

PACD 2006

Yves de Lassat de Pressigny*
Centre d'Essais en Vol, FR

Richard Benney†
US Army Natick Soldier Research, Development and Engineering Center

Mick Vallance‡
Joint Air Transportation Evaluation Unit, UK

Jan-Henrik Wintgens§
German Military Flight Test Center

DGA (the French MoD Procurement Agency) and the French Air Force organized the first NATO Precision Airdrop Capability Demonstration (PACD) in Europe. This demonstration was held on 3rd-5th July 2006 at the Centre d'Essais de Lancement de Missiles (CELM, Missiles Launching Test Centre at Biscarrosse- Landes). During the two-day event, 30 precision airdrop systems and 6 paratroopers were dropped. Five Nations contributed to the demonstration providing aircraft, paratroopers and sponsoring precision airdrop systems: France, Germany, Italy, United Kingdom and the United States of America. Precision Airdrop for Special Operation Forces is one of NATO's priorities for Defence Against Terrorism. A specific objective of the 1st French PACD demonstration was to include "operation scenarios" to illustrate specific use cases, with NATO providing some of these scenarios. For the first time during a precision airdrop demonstration, stand off scenarios were used to demonstrate the capability of the system to reach the impact point after a drop above the ocean miles away from the DZ. The Flight Test Centre base at Toulouse developed a special simulation tool called ASTRAL to determine the Computed Air Release Point (CARP) for each system. Its input data included wind profile data obtained by upper air soundings above the CELM, the ballistic and glide parameters of each system and industry systems criteria. ASTRAL calculations ensured that each system had the capability to reach its planned Impact Point and also ensured that the system would not land outside of the range should a malfunction occur. The main difficulty was the special topography of the drop zone which was located between a lake and the ocean and bordered on three sides by forests. The organization of PACD was a real challenge, involving the co-ordination of 5 nations, 2 branches of the French MoD, an airbase and the missile test range who the hosted the event but were not familiar with airdrop activities. PACD achieved all of its goals at Biscarosse and demonstrated a coherent precision airdrop demonstration with participants of various cultures, equipment, know-how and habits.

Nomenclature

PACD = Precision Airdrop Capability Demonstration
CARP = Computed Air Release Point

* Maj., Aerospace Engineer, CEV, Toulouse, FR. AIAA Member

† Aerospace Engineer, Division Leader Aerial Delivery Equipment and Systems Division, US Army NSRDEC, Natick, MA. AIAA Associate Fellow

‡ Sqn. Ldr., 2IC JATEU, Brize Norton, UK. AIAA Member

§ Test Manager for Air Drop Systems, WTD 61, Manching, DE. AIAA Member

I. Introduction

The NATO Conference of National Armaments Directors (CNAD) decided in October, 2005 to request the organization of the PACD 2006 in France. Precision airdrop demonstrations are a booster for the coordinated development of airdrop systems and definition of concepts of operation. A PACD in Europe had become an obvious step to make because of the increasing number of European manufacturers, and the opportunity to get a NATO audience, whereas at the US Army Yuma Proving Ground (YPG) demonstrations, the audience is primarily from the US. Indeed, Precision Airdrop for Special Operation Forces is one of NATO's priorities for Defense Against Terrorism (DAT) and what was (since 2001) a lead activity in the US is now a common development field for several nations. For that reason, PACD 2006 had an additional dimension compared to previous demonstrations: airdrop cases were defined according to operational scenarios and associated operational constraints, such as utilizing maximum horizontal stand-off to avoid ground to air threats or deceive the DZ identification from enemy forces, imposed paths to account for geographic constraints (for example, landing along a runway), or more difficult challenges like landing on top of a sand hill.

France lacks very large unpopulated areas, and safety issues are significant when compared to the situation at many US Drop Zones. The only French site adapted for precision airdrop from a significant altitude is CELM (Centre d'Essais de Lancement de Missiles) in Biscarrosse. Despite its dimensions, the compromise between a performance demonstration and safety was challenging and the organizing nations agreed to centralize the air release point determination so as to ensure uniformity in safety levels despite the use of 12 different systems designed or operated by 8 nations.

II. The ground facilities

A. French Air Force Airbase in Cazaux

The French Air Force was the actual initiator of the French PACD. It provided the air base infrastructure and ground coordination and support teams, deployed by BA 120 (air base in Cazaux) and CEAM (the air force military evaluation center), and is the official organizer and contractor for all other national participation.

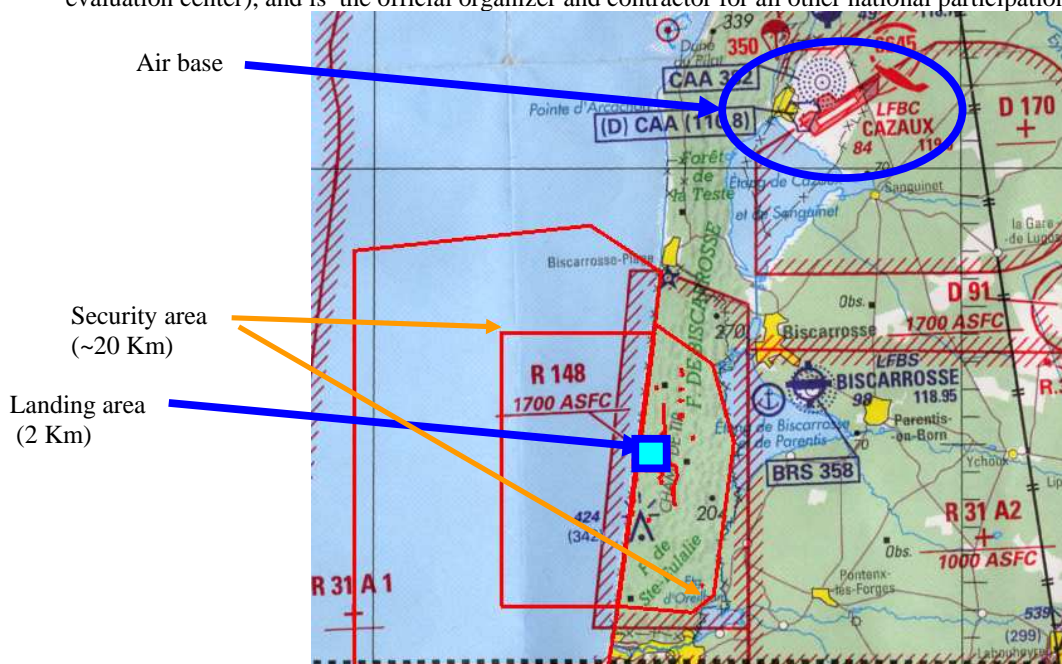


Figure 1: The airbase, DZ and security area.

Among many challenges, the air base had to manage the early arrival of the US C-130, due to operational constraints forcing the US team to do all precision airdrop system rigging in France. The airbase successfully provided ground support (ballast, hauling, etc ...) though it is a fighter airbase and heavy support was needed and planned specifically for the PACD.

B. The drop zone

CELM is a part of the DGA, the French armament procurement agency. It provides testing and evaluation infrastructure and equipment that armed forces don't have, and operate this equipment. It is situated facing the ocean, which allows for use of a testing area of more than 20 Km despite the depth of only 6 Km of the ground area to civilian populated areas. Along with the testing area, CELM provides real-time video and trajectory broadcast which allows both observing and control of testing in progress real-time.



Figure 2: The DZ in CELM (barren area and fake runway) and real-time monitoring display.

The monitoring is provided by radar and optical trajectory tracking equipment. The CELM also has ground, maritime and air safety teams to manage exclusion areas including the safety areas, in a region otherwise crowded by pleasure or fishing ships and light aviation from the nearby civilian airfields (Fig.1, LFBS airfield is the closest).

III. Demonstration and Safety management aspects

A. Safety issues

As can be seen on Fig. 1 and 2, the testing area is surrounded by high-density population areas. PACD 2006 was the first such multi-national precision airdrop capability demonstration event in France, and the host site asked CEV (Centre d'Essais en Vol, or Flight Test Center, the second DGA participant to PACD and coordinator center for DGA participation) to centralize the CARP safety calculations, so that a uniform level of safety was reached despite the various origins of the participants.

Former CEV experience demonstrated an effective risk for possible malfunctions of each airdrop system at early development stages. The worst consequence being a failure resulting in a straight flight phase which was observed in 2005. Such a blockage also occurred during PACD 2006; although it happened during an "orbit" phase, it points out that such logic and/or hardware failures are still very real possibilities that can lead the system to fly to any point within its gliding capability also known as a safety fan.

Being used to check air release points, CEV considered two options: checking CARPs chosen by the aircrews and/or industry, or generating all the CARPs based on industry provided system criteria. The second option was recommended, which avoids a sometimes long and painful trial and error process to conciliate two opposed logic's (demonstration purpose and safety purpose), and because the necessary real-time communication with multiple teams would have been difficult. The method used included a 3 person CEV team who worked continuously from 90 minutes before the drops. This resulted in minimal extra time for negotiation with the operating teams..

B. Demonstration and safety management organization

Preparatory phase :

The preparatory phase began in March 2006. The work conducted by CEV included: collection of ballistic and glide performances for each system, to collection of industry's instructions and approach to determine an optimal CARP for each system, to checking the maximum altitude compatible with safety aspects for each system and to generate footprints with ASTRAL (an airdrop simulation software application) for CELM to make its safety analysis and determinations. The first edition of the results was available on 31 March 2006 and several updates were made with industry's feedback right up to the actual PACD.

CELM made its safety analysis based on CEV data, with a target probability of under 10^{-4} for a system to damage ground installations and under 10^{-6} for a system to impact people inside or outside the testing area. The

safety analysis conclusion resulted in having all facilities evacuated of personnel except the main base, outside the testing area, and the facilities inside the area dedicated to the PACD.

Operational organization :

CELM provided upper air sounding every 30 minutes to provide wind profile data for the CARP generation.

The CEV team in CELM mission control room generated CARPs a priori 90 minutes before the first planned drop and faxed the data to the crews in Cazaux air force base.

The CEV updated the CARPS continuously 2 passes in advance for all planned drops to ensure the event stayed within the pre-planned schedule (all drops were conducted within 5 minutes of the planned schedule during the PACD).

The CELM validated performance and safety aspects (the system can reach the IP, can't leave the safety area, and the most probable failures such as ballistic free fall or a continuous spiral would not fall onto the PACD ground team) and recorded the CARPs on its monitoring system (Fig 2, right). Both US and UK military participants were also present in the mission control room to share experience with the French team via separate simulation tools. This added experience was welcome and provided added confidence to these participating Nations.

The CELM broadcasted the updated CARP to each crew while in-flight and controlled the drops with "CLEAR TO DROP" and "NO DROP, NO DROP" instructions.

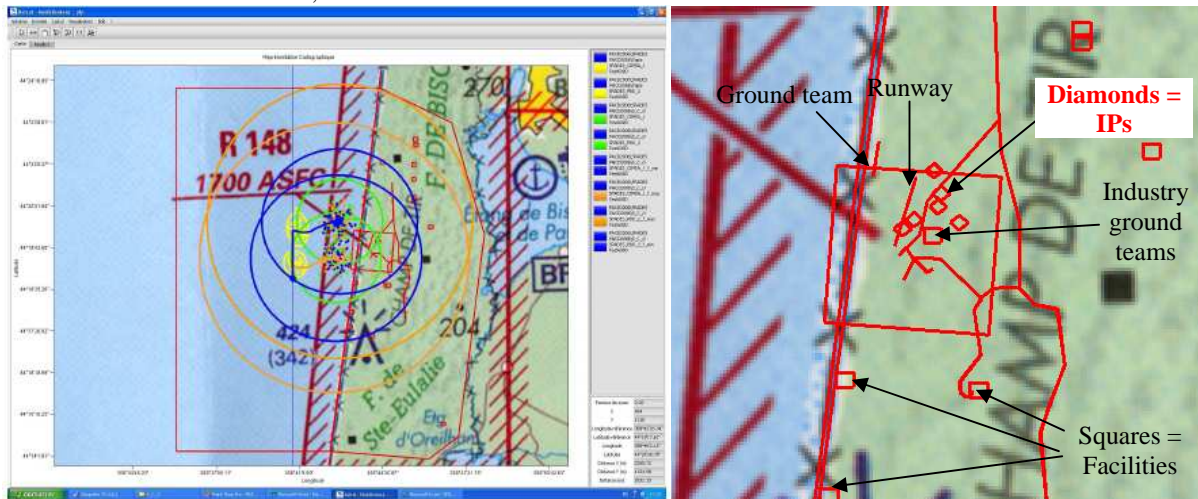


Figure 3: ASTRAL interface for CARP management and a detail of the DZ. The legend to the right of ASTRAL allow to identify the system and simulation case (ballistic is yellow, max glide is orange, min glide is blue, industry clearance is green.)

The CEV provided two CARP generation specialists and one additional non specialist airdrop expert as a value added communication interface with CELM and the other nations. CELM had its own test director who interfaced with the flight director. Such an large team may seem to have added complication, but the rigorous division of tasks (compute, format and trace, validate and implement, and exploit CARP data) allowed all participants in the mission control room to keep a continuous rhythm for ground operations compatible with and within the timelines planned for the 4 hours continuous demonstration during each of two days.

IV. Air operations

A. Flights

The airdrop demonstration was conducted in two 4 hours slots, on July, 4 and 5 2006 during the morning hours.

Each slot consisted of 11 successive aircraft run-ins with 1 or 2 airdrop system drops per pass, and an additional 4 paratroopers deployed on the last pass. The first sequence of airdrops was conducted by a US C-130, the second by a German C160, the third by a French C160, and the fourth again by the US C-130. The flight operation went on smoothly thanks to a preparatory work that begun with a French exercise at CELM in 2005, a second such exercise the week before PACD 2006, and a 4 flight ship dry run rehearsal (with no-drops) on July, 3.

On July, 4 some planned airdrop release altitudes had to be adapted (lowered) due to adverse weather conditions. A broken layer of heavy clouds from 4,000 to 5000 ft led to a last minute canceling of the EADS/Paralander drop (due to a sensitive ground height sensor or which there was some concern would trigger on the thick cloud cover and

that required the German crew to unload the system a few minutes before take-off. CADS had to be dropped at 3,000 ft due to the visibility requirement (for PACD) of the accompanying paratroopers (visibility of both the CADS and the DZ). The challenging yet realistic weather also challenges the quality and collection of some video tracking and prevented the collection of full trajectory data (from some instrumentation) for the early part of the systems flights.

On July, 5, the VIP day, the weather had cleared significantly with only scattered clouds, allowing better tracking and video of the airdrop systems. The only trouble difficulty within the aircrafts over the two day of flight tests was a hung load (the last planned Sherpa drop) on the first US C-130 flight.

Pas#	# of drops	System/Company	Total mass (kg)	Sponsor Nation	Company Nation	Proposed Aircraft	Scenario #	Drop altitude ft	Flight Axis	Impact point	"Time" est. (min)	Add Time
1	2	Dropsondes/PSI		US	US	US C-130	1	15 000	W-E	Ocean	15	15
2	1	26 Ft RingSlot	725	US	US	US C-130	1	15 000	W-E	2	15	30
3	2	AGAS/Capewell	820	US	US	US C-130	1	15 000	W-E	4	20	50
4	2	SCREAMER/Strong	900	US	US	US C-130	2	10 000	W-E	2	15	65
5	2	Sherpa/MMIST	450	US	CA	US C-130	3	8 000	S-N	8 (3 or 4)	20	85
6	1	ParaLander/EADS	570	GE	GE	GE C-160	4	10 000	S-N	3	20	105
7	1 or 2 ¹	SPADES (250) /Dutch Space	250	US	NL	GE C-160	5	6 000	S-N	6	20	125
8	2	Panther 2500 /Aérazu ²	860	FR	FR	FR C-160	5	6 000	S-N	6	20	145
8	2	Panther 500 /Aérazu ³	250	FR	FR	FR C-160	5	7 000	S-N	6	20	165
9	2	SkyPorter/UTRI	172	IT	IT	FR C-160	6 (or 3)	8 000	S-N	7	20	165
10	2	Firefly/Para-flite	680	US	US	BE C-130	6	6 000	S-N	7	15	180
11	1	CADS/Flight-Refueling	160	UK	UK	BE C-130	7	10 000	S-N	5	20	200
11	4	UK Paratroopers	-	UK	UK	BE C-130	7	10 000	S-N	5	20	200
Total	21+4	12 different systems	-	5	7	4	7	-	-	-	-	200

Figure 4: PACD 2006 drop schedule. ¹ : 1 load July, 4 and 2 loads July, 5. ² : July, 4 only. ³ : July, 5 only. One Firefly was cancelled on day 2 because of an incident on day 1. One Skyporter was canceled on day 1 because of logistical issues.

B. The Airdrops

Many of the airdrop systems at PACD suffered a wide range of malfunctions and failures. These varied from the most elementary, a hung load within the aircraft, to the most dramatic failures, ballistic free-fall and loss/destruction of a system. One of the system suffered canopy damage during opening, yet it managed to steer and correctly guide itself to the drop zone.

Many other malfunctions were observed which in some cases appeared to be in the planning/programming stage and/or guidance navigation and control (GN&C) logic failures in the software. One system appeared to experience a GN&C logic failure in an early pre-planned wind determination maneuver phase, causing it to circle endlessly to the ground. Once in 2005, CEV observed a similar failure on another precision airdrop type system, but in a straight flight phase, causing the worse safety issue, maximum glide in an often arbitrary near straight line direction. One system managed to maintain steering control downwind of the IP after passing it, revealing either a badly programmed IP or perhaps incorrect pre-flight planned GPS ground IP input. Such malfunctions, observed two years in a row appear to show that failure cases should always be considered and that safety analysis is always required when using precision airdrop systems in test, training or real operations.

Drop failed	Canopy damage	Canopy failure	Guidance malfunction	Guidance failure	System lost to sea
1	1	2	6	4	2

Figure 5: PACD 2006 malfunction summary.

Not surprisingly with so many malfunctions occurring throughout the PACD, the average landing precision was not as good as overall as at the PATCAD 2005 at YPG.

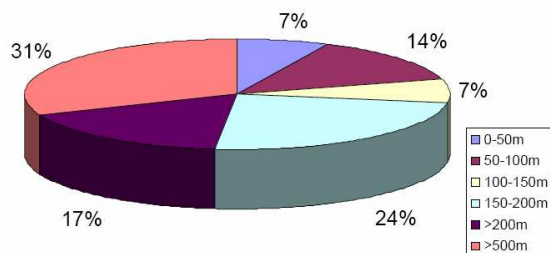


Figure 6: Statistics on landing precision for PACD 2006

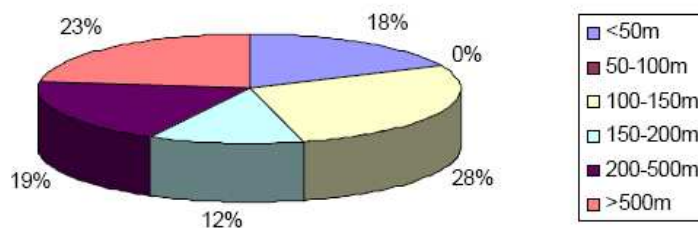


Figure 7: Statistics on landing precision for PATCAD 2005

On a positive note, some systems were dropped over the sea as far as 6,000 m area from the DZ and from an altitude of 2,100 m yet were able to reach the IP and land with an accuracy of approximately 100 m. Another system, dropped closer to the DZ and of a lighter weight, had an accuracy of approximately 50 m for the IP on top of a sand hill. Several systems programmed with pre-planned (scenario based) trajectory constraints (such as no-fly zones or fictitiously imposed geography constraints) were able to place themselves into a final position near the runway as requested.

V. Conclusion

The first NATO sponsored precision Airdrop Capability Demonstration was held in France on 3-6 July 2006. An audience of over 120 visitors witnessed the event which included briefings from nations and contractors on day one and two days of precision airdrops from three different aircraft. Significant information sharing was obtained through the PACD to include some hands-on demonstrations of hardware which was accomplished through static displays. The PACD concluded with an exceptional banquet with all participants at the CEV.

A series of malfunctions and failures caused an overall poor average accuracy result despite a handful of outstanding individual performances. This clearly demonstrated the need for a large ground safety zone and the need for improvements in many precision airdrop systems and associated technologies.

However, with 29 airdrops executed out of the 33 planned, and some very good accuracy results demonstrated within some of the NATO provided scenarios imposed by the organizer, the PACD 2006 demonstrated an actual improvement in some precision airdrop capabilities. Such results and the actual multinational dimension of this event made it a success, and a major milestone towards meeting some of the NATO precision airdrop DAT objectives to include interoperable and a fast reaction precision airdrop capability for NATO Nations.