South. The remainder of this analysis will deal with approaches from the south. Figure 3 shows the mountainous terrain east, west, and south of the SUN airport (which is highlighted at the extreme upper part of the Figure). The lower terrain of the open valley well south of the airport is seen with irrigation circles. The relevant obstacle clearance surface for any proposed instrument procedure and its missed approach, whether relying on ground-based signals or satellite signals, must be overlaid on this terrain to determine if a fight path is feasible to reasonable minima (i.e., substantially better minima than the existing public NDB procedure's 2700 - 5).

Figure 3. SUN Airport (Highlighted) and Terrain to East, West, and South

Recalling that terrain north of the airport is generally higher than that shown in Figure 3, instrument approach procedure minima for approaches from the south at this airport are primarily controlled by the missed approach segment, rather than terrain underlying the approach segment. This in turn means that the climb gradient (or, simply, steepness) and flight path of the missed approach are critical components of obtaining the resulting minima. The standard climb gradient for missed approaches is between 200 and 350 feet per nautical mile (ft/NM). This standard climb rate is achievable by common light aircraft and determines the minima for a public approach suitable for a wide variety of aircraft. For operators with aircraft capable of substantially higher climb rates, lower minima can be authorized via a "special" instrument approach procedure, also known as an "AR" (for Authorization Required) procedure.

The best general solution for this issue is to define a public approach procedure meeting obstacle clearance criteria with better-than-NDB minima, and for which most operators are already equipped.

The existing (Attachment 1) and developmental TLS (Attachment 2, never commissioned) procedures are again tabulated in Table 2, characterized by some of their technical details, such as the Final Approach Course (FAC) descent angle, climb gradient, and missed approach point location. It is immediately evident that the better minima are achieved for climb gradients required in the missed approach segment which are substantially higher than the long-standard 200 ft/NM (now 200-350) – i.e., only for special approaches. Special approaches, however, are generally not practical or desirable for private owners or itinerant/occasional use aircraft, due to the costs which must be borne for procedures design and maintenance and recurring flight inspections.

Table 2. Approaches from the South, Existing and Previously Proposed

IAP Name	Cat C Aircraft Minima	FAC Descent Angle	FAC Offset Angle	Climb Gradient Required, ft/NM	MAP
RNAV (RNP) Y RWY 31 RNP 0.3 (AR)	1000-3	3.50	5	330 to 14,000 MSL	THR (OLUYA waypoint)
RNAV (GPS) W RWY 31 LNAV MDA (Public)	1800-3	3.11	14	200	THR
RNAV (GPS) X RWY 31	1700-3	3.11	14	414 to 7500' MSL	THR
RNAV Z RWY 31 (GPS) (G4 and G5 only)	1000-2	3.60 to TADOE (1) 3.09 to THR	11	385 to 10,000' MSL	~2.5 prior THR
NDB/DME OR GPS-A (Public)	2700-5	N/A	21	200	5 DME (~5 prior THR)
TLS RWY 31 (Developmental) (AR) (Previous, never used)	1100-3	3.43	9.21	430 to 7,800 MSL	7.4 DME (2.9 prior THR)
TLS RWY 31 (Developmental) (AR) (Previous, never used)	900-2 ½	3.00	9.22	300	2.5 prior THR

The RNP Y procedure, with minima of 1000-3 and a climb-gradient of 330 ft/NM, requires advanced avionics capable of Required Navigation Performance, assuring containment of the aircraft within specified airspace volumes. At least one Sun Valley air carrier (Horizon) has this capability. However, the missed approach path to the north and west is 81 miles long, and as a result, this procedure is rarely used.

The public GPS W procedure, with minima of 1800-3 and a standard climb gradient of 200 ft/NM, requires dual, fully independent avionics for air carriers. This procedure is used by Horizon and possibly Sky West.

The GPS X procedure, with minima of 1610-3 and an aggressive climb gradient of 414 ft/NM, also requires dual, fully independent avionics for air carriers. This procedure is in use by at least one carrier, and provides the best current mimina (given that the RNP Y procedure is not used and the GPS Z approach is for only two aircraft types).

The GPS Z procedure, with minima of 910-2, very aggressive climb gradients of 385 ft/NM to 10,000', and a somewhat steep descent angle of 3.6 degrees, is approved for only G4 and G5 aircraft, and requires dual, fully independent avionics. It is currently used by NetJets.

The public NDB/DME procedure, with minima of 2700-5 and a standard climb gradient of 200 ft/NM, requires only common avionics carried by nearly all aircraft rated for instrument flight. However, the high ceiling and visibility requirements prevent the use of this procedure much of the time during inclement weather, and it is not authorized at night. A conservative estimate, based on data in the T-O Engineers and Mead & Hunt Analysis, is that landings would not be possible with this procedure at least 20% of the time annually, and a substantially higher percentage of the time during the December-February months. The NDB/DME facilities are installed on the side of a hill, with the DME signals shadowed such that they are generally receivable only after overflying the DME inbound.

The two TLS approaches, with nominal minima of approximately 1000-3, would have required moderate and high climb gradients, and roughly match the minima of the unused RNP Y and the GPS Z procedures, but with lower descent angles. TLS procedures were developed using ILS TERPS criteria, suggesting that an ILS installation supporting an approach from the south may be feasible. (The TLS procedures in Attachment 2 may not meet current procedures development criteria, which include adjustments in Required Obstacle Clearance for precipitous terrain.)

Imminent New Approach Procedure. Horizon will likely receive FAA approval for RNP .1 approaches during the summer of 2013. They have evaluated an RNAV RNP .1 approach from the north and believe they can obtain minimums as low as 300 DA/H and 1 mile visibility with an approach angle as low as 3.2 degrees. This could allow landings in all but the most severe weather. (RNP approaches require avionics capable of assuring aircraft containment within, in this case, 0.1 or 0.3 miles either side of the desired ground track.)

Options

Given basic limitations for approaches from the south such as a descent angle maximum of 3.60 degrees and a climb gradient maximum of 350 ft/NM for most operators, several potential new instrument approaches appear feasible, and some existing approaches might be modified for generally minor improvements. At present, these options have received only an elementary TERPS analysis. They are tabulated in Table 3 and discussed briefly below.

Table 3. Potential new IAPs or Modification of Existing IAPs

	Approach	Potential Minima (very approximate)	Climb Gradient Required, ft/NM	Usage
1	Offset ILS/LDA similar to GPS-W	1800-3	200	Public
2	Offset ILS/LDA similar to GPS-W	1600-3	≤240	Public
3	Offset ILS/LDA similar to GPS-W	1400-3	≤300	Public
4	Offset ILS/LDA similar to TLS & RNAV-Y	1000-3	400-450	Special
5	RNAV GPS W (modified)	1600-3	>250	Special
6	NDB/DME	2700' or 3 NM reduced?	≤240 >250	Public
7	WAAS-based LPV	1800-3	200-300	Public
8	Modify RNAV W and (future?) ILS missed approaches with navaid to the west			

<u>Background for ILS-based Options.</u> Four of the options involve a full or partial ILS installation, and vary in detail based on characteristics such as climb gradient or FAC. They are based in part on the observation that if a GPS approach (RNAV GPS W) can provide 1800-3 with a standard climb gradient, and its missed approach is controlled by terrain, then an ILS approach along the same ground track may be able to provide similar minima. (Both the ILS and the larger Localizer Directional Aid (LDA) final approach obstacle clearance trapezoids are narrower than an RNP .3 Containment Area., and might eliminate some obstacles in the final approach area. A narrower final approach surface would result in a narrower missed approach trapezoid, which in turn could eliminate some obstacles in the missed approach segment as well.)

It is very likely that a federal ILS installation was not seriously considered by the FAA for several reasons. One is that many in the FAA would consider installing an ILS (which normally supports minima of 200-1/2 or better) a waste of an ILS system, if it provided public minima of only 1800-3. Another is the onset of promising new technologies and expectations for their implementation. For example, the late 1980s and early 1990s were considered the "MLS decade", with that new technology expected to displace ILS nationwide Indeed, as previously mentioned, an early non-fed MLS installation supported SUN for several years. But as the MLS decade neared its end, FAA's initial MLS large-volume procurement contract faltered, and newer technologies such as satellite navigation were increasingly expected to replace ILS. It required another decade (to approximately 2005) before GPS-based satellite approaches appeared in significant volume with similar-to-ILS minimums. Together with the plans to relocate the airport, these considerations may have suppressed the consideration of an ILS at SUN for several decades.

An ILS approach may be based on a variety of ground equipment configurations, each with its own siting and TERPS criteria. These include a Localizer for azimuth guidance and a Glide Slope (GS) for descent guidance, a Localizer (only), a Localizer Directional Aid with Glide Slope (LDA/GS), or an LDA without a GS. A straight-in ILS has its electronic course aligned within three degrees of the runway heading. An LDA is a localizer with its course aligned more than three degrees from the runway heading.

Siting an ILS azimuth (Localizer or LDA) facility at SUN is challenging. Terrain south of the airport requires a clockwise-offset course for reasonable minima, as corroborated by the various FAC values in Table 2, each with at least five degrees of offset. LDA siting criteria generally require that the electronic course line cross the extended runway centerline up to approximately 5000' prior to the threshold, with some minima penalty for other configurations. At SUN, there is insufficient room between the runway safety area boundary east of the runway and the airport perimeter fence to comfortably locate an LDA antenna system complying with all siting criteria. Placing the antenna system south of the threshold causes the antenna system critical area (an area protected from transient conditions that cannot be flight inspected, such as moving or parked aircraft or vehicles) to extend off airport property, where it cannot be controlled. However, given that any ILS or localizer/LDA-based approach at SUN will have minima well above the usual Category I ILS minima of 200-1/2, it may be feasible to obtain waivers to some of these constraints.

<u>Discussion of Options.</u>

1. Install an offset ILS, LDA/GS, or LDA without a GS, with a standard climb gradient in the missed approach procedure. This procedure would be similar to the existing RNAV (GPS) W approach, with similar minima (i.e., 1800-3), and would benefit any operator not flying the existing GPS-W approach, since essentially any instrument-equipped aircraft has ILS capability. It would be a substantial improvement for those operators currently using the NDB, since they are unlikely to have GPS capability. With a standard climb gradient, it would be a public approach.

2. Same as option 1, but require a mild climb gradient (e.g., 240 ft/NM). This might result in minima of perhaps 1600-3, and would benefit any operator not flying the existing GPS-W approach.

3. Same as option 1, but require a more aggressive climb gradient. This would result in a special procedure with a potentially significant improvement (e.g., from 1800 to perhaps 1400'). This would benefit any operator not flying the existing GPS-W approach but with aircraft capable of the increased climb rate. It would also benefit any operator currently using the NDB approach with an aircraft capable of the increased climb rate.

4. Same as option 1, but design the procedure to mimic the previous proposed and designed TLS procedures. (TLS approach procedures were developed approximately 10-15 years ago using TERPS ILS criteria, and this effort may have been the first serious look at low minima from the south at SUN.) This option would require an approach angle around 3.50 degrees, but would be followed by a substantial climb gradient between 400 and 450 ft/NM, and therefore would be a special, but with minima in the vicinity of 1000-3. (Since the TLS approaches were not placed into service before the TLS was removed, it is possible they are not viable using today's criteria, though two independent sources designed the two IAPS with similar results.) The TLS front approach courses (9.2 degrees offset from runway centerline) appear to have been

carefully selected to optimize the minima, and are notably different from those for the RNP Y and GPS W approaches. This may explain the difference in minima between the RNP/GPS approaches and the TLS approaches. (A detailed TERPS study will be required to confirm this.) Such an approach would benefit air carriers and corporate operators with aircraft capable of the substantial climb gradient, and who are willing to qualify for the special procedure.

5. Modify the existing RNAV GPS-W procedure, which is a public approach using a 200 ft/NM climb gradient, to require a more aggressive climb gradient. This should allow descending to slightly better minima, perhaps 1600' rather than 1800. This incremental improvement would benefit those operators already flying the existing GPS-W approach. (This method was likely used to create the RNAV (GPS) X RWY 31 procedure (i.e, a 414 ft/NM climb gradient). Variations on this option include petitioning the FAA to designate the RNAV (GPS) X RWY 31 procedure a standard procedure with the 414 ft/NM gradient, and modifying the missed approach (e.g., turn point and heading).

6. Modify the existing 2700-5 NDB/DME procedure to require an increased climb gradient. Presently, the 2700-5 minima are for public use with a standard 200 ft/NM gradient. If that were increased, an improvement to either the 2700' or the 5 NM figure might be feasible at the expense of requiring a climb gradient exceeding 240 ft/NM. This would benefit those operators already using the NDB/DME approach who are capable of the climb gradient – e.g., any air carriers flying the NDB. Further, the night restriction could be investigated for potential mitigations

7. Design a Localizer with Precision Vertical (LPV) satellite-based approach. Such approaches rely on the Wide Area Augmentation System (WAAS), and are an initiative of the FAA. The procedures development criteria for LPV are similar to those for ILS. The minima are likely to be controlled by the missed approach, similar to the GPS-W option, and a detailed study will be necessary to determine if better minima might be achievable. Such an approach requires appropriate avionics equipage; however, at least one SUN carrier has several aircraft with this capability. A request to develop an LPV procedure should indicate that an approach angle up to 3.60 degrees would be acceptable.

8. Modify the existing RNAV RNP procedure's missed approach to reduce its 81 NM long miss ground track. This could also be applied to any of the other options above (e.g., ILS) if the resulting missed approach is better than existing missed approach designs. One method would increase the climb gradient above the existing 330 ft/NM and turn the missed approach (left or right) around the NUCIV waypoint (Attachment 1). This option might also be accomplished by placing a ground-based navaid to the east or west of the airport aligned to provide a miss ground track through one of the several east-west valleys. Siting such a facility requires an aggressive solution in this terrain, and meeting flight inspection requirements for the quality of the signals will be a challenge requiring a good antenna system. Adding a ground-based missed approach to the RNAV RNP procedure results in a "blended" procedure – this is uncommon but has been done on previous occasions. Such a procedure would be a special and require a procedures waiver.

Conclusions

1. The RNAV RNP Y procedure is rarely if ever used because of its 81 NM missed approach. Reducing the length of the missed approach even at the expense of raising the minimums would make the procedure more viable and might attract more operators.

2. Raising the climb gradient on the RNAV GPS W procedure to 240 ft/NM or even 300 ft/NM would not result in a significant reduction in minimums. (Note the RNAV GPS X has a 1610 DA/H but requires a climb gradient of 414'/NM.)

3. The RNAV GPS X procedure requires a 414 ft/NM climb gradient to 7500 feet. Changing the missed approach turn point and heading might result in a lower climb gradient, possibly below 400 ft/NM. Since most aircraft are not capable of a 414'/NM climb gradient, even for a short distance, reducing the gradient would make the procedure available to more aircraft.

4. The RNAV Z procedure is a special procedure designed for Gulfstream 4s and 5s and limited to use by NetJets. Any changes to this procedure would be solely at the discretion of NetJets, and would be unlikely to benefit other operators.

5. The NDB/GPS-A procedure has a 2682 DA/H and a standard missed approach climb gradient. Raising the climb gradient might not result in a significant reduction of minimums because of the large obstacle clearance trapezoid associated with NDB procedures. (The effectiveness of a greater than standard climb gradient would be related to how close the controlling obstructions are to the missed approach point - the farther away, the better for improvement by excessive gradient.)

6. An offset ILS or LDA-based approach could provide public minimums as low as 1790 DA/H and 3 miles visibility. Lower minimums could be achievable with a higher climb gradient in the missed approach.

7. A glide slope would not substantially reduce the minimums on an offset ILS or LDA approach. However it would benefit the pilot by allowing the glide slope to be monitored continuously throughout the visual segment of the approach. This would be particularly beneficial at night.

8. Installing an NDB or other navaid east or west of Hailey to support misses to the west could improve some missed approaches by allowing secondary obstacle clearance reduction earlier on the flight path, or possibly throughout the missed approach. This could eliminate some of the missed approach obstacles and result in lower minimums, lower climb gradient, or both.

9. An RNP .1 approach from the north, if confirmed feasible, could allow landings in all but the most severe weather for suitably equipped aircraft.

10. An LPV approach from the south likely would achieve minima similar to an ILS approach, but would require aircraft with suitable avionics.

11. The seven approaches developed for SUN over the past two decades use five different Final Approach Course offset angles. Five of these of these approaches are still active. Discounting the NDB procedure, four have offset angles between 5 and 14 degrees. Some of the differences may be attributed to the different types of approaches, or they may vary at the discretion of the installers and/or developers. However, a more in-depth review might define an optimum offset angle that would be suitable for all the approaches.

Recommendations

1. Amend the RNAV RNP Y procedure to reduce the 81 NM missed approach.

2. Study modifying the RNAV GPS X procedure's turn point and heading to reduce the required climb gradient.

3. Develop an offset ILS or LDA/GS approach from the south (with an approach angle up to 3.60 degrees), possibly with a strategically located navaid east or west of Hailey to provide a miss to the west.

4. Consider a strategically located navaid east or west of Hailey to support misses to the west, for approaches other than the proposed ILS or LDA/GS. (This would result in blended approaches in some cases.)

5. Work with Horizon to develop a RNAV RNP RWY 13 approach from the north.

6. Develop an LPV approach (with an approach angle up to 3.60 degrees). (For the short- or mid-term time frame, this would be attractive only if Recommendation 3 is infeasible. For the longer term, as more aircraft equip for advanced satellite-based procedures, the benefits of this option will increase.)

7. Study existing procedures (except the NDB approach) to determine if a different FAC offset angle would improve minima, and potentially be more usable for all the approaches.

Next Steps

All seven Recommendations require a detailed TERPS study effort as the basis for any additional work. While such a study might require several weeks for each recommendation, actual design and implementation by the FAA of new procedures requires up to 18 months Early and close coordination with the FAA's Regional Approach Procedures Team (RAPT) is necessary.

Each Recommendation provides a different benefit affecting different subsets of the operators. Clearly, Recommendation 3 (implement some form of ILS) has the largest general benefit, because it could support public and special approaches for all operators and provide a substantial improvement over the existing NDB minima. Recommendations 3 and 4 involve ground-based facilities. Assuming either of these is adopted, the high-level activities involved and their individual time requirements are listed below, excluding related processes such as enrivonmental impact studies. (Some of the activities may run concurrently; some require good weather conditions.)

1. Joint TERPS and feasibility siting work to determine search areas for the facilities (1-2 months)
2. Completion of a detailed siting study (2-3 months)
3. Site test (if needed or recommended by the siting study) of any proposed missed approach facility (1-2 months)
4. Procurement and delivery of equipment (6-12 months including bid package preparation, advertising and bidding time, and award)
5. Design of the installations (1 month)
6. Contracting time for civil and electrical installation work (3 months)
7. Electronic Installation, Tune-up, Commissioning Flight Inspection, and Procedure Publication (2-4 months)

A rough order-of-magnitude cost estimate for Recommendation 3 (some form of ILS) is $1-$2M, with equipment costs being up to about $500k of that amount.. Installation of localizer and glide slope facilities at Hailey is not overly demanding from a construction point of view - power is available nearby, and physical access and security are straightforward. A rough cost estimate for Recommendation 4 (missed approach facility if beneficial) is more difficult at this concept stage, because the locations may need to be in mountainous terrain, where power and physical access, and potentially land acquisition costs, can be surprisingly high.

<u>Attachments</u>

1 Existing Standard Instrument Approach Procedures
2 Previous TLS Approach Procedures (never commissioned)

<u>References</u>

1. FAA Order 8260.3B, *United States Standard for Terminal Instrument Procedures (TERPS)*
2. FAA Order 6750.16B, *Siting Criteria for Instrument Landing Systems*
3. *SUN Reliability Analysis Summary*, February, 2012, by T-O Engineers and Mead & Hunt

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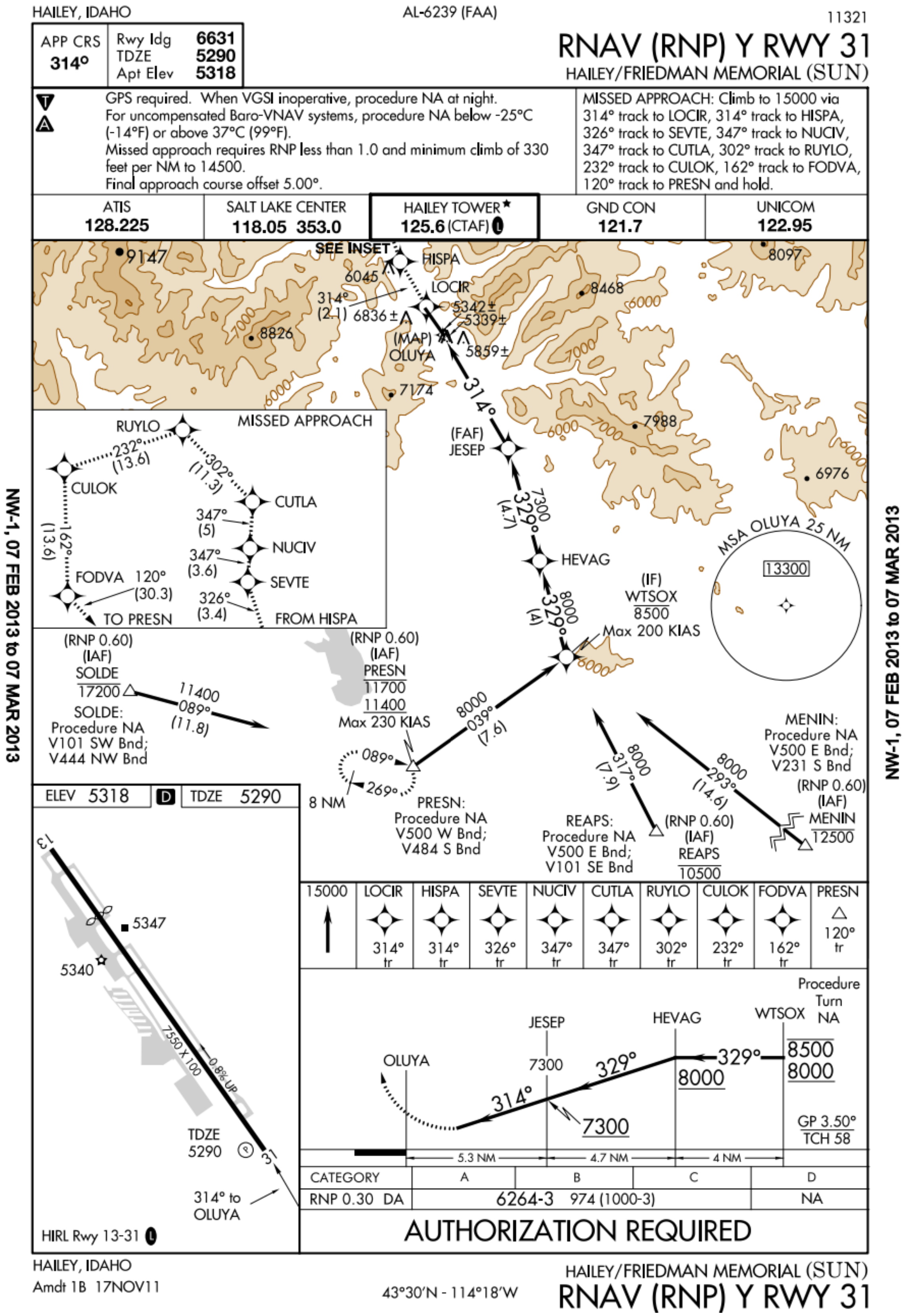
ATTACHMENT 1 – Existing Instrument Approach Procedures



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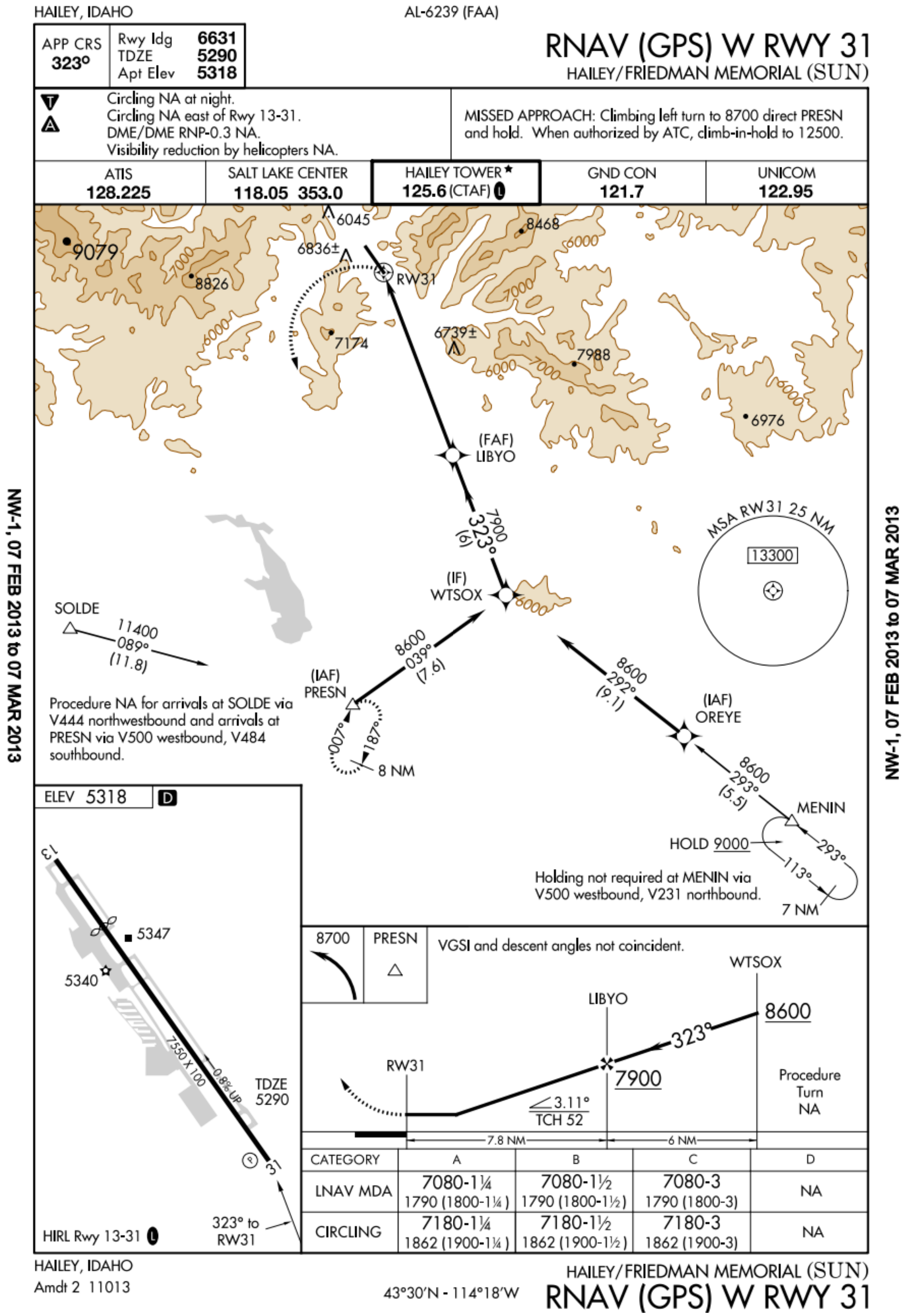

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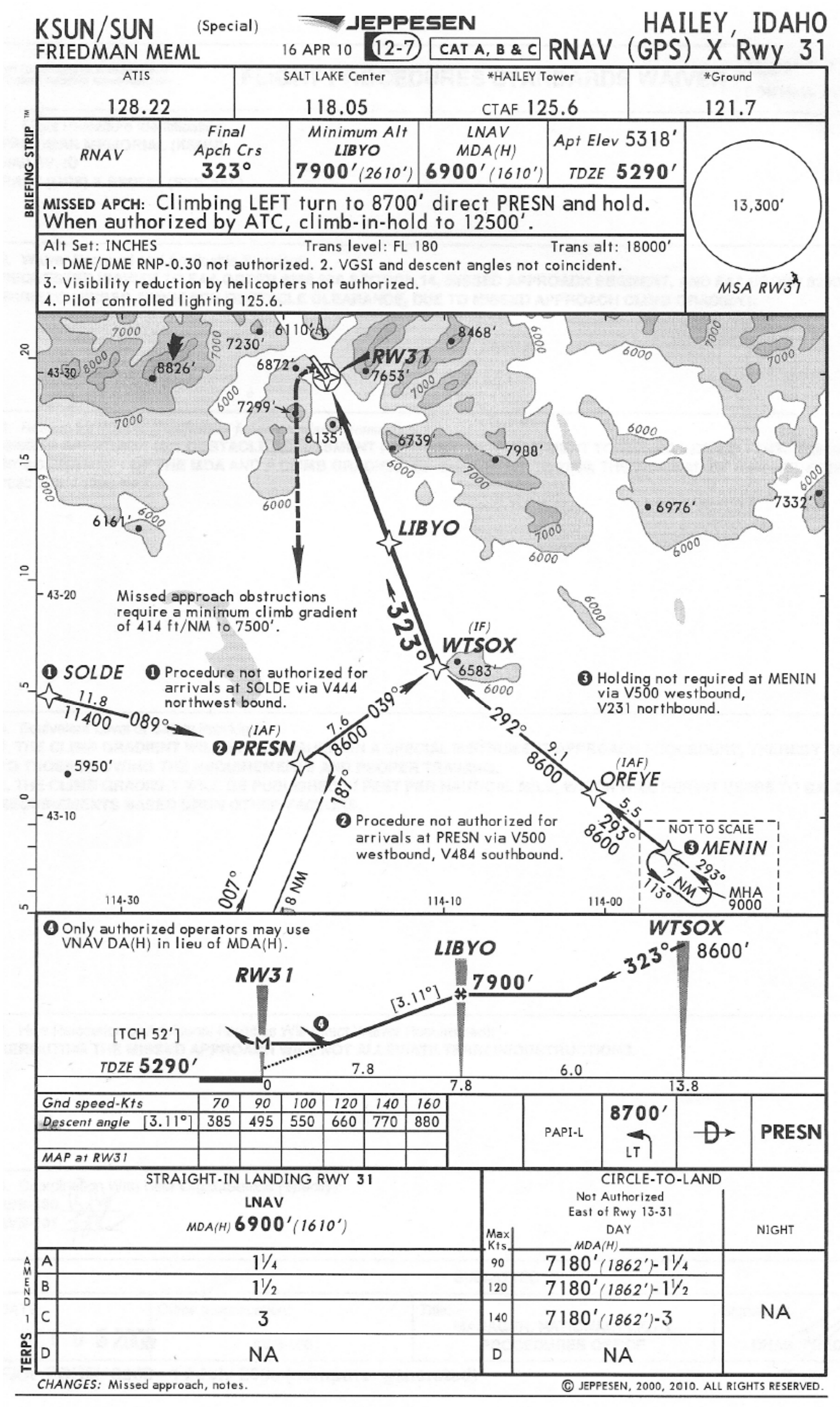

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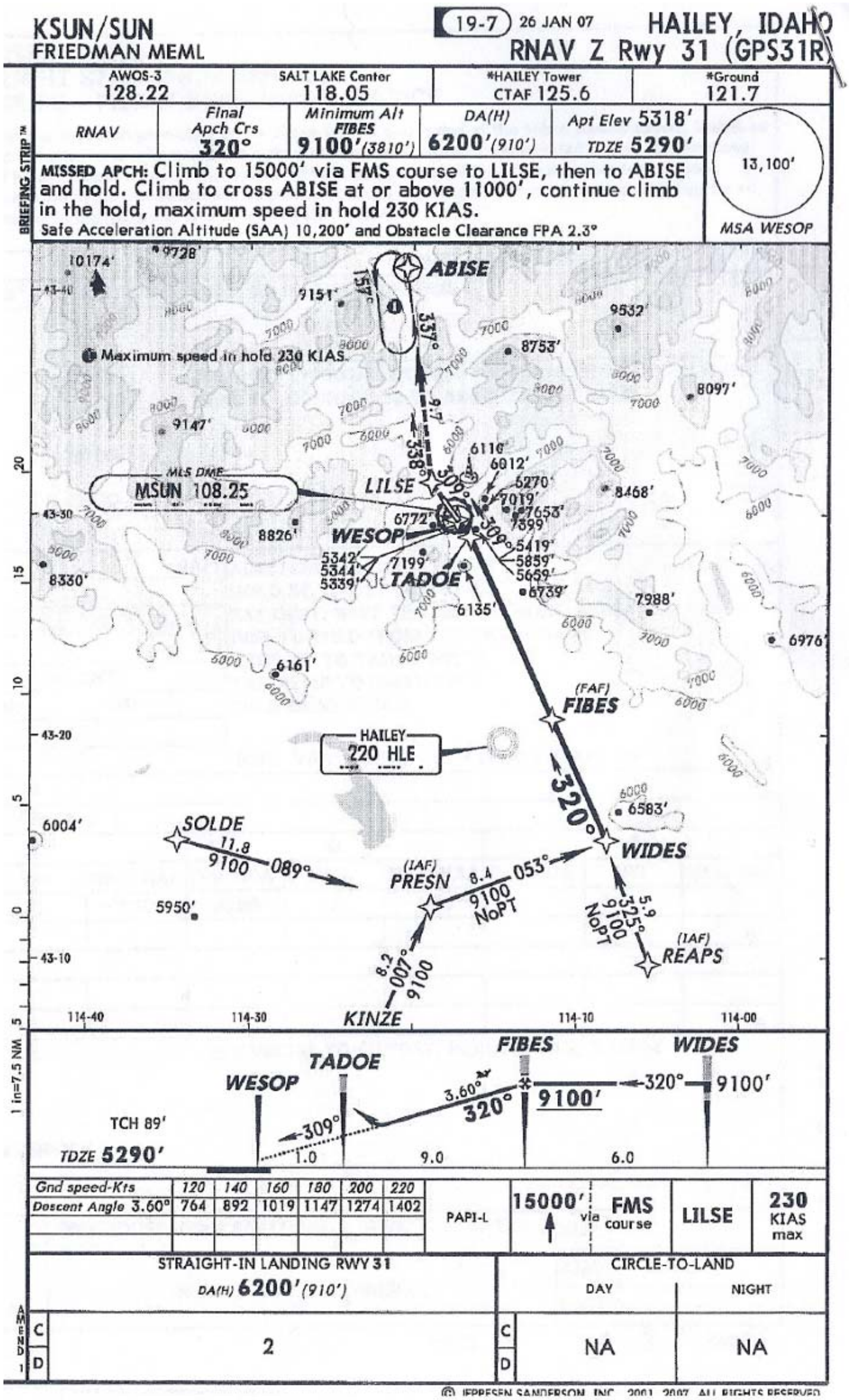
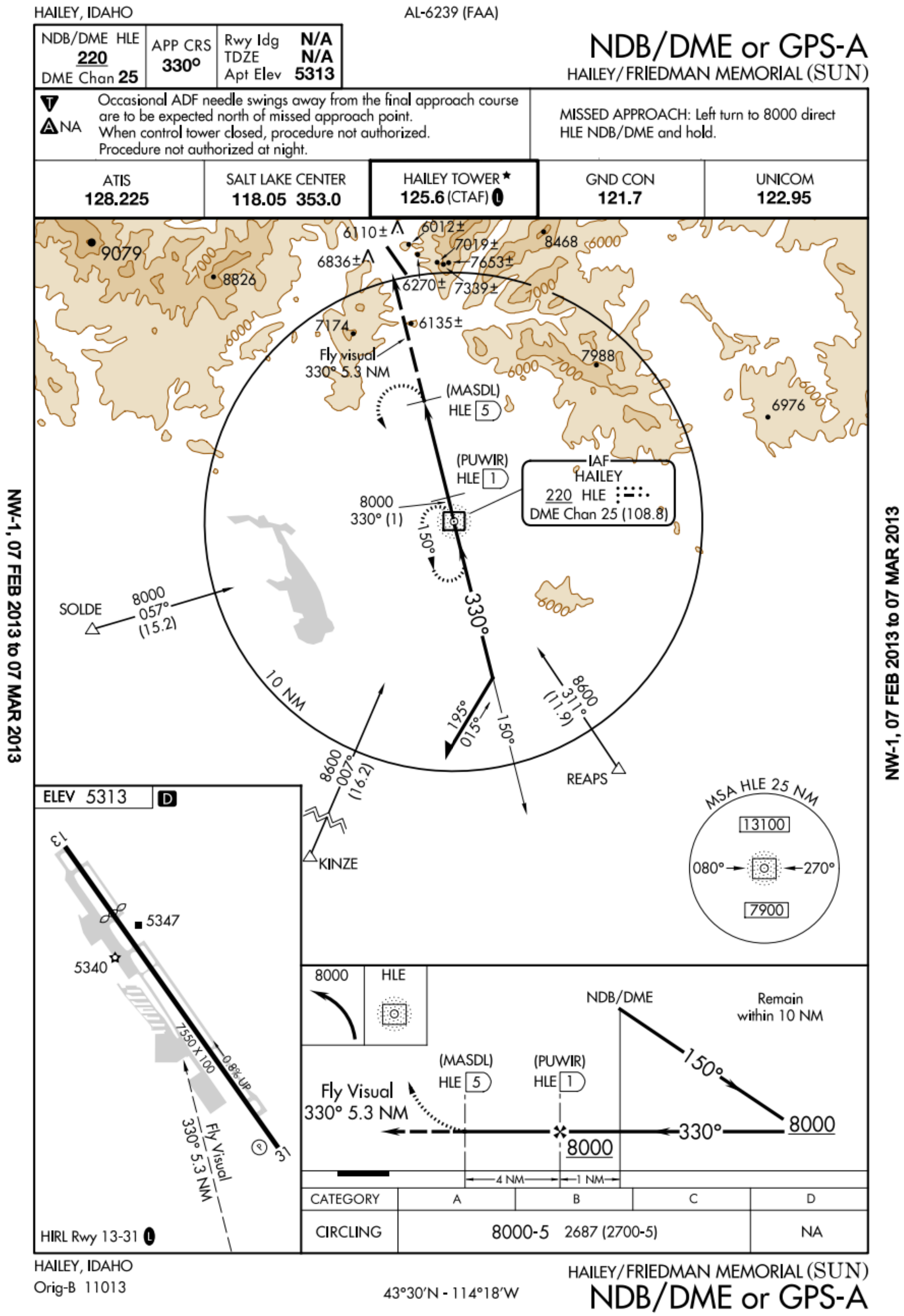
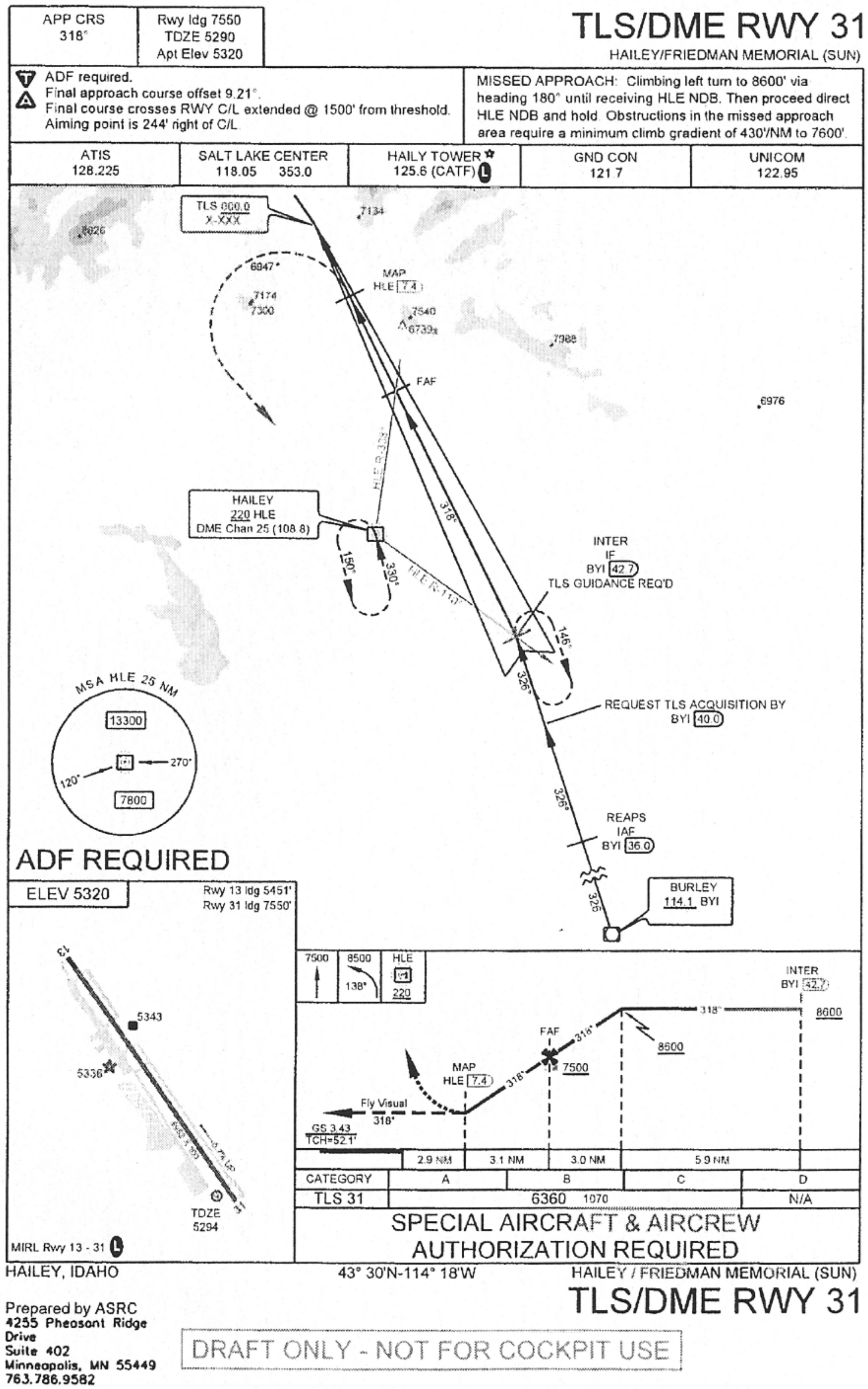


ATTACHMENT 1 – Existing Instrument Approach Procedures (Continued)



ATTACHMENT 2 – Previous TLS Approach Procedures (never commissioned)



ATTACHMENT 2 – Previous TLS Approach Procedures (never commissioned)