Graphic IFR Departure Procedures

If the FAA had provided a graphical depiction similar to a SID, the USAF C-130 crew might still be alive.

By Wally Roberts

THE CREW OF A U.S. AIR FORCE C-130 was departing Jackson Hole, WY (JAC) on an IFR clearance when they crashed into high terrain east of the airport. The cause of the August, 1996 accident was blamed on the crew's failure to follow the published IFR departure procedure at JAC.

After a brief review of this accident, I'll discuss a proposed solution to a systemic problem with IFR departure procedures. I'll also review the fundamental aspects of IFR departure procedures.

Night departure

The C-130 had departed Runway 18 at JAC on a clear, but moonless night. Although I don't know the initial route clearance assigned by ATC, I suspect it contained only the Jet route clearance and an initial altitude assignment into the Jet route structure, also perhaps with a "report over XYZ VOR" (the first VOR on the assigned Jet route).

Whether it was a clearance into the Jet route structure, or into the low-altitude Victor airway structure, the principles remain unchanged: there was no assigned departure procedure because none was needed by ATC for non-radar separation from other IFR traffic.

It was solely up to the flight crew to determine whether there were IFR departure procedures for the airport and, if so, whether they needed to use them for the departure phase of flight. Instead, it appears this crew elected to turn east shortly after takeoff for a direct routing to the assigned route clearance fix. In the process they flew into terrain at 11,000 feet, 15 miles east of the airport.

Hipshooting the blame

The USAF command structure wasted no time placing the entire blame on the C-130's hapless flight crew, for failure to use the published IFR departure procedure for Runway 18. There was apparently no critical look by the authors of the accident report into the training and publication aspects of IFR departure procedures, and the insidious differences between radar and non-radar mountainous terminal areas.

This was a professional military flight crew, presumed to have been up to the task of carrying presidential equipment and a senior U.S. Secret Service agent. Would a crew with these credentials ignore the training they had received about non-radar departure procedures from mountainous airports? Would they have ignored the terrain had they been provided a special airport qualifications package, or at least been required to use and brief from a sectional aeronautical chart in conjunction with the IFR departure procedures for the airport?

Radar and too many SIDs

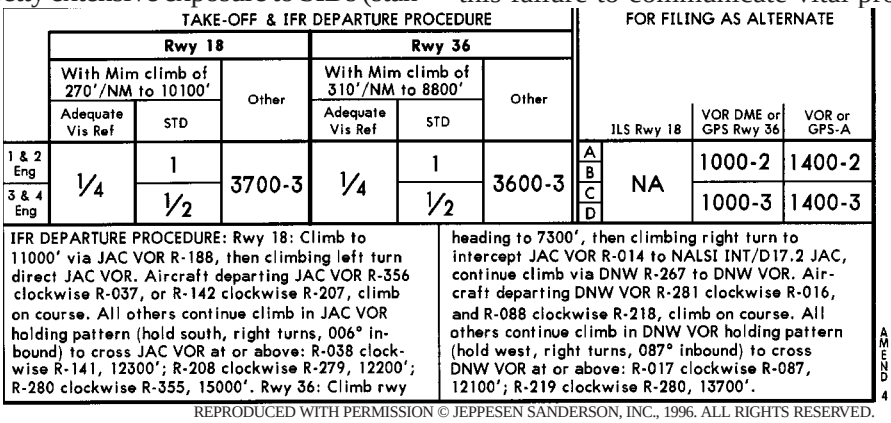
I suspect this ill-fated crew had received the all-too-typical training and exposure to today's FAA air traffic system. Their training was probably replete with radar vectors to the airway as soon as the wheels went into the wells. Also, they had probably received their share of "mini" vectors, where ATC gave one little turn to intercept the en route airway not far from the airport.

In other cases, they likely had some pretty extensive exposure to SIDs (standard instrument departures), which are always charted. Further, SIDs constitute part of the ATC clearance when they are to be flown.

Unlike IFR departure procedures, which are developed for the pilot's safety, SIDs have their principal genesis in the convenience of air traffic control. SIDs are a textual and graphical presentation of what otherwise would be a repetitive and complex verbal ATC clearance.

There's nothing wrong with SIDs in and of themselves. However, the absence of either a SID or a departure radar vector instruction conveys to far too many pilots that departing is a no-brainer since the "Good Hands of ATC" haven't proclaimed a departure procedure in the initial ATC clearance.

I'm not faulting ATC policy, per se. What I am faulting is the reality that both the military aviation branches and the FAA let ATC policy push operations and standards policies into the background to the point of obscurity. Why else do we see SIDs carefully charted, yet complex IFR departure procedures are relegated to sometimes nearly incomprehensible text that is easily overlooked without some really good, reinforced training in terminal instrument procedures? Other industry players share with the government agencies in this failure to communicate vital pro-



TAKE-OFF & IFR DEPARTURE PROCEDURE

	Rwy 18			Rwy 36		
	With Mim climb of 270'/NM to 10100'		Other	With Mim climb of 310'/NM to 8800'		Other
	Adequate Vis Ref	STD		Adequate Vis Ref	STD	
1 & 2 Eng	1/4	1	3700-3	1/4	1	3600-3
3 & 4 Eng		1/2			1/2	

FOR FILING AS ALTERNATE

	ILS Rwy 18	VOR DME or GPS Rwy 36	VOR or GPS-A
A	NA	1000-2	1400-2
B			
C		1000-3	1400-3
D			

IFR DEPARTURE PROCEDURE: Rwy 18: Climb to 11000' via JAC VOR R-188, then climbing left turn direct JAC VOR. Aircraft departing JAC VOR R-356 clockwise R-037, or R-142 clockwise R-207, climb on course. All others continue climb in JAC VOR holding pattern (hold south, right turns, 006° inbound) to cross JAC VOR at or above: R-038 clockwise R-141, 12300'; R-208 clockwise R-279, 12200'; R-280 clockwise R-355, 15000'. Rwy 36: Climb rwy heading to 7300', then climbing right turn to intercept JAC VOR R-014 to NALSI INT/D17.2 JAC, continue climb via DNW R-267 to DNW VOR. Aircraft departing DNW VOR R-281 clockwise R-016, and R-088 clockwise R-218, climb on course. All others continue climb in DNW VOR holding pattern (hold west, right turns, 087° inbound) to cross DNW VOR at or above: R-017 clockwise R-087, 12100'; R-219 clockwise R-280, 13700'.

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***Figure 1**. The IFR departure procedure for JAC requires close scrutiny. Imagine if SIDs were presented in the same format.*

cedures effectively to pilots.

Maze of text

IFR departure procedures are established by the FAA's designers of instrument approach procedures (IAPs) for any airport that has at least one IAP, and the obstacle-environment in the airport's terminal area requires a defined departure route to laterally avoid terrain and obstacles that cannot safely be overflown. Figure 1 (page 10) is the "Take-Off & IFR Departure Procedure" portion of the Jeppesen airport diagram chart for JAC. This maze isn't Jeppesen's fault. They have done a better job than NOS in setting forth the terse information provided by the FAA.

This convoluted maze of text actually represents two separate procedures: Runway 18 and Runway 36. You can imagine the outcry if the aviation community had permitted SIDs to evolve in this manner; that is, several dozen words, but no picture to describe the complex "Flamer One" SID at Metroplex Interstates Airport. It doesn't take much of a leap of logic to imagine text-only IAPs!

A better way

Figure 2 (on right) and Figure 3 (page 12) are my conception of charts for the two JAC IFR departure procedures. Had charts like this been in the ill-fated C-130 crew's flight manual in a prominent place enjoyed by SIDs, would this tragic accident have occurred? While no one can answer that question with certainty, such charts would have at least turned the human-factors aspects of the departure problem in the crew's favor.

My charts aren't the final word. Rather, they set forth a concept consistent with the use of SIDs. I haven't shown the altitude to be achieved circling the airport for the aircraft that can't make good the climb gradient. That is presently an area lacking in TERPs, Chapter 12 departure criteria. A complete criteria in this regard would require the FAA or military procedures specialist to establish the altitude over the airport that will permit a climb gradient of only 200 ft/nm, instead of the specified higher climb gradient for flight straight on to the departure track.

Another possibility could be to move the take-off minima to the chart. This would be consistent with IAP charting concepts, and would relieve the pilot from pouring over information that doesn't pertain to the operation at hand.

Additional charts

Figure 4 (page 13) is the JAC terminal area from the Jeppesen low altitude en route chart. It's essential the chart be out and folded to highlight an area similar to Figure 4 as part of the preflight, as well as actual departure, from a difficult mountain airport like JAC. The sectional chart should be similarly folded and at hand.

Figure 5 (page 14) is the overview chart from Jeppesen's optional Airport Qualification chart for JAC. Many airlines subscribe to these supplemental charts for operations at mountain airports such as JAC. Had the C-130 crew been trained in the use of this type of chart and been provided the chart by their commanders, another vital piece of information that could have prevented the tragic crash would have been in the hands of the crew.

Review

Every airport in the U.S. with at least one public IAP is evaluated by an FAA terminal procedures specialist for departure obstacles. The airspace is evaluated at a 40:1 slope along a specific departure zone (Zone 1) for two miles from the departure end of each runway. With one unusual exception, it's assumed a departing airplane will never turn at less than 400 feet above airport elevation. It's assumed the worst-case airplane will cross the departure end of the runway at 35 feet, and climb at 200 feet per mile to the end of Zone 1. Two hundred feet per mile is the sum of a 40:1 slope (152 ft/nm) plus an arbitrary additive of 48 feet per mile.

Zone 2 picks up from Zone 1 and is a 180-degree piece of pie, evaluated at a 40:1 slope from 400 feet above the airport elevation to the lowest en route altitude. Zone 3 is the 180-degree piece of pie in the opposite direction of take-off.

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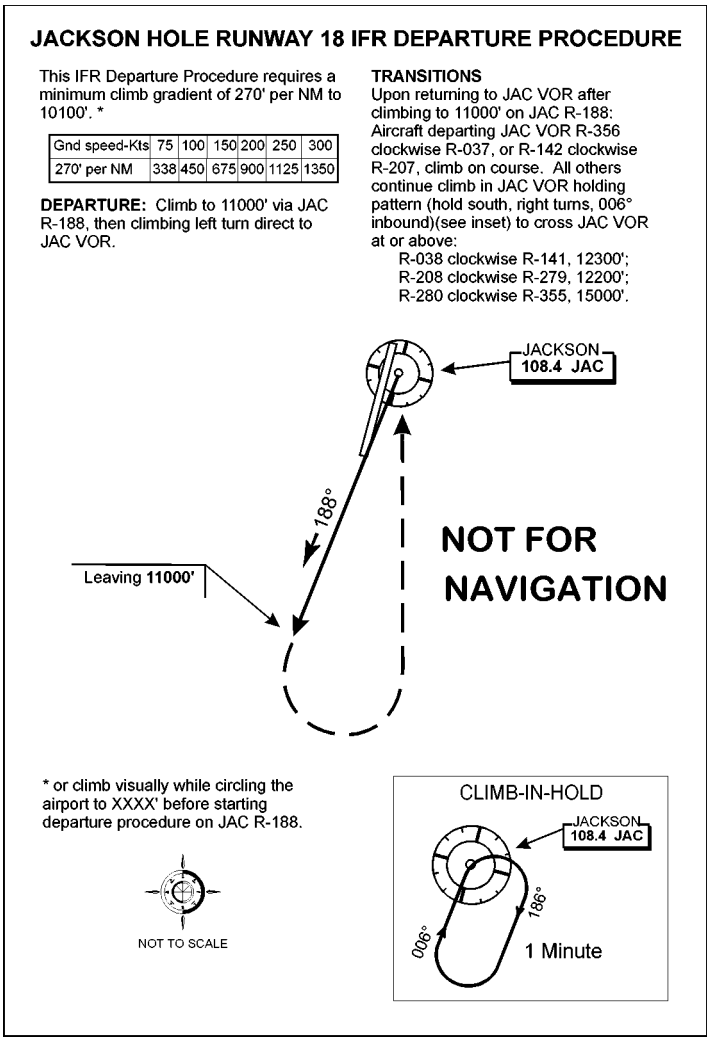

***Figure 2**. Author's conception of graphical depiction for JAC Runway 18 IFR departure procedure.*

Graphic. . .

(continued from page 11)

If all three of these zones are 40:1-clear the runway will have standard take-off minimums and there will be no IFR departure restriction or IFR departure route procedure. At such an airport, once reaching 400 feet on runway heading you can proceed in any manner consistent with your ATC clearance.

Where an obstacle problem is found in part of Zones 2 or 3, the problem can sometimes be excluded with a restriction, rather than a full route IFR departure procedure. An example, "Runway 18 departures, do not turn east until leaving 900 feet." This would mean turns to the west could be made at 400 feet above airport elevation, but turns to the east could not be made below 900 feet msl.

When a turn is required

The pilot who turns below 400 feet risks flying into a less-than-400-foot-high obstacle, such as a control tower or hotel. Where a departure requires a turn, and a turning altitude or fix is prescribed, then that is where the turn must be made. If a turn is required, and no altitude or point is specified, it's always 400 feet, the "early turn" being the only below-400-foot exception. If you have 400 feet at mid-field, it's okay to turn then provided there are no conflicting instructions. You're protected for turning at 400 feet from a point 2,000 feet from the beginning of the runway to two miles beyond the departure end of the runway.

If a course or heading change of less than 15 degrees is required in the initial stage of the departure, that is considered to be a non-maneuvering turn in TERPs, and should be accomplished as soon as the pilot feels comfortable making the slight maneuver. Capturing the radial on the Runway 18 departure at JAC is a case in point. (Also, some ILS missed approach procedures have less-than-15-degree course change just after the DH-point. That realignment should be made below 400 feet.)

The one exception for a maneuvering turn below 400 feet is where the departure procedure says "turn as soon as practicable." This is known as the "early turn" exception and will never have standard take-off minima. A take-off minimum of at least 400-1 will be required to turn to see-and-avoid the close-in obstacle. Normally, such obstacles are dealt with by applying a climb gradient but sometimes the result would be too steep of a climb gradient for most aircraft.

At some locations, you'll see a mandatory ceiling and visibility without an early turn requirement. This is where the procedures specialist has determined that no particular turn is required, but see-and-avoid is required for a close-in obstacle.

Minima & climb gradients

Refer again to Figure 1. The take-off minima and climb gradient requirements are typical of a mountain-area airport. Note both runways have standard (and air carrier lower-than-standard) take-off minimums, provided the specified climb gradient can be met. If the climb gradient cannot be met, then it's 3,700/3 for Runway 18 and 3,600/3 for Runway 36.

What isn't clear, however, is how the pilot should avoid obstacles when the aircraft can climb only 200 feet per mile and the specified ceiling and visibility is adhered to. There is considerable disagreement within the FAA on this issue. The conservative bet is to circle the airport visually until your altitude equals the airport elevation plus the ceiling value. This has its own set of perils at night or under poor visibility conditions at an unfamiliar airport.

A lot of work is overdue by the FAA in this area, from charting a safe visual climb area to specifying the altitude to be achieved before departing the visual climb area. If you can't make good a sustained climb gradient requirement, don't depart an unfamiliar mountain airport under IMC or dark-night conditions.

Where an IFR departure procedure (such as those for JAC) specify a climb gradient to an intermediate altitude (less than the MEA), once the intermediate altitude is achieved, the "basic" climb

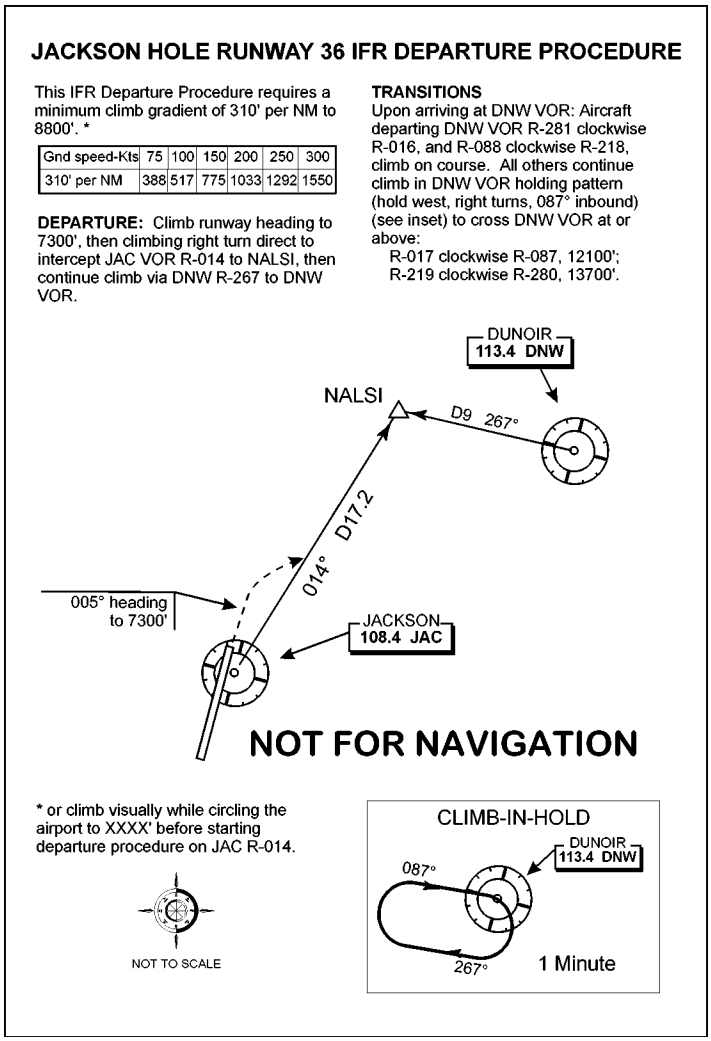

***Figure 3**. Author's conception of graphical depiction for JAC Runway 36 IFR departure procedure.*

gradient of 200 ft/nm applies from that point to the MEA. Remember, 200 ft/nm is always the minimum unless a higher gradient is specified.

Sometimes the FAA will mark a given runway as "NA" for IFR takeoff. This means it isn't authorized for commercial IFR takeoffs and shouldn't be used by the not-for-hire pilot either. Unlike approach minima, the not-for-hire pilot isn't even bound by the IFR departure procedure itself, unless given by ATC in an IFR clearance. Common sense is another matter.

The "big valley" trap

The FAA staff doesn't like doing any more work than necessary, so their interpretation of the "minimum en route altitude" required of TERPs, Chapter 12 departure criteria is the lowest MEA. This works fine at places like JAC, where the terrain is steep and close to the airport. The published MEAs of the airport's terminal airway structure form the terminus of the IFR departure procedure. However, where high terrain penetrates either Zones 2 or 3, but is far enough away that the lowest FAR 91 MEA can be achieved, the FAA walks away from it at that point.

For example, there is a hypothetical airport in a flat valley at 5,000 feet msl. The valley is surrounded by mountains rising to 12,000 feet at 25 miles. At first glance you'd think that mountains at 25 miles which are 7,000 feet higher than the airport would require a climb gradient of 328 feet per mile [7,000 feet + (25 miles x 48 ft/nm clearance) divided by 25]. Further, such a location should usually have an IFR route departure procedure to assist the pilot along the least demanding climb-gradient route.

Well, surprise! Such an airport would likely have no climb gradient specified and no IFR departure procedure. This is because the FAA applies FAR 91.177(2) (minimum off-route level-flight IFR altitudes). Thus, at a mountain airport, if 2,000 feet agl can be achieved with a four-mile buffer in all directions, then the FAA terminates

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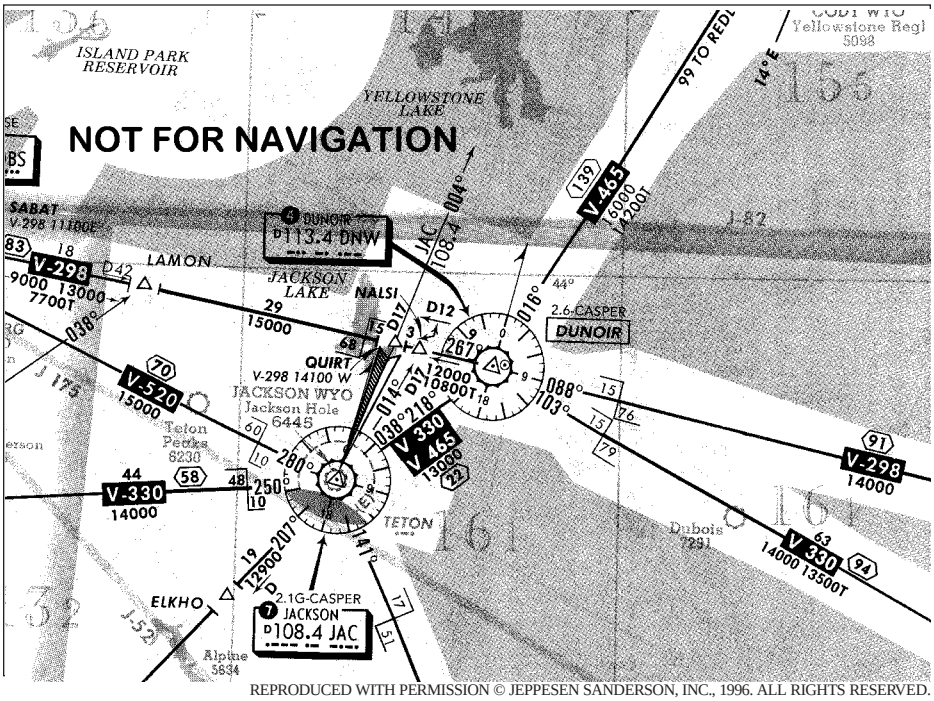

Figure 4. The en route chart should be briefed and available on departure.

Graphic. . .

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their Zones 2 and 3 evaluation. At a 40:1 slope, 2,000 vertical feet are achieved in 13.2 miles. Add the four-mile FAR 91.177 buffer, and the FAA takes a hike at 17.2 miles at a "big valley" airport.

I've seen some indications the FAA is moving away from this policy position. Until they make it public, however, treat any mountain airport with an IAP but without an IFR departure procedure with the utmost of caution when contemplating an off-route, diverse departure under IMC.

Wally Roberts is a retired airline captain, former chairman of the ALPA TERPs and an active ATP/CFII in San Clemente, CA.

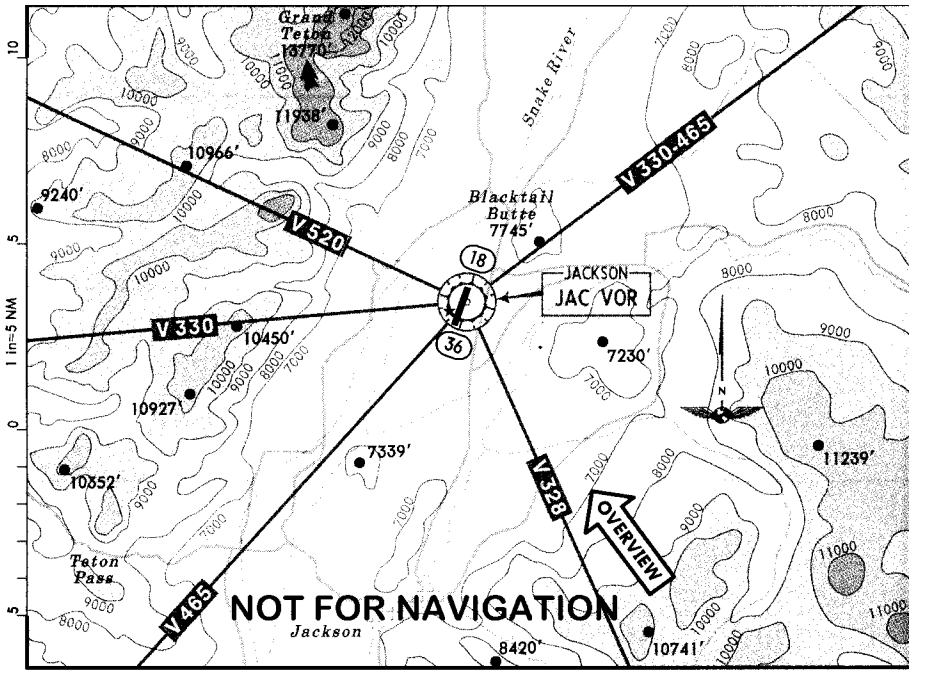

Figure 5. The Jepp airport qual chart is handy when departing a mountain airport.

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