# WATTS ANTENNA COMPANY

***....the Industry Leader in Advanced Instrument Landing System (ILS)***
***Antenna Products and Development***

## Re-evaluating ILS Sensitive and Critical Areas

As a result of its broad customer base comprising international and domestic U.S. clientele, Watts Antenna Company designs its systems with an eye to multiple regulatory regimes, most notably the International Civil Aviation Organization (ICAO) and the Federal Aviation Administration (FAA). For ILS purposes, the controlling documents for these agencies are ICAO Annex 10 and the ILS Siting Handbook (Order 6750.16), respectively. A summary description of their key differences appears in the chart below:

| ILS Standards (ICAO vs FAA) | | | | |
|---|---|---|---|---|
| Characteristic | ICAO<br>(Annex 10) | | FAA<br>ILS Siting Handbook<br>(Order 6750.16) | |
| Area and protection conditions | Critical Area | Protected during all (e.g. good weather) ILS usage | Critical Area | Normally protected (with exceptions) when weather worse than 800 ft ceilings and/or 2 miles visibility |
| | Sensitive Area | Movement controlled during ILS operations | | |
| Hold Lines | Varies with aircraft type | | Sited for most demanding aircraft size and LOC course width | |
| Size dependent on static multipath? | Yes | | No | |
| Area sizes defined for... | Small, medium, large aircraft<br>category of operation (I, II, III, etc.)<br>ILS antenna system type | | | |

Immediately, two important differences become apparent. One, the FAA does not recognize a sensitive area (unlike ICAO) and two, the FAA does not consider static multipath when calculating an airport's critical area. (As cited on the above chart, critical area boundaries are identified by painted markings and lighted signs called *hold lines*.)

[Note: While we're defining terms, another source of confusion is the seeming interchangeability of the terms *glide slope* and *glide path*. The FAA defines the glide path as that portion of the glide slope which intersects the localizer. Watts Antenna Company named its MODEL GP-5A DIRECTIONAL IMAGE GLIDE PATH ANTENNA with the full intent of stressing this distinction.]

ICAO defines critical and sensitive areas this way:

Critical Area (CA) -- "...an area of defined dimensions...where vehicles, including aircraft, are excluded during all ILS operations."

Sensitive Area (SA) -- "...area beyond the critical area where the parking and/or movement of vehicles, including aircraft, is controlled to prevent the possibility of unacceptable interference...during ILS operations. The SA is protected ...[from objects] ... outside the CA but still normally within the airfield boundary."

As Watts Antenna Company stated years ago in its TECHNICAL SUMMARY: WA-TS 98.001:

> *"One cannot consider the size of the critical area without first considering the magnitude of the guidance signal error produced by static sources of reflection in the airport environment...ICAO Annex 10 defines the requirements for considering the impact of the static errors in defining the critical and sensitive areas. The formula, with variables redefined here for clarity, involves the root-sum-square of the errors produced by static sources and those produced by ground operations.*

$$\text{Allowable Remaining Error} = \sqrt{\text{Category Tolerance}^2 - \text{Existing Static Error}^2}$$

The square root of the sum of the squares (RSS) is deemed valid for an ILS analysis because ICAO is attempting to calculate an aggregate tolerance for the combined effects of dynamic multipath (stated in the equation above as Allowable Remaining Error) and static multipath (stated above as Existing Static Error.) The composite accuracy is not merely the arithmetic average of the accuracies (or uncertainties), nor will it simply be the sum of them. ICAO defines the protected area based on the Allowable Remaining Error. Of course, another way to state this equation is in the inverse or traditional root-sum-square form. Moreover this ICAO formulation is conservative by design. As we pointed out later in the above referenced document…

> *The root-sum-square method is deemed justified by ICAO because it is not likely that the errors, static and dynamic, will be received by an aircraft on approach in an in-phase condition and that the errors should not be simply added. Although this may not be likely, it is entirely possible. However, application of a formula involving a simple summation would place unrealistic constraints on ground operations and would require vast protected zones.*

Another implication of the RSS method can best be described as a *zero-sum effect*, that is, static objects causing large course bends leave less margin for dynamic multipath. Another way of expressing this is that a pick-up of tolerance from one allows tolerance degradation from the other. Percentage of tolerances are typically expressed in >25%, >50%, >75% and >100%.

ICAO recommends combining static and dynamic multipath using the RSS method: *"If the course structure is already marginal due to static multipath effects, less additional interference will cause an unacceptable signal. In such cases a larger-size sensitive area may have to be recognized."* The FAA's practice is to define critical area sizes at 100% of tolerance, ignoring any static multipath.

Modeling dynamic multipath is a complex, multivariate science. This is due to the almost limitless permutations that can contribute to the phenomenon. Since taxiing and temporarily parked aircraft are the dominant source of dynamic ILS guidance degradation, no two configurations are ever identical. The virtually infinite multipath configurations argue for conservative or worst-case regulatory and design scenarios.

In the U.S., critical areas are operationally managed by the Air Traffic Controllers (ATC) subject to three key exceptions:

- Good weather exception: Less than 800 feet ceiling and/or visibility less than 2 miles

*except for…*

- Preceding aircraft exception: A preceding arriving aircraft on the same or another runway that passes over or through the area while landing or exiting the runway.

- Departing aircraft exception: A preceding departing aircraft or missed approach on the same or another runway that passes through or over the area.

Really, the weather exception is a sixties-era anachronism as it dates back to a time when:

- Aircraft were smaller (“big” was B-707),
- Category II and III operations were relatively rare
- Autoland operations weren’t yet available
- Airports were less congested

As a result of these three exceptions, the inner portion of the U.S. critical area, for which ICAO restricts aircraft for all ILS operations, is left comparatively unprotected.

Additionally, current FAA US CA/SA boundaries are defined on the basis of the largest aircraft expected at the airport as well as a three-degree course width, regardless of runway length. The techniques impose additional burdens on airport capacity as a single set of hold lines (for the largest aircraft) are used.

There's a common misconception among laymen that low-visibility weather contributes directly to air-flight delay as a result of degraded visibility or hazardous runway conditions. This is not the case. To the extent that Instrument Flight Rules (IFR) apply, Visual Flight Rules (VFR) are abandoned and Low Visibility Procedures (LVP) go into effect. Strictly speaking then, the delay is not due to weather *per se*, but rather the aircraft having to await landing guidance from an ILS or comparable precision landing system. It should be noted that, due to Transponder Landing Systems (TLS) requiring only one plane per approach, an even greater delay factor is imposed on runway assets.

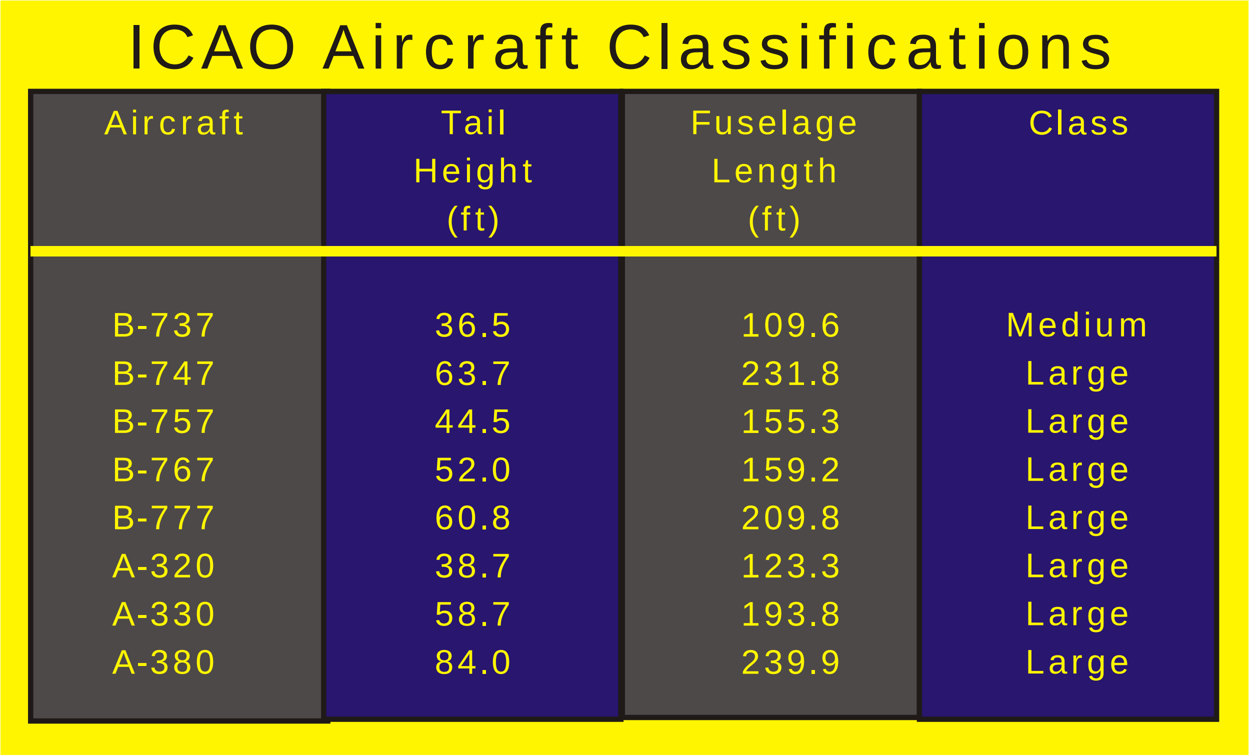
LVP presents the single largest limiting factor on runway capacity. In fact a common rule-of-thumb is that LVP can account for a fifty percent reduction in runway capacity. Needless to say any steps that can be taken to reduce ILS' 'overhead' on runway capacity are welcome, particularly in an environment where increased passenger miles are expected to outpace capacity and efficiency enhancements for years to come. One way to optimize ILS performance and limit LVP-related degradation is to reduce the required size of the sensitive area. The benefits are clear:

- For an aircraft awaiting clearance to land, it means reduced waiting periods to ensure that the critical and sensitive area requirements are met.

- For the aircraft awaiting take-off clearance it means that the pilot can position the aircraft closer to the runway threshold and that minimal delay can be expected.

- For the controller this means they can position aircraft awaiting take-off closer to the runway and landing aircraft must go a shorter distance before clearance can be given to the next aircraft in the sequence.

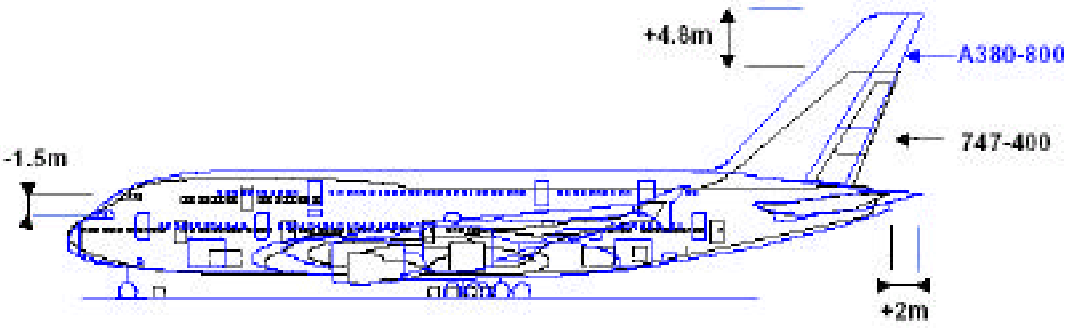
A re-evaluation of ILS sensitive areas has taken on increased urgency with the advent of newer, larger aircraft such as the Airbus A-380. A cursory review of aircraft tail heights (in the chart below) clearly shows the A-380's potential for producing material effects on dynamic multipath phenomena and sensitive area requirements. A-380 hangars will also affect static multipath analyses.



## ICAO Aircraft Classifications

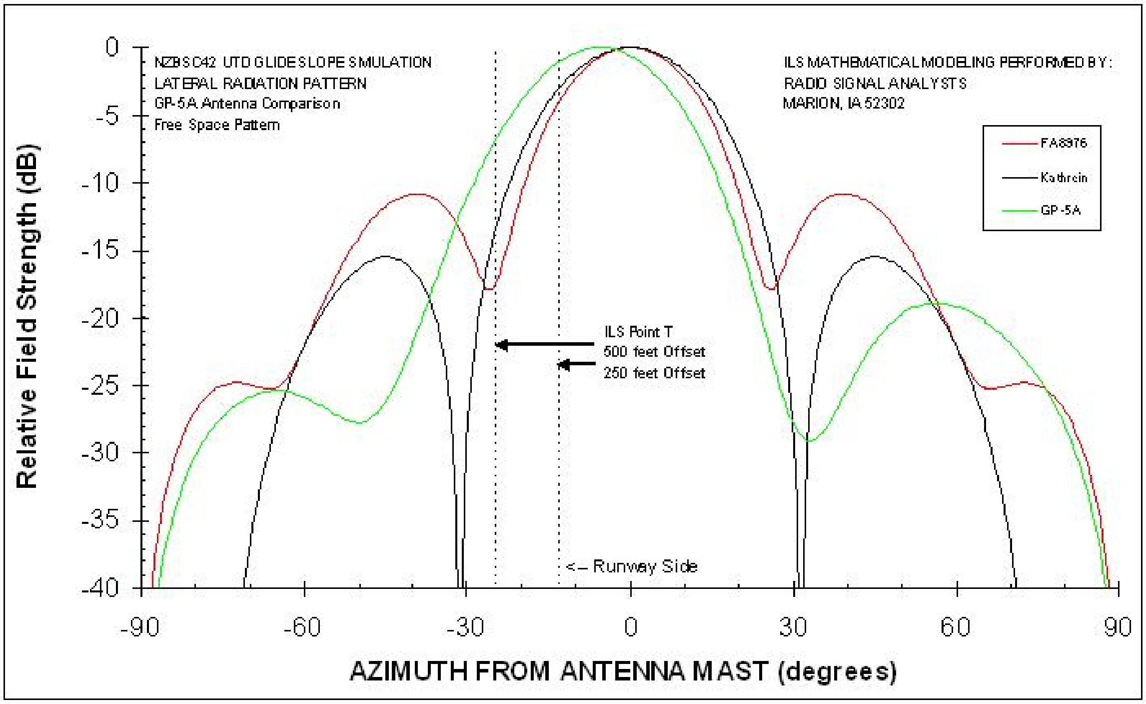
| Aircraft | Tail Height (ft) | Fuselage Length (ft) | Class |
|---|---|---|---|
| B-737 | 36.5 | 109.6 | Medium |
| B-747 | 63.7 | 231.8 | Large |
| B-757 | 44.5 | 155.3 | Large |
| B-767 | 52.0 | 159.2 | Large |
| B-777 | 60.8 | 209.8 | Large |
| A-320 | 38.7 | 123.3 | Large |
| A-330 | 58.7 | 193.8 | Large |
| A-380 | 84.0 | 239.9 | Large |

The diagram below further serves to illustrate the dimensional variations between a 747-400 and an A380-800. Again, one should pay particular attention to the tail height differentials.



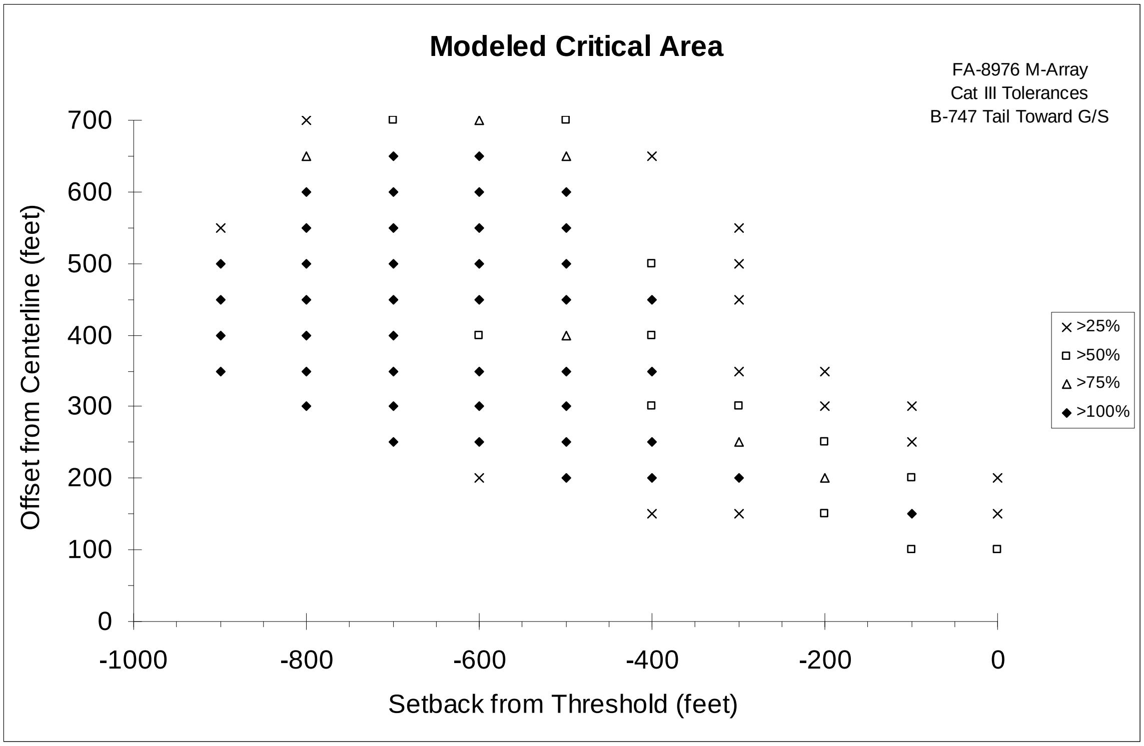
As a 2004 Obstacle Clearing Panel put it, in relation to the Paris Charles-de-Gaulle Airport (CDG):

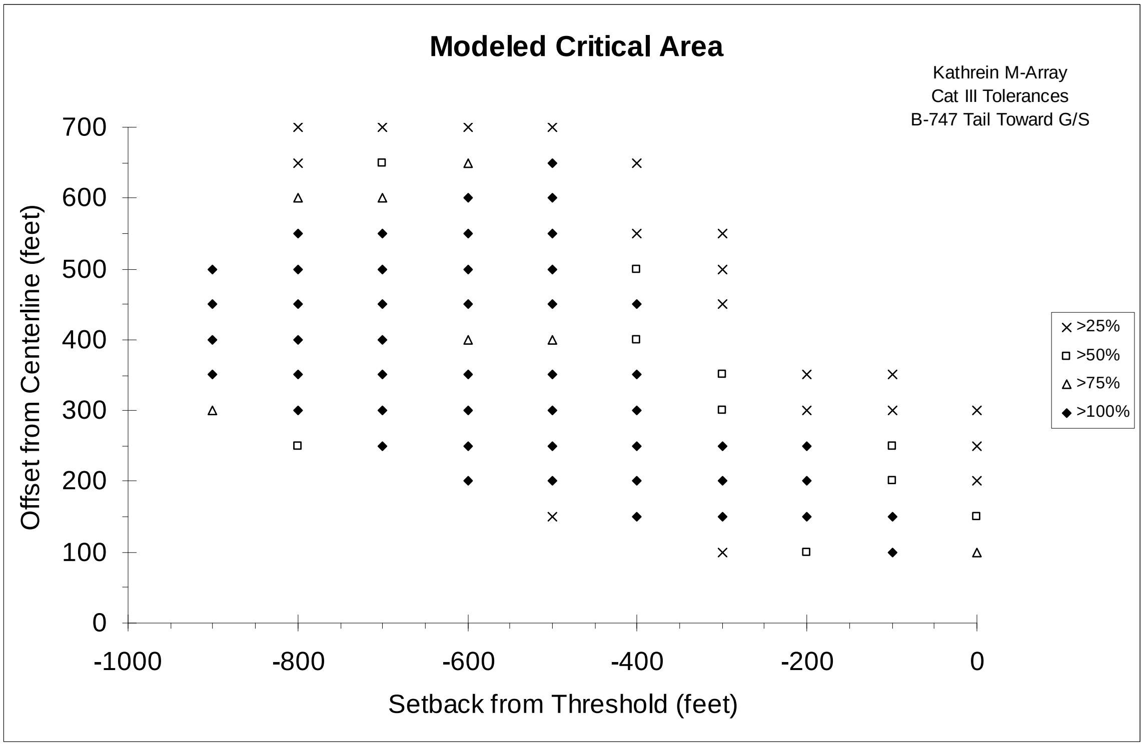
> *"Because the A380 geometric characteristics slightly exceed the current reference aircraft (i.e. the 747-400), the size of the sensitive area should be assessed on a case by-case basis taking into account specific aerodrome layout, antenna characteristics and traffic density."*



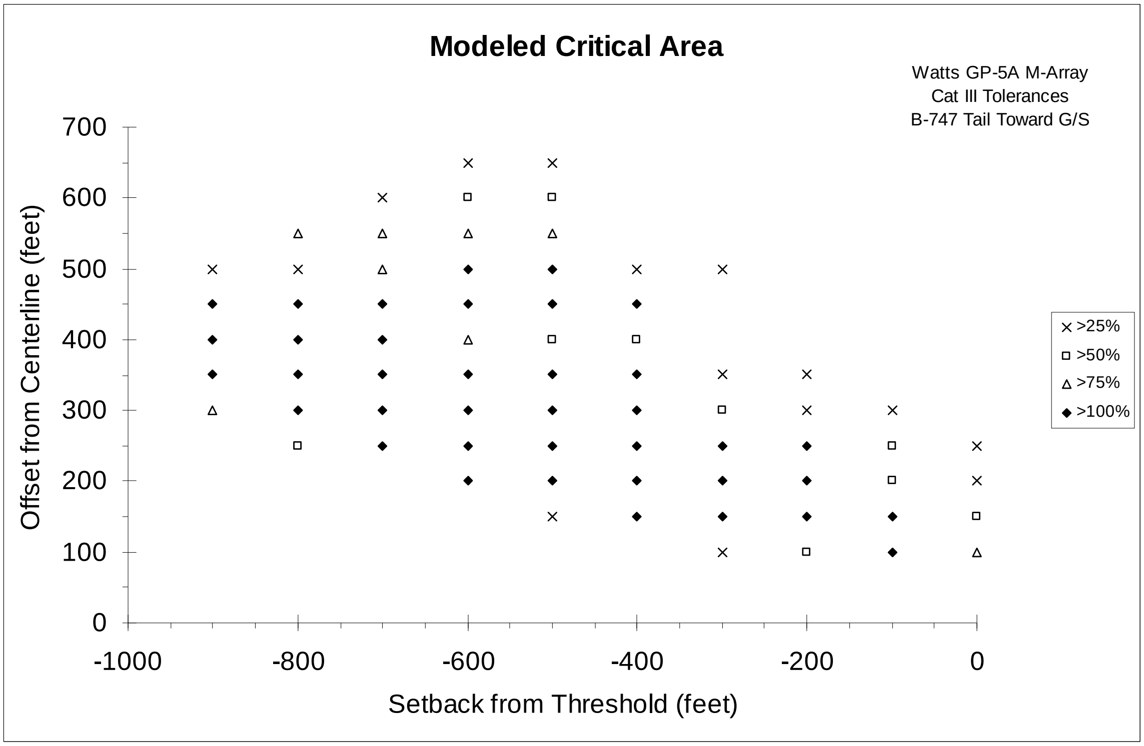
With respect to Watts Antenna Company's **<u>MODEL GP-5A DIRECTIONAL IMAGE GLIDE PATH ANTENNA</u>,** the graph (above) shows a radiation pattern comparison of the GP-5A with the FA-8976 (FAA standard for 25 years) and the Kathrein antenna (International antenna used for 25 years). The radiation pattern shows why the GP-5A is a game-changing performer. Notice that the area in the plus direction is on the tower side of the runway where aircraft would taxi. The reduced RF level there allows the aircraft to pass the tower and taxi the length of the taxiway. Also notice that the RF pattern of the GP-5A is steered toward the approaching aircraft azimuth so that a stronger direct signal is received to reject any potential multipath. The influence of multi-path is a direct to reflected signal ratio so a double benefit is gained.

The following chart shows the FA-8976 with a 747 parallel to the runway with the tail towards the tower (CAT III tolerances). M-Array tower at 400 feet offset.





The chart just above shows the Kathrein Antenna with a 747 parallel to the runway with the tail towards the tower (CAT III tolerances).  M-Array tower at 400 feet offset.



In the chart just above we have the Watts GP-5A with a 747 parallel to the runway with the tail towards the tower (CAT III tolerances). M-Array tower at 400 feet offset.

The other three plots are industry recognized critical area plots where a 747 class aircraft is mathematically simulated at various locations around an m-array tower displaced 400 feet from the centerline. The bold cross symbol represents the locations that are 100 percent or more of the allowable tolerance. Both the Kathrein and the FA 8976 have 100 percent marks at 650 feet which is 250 feet beyond the tower offset. This is why the aircraft cannot pass by without producing out-of-tolerance multipath with the existing tower systems. A 747 would have to pass by at 300 feet from the tower.

The GP-5A (pictured right) has the last 100 percent mark at 500 feet which is only 100 feet from the tower. The aircraft would pass by the tower at 150 feet and, considering the approximately 211 foot wingspan, would allow a mere 35 feet tower-to-wing separation which is probably too close given the equipment shelter also. Thus the one remaining constraint becomes the Obstacle Free Zone (OFZ) and how closely the tower and runway can be approached depending on whether the tower is 21, 28 or 42 feet tall.

At Watts, we're making NextGen happen *now*.